TC 3-97.61

# MILITARY MOUNTAINEERING

NOVEMBER 2025

DISTRIBUTION RESTRICTION: Approved for public release; distribution is unlimited.
This publication supersedes TC 3-97.61, dated 26 July 2012.

HEADQUARTERS, DEPARTMENT OF THE ARMY

This publication is available at the Army Publishing Directorate site (https://armypubs.army.mil) and the Central Army Registry Site (https://atiam.train.army.mil/catalog/dashboard).

Training Circular
No. 3-97.61

Headquarters
Department of the Army
Washington, DC, 26 November 2025

# MILITARY MOUNTAINEERING

## Contents

Page

**Preface** ..... **xv**
**Introduction** ..... **xvii**
**CHAPTER 1** ..... **1**
**MOUNTAIN ENVIRONMENT** ..... **1**
**Section I – Mountain Terrain** ..... **1**
Definition: Types and Formations of Mountains ..... 3
Mountain Building ..... 3
Terrain Features and Terms ..... 4
**Section II – Mountain Terrain Composition** ..... **4**
Vegetation ..... 4
Rock ..... 5
Rivers ..... 7
Snow ..... 7
**Section III – Terrain Analysis** ..... **8**
Observation and Fields of Fire ..... 8
Avenues of Approach ..... 8
Key and Decisive Terrain ..... 9
Obstacles ..... 9
Cover and Concealment ..... 9
Mountain Classifications ..... 9
**Section IV – Mountain Weather** ..... **12**
Mountain Weather Factors ..... 12
Planning for Weather ..... 14
Weather Forecasting ..... 14
**CHAPTER 2** ..... **17**
**TRAINING MILITARY MOUNTAINEERS** ..... **17**

DISTRIBUTION RESTRICTION: Approved for public release; distribution is unlimited.

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**Section I – Levels of Mountaineer ..... 17**
Candidates for Formal Mountain Training ..... 17
Level 1: Basic Military Mountaineer ..... 18
Level 2: Advanced Military Mountaineer ..... 19
Level 3: Master Military Mountaineer ..... 19
**Section II – Training Individual Mountain Skills ..... 20**
Unit-Level Training Programs ..... 20
Progression of Mountain Skills ..... 21
**CHAPTER 3 ..... 25**
**ENVIRONMENTAL INJURIES ..... 25**
**Section I – Environmental Injury Prevention ..... 25**
Illnesses and Injuries ..... 25
Treatment and Evacuation ..... 25
Injuries Related to Cold Exposure ..... 25
Cold-Weather Considerations ..... 29
**Section II – Altitude Effects, Injuries, and Acclimatization ..... 36**
Acclimatization ..... 36
Acute Mountain Sickness ..... 36
High-Altitude Pulmonary Edema ..... 37
High-Altitude Cerebral Edema ..... 38
**CHAPTER 4 ..... 41**
**MOUNTAIN SUBSISTENCE AND SUSTAINMENT ..... 41**
**Section I – Physical Traits of the Military Mountaineer ..... 41**
Physical Training for the Mountain Environment ..... 41
Nutrition for the Mountain Environment ..... 43
Acclimatization ..... 45
Fatigue ..... 45
**Section II – Cold-Weather Sustainment ..... 45**
Clothing ..... 46
Extended Cold-Weather Clothing System ..... 51
**Section III – Small Group Mountain Sustainment and Subsistence ..... 51**
Soldier Load Management ..... 52
Water Procurement ..... 54
Aerial Resupply ..... 56
**Section IV – Bivouac Considerations ..... 56**
Bivouac Site Location ..... 57
Glacier Bivouac Procedures ..... 57
Shelters ..... 57
Lightweight Stoves ..... 61

**CHAPTER 5** ..... **63**
**AVALANCHE** ..... **63**
**Section I – Avalanche Hazards** ..... **63**
Avalanche Elements ..... 64
Types of Avalanches ..... 68
Forecasts ..... 70
**Section II – Avalanche Risk Management** ..... **72**
Unit-Level Responsibilities ..... 72
Military Mountaineer Responsibilities ..... 72
**Section III – Avalanche Search and Rescue** ..... **75**
Avalanche Search ..... 75
Group Checks ..... 76
Avalanche Rescue ..... 77
**CHAPTER 6** ..... **83**
**MOUNTAIN MOBILITY** ..... **83**
**Section I – Individual Movement Techniques** ..... **83**
Mobility ..... 83
Mountain Walking ..... 84
Climbing Rock ..... 90
**Section II – Movement Over Snow and Ice** ..... **113**
Mobility Over Snow and Ice ..... 113
Movement Over Snow ..... 119
Ice Climbing ..... 130
**Section III – Load Management for Mobility** ..... **136**
Load Management ..... 136
Planning ..... 136
Scrambling and Climbing Load Management ..... 137
**CHAPTER 7** ..... **139**
**NAVIGATION IN MOUNTAINOUS TERRAIN** ..... **139**
**Section I – Military Land Navigation in Nontechnical Mountainous Terrain** ..... **139**
Navigational Equipment ..... 139
Navigational Techniques ..... 141
Route Planning ..... 143
**Section II – Navigation in Technical Mountainous Terrain** ..... **146**
Reconnaissance ..... 146
Roped Movement Techniques ..... 147
Route Finding ..... 147
**CHAPTER 8** ..... **149**
**KNOT TYING AND ROPE MANAGEMENT** ..... **149**

**Section I – Types of Rope, Webbing, and Carabiners ..... 149**
Ropes and Cords ..... 149
Webbing and Slings ..... 150
Carabiners ..... 152
**Section II – Basic Terminology ..... 154**
Running End ..... 154
Standing End ..... 154
Bight ..... 155
Loop ..... 155
Turn ..... 155
Round Turn ..... 155
Half Hitch ..... 155
Tail ..... 155
Dressing ..... 155
Setting ..... 155
**Section III – Knot Tying and Considerations ..... 156**
Types of Knots ..... 156
Knot Tying Considerations ..... 157
Knot Tying Techniques ..... 158
**Section IV – Ropes: Preparation, Care, Inspection, Coiling, Carrying, and Throwing ..... 189**
Preparing Ropes ..... 189
Care and Maintenance ..... 189
Inspection ..... 190
Coiling and Carrying Rope ..... 190
Throwing the Rope ..... 192
**CHAPTER 9 ..... 195**
**ANCHOR SELECTION AND CONSTRUCTION ..... 195**
**Section I – General Principles: Single and Multipoint ..... 195**
Single-Point Anchors ..... 195
Multipoint Anchors ..... 199
**Section II – Trees ..... 204**
Considerations ..... 204
Rope Anchors ..... 204
High-Strength Tie Off (Tensionless Hitch) ..... 205
Multipoint Tree Anchors ..... 206
Bushes and Shrubs ..... 206
**Section III – Rock Anchors ..... 206**
Boulders and Rock Protrusions ..... 206

Chockstones ..... 207
Tunnels, Arches, and Pinch Points ..... 208
Artificial Rock Protection ..... 209
Pitons ..... 210
Bolts ..... 214
Chocks ..... 217
Camming Devices ..... 219
**Section IV – Ice Anchors ..... 222**
Types of Ice Anchors ..... 222
Ice Pillars, Ice Screws, and V-Threads ..... 222
**Section V – Earth Anchors ..... 228**
Deadman Anchor ..... 228
Picket HoldFast ..... 228
**Section VI – Snow Anchors ..... 229**
Pickets and Ice Axes ..... 229
Bollard Anchor ..... 232
**CHAPTER 10 ..... 235**
**ROPE SYSTEMS FOR CLIMBING ..... 235**
**Section I – Risk Mitigation ..... 235**
Managing Risk ..... 235
Reducing the Likelihood of a Fall ..... 235
**Section II – Considerations for Moving Unroped ..... 236**
**Section III – Belayed Climbing ..... 237**
Types of Belayed Climbing ..... 237
Operational Considerations ..... 244
**Section IV – Top Rope Climbing ..... 244**
Equipment Considerations ..... 245
Preparation ..... 248
Training Site Consideration ..... 248
Training Site Anchors ..... 249
Inspections ..... 249
Top Rope Belay ..... 250
Climbing Commands ..... 253
**Section V – Lead Climbing ..... 254**
Equipment Considerations ..... 254
Belaying a Lead Climber ..... 258
Lead Climber ..... 259
**Section VI – Alpine Belay Techniques ..... 268**
Body Belays ..... 268

Shoulder Belay ..... 269
**Section VII – Climbing in a Team of Three ..... 271**
Caterpillar ..... 271
End Roping ..... 271
Parallel ..... 272
Fixed Strands ..... 273
**CHAPTER 11 ..... 275**
**FIXED ROPES ..... 275**
**Section I – Basic Fixed-Rope Techniques ..... 275**
Fixed-Rope Considerations ..... 275
Simple Fixed Ropes ..... 276
Fixed Ropes with Intermediate Anchors ..... 278
Fixed Ropes in Vertical Terrain ..... 282
**Section II – Types of Rappelling ..... 287**
Rappelling Fundamentals ..... 288
Rappelling Techniques ..... 291
**Section III – Ascending and Descending Transitions ..... 299**
Techniques ..... 299
Special Equipment ..... 299
**CHAPTER 12 ..... 303**
**HAULING AND LOWERING TECHNIQUES ..... 303**
**Section I – Hauling Techniques ..... 303**
Mechanical Advantage ..... 303
Hauling System Components ..... 303
Mechanical Advantage Calculation ..... 304
Categories of Hauling Systems ..... 306
Techniques to Reduce Friction ..... 309
Vertical Hauling and A-Frame ..... 311
Redirected Hauling Systems ..... 313
Offset Compound Hauling Systems ..... 314
**Section II – Lowering Techniques ..... 315**
Lowering Concepts ..... 315
Techniques and Devices for Creating Friction ..... 315
Techniques for Creating Hands-Free Backup ..... 318
Concepts for Passing a Knot ..... 321
**CHAPTER 13 ..... 323**
**MOUNTAIN STREAM CROSSING ..... 323**
**Section I – Mountain Stream Fundamentals ..... 323**
Reconnaissance ..... 323

Preparation of Troops and Equipment ..... 324
**Section II – Crossing Techniques ..... 324**
Individual Crossings ..... 325
Team Crossings ..... 326
Belayed Crossings ..... 327
Swimming ..... 330
**Section III – Additional Considerations and Hazards ..... 331**
Safety Guidelines for River and Stream Crossings ..... 331
Water Surface Clues ..... 331
**CHAPTER 14 ..... 333**
**GLACIER TRAVEL AND CREVASSE RESCUE ..... 333**
**Section I – Glacier Fundamentals ..... 333**
Glaciers ..... 333
Glacier Obstacles ..... 334
**Section II – Fundamentals of Glacial Travel ..... 335**
Equipment ..... 335
Use of the Rope ..... 336
Route Finding and Crevasse Detections ..... 342
**Section III – Crevasse Rescue Techniques ..... 346**
Crevasse Fall Considerations ..... 347
Steps to Take for Crevasse Fall ..... 347
**Section IV – Training ..... 352**
**CHAPTER 15 ..... 353**
**MOUNTAIN RESCUE AND EVACUATION ..... 353**
**Section I – Rescue Operations ..... 353**
Deliberate ..... 353
Improvised ..... 353
Planning ..... 353
Considerations ..... 354
General Steps ..... 354
Specialized Training ..... 354
Prolonged Field Care ..... 355
**Section II – Casualty Movement Techniques ..... 355**
Moving Casualties Without Litters ..... 355
Moving Casualties in Litters ..... 358
Low-Angle Rescue ..... 361
High-Angle Rescue ..... 364
**CHAPTER 16 ..... 371**
**ROPE BRIDGES ..... 371**

**Section I – Techniques ..... 371**
Construction ..... 371
Redundancy ..... 375
Methods of Crossing ..... 375
Artificial Height ..... 377
Retrieval ..... 381
High Lines ..... 381
**Section II – Guiding Lines ..... 382**
**APPENDIX A ..... 385**
**CLIMBING ROUTE CLASSIFICATION ..... 385**
**APPENDIX B ..... 389**
**ROUTE PLANNING TOOLS ..... 389**
**APPENDIX C ..... 393**
**TECHNICAL EQUIPMENT ..... 393**
**Glossary ..... 399**
**References ..... 405**
**Index ..... 407**

# Figures

Figure 1-1. Soldiers in mountainous terrain ..... 2
Figure 1-2. Terrain levels ..... 10
Figure 4-1. Individual caloric requirements ..... 44
Figure 4-2. Modular cold-weather glove system ..... 48
Figure 4-3. Mountaineering boots ..... 50
Figure 4-4. Extended cold-weather clothing system ..... 51
Figure 4-5. Floorless shelter (10-man arctic tent) ..... 58
Figure 4-6. Poncho lean-to ..... 59
Figure 4-7. Snow-cave shelter ..... 61
Figure 5-1. Movement through avalanche terrain ..... 64
Figure 5-2. Snowpack layers ..... 65
Figure 5-3. Slope angle ..... 67
Figure 5-4. Slope shape ..... 68
Figure 5-5. Avalanche problem types ..... 70
Figure 5-6. Avalanche danger scale ..... 71
Figure 5-7. Avalanche problems ..... 72
Figure 5-8. Individual avalanche equipment ..... 76
Figure 5-9. Signal search ..... 78
Figure 5-10. Probing ..... 79
Figure 5-11. Shoveling ..... 80
Figure 6-1. Foot placement ..... 86
Figure 6-2. The rest step ..... 88
Figure 6-3. Rock-climbing specific footwear ..... 91
Figure 6-4. Climbing helmets ..... 92
Figure 6-5. Downward or counterpressure ..... 94
Figure 6-6. Counterbalance ..... 95
Figure 6-7. Footholds ..... 96
Figure 6-8. Handhold techniques ..... 96
Figure 6-9. Slab body position ..... 97
Figure 6-10. Rest or shake out ..... 98
Figure 6-11. Mantling ..... 99
Figure 6-12. Stemming ..... 100
Figure 6-13. Underclinging ..... 101
Figure 6-14. Liebacking ..... 102
Figure 6-15. Mixed face and crack climbing ..... 103
Figure 6-16. Hand jams ..... 104
Figure 6-17. Fist jams ..... 105
Figure 6-18. Finger jams ..... 105
Figure 6-19. Foot jams ..... 105
Figure 6-20. Toe jams ..... 106
Figure 6-21. Arm bar and chicken wing ..... 106
Figure 6-22. Stemming in a dihedral ..... 107
Figure 6-23. Stemming in a chimney ..... 108
Figure 6-24. Chimney climbing technique ..... 109
Figure 6-25. Hand traverse ..... 110
Figure 6-26. Gaining ledges ..... 111
Figure 6-27. Down climbing ..... 112
Figure 6-28. Alpine touring skis ..... 114
Figure 6-29. Snowshoes ..... 115
Figure 6-30. Ahkio sleds ..... 116
Figure 6-31. Crampons ..... 116
Figure 6-32. Mountain axes ..... 117
Figure 6-33. Ice tools ..... 118

Figure 6-34. Step cutting ..... 120
Figure 6-35. Glissading ..... 121
Figure 6-36. Flatfooting ..... 122
Figure 6-37. Ice axe uses in low-angle terrain ..... 122
Figure 6-38. Flatfooting with axe in cross-body position ..... 123
Figure 6-39. Flatfooting with axe in anchor position ..... 123
Figure 6-40. Front pointing ..... 124
Figure 6-41. Front pointing with axe in dagger positions ..... 125
Figure 6-42. Front pointing with axe in anchor positions ..... 125
Figure 6-43. Front pointing using axes in ice climbing ..... 126
Figure 6-44. Descending steep slopes ..... 128
Figure 6-45. Self-arrest ..... 129
Figure 6-46. Waterfall ice ..... 130
Figure 6-47. Alpine ice ..... 131
Figure 6-48. Ice tool grip ..... 133
Figure 6-49. Basic body position ..... 134
Figure 6-50. Climbing over bulges ..... 135
Figure 8-1. Kernmantle rope construction ..... 149
Figure 8-2. Types of webbing: tubular joined with a knot and a sewn webbing ..... 151
Figure 8-3. Slings and runners ..... 152
Figure 8-4. Carabiner components ..... 153
Figure 8-5. Improper carabiner loading ..... 154
Figure 8-6. Examples of rope-tying terminology ..... 156
Figure 8-7. Overhand and inline figure eight ..... 158
Figure 8-8. Figure-eight slip knot ..... 159
Figure 8-9. Figure eight on a bight ..... 160
Figure 8-10. Rerouted figure-eight knot ..... 161
Figure 8-11. Two-loop figure eight ..... 162
Figure 8-12. Directional figure eight ..... 163
Figure 8-13. Alpine butterfly knot ..... 164
Figure 8-14. Figure-eight bend ..... 165
Figure 8-15. Water knot ..... 166
Figure 8-16. Flat overhand ..... 167
Figure 8-17. Double fisherman’s knot ..... 168
Figure 8-18. Square knot ..... 170
Figure 8-19. Bowline knot ..... 171
Figure 8-20. Triple bowline ..... 172
Figure 8-21. Bowline on a bight ..... 173
Figure 8-22. Girth hitch ..... 174
Figure 8-23. Middle-of-the-rope prusik knot ..... 175
Figure 8-24. End-of-the-rope prusik knot ..... 176
Figure 8-25. Autoblock knot ..... 177
Figure 8-26. Klemheist hitch ..... 178
Figure 8-27. Bachmann hitch ..... 179
Figure 8-28. Middle-of-the-rope clove hitch ..... 180
Figure 8-29. End-of-the-rope clove hitch ..... 181
Figure 8-30. Munter hitch ..... 182
Figure 8-31. Super Munter hitch ..... 182
Figure 8-32. Munter mule knot using cord ..... 184
Figure 8-33. Munter mule knot using installation rope ..... 184
Figure 8-34. Garda hitch ..... 185
Figure 8-35. Big honking knot ..... 186
Figure 8-36. Field expedient harness ..... 188
Figure 8-37. Butterfly coil with farmer’s tie off ..... 191
Figure 8-38. Mountain coil ..... 192
Figure 9-1. Opposite and opposed carabiners ..... 196

Figure 9-2. Single-point webbing anchors: single loop, double bight, and girth hitch ..... 197
Figure 9-3. Single and double basket hitch ..... 198
Figure 9-4. Single and double basket hitch with master point ..... 199
Figure 9-5. Ideal angle required between anchor points to reduce force ..... 200
Figure 9-6. Self-equalizing anchor ..... 202
Figure 9-7. Pre-equalized anchor ..... 203
Figure 9-8. Anchoring a rope to a single-point tree anchor ..... 205
Figure 9-9. High-strength anchor ..... 206
Figure 9-10. Boulders and protrusions used as anchors ..... 207
Figure 9-11. Chockstone used in a construction ..... 208
Figure 9-12. Natural tunnel or hole in the rock ..... 209
Figure 9-13. Examples of piton ..... 211
Figure 9-14. Hero-loop ..... 212
Figure 9-15. Piton removal ..... 213
Figure 9-16. Expansion bolt ..... 215
Figure 9-17. Glue-in bolt ..... 216
Figure 9-18. Chock pick ..... 217
Figure 9-19. Chocks ..... 218
Figure 9-20. Spring-loaded camming device placement ..... 221
Figure 9-21. Cord anchor with multiple points ..... 222
Figure 9-22. Ice pillar ..... 223
Figure 9-23. Long ice core protruding from screw indicates good ice quality ..... 224
Figure 9-24. Multipoint ice anchor construction ..... 225
Figure 9-25. Ice screw placement ..... 226
Figure 9-26. V-thread anchors ..... 227
Figure 9-27. Constructing a V-thread anchor ..... 228
Figure 9-28. Picket holdfast ..... 229
Figure 9-29. Snow picket placement ..... 230
Figure 9-30. Multipoint snow anchor ..... 231
Figure 9-31. Deadman anchor/T-trench anchor in snow with ice axe ..... 232
Figure 9-32. Snow bollard anchor ..... 233
Figure 10-1. Soldier moving unroped ..... 236
Figure 10-2. Aid climbing ..... 239
Figure 10-3. Simultaneous climbing: two Soldiers climbing together with intermediate protection from falling ..... 240
Figure 10-4. Short roping ..... 242
Figure 10-5. Hasty belay ..... 243
Figure 10-6. Kiwi coil ..... 244
Figure 10-7. Top rope climbing ..... 245
Figure 10-8. High-angle mountaineering kit harness tie-in ..... 247
Figure 10-9. Top rope climbing set up ..... 249
Figure 10-10. Top rope belay with tube-style device ..... 251
Figure 10-11. Tubular device belay action ..... 252
Figure 10-12. Munter belay technique ..... 253
Figure 10-13. Climbing harness tie-in and equipment racking ..... 255
Figure 10-14. Rock-climbing shoes ..... 257
Figure 10-15. Belaying the lead climber ..... 259
Figure 10-16. Use of runners to extend and reduce rope drag ..... 261
Figure 10-17. Proper extension of cams and chocks using runners ..... 262
Figure 10-18. Proper clipping techniques ..... 263
Figure 10-19. Belaying using a Munter hitch ..... 265
Figure 10-20. Belaying a climber using an autolocking device in guide mode ..... 266
Figure 10-21. Hip belay ..... 269
Figure 10-22. Shoulder belay ..... 270
Figure 10-23. Terrain belay ..... 271
Figure 10-24. Clipping to a cow’s tail and end roping ..... 272

Figure 10-25. Parallel climbing two stands ..... 273
Figure 10-26. Belaying two climbers with an autolocking device ..... 273
Figure 11-1. Simple fixed rope use in easy terrain ..... 276
Figure 11-2. Simple fixed-rope attachments in moderate terrain ..... 278
Figure 11-3. Intermediate anchors in moderate terrain, example ..... 279
Figure 11-4. Two personal safeties attachment ..... 280
Figure 11-5. Ascender-carabiner method ..... 281
Figure 11-6. Prusik ascent ..... 283
Figure 11-7. Double-ascender ascent ..... 285
Figure 11-8. Etrier styles ..... 287
Figure 11-9. Tagline retrievable rappel using a tagline ..... 290
Figure 11-10. Hasty rappel ..... 292
Figure 11-11. Munter hitch rappel ..... 293
Figure 11-12. Figure-eight descender ..... 294
Figure 11-13. Rappelling with a tube-style device ..... 295
Figure 11-14. Extended device and hands-free break ..... 297
Figure 11-15. Assisted braking device ..... 300
Figure 11-16. Rapid ascent and descent method ..... 301
Figure 12-1. T-Method for simple 2:1 system ..... 305
Figure 12-2. T-Method for simple 3:1 system ..... 306
Figure 12-3. Simple 2:1 hauling system ..... 307
Figure 12-4. Simple 3:1 hauling system ..... 307
Figure 12-5. Simple 5:1 hauling system ..... 308
Figure 12-6. Compound 6:1 hauling system ..... 308
Figure 12-7. Compound 9:1 hauling system ..... 309
Figure 12-8. Types of pulleys ..... 310
Figure 12-9. High directional ..... 311
Figure 12-10. Vertical haul line ..... 312
Figure 12-11. A-frame or master point ..... 313
Figure 12-12. Redirected and offset compound hauling system ..... 314
Figure 12-13. Terrain lower ..... 316
Figure 12-14. Munter hitch ..... 317
Figure 12-15. Redirected belay device ..... 318
Figure 12-16. Friction hitch on load strand (releasable) ..... 319
Figure 12-17. Friction hitch on brake strand of Munter hitch ..... 320
Figure 12-18. Friction hitch on brake strand of redirected belay device ..... 321
Figure 12-19. Isolating a damaged section of rope ..... 322
Figure 13-1. Individual crossing ..... 325
Figure 13-2. Chain method for stream crossing ..... 326
Figure 13-3. Insert side view, top view, and traveling ..... 327
Figure 13-4. Belay with handline ..... 329
Figure 13-5. Moving on handline with belay ..... 330
Figure 14-1. Glacier features ..... 335
Figure 14-2. Two-person rope team ..... 338
Figure 14-3. Three-person rope team ..... 339
Figure 14-4. Preparation chest harness, rucksack removal sling for use with prusik ascent ..... 340
Figure 14-5. Using prusik to belay other Soldiers ..... 341
Figure 14-6. Crossing perpendicular to crevasses ..... 344
Figure 14-7. End running crevasses ..... 345
Figure 14-8. Using a snow bridge ..... 345
Figure 14-9. Echelon formation ..... 346
Figure 14-10. Stopping a crevasse fall ..... 348
Figure 14-11. Construct the anchor and transfer the load ..... 349
Figure 14-12. Direct haul using a 3:1 hauling system ..... 350
Figure 14-13. Drop-loop rescue system (2:1) ..... 351
Figure 15-1. Webbing or rope carry ..... 356

Figure 15-2. Rope coil carry ..... 357
Figure 15-3. Tandem rappel rigging ..... 358
Figure 15-4. Rope litter drag ..... 360
Figure 15-5. Litter rigged for vertical orientation ..... 361
Figure 15-6. Basket litter rigged for vertical orientation ..... 362
Figure 15-7. Litter rigged for lowering with long-tailed bowline and attendant attached ..... 363
Figure 15-8. Litter rigged horizontal orientation with hoist straps ..... 365
Figure 15-9. Basket litter rigged for horizontal orientation ..... 365
Figure 15-10. Interlocking long tail bowlines ..... 367
Figure 15-11. Tandem prusik belay ..... 368
Figure 16-1. Transport tightening system ..... 372
Figure 16-2. Mule knot secured with an overhand knot ..... 373
Figure 16-3. Round turn around anchor and two half hitches on a bight ..... 374
Figure 16-4. High strength tie off (tensionless hitch) ..... 374
Figure 16-5. Litter rigging ..... 377
Figure 16-6. Artificial height (A-frame) used with high line ..... 378
Figure 16-7. A-frame horizontal and vertical wraps ..... 379
Figure 16-8. A-frame spreader ..... 380
Figure 16-9. Anchoring the A-frame to the installation rope ..... 380
Figure 16-10. Carrying sling ..... 382
Figure 16-11. Guiding lines ..... 383
Figure B-1. Munter route table, example (with basic navigation information) ..... 391
Figure B-2. Munter calculation formula and modifier guide ..... 391
Figure B-3. Munter route table, example (completed) ..... 392

# Tables

Table 1-1. Operational Terrain Levels ..... 10
Table 1-2. Dismounted mobility classes ..... 11
Table 1-3. Weather hazards and their effects on troops ..... 14
Table 7-1. Whiteout navigation card, example ..... 145
Table 7-2. Time-distance formulas ..... 146
Table 8-1. Knotted kernmantle rope retained strength (single strand) ..... 157
Table 10-1. Climbing commands ..... 254
Table C-1. High-angle mountaineering kit components ..... 393
Table C-2. High-angle mountaineering kit product information ..... 393
Table C-3. High-angle mountaineering kit national stock number list ..... 394
Table C-4. Assault climbing team kit components ..... 395
Table C-5. Assault climbing team kit product information ..... 395
Table C-6. Assault climbing team kit national stock number list ..... 395
Table C-7. Snow and ice mobility kit components ..... 397
Table C-8. Snow and ice mobility kit product information ..... 397
Table C-9. Snow and ice mobility kit national stock number list ..... 398

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# Preface

TC 3-97.61 is the Army's doctrinal publication for military mountaineering. It provides doctrinal guidance and direction for how U.S. forces train military mountaineers to operate in complex and mountainous terrain.

This training circular is designed to work in conjunction with and complement ATP 3-21.50 and ATP 3-90.97. This manual enables leaders and Soldiers to understand mountain and cold-weather environments; their effects on personnel, operations, and equipment; and most importantly, how units train Soldiers to prepare to deploy in complex mountain environments.

The principle audience for this publication is all members of the profession of arms. Commanders and staffs at all levels, including Army headquarters serving as joint task force or multinational headquarters, should also refer to applicable joint or multinational doctrine concerning military mountaineering techniques and procedures. Trainers and educators throughout the Army will use this publication to tailor their curriculum to the demands of military mountaineering.

This publication provides the conceptual framework for conventional forces to train Soldiers in military mountaineering and serves as a foundation for more demanding collective mountain warfare training. It addresses training for mountain and cold weather at the tactical level. (See ATP 3-21.50 for higher-level collective information.)

Commanders, staffs, and subordinates ensure that their decisions and actions comply with applicable United States, international, and, in some cases, host-nation laws and regulations. Commanders at all levels ensure that their Service members operate in accordance with the law of armed conflict and the rules of engagement. (See FM 6-27 for legal compliance.)

The use of a trade or brand name does not constitute endorsement of the product or website.

TC 3-97.61 uses joint terms where applicable. Selected joint and Army terms and definitions appear in both the glossary and the text. Terms for which TC 3-97.61 is the proponent publication (the authority) are marked with an asterisk (*) in the glossary. When first defined in the text, terms for which TC 3-97.61 is the proponent publication are boldfaced and italicized, and definitions are boldfaced. When first defining other proponent definitions in the text, the term is italicized with the proponent designator and number at the of the definition. Following uses of the term are not italicized.

TC 3-97.61 applies to the Active Army, Army National Guard/Army National Guard of the United States, and United States Army Reserve unless otherwise stated.

The proponent for this publication is the United States Army Maneuver Center of Excellence. The preparing agency is the United States Army Maneuver Center of Excellence, Department of Tactics, Training, and Doctrine. Send comments and recommendations on DA Form 2028 (*Recommended Changes to Publications and Blank Forms*) to Commander, U.S. Army Mountain Warfare School, ATTN: MWS-Z, 08 Mountain School Road, Jericho, Vermont 05465; by email to: ng.vt.vtarng.list.amwsinfo@army.mil; or submit an electronic DA Form 2028.

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# Introduction

Operating in a mountainous environment is a continual exercise in problem solving and critical thinking. This document presents proven, utilitarian techniques for approaching the mountain and cold-weather problem issues. This training circular should not be interpreted as prescriptive in nature but rather a starting place and solid reference for best practices and risk mitigation. There is no substitute for experience and practice when dealing with mountainous environments. As the old adage goes, "There are bold climbers and there are old climbers. There are no bold old climbers."

TC 3-97.61 incorporates changes to terminology, concepts, constructs and proven tactics, techniques, and procedures (TTP) developed during the past decade in military mountaineering.

The following summarizes each chapter and appendix in TC 3-97.61:

- Chapter 1 establishes a working definition and classification of mountainous terrain. While some of this content is self-explanatory, it is imperative for leaders, especially in the light Infantry community, to be intimately familiar with the dismounted mobility classification tool and its implications on movement and maneuver.
- Chapter 2 contains important changes to the qualification levels of military mountaineers and basic guidance on unit-level training programs. While operating in mountainous terrain is an environmental variable and not a mission, leaders must understand that they will often be forced to fight both the enemy and the environment. A unit that can successfully fight in the mountains can rapidly adapt to fighting in other conditions; in contrast, a unit untrained in mountain operations will not be able to rapidly transition.
- Chapter 3 contains information on the multitude of environmental injuries common to operating in the mountains. Diagnosing and treating these injuries should be a training priority for medical personnel preparing to move into a cold weather or high-altitude environment.
- Chapter 4 touches on the requirement for a base high level of physical fitness due to the exertion needed to exist and move in mountainous terrain. Soldiers require additional caloric intake to maintain peak performance in these conditions. While it may seem counterintuitive, dehydration is a common problem experienced by Soldiers operating in the cold. Critical to the success of any unit operating in these conditions is not only having the proper clothing and equipment but also understanding its proper wear and application. Knowing how to function and being "comfortably cool" are acquired skills.
- Chapter 5 focuses on identifying and mitigating the avalanche threat. Snow science is a discipline in itself, but by following these basic tenets, units can intelligently navigate the risks of operating in avalanche terrain and respond to avalanches when they occur.
- Chapter 6 provides details on movement techniques unique to the mountain environment and introduces basic climbing equipment and principles. This chapter also provides information on over-snow mobility including the use of alpine ski techniques, snowshoeing, the wear and application of crampons, and ice climbing.
- Chapter 7 elaborates on many of the principles found in TC 3-25.26. Specifically, it focuses on the nuance of orientation and navigating and route finding under conditions where the most direct route is often undesirable due to limitations imposed by technical terrain features.
- Chapter 8 provides step-by-step guides to the knots military mountaineers will require during system construction and navigating terrain problems. A thorough understanding and working knowledge of these knots and principles are required before attempting any of the tasks detailed in the remainder of this training circular. All unit members operating in mountainous terrain need to be proficient in the contents of this chapter. As this knowledge is extremely perishable, refresher training on these topics should be a recurring part of any training schedule.
- Chapter 9 details the general principles of anchor construction and provides step-by-step instructions for constructing tree, rock, earth, snow, and ice anchors. As most mountaineering accidents occur

at the anchor, increased focus should be given to gaining Soldier experience in anchor site selection and construction.

- Chapter 10 covers under what conditions it is appropriate to move on and off rope. Specifically addressed are top rope climbing, lead climbing, alpine belay techniques, and three-man climbing techniques. Top rope climbing is the preferred method to familiarize untrained personnel and level 1 mountaineers with the principles of climbing. In an operational environment, leaders must balance the need for speed and security with the inherent fall hazards associated with climbing outside of a training environment.
- Chapter 11 discusses fixed ropes. Moving along a fixed rope is a terrific way to reduce fall hazards and increase control of the element while moving through technical terrain. In a limited amount of time, inexperienced personnel can be taught to navigate difficult terrain successfully and safely along fixed ropes. Also discussed in this chapter are principles of rappelling and more advanced methods of ascending and descending while hanging from a fixed rope.
- Chapter 12 is an overview on how operating in a mountainous environment often requires moving Soldiers, weapon systems, and equipment up, over, down, and around steep rugged terrain. This chapter also delivers instructions on the principles of mechanical advantage for lifting and creating friction in lowering.
- Chapter 13 covers the advantages, disadvantages, and applicability of individual, team, and belayed crossing techniques. Seasonal snowmelt will frequently create water obstacles of varying width, depth, and current. Ideally, any personnel who may be required to perform stream crossings are competent swimmers. Risk management during any water crossing should include personnel serving in a lifeguard/safety role and medics prepared to treat hypothermia.
- Chapter 14 discusses the fundamentals of glacier travel and crevasse rescue. Glaciers cover 10 percent of the earth's land. Climate change has increased the trafficability of the Arctic Northwest Passage and technological gains have made it possible to access natural resources in several inhospitable climates where it was previously infeasible. The Army's ability to maneuver and fight on glaciers will become increasingly relevant in the coming years.
- Chapter 15 elaborates on the requirements for units operating in these environments to prepare for prolonged field care and practice high- and low-angle rescue scenarios.
- Chapter 16 outlines techniques for establishing tensioned rope systems used to move equipment and casualties over linear-vertical terrain obstacles. These techniques can save time and reduce the risk associated with crossing such obstacles. Mountain streams and ravines present a significant hazard and barrier to dismounted troop and equipment movement.
- Appendix A describes prominent classification systems for general dismounted movement in terrain, as well as various types of rock climbing and ice climbing routes. Military mountaineers require a common language for classifying routes so that difficulties associated with navigating them can be clearly communicated during operations.
- Appendix B discusses the use of nonmilitary route planning resources, such as online collections of climbing routes and guidebooks. Open-source route planning tools complement doctrinal techniques and military resources. Given that few suitable mountaineering sites exist on military installations, off-post sites need to be considered for training.
- Appendix C covers general standards for mountaineering equipment and identifies the contents and implications of various Army mountaineering kits. Throughout this publication, military mountaineering equipment is presented and discussed along with the techniques to employ it as applicable. However, certain general aspects of military mountaineering equipment do not fit into the flow of any of this training circular's primary chapters.

## Chapter 1

# Mountain Environment

Around the world, mountain ranges form natural borders and boundaries. Historically, they have formed the edge of human settlement and wilderness; today, mountains still define many national borders and conflict regions. Mountain environments are demanding and tough, with conditions that interfere with all warfighting functions. To fight in the complex terrain of mountainous regions, military mountaineers must become familiar with the significant challenges that this environment presents. This rugged terrain will prove to be an overwhelming challenge to the untrained and inexperienced Soldier. Military mountaineers must understand how mountain environment characteristics affect them, the mission, their equipment, and the enemy during military operations. Rough terrain slows movements and canalizes troops into narrow corridors. Steep slopes make vehicle traffic possible only on roads that require extensive engineering and are vulnerable to attack and natural hazards, such as rockslides and avalanches. Harsh weather limits air resupply and close air support. Radio communications can only be maintained by securing exposed ridge tops. Key terrain often requires significant effort to secure and an even larger commitment to sustain. To succeed in this environment, Soldiers must be prepared mentally and physically.

## SECTION I – MOUNTAIN TERRAIN

1-1. Mountains exist all over the world and their character is defined by their climate and geology. Regardless of their differences, a common feature of all mountains is rugged terrain. This rugged, broken environment presents additional challenges to movement and survival to those experienced in most combat environments. Operations in the mountains require Soldiers to be physically fit and leaders to be experienced in this terrain. (See figure 1-1, page 2.) Problems arise in moving men and transporting loads up and down steep and varied terrain. Operational success is contingent on our ability to understand the environment, recognize hazards, and anticipate problems.

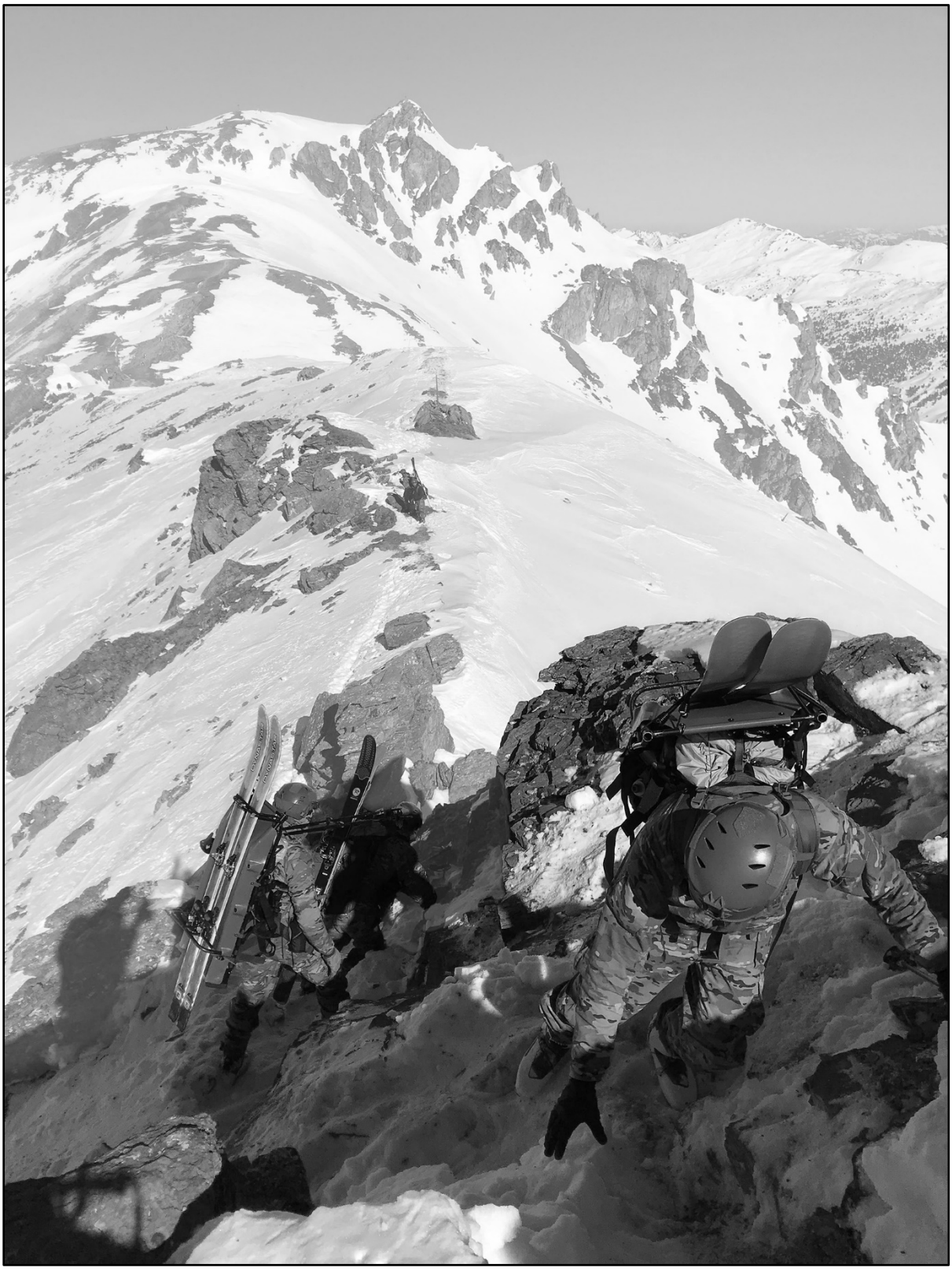


**Figure 1-1. Soldiers in mountainous terrain**

# DEFINITION: TYPES AND FORMATIONS OF MOUNTAINS

1-2. Mountains are landforms that rise more than 500 meters above the surrounding plain and are characterized by steep slopes. They may rise abruptly from the plains to form a giant barrier or ascend gradually as a series of parallel ridges extending unbroken for great distances. Cliffs and precipices may be near vertical or even overhanging. Mountains may have isolated peaks, rounded crests, eroded ridges, and high plains. They may be cut by valleys, gorges, and deep ravines. High rocky crags with glaciated peaks and year-round snow-cover exist in mountain ranges at most latitudes along the western portion of the Americas, in Europe, and in Asia.

# MOUNTAIN BUILDING

1-3. Understanding the processes and the conditions under which mountains form helps us to understand their structures and hazards. The two primary mechanisms for mountain building are volcanic and tectonic activity. Volcanoes are constructed from lava and ash, which begin within the earth as magma. Tectonic activity causes plates to collide, heaving up fold mountains, or to pull apart and crack, forming fault-block mountain ranges.

## TYPICAL MOUNTAIN STRUCTURES

1-4. The massive slabs composing the outer layer of the earth are called tectonic plates. Their movement relative to each other creates earthquakes, volcanoes, ocean trenches, and mountain ridge systems. The different horizontal and vertical stresses that create mountains usually produce complex patterns. Each type of stress produces a typical structure, and most mountains can be described in terms of the following structures:

- Dome mountains—a simple, upward bulge of the crust forms dome mountains. They are usually the result of the upward movement of magma and the folding of the rock layers overhead. Erosion may strip away the overlying layers, exposing the central igneous core.
- Fault-block mountains—faulting, or cracking of the crust into large chunks, often accompanies upwarp, a broad low arching of the surface, which results in fault-block mountains. The motion of chunks along these faults creates various forms of mountains.
- Fold mountains—tectonic forces, in which continental plates collide or ride over each other, have given rise to the most common mountain form: fold mountains. When erosion strips down the overburden of rock from folded mountain ranges, the oldest, central core is all that remains.
- Volcanic mountains—along convergent plate boundaries, volcanic activity increases. As volcanic activity is forced underneath an overriding neighbor, continental crust melts and turns to magma within the mantle. Since it is less dense than the surrounding material, it rises and erupts to form volcanoes.
- Complex mountains—most ranges are complex mountains with portions that have been subject to several processes. These processes occur at both the macro and the micro level. One massive fold can make an entire mountain peak; however, there are folds measured by rope length, and tiny folds found within a handhold.

## EROSION AND GLACIATION

1-5. Even as mountain massifs are being pushed up, they begin to crumble and wear away. The two main processes that shape mountains are erosion and glaciation.

1-6. Erosion is when precipitation scours soil and loose rock from the steep slopes of mountains. Cycles of freeze-thaw exert tremendous force in cracks and fissures in the rock. These forces break apart softer rock and wash the fragments away down creeks and drainages, forming many of the gullies and smaller terrain features on the mountains.

1-7. Glaciation is when glaciers are rivers of ice and rocks that slowly move down mountains. They form when the rate of snowfall exceeds the rate of melting in summer months. After accumulations over hundreds of years, the snow compresses into ice that can range from ten to several hundred feet thick. Glaciers can be small and only cover a portion of a mountain, or they can be massive with a series of glaciers covering a mountain range. They are a powerful force for carving and moving rock and form many of the large features we observe in the mountains.

# TERRAIN FEATURES AND TERMS

1-8. Common geologic terminology includes—

- Summit, peak—the highest point.
- Spire—a tall, narrow rock formation, resembling a steeple.
- Ridge—a line of high ground with height variations along its crest.
- Valley—low ground bordered on the sides by higher ground. A valley may or may not contain a stream course. A valley generally has maneuver room within its confines.
- Hanging valley—a valley whose lower end is high on a sheer wall of a larger valley into which it flows.
- Saddle—a dip or low point along the crest of a ridge. A saddle is not necessarily the lower ground between two hilltops; it may be a break along an otherwise level ridge crest.
- Pass—any route from one valley over higher ground to another valley. Usually, a relatively low point along a ridge. Many regional synonyms exist to describe pass, such as the word notch in New England.
- Col—the low point on a ridge joining two peaks. Glaciologists reserve this term for gaps of glacial origin, but others use it much more generally.
- Cirque—a bowl-shaped valley high on a mountain, usually of glacial origin. Also referred to as simply a bowl.
- Draw—like a valley, except that it normally is a less developed stream course. The ground slopes upward on each side and toward the head of the draw.
- Gully—a channel caused by erosion, especially by water running down a slope. A gully is generally narrower and steeper than a draw.
- Couloir—a narrow snow- or ice-filled gully.
- Spur—a usually short, continuously sloping line of higher ground, normally jutting out from the side of a ridge.
- Arête—a narrow, rocky spur.
- Buttress—a prominent feature that juts out from a rock or mountain, like the buttress that supports the roof of a cathedral.
- Gendarme—a steep-sided tower along a ridge, guarding or blocking the way.
- Shoulder—a lateral protrusion on a mountain, or a point on the mountain where the slope changes, forming a convex shape.
- Headwall—vertical or near-vertical section of slope at the uphill end (head) of a valley, ravine, or cirque.
- Cliff—a vertical or near-vertical slope.
- Ledge—a narrow, flat spot along an otherwise vertical face.
- Snow field—a field of perennial snow.

## SECTION II – MOUNTAIN TERRAIN COMPOSITION

1-9. Mountain terrain composition can substantially affect the speed and safety of movement during military operations. An understanding of compositional factors is important to determine appropriate movement techniques, appropriate protective techniques, and realistic estimations of movement time.

# VEGETATION

1-10. Surface composition is highly variable in mountainous terrain. Slopes can be steep, broken, rocky, thickly vegetated, and ice or snow covered. Any of these conditions can have a significant impact on military operations, and often more than one of these conditions are found concurrently.

### CLIMATE

1-11. Major mountain ranges force air masses and storm systems to drop significant amounts of rain and snow on the windward side of the range. As air masses pass over mountains, the leeward (opposite of the windward side) slopes receive far less precipitation than the windward slopes. It is common for the climate on the windward side of a mountain range to be humid and the climate on the leeward side to be arid. This

phenomenon affects both coastal and inland mountains. As a result, vegetation and forest characteristics are different between these areas.

### ARID REGIONS

1-12. In areas receiving little rainfall, there may be little vegetation. Much of the terrain is composed of hard ground, which is firmly compacted, rocky soil. Any existing vegetation is minimal and provides minimal protection from the elements.

### DENSE FOREST

1-13. In most temperate mountain ranges, the lower elevations are covered in dense forest. These areas can provide good concealment and protection from weather. Steep slopes may require greater levels of fitness and more time to move through than woodlands in flat terrain, but the tactics, techniques, and procedures (TTP) for moving and fighting remain the same.

### THICK BRUSH

1-14. Near tree line, high winds, ice buildup, and poor soil cause the trees to grow in dense mats. The branches may grow together so tightly that Soldiers may have to walk above or crawl below the tangle of branches. Natural breaks, such as old rockslides, creek beds, and existing trails may provide corridors for movement. Concealment is excellent as the outline is broken well, but any movement can be easily visible. Small-diameter spruce and fir trees provide limited cover from small arms fire.

### GRASSY SLOPES

1-15. Higher in the mountains, soil depth and quality deteriorate, and conditions become too harsh for trees. Slopes with enough soil are often covered with grass tussocks and low shrubs. Passing above tree line, the first major change in hazards occurs. Without trees and vegetation, there is the possibility of long, tumbling falls that cannot be arrested. Grassy slopes are slippery after rain, new snow, and dew. After long, dry spells, clumps of slope tend to become fragile and break away. From a tactical standpoint, moving above tree line changes the exposure of our elements. Open areas can be observed from long distances. Limited cover means large elements can be decisively engaged in open areas by relatively small elements in advantageous terrain or by indirect fires directed by observation posts. Tactical maneuver above tree line favors small elements, using terrain masking and surprise.

## ROCK

1-16. Steep slopes have few features that hold soil. Where soil is washed away, there is only exposed rock. Rock comes in many forms and is classified by origin and mineral composition:

- Igneous rocks—igneous rocks form from cooled magma. The two main categories are intrusive and extrusive:
  - Plutonic (intrusive) rocks—slow crystallization from deeply buried magmas generally means good climbing, since the minerals formed are relatively large and interwoven into a solid matrix. Weathering develops protrusions of resistant minerals, which make for either a rough-surfaced rock with excellent friction or, if the resistant crystals are much larger than the surrounding matrix, a surface with numerous knobby holds.
  - Granite—granite is a very hard rock and provides good climbing. It produces less rockfall than softer rock, but when rock breaks away, it may be as large boulders. After a rain, granite dries quickly. Most protection is found in cracks. Face climbing can be found; however, it is not easily protected.
  - Volcanic (extrusive) rocks—explosive eruptions eject molten rock so quickly into the air that it hardens into loose aerated masses of fine crystals and uncrystallized glass (obsidian). When this ash consolidates while molten or after cooling, it is called tuff—a weak rock that breaks down quickly and erodes easily. Quieter eruptions, from which widespread lava flows from large fissures, produce basalt. Basaltic rocks are fine-grained and often sharp-edged.
- Sedimentary rocks—sedimentary rocks are born high in the mountains, where erosion grinds down debris and moves it down to rivers for transportation to its final deposition in valleys, lakes, or oceans. As sediments accumulate, the bottom layers are solidified by pressure and by mineral

cements precipitated from percolating groundwater. Gravel and boulders are transformed into conglomerates, sandy beaches into sandstone, beds of mud into mudstone or shale, and shell beds and coral reefs into limestone or dolomite. Although, in general, sedimentary rocks are much more friable than those cooled from molten magmas, pressure and cementing often produce solid rocks.

- Chalk and limestone—chalk and limestone are slippery when wet. Limestone is usually solid; however, conglomerate-type stones may be loose. Limestone has pockets, face climbing, and cracks.
- Sandstone—sandstone is usually soft, causing handholds and footholds to break away under pressure. Chocks placed in sandstone may or may not hold. Sandstone should be allowed to dry for a couple of days after rain before climbing on it; wet sandstone is very soft. Most climbs follow a crack. Face climbing is possible, but any outward pull breaks handholds and footholds. Sandstone is usually difficult to protect.

- Metamorphic rocks—these are igneous or sedimentary rocks that have been altered physically or chemically by the tremendous heat and pressures within the earth. After sediments are solidified, high heat and pressure can cause their minerals to recrystallize. Shale changes to slate or schist, sandstone and conglomerate into quartzite, and limestone to marble. These changes may be minimal, only slightly altering the sediments, or extensive enough to produce gneiss, which is almost indistinguishable from igneous rock. Higher degrees of metamorphism or metamorphism of the right rocks provide a solid climbing surface. Examples are slate and gneiss, which can be firm and brittle in the same area (red coloring indicates brittle areas). Rock fall danger is high, and small rocks may break off when pulled or when pitons are placed.

## MOVEMENT ON ROCK

1-17. As softer rock and materials are eroded, the remaining rock formations are often steeper and more prominent than the surrounding surfaces. These cliffs, buttresses, and rocky arêtes often form terrain features that can mask maneuver, and their weaknesses form the unlikely avenues of approach used for infiltration and attacks. Moving over rock is risky and the consequences of falling can be high. A fall often cannot be arrested and leads to death or injury. The movement skills for negotiating steep rock faces and the technical skills for protecting that movement comprise a major portion of mountaineering training.

## SCREE

1-18. Scree refers to small rocks, from pebble size to dinner-plate size. It accumulates in areas abundant with weak, brittle rock. These small stones do not settle into stable slopes. Climbing scree is inefficient because it is unstable, with each step sliding down as weight is placed upon it. Firmer footing may be found around the edge of rock outcroppings. Scree can be descended quickly by sliding on one's feet but should be done so under control.

## TALUS

1-19. Talus refers to rocks larger than a dinner plate but smaller than boulders. They can be used as steppingstones to ascend or descend a slope. The stability of talus can vary. Time, exposure to weather, snow, and foot traffic all help to shift rocks into positions where they are more secure and dislodge insecure rocks. More recent rockfall is often less stable, and it is more likely that large rocks will be displaced as one moves through it. Rockfall can be a hazard, but the most prevalent hazard is loose footing, which causes lower orthopedic injuries. Ascending talus is more efficient than ascending scree and requires less energy.

## BOULDERS

1-20. Boulders are rocks that are larger than can be carried. They indicate good rock quality in the surrounding cliffs. In general, boulders form into relatively stable fields where Soldiers may need to hop from boulder to boulder and can do so without dislodging them. Boulders can be in precarious positions and can be catastrophically destructive if they roll. The large spaces between boulders and their solid nature can provide effective cover.

## MANAGING ROCKFALL

1-21. Blocks and scree at the base of a cliff can indicate recurring rockfall. Light-colored spots on the rock wall above may indicate the impact of falling rock or areas where large portions of rock have recently

detached. Avoiding boulder fields, talus, and cliffs that show extensive signs of rockfall is the best way to avoid the threat of rockfall. Gullies and couloirs, while offering breaks in steeper terrain, also act as funnels for falling rock or ice. When traveling suspect areas, alert the group of the hazard and choose a path that does not place Soldiers in a position below others who may dislodge rocks. In small groups, keeping close together prevents falling rock from generating enough force to cause harm. At other times, the best measure may be to use sheltered stances, exposing only one or two Soldiers to the hazard at a time. During thaws in the spring and early summer, timing may be the best tool. Avoid traveling in gullies and other areas prone to rockfall during the heat of the day, when rocks may be shifting positions.

# RIVERS

1-22. Mountains are home to several water sources, including freshwater springs, lakes, and streams. Mountain streambeds may be dry or contain a significant amount of water. Steep contours make for fast moving water; small streams can be dangerous to cross. Water level fluctuates rapidly with storm runoff or snowmelt. Flash floods are possible after heavy rain. The likelihood of a flash flood after heavy rain can be greater during spring snowmelt. A storm that produces heavy rain higher on the mountain could produce a flash flood lower on the mountain. It is important to be aware of this risk and plan accordingly.

# SNOW

1-23. In most of the mountain ranges on earth above 5,000 feet, snowfall potential exists year-round.

## TYPES OF SNOW

1-24. There are many different types of snow with their own unique characteristics. Each type presents various challenges during military operations.

### New Snow

1-25. New snow makes easy terrain slick and dangerous. Maneuvering elements leave tracks that show their routes and relative size. It makes roads impassable for units that cannot clear them of snow and with vehicles that are not equipped with tire chains for traction. The distance for foot movements is significantly reduced for troops without snowshoes, skis, and over-the-snow vehicles. Movements are slowed even for properly trained and equipped troops. Steep, snow-covered terrain presents the risk of avalanches.

### Firm Spring Snow (Firm Snow)

1-26. As snow goes through cycles of warming and cooling, it settles into a denser snowpack. A snowpack is the entire mass of snow covering a given area of terrain. Dense, old snow can provide a uniform surface that covers obstacles. The character of the snow can vary greatly with temperature and sun exposure. Snow is generally firm during the night and early morning, providing efficient travel but an increased risk of long sliding falls. The snow softens with warmer temperatures and direct sunlight.

### Soft Snow

1-27. Soft snow can be easier to negotiate without stiff boots and crampons, and the fall hazard is reduced. However, if it is too soft, travel becomes more difficult. Movement on steeper slopes requires an ice axe, crampons, and the necessary training with this equipment. (See chapter 6, section II.)

## ICE

1-28. Ice forms in a few different ways as described below. Any movement on ice demands crampons. (See chapter 6, section II.)

- Alpine ice forms in steep, sheltered couloirs and on glaciers, where firm snow consolidates into a mass of ice. It forms in a plane at the angle of the slope. Even at moderate angles, it can be physically demanding due to the lack of stances for rest and the hardness of the ice.
- Waterfall ice forms when ambient temperatures are cold enough to freeze water quickly and water flows or seeps over cliffs and exposed rock faces. Waterfall ice can form much steeper flows than

alpine ice, often with freestanding vertical columns or overhangs where drips freeze quickly. However, waterfall ice also forms bulges and steps that allow stances to rest and place protection.

- Verglas is a thin sheet of ice that forms when rain or dripping water freezes on colder rocks. Verglas is too thin to climb like ice and makes conventional rock climbing impossible.

### GLACIERS

1-29. When enough ice accumulates in the peaks, it begins to flow down the mountain. Valleys in the high mountains may be buried under massive glaciers and present additional hazards, such as hidden crevasses and icefalls. Dismounted movement across glaciers is hazardous; however, glaciers often provide the easiest passage through the more technical terrain on surrounding slopes and faces. (See chapter 14 for information on glacial travel.)

## SECTION III – TERRAIN ANALYSIS

1-30. Terrain analysis is critical to every decision and task when planning an operation in mountainous terrain. Substantial experience moving and living in a wide variety of terrain is essential to effective terrain analysis. Military mountaineers can use the standard Army acronym for observation and fields of fire, avenues of approach, key terrain, obstacles, and cover and concealment (OAKOC) as a guide during terrain analysis.

## OBSERVATION AND FIELDS OF FIRE

1-31. Observation in mountains varies extensively due to weather and ground cover. The dominating height of mountainous terrain and sparse vegetation generally permits excellent long-range observation. Well-placed elements in the high ground can typically observe and affect much of the terrain. However, rapidly changing weather with frequent periods of high winds, rain, snow, sleet, hail, and fog can limit visibility. The rugged nature of the terrain often produces dead space at midranges.

1-32. Low cloud cover at higher elevations may neutralize the effectiveness of operations established on peaks or mountaintops. High wind speeds and sound often mask the noises of troop movement. Several operations may need to be established laterally, in-depth, and at varying altitudes to provide visual coverage of the battle area.

1-33. Conversely, the nature of the terrain can provide concealment from observation. This concealment can be obtained in the dead space. Mountainous regions are subject to intense shadowing effects when the sun is low in relatively clear skies. The high contrast from light to shaded areas considerably reduces visual sharpness within shaded regions. These shadowed areas can provide increased concealment when combined with other camouflage, and they should be considered in maneuver plans.

1-34. Fields of fire, like observation, are excellent at long ranges. However, dead space is a problem at short ranges. Rocky, broken terrain favors dispersed teams that can cover the many approaches to their position. Range determination is deceptive in mountainous terrain. Soldiers must routinely train in range estimation in mountainous regions to maintain their proficiency.

## AVENUES OF APPROACH

1-35. The rugged nature of terrain creates many natural obstacles. Maneuver elements are constrained to the few movement corridors for which they have the appropriate training and equipment to negotiate. Mountains usually favor the defense. Units in dominating terrain can ward off large attacks easily. However, the difficulty of sustaining forces in the high ground, their exposure to bad weather, as well as the many approaches created by the rugged terrain means defending forces cannot cover all avenues of approach. They focus their limited combat power on the approaches from which they expect an attack. Historically, large attacks along easy approaches in the mountains have failed. Attacks are more likely to succeed by using troops that can exploit unexpected avenues of approach, with adequate reconnaissance, rehearsals, and the element of surprise.

# KEY AND DECISIVE TERRAIN

1-36. Mountain warfare is a fight to control roads, and the lines of communication (LOCs) located in valleys. Controlling them enables the movement of road-bound critical supplies and heavy combat assets, such as tanks that must transit through the mountains to other fronts of the battlefield. The decisive terrain for control of these LOCs is often the passes. Here, the valleys narrow and rise, limiting the maneuver of armor and mechanized units. The terrain canalizes these forces into terrain dominated by the surrounding heights. Here, these assets experience degradation of their maneuver and firepower capability, making them vulnerable to attacks from mobile and light mountain infantry forces. The unit that holds this decisive terrain can protect its own heavy assets as it moves through mountainous terrain and destroys enemy assets attempting to take the same route.

1-37. The high ground offers a tactical advantage to whoever holds it. In the valley, cover shrinks when engaged from an elevated position. On the heights, even relatively small cover gives protection from direct fires from the valley and using ridge crests allows units to maneuver while masked by terrain. However, the tactical advantage of holding high ground is also resource intensive. Occupying and then sustaining mountain positions require a significant commitment of support that may make long-term occupation difficult or impossible.

# OBSTACLES

1-38. Mountain terrain is defined by its rugged character. Cliff bands, steep gullies full of loose rock, and other natural obstacles exist throughout the terrain. All can be used to slow or canalize opposing forces into decisive engagement areas. In difficult terrain, fewer resources may be needed to improve obstacles.

# COVER AND CONCEALMENT

1-39. When moving in the mountains, outcroppings, boulders, heavy vegetation, and intermediate terrain can provide cover and concealment. The digging of fighting positions and temporary fortifications is difficult because soil is often thin or stony. Selecting dug-in positions require detailed planning. Some rock types, such as volcanic tuff, are easily excavated. In other areas, boulders and other loose rocks can be used for building hasty fortifications. In alpine environments, snow and ice blocks may be cut and stacked to supplement dug-in positions.

1-40. Above tree line, lack of vegetation significantly reduces concealment. Movement requires careful terrain analysis and route planning, using terrain to mask movement from enemy observation. Hide sites and defensive positions built in locations with good observation angles are often exposed; they require careful camouflaging.

# MOUNTAIN CLASSIFICATIONS

1-41. The military uses two systems to classify mountain terrain: operational terrain levels and dismounted mobility classifications. Operational terrain levels describe the tactical advantages and disadvantages based on their difficulty to access and secure. The dismounted mobility classification describes the individual mobility skills required to move safely and effectively through that terrain. These classifications are crucial tools for planners and leaders. They enable the appropriate terrain analysis and help to facilitate planning feasible and realistic operations in mountain environments.

## OPERATIONAL TERRAIN LEVELS

1-42. Level I terrain is located at the bottom of valleys and along the main LOCs see table 1-1 and figure 1-2, page 10. These areas typically contain resources, population centers, or mobility corridors that are vital to mission success. Opening, blocking, or controlling these regions and LOCs is therefore always a tactical objective in mountain combat operations. At this level, maneuver space is restricted, but armored forces can operate effectively along valley roads and trails. Infantry and armored forces are typically task-organized together at this level to ensure freedom of movement and protection along LOCs. While armor provides mobility and firepower within the confines of the valley floor, infantry and other high mobility units secure adjacent high ground. Units operating in level I terrain must consider how higher terrain—particularly

level II—can influence their mission, including exposure to enemy observation, fires, and maneuver from above.

1-43. Level II terrain consists of the highlands that overlook and influence level I terrain. Level II terrain is often found between valley floors and the higher mountain peaks. Units occupy level II terrain because it provides a tactical advantage through observation, fires, and maneuver over the valleys below. In mountain operations, control of level II terrain, rather than the actual summit, often determines key terrain. However, units positioned in level II must also account for how higher level III terrain may allow enemy forces to observe, flank, or otherwise influence their position. Infrastructure in level II terrain is typically sparse or nonexistent. If present, roadways may include narrow roads or trails that follow ridgelines or cross saddles. Such roadways often serve as secondary LOCs.

1-44. Level III terrain includes the dominant terrain of summit regions. These areas typically do not allow forces to directly influence level I terrain, but they may dominate or affect operations in level II. Operations in level III terrain are challenging due to extreme environmental exposure, limited infrastructure, and separation from adjacent units and logistical support. However, level III terrain can provide acclimatized troops with advanced mountaineering training with opportunities to support forces in level I and II terrain. Such supporting activities include flanking enemy positions, infiltrating along unexpected avenues of approach, and striking key vulnerabilities such as LOCs, logistics nodes, air defense sites, or command infrastructure.

**Table 1-1. Operational terrain levels**

| *Level* | *Description* | *Operational Significance* |
|---|---|---|
| **I** | Valleys and main lines of communication | Contains operational centers of gravity such as roads, population centers, and sustainment routes. Achieving objectives in level I drives operations into higher terrain. |
| **II** | Ridges, slopes, and passes that overlook level I terrain | Directly controls or influences level I terrain. Provides tactical advantage through observation, fires, and maneuver. |
| **III** | Summit regions and high mountain terrain far removed from level I | Can influence or control level II terrain but sometimes is beyond operational relevance. Can enable flanking, infiltration, and shaping operations by skilled troops. High resource requirement to conduct and sustain operations. |

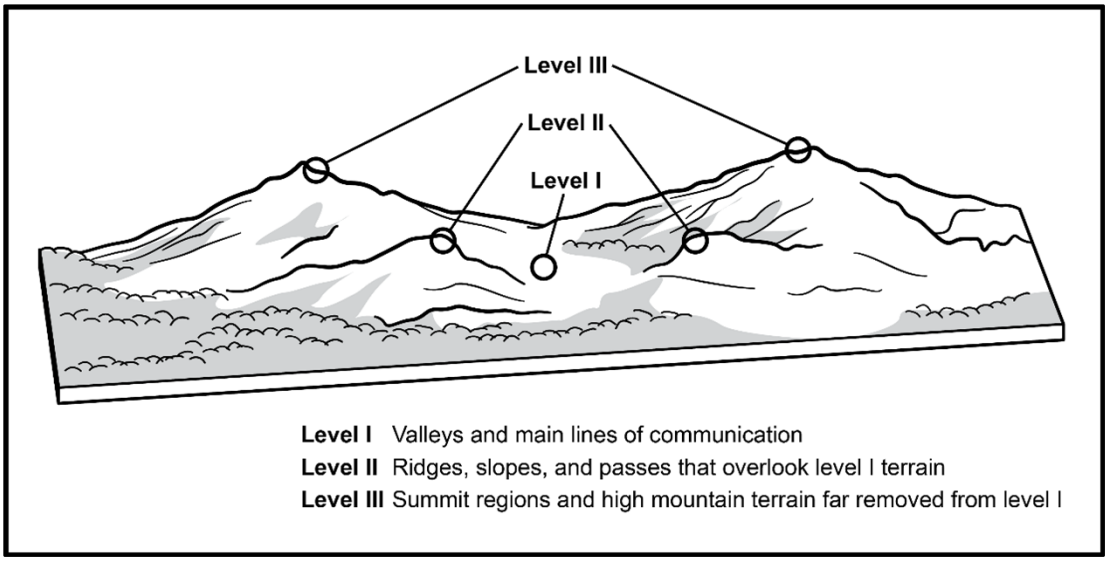



**Figure 1-2. Terrain levels**

## DISMOUNTED MOBILITY CLASSIFICATION

1-45. Most mountainous terrain severely restricts mobility. The dismounted mobility classification is a tool that rates the terrain based upon difficulty of movement and consequence of a fall and provides general guidelines on risk management. It uses the same categories as the Yosemite Decimal System (YDS), which is used to rate climbing in the United States. It is used across all types of mountainous terrain and defined as a rough framework for communicating the appropriate risk treatment and required technical systems and resources for negotiating the terrain. It is subjective, and risk treatment will vary based upon the group, surface conditions, and weather.

1-46. 1st-class terrain is defined as gentle slopes or easy trails. This terrain is negotiated with simple walking techniques. This can be anything from established trails to cross-country movement over terrain with stable footing and moderate grades. Mobility challenges in this terrain may include dense vegetation, stream crossings, and challenging route planning. Risks are limited to navigation errors and hazards posed by stream-crossings, weather, and altitude. (See table 1-2.)

1-47. 2nd-class terrain involves off-trail scrambling in steeper, more rugged terrain, often with extensive scree, talus, or boulder fields. Hands are often used for balance. Good physical conditioning is required, but no technical solutions are needed for safe movement. Route-finding skills are even more important for efficient and safe travel across or around terrain that is more difficult, vegetation, stream-crossings, and rockfall hazards. The risk of injury from slips and rockfall is moderate, but generally, the likelihood and consequence of a fall is low. Moving a casualty will generally require simple rope systems. (See table 1-2.)

1-48. 3rd-class terrain requires scrambling. Hand and footholds are numerous and easy to find, requiring limited climbing experience. Movement may be easy, but falls can cause serious injury. Advanced route-finding skills are necessary to avoid difficult and dangerous terrain. Experienced mountaineers will usually travel unroped. Using fixed ropes or belays are required for Soldiers moving during limited visibility, bad weather, or when carrying heavy loads. All Soldiers moving in 3rd-class terrain should have training in individual mobility, good physical fitness, and proficiency with rope systems used. Route finding and risk decisions should be made by someone with formal mountaineering training. (See table 1-2.)

1-49. 4th-class terrain requires moderate to difficult scrambling. Holds are numerous but must be tested and are frequently smaller and more difficult to find than in 3rd-class terrain. The terrain is often broken, with short, steep steps of less than 15 meters, interspersed with blocky ledges. It is often exposed. Serious injury or death can occur if an unroped fall occurs. Climbing should be protected by belays or fixed ropes. Advanced military mountaineers are required to find routes and provide belays or fix ropes for less experienced troops where necessary. It requires significant time and resources to manage risk for large elements. It is more efficiently traveled by small teams. 4th-class terrain is the most difficult terrain in which to evaluate and manage risk. (See table 1-2.)

1-50. 5th-class terrain is climbing terrain. Significant injury or death can occur from an unroped fall. Climbing is protected by belay techniques and intermediate protection. Steep rock often requires that anchors be built with rock gear. Advanced military mountaineers are trained to lead climbs to negotiate this terrain. Large groups can descend through bands of 5th-class terrain more quickly by rappelling. Ascent requires more time and equipment, as well as proficiency in rope ascending across the entire element. (See table 1-2.)

**Table 1-2. Dismounted mobility classes**

| *Class* | *Terrain* | *Mobility Requirements* | *Skill Level Required* |
|---|---|---|---|
| 1 | Gentler slopes or trails. | Walking techniques. | Unskilled (with some assistance) and basic mountaineers. |
| 2 | Steeper or rugged terrain. | Some use of hands. | |
| 3 | Easy climbing. | Fixed ropes where exposed. | Basic mountaineers (with assistance from assault climbers). |
| 4 | Sleep or exposed climbing. | Fixed ropes required. | |
| 5 | Near vertical. | Technical climbing required. | Assault climbers. |

1-51. Operations conducted in 1st- and 2nd-class terrain require little to no mountaineering skills. Special teams may require some training and ropes for moving casualties. Operations in 3rd-, 4th-, and 5th-class terrain require a higher level of mountaineering skills throughout the element for safe and efficient movement. Elements moving through terrain obstacles are easily fixed. Operations moving through exposed terrain should have plans for maintaining security and for contingencies during the movement.

## SECTION IV – MOUNTAIN WEATHER

1-52. Weather presents its own hazards in the mountains. It also increases the hazards posed by terrain. On routes with snow or glacial hazard, variations in temperature and cloud cover can significantly affect speed and safety. Strong winds can make exposed ridges unclimbable. Rain, in addition to causing discomfort and potentially hypothermia, makes rock slick and increases the likelihood of a fall. Rain washing through debris in gullies increases the danger of rockfall. Summer thunderstorms move quickly and hammer exposed ridges and peaks with lightning.

1-53. Bad weather increases hazard and physical discomfort. Civilian mountaineers plan climbs with "weather windows" to allow flexibility. Military mountaineers often have less flexibility in plans and timelines. Some weather hazards can be managed by more conservative terrain choices, additional cold-weather clothing and equipment, and training focused on producing self-reliant Soldiers who can endure poor conditions. Plans should be flexible with multiple layers of redundancy for sustainment. Bad weather may force early resupply or the adjustment of operations to accommodate the lack of ground and aerial resupply.

# MOUNTAIN WEATHER FACTORS

1-54. Weather analysis is the collection, processing, evaluation, and interpretation of relevant military aspects of weather. It is the evaluation of forecasted weather effects on operations. The military aspect of weather—visibility, wind velocity, precipitation, cloud cover, temperature, humidity, and atmospheric pressure—and their effects on operations remain the same as in other environments. However, elevation and terrain with significant relief create effects unique to the mountain environment. Weather in the mountains follows larger patterns, but local factors cause weather systems to produce more precipitation and make the effects of storms and instabilities greater and longer lasting. (See table 1-3, page 14.) (See ATP 2-01.3 for more information on weather analysis.)

### ATMOSPHERIC PRESSURE, TEMPERATURE, HUMIDITY

1-55. Changes in atmospheric pressure are the underlying cause of many factors. Atmospheric pressure is the weight of the atmosphere in an area. As elevation increases, pressure is reduced, causing lower air density. Aircraft capabilities and human performance decrease. Sunlight is less filtered, causing quicker warming and cooling.

1-56. Reduced pressure also affects temperature. Air temperature decreases as elevation increases in the mountains at the adiabatic rate or about 3 degrees (°) Fahrenheit (F) to 5 °F for every 1,000 feet of elevation gain. Cooler air holds less moisture. As air masses pass over mountains, they are lifted by the terrain—a process known as orographic lift. If the air cools to its saturation temperature, its water vapor condenses and becomes a visible cloud. Lenticular clouds, named for their lens shape, are cloud caps that often form above peaks because of orographic lift and precipitates such as fog, rain, or snow. This process increases the severity and length of storms and produces unique localized weather.

1-57. Mountain air is incredibly dry. Dehydration is more likely in the mountains if Soldiers are not properly hydrated. (See chapter 3 for more information.)

### VISIBILITY, CLOUD COVER, AND PRECIPITATION

1-58. On clear days, high elevations provide opportunities to see great distances. However, minor atmospheric disturbances produce fog, clouds, and precipitation that reduce visibility. Weather systems that would not influence operations in the lowlands often do in the mountains. Clouds are common in mountain environments and may form quickly. Precipitation occurs more often on the windward side of mountain

ranges than on the leeward side. Snow is common in the mountains and may occur during any season at elevations above 1,500 meters (5,000 feet).

1-59. Local thunderstorms often pass quickly but bring driving snow and sudden wind squalls. Lightning is common in mountain storms and normally discharges on high points and prominent features. Peaks, ridges, rock walls, isolated trees, fixed wire installations, cracks that guide water, cracks filled with earth, shallow depressions, shallow overhangs, and rock needles should be avoided; shelter should be obtained around dry, clean rock without cracks.

1-60. Storms caused by widespread atmospheric disturbances often involve strong winds and heavy precipitation. These conditions may last several days longer than in the lowlands. Low temperatures, high winds, and blinding snow often accompany winter storms in alpine regions.

## WIND VELOCITY

1-61. Mountains more frequently create variation in wind than in most other environments. Valleys often protect Soldiers from strong winds, but the ridges and passes of mountains are seldom calm. Wind velocity generally increases with altitude and is intensified by mountainous terrain. Wind speed increases when winds are forced over ridges and peaks or when funneled through narrowing mountain valleys, passes, and canyons. (This is known as the Venturi effect.) Exposed mountainsides and summits are especially susceptible to strong winds. Topography usually controls local wind direction.

1-62. When the wind speed is doubled, the force on an object buffeted by the wind is quadrupled; therefore, bivouacs or patrol bases should be established in areas not subject to extreme winds. Colder air temperatures along with wind produce wind chill. Soldiers in a static security posture in these conditions are more likely to experience cold-weather injuries. (See chapter 3 for cold-weather injuries.)

1-63. Warming and cooling cycles cause local air movements. Valley breezes moving up a slope are more common in the morning and are known as anabatic winds; descending mountain breezes known as “katabatic winds” are more common in the evening.

**Table 1-3. Weather hazards and their effects on troops**

| *Weather Condition* | *Flat to Moderate Terrain Effects* | *Added Mountain Effects* |
|---|---|---|
| **Sunshine** | • Sunburn.<br>• Snow blindness.<br>• Temperature differences between sun and shade. | • Increased risk of sunburn and snow blindness.<br>• Severe, unexpected temperature variations between sun and shade.<br>• Avalanches. |
| **Wind** | • Wind chill. | • Increased risk and severity of wind chill.<br>• Blowing debris or driven snow causing reduced visibility.<br>• Avalanches. |
| **Rain** | • Reduced visibility.<br>• Cooler temperatures. | • Landslides.<br>• Flash floods.<br>• Avalanches. |
| **Snow** | • Cold-weather injuries.<br>• Reduced mobility and visibility.<br>• Snow blindness.<br>• Blowing snow. | • Increased risk and severity of common effects.<br>• Avalanches. |
| **Storms** | • Rain/snow.<br>• Reduced visibility.<br>• Lightning. | • Extended duration and intensity greatly affecting visibility and mobility.<br>• Extremely high winds.<br>• Avalanches. |
| **Fog** | • Reduced mobility or visibility. | • Increased frequency and duration. |
| **Cloudiness** | • Reduced visibility. | • Greatly decreased visibility at higher elevations. |

# PLANNING FOR WEATHER

1-64. Mountain weather can be a dangerous obstacle to operations or a valuable aid, depending on how well it is understood and to what extent advantage is taken of its characteristics.

1-65. Weather often determines the success or failure of a mission. Military operations plans must be flexible. The clouds that often cover mountaintops and fog that covers valleys are excellent tools for concealing movements normally made during darkness or in smoke. Limited visibility can be used as a combat multiplier.

1-66. The safety of most high mountain regions, especially in winter, depends upon the change of a few degrees of temperature above or below the freezing point. Ease and speed of travel depend mainly on the weather. Terrain that can be crossed swiftly and safely one day may become impassable or dangerous the next due to snowfall, rainfall, or warmer temperatures; the reverse can happen just as quickly. The prevalence of avalanches depends on terrain, snow conditions, and weather factors.

1-67. Weather affects Soldiers' abilities to see enemies, terrain, and teammates, as well as their ability to move through the terrain. Access to weather information during the planning process drives tactical decisions. Whether patrolling or static, military mountaineers should constantly evaluate the following:

- What is the weather currently?
- What was the weather recently and when did it change last?
- When is the next forecasted change coming?
- How does it affect us?

# WEATHER FORECASTING

1-68. Reports from other localities and from any weather service, including the Air Force, Navy, or the National Weather Service, are helpful. Weather at various elevations may be quite different because cloud

height, temperature, and barometric pressure will all be different. There may be overcast and rain in a lower area, with mountains rising above the low overcast into warmer clear weather. To be effective, a forecast must reach the small-unit leaders who are expected to utilize weather conditions for missions. Normally located within a chief of staff intelligence office or battalion or brigade intelligence office and designated as a special staff officer, the U.S. Air Force staff weather officer provides and coordinates weather support and services. (See AR 115-10 and AR 5-25 for additional guidance.)

1-69. Weather patterns form at the continental scale and involve many factors. Individuals on the ground cannot create weather forecasts from locally observed conditions and it is unrealistic to expect them to do so. It is critical that weather data produced at higher levels is pushed down to forces on the ground. However, individuals on the ground must recognize that there is inherent uncertainty in all forecasts, and local factors may produce unexpected conditions. Paying attention to changing trends can prevent Soldiers from being unprepared for changing conditions. Many of the trends that indicate changing weather are easily observed.

1-70. Monitoring changes in barometric pressure provides one of the reliable indicators of changing weather. High-pressure systems bring cooler, drier weather. As air pressure rises, it prevents moisture from rising and forming in the atmosphere, allowing for clearer skies and cooler temperatures. Lower air systems bring warmer, wetter weather and atmospheric instability. As air pressure falls, it allows moisture to rise and condense, allowing clouds to form.

1-71. Pay attention to key indicators of changes. Analog altimeters measure barometric pressure and can be used to identify an increase and decrease in pressure when stationary for a prolonged period. (See chapter 7 for information on altimeters.)

### DETERIORATING TRENDS

1-72. Military mountaineers must pay careful attention to indicators of deteriorating weather trends. The following are common indicators:

- Marked wind direction shifts. A high-pressure system wind flows clockwise. A low-pressure system wind flows counterclockwise. The closer the isometric lines are, the greater the differential of pressure and the greater the wind speeds.
- Marked wind speed increases.
- Changes in obstructions to visibility.
- Increasing cloud coverage.
- Increase in precipitation. A steady drizzle is usually a long-lasting rain.
- Lowering cloud ceilings.
- Marked cooler temperature changes, which could indicate that a cold front is passing through.
- Marked increase in humidity.
- Decrease in barometric pressure indicates a lower-pressure system is moving through the area. This can be measured using a digital or analog altimeter.

### IMPROVING TRENDS

1-73. Predicting coming favorable weather conditions is important during operations planning. The following are common indicators of favorable weather trends:

- Steady wind direction, which indicates no change in weather systems in the area.
- Decreasing wind speeds.
- Clearing of obstructions to visibility.
- Decreasing or ending precipitation.
- Decreasing cloud coverage.
- Increasing height of cloud ceilings.
- Changing temperature slowly gets warmer.
- Decreasing humidity.
- Increasing barometric pressure indicates that a higher-pressure system is moving through the area. This can be measured using a digital or analog altimeter.

## CLOUDS

1-74. At the boundaries of major weather systems where different air masses collide, warm air is lifted into the atmosphere, causing clouds and precipitation. Fronts create distinctive cloud formations. Warm fronts, where the incoming warm air gradually displaces cold air below, present as steadily thickening and lowering clouds over a few days. Cold fronts create an uplift that is more violent and may come as a single, larger storm system.

### High-Level Clouds

1-75. High-level clouds (above 6,000 meters) are formed of ice crystals, with a fibrous structure and blurred outlines. The sky is often covered with a thin veil that partly obscures the sun or, at night, produces a ring of light around the moon. Cirrus clouds indicate moisture aloft and the approach of a traveling storm system. Precipitation is often 24 to 36 hours away. As a storm approaches, the high-level clouds thicken and lower.

### Mid-Level Clouds

1-76. Mid-level clouds (2,000 to 6,000 meters) appear more distinct than high-level clouds because of a mixed composition of water droplets and ice. Mid-level clouds often form in advance of a cold front. Puffy, mid-level clouds on a warm, humid summer morning are commonly followed by thunderstorms later in the day. “Fair weather” cumulus are clouds scattered rather than even in a blue sky and suggest arrival of high pressure and clear skies.

### Low-Level Clouds

1-77. Low-level clouds (below 2,000 meters) are mostly composed of water droplets. Most precipitation originates from low-level clouds because rain or snow usually evaporates before reaching the ground from higher clouds. Low-level clouds usually indicate impending precipitation.

### Vertical Development (Cumulonimbus)

1-78. Large, vertical development clouds often form on the steep, leading edge of a cold front. They can develop as individual towers or form a line of towers called a squall line. Their formation is fueled by vigorous convective updrafts. These storms tend to develop during the afternoon and early evening when the effects of heating from the sun are the strongest.

## Chapter 2

# Training Military Mountaineers

Operational success in complex, compartmentalized, and objectively hazardous terrain largely rests on the shoulders of a unit's military mountaineers. Often, these are the only unit members with significant experience living and moving in mountainous terrain. Units with highly experienced mountaineers and well-developed mountain programs will be better prepared to engage in mountain warfare and will likely prove more successful. Military mountaineers serve as advisors for the development of such programs and trainers for mountain knowledge and skills; they also ensure safe training conduct in hazardous terrain. When used effectively, mountaineers provide their units with the ability to successfully live in extreme environments and move efficiently in terrain inaccessible to other units. Additionally, advanced and master military mountaineers serve as planners and advisors to commanders for combat operations in mountainous terrain. They are the primary means for a commander to lead units through complex terrain, emplace special teams at inaccessible points of domination, and conduct casualty evacuation (CASEVAC) in 5th-class terrain. The selection, formal training, and development of military mountaineers are critical to the effectiveness of all units operating in mountainous terrain.

## SECTION I – LEVELS OF MOUNTAINEER

2-1. Three doctrinal levels of military mountaineer correspond with increasing experience and formal school graduation requirements for qualification—basic, advanced, and master military mountaineers. Each level of mountaineer is expected to be capable of performing an increasingly complex set of skills and functions in preparing for and leading mountain warfare operations.

2-2. Additionally, contemporary mountain operations and training have highlighted the need to identify what capabilities are necessary for all Soldiers in mountainous terrain, given that 100 percent of a unit achieving even basic military mountaineer qualification is likely impossible due to a unit's operating tempo and personnel turnover. Soldiers belonging to units that anticipate participating in mountain operations who have not received formal mountaineer training will be referred to as mountain Soldiers. Additionally, some guiding criteria for selecting Soldiers for formal mountaineering training should be followed so that success is more likely.

### CANDIDATES FOR FORMAL MOUNTAIN TRAINING

2-3. Ideal military mountaineers are self-motivated, critical thinkers requiring minimal supervision and direction to succeed in assigned tasks. They are undaunted by difficulty or adversity and possess a strong desire to work and live in mountainous terrain.

2-4. Although all Soldiers operating in mountainous terrain benefit from formal mountaineering training, opportunities for training are limited. Commanders should select Soldiers who possess characteristics, which allow them to both successfully pass courses and return with the ability to improve their unit's mountain capability.

2-5. Candidates should embody the following characteristics:

- Independent and self-motivated.
- Mentally and physically fit.
- Sure-footed and agile (necessary for scrambling or climbing).
- Comfortable with heights.
- Experienced in living and working in a cold-weather environment.
- Skilled at map reading and land navigation without electronic aids.
- Quick learner of technical skills.

2-6. Leader candidates should possess the following characteristics:
- Leadership experience in tactical operations up to their level of responsibility.
- Capable of solving problems and taking initiative based on commander's intent.
- Possess teaching and mentorship skills.
- Comfortable serving as advisors to senior leadership.

2-7. Officer candidates should possess the following characteristics:
- May serve in the future, or currently serve, as commander for a unit that will operate in mountainous terrain.
- May serve in the future, or currently serve, as operations or training planner for a unit that will operate in mountainous terrain.

# LEVEL 1: BASIC MILITARY MOUNTAINEER

2-8. **A *basic military mountaineer* is a Soldier who graduated from the Basic Military Mountaineer Course. Basic military mountaineers have been trained in basic mountaineering techniques, such as fundamental mobility skills necessary to move safely and efficiently in mountainous terrain, and are also known as level 1 military mountaineers.** Soldiers should be comfortable functioning in this hazardous terrain and extreme environmental conditions. They should be able to assist higher-level mountaineers in rigging and using all basic rope installations. Basic military mountaineers should be able to perform duties as the follower or second on a roped climbing team and be able to operate all basic rope systems. They may provide limited assistance and simple skills training to personnel unskilled in mountaineering techniques under the close supervision of higher-level mountaineers. Particularly adept Soldiers may be selected as members of special-purpose teams led and supervised by higher-level mountaineers. Risk mitigation decisions ultimately belong to commanders, but level 1 qualification should not be considered sufficient experience to inspect rigging without advanced mountaineer supervision.

2-9. Units planning to operate in mountainous terrain should maximize the number of level 1 mountaineers. Leaders of units intending to operate in mountainous terrain should be, at a minimum, level 1 mountaineers.

2-10. Basic military mountaineers are trained in the following mountain-specific skills:
- Characteristics of the mountain environment (summer and winter).
- Mountaineering safety.
- Use, care, and packing of individual cold-weather clothing and equipment.
- Care and use of basic mountaineering equipment.
- Mountain bivouac techniques.
- Familiarized with mountain communications.
- Mountain travel and walking techniques.
- Familiarized with hazard recognition and route selection.
- Mountain navigation.
- Basic medical evacuation (MEDEVAC).
- Rope management and knots.
- Natural anchors.
- Familiarized with artificial anchors.
- Belay and rappel techniques.
- Establish and employ fixed ropes on simple terrain.
- Climbing fundamentals.
- Rope bridges.
- Hauling and lowering systems.
- Individual movement on snow and ice.
- Mountain stream crossings.
- First aid for mountain illnesses and injuries.
- Familiarized with avalanche avoidance and rescue.

***Note.*** Level 1 qualified personnel should be identified and prepared to serve as assistant instructors to train unqualified personnel in basic mountaineering skills. All high-risk training must be conducted under the supervision of qualified level 2 or 3 personnel.

# LEVEL 2: ADVANCED MILITARY MOUNTAINEER

2-11. **An *advanced military mountaineer* is a Soldier who has graduated from the Basic Military Mountaineer Course and at least one of the Advanced Military Mountaineer courses. An advanced military mountaineer has been trained in advanced mountaineering techniques and is also known as a level 2 mountaineer.** Operationally, an advanced military mountaineer is also known as an ***assault climber*, which is a role assigned to a Soldier or team during tactical operations who is responsible for the location and establishment of technical routes in class 3 or higher terrain; ideally, a level 2 mountaineer. A *technical route* is a route through steep or broken mountainous terrain that presents significant risk of fall injury and requires special movement techniques or ropes to ensure adequate safety for Soldiers moving through it.** Ideally, assault climbers are level 2 mountaineers. Advanced military mountaineers are responsible for rigging, inspecting, using, and operating all basic rope systems. They are trained in additional rope management skills, knot tying, belay, and rappel techniques, as well as using specialized mountaineering equipment. Advanced military mountaineers can rig complex, multipoint anchors and high-angle raising and lowering systems. Level 2 qualification is required to supervise all high-risk training associated with level 1 skills.

2-12. Units planning to operate in mountainous terrain should possess enough level 2 mountaineers to train lower-level personnel in mountain skills and lead small teams through hazardous terrain during operations. Company-level and higher unit leaders who possess level 2 training are better prepared to negotiate the challenges inherent in sustaining and moving their units in consequential terrain. Company-level and higher unit leaders better understand which training is appropriate and important to their personnel at all levels of mountaineering.

2-13. Advanced military mountaineers are trained in the following mountain-specific skills:

- Use specialized mountaineering equipment.
- Conduct multipitch climbing on rock.
- Conduct multipitch rappelling.
- Establish and operate hauling systems.
- Establish, employ, and supervise unit movement on fixed ropes on complex terrain.
- Conduct roped movement techniques on moderate angle snow and ice.
- Establish evacuation systems and perform high-angle rescue.
- Recognize and evaluate terrain, weather, and hazards.
- Perform avalanche rescue operations.
- Perform rescue operations on mountainous terrain.
- Perform glacier travel and crevasse rescue.
- Conduct unit mountain skills sustainment and improvement training.

# LEVEL 3: MASTER MILITARY MOUNTAINEER

2-14. A master military mountaineer is a Soldier who has graduated from the Basic and Advanced Military Mountaineer courses and endorsed by the Master Mountaineer Board (MMB). **A *master military mountaineer* is a Soldier extensively trained and experienced with mountaineering techniques who the commander appoints to serve as a subject matter expert. Master military mountaineers should be graduates of the Basic Military Mountaineer Course and Advanced Military Mountaineer courses. They possess all the skills of the advanced military mountaineer and have extensive practical experience in a variety of mountain environments in both winter and summer conditions**. Level 3 mountaineers should have well-developed hazard evaluation and safe route-finding skills over all types of mountainous terrain. Master military mountaineers serve as advisors to commanders and staff during planning on mountain warfare considerations across all warfighting functions. The master military mountaineer is the highest level of qualification and is the principal trainer for conducting mountain operations. The MMB is subordinate to the Army Mountaineering Board and endorses or suggests additional

training for Soldiers submitting packets. The MMB sets packet criteria to validate Soldier capability to perform the tasks in paragraph 2-16. The MMB's endorsement assists commanders in appointing qualified Soldiers to perform level 3 tasks.

2-15. Company-level units and higher that plan to operate in mountainous terrain should have one or more level 3 mountaineers assigned. Battalion-level units and higher should have at least one senior-ranking level 3 mountaineer assigned to their operations staff sections to ensure commanders are informed of all mountain considerations that could affect operations.

2-16. Master military mountaineers are knowledgeable and proficient in the following mountain-specific skills:

- Develop and oversee unit mountain skills sustainment and improvement program.
- Prepare route, movement, bivouac, and risk management.
- Perform avalanche hazard evaluation and mitigation.
- Plan and supervise high-angle rescue.
- Organize and lead avalanche rescue operations.
- Plan and supervise roped movement techniques on steep snow and ice.
- Plan and supervise glacier travel and crevasse rescue.
- Plan and conduct over snow mobility.
- Conduct multipitch climbing on rock, snow, and ice.
- Lead units over technically difficult, hazardous, or exposed terrain in both winter and summer conditions.

## SECTION II – TRAINING INDIVIDUAL MOUNTAIN SKILLS

2-17. Unit preparedness for operations in mountainous terrain is contingent on the effectiveness of the training program its commander implements. Commanders and trainers must understand how to prioritize mountain skill training, so skills are built in a progressive fashion that supports a unit's collective task capability. General mountaineering skills and experience must be developed before complex technical skills and before collective tasks can be effectively performed. Attempting complex training in mountainous terrain before all participants are proficient in self-sustainment and basic mobility skills will likely cause a failure to achieve training goals and possibly serious injury or death.

# UNIT-LEVEL TRAINING PROGRAMS

2-18. Commanders anticipating operations in mountainous terrain should establish a mountaineering training program and program coordinator like a unit marksmanship program. An appropriate noncommissioned officer in charge (NCOIC) and officer in charge (OIC) should be tasked with this additional duty. The primary training coordinator (NCOIC) should be a level 3 master military mountaineer and senior noncommissioned officer with maneuver leader experience, as well as experience facilitating individual-, team-, and unit-level training events. The OIC should have a level 2 or higher qualification to create and manage a successful training plan and risk management process. Additionally, commanders should strive to maintain a cadre of formally trained level 1 and level 2 mountaineers comprised of experienced junior noncommissioned officers who can teach mountain skills and supervise high-risk mountain training. Commanders should carefully consider the number and distribution of this cadre throughout a unit. Spreading mountaineers throughout smaller units increases opportunities for them to teach skills to other Soldiers and incorporates them into smaller unit collective training events. Periodically, consolidated training should be conducted for each level of mountaineer, and unit commanders should plan collective training events that involve mountaineering techniques.

2-19. Commanders at battalion level and higher should establish similar NCOIC and OIC additional duties for planning mountain operations and providing guidance and support to company-level trainers in accordance with (IAW) their intent for mountain capability. Ideally, an NCOIC at this level would be an accomplished mountaineer, with substantial experience leading Soldiers in the full range of mountainous terrain and environmental conditions, as well as having served as a lower-level unit mountain training coordinator. OICs at this level should be experienced level 2 mountaineers and should have either served as OICs of unit mountaineering training programs or the commander of a unit that developed one in the past. Since some mountain training is inherently high risk, battalion and higher-level commanders should establish clear risk mitigation guidance under the guidance of their master military mountaineer.

# PROGRESSION OF MOUNTAIN SKILLS

2-20. Mountain training planners must clearly understand how to prioritize the development of mountain skills. Three broad individual skillsets that are critical to developing a unit's tactical effectiveness in mountainous terrain are—

- Sustainment and survival in the mountainous environment skills—cold-weather clothing and moisture management strategies, bivouac techniques, and survival techniques.
- Mobility skills—individual movement skills and surefootedness. These exist at the intersection of fitness and movement technique mastery.
- Technical rope system skills—these comprise everything involved in the use of ropes and specialized equipment for protection, obstacle negotiation, and load movement.

## SUSTAINMENT AND SURVIVAL SKILLS

2-21. Units proficient in small group sustainment and larger unit resupply and communications TTPs have an overwhelming advantage over units that lack this experience in mountain environments, regardless of technical and tactical capabilities.

2-22. While Soldiers must be comfortable living in an environment in which they are training or operating, this is particularly true in a mountainous, cold-weather environment. Soldiers struggling to stay warm are unable to focus on performing tasks that are more complex. All unit members must be familiar and acclimated to cold weather, otherwise unit members who are acclimated to the cold become occupied caring for those who are not. Typically, most of this training does not require high mountain terrain—just cold weather and terrain that is remote and difficult to access.

2-23. As a unit gains proficiency in these skills, training locations should move into more difficult to access terrain, and periods of sustainment should increase. Eventually, moving into terrain at moderate to high altitude increases Soldier skill progressions and tasks become second nature. Typically, such training provides opportunities for the unit to develop collective sustainment, resupply, and communications TTPs, which are more important to successful operations in mountainous terrain than any other collective proficiencies.

## MOBILITY SKILLS

2-24. Mobility is critical to unit success in mountain warfare. High mobility skills allow units to outmaneuver their enemies no matter where they encounter them. The higher the skills, the more dominant terrain is accessible to the unit. The primary purpose of developing mobility skills is to increase the difficulty of terrain that Soldiers can move in unroped while carrying packs and combat loads. This expands the range of patrolling activities without the tactical disadvantage of using rope systems for fall protection, which is any anchor clipped to a running rope used in belay systems that limits the distance a roped climber falls, should a fall occur.

2-25. The hallmarks of individual movement skill proficiency are surefootedness and endurance. They describe a Soldier's ability to walk, scramble, and climb safely without the need for protection. Fitness is an important component in developing mobility skills. General fitness infrequently translates to high mobility skill without specific movement technique training. After sustainment, these are the most important skills to build warfighting capability in mountainous terrain.

## TECHNICAL ROPE SKILLS

2-26. Technical rope skills are necessary for units to access and move in operational terrain above level 2. Although it is seldom necessary for large units to move in such high consequence terrain, small-specialized teams can use it to provide tremendous advantage for their parent units by doing so. Snipers, reconnaissance teams, fire support teams, forward observer teams, or special operations teams can use unlikely avenues of travel located there for concealment and position themselves on points of domination, which are inaccessible to the enemy. From there, they can provide real-time intelligence to commanders, direct air assets, indirect fires, or provide overwatch for troops moving through easier terrain that is vulnerable to enemy attack. Advanced military mountaineers with technical rope skills must guide them safely through such hazardous terrain.

2-27. The unit requirement for personnel who are highly proficient in technical rope skills is relatively low. Technical rope skills, though complex to teach, are the lowest priority skills for units preparing to operate in mountainous terrain. This does not mean that these skills should not be taught but that other skills should be prioritized.

2-28. Unit training programs should focus on training most Soldiers to low or moderate (level 1) mountaineer levels of rope use proficiency, and a minority of particularly interested and capable Soldiers to high proficiency (level 2).

## SUSTAINMENT AND ENHANCEMENT TRAINING FOR MILITARY MOUNTAINEERS

2-29. Formally, qualified military mountaineers provide training to non-qualified members and require sustainment and skills advancement training. The Basic Military Mountaineer Course successfully introduces graduates to the full array of level 1 skills and techniques but is only 2-weeks long and does not fully teach them how to integrate with level 2 mountaineers to maximize a unit's mobility capability during the conduct of specific missions in mountainous terrain. The same is true for the Advanced Military Mountaineer Course. Graduates should have been exposed to all skills and techniques necessary to access all levels of terrain during military operations, but they should not be considered experienced. To be operationally capable, both levels 1 and 2 mountaineers require additional training experience fulfilling their roles and improving proficiency.

### Individual Training for Untrained Mountain Soldiers

2-30. Units with members who have experience in harsh environments and moving in steep terrain possess a significant advantage. Soldiers who are unprepared to live and move in the mountains will find it difficult to conduct combat operations there. Commanders should ensure all Soldiers in their formation are familiarized with the skills and knowledge outlined in paragraphs 2-34 through 2-40 when planning mountain operations.

2-31. These Soldiers should be trained in foundational skills necessary for sustainment and mobility in mountainous terrain. These skills include characteristics and hazards of the mountain environment, cold-weather sustainment, basic minimalist bivouac techniques, rough terrain walking, load management, simple movement techniques, basic knot tying, and rope handling.

2-32. Level 1 mountaineers, under the supervision of higher-level military mountaineers, should train untrained Soldiers IAW the commander's mountaineering program.

2-33. Units should create regular opportunities for untrained mountain Soldiers to integrate sustainment and mobility skills into their tactical training events.

### Continued Individual Training for Level 1 Mountaineers

2-34. Training for level 1 mountaineers should focus on improving sustainment skills, mobility skills, low-level technical skills, and assisting level 2 mountaineers in establishing technical rope systems.

2-35. Level 2 mountaineers should provide technical sustainment and improvement training for level 1 mountaineers IAW the commander's mountaineering program and under the guidance of a level 3 mountaineer.

2-36. Units should create regular opportunities for level 1 mountaineers to integrate sustainment and mobility skills into their tactical training events. Examples are incorporating low-angle CASEVAC scenarios in rough terrain or using simple fixed lines to help squad movement on steep slopes into platoon situational training exercises.

### Continued Individual Training for Level 2 Mountaineers

2-37. Typically, level 2 mountaineers should be provided the time and resources to conduct sustainment and improvement training. This training should be planned and conducted under the guidance and supervision of level 3 mountaineers. Optimally, periodic, high-commitment mountain training events should be planned for level 2 and led by level 3 mountaineers. All training for level 2 mountaineers should focus on building experience in those skills that the commander determines necessary to perform operationally. In the absence of specific mission-essential task list tasks to focus on, level 2 training should concentrate on route selection,

sharpening mobility skills, and climbing protective techniques in 5th-class terrain, leading small groups in 4th-class terrain, and conducting technical rescue training. These should be conducted in both summer and winter environmental conditions.

### *Shadowing*

2-38. Whenever possible, level 2 mountaineers should participate in providing formal mountaineering training by shadowing or by being an assistant instructor for the Basic Military Mountaineer Course or Advanced Military Mountaineer Course. Opportunities to do so can be coordinated through the Army Mountain Warfare School in Vermont, the Northern Warfare Training Center in Alaska, and the 5th Ranger Training Battalion in Georgia. Participating in formal mountaineering training programs ensures level 2 mountaineers are exposed to current techniques and training safety measures, provides experience with developing training programs, and helps prepare them for level 3 qualification and responsibilities.

### *Vertical Danger Area Ascent or Descent*

2-39. Units should occasionally create opportunities for level 2 mountaineers to integrate higher technical skills into tactical training events, such as a vertical danger area (VDA) ascent or descent task. **A *vertical danger area* is steep terrain that significantly restricts a unit's ability to maneuver, thereby putting the unit at significant tactical disadvantage should enemy contact be made while moving through the VDA**. As units integrate linear danger area crossings into a field training exercise or live-fire exercise, they can also integrate a VDA ascent or descent task into a squad training lane. Training employs a unit's level 2 mountaineers, refreshes level 1 tasks, and adds a level of realism and rigor to an otherwise normal squad situational training exercise lane.

## Continued Individual Training for Level 3 Mountaineers

2-40. Even the most accomplished mountaineers require periodic sustainment training. Most often, this can be accomplished by participating in level 2 training. However, new mountaineering techniques are regularly developed, so whenever possible, level 3 mountaineers should undergo specialty training that is focused on increasing unit capability IAW the commander's intent. Additional training in mountain rescue operations and avalanche forecasting may be particularly useful to units anticipating operations in more committing mountainous terrain. Opportunities exist for this at Army mountain training centers or through appropriately certified civilian mountaineering training organizations.

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## Chapter 3

# Environmental Injuries

Operations in mountainous areas will expose Soldiers to a variety of harsh environmental conditions not found in lowland areas. Soldiers exposed to these conditions are at a heightened risk of becoming a casualty. This risk increases with lack of experience and training. Troops conducting operations in mountainous regions often encounter cold temperatures that can degrade physical performance, impact morale, and create cold-weather casualties. The lack of oxygen in high-altitude environments impairs many aspects of normal Soldier tasks. Soldiers may develop altitude illnesses that can produce debilitating symptoms and require immediate MEDEVAC. If not accounted for in the planning process, these conditions will negatively impact the mission. Soldiers will become fatigued sooner in this environment and must reduce their pace or lighten their load to remain healthy and effective. With experience and proper training, Soldiers will become more durable and lethal in this environment.

## SECTION I – ENVIRONMENTAL INJURY PREVENTION

3-1. Units operating in mountainous regions are exposed to various types of injuries and illnesses unassociated with other areas. Medical considerations are like those for other environments; however, there are some unique aspects of mountain operations to consider to provide effective support.

## ILLNESSES AND INJURIES

3-2. Most injuries in the mountain environment are orthopedic and soft-tissue injuries. These include sprains, strains, abrasions, contusions, and fractures. Skills in basic first aid are essential to all Soldiers operating in the mountains and should be reinforced with regular sustainment training. (See TB MED 505 for more information.) Medical personnel should receive training in identifying and treating these prior to deployment.

## TREATMENT AND EVACUATION

3-3. In harsh mountain weather, the most important course of action is to provide injured Soldiers with medical aid as soon as possible. Immediate first aid is given on site. Due to rough terrain, medical units can seldom reach unit aid stations by vehicle to evacuate casualties. Litter bearers must move casualties to the rear where they can be evacuated by ground or air to clearing stations. The victim must be protected from the weather and shock during transportation. Rendezvous points are coordinated with medical units as far forward as possible. All litter bearers must receive training in evacuation techniques and first aid. Lightly wounded personnel may need assistance to move over rough terrain. (See chapter 15 for CASEVAC TTP in mountainous terrain.)

## INJURIES RELATED TO COLD EXPOSURE

3-4. There are several common injuries associated with cold temperature exposure. Some are more commonly associated with hot weather but present just as serious a threat in cold conditions.

### DEHYDRATION

3-5. Dehydration is the loss of bodily fluids that prevents or slows normal bodily functions. This is usually caused by overexertion and improper water intake. Although the mechanism that causes dehydration is not specifically cold temperatures, the environment and the body's natural response to the cold often lead to Soldiers becoming dehydrated. Dehydration precedes all cold-weather injuries and is a major symptom of acute mountain sickness (AMS). Dehydration contributes to poor performance in all physical activities, even more so than lack of food. Cold-weather requirements for water are no different from in the desert. In fact, they may exceed desert requirements because of the increased difficulty in moving with extra clothing and through the snow. At high altitudes, the air is dry. Combined with a rapid rate of breathing, as much as 2 liters

of liquid may be lost each day through respiration. A Soldier needs about 3 to 6 liters of water each day to prevent dehydration when living and performing physical labor in a cold or mountainous environment. Leaders should monitor their Soldiers' water intake, since motivation to drink cold water in a cold environment is low. Coffee and tea are diuretics and cause excessive urination, which contributes to dehydration. They should be avoided. However, providing other noncaffeinated hot liquids is a good way to encourage Soldiers to drink more water. The adequacy of liquid intake can best be judged by the color of urine and volume. Dark, amber-colored urine instead of light yellow or the absence of a need to urinate upon awakening from a night's sleep is an indicator of dehydration. Thirst is not a good indicator of hydration.

### Contributing Factors

3-6. Factors that contribute to dehydration in cold weather are—

- The thirst mechanism does not function properly in cold weather.
- Water is often inconvenient to obtain and purify.
- The air in cold climates and at high altitudes lacks moisture.
- Cold causes frequent urination.

### Symptoms

3-7. Symptoms of dehydration include darkening urine, decreased amounts of urine being produced, dry mouth, tiredness, mental sluggishness, lack of appetite, headache, fainting, rapid heartbeat, dizziness, higher temperature, upset stomach, and unconsciousness. The symptoms of dehydration resemble those of hypothermia. To distinguish between them, open the victim's clothes and feel the stomach. If the stomach is cold, the victim is probably hypothermic; if it is warm, the victim is probably dehydrated. However, this test is inconclusive since cold-weather dehydration can also lead to total body cooling. The cold environment may act as a diuretic and impair the body's ability to conserve fluids. Cold diuresis is an increase in urine output, which is the body's response to cold-weather immersion. This can contribute to dehydration, which is the precursor to several other cold-weather injuries, both freezing and non-freezing.

### Treatment

3-8. Prevent dehydration by consuming 3 to 6 liters of fluids each day (forced drinking in the absence of thirst is mandatory) and avoid caffeine and alcohol. Keep the victim warm and treat them for shock. In advanced cases, administer fluids by mouth if the victim is conscious. Ingesting snow will contribute to loss of body heat. Allow the victim to rest. If the victim fails to improve within 1 hour or is unconscious, evacuate to a medical facility immediately.

## HEAT INJURIES

3-9. Heat injuries, although associated with hot weather, can occur in cold-weather environments. Planning, periodically inspecting personnel clothing (ventilation) and equipment, balancing water and food intake, and resting can prevent most heat injuries.

### Heat Cramps

3-10. Heat cramps are muscle spasms that result from loss of large amounts of salt and water through exertion. Heat cramps are caused by an accumulation of lactic acid in the muscles and a loss of salt through perspiration.

#### *Contributing Factor*

3-11. Strenuous exertion causes the body to rise in temperature and to produce heavy perspiration.

#### *Symptoms*

3-12. Symptoms of heat cramps include pain and cramping in the arms, legs, back, and stomach. Victims sweat profusely and cannot quench their thirst.

***Treatment***

3-13. Have the victim rest in a cool, shady area, breathe deeply, and stretch the cramped muscle as soon as possible to obtain relief. Loosen the victim's clothing and provide cool water to drink. Monitor the victim's condition and seek medical attention if pain and cramps continue.

## Heat Exhaustion

3-14. Heat exhaustion is rapid water and salt depletion that can occur after exposure to high temperatures or intense exertion. It is often accompanied by dehydration. Heat exhaustion may occur when Soldiers exert themselves in any environment and overheat. The blood vessels in the skin become so dilated that they reduce blood flow to the brain and other organs.

***Contributing Factors***

3-15. Factors that contribute to heat exhaustion are strenuous activity in hot areas, troops that are not acclimated, inappropriate diet, and insufficient water or rest.

***Symptoms***

3-16. Symptoms of heat exhaustion may resemble fainting but may also include weakness, dizziness, confusion, headache, cold clammy skin, and nausea. The victim may also have a rapid but weak pulse.

***Treatment***

3-17. Move the victim to a cool, shady area and loosen clothing and boots. Have the victim drink water and, if possible, and if weather conditions are conducive, immerse the victim's body in water to aid in cooling. Elevate the victim's legs to help restore proper circulation. Monitor the victim's condition, and seek medical attention if symptoms persist. Without proper intervention, heat exhaustion can lead to heat stroke.

## Heat Stroke

3-18. Heat stroke occurs when the core body temperature exceeds 104°F, commonly a result of prolonged exposure to or physical exertion at higher temperatures. Heat stroke is a life-threatening situation caused by overexposure to the sun. The body is so depleted of liquids that its internal cooling mechanisms fail to function.

***Contributing Factors***

3-19. Factors that contribute to heat stroke are prolonged exposure to direct sunlight, overexertion, dehydration, and depletion of electrolytes.

***Symptoms***

3-20. Symptoms of heat stroke include hot, dry skin; dizziness; confusion and incoherency; headache; nausea; seizures; breathing difficulty; a slow pulse; and loss of consciousness.

***Treatment***

3-21. Cool the victim immediately and restore breathing and circulation. If the victim is conscious, administer water. If possible, and if weather conditions are conducive, submerge the victim in water to reduce temperature, treat for shock, and prepare for immediate evacuation.

## SOLAR INJURIES

3-22. Solar injuries can happen in warm or cold weather. These types of injuries can be just as incapacitating as most other injuries but usually are not fatal. Peak hours of ultraviolet (UV) radiation are between the hours of 10 a.m. and 3 p.m. Because of the long wavelengths of UV light, cloudy days can be more dangerous than sunny days. On sunny days, the Soldier takes more care due to the bright conditions. On cloudy days, the Soldier tends not to wear sunglasses or sunscreen.

## Sunburn

3-23. Excessive UV radiation from sunlight is a serious threat to military personnel operating in high mountain regions during daylight hours because of several factors increasing its damaging potential. UV exposure can cause significant short-term disability to military personnel through severe sunburn.

### *Contributing Factors*

3-24. Decreased UV filtering by the thinner atmosphere at high altitude causes an increased intensity of exposure (approximately 4 percent for every 1,000 feet of elevation increase) and a shift of the UV spectrum to more harmful short wavelengths. Reflection from snow and ice increases the intensity of exposure (approximately 75 percent of incident radiation is reflected). Soldiers vary greatly in their risk of sunburn based on their skin type and pigment.

### *Symptoms*

3-25. Symptoms of sunburn are painful, burning, red, or blistered skin with slight swelling. The skin may be warm to the touch. In severe cases, chills, fever, and headaches may occur.

### *Treatment*

3-26. Limiting skin exposure with clothes and sunscreen (sun protection factor 15 and above) will prevent most sunburns. Applying to skin areas that are normally shaded, such as the eyelids and under the chin, is necessary to reduce the likelihood of sunburn from light reflected off snow and rocks. Opaque agents, such as zinc oxide, red veterinary petrolatum, or titanium dioxide; can be used for high-risk body areas, such as the nose, lips, and tops of the ears. The agents should be used carefully in a tactical situation where they could make a Soldier more visible to opposing forces. Diagnosis, prevention, treatment, and prognosis of solar radiation injuries are the same as at low altitude. (See TB MED 505.)

## Snow Blindness

3-27. Snow blindness results when solar radiation “sunburns” the eyes. Snow blindness can occur in a few hours of exposure, and there is no sensation of abnormality other than brightness as a warning that eye damage is occurring.

3-28. Using eyewear or goggles that block more than 90 percent of UV radiation will help prevent snow blindness. To prevent injury from reflected light, protective eyewear should have side shields. Additionally, eyewear should have a safety cord or strap to prevent it from being lost accidentally. If sunglasses are not available, opaque eye covering (for example, tape-covered eyeglasses) with narrow, horizontal slits provide adequate field-expedient eye protection.

### *Symptoms*

3-29. Eyes may feel painful and gritty, and there may be tearing, blurred vision, severe light sensitivity, and headache. Symptoms are worst for 6 to 8 hours after exposure and resolve in 48 to 72 hours.

### *Treatment*

3-30. Treating snow blindness involves patching the eye and controlling the pain. Cool compresses over the eyes help alleviate some discomfort. Dilating the pupil and using ocular antibiotics are helpful. Pain control may require oral analgesics, sedatives, or both. The prognosis is generally good, although snow blindness may take several days to resolve. The pain and visual decrements will require temporary, but significant, duty limitations. In severe cases, permanent damage can occur.

## BLISTERS

3-31. Blisters often only cause minor discomfort but can become severe enough to restrict a person’s physical activity and mobility temporarily. In some cases, friction blisters have developed into serious complications and infections requiring antibiotics and medical treatment. As one of the most common injuries to the military mountaineer, blisters present a notable adverse impact to mobility and mission readiness.

### Contributing Factors

3-32. Rough and sloped terrain increases friction generated between the skin and footwear during foot movements, leading to a higher incidence of blister development.

### Symptoms

3-33. Blisters are raised, painful, fluid-filled protrusions.

### Treatment

3-34. Before a blister forms or when a Soldier first notices one, cover a hotspot with moleskin (over the area and beyond it). Use tincture benzoin to help the moleskin adhere to and toughen the skin. Once a blister has formed, cover it with a dressing large enough to fit over the blister, and then tape it. Never drain blisters unless they are surrounded by redness or if draining pus indicates infection. If this occurs, drain the blister from the side with a clean, sterile needle. After cleaning with soap and water, gently press out the fluid, leaving the skin intact. Make a doughnut of moleskin to go around the blister and apply to the skin. For toe blisters, wrap the entire toe with adhesive tape over the moleskin. (Toenails should be trimmed straight across the top, leaving a 90° angle on the sides. This provides an arch, so the corners do not irritate the skin.)

## Carbon Monoxide Poisoning

3-35. This is the replacement of oxygen in the blood with carbon monoxide, preventing adequate oxygenation of cells in the body.

### Contributing Factor

3-36. A contributing factor is inhaling fumes from burning fuel, such as fires, stoves, heaters, and running engines, without proper ventilation.

### Symptoms

3-37. Symptoms are like other common illnesses and include headaches, fatigue, excessive yawning, nausea, dizziness, drowsiness, confusion, and unconsciousness. Death may occur. Three visible symptoms are bright red lips, mouth, and inside of the eyelids.

### Treatment

3-38. Remove the victim from the source of contamination; administer oxygen, if available; and evacuate to a medical facility. Severe complications may develop even in casualties who appear to have recovered. If the victim is unconscious, administer rescue breathing and cardio-pulmonary resuscitation (CPR) as needed.

# COLD-WEATHER CONSIDERATIONS

3-39. Military mountain operations can occur in the coldest weather and with minimal logistical support, leaving troops under-equipped for hostile conditions. Individuals in these situations must rely on their prior training and strong leadership in cold stress management. This training can determine whether the mission will succeed or fail with either few or high casualty rates. Individuals in these situations often are not fully prepared, and, consequently, unit commanders and trainers must actively plan to prevent cold casualties. Soldiers need to be confident that they can master the environment by using preventive measures. Lessons learned from previous cold-weather deployments must be emphasized. Leaders must learn their unit's capabilities and manage cold exposure relative to the provided guidance. Soldiers must be prepared to survive, move, and fight in winter conditions. Intense cold affects the mind as well as the body. Simple tasks take longer to perform and take more effort than in a temperate climate. When weather conditions become extreme, the problems of survival become more significant. Warmth and comfort become top priorities. The effects of extreme cold and the probability of injury are magnified by a lack of proper diet and sleep. The most important measure in preventing cold-weather injuries is the education of personnel and their leaders.

## TYPES

3-40. Cold injuries may be divided into two types: freezing and non-freezing. The freezing type is known as frostbite. The nonfreezing type includes hypothermia, chilblain, and immersion foot. Cold injuries result from impaired circulation and from cold and ice forming upon the tissues of the body. Temperature alone is not a reliable guide as to whether a cold injury can occur. Low temperatures are necessary for cold injuries to occur, but freezing temperatures are not. Wind speed can accelerate body heat loss under both wet and cold conditions.

## PREVENTATIVE MEASURES

3-41. Commanders should ensure the following measures are taken to prevent cold-weather injuries:

- Soldiers' uniforms are kept as dry as possible and are protected from the elements.
- Soldiers are educated on proper use of clothing systems to avoid the effects of overheating and perspiration (layer dressing and ventilation).
- The buddy system is used to watch for early signs of cold-weather injuries.
- All Soldiers waterproof their equipment.
- The rate of movement should be slow, deliberate, and careful. Soldiers should not move out at a force march pace and then be stationary after they have perspired heavily. Soldiers should not wear excessive cold-weather clothing while moving.

## RISK FACTORS

3-42. Several demographic, behavioral, and past history characteristics increase risk for cold-weather injuries.

### Body Composition

3-43. Individuals with a high amount of body surface area relative to their body mass (long and lean) lose more body heat in the cold than individuals with a small surface area relative to their body weight (short and stocky) do. The reason for this is that the principal means of heat loss in the cold is at the skin surface. This effect is somewhat reduced in short, stocky people because a large body mass maintains a constant temperature better than a small body mass.

### Sex

3-44. The peripheral (for example, hands and feet) cold-injury rate for female Soldiers is two times higher than the rate for males. Sex differences during cold exposure are almost entirely attributable to women's generally greater body fat content and thicker fat layer under the skin compared to men of comparable age and weight. Women typically have a greater surface area but smaller total body mass (thus lower total body heat content) than men do.

### Race

3-45. African-American male and female Soldiers are two to four times more likely to suffer a cold-weather injury versus their Caucasian counterparts. This increased risk is consistent across all career management fields, which suggests that occupational exposure does not account for the differences between African-Americans and Caucasians. Differences between races may be due to cold-weather experience, but more likely they are due to anthropomorphic considerations (longer, thinner digits) and perhaps greater surface-area-to-mass ratio.

### Fitness and Training

3-46. Overall, physical training and fitness levels appear to have only minor influences on cold management. Fitter individuals can sustain more physical activity at a higher intensity and longer duration; therefore, they produce more heat from exercise for longer periods when compared to less fit individuals.

### Fatigue

3-47. Physical fatigue can impair shivering and peripheral vasoconstriction responses during cold exposure. Therefore, physical fatigue can increase the Soldier's risk for hypothermia. Fatigued Soldiers cannot sustain sufficient activity levels to maintain body temperature during severe cold exposure.

### Age

3-48. Soldiers who are 45 years of age or older may be less cold tolerant than younger people, either because of a decline in physical fitness or because of reduced vasoconstriction and heat conservation in comparison to their younger counterparts.

### Dehydration

3-49. Dehydration can increase susceptibility to cold injury by decreasing the ability to sustain physical activity (particularly if accompanied by heat stress from exercising in heavy clothing) and, therefore, decreasing the ability to sustain thermal balance. In addition, dehydration might impair cognitive function and cause Soldiers to use poor judgment. Dehydration has not been shown to reduce peripheral skin temperatures and does not impair shivering.

### Sustained Operations

3-50. Exertional fatigue, sleep restriction, and underfeeding are common stressors during sustained operations and together impair a Soldier's ability to maintain thermal balance in the cold. The metabolic heat production response degrades and impairs the ability to sustain exercise performance. Soldiers engaged in sustained operations also may make more judgment errors when tired and increase their exposure and risk of injury. A given cold stressor is more likely to induce cold injury after a long period of sustained operations compared to earlier in the operation. This emphasizes the need for planned rest, sleep, feeding, and recovery before conducting stressful operations in the cold.

### Food and Nutrient Consumption

3-51. Consuming too little nutrients can result in hypoglycemia (low blood sugar), which can impair shivering. Hypoglycemia contributes to an inability to sustain physical activity and the associated exercise-induced heat production during cold exposure. No food for 48 hours, even in the absence of hypoglycemia, results in an impaired ability to shiver and increased risk of hypothermia.

### Alcohol

3-52. Although alcohol may impart a sense of warmth, any peripheral vasodilation increases heat loss and the risk of hypothermia. Alcohol can cause hypoglycemia, which will decrease shivering responses and the ability to sustain physical work. In addition, alcohol blunts the senses and impairs judgment, so the Soldier may not feel the signs and symptoms of a developing cold injury. Soldiers must not consume alcohol while exposed to cold weather.

### Nicotine

3-53. Smoking or chewing tobacco can increase susceptibility to frostbite by increasing vasoconstriction in the periphery (for example, the hands). Heavy smokers (two to three packs per day) have a 30-percent higher incidence of peripheral cold injury, perhaps because nicotine reduces the body's response to the cold. Smoking and chewing will be discouraged during cold-weather operations.

### Previous Cold Injuries

3-54. If Soldiers have had previous cold injuries, they are at higher risk for subsequent cold injuries.

## Associated Injury

3-55. Injuries resulting in shock or blood loss reduce blood flow to extremities and may increase the injured individual's susceptibility to cold injury, which, in turn, can accelerate shock.

## COLD-WEATHER INJURIES

3-56. **A *cold-weather injury* is any preventable injury resulting from exposure to cold environmental conditions**. Some of the most common nonfreezing cold-weather injuries are described in paragraphs 3-57 through 3-75.

## Hypothermia

3-57. Hypothermia is the lowering of the body core temperature at a rate faster than the body can produce heat. Hypothermia may be caused by exposure or by sudden wetting of the body, such as falling into a lake or being sprayed with fuel or other liquid. Hypothermia can occur even on moderate days with temperatures of 40°F to 50°F with little precipitation if heat loss exceeds heat gain, and the Soldier's condition can deteriorate. Hypothermia is classified as mild (core temperature above 90°F or 32°Celsius [C]) or severe (core temperature below 90°F or 32°C). An individual is considered "clinically hypothermic" when their core temperature is less than or equal to 95°F.

3-58. Methods of heat loss:

- Radiation—direct heat loss from the body to its surrounding atmosphere is called radiation heat loss. The head can radiate up to 80 percent of the total body heat output. On cold days, personnel must keep all extremities covered to retain heat. Heat loss from extremities accounts for the largest amount of heat lost from the body.
- Conduction—direct transfer of heat from one object in contact with another (being rained on or sitting in snow).
- Convection—loss of heat due to moving air or water in contact with the skin. Wind chill is convection cooling. Clothing that ventilates, insulates, and protects must control the layer of warm air next to the skin.
- Evaporation—evaporation of perspiration causes heat loss. Wet clothing can cause heat loss by conduction and evaporation. Dressing in layers allows Soldiers to remove or add clothing as needed.
- Respiration—when cold air is inhaled, the air is warmed, then exhaled, resulting in a significant source of heat loss.

### *Contributing Factors*

3-59. Factors that contribute to hypothermia are—

- Dehydration.
- Poor nutrition.
- Diarrhea.
- Decreased physical activity.
- Accidental immersion in water.
- Change in weather.
- High winds.
- Inadequate types or amounts of clothing.

### *Symptoms*

3-60. Body temperature refers to the core (rectal) temperature. Symptoms become progressively worse as the body temperature drops.

- 96°F:
  - Shivering (begins about 2° below normal body temperature).
  - Uncontrollable shivering (about 96°F).
  - Inability to care for self.
  - Clumsiness (stumbling or falling).
  - Slow reactions.

  - Mental confusion.
  - Difficulty speaking.
- 95°F to 90°F:
  - Sluggish thinking.
  - Irrational thought.
  - Apathy.
  - False sense of warmth.
  - Cold skin.
  - Pale or bluish skin.
  - Inability to perform simple tasks.
  - Amnesia.
  - Hallucinations.
  - Decreased heart and respiratory rate.
  - Weak pulse.
  - Dilated pupils.
  - Slurred speech.
  - Visual disturbance.
- 90°F to 85°F. Shivering may stop. In addition, a Soldier may experience—
  - Irrationality.
  - Incoherence.
  - Loss of contact with the environment.
  - Muscular rigidity.
  - Disorientation.
  - Exhaustion.
- 85°F and below:
  - Muscle rigidity.
  - Unconsciousness.
  - Comatose state.
  - Faint vital signs.
  - Faint or impalpable pulse.
  - Breathing possibly too shallow to observe.

***Prevention***

3-61. Prevent hypothermia by using the buddy system to watch each other for symptoms and consume adequate amounts of liquids, rest, and eat properly.

***Avoidance***

3-62. Hypothermia can be avoided by dressing in layers, which permits easy additions or removal to prevent overheating, becoming too cold, or getting wet or windblown. If Soldiers are in a situation that precludes staying warm and dry, they should seek shelter. Eating sugary foods and physical activity helps to produce body heat.

***Treatment***

3-63. Treatment methods vary based on the severity of the hypothermia. Mild cases—if Soldiers show symptoms of hypothermia, prevent additional heat loss by getting them into a shelter, if available; removing wet clothing; and replacing it with dry, insulated clothing. If they are capable, feed Soldiers fast energy food and hot liquids and increase their physical activity level to generate heat. If they are unable to move, insulate them from the ground, and consider directing warm Soldiers to share a sleeping bag (cover head) with injured Soldiers to transfer body heat. This method of warming can compromise warmer Soldiers' core temperatures as well if they are not sufficiently fed, warm, and healthy. Make a diagnosis (for example, by obtaining a rectal temperature). Rehydrate the Soldier with warm liquids, sweets, and food. If the tactical situation allows, build a fire. Above all else, keep Soldiers conscious until their vital signs are normal, and seek medical assistance.

3-64. Severe cases—if the victim is unconscious or appears dead without any obvious injury, prevent further heat loss. Avoid rapidly rewarming an unconscious victim, which can create problems. Evacuating as soon as possible is preferable. At all times, the victim should be handled gently so as not to cause the cold blood from the extremities to rush to the heart. Immediately transport the victim to the nearest medical facility. Field reheating is not effective and may be hazardous. Provide artificial respiration if breathing stops. If no pulse is detectable, be aware that in hypothermia there is often effective circulation for the victim's hypothermic state. In such a case, cardiac compression (such as CPR) may be fatal. The exception is acute hypothermia with near drowning.

3-65. Use the following treatment methods based on the severity of the victim's hyperthermia:

- Breathing warm, moist air is the fastest way to warm the inside of the body. If breathing steam is not possible, place tubing under the rescuer's shirt so the victim will still breathe warm, moist air. This process can be done while on the move. In addition to breathing moist, warm air, the victim must be gradually rewarmed using external heat sources. Padded hot water bottles or heated stones should be placed in the armpits.
- If conscious, the victim can be given warm, sugary drinks.
- All bodily systems in hypothermia are brittle so treat the victim gently. While making these attempts, try to evacuate the victim. Severe complications may arise as the body temperature rises, which may result in cardiac arrest even though the victim seems to be doing well.

## Immersion or Trench Foot

3-66. The circulatory and nervous systems of the feet are damaged from prolonged exposure to cold and wet at above freezing temperatures. This can happen wearing boots or not. A Soldier may not feel symptoms until the injury has already begun.

### *Contributing Factors*

3-67. Factors that contribute to immersion or trench foot are—

- Stepping into water that comes over the boot tops.
- Not changing socks often enough.
- Improper hygiene.
- Prolonged exposure (3 to 5 days).

### *Symptoms*

3-68. Symptoms of immersion or trench foot include the sensation of tingling, numbness, and then pain. The toes are pale and feel cold and stiff. The skin is wet and soggy with the color turning from red to bright red, progressing to pale and mottled, and then grayish blue. As symptoms progress and damage appear, the skin becomes red and then bluish or black. Swelling may occur. Because the early stages of trench foot are not painful, Soldiers must be constantly aware to prevent it.

### *Treatment*

3-69. To prevent this condition, keep the feet dry and clean. Change socks often, drying the insides of boots, massaging the feet, and using foot powder. Drying the feet for 24 hours usually heals mild cases. Moderate cases usually heal within 3 to 5 days. The feet should be handled gently—not rubbed or massaged. They should be cleaned with soap and water, dried, elevated, and exposed to room temperature. Victims must stay off their feet and seek medical attention. Severe cases, when feet are not allowed to dry, are evacuated as a litter casualty.

## Chilblain

3-70. Chilblain (also known as pernio or kibe) is a superficial cold injury typically occurring after approximately 1 to 5 hours in cold-wet conditions, at temperatures below 50°F. A discolored rash or small red spots may appear on the skin, most often on the fingers but can commonly occur on the ears, face, and exposed skin. The lesions are swollen, tender, itchy, and painful. Upon rewarming, the skin becomes

inflamed, red, and hot to the touch, and swollen with an itching or burning sensation that may continue for several hours after exposure.

## Frostbite

3-71. Frostbite is the freezing or crystallization of living tissues due to heat being lost faster than it can be replaced by blood circulation or from direct exposure to extreme cold or high winds. Exposure time can be minutes or instantaneous. The extremities are usually the first to be affected. Damp hands and feet may freeze quickly since moisture conducts heat away from the body and destroys the insulating value of clothing. Heat loss is compounded with intense cold and inactivity. Frostbite can be prevented with properly maintained and used clothing and equipment. The extent of frostbite depends on temperature and duration of exposure. Frostbite is one of the major nonfatal cold-weather injuries encountered in military operations but does not occur above an ambient temperature of 32°F.

### *Categories of Frostbite*

3-72. Superficial (mild) frostbite involves only the skin. The layer immediately below usually appears white to grayish with the surface feeling hard, but the underlying tissue is soft. Deep (severe) frostbite extends beyond the first layer of skin and may include the bone. Discoloration continues from gray to black, and the texture becomes hard as the tissue freezes deeper. This condition requires immediate evacuation to a medical facility.

### *Contributing Factors*

3-73. Factors that contribute to frostbite are—

- Dehydration.
- Below-freezing temperatures.
- Skin contact with super cooled metals or liquids.
- Use of caffeine, tobacco, or alcohol.
- Neglect.

### *Symptoms*

3-74. Symptoms of frostbite vary and may include a cold feeling, pain, burning, numbness, and, in the final stages, a false sense of warmth. The skin first turns red, then pale. The skin may be bluish in color and then may appear frosty or waxy white. The skin may feel hard, be immovable over the joints and bony prominences, or be frozen. Identifying deep versus superficial frostbite is difficult to determine and often requires 3 to 7 days after rewarming for medical personnel to diagnose. Blisters, swelling, and pain may occur after thawing.

### *Treatment*

3-75. Using the buddy system is one of the primary ways to prevent frostbite. Buddies must watch each other for symptoms of frostbite and provide mutual aid if frostbite occurs. Frostbite should be identified early with prompt first aid care applied to prevent further damage:

- Treat early signs of frostbite by rewarming with skin-to-skin contact or by sheltering the body part under the clothing next to the body. Do this immediately. If tissues have frozen, evacuate the victim before they thaw. If the feet are involved, evacuate the victim as a litter patient.
- Thawing of a frostbitten victim is a hospital procedure. If the victim has frostbite with frozen extremities, protect the frozen parts and evacuate as a litter patient.
- If frostbite is not recognized before it thaws, do not let the area re-freeze since this causes more damage. The most often affected body parts are the hands, fingers, toes, feet, ears, chin, and nose. If evacuating victims as a litter case is not possible and the body part has not yet thawed, have the victims walk out on their own. Walking out on frozen feet is better than having them thaw and refreeze. Self-evacuation may be tactically necessary. Walking on frozen feet does less harm than walking on thawed feet.

- If reheating is inevitable, do not overheat the affected body parts near flame; the warming temperature should not be greater than normal body temperature. Do not rub the parts; the crystallized tissues may break internally and cause more damage. Do not pop blisters; cover them with a dry, sterile dressing. Keep the victim warm (apply loose, bulky bandages to separate toes and fingers).
- Once a part is rewarmed, it will become painful. Pain may be managed with narcotic analgesics.
- Once the foot is rewarmed, it will swell and putting the boot back on will not be possible.

## SECTION II – ALTITUDE EFFECTS, INJURIES, AND ACCLIMATIZATION

3-76. As altitude increases, the overall atmospheric pressure decreases. Decreased pressure is the underlying source of altitude illnesses. Whether at sea level or 20,000 feet, the surrounding atmosphere has the same percentage of oxygen. As pressure decreases, the body has a much more difficult time passing oxygen from the lungs to the red blood cells and thus to body tissues. This lower pressure means lower oxygen levels in the blood and increased carbon dioxide levels.

# ACCLIMATIZATION

3-77. When the unit arrives at an operation area, all personnel require a period of conditioning and acclimatization. The schedule should allow for longer and more frequent periods of rest. The rigors of establishing an assembly area exhaust most personnel who are not acclimated. Water, food, and rest should be considered priorities, ensuring enough while individual metabolisms and bodies become accustomed to functioning at higher elevations. Since the acclimatization process cannot be shortened, and the absence of acclimatization hampers the successful execution of operations, planning for deployments to higher elevations should consider the following:

- Above 8,000 feet, a unit should ascend at a rate of 1,000 to 2,000 feet per day. Units can leapfrog, taking extended rest periods.
- Units should not resort to using pharmaceutical pretreatment with carbonic anhydrase inhibitors, such as acetazolamide. These drugs have side effects that mimic the signs and symptoms of AMS. Inexperienced medics may have difficulty recognizing the differences between the side effects of the drug and a condition that could possibly be life threatening. Additionally, these drugs are diuretics, which results in higher hydration levels (at least 25-percent increase per Soldier per day). These higher hydration levels create a larger logistical demand on the unit by requiring more water, more time to acquire water, more water purification supplies, and, if in a winter environment, more fuels for melting snow and ice for water.
- Carbonic anhydrase inhibitors, such as acetazolamide, are effective in treating mild and severe AMS. These drugs should accompany attached medical personnel because they can treat the Soldier suffering from AMS and, although rest may be required, evacuation may not be needed.
- Do not move troops directly to high altitudes even if allowances can be made for inactivity for the first 3 to 5 days before mission commitment. Moving troops directly to high altitude can increase the probability of altitude sickness. Even if inactivity follows deployment, the incidence of altitude sickness is more likely than with a gradual ascent.

# ACUTE MOUNTAIN SICKNESS

3-78. AMS is the body's response to physical distress from difficulty adjusting to lower oxygen levels at high altitude. AMS is a temporary illness that can affect any Soldier, regardless of mountaineering experience. Soldiers are subject to this sickness at altitudes as low as 5,000 feet. Incidence and severity increase with altitude and when quickly transported to high altitudes. Disability and ineffectiveness can occur in 50 to 80 percent of the troops who are rapidly brought to altitudes above 10,000 feet. At lower altitudes, or where ascent to altitudes is gradual, most personnel can complete assignments with moderate effectiveness and little discomfort.

3-79. Personnel arriving at moderate elevations (5,000 to 8,000 feet) usually feel well for the first few hours; a feeling of exhilaration or well-being is typical. There may be an initial awareness of breathlessness upon exertion and a need for frequent pauses to rest. Irregular breathing can occur, mainly during sleep; these changes may cause apprehension. Severe symptoms—such as nausea, sluggishness, fatigue, headache,

dizziness, insomnia, depression, uncaring attitude, rapid and labored breathing, weakness, and loss of appetite—may begin 4 to 12 hours after arriving at higher altitudes.

3-80. A headache is the most noticeable symptom of AMS and may be severe. Even when a headache is not present, some loss of appetite and a decrease in tolerance for food occurs. Nausea, even without food intake, occurs and leads to less food intake. Vomiting may occur and contribute to dehydration. Despite fatigue, personnel are unable to sleep. The symptoms usually develop and peak by the second day. They gradually subside over the next several days so that the total course of AMS may extend from 5 to 7 days. In some instances, the headache may become incapacitating, and the Soldier should be evacuated to a lower elevation.

3-81. Treatment for AMS includes the following:

- Oral pain medications, such as ibuprofen or aspirin.
- Rest.
- Frequent consumption of liquids and light foods in small amounts.
- Movement to lower altitudes (at least 1,000 feet lower) to alleviate symptoms, which provides for a more gradual acclimatization.
- Realization of physical limitations and slow progression.
- Practice of deep-breathing exercises.
- Use of acetazolamide in the first 24 hours for mild to moderate cases.

3-82. AMS is nonfatal, although if left untreated or further ascent is attempted, development of high-altitude pulmonary edema (HAPE) or high-altitude cerebral edema (HACE) can be seen. Severe persistence of symptoms may identify Soldiers who acclimatize poorly and, thus, are more prone to other types of mountain sickness.

# HIGH-ALTITUDE PULMONARY EDEMA

3-83. HAPE is a swelling and filling of the lungs with fluid, caused by rapid ascent. HAPE occurs at high altitudes and limits the oxygen supply to the body. HAPE—

- Occurs under conditions of low-oxygen pressure, is encountered at high elevations (over 8,000 feet) and can occur in healthy Soldiers.
- Can cause death. Incidence and severity increase with altitude. Except for acclimatization to altitude, no known factors indicate resistance or immunity. Few cases have been reported after 10 days at high altitudes. For Soldiers who remain at the same altitude, the incidence of HAPE is less frequent than that of AMS. No common indicator dictates how a Soldier will react from one exposure to another.

## CONTRIBUTING FACTORS

3-84. The following factors are associated with the development of HAPE:

- A history of HAPE.
- A rapid or abrupt transition to high altitudes.
- Strenuous physical exertion.
- Exposure to cold.
- Anxiety.

## SYMPTOMS

3-85. The following symptoms are associated with the development of HAPE:

- Progressive dry coughing with frothy white or pink sputum (this is usually a later sign) and then coughing up blood.
- Cyanosis—a blue color to the face, hands, and feet.
- An increased ill feeling, labored breathing, dizziness, fainting, repeated clearing of the throat, and development of a cough.
- Respiratory difficulty, which may be sudden, accompanied by choking and rapid deterioration.
- Progressive shortness of breath, rapid heartbeat (pulse 120 to 160 beats per minute), and coughing (compared to others who arrived at the same time to that altitude).

- Crackling, cellophane-like noises (known as rales) in the lungs caused by fluid buildup. A stethoscope is usually needed to hear them.
- Unconsciousness, if left untreated. Bubbles form in the nose and mouth, and death results.

### PREVENTION

3-86. HAPE is prevented by good nutrition, hydration, and gradual ascent to altitude (no more than 1,000 to 2,000 feet per day to an area of sleep). A rest day, with no gain in altitude or heavy physical exertion, is planned for every 3,000 feet of altitude gained. If Soldiers develop symptoms despite precautions, immediate descent is mandatory to receive necessary treatment, rest, warmth, and oxygen. They should be quickly evacuated to lower altitudes. A descent of 300 meters may help; do not delay manual descent to await air evacuation. If untreated, HAPE may become irreversible and cause death. Cases that are recognized early and treated promptly may expect to recover with no aftereffects. Soldiers who have had previous attacks of HAPE are prone to second attacks.

### TREATMENT

3-87. Treat HAPE with—

- Immediate descent (2,000 to 3,000 feet minimum), if possible. If not, then treat it in a hyperbaric chamber.
- Rest (litter evacuation).
- Supplemental oxygen, if available.

## HIGH-ALTITUDE CEREBRAL EDEMA

3-88. HACE is the accumulation of fluid in the brain, which results in swelling and a decrease in brain function that may result in death. HACE is caused by a rapid ascent to altitude without progressive acclimatization. Preventing HACE is the same as for HAPE. HAPE and HACE may occur in experienced, well-acclimated mountaineers without warning or obvious predisposing conditions. Both types of edemas can be fatal. When the first symptoms occur, immediate descent is mandatory.

### CONTRIBUTING FACTORS

3-89. The following factors are associated with the development of HACE:

- Rapid ascent to heights over 8,000 feet.
- Aggravation by overexertion.

### SYMPTOMS

3-90. Symptoms include mild personality changes, paralysis, stupor, convulsions, coma, inability to concentrate, headaches, vomiting, decrease in urination, and lack of coordination. The main symptom of HACE is a severe headache. Another manifestation of HACE is a headache combined with any other physical or psychological disturbances. Headaches may be accompanied by a loss of coordination, confusion, hallucinations, and unconsciousness. These may be combined with symptoms of HAPE. Victims are often mistakenly left alone since others may think they are only irritable or temperamental; no one should ever be ignored. The symptoms may rapidly progress to death. Prompt descent to a lower altitude is vital.

### PREVENTION

3-91. HACE is prevented by good nutrition, hydration, and gradual ascent to altitude (no more than 1,000 to 2,000 feet per day to an area of sleep). A rest day, with no gain in altitude or heavy physical exertion, is planned for every 3,000 feet of altitude gained. If a Soldier develops symptoms despite precautions, immediate descent is mandatory to receive prompt treatment, rest, warmth, and oxygen. They should be quickly evacuated to lower altitudes. A descent of 300 meters may help; manual descent is not delayed awaiting air evacuation. If untreated, HACE may become irreversible and cause death. Cases that are recognized early and treated promptly may expect to recover with no aftereffects. Soldiers who have had previous attacks of HACE are prone to second attacks.

## TREATMENT

3-92. Treat HACE with—

- Supplemental oxygen.
- Rapid descent and medical attention.
- Use of a hyperbaric chamber if descent is delayed.

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## Chapter 4

# Mountain Subsistence and Sustainment

Units receiving mountain training show a marked advantage in harsh mountain environments than those that do not. Normal activities, such as navigating, communicating, and moving, require specialized techniques. To gain confidence and experience, Soldiers must conduct realistic mountain training. They should be expected to perform under any environmental conditions. Extended training exercises test the sustainment mechanisms in place for the unit and expose the Soldier to the isolation common to mountain operations. Training should reflect the harsh mountain environment and should focus on the following:

- Fitness and nutrition.
- Ability to survive and operate in a cold-weather environment.
- Resupply methods.
- Soldier load management.
- Bivouac considerations.

## SECTION I – PHYSICAL TRAITS OF THE MILITARY MOUNTAINEER

4-1. Operations in mountainous terrain are extremely taxing on the human body. The combined effects of harsh weather, difficult dismounted movements, and elevation require Soldiers to be in superior physical condition. The more adapted Soldiers are to the conditions in which they fight, the greater chance they have of success in executing their mission. To adapt to the mountain environment, Soldiers must train in similar environmental conditions and simulate the physical workload of operations in mountainous terrain. Simulating the stresses of mountain warfare on the Soldier's body in a training environment allows necessary adaptations to be made.

## PHYSICAL TRAINING FOR THE MOUNTAIN ENVIRONMENT

4-2. Physical fitness training considerations can be broken down into two categories:

- Fitness aspects, which are important to Soldiers' abilities to perform in mountainous terrain.
- Fitness training programs that should guide commanders in developing their unit's capability to perform effectively in mountainous terrain.

### INDIVIDUAL FITNESS CONSIDERATIONS

4-3. Operating in the mountains demands a higher level of fitness from the individual Soldier. Even basic movement techniques require a higher level of exertion and as the terrain becomes increasingly technical, so too does the physical demand. This; coupled with increased loads, adverse environmental conditions, and altitude effects; can render a Soldier with substandard fitness ineffective. The mountain Soldier must possess the capacity to reach the objective with the energy to fight while moving safely through hazardous terrain.

4-4. A Soldier must demonstrate proficiency in many facets of fitness to prepare for mountain operations. Soldiers must have a holistic approach to their workout programming and selection. They should not focus entirely on one aspect of fitness. Mountain Soldiers must train for their job with a level of dedication like that of professional athletes training to compete. There are many similarities between mountain Soldiers and athletes, but there are key differences as well. Athletes train to compete in a known sport, governed by rules. Mountain Soldiers may be faced with unknowns and have a less defined concept of how they will need to perform during mountain operations. These differences drive the well-rounded, holistic approach to fitness required for Soldiers who may fight in mountainous terrain.

### Aerobic Capacity

4-5. Aerobic capacity allows the mountain Soldier to move for long periods and helps determine potential capacity of endurance for long movements. Aerobic capacity refers to the Soldier's ability to use oxygen to create energy for extended periods. Dismounted movements and the carrying of a casualty in mountainous terrain are examples of tasks requiring endurance. Training in a low-intensity, high-volume manner conditions the aerobic energy system and develops the necessary levels of endurance. FM 7-22, table 6-2, covers training such as ability group runs, terrain runs, foot marches, and endurance training machines to help increase aerobic endurance for unit members.

### Anaerobic Capacity

4-6. Anaerobic capacity allows a Soldier to sprint or have high levels of exertion for a short period. Little oxygen is needed for this type of energy production. The anaerobic energy system can create large amounts of force for a short period. Mountain Soldiers require a high level of anaerobic capacity to move under fire and perform tasks that require a short burst of energy. Training in a high-intensity, low-volume manner conditions the anaerobic energy system and provides the necessary levels of explosive energy. FM 7-22, table 6-2, covers training such as 30:60s, hill repeats, and shuttle runs to help condition the anaerobic energy system of unit members.

### Resistance Training

4-7. Resistance training increases the performance of the muscle tissue found in Soldiers' bodies and increases bone density. Properly trained muscle tissue protects Soldiers' joints during mountain operations, leading to greater durability in this harsh environment. Resistance training can affect the body in different ways. Mountain Soldiers must use resistance training correctly. Soldiers who operate in mountainous terrain should avoid excess bulking of their muscle tissue as this decreases their endurance capabilities. Soldiers do not need large muscles to have strength; adequate strength can be developed using resistance training to gain lean muscle mass. Strength is primarily a function of the brain's connection to the muscles (neuromuscular pathways), not the size of the muscles. Soldiers should use resistance training to increase the function and durability of the body, not aesthetics. This training should be designed to increase muscular endurance, lean muscle mass, and strength. A master fitness trainer can design training programs to help individual Soldiers and commanders achieve their desired results. FM 7-22, table 6-2, covers training, such as the climbing drill, push-up and sit-up drill, and the strength and conditioning circuit, to guide Soldiers through types of resistance training.

## UNIT FITNESS CONSIDERATIONS

4-8. The commander should develop a conditioning or training program to bring a unit to a level where it can operate successfully in mountain conditions. Training priorities should be established. As with all military operations, training is a major influence on the success of mountain operations. Fitness is the foundation upon which all other mountain skills are built. Proper levels of fitness increase the lethality and durability of Soldiers operating in mountainous terrain.

4-9. A physical training program for operations in mountainous terrain should not be taken lightly. This type of program is time-consuming and requires buy-in from all levels of the deploying unit's chain of command. Exercise equipment that allows for proper training should be obtained. Prior to conducting this training, Soldiers should assess their fitness levels. This assessment is an important tool for commanders and master fitness trainers to understand what is needed in the exercise program. Once an exercise program is generated, a unit may begin to train. The program should focus on increasing Soldiers' physical abilities to perform their job in a tactical and mountainous environment.

4-10. U.S. forces do not routinely train in mountainous terrain. Therefore, extensive preparations are needed to ensure individual and unit effectiveness. Units should be conditioned physically and psychologically before undertaking rigorous mountain operations. Units must work well as a team to cope with the terrain, environment, and enemy situation. Certain factors should be considered:

- What are the climatic and terrain conditions of the area of operations?
- How much time is available for conditioning and training?

- What additional personnel will accompany the unit? Will they be available for training and conditioning?
- What is the unit's current level of physical fitness?
- Does the unit have master fitness trainers creating exercise programs specific to the mountain environment?
- Is there an exercise facility that will allow Soldiers to physically train themselves using the master fitness trainer's program?
- What is the level of individual expertise in mountaineering?
- What type of operations can be expected?
- Which areas in the United States most closely resemble the area of operations?
- Are predeployment areas and ranges available?
- Does the unit have trainers with experience in mountain warfare?

4-11. Physical capability is not solely gained during 1 hour per day in the gym. The participating Soldier must have the discipline to adhere to proper nutrition planning and get adequate rest. To maximize recovery during this period, Soldiers should sleep 8 to 9 hours during a 24-hour period to minimize the chance of injury and increase performance gains.

# NUTRITION FOR THE MOUNTAIN ENVIRONMENT

4-12. The food Soldiers eat directly correlates to the energy levels they expend, including their ability to recover from strenuous activity as well as many other factors. An understanding of how different types of nutrients affect the body will help the Soldier eat better. Soldiers participating in an intense physical training program should not diminish their gains from the training with poor nutrition. When physical training and proper nutrition are combined, Soldiers have more success in achieving and sustaining the fitness required for operations in mountainous terrain.

## HYDRATION IN THE MOUNTAIN ENVIRONMENT

4-13. Water is vital to the health and performance of the mountain Soldier. Dehydration decreases cognitive and physical performance. Soldiers commonly face conditions, such as cold weather and high elevations, in mountainous terrain. Both elements affect the body's ability to stay properly hydrated. A cold climate decreases the sensation of thirst and causes cold-weather diuresis (excessive urination). These both decrease fluid levels in the body and can lead to a performance-limiting state of dehydration. High elevation combined with cold temperatures can further dehydrate a Soldier. Less oxygen leads to an increased respiration rate. While breathing, Soldiers exhale water vapor. Rapidly breathing dry air decreases fluid in the body.

4-14. Soldiers and leaders should ensure the availability and consumption of fluids. Hydrating before, during, and after periods of exertion allows for adequate levels of performance and acclimatization. Other factors necessary for maintaining fluid balance in the body include consuming appropriate levels of sodium, electrolytes, and other necessary nutrients. Bananas and other fruits are great examples of electrolyte rich snacks.

## MACRONUTRIENTS

4-15. Nutrients are compounds in foods essential to life that provide the body with energy and building blocks for repair and growth. Nutrients required in large amounts are called macronutrients. Proteins, fats, and carbohydrates are the three types of macronutrients that must be consumed in certain proportions to maintain a healthy body. These important nutrients allow the human body to perform and acclimate in mountainous environments.

### Proteins

4-16. Protein is a macronutrient responsible for maintaining and restoring muscles, providing key enzymes, and strengthening immunity. Protein also helps preserve lean muscle mass and increase strength and endurance. Protein serves many functions that support physical activity. Protein repairs muscle after exertion and creates energy during prolonged periods of submaximal exertion. The recommended requirement is 0.8 grams of protein for every 2.2 pounds of body weight, but this can fluctuate with activity levels. Protein requires water for digestion and may facilitate dehydration. Proteins provide the body with about 4 calories of energy per gram.

### Fats

4-17. Fats are critical to physical performance, recovery from exercise, and cardiovascular health. Fats are the body's natural and most concentrated source of stored food energy. Main sources of fats are meats, nuts, butter, eggs, milk, and cheese. Fats should comprise 25 to 30 percent of the total daily caloric intake. Fats require more water and oxygen to digest than protein. Fats provide the body with approximately 9 calories of energy per gram. Fat is the most energy dense of the three macronutrients. It is harder for the body to use fat in an efficient manner to produce energy during periods of exertion. Fats are harder to digest at higher altitudes.

### Carbohydrates

4-18. Carbohydrates are the chief energy source for high-intensity physical activity, and they are important for meeting overall energy needs. Carbohydrates are an important source of calories and provide the body with dietary fiber and a variety of micronutrients. Nutritionally, the most useful sources of carbohydrates are foods, such as unrefined grains, vegetables, and fruit. Carbohydrates should comprise up to 50 percent of the total daily caloric intake. Carbohydrates provide the body with around 4 calories of energy per gram.

## BALANCED DIET

4-19. Eating a balanced diet provides the energy needed to conduct daily activities and to maintain internal body processes. A balanced diet containing adequate amounts of macronutrients, vitamins, and minerals ensures an efficient metabolism. Since operations in mountainous terrain are strenuous and demand high-energy use, a balanced diet is necessary. A proper diet requires Soldiers to be aware of how many calories they must consume. Soldiers of different ages, weights, and sexes have different nutritional needs. Caloric requirements differ between Soldiers, especially when accounting for levels of activity.

4-20. Mountain Soldiers should take the time to understand their own caloric requirements. (See figure 4-1.) Individual variables coupled with a variety of environmental conditions, cold weather, or altitudes make it difficult to generalize a Soldier's daily requirement, and it could range from 4,500 to 6,000 calories a day.

4-21. Vitamins allow chemical reactions in the body to happen so that they may use the energy found in the three macronutrients. Without these reactions, the energy from the calories in the macronutrients cannot be turned into adenosine triphosphate that the cells in our body use for energy, allowing them to function. Vitamins and minerals are found in vegetables, fruits, and meats. There are many different micronutrients, and it can become hard to track ingestion of all types. Physically active Soldiers should pay special attention to consume adequate amounts of iron, vitamin D, and antioxidants through a balanced diet. If a diet deficient in fresh foods containing essential vitamins and minerals is not available during a deployment, vitamin supplements are a suitable substitute.

**Resting Energy Expenditure (Calories Used at Rest)**

- Each Soldier's resting energy expenditure is different.
- It is important to know one's resting energy expenditure to know how many calories to consume.
- Resting energy expenditures can be multiplied by activity factors to get total caloric requirements for different levels of exertion. This is important to know to ensure Soldiers get proper nourishment while operating in challenging terrain. (See the Special Operations Forces Nutrition Guide, pages 4 to 5, for detailed information on performing these calculations.)

**Figure 4-1. Individual caloric requirements**

4-22. Extra food should be carried in case resupply operations fail. Food should be lightweight, easy to digest, and be able to be eaten hot or cold. Meals, ready to eat meet these criteria and provide the basic food groups.

Commanders may consider supplementing meals, ready to eat with breakfast bars, fruits, juices, candies, cereal bars, and chocolate. Bouillon cubes can replace the required salt intake, and it can warm cold bodies and stimulate the appetite. Hot beverages of soup, juices, powdered milk, and cider should also be considered. Since coffee, tea, and hot chocolate are diuretics, consuming these beverages should not be relied upon for hydration (see AR 40-25).

4-23. Calories from carbohydrates, protein, and fat digest, absorb, and metabolize at different rates in our body. The timing of nutrient intake will affect the individual's physical, behavioral, and cognitive well-being. High-energy snacks help maintain performance during long movements. Soldiers should also consume a high-carbohydrate snack to replenish energy stores and maximize recovery immediately following foot movements or hard physical work.

4-24. Certain drugs, medications, alcohol, and smoking have adverse effects on the circulation, perspiration, hydration, and judgment of Soldiers. They should be avoided, if possible, when operating in extremely cold conditions or at high altitudes.

### NUTRITION OF ELEVATION

4-25. Success in mountain operations depends on proper nutrition. Because higher altitudes affect eating habits, precautions must be taken. If possible, at least one hot meal each day should be eaten, which may require personnel to heat their individual rations. (See USARIEM TN-01/4 for more information on nutrition.)

4-26. Soldiers can experience physiological acclimatization with abrupt ascents to high altitudes. The circulatory system works to provide the needed oxygen to the body. Large meals require the digestive system to work harder than usual to digest food. Large meals may be accompanied by indigestion, shortness of breath, cramps, and illness. Therefore, relatively light meals that are high in carbohydrates are best while acclimatizing at higher elevations. Personnel should eat moderately and rest before strenuous physical activity. Since fats and protein are harder to digest, less digestive disturbances may occur if meals are eaten before resting. A diet high in carbohydrates is not as dense in energy and may require eating more often. Consuming carbohydrates, beginning in the morning and continuing through mid-afternoon, are important in maintaining energy levels.

## ACCLIMATIZATION

4-27. The following elements are characteristic of nutritional acclimatization in mountain operations:

- Weight loss during the first 2 to 3 days at high elevation.
- Loss of appetite with symptoms of AMS.
- Loss of weight usually stops with acclimatization.
- At progressively higher elevations (greater than 14,000 feet), the tolerance of fatty or high-protein foods rapidly decreases. A high-carbohydrate diet may lessen the symptoms of AMS and may digest better than fat at high altitudes. (See USARIEM TN-01/4.)

## FATIGUE

4-28. Increased fatigue can cause Soldiers to become disinterested in eating properly. Decreased consumption can result in malnutrition because of the unpleasant taste of cold rations. Leaders should ensure that fuel tablets and squad stoves are available or that natural flammable materials are used, if possible. Although there is no physiological need for food to be hot, hot food does increase morale and a sense of well-being. Losing weight in the first few days can occur because of dehydration, metabolic changes, and loss of appetite. Carbohydrate-rich beverages, such as fruit juices and sports drinks, increase carbohydrates, energy, and liquid intake when the normal appetite response is blunted at altitude.

# SECTION II – COLD-WEATHER SUSTAINMENT

4-29. The ability to operate for extended periods in cold weather is an essential skill if a unit wishes to be successful in mountainous terrain. Individual skills and collective unit skills required for cold weather must be practiced before deploying to a cold region of the world. The skills required for survival in the cold must be known so they do not become the sole focus once the unit is faced with harsh conditions. For a unit to

accomplish its mission in cold, unforgiving weather, it must have the equipment necessary to live and operate in extreme conditions. Cold weather can affect many facets of daily life, from nutrition to clothing.

# CLOTHING

4-30. The clothing system refers to every piece of clothing placed against the skin (base layer), the insulating layers, and the outermost garments (shell), which protect the Soldier from the elements. When clothing is worn properly, the Soldier can function better; when clothing is worn improperly, Soldiers can develop hypothermia or frostbite. Wearing cold-weather clothing provides a barrier against weather and heat retention, moves moisture away from skin, dries quickly, and allows for adequate dexterity.

4-31. Clothing for the cold-weather environment must manage Soldiers' temperatures and control moisture. Clothing must be able to vent and breathe so a Soldier does not become overheated and perspire excessively. The clothing must also create insulation to shelter the Soldier from extreme temperatures. Clothing must manage moisture that comes from external sources, such as rain, or from internal sources, such as perspiration.

4-32. One of the most effective ways to manage moisture from perspiration is to set a pace that limits exertion. In a cold-weather environment, patrols should move at a pace that will not saturate Soldiers' insulating layers with sweat. Rest halts allow Soldiers an opportunity to adjust layers and control their own individual temperatures.

4-33. Fitness, load, body composition, and metabolism all affect individual clothing needs. There should be room for individual variation in the wear of cold-weather clothing, but clothing decisions should be based on the principles of moisture management, trapped air spaces, and protection from the elements. The components of any clothing system can be broken down into the following general categories to match those principles.

## BASE LAYER

4-34. The base layer is a thin, lightweight moisture-wicking layer worn against skin and moves moisture away from the skin to prevent heat loss from conduction. Base layers should be constructed of wool, synthetic, or silk fabrics.

## INSULATING LAYERS

4-35. Insulating layers are those layers worn over the base layer and under the shell. Insulating layers provide additional warmth by resisting the transfer of heat. Modern insulating layers allow moisture to move easily, and they trap air to increase the insulating factor. Several thin layers of insulation provide more warmth than one thick layer. Insulating layers should be constructed from wool, synthetic, or down fabrics. Insulating layers help Soldiers retain heat and not lose heat through convection.

## SHELL

4-36. The shell is the outermost layer worn. The shell is the primary barrier between the elements and the body and prevents outside moisture from getting in, while allowing inside moisture out. Shells must have some ventilation capacity to prevent overheating. There are two types of shells.

4-37. A hard shell is generally more moisture and wind repellant and provides better protection against the elements at the cost of breathability. Soldiers cannot ventilate their bodies as well with a hard shell. The hard shell is a good outer layer to be worn in extreme conditions or static environments.

4-38. A soft shell is a more breathable option. The soft shell is not as moisture and wind repellent as hard shells but is more breathable. The soft shell is a good outer layer to be worn when active as it provides better ventilation and breathability.

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***Note***. Cotton layers should NEVER BE WORN as any layer during operations in a cold environment.

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## GAITERS

4-39. Gaiters protect the lower leg from snow, ice, mud, twigs, and stones. Using waterproof fabrics or other breathable materials laminated to nylon makes the gaiter an integral component of the cold-weather clothing

system. Gaiters are not presently fielded in the standard extended cold-weather clothing system and, in most cases, will need to be locally purchased. Gaiters are available in four styles:

- Trail gaiters are short, typically extending just above the boot. They keep snow and debris out of boots in the spring and summer.
- Alpine gaiters extend up to the knee and keep deep snow out of boots in the winter.
- Expedition gaiters are thicker, designed to fit around a larger plastic mountaineering boot, and sometimes have added built-in insulation.
- The integrated gaiter is a boot with a built-in gaiter, eliminating the need for a second piece of equipment.

## HAND WEAR

4-40. Even during the summer months, temperatures in the mountains can dip below the freezing point. While mittens are warmer than gloves, the finger dexterity needed to do most tasks makes gloves the primary cold-weather hand wear.

4-41. The principles that apply to clothing also apply to gloves and mittens. A modular approach should be taken when wearing hand wear. (See figure 4-2, page 48.) They should provide moisture transfer from the skin to the outer layers—the insulating layer must insulate the hand from the cold and move moisture to the shell. The outer layer must be weather resistant and breathable. Both gloves and mittens should be required for all Soldiers during mountain operations, as well as replacement liners for both. This will provide enough flexibility to accomplish all tasks and keep the users' hands warm and dry.

4-42. Just as the clothing system is worn in layers, gloves and mittens work best using the same principle. Soldiers should have multiple sets of hand wear. They should have multiple thin liner gloves, intermediate climbing gloves, thicker gloves for working with carabiners in the extreme cold, trigger-finger mittens for using their personal weapon in the extreme cold, and thick mittens to protect their hands in the extreme cold. When outer layer gloves are removed, they can be placed in the jacket to keep warm.

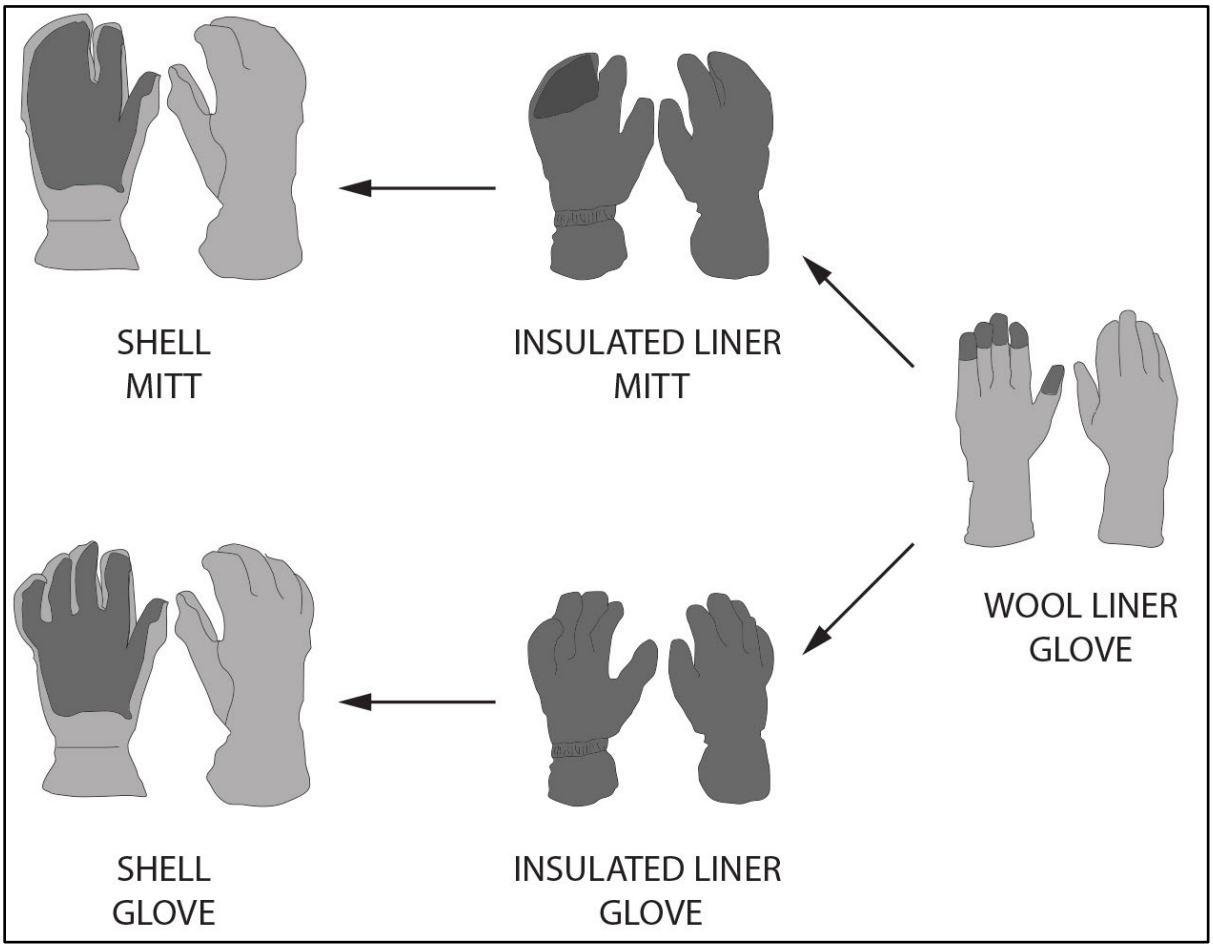



**Figure 4-2. Modular cold-weather glove system**

## HEADWEAR

4-43. Headwear in mountainous environments should take a modular approach as well. A single hat does not perform well in every condition; several hats should be available to mountaineers: a thin moisture-wicking hat to wear under the helmet or during active movements; an intermediate fleece cap for protection in cold, dry environments; and a heavy thick cap for extreme cold. For colder climates, a neck gaiter can be added. The neck gaiter is a tube of synthetic material that fits around the neck and can reach up over the ears and nose. For extreme cold, a balaclava can be added. This covers the head, neck, and face, leaving only a slot for the eyes. Worn together, the combination is warm and provides for moisture movement, keeping the wearer drier and warmer.

## FOOTWEAR

4-44. Soldiers may encounter various environmental conditions within relatively short distances in mountainous, plateau, and other highland areas. (See CTA 50-900.) In such places, clothing allowances that are adequate for adjacent lower areas may not provide sufficient protection for diverse highland areas; therefore, in these higher or more rugged areas, commanders may authorize, at their discretion, additional clothing items and special mountaineering equipment, as required.

4-45. Mountain climates are colder than surrounding areas. Even in summer months, it may be necessary to equip troops with cold-weather boots. The intermediate cold-weather boot provides adequate protection for summer conditions in most mountain ranges with high elevation (2,500 to 4,000 meters) located in temperate

regions. It can be appropriate footwear for Soldiers whose mission only requires mobility in easy terrain. (See figure 4-3, page 50.)

4-46. Leather mountaineering boots are designed to provide more capability in mountainous terrain. They are typically warmer and more water resistant than combat boots are. Rigid leather mountaineering boots provide better edging while climbing alpine rock. They also perform better when kicking steps in firm snow or wearing crampons. In general, a leather mountaineering boot with moderately stiff soles and upper section works well for most military mountaineering tasks. Although they are not available through the supply system, they can be a commercial, off-the-shelf purchase. (See figure 4-3, page 50.)

4-47. During the winter months, most mountain ranges experience periods of extreme cold (–26°F to – 40°F). The extreme cold-weather boot (with vapor barrier [VB]) provides adequate protection from the extreme cold, but it is not an adequate platform for mountaineering tasks in these conditions. Plastic mountaineering boots provide a more versatile platform for any condition encountered in the mountains, while keeping the foot dryer and warmer. Plastic mountaineering boots are a double boot, consisting of a hard, plastic shell, and an inner insulating boot. The stiffness of the shell makes it compatible with crampons, snowshoes, and skis. The hard, plastic shell provides waterproofing, while the inner liner remains free of snowmelt, making it an ideal boot in wet conditions. Plastic mountaineering boots are the optimal footwear for extended operations in cold mountainous environments. (See figure 4-3, page 50.)

***Note***. Maintenance of all types of footwear must closely follow the manufacturers' recommendations.

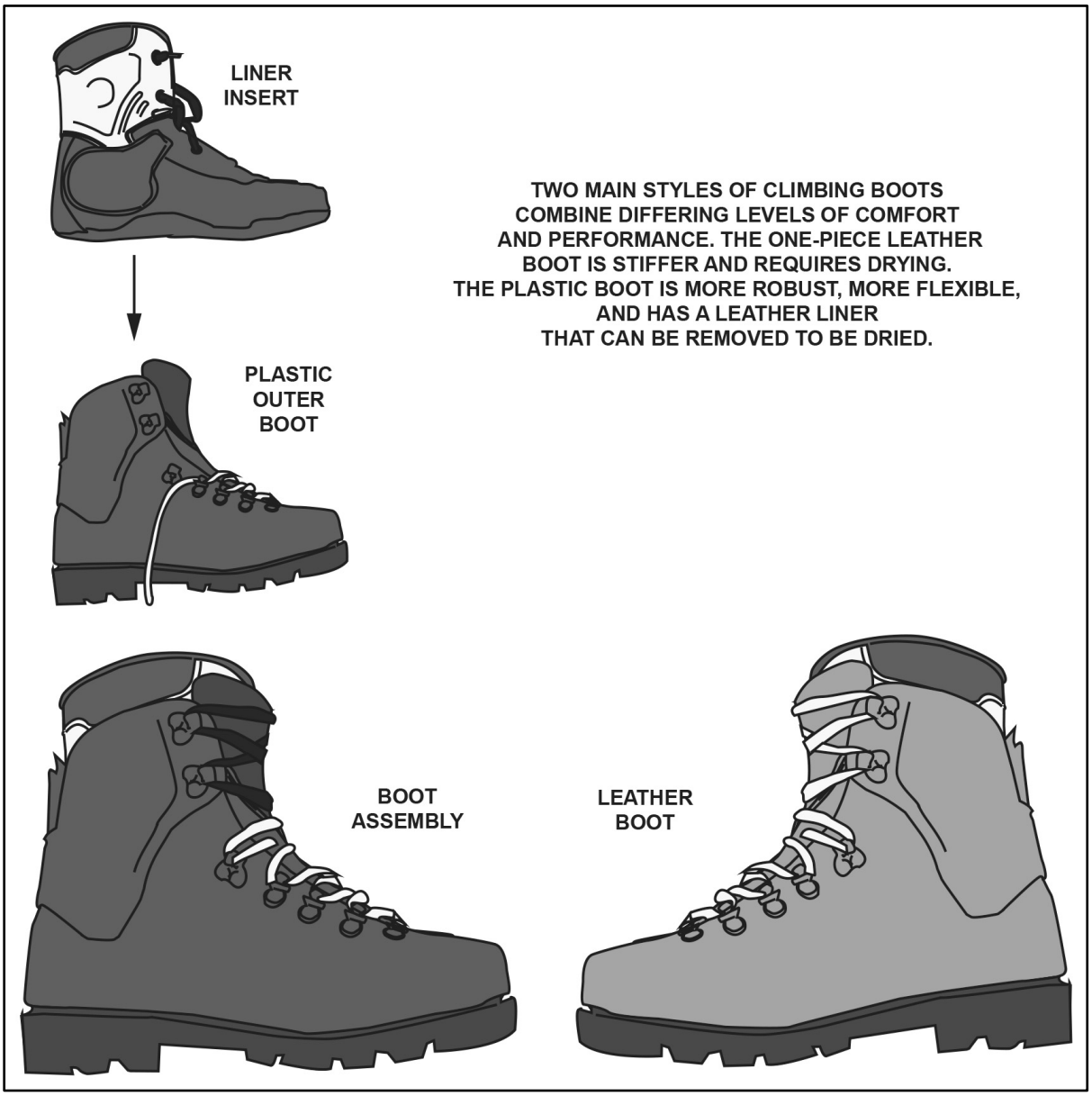



**Figure 4-3. Mountaineering boots**

## SOCKS

4-48. Socks cushion the foot, remove excess moisture, and insulate from cold temperatures. Improper wear and excess moisture can cause hot spots and blisters. Socks can be worn as a layered system:

- The first layer should be a moisture-wicking material that moves moisture from the foot surface to the outer sock.
- The outer sock should also be made of moisture-wicking materials but should be complemented with materials that provide cushioning and abrasion resistance.
- A third layer can be added depending upon the climatic conditions:
  - In severe wet conditions, a waterproof-type sock can be added to reduce the amount of water that would saturate the foot. This layer would be worn over the first two layers if conditions were extremely wet.

- In extremely cold conditions, a VB sock can be worn either over both original pairs of socks or between the moisture-wicking layer and the insulating layer. If the user is wearing VB boots, the VB sock is not recommended.

## EXTENDED COLD-WEATHER CLOTHING SYSTEM

4-49. The extended cold-weather clothing system is the currently issued cold-weather clothing system. (See figure 4-4.)

- Level 1: Base layer—a crewneck shirt constructed with a lightweight material that is highly breathable and has moisture-wicking properties. Kit includes two sets.
- Level 2: Grid fleece (waffle)—a midweight long-sleeve shirt and elastic waistband drawers constructed with a heavyweight material, which offers stretch for increased comfort during movement, is highly breathable, and has moisture-wicking properties. Kit includes one set.
- Level 3: Fleece jacket—a zipper jacket with raglan sleeves constructed with a material that creates air pockets that trap air and retain body heat, providing outstanding warmth without weight. This material also offers excellent breathability and the ability to dry quickly. However, this layer is not recommended as an outer garment for use during inclement or windy weather. Kit includes one piece.
- Level 4: Wind jacket—a nylon or spandex jacket. It offers wind protection and environmental comfort with low weight and bulk and is quick drying. Kit includes one piece.
- Level 5: Soft-shell jacket and trousers—constructed with a waterproof fabric, is quick drying, highly durable, and breathable. Kit includes one piece.
- Level 6: Wet weather jacket and trousers—constructed with a two-layer waterproof and windproof fabric with sealed seams and is extremely breathable. Kit includes one piece.
- Level 7: Extended cold-weather parka and trousers—three-layer construction that is fabricated with an outer layer, an insulation layer, and an inside layer of lightweight rip-stop material. They are water resistant, highly durable, and breathable. Kit includes one piece.




**Figure 4-4. Extended cold-weather clothing system**

## SECTION III – SMALL GROUP MOUNTAIN SUSTAINMENT AND SUBSISTENCE

4-50. There is no one standardized way to plan for sustainment in mountain operations. Each mission has its own set of complications. Layers of contingencies should be built into the plan for sustainment. If one method fails due to any number of unforeseen circumstances, another method of sustainment must be ready to provide Soldiers with what they need. Gear that Soldiers carry must not be so heavy it makes them vulnerable.

Methods to procure water must be available. Detailed coordination must be made with air assets to provide aerial resupply.

# SOLDIER LOAD MANAGEMENT

4-51. Operations in mountainous terrain require Soldiers to carry only mission-essential items as they move through challenging terrain. Individual Soldiers, small teams, and large units must be able to adjust their equipment. They must understand the fundamentals of cross-leveling essential equipment to avoid excess gear. Understanding and practicing these simple, yet often overlooked, skills can make a unit lighter, faster, and more lethal in mountainous terrain. No amount of training can change the body's reaction to carrying excessive loads. Analyzing the situation and the level of risk are the keys to determining what is mission essential. All leaders should familiarize themselves with ATP 3-21.18, where they can access table 3-4, which is a helpful guide for leaders when planning loads for dismounted movements. (See chapter 6 for detailed information on load management to maximize mobility.)

## CHOICE OF EQUIPMENT

4-52. Mission requirements and unit standard operating procedures (SOPs) will influence the choice of gear carried, but the following lists provide a sample of what should be considered during mission planning.

### Personal Gear

4-53. Personal gear includes an emergency survival kit with signaling material, fire-starting material, and water procurement material. Pocket items should include a knife, whistle, pressure bandage, notebook with pen or pencil, sunglasses, sunblock and lip protection, map, compass, and altimeter.

### Standard Gear

4-54. Standard gear that can be individually worn or carried includes cushion-soled socks; combat or mountain boots, combat uniform and cap; load-carrying equipment with canteens, magazine pouches, and first aid kit; individual weapon; a large rucksack containing hard-shell top and bottom; insulating layers; helmet; poncho; and sleeping bag.

### Mountaineering Equipment and Specialized Gear

4-55. The element's leadership should scrutinize mountaineering equipment. The equipment should allow Soldiers to move safely through any known technical terrain. Identifying hazards and obstacles during the planning phase is a crucial step to help determine the appropriate gear for the given mission. Required mountaineering equipment is never set in stone, and each patrol or mission may require different equipment.

### Daypack

4-56. When Soldiers plan to be away from the bivouac site for the day on a patrol or mountaineering mission, they carry a light daypack. This pack should contain—

- Extra insulating layer.
- Hard-shell layer, such as a waterproof jacket and pants or poncho.
- First aid kit.
- Flashlight or headlamp.
- Canteen or water bottle.
- Cold-weather hat or scarf.
- Rations for the time away from the base camp.
- Survival kit.
- Improvised harness materials or climbing harness.
- Necessary mountaineering equipment for technical terrain.
- Gloves.

## TEN ESSENTIALS

4-57. Regardless of what equipment is carried, the individual military mountaineer should always carry 10 essentials when moving through the mountains.

### Navigational Tools

4-58. Knowledge of the terrain and a well-developed route plan are the two most important tools for avoiding issues in the mountains. A map should be carried along with appropriate navigational aids like a compass, altimeter, and Global Positioning System (GPS) device.

### Headlamp and Night Vision Devices

4-59. Night vision devices are powerful tools for target identification and discrimination and are critical tools in the mountains. However, their narrow focal plane at close ranges is minimally helpful when scrambling in rough terrain. Light enables faster and safer movement and scrambling. Preventing enemy observation should always be a primary concern, but for maneuver in terrain that is masked from observation where risk of a fall is a greater threat, a light is valuable. Headlamps are also important for camp tasks, planning, and map work.

### Sunglasses and Sunscreen

4-60. In alpine or snow-covered terrain, sunglasses are vital for preventing snow blindness. Side shields, which minimize light entering from the side, permit ventilation to help prevent lenses from fogging. Each independent climbing team should carry at least one extra pair of sunglasses.

### Extra Clothing

4-61. Clothing is the primary protection from the environment and needs to match the conditions and the pace of a movement. Extra clothing includes the additional layers needed for static operations or enduring the long, inactive hours of an unplanned bivouac, such as the following:

- Waterproof, breathable shells to protect from unexpected wind or precipitation.
- Extra underwear to replace sweat-soaked underwear.
- Extra hats or balaclavas.
- Extra pair of heavy socks.
- Extra pair of insulated mittens or gloves.
- Extra insulation for the upper body and the legs (winter or severe mountain conditions).

4-62. To back up foul weather gear, bring a poncho or extra-large plastic trash bag. A reflective emergency space blanket can be used for hypothermia first aid and emergency shelter. Insulated foam pads prevent heat loss while sitting or lying on snow. Finally, a bivouac sack can help by protecting insulating layers from the weather, cutting the wind, and trapping essential body heat.

### Water and Water Containers

4-63. These include wide-mouthed water bottles for water collection, hands-free backpack hydration systems, and a small length of plastic tubing for water procurement at snowmelt seeps and rainwater puddles on bare rock. Wide-mouth containers are easy to fill, easy to clean, and easy to clear out if ice forms. Hydration bladders are convenient, but they can break and have freezing issues in the tube.

### First Aid Kit

4-64. Small teams in the mountains often operate independently. In addition to the improved first aid kit, each Soldier should carry first-aid supplies to address common mountaineering injuries, such as punctures and abrasions with severe bleeding, broken bones, serious sprains, and blisters. Splinting material for stabilizing orthopedic injuries is an important addition.

### Lighter and Fire Starter

4-65. Lighters are handy for starting fires, but they should be backed up by matches stored in a waterproof container with a strip of sandpaper. Fire-starting material is key to igniting wet wood for emergency campfires. Candles, heat tabs, and canned heat all work. These can also be used to quickly warm water or soup in a canteen cup. In alpine zones above the tree line with no available firewood, a stove works as an emergency heat source.

### Knife

4-66. A small folding knife is a helpful tool for its weight. It can be useful for cutting rope or cordage or for food preparation and shelter construction. A knife is important for first aid when improvising interventions with limited medical supplies. A multipurpose pocket tool is also helpful.

### Repair Kit

4-67. A repair kit should include—

- Stove tools and spare parts.
- Duct tape.
- Patches.
- Safety pins.
- Heavy-duty thread or dental floss.
- Sewing kit.
- Cord or wire.

### Extra Food

4-68. Soldiers should carry one day's extra worth of food in case of delay caused by bad weather, injury, or navigational error.

### Small Unit Cross-Leveling

4-69. A small team of Soldiers must analytically look at the packing and choice of team gear. Everyone must be aware of essential-item locations. They must also ensure there is no unnecessarily redundant equipment. In challenging terrain, unnecessary weight slows Soldiers and reduces situational awareness.

### Squad or Team Emergency Pack

4-70. When a squad-sized element leaves the bivouac site, squad safety gear should be carried in addition to individual daypacks. This can be either loaded into one rucksack or cross-leveling among squad members. In the event of an injury, CASEVAC, or unplanned bivouac, these items may make the difference between succeeding and failing the mission. Squad safety gear comprises the following items:

- Sleeping bag.
- Sleeping mat.
- Squad stove.
- Fuel bottle.
- Litter or packaging material.

4-71. The following mnemonic, DROP, can help leaders ensure an appropriate load plan is achieved:

- D—Determine level of mobility.
- R—Reduce redundant or nonessential equipment.
- O—Organize resupply.
- P—Police Soldiers.

## WATER PROCUREMENT

4-72. Supplying adequate water to maintain hydration is a sustainment challenge. Fluids lost through respiration, perspiration, and urination must be replaced. However, water is heavy, and even a few days'

supply will overburden Soldiers. If the water supply is insufficient, then physical activity must be reduced. However, Soldiers cannot adjust permanently to a decreased water intake.

4-73. Individual loads and support requirements can be reduced if small units can procure water from the environment. Water found in mountain streams and pools is often clean, but it cannot be assumed potable. Soldiers should be educated to drink water only from safe sources. Emphasis must be placed on the three rules of water discipline:

- Only drink treated water.
- Conserve water for drinking. Potable water in the mountains may be in short supply.
- Do not contaminate or pollute water sources.

## WATER SOURCES

4-74. Water is scarce above the timberline. After setting up a perimeter, such as a patrol base, assembly area, or a defense; a watering party should be employed. Mountain streams, springs, rain, and lakes provide good sources of water. In areas where water trickles off rocks, a small piece of tubing can be used to fill canteens, or a shallow reservoir may be dug from which to collect water (after the sediment settles).

4-75. Snow may be melted to procure water, which is a time-consuming process that requires significant fuel. Water should be collected at midday when the sun thaws the snow. In glaciated environments, fine particulate can be found in the runoff and should be filtered. After sundown, high mountain areas freeze. Storing water next to a Soldier or placing it in a sleeping bag at night can protect water from freezing.

## BIOLOGICAL CONTAMINANTS

4-76. Virtually all surface waters are microbiologically contaminated. There are three types of disease-causing microorganisms: protozoa, bacteria, and viruses.

4-77. Protozoa are the largest of waterborne bugs measuring in the 1-micron range. Giardia and cryptosporidium are the most infamous of the group. The infective cysts and oocysts of protozoa are extremely robust and can survive for months in a water source. They thrive in domestic and wild animals, as well as humans. Cryptosporidium oocysts are known for their resistance to chemical treatment. Most disinfectants are ineffective, and the few that require long dwell times to do the job.

4-78. Bacteria are an order of magnitude smaller than protozoa measuring in the 0.2-micron range. The most well-known bacteria are Escherichia coli (commonly referred to as E. coli); others include campylobacter, salmonella, and shigella. Bacteria are not as hearty, surviving in water for weeks instead of months. However, unlike protozoa and viruses, which require a host to multiply, some bacteria grow in water and are found in higher numbers than protozoa and viruses. Both animals and humans often carry bacteria, such as protozoa; as a result, many water sources are contaminated with bacteria. Beware of water sources near agricultural operations.

4-79. Viruses—some notorious waterborne viruses are poliovirus, hepatitis, and norovirus. Waterborne viruses are very resilient and can survive for months in water. Viruses are generally species-specific; in other words, those that infect animals do not infect humans and vice versa. Because of this and the modern sanitation measures taken in developed countries, not as many water sources are contaminated with viruses. In developing countries with little or no sewage control, the opposite is true. However, as more people are becoming active outdoors, more rivers, lakes, and streams are at risk of viral contamination.

## CHEMICAL CONTAMINANTS

4-80. Filters and purifiers provide microbiologically safe drinking water. The carbon in the filters and disinfectant of the purifiers will adsorb or react with chemical contaminates, such as herbicides, pesticides, and volatile organic compounds. However, filters or purifiers will not protect from high chemical concentrations or heavy metal contamination. It is best to avoid water sources such as mining tailing ponds or those near agricultural operations.

### WATER PURIFICATION

4-81. Water should always be treated. No matter how clean the snow or water may appear, it should always be considered contaminated. There are many techniques to purify water, each with inherent advantages and disadvantages.

4-82. Boiling kills biological contaminants but does not eliminate chemical contaminants. Filtration should also be used if chemical contaminants are suspected. To ensure all biological contaminants have been killed, let the water boil for 1 minute. This method requires time and fuel while allowing water to be treated away from the source.

4-83. Chemical treatment can be accomplished with iodine or chlorine dioxide. These treatments are available commercially and come with instructions for proper use. Chemical treatment will kill almost all biological contaminants but are ineffective against cryptosporidium. It requires time for these chemical treatments to be effective, and, in cold temperatures, it takes longer. This method allows water to be treated away from the source and on the go.

4-84. UV lights are an effective way to kill all biological contaminants but do not treat for chemical contaminants. They require batteries and in cloudy debris-filled water, it may not kill all contaminants. Ensure water is filtered if it is cloudy before use. This method can be used away from the source.

4-85. Filters are compact and lightweight. They work by filtering out particulate, chemicals, and biological contaminants. Filters are not capable of removing any chemical contaminants that are dissolved in the water. Certain filters may not be able to filter out smaller biological contaminants as the pores of the filter are too large to remove them. These types of filters are designed to remove waterborne protozoa and bacteria but not viruses. The benefit of these types of filters is that water moves more rapidly through them. Filters that can filter smaller contaminants are often referred to as water purifiers. Water purifiers are designed to remove protozoa, bacteria, and viruses, offering a higher level of defense by combating all three. The drawback to these types of filters is that they filter water at a slower rate and may clog when filtering very cloudy water. Be sure to read the capabilities of the filter and treat the water with multiple methods, if necessary. Filters can freeze in cold temperatures if they are not properly cleared after use. In extreme temperatures, they may not operate at all. Filters require treating water at the source.

## AERIAL RESUPPLY

4-86. Movement of supplies by air is often the preferred method for remote, hard to reach locations. This is only possible when assets are available and the weather, terrain, and situation allow it. Air distribution in the mountains requires detailed planning, effective liaison, and a habitual relationship between the aviation crew and the ground unit. Direct communication between the unit and the air delivery asset is coordinated early in the planning process to help ensure proper delivery.

4-87. Aerial resupply, though effective, is limited by weather, which must be permissive from the point of origin to the point of delivery, and all stops in-between. Fog, cloud cover, sudden storms, ice, and unpredictable air currents can shut down air support. Higher elevations will decrease aircraft lift capabilities. Temperature and air density at altitude restrict an aircrew's ability to carry loads into the high mountains. Erratic weather conditions in the mountains will frequently prevent rotary- and fixed-wing aircraft from flying; this may last for multiple days.

4-88. Suitable drop zones in the mountains are difficult to find. A common resupply delivery is accomplished by helicopters flying at a low altitude above the mountain terrain delivering unit-configured loads. Supplies should be packaged for immediate Soldier transport upon delivery. (For more information on options, see ATP 3-21.50, ATP 4-48, and supporting aviation assets.)

## SECTION IV – BIVOUAC CONSIDERATIONS

4-89. Mountainous regions often have strong turbulent winds, cold temperatures, and a general lack of concealment above the timberline. The wind overhead creates an extensive lee near the mountain. An inland wind blowing 50 miles per hour (mph) may not strike the ground for several kilometers after passing the edge of a cliff or a very steep slope. Such a lee is an attractive bivouac site from the standpoint of wind protection.

Note that such a lee area is often an area of maximum snow deposit. Frequent requirements to dig out vehicles, walkways, and weapons positions may offset the wind-free advantages of a lee site during snowfall or snow-blowing weather. Avalanche hazard areas must be avoided. Cold air is heavier than warm air and frequently settles in valleys. If tactically feasible, it is better to establish a bivouac up the hillside above the valley floor and below the timberline.

# BIVOUAC SITE LOCATION

4-90. The following are considerations for selecting a bivouac site in the mountains:

- Cover and concealment—cover and concealment from air and ground observation is essential for the bivouac area. Forested areas pose few problems in comparison to areas above the tree line. Operations above tree line or at altitude may offer less cover and concealment. Bivouac may need to be established below tree line to support operations conducted above tree line.
- Wind protection—protection from the wind is a prime consideration. Depending on the area of operations, bivouac site selections may vary due to the unpredictability of winds at elevation.
- Ground condition—the condition of the ground is important. In warm conditions, bivouac should be located on hard ground. In snow-covered terrain, avoid digging to the ground, as this may collect water due to the thawing of the snow, or rain. A layer of snow should be left for ground insulation, comfort, and water absorption. The depth that is dug in will vary depending on the site selection and snow depth.
- Construction materials—construction materials play an important part in selecting a bivouac. When reconnoitering an area, consider such things as the availability of firewood, water procurement, and snow for snow shelters.
- Hazard awareness—bivouac sites must be protected from mountain-specific hazards that are not commonly encountered, such as rockfall, icefall, flooding, and avalanche-runout zones. These hazards are not always obvious so good awareness and vigilance must be used when selecting these sites in mountainous terrain.

# GLACIER BIVOUAC PROCEDURES

4-91. When locating a bivouac site or a gathering area where the team might need or want to unrope, at least one person will need to probe the area for hidden crevasses. (See chapter 14, section II, for detailed information on probing a potential bivouac site.)

4-92. Once an area is determined to be safe, it must be marked to keep personnel within that area. Typically, wands are carried as flagging material specifically for this purpose. Water procurement sites (uphill) and latrines (downhill) must be determined for safety to avoid contamination.

4-93. Multiple tent sites can be connected, which keeps tents closer together. Probe all areas between the tents if planning to move in those areas. Closer tents will make communicating between tent groups and rope teams easier.

4-94. If there is a chance for severe storms with high winds, snow walls may be constructed to protect the tent site from wind. The walls can be constructed from loose snow piled on the perimeter, or blocks can be cut from consolidated snow layers. In deep, soft snow, digging 3 or 4 feet to find a consolidated layer will result in enough snow moved to build up decent walls around the tent site. For block construction, move the soft snow from the surface into the wall foundation areas (down to a consolidated layer of snow).

# SHELTERS

4-95. Operations in mountainous terrain require Soldiers to be familiar with a variety of bivouac shelter construction techniques. Ideally, purpose-designed shelters should be used. However, given the erratic nature of weather in mountainous terrain, Soldiers should also be prepared to improvise survival shelters for emergency bivouac situations that occur when carrying manufactured shelters is not feasible.

## TENTS

4-96. When selecting a tent, the mission must be defined to determine the number of people the tent must accommodate. The climate should also be taken into consideration. A tent used for warmer temperatures will

greatly differ from tents used in colder, harsher environments. Tent manufacturers offer many designs of different sizes, weights, and materials. Mountaineering tents are made of breathable or weatherproof material. A single-wall tent allows for moisture inside the tent to escape through the tent's material. A double-wall tent has a second layer of material (referred to as a fly) that covers the tent. The fly protects against rain and snow, and the space between the fly and tent helps moisture to escape from inside. Before using a new tent, the seams should be treated with seam sealer to prevent moisture from entering through the stitching. The frame of a tent is usually made of an aluminum or carbon fiber poles. The poles are connected with an elastic cord that allows them to extend, connect, and become long and rigid. When the tent poles are secured into the tent body, they create the shape of the tent. Tents are rated by a relative strength factor; the speed of wind a tent can withstand before the frame deforms. Temperature and expected weather for the mission should be determined before choosing the tent.

## FLOORLESS SHELTERS

4-97. Floorless shelters are lighter and more packable than conventional tents. Soldiers can enter and exit the tent with boots on without bringing dirt into the tent or ripping the floor of a conventional tent. They can be pitched in many different types of terrain for many different uses. They can provide overhead cover while staying in a static position for a long period. They offer much more ventilation, allowing the use of a stove inside and no worry of spilling fuel onto the tent floor. Because floorless shelters are lightweight and easier to pack than conventional tents, it is possible to carry a much larger shelter. A tarp, poncho, or piece of house wrap makes a clean and dry floor area near the sleeping bags if the ground is damp. Floorless shelters do have some drawbacks. They are not suitable above the tree line due to the lack of anchoring and potential high winds. They need soil into which to drive the stakes. If extreme cold temperatures are encountered, they have much more ventilation and are inherently colder than a conventional tent. (See figure 4-5.)

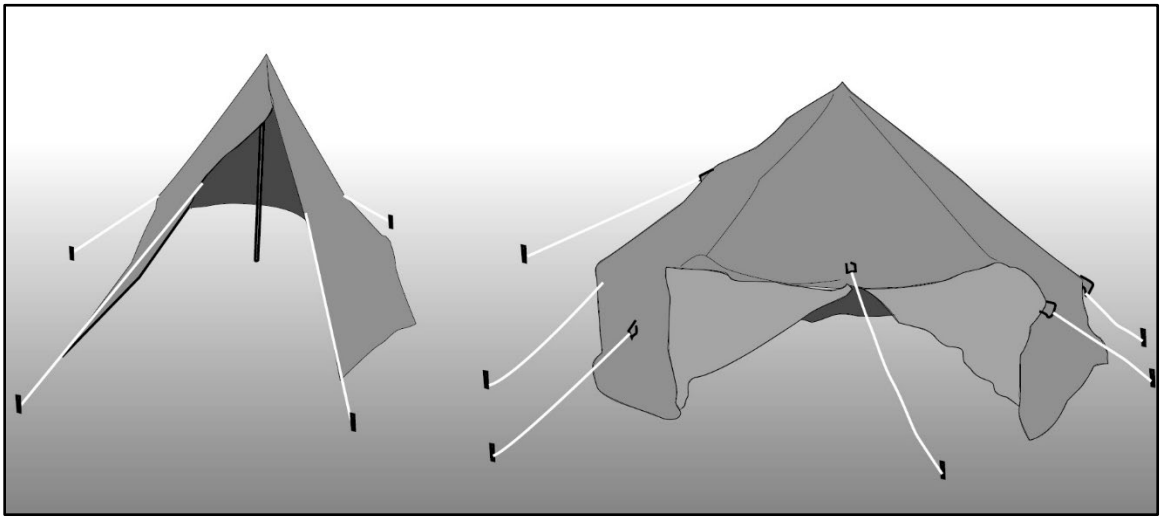


**Figure 4-5. Floorless shelter (10-man arctic tent)**

## EMERGENCY BIVOUAC SHELTERS

4-98. The equipment that a Soldier carries, and the environment determine the type of shelter that can be built. Shelters can be built in wooded areas, open country, and barren areas. Wooded areas usually provide the best location, while barren areas have only snow as building material. Wooded areas provide timber for shelter construction, wood for fire, concealment from observation, and protection from the wind.

***Note.*** In extreme cold, do not use metal, such as an aircraft fuselage, for shelter. The metal conducts away from the shelter what little body heat the Soldier can generate.

4-99. Shelters made from ice or snow usually require tools, such as ice axes or saws. Significant time and energy must be expended to build these shelters. Be sure to ventilate an enclosed shelter, especially if the

intent is to build a fire for warmth. Always block a shelter's entrance, if possible, to keep the heat in and keep out the wind. Use a rucksack or snow block. Construct a shelter no larger than needed. This will reduce the amount of space to heat. A common error in cold-weather shelter construction is making the shelter so large that it steals body heat rather than helping conserve it.

4-100. If possible, avoid sleeping directly on the ground. Lay down some pine boughs, grass, or other insulating material to keep the ground from absorbing body heat.

4-101. Never fall asleep without turning off the stove or lamp. Carbon monoxide poisoning can result from a fire burning in an unventilated shelter. Carbon monoxide is a great danger. It is colorless and odorless. Any time there is an open flame, it may generate carbon monoxide. Always check for proper ventilation. Even in a ventilated shelter, incomplete combustion can cause carbon monoxide poisoning. Usually, there are no symptoms. Unconsciousness and death can occur without warning. Sometimes, however, pressure at the temples, burning of the eyes, headache, pounding pulse, drowsiness, or nausea may occur. The one visible sign of carbon monoxide poisoning is a cherry red coloring in the tissues of the lips, mouth, and inside of the eyelids. Soldiers must immediately be moved to fresh air if they begin to exhibit any of these symptoms.

## Poncho Lean-To

4-102. A poncho lean-to takes only a short time and minimal equipment to build. (See figure 4-6.) Material requirements are a poncho, 6 to 9 feet of rope or cord, 3 stakes about 12 inches long, and 2 trees or 2 poles that are 6 to 9 feet apart. Before selecting the trees or the location of the poles, check the wind direction to ensure that the back of the lean-to is facing into the wind.

4-103. When using the lean-to for more than one night or if rain is expected, make a center support for the lean-to. Make this support with a line. Attach one end of the line to the poncho hood and the other end to an overhanging branch. Ensure there is no slack in the line.

4-104. Another method for creating a center support is to place a stick upright under the center of the lean-to. However, this method restricts space and movement in the shelter.

4-105. For additional protection from wind and rain, place some brush, a rucksack, or other equipment at the sides of the lean-to. To reduce heat loss to the ground, place some type of insulating material, such as leaves or pine needles, inside the lean-to. (See ATP 3-50.21 for more information.)

***Note.*** When at rest, Soldiers lose as much as 80 percent of their body heat to the ground.

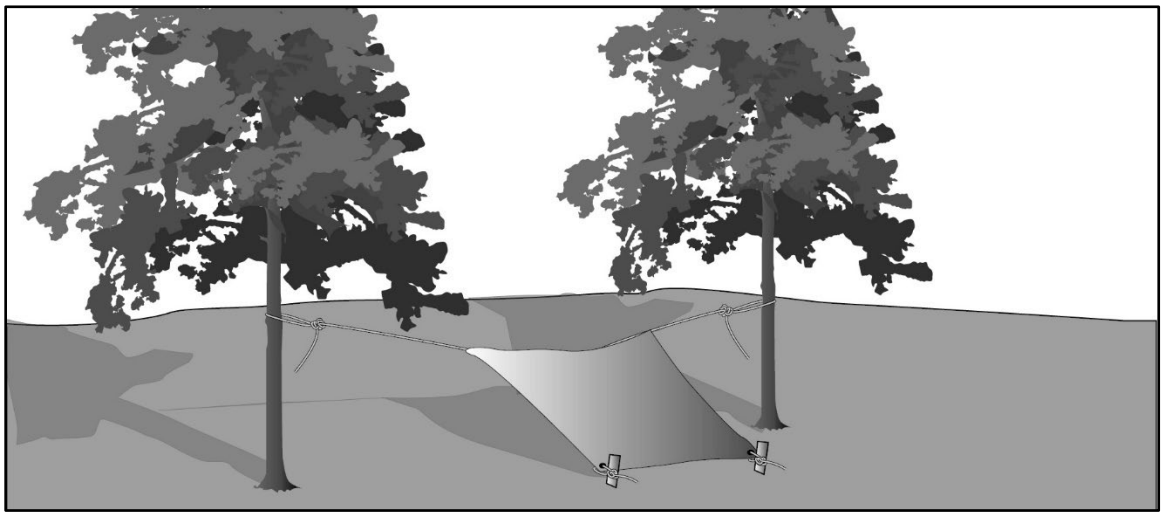


**Figure 4-6. Poncho lean-to**

### Field Expedient Lean-To

4-106. In a wooded area that has enough natural materials, a field-expedient lean-to can be constructed with only a knife. It takes longer to make this type of shelter than it does to make other types, but it protects against the elements. It requires two trees (or upright poles) about 6 feet apart, one pole about 6 feet long and 1 inch in diameter, 5 to 8 poles about 9-feet long and 1 inch in diameter for beams; cord or vines for securing the horizontal support to the trees; and other poles, saplings, or vines to crisscross the beams. (See ATP 3-50.21.)

## NATURAL SHELTERS

4-107. Do not overlook natural formations that provide shelter. Examples are caves, rocky crevices, clumps of bushes, small depressions, large rocks on leeward sides of hills, large trees with low-hanging limbs, and fallen trees with thick branches. When selecting a natural formation, stay away from low ground, such as ravines, narrow valleys, or creek beds. Low areas collect the heavy cold air at night and are therefore colder than the surrounding high ground. Thick, brushy, low ground also harbors more insects. Check for ticks, mites, scorpions, stinging ants, and venomous snakes. Look for loose rocks, dead limbs, or other natural growth that could fall on the shelter. (See ATP 3-50.21.)

### Snow-Cave Shelter

4-108. The snow-cave shelter is an effective shelter because of the insulating properties of snow (See figure 4-7.) A snow-cave shelter requires significant time and energy to build, and during construction, clothing can become quite wet. Find a drift about 3-meters (the length of an avalanche probe) deep that can easily be dug into. While building this shelter, keep the roof arched for strength and allow melted snow to drain down the sides. Build the sleeping platform higher than the entrance. Separate the sleeping platform from the snow-cave's walls or dig a small trench between the platform and the wall. This platform and a smooth ceiling will prevent the melting snow from dripping on clothing and equipment. The construction is especially important to ensure an efficient means of retaining heat. Ensure the roof is high enough to sit up on the sleeping platform. Block the entrance with a snow block or rucksack. The walls and ceiling should be at least 12-inches thick. Install a ventilation shaft. If there is no drift large enough to build a snow cave, a variation can be built by piling snow into a mound large enough to dig out. (See ATP 3-50.21.)

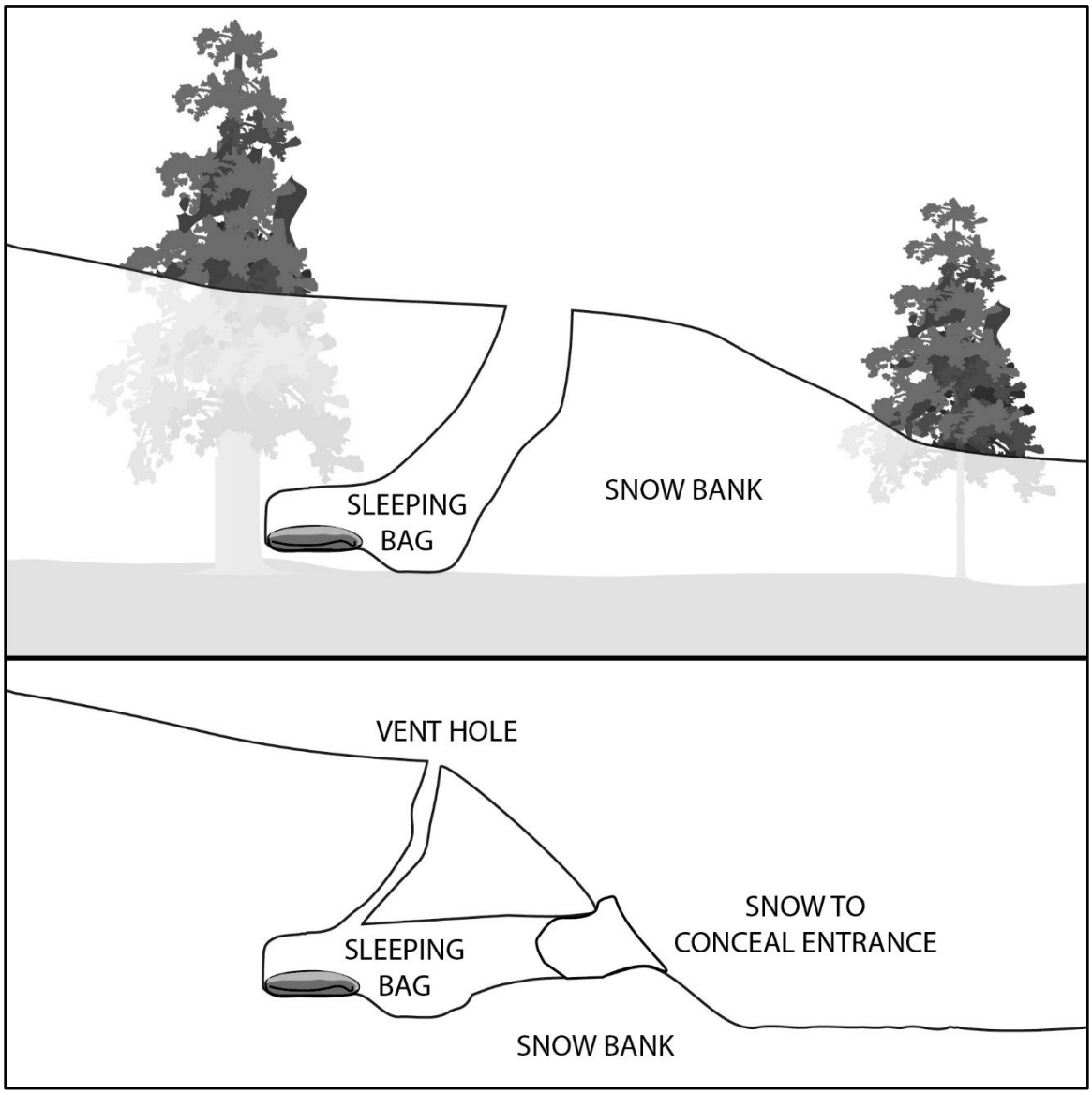



**Figure 4-7. Snow-cave shelter**

### Snow-Trench Shelter

4-109. The snow trench is a hasty shelter designed to allow Soldiers to sleep below the snow and wind level while using the snow's insulating qualities. To build a snow-trench shelter, follow the following steps:

- Cut snow blocks about 1 foot by 1 foot by 2 feet and construct the walls by interlocking the snow blocks with overlapping placements. The walls should be slightly higher than the tent. At a minimum, build walls on the windward side of the tent site. Snow walls can also provide shelter from wind for food preparation and when using latrines.
- In areas of compacted snow, cut snow blocks and use them as overhead cover. If not, use a poncho or other material. Build only one entrance and use a snow block or rucksack as a door.

## LIGHTWEIGHT STOVES

4-110. Lightweight stoves should be used during mountain operations to reduce Soldier load and as a cold-weather emergency risk mitigation measure. They should be issued at the team level and provide 3 to 4

Soldiers with the ability to rehydrate rations, melt snow into water, heat water to warm Soldiers with cold weather or other injuries, and generate heat in small shelters during emergencies.

4-111. Soldier load can be greatly reduced by carrying lightweight stoves and fuel in winter environments. This is because they can create far more water by volume for the same carried weight than just carrying water. The actual amount varies dependent on altitude, temperature, and fuel type.

4-112. Factors that should be considered when choosing lightweight stoves for mountain operations are weight, altitude, operational temperature, fuel availability, and reliability.

## STOVE TYPES

4-113. Most mountaineering stoves are either canister-fuel or liquid-fuel:

- Canister-fuel stoves are simpler to operate than liquid fueled stoves. The gas, already pressurized, flows from the fuel canister into the burner, where it ignites, in the same manner as a domestic kitchen stove. Canister-fuel stoves are generally accepted as being more efficient for weight carried than liquid fuel. However, canister-fuel stoves are unreliable in cold temperatures. They are not recommended for use in freezing temperatures or at high altitudes.
- Liquid-fuel stoves are more complex because the liquid fuel must be vaporized prior to burning. In many stoves, the priming pressure is generated by a small hand pump that forces air into the fuel container. Liquid-fuel stoves are typically capable of burning multiple types of fuel. They generally operate well in cold weather and at high altitude. Liquid fuel costs less than canister fuel. Some forms of fuel, such as kerosene or diesel, are readily available worldwide. Liquid-fuel stoves are the most widely used for mountaineering due to their wide versatility.

## STOVE USE

4-114. Stoves should be tested and maintained prior to operational use. Soldiers should be familiar with stove disassembly, cleaning, and troubleshooting prior to operational use. A repair kit and the tools needed to fix these stoves should always be packed together. The reliability of the stove has a huge impact on the success of the mission and the morale of personnel.

4-115. When in use, hot stoves must be kept away from equipment and ammunition. At higher elevations, the heating times may be doubled. To conserve fuel, stoves, fires, and fuel tablets should be protected from the wind.

## Chapter 5

# Avalanche

World War I is remembered for the brutal fighting in the trenches in France and Belgium. However, in the fighting between Italy and the Austro-Hungarian Empire, Soldiers saw some of the most intense mountain fighting in human history. After the Italians checked the Austrian offensive through the passes of the Alps, both sides fought higher and higher into the mountains. Small, light units of mountaineers clashed over new ground high in the peaks, while the armies dug in on the peaks they had secured. Positions and paths were blasted out of the rock and carved through the glaciers to move personnel and materiel to the fighting in the heights.

By the winter of 1916, the line had mostly stabilized, and both armies were hunkering down for winter. Both sides had established extensive networks of trails and camps to support their forward positions; however, much of the infrastructure had been built in avalanche paths. In the second week of December, a major snowstorm blew in, loading the slopes and causing massive avalanches across the range.

Both nations suppressed the number of casualties they received, and no official Italian records exist, but what evidence did survive paints a grim picture. The lowest estimates place casualties at around 4,000 during the storm. Some records support numbers as high as 10,000. Today, their bodies are still melting out of the glaciers below.

## SECTION I – AVALANCHE HAZARDS

5-1. During winter months and throughout the year, snow covers the slopes. Steep, snow-covered terrain, in addition to mobility challenges and fall hazards, present the risk of avalanches. This hazard is easy to underestimate. It is not clearly visible, and, due to the complexity of the factors involved, there is a high degree of uncertainty, but the consequences of ignoring the hazard are high. Avalanches have taken the lives of more troops engaged in mountain warfare than all other terrain hazards combined.

5-2. An avalanche is an unstable snowpack, located on particularly angled terrain, where the bonds between layers or several layers of snow have broken, causing a mass of snow to slide downhill. When operating in the mountains during the winter, these instabilities in the snowpack may make large areas too dangerous for travel. These snow slopes may appear unthreatening but may have weak layers buried in the snowpack that can be easily triggered. Military elements may gravitate into avalanche terrain to avoid steeper technical terrain or enemy observation. Avalanches can generate incredible destructive force, destroying equipment, killing or burying Soldiers, and blocking key roads. Whether operating dismounted in high alpine terrain or as a mounted force in valley bottoms, units must be aware of avalanche hazards. They must incorporate the evaluation of avalanche danger into the planning process and learn to recognize and avoid hazardous terrain. (See figure 5-1, page 64.)



**Figure 5-1. Movement through avalanche terrain**

# AVALANCHE ELEMENTS

5-3. Avalanches occur when the weight of accumulated snow on a slope exceeds the cohesive forces that hold the snow in place. There are three elements needed to create an avalanche: an unstable snowpack, terrain steep enough to slide, and a trigger that initiates the failure of bonds holding the snow in place.

## SNOWPACK

5-4. Layers of snow accumulate with each new snow or wind event. Variation in temperature and atmospheric conditions form layers with different types of snow crystals. These layers are subject to changes in texture and strength throughout the winter, as they are exposed to sun, wind, and temperature changes. Each layer in the snowpack will have distinct characteristics. Strong layers are made up of well-bonded, small, rounded grains. Weak layers are made up of larger, angular, poorly bonded grains.

### Snowpack Concerns

5-5. Instabilities are weaknesses within the snowpack as described below (see figure 5-2):

- Weak layers—weak layers may collapse under load, initiating an avalanche. Poorly bonded crystals can act like ball bearings between stronger layers. Weak layers can change over time, becoming stronger, denser layers. This happens more quickly in temperatures above freezing. However, many avalanche cycles are due to weak layers that resist this change and retain their large grain size and

angular shape for long periods. These types of layers are known as “persistent” weak layers. These are common in prolonged colder temperatures.

- Weak bonds between layers—differences in the size and compositions of crystals between layers inhibit bonding. Large differences between layers are the primary source of instability.
- Bed surface—the bed surface is the surface over which a fracture and subsequent avalanche release occurs. Smooth, uniform sliding surfaces provide less friction to hold the snow in place. Examples are firm old snow layers, rain crusts, and sun crusts.

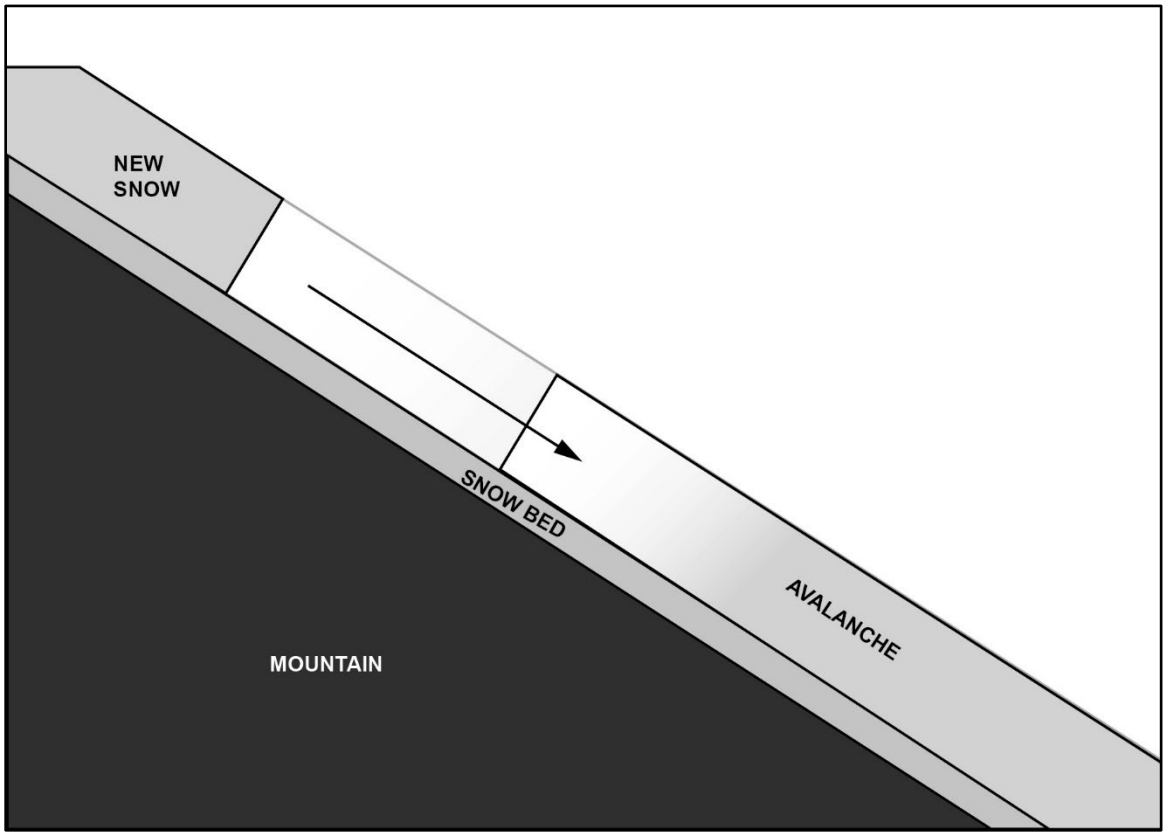



**Figure 5-2. Snowpack layers**

## Loading

5-6. When instability exists in the snowpack, another important factor is the load placed on top of the weak layer. With the added weight of accumulated snow, it increases the shear forces within the snowpack:

- New snow—during snowstorms, snowfall will rapidly increase the forces placed on the snowpack. Snowfall of more than 2.5 centimeters (cm) (1 inch) of snow an hour or more than 30 cm (1 foot) of snow in 24 hours is considered critical loading. Avoid traveling in avalanche terrain during critical loading.
- Wind loading—sustained winds will transport snow from windward slopes and ridge tops, depositing it in sheltered features on leeward aspects. With high winds, even small deposits of new snow can produce significant loading. Top loading occurs when wind deposits snow over the top of a ridge. Side loading (or cross loading) occurs when snow is blown across the slope and deposited in gullies or on the leeward sides of ridges.
- Rain—rain rapidly increases the load on the snowpack and erodes bonds between snow crystals and layers. After a period of sustained cold where weak layers have been preserved in the snowpack, rain can produce dense, wet avalanches that are very destructive.

## TERRAIN FACTORS

5-7. Terrain is the second factor that determines if an avalanche can occur. The character of a snowpack and opportunities for whether instabilities develop are determined by its elevation and aspect. A slope's characteristics—slope angle, shape, and physical characteristics—determine the likelihood of a slide. Recognizing and avoiding avalanche terrain are the keys to managing avalanche risk.

### Elevation

5-8. Precipitation, temperature, and wind often vary significantly at different elevations. This results in differences in the snowpack, all of which influence the type, size, distribution, and sensitivity of avalanches.

5-9. Increased precipitation—as weather systems are lifted over mountains (orthographic lift), the air cools and can hold less moisture, causing additional precipitation at elevation. Increased precipitation causes increased loads on the snowpack.

5-10. Temperature—warming in the snowpack temporarily increases instability as bonds melt but improves stability when it re-freezes. Cooler temperatures at higher elevations inhibit stabilization. Instabilities can persist for much longer.

### Aspect to Wind

5-11. Sustained winds of 15 mph or higher transport snow from the windward aspect of the slope and deposit it in the form of wind slabs on the leeward slopes. Leeward slopes can accumulate three to five times the amount of snow that falls in sheltered locations. Slopes on the windward side have much of their new snow "scoured" off by the wind and are generally more stable than leeward slopes. Leeward slopes tend to form dangerous cornices and large, unstable slabs of snow.

### Aspect to Sun

5-12. Solar radiation causes drastic temperature swings in the snowpack. South-facing slopes can be dangerous on warm, sunny days immediately following storms. However, over time, these slopes stabilize as the added heat promotes bonding between layers. Snow on north-facing slopes does not stabilize as quickly and is more hazardous through most of the winter.

***Note***. This effect is reversed in the Southern Hemisphere.

### Start Zone Characteristics

5-13. The steepness of a slope, or its slope angle, is the primary factor that determines if an avalanche will occur. Most large avalanches occur on slopes between 30° and 45°. Slopes above 60° often do not build up significant quantities of snow because they are too steep. Snow will slide off as frequent, small sloughs. Under most conditions, slopes below 25° do not slide. (See figure 5-3.)

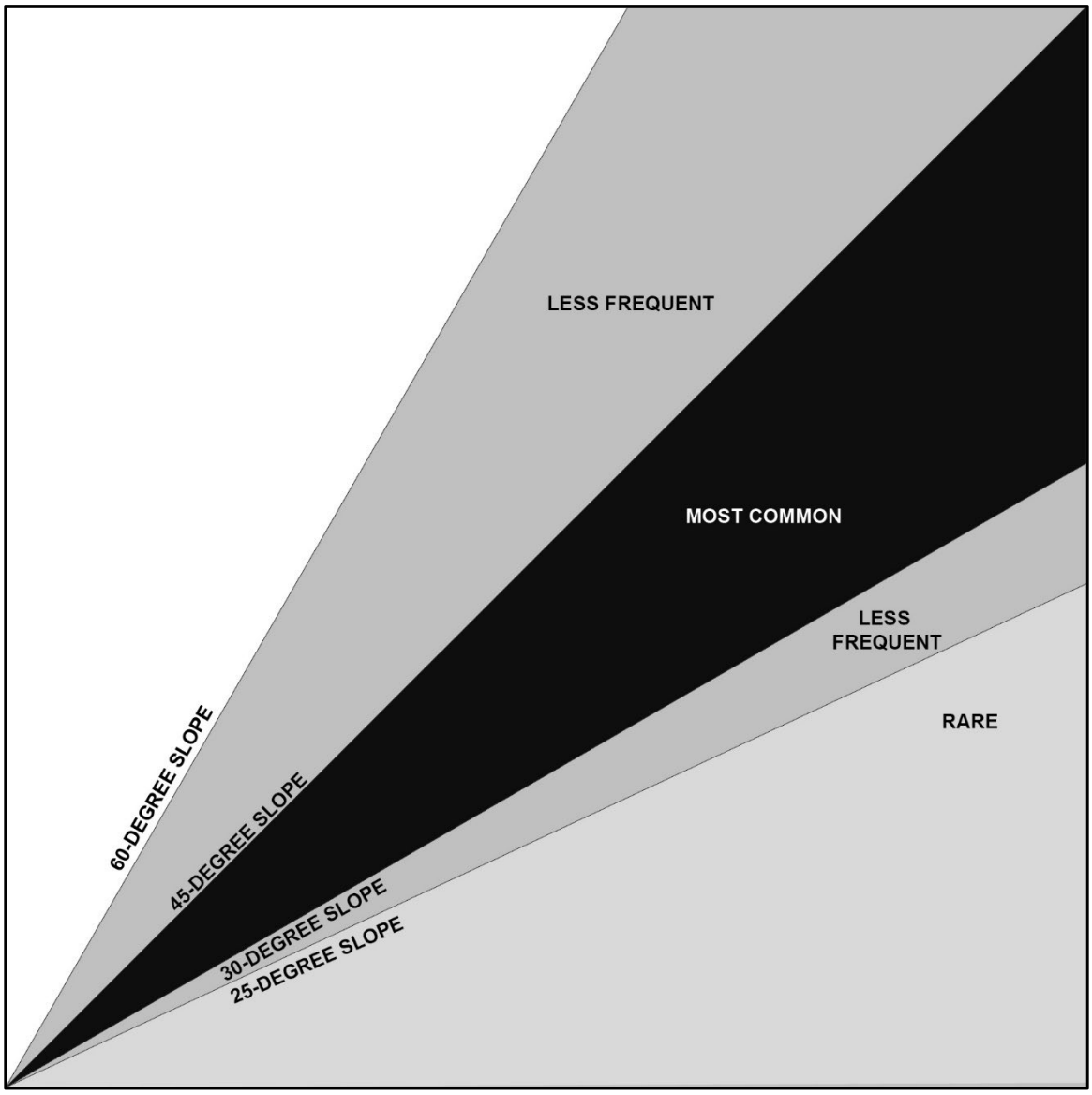



**Figure 5-3. Slope angle**

5-14. The shape of the slope will also affect the forces within the snowpack, concentrating tension in specific areas where it requires less force to trigger an avalanche. (See figure 5-4, page 68.)

- Profile or shape—
  - Convex slopes. Slabs are most likely to fracture just below the bulge where stress is greatest. Convex rollovers have little support and are often steeper than the surrounding slope, making them a likely trigger point.
  - Planar slopes. On these broad, smooth slopes, avalanches can happen anywhere. Slabs often fracture below cliff bands.
  - Concave slopes. These slopes provide a certain amount of support through compression at the base of the hollow, but they are still capable of avalanching, especially on large slopes.
- Anchoring—
  - Boulders, trees, and ledges act as anchors and help hold the snow in place until they are buried.

- Anchors can be areas of stress concentration because the snow upslope is held in place while the snow below or to the sides are pulled downhill by gravity. For this reason, anchors can be starting points for initial failure to occur, and fractures often run from tree to tree or rock to rock.

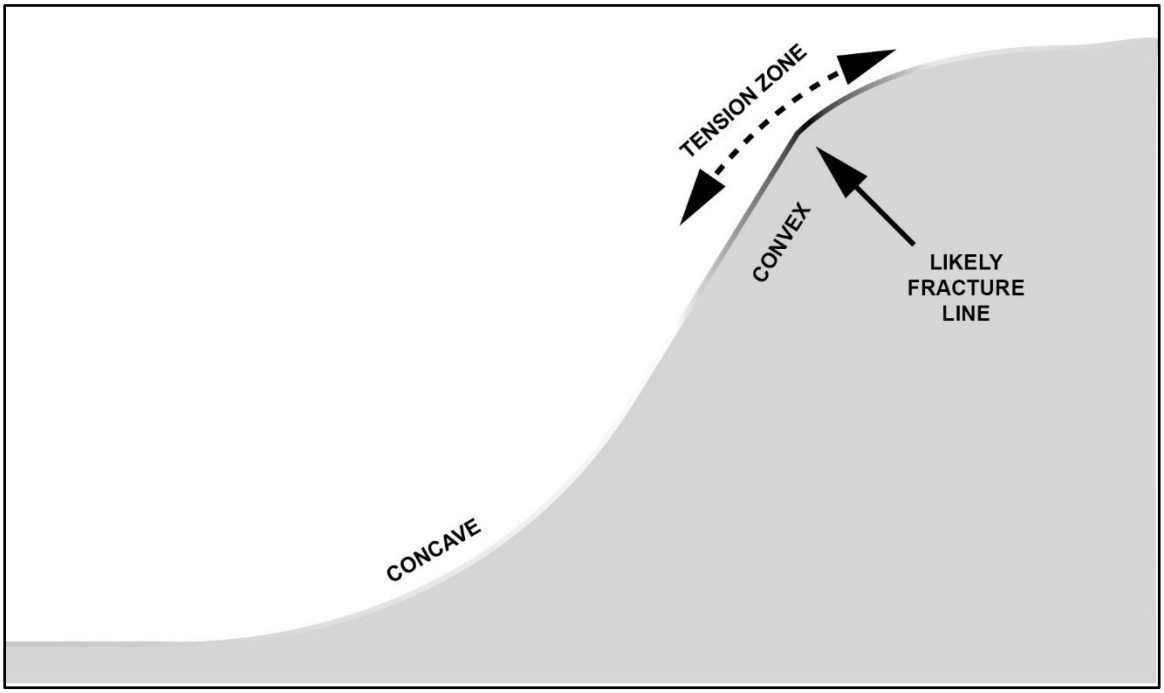



**Figure 5-4. Slope shape**

### Terrain Traps

5-15. Terrain traps are features that increase the consequences of being caught in an avalanche. Examples include cliffs, gullies, creeks, lakes, trees, benches, or roads where debris will pile up, crevasses, or bergschrunds. Some terrain traps increase trauma during an avalanche. Others increase burial depth, making survival more unlikely.

### TRIGGERS

5-16. All avalanche triggers, whether caused by natural forces or human actions, are due to overloading the cohesive strength of the snowpack:

- Natural—avalanches may be triggered by new snow, falling rock, snow, ice, or smaller avalanches. Solar warming erodes bonds and can trigger avalanches. Naturally occurring avalanches are a critical warning sign that the conditions for an avalanche exist on similar slopes. If natural avalanches are possible, human triggered avalanches are likely.
- Human—most victims trigger the avalanches that kill them. People apply significant force to the snowpack. The impact of that force depends on snow density and distribution of force. A Soldier traveling on skis will not stress the snowpack as deep as a Soldier on foot will. Vehicles apply even more force. When a collapse occurs in a weak layer, it can propagate long distances up or across the slope.

## TYPES OF AVALANCHES

5-17. Avalanches can be categorized into two broad categories: loose snow and slab avalanches. (See figure 5-5, page 70.) Loose snow slides start with less snow and pick up more snow as they descend. Slab avalanches occur when one or more layers of cohesive snow break away as a unit and are generally more destructive.

5-18. There are many variations of these types, each with distinct characteristics. These characteristics are defined by the structures within the snowpack, how an avalanche is released, and where it is found in the terrain. These avalanche problems guide group discussions, route planning, terrain choices, and the observations made during snowpack evaluation.

### LOOSE-DRY AVALANCHES

5-19. A loose-dry avalanche is a release of dry, unconsolidated snow. These avalanches occur within layers of soft snow near the surface of the snowpack. Loose-dry avalanches start at a point and entrain snow as they move downhill, forming a fan-shaped avalanche. Other names for loose-dry avalanches include point-release avalanches or sluffs. Loose-dry avalanches can trigger slab avalanches that break into deeper snow layers. Loose-dry avalanches are usually less dangerous than other avalanche problems but can be hazardous when combined with terrain traps, such as gullies, rocks, dense timber, cliffs, or crevasses. (See figure 5-5, page 70.)

### STORM SLAB AVALANCHES

5-20. A storm slab avalanche is a release of a soft cohesive layer (a slab) of new snow that breaks within the storm snow or on the old snow surface. Storm-slab problems last between a few hours and a few days but often stabilize quickly. (See figure 5-5, page 70.)

### WIND SLAB AVALANCHES

5-21. A wind slab avalanche is the release of a cohesive layer of snow (a slab) formed by the wind. Wind transports snow from the upwind sides of terrain features and deposits snow on the downwind side. Wind slabs are often smooth and rounded, sound hollow sometimes, and can range from soft to hard. Wind slabs form in specific areas and are confined to lee and cross-loaded terrain features. They can be avoided by sticking to sheltered or wind-scoured areas. (See figure 5-5, page 70.)

### PERSISTENT SLAB AVALANCHES

5-22. A persistent slab avalanche is a release of a cohesive layer of soft to hard snow (a slab) in the middle to upper snowpack, when the bond to an underlying persistent weak layer breaks. Persistent weak layers can continue to produce avalanches for days, weeks, or even months, making them challenging to manage. As additional snow and wind events build a thicker slab on top of the persistent weak layer, this avalanche problem may develop into a deep, persistent slab. They can be triggered by light loads and last weeks after the last storm. The slabs often propagate in surprising and unpredictable ways, making this problem difficult to predict and manage, and require a wide safety buffer to handle the uncertainty. The best ways to manage the risk from persistent slabs are to make conservative terrain choices. (See figure 5-5, page 70.)

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***Note***. Storm slabs and wind slabs formed over persistent weak layers are also considered persistent slabs.

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### DEEP, PERSISTENT SLAB AVALANCHES

5-23. A deep, persistent slab avalanche is a release of a thick, cohesive layer of hard snow (a slab), when the bond breaks between the slab and an underlying “persistent” weak layer, deep in the snowpack or near the ground. Deep, persistent slabs are difficult to trigger but are very destructive and dangerous because of the large mass of snow involved. Once developed, they can persist for months or an entire winter season. They are often triggered from areas where the snow is shallow and weak and are difficult to forecast and manage. (See figure 5-5, page 70.)

### WET-LOOSE AVALANCHES

5-24. A wet-loose avalanche is a release of wet, unconsolidated snow or slush. These avalanches occur within layers of wet snow near the surface of the snowpack but may quickly gouge into lower snowpack layers. Like dry-loose avalanches, they start at a point and entrain snow as they move downhill, forming a fan-shaped avalanche. They often carve channels or paths through the snowpack to which subsequent avalanches are constrained. They move slowly but can contain enough mass to cause significant damage to trees, cars, or buildings. To avoid wet-loose avalanches, travel when the snow surface is colder and stronger. Plan movements to avoid crossing on or under very steep slopes in the afternoon. Move to colder, shadier slopes

once the snow surface turns slushy. Avoid steep, sunlit slopes above terrain traps, cliffs, and long steep slopes. (See figure 5-5.)

### WET SLAB AVALANCHES

5-25. A wet slab avalanche is a release of a cohesive layer of wet snow (a slab) when the flow of liquid water weakens the bond between the slab and the surface below (snow or ground). They often occur during prolonged warming events or rain-on-snow events. Wet slabs can be very destructive. Avoid terrain where and when wet slab avalanche activity is expected. Give suspect slopes a wide safety buffer to handle the uncertainty. (See figure 5-5.)

### CORNICE FALL

5-26. Cornice fall is the release of an overhanging mass of snow that forms as the wind moves snow over a sharp terrain feature, such as a ridge, and deposits snow on the downwind (leeward) side. Cornices range in size from small wind lips of soft snow to large overhangs of hard snow that are 10 meters (30 feet) or taller. They can break off suddenly. Even small cornices can have enough mass to be destructive and deadly. Cornice fall can entrain loose surface snow or trigger slab avalanches. Cornices can never be trusted and avoiding them is necessary for safe travel. Stay well back from ridgeline areas with cornices. They often overhang the ridge edge; they can be triggered remotely. Avoid areas underneath cornices, especially during periods of significant warming. (See figure 5-5.)

### GLIDE (FULL DEPTH) AVALANCHES

5-27. A glide avalanche is a release of the entire snow cover at the ground surface. Glide avalanches can be composed of wet, moist, or almost entirely dry snow. They occur in very specific paths, where the slope is steep enough and the ground surface is smooth. They often occur on south-facing slopes during periods of strong sun and warm temperatures. They may be proceeded by full depth cracks (glide cracks), though the time between the appearance of a crack and an avalanche can vary between seconds and months. Predicting the release of glide avalanches is very challenging. Because they only occur on very specific slopes, avoidance is key to safe travel. Glide cracks and other glide avalanches are indicators. (See figure 5-5.)

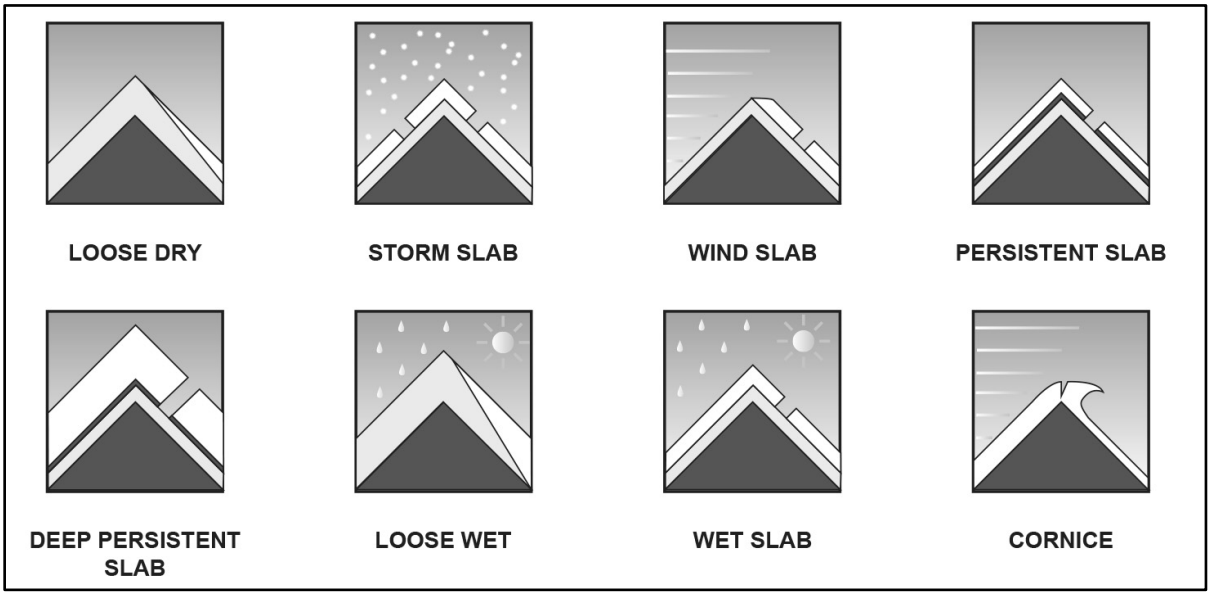



**Figure 5-5. Avalanche problem types**

## FORECASTS

5-28. In areas with extensive avalanche terrain and conditions, there are regional offices with staff members that monitor weather and snowpack conditions and produce forecasts to warn the public of avalanche hazards.

Forecasts are created using a combination of weather models, remote weather stations, snowpack data, and field observations. Forecasts use the North American Avalanche Danger Scale and add additional information regarding specific avalanche problems, location in the terrain, likelihood of triggering, and expected size.

## NORTH AMERICAN DANGER SCALE

5-29. The North American Avalanche Danger Scale is a tool used by avalanche forecasters to communicate the potential for avalanches to cause harm or injury to backcountry travelers. It converts the forecasters' projections of the size and distribution of avalanches and likelihood of triggering into travel advice. (See figure 5-6.)

## AVALANCHE PROBLEM

5-30. In addition to the danger rating, forecasters publish a more detailed discussion of the avalanche problem. The avalanche problem describes the types of potential avalanche, the expected location based on aspect and elevation, the likelihood of triggering, and the expected size. Specific avalanche problems with similar ratings on the danger scale may present differently and require different terrain choices. (See figure 5-7, page 72.)

## USING THE FORECAST

5-31. The forecast is a starting point to guide planning for patrols or missions. In addition, planners should consult a record of the season's conditions and current weather. Group discussion, identifying the hazard, communicating recent observations, and planning routes with clear decision points are all part of the decision-making framework used to manage avalanche risk.

| DANGER LEVEL | | Travel Advice | Avalanche Likelihood | Avalanche Size & Distribution |
|---|---|---|---|---|
| 5 Extreme |  | Avoid all avalanche terrain. | Natural and human-triggered avalanches certain. | Large to very large avalanches in many areas. |
| 4 High |  | Very dangerous avalanche conditions. Travel in avalanche terrain not recommended. | Natural avalanches likely: human-triggered avalanches very likely. | Large avalanches in many areas: or very large avalanches in specific areas. |
| 3 Considerable |  | Dangerous avalanche conditions. Careful snowpack evaluation, cautious routefinding and conservative decision-making essential. | Natural avalanches possible: human-triggered avalanches likely. | Small avalanches in many areas, or large avalanches in specific areas, or very large avalanches in isolated areas. |
| 2 Moderate |  | Heightened avalanche conditions on specific terrain features. Evaluate snow and terrain carefully, identity features of concern. | Natural avalanches unlikely: human-triggered avalanches possible. | Small avalanches in specific areas, or large avalanches in isolated areas. |
| 1 Low |  | Generally safe avalanche conditions. Watch for unstable snow on isolated terrain features. | Natural and human-triggered avalanches unlikely. | Small avalanches in isolated areas or extreme terrain. |

**Figure 5-6. Avalanche danger scale**

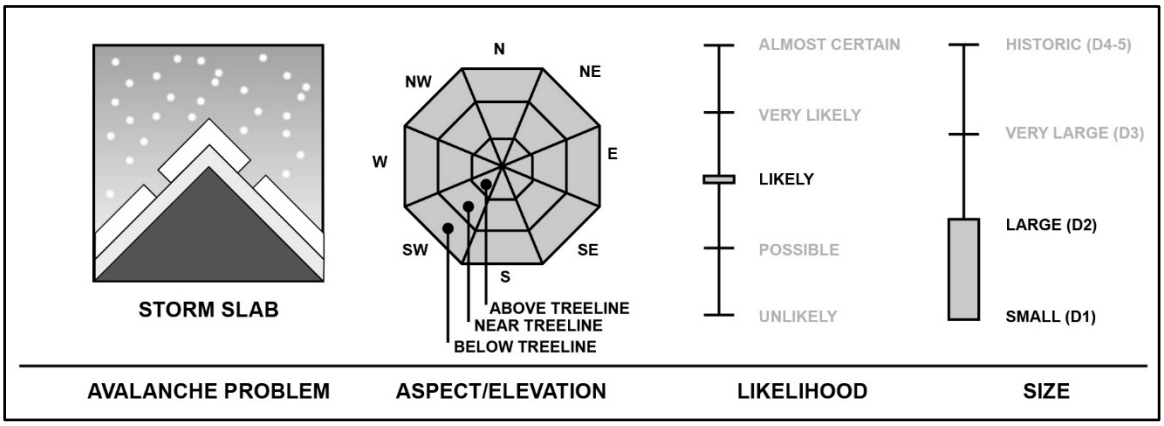



**Figure 5-7. Avalanche problems**

## SECTION II – AVALANCHE RISK MANAGEMENT

5-32. More than any other hazard faced in the mountains, avalanches pose the most significant threat of a catastrophic accident for an entire element. There is inherent uncertainty in any forecast, even those produced by avalanche professionals, and the consequence of being caught in an avalanche are high. The best control measure is avoiding all avalanche terrain. However, this is not always possible. In some mountain ranges, even valleys, roads, and railways are threatened by avalanches when dangerous weather conditions are present. Key terrain and approaches to it may be in avalanche terrain. Much of the time, the snowpack may be stable and safe for travel, but without an understanding of specific hazards and their locations in the terrain, units can be dangerously exposed.

5-33. Education is the greatest tool for managing avalanche hazard. Unit commanders are responsible for implementing avalanche training. They must understand the hazards that Soldiers may be exposed to and ensure that subordinate leaders and Soldiers are prepared for those threats. Units should have designated unit members with formal avalanche training and education.

# UNIT-LEVEL RESPONSIBILITIES

5-34. Avalanche hazard shuts down large areas to maneuver. As part of their intelligence preparation of the battlefield, units need to analyze terrain, snowpack, and weather factors to develop a forecast for subordinate elements. Route planning, terrain selection, and risk decisions are all driven by a forecast.

5-35. When training in the United States, units may have access to avalanche forecasts being generated at avalanche centers in our geographic regions. These forecasts identify the avalanche problems and locations in the terrain and assign them a danger rating based off the likelihood of triggering them and their size. These forecasts guide route planning and help to evaluate the overall risk. To develop an operational capability, units must identify and develop key personnel that can evaluate the hazards using weather data and snowpack observations within their area of operations.

# MILITARY MOUNTAINEER RESPONSIBILITIES

5-36. Route planning and decision making are the primary tools to reduce exposure and avoid avalanche prone terrain and being caught in an avalanche. The following skills are critical for travel in avalanche terrain:

- Terrain analysis—military mountaineers must be able to use information from an avalanche forecast to identify and inform commanders of hazardous slopes and safe corridors within their area of operations. They must also recognize terrain traps. To travel safely below avalanche terrain, they must estimate run-out zones (how far an avalanche may travel before it stops). This can vary and is determined by snow cover and snow depth.
- Route selection—routes with terrain angles that are less than 30° and greater than 45° should be identified, and care must be taken to ensure routes are not threatened by overhead avalanche hazard. The safest routes are on ridge tops, slightly on the windward side. Valley bottoms can provide safe

routes, but lines of travel must be far from the bottom of slopes, clear of any run-out zones. Avoid cornices from above or below. Take advantage of dense timber, ridges, or rocky outcrops as islands of safety. Use them for rest stops.

- Critical weather analysis—changes in the following weather factors that increase loads on the snowpack or erode bonds will directly contribute to increasing avalanche danger:
  - Rain.
  - Snowfall of more than 2.5 cm (1 inch) an hour or more than 30 cm (1 foot) in 24 hours.
  - New or recent wind loading.
  - Rapid rise in temperature.
- Stability analysis—direct signs of instability, such as those noted below, should be viewed as clear evidence of immediate danger to Soldiers traveling in similar terrain:
  - Evidence of avalanching and recent avalanches on similar slopes.
  - Shooting cracks—a shooting crack is evidence of a slab or weak layer combination.
  - Whoomphing sounds—hollow sounds when moving through the snow. These are evidence of the collapse of a weak layer. On a steeper slope, a whoomph could trigger an avalanche.
- Deliberate triggering:
  - Types—avalanches can be triggered using explosives. Soldiers can use recoilless rifles, artillery, and mortars to trigger avalanches. Small charges of C4 explosive (1 to 2 kilograms) with a time fuse are effective if Soldiers can drop the charge to a point in the slope that triggers an avalanche.
  - Uses—deliberate triggering can be used for force protection. Soldiers can trigger small avalanches so that larger avalanches do not threaten key positions and infrastructures. Soldiers can use avalanches to deny key terrain to the enemy, and to block roads and narrow passes. Mountaineer Soldiers can use deliberate triggering of avalanches offensively to isolate elements that they desire to engage with direct fire and indirect fire assets.
  - Principles—understanding what cause avalanches and where they are likely to occur are useful for selecting the best triggering locations. Choose a point of maximum tension in the snowpack to detonate the charge.
- Planning and supervising avalanche training—leaders must ensure that all Soldiers operating in avalanche terrain practice and rehearse individual avalanche protective measures. They must be capable of coordinating and leading the rescue if someone is caught in an avalanche.

## INDIVIDUAL RESPONSIBILITIES

5-37. All Soldiers operating in avalanche terrain must be proficient in basic avalanche tasks. They must be able to travel in the terrain, be proficient with all equipment, and well drilled in tasks for companion rescue.

- Travel techniques—just as battle drills are rehearsed for tactical movement, troops moving in avalanche terrain must practice and rehearse movement techniques for limiting exposure to avalanche hazard by—
  - Having a planned and rehearsed communication strategy. Be deliberate when passing through pockets of increased hazard.
  - Zipping up clothing and other layers.
  - Posting a spotter to observe the entire element as it passes through. Send one person across at a time. Stop on islands of safety. All Soldiers should travel in the same track. Set the track high, above potential start zones.
- Avalanche safety equipment—every Soldier operating in avalanche terrain should be equipped with the three basic items of avalanche rescue equipment. They should be trained and rehearsed in their use.
  - Shovel—to dig out the victim. It should be constructed of aluminum and collapsed or disassembled in a pack where it is protected and will not be lost but easily accessed. E-tools are insufficient for this purpose.
  - Transceiver—an active radio-beacon transceiver designed for finding people buried under snow. When turned on, it broadcasts a signal that other transceivers can locate with a range of about 30 meters.
  - Probe—a long pole used to confirm the location of an avalanche victim and to measure how deeply they are buried.

- Survival—try to escape quickly out of the side of the avalanche. An alternative for if or when Soldiers are caught in the start zone and before debris gains speed is to arrest in the bed surface and let the snow flow past. If Soldiers are caught, they should discard equipment and attempt to swim to stay closer to the surface. If their head goes under the snow, they should shut their mouth and use their elbow to form an air pocket in front of their face by reaching across the body and grabbing the opposite shoulder strap of the rucksack. Many avalanche victims suffocate because their mouth and nose are plugged with snow. The opposite arm can be used to attempt to reach for the surface. Although often difficult to tell surface direction when tumbling, many victims have been quickly found when a rescuer found a hand or body part sticking out of the snow. When the snow stops, try to relax. If Soldiers feel themselves about to pass out, they should not fight it. Once unconscious, respirations are shallower, pulse rates slower, and body temperature lower, all of which help to conserve oxygen.
- Companion rescue—a fast, efficient transceiver search and shoveling are key to the survival of an avalanche victim. Avalanche rescue is covered in-depth in section III.

## SNOWPACK EVALUATIONS

5-38. Snowpack stability evaluation can be difficult in the absence of direct evidence, such as recent avalanches, whoomphing, or shooting cracks. It is also especially difficult when it has been several days since new loading has occurred (rain, new snow, wind-transported snow), several days without significant temperature changes, or in situations where a "persistent" weak layer exists in the snowpack. During these times, experienced Soldiers may use a multitude of tests to help determine stability and identify particularly dangerous terrain. These tests are limited, because their accuracy is localized to the vicinity and should only be used to determine where not to go. Typically conducted by master mountaineers, these tests require a high degree of skill and training both to perform and interpret; therefore, specific procedures are not covered in detail in this manual. Most of these tests require the digging of snow pits in safe locations that are specifically representative of terrain that is in question (same aspect and elevation). These snow pits can have a range of dimensions that can be modified depending upon the types and quantities of tests to be conducted; however, they are typically 2-meters across the slope by 1.5-meters up slope and dug to below the depth of any weak layers in question.

- Layer identification—used to identify specific areas of concern within the snowpack, for example, layers with major differences in characteristics. This could be major differences in hardness, softness, gain size, and shape.
- Shovel tilt—used to evaluate bonding between the most recent storm snow and the old snow surface. Also used to identify thin weak layers not found during layer identification. Limited to the top 45 cm of the snowpack.
- Compression test—used to locate weak layers in the top 1 meter of snow and to provide an indication of triggering potential on nearby slopes with similar conditions.
- Extended column test—used to test for the potential of crack propagation of a pre-identified slab or weak layer combination in the upper 1 meter of the snowpack.
- Propagation saw test—used to test for the potential of crack propagation of a pre-identified slab or weak layer combination that is greater than 1-meter deep.
- Rutschblock—used to test stability of pre-identified weak layers up to 1-meter deep with skis.
- Explosives—used to test slopes and trigger slides in the top layers of the snowpack. Placement in the sensitive regions of the start zone is critical for getting a reaction.
- Hasty tests (hand shear, pole plants, test slopes)—nonstandardized tests that can be used quickly while traveling in the terrain to determine signs of instability or to recognize when conditions are changing.

5-39. Avalanches pose a significant threat to Soldiers operating in mountainous terrain. Unlike fall hazards, or weather conditions, avalanche hazard is not easily observed. If units wish to maintain the ability to conduct operations during winter months or in regions of the world with the possibility of snow throughout the year, they must develop the capability to assess avalanche hazard. This means identifying individuals for further training and education, incorporating avalanche forecasts into the planning process, and ensuring that all Soldiers operating in the terrain are equipped and trained for the avalanche threat.

## SECTION III – AVALANCHE SEARCH AND RESCUE

5-40. The primary risk mitigation tool in avalanche terrain is avoidance. In the planning phase, Soldiers should make every effort to patrol routes that avoid avalanche hazards. The planning phase includes having clear decision points from which to evaluate conditions and viable alternate routes. However, when evaluating an avalanche hazard, there is often a high degree of uncertainty. When mistakes are made, the consequences are high. Avalanches produce incredible energy. Soldiers caught in an avalanche may be injured or killed by blunt force trauma from collisions with rock, ice, and trees. If they come to rest with an intact air pocket, they may succumb to hypothermia or shock. However, most avalanche victims die from asphyxiation. Without an air pocket, unconsciousness may come in minutes, followed rapidly by permeant brain injury and death. Evidence has shown that after 15 minutes, the chances of surviving complete burial decreases from 90 percent to 30 percent. It is critical that all Soldiers operating in avalanche terrain are equipped with avalanche safety equipment and are drilled in companion rescue.

# AVALANCHE SEARCH

5-41. All individuals traveling into terrain in which avalanches could possibly occur must be familiar with and carry the following equipment: avalanche transceiver, lightweight shovel, and collapsible probe. Soldiers must be adequately trained in their use during avalanche rescue.

### TRANSCEIVER

5-42. Avalanche transceivers (beacons) are radio transceivers that emit a pulsed signal. (See figure 5-8, page 76.) When turned on, they broadcast a signal that other transceivers can locate within a range of approximately 30 meters. Other transceivers can be switched into a search mode to receive that signal and find transceivers buried under the snow. Soldiers should wear their transceiver over the top of their base layers but underneath insulating layers that may be removed or added throughout the course of the day. Soldiers should always wear their transceiver below a layer to protect it in case of an avalanche.

5-43. Electronic interference has been shown to interfere with the range and accuracy of avalanche transceivers, especially in search mode. Manufacturers recommend that transceivers are worn 30 cm (12 inches) away from any radios, cell phones, and GPS devices to ensure that there is no metal or reflective material (such as meals, ready to eat wrappers) in the area around where the device is worn. This may not be possible when wearing combat equipment, but in a training environment, every effort should be made to adhere to manufacturer recommendations. In search mode, manufacturers recommend that Soldiers turn off all other devices and keep the transceiver at least 50 cm from other devices. If possible, Soldiers with radios and active electronic equipment should delegate transceiver searches to those without electronic equipment and radios.

### SHOVEL

5-44. Shovels suitable for avalanche rescue are lightweight and made of aluminum. They are durable enough to cut through dense avalanche debris but light enough to for Soldiers to carry while skiing or mountaineering. Soldiers can collapse or disassemble their shovel to carry it inside their pack. Soldiers should pack their transceiver, so it is quickly accessible. (See figure 5-8, page 76.)

### PROBE

5-45. Probes are used to confirm the location of a burial before digging. Probes are approximately 3-meters long. They collapse to fit disassembled inside a pack but deploy quickly with a pull of the connecting cable. They should lock into place automatically. Soldiers should carry their probes inside their pack in a location where it is protected and immediately accessible.

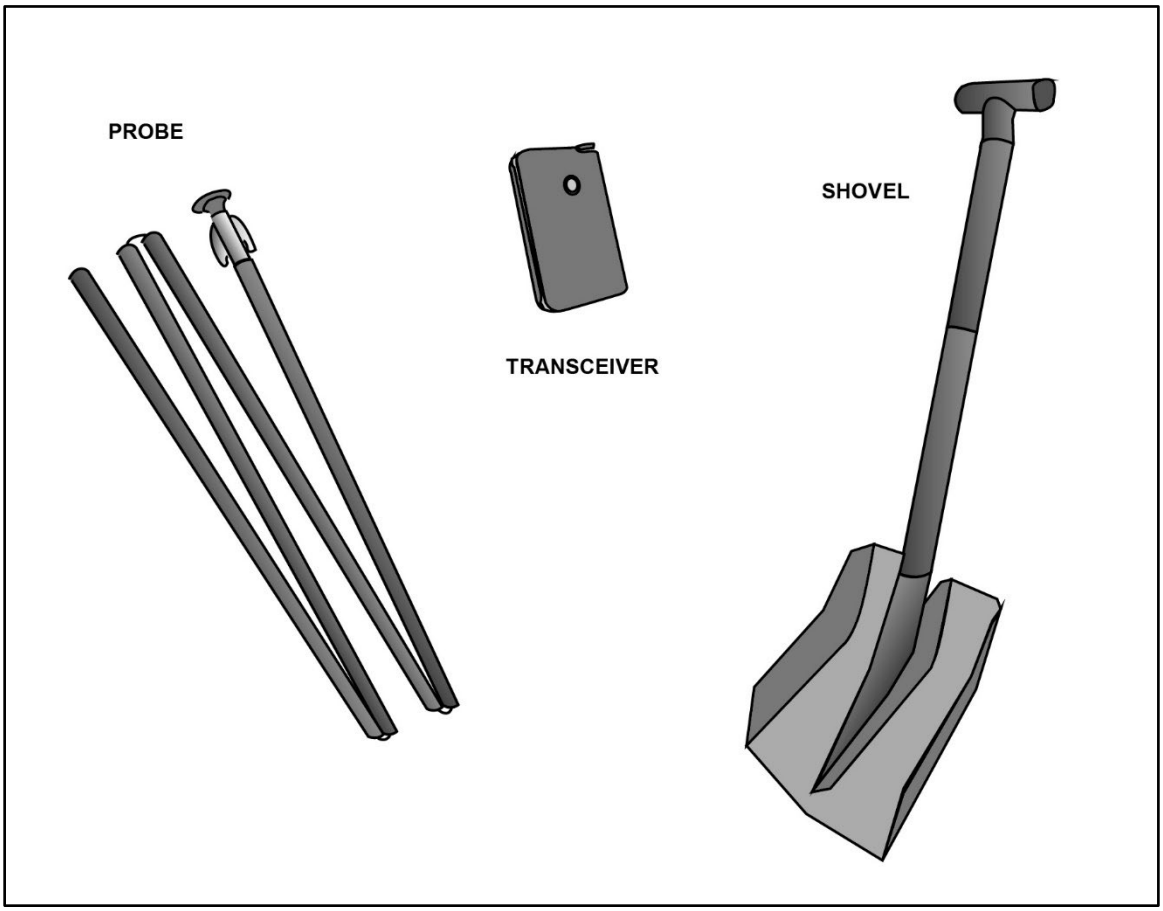



**Figure 5-8. Individual avalanche equipment**

# GROUP CHECKS

5-46. All Soldiers must be familiar with the group avalanche equipment functions check process before movement into avalanche terrain. All leaders must be familiar with conducting these functions checks to ensure that their unit is prepared to respond to an avalanche burial event. All Soldiers must be familiar with avalanche response actions. SOPs and rehearsals should be conducted in the same manner as battle drills.

## PRECOMBAT CHECKS

5-47. Soldiers must be trained and familiar with each equipment item and how it functions. Individual and team rehearsals, transceiver checks, and rescue drills are necessary:

- Check that individual rescue equipment is functional and stowed appropriately.
- Conduct verbal rehearsals of all avalanche tasks, movement through danger areas, and avalanche rescue.

## TRANSCEIVER CHECK

5-48. A group check confirms that each member of the element knows how to turn on the device and switch between modes, ensures that every device can receive and search for a signal, and that every device transmits a signal. Manufacturers recommended procedures for group checks might vary.

- Locate an area away from other groups that may cause conflicting signals. Stand in a half circle an arm's length or more apart, with the leader a few meters away in the middle of the group.
- Turn transceivers on. As the transceivers power on, each individual confirms that the transceiver runs a self-check, and the display is ok. Note battery strength and report it aloud to the group. For

patrols or missions lasting less than 24 hours, battery life should be a minimum of 50 percent. For multi-day missions, each Soldier should begin with fresh batteries.
- Switch all transceivers to search mode. Silence indicates that everyone is ready and ensures that no transmitting units are in packs or sleds.
- The leader then switches to transmit/send and checks that each group member can receive a signal by walking toward each group member one by one while group members read their display aloud.
- Turn all units to transmit. The leader ensures that group members stow their unit for the day, secured under an outside layer, and 30 cm from a cell phone or radio.
- The leader returns to Search mode and confirms all group members are transmitting. The check-leader then switches to transmit mode and confirms to at least one group member, who also verifies that the leader's device is transmitting and properly stowed.

# AVALANCHE RESCUE

5-49. Units must be prepared to conduct avalanche rescue when operating in avalanche terrain. Avalanches, especially those involving Soldier burial, will significantly affect tactical operations. Commanders must provide clear guidance regarding subordinate unit response to avalanche burial events during tactical operations. This guidance should cover avalanche victim rescue priority in relation to mission conduct, affected unit response SOPs, higher unit response capabilities and SOPs, and reporting expectations. Maneuver units must be capable of finding and digging out victims quickly. Unit commanders must plan for and be prepared to organize rescue operations for avalanche mass casualty events, as well as deliberate body location and recovery.

## ORGANIZING THE RESCUE

5-50. The normal chain of command may be broken if a leader is buried or separated. Everyone should be prepared to organize and take charge of a rescue. Every Soldier must be prepared to make critical decisions and tasks for an efficient and successful rescue.
- Assess safety—determine if there is further avalanche hazard. If there is risk of secondary avalanches (hangfire), limit the number of personnel exposed to further hazard. Post a watch and a relay to maintain communications.
- Headcount—get an accurate headcount to find out how many Soldiers are buried.
- Report or call for help—do not waste time; report the accident to get resources moving if a Soldier needs them. If possible, delegate and leave a relay up high to maintain communications. Do not let radio operators in the rear or at a dispatch delay or interfere with the rescue.
- Switch all transceivers to Search mode—physically ensure that all unit members have switched their transceivers to Search mode to avoid disrupting the searchers. Just one rescuer still transmitting will confuse the searchers and waste precious time.
- Assign roles—in small teams, everyone may need to help with the transceiver search. In a larger group, assign some to search and others to prepare probes and shovels.
- Determine where to search—the spotter should have been able to observe a point last seen. Search the fall line below the point last seen. Search the run-out zone and other areas of deposition, such as terrain traps. Search in line with equipment clues if they exist.

## TRANSCEIVER SEARCH

5-51. Transceiver searches involve three distinct phases: signal search, course search, and fine search.
- Signal search—begin searching for a signal. Get all the searchers online with 40-meter spacing to ensure that the search ranges overlap across the entire search area. If alone, or covering a very wide search area, use a search pattern that covers the entire path. Movement should be rapid but deliberate. Keep eyes up, searching for physical clues. (See figure 5-9, page 78.)
- Course search—once a signal is found, the transceivers change tones and light up with a distance and direction. Slow down and follow the arrow. Communicate with the other searchers, calling out the distance reading. At 10 meters, slow down even further. Ensure the transceiver aligns with the direction arrow. Continue moving slowly and bring the transceiver lower and closer to the surface of the snow. Avoid sudden movements or changes in orientation.

- Fine search—inside 3 meters, transition to a fine search. The transceiver should be moving in a plane just above the surface of the snow. Maintain orientation throughout the rest of the search. Do not twist or turn it. Continue the azimuth of approach until the numbers start to rise. Return to the low point, and search side to side, far enough to see the numbers rise, returning to the point with the lowest number.

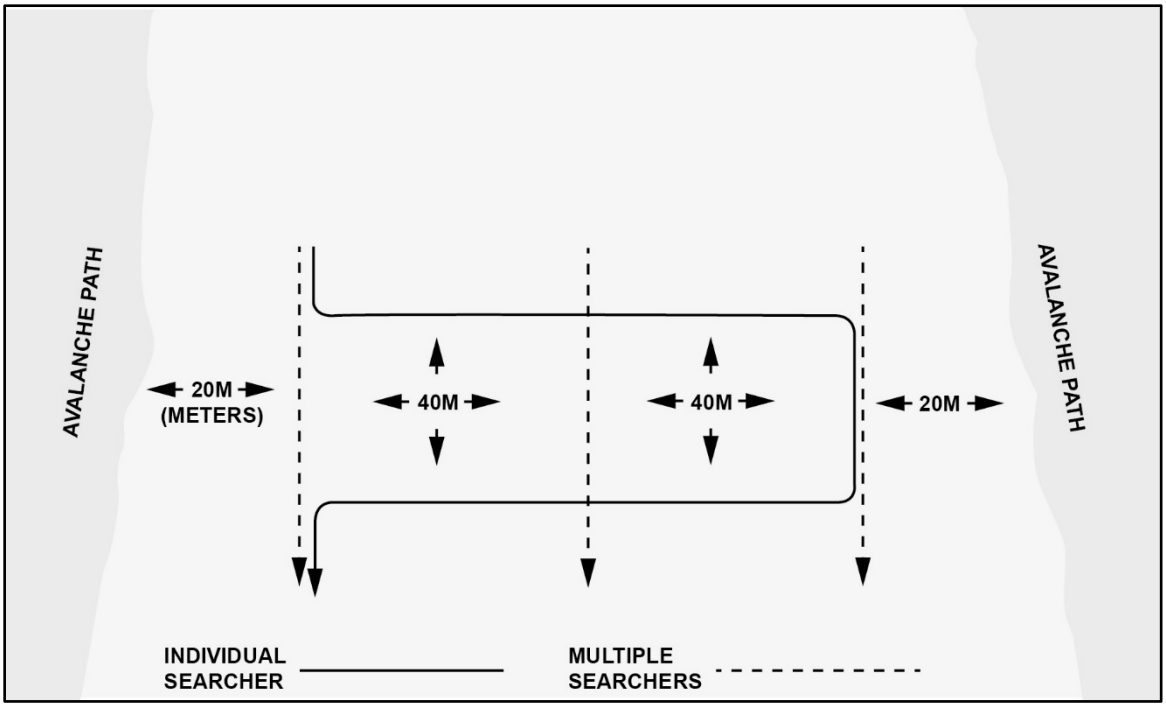



**Figure 5-9. Signal search**

## PROBING

5-52. Mark the lowest point with a foot or hand. Probe at the low point, perpendicular to the snow surface. Probing must be conducted with both hands. (See figure 5-10.) If no strike is felt, probe again 2 cm uphill and continue to probe in a spiral search pattern. Once a probe strike is achieved, do not remove the probe. This probe is a valuable reference point that must be visible to ensure Soldiers do not waste effort and energy during shoveling.

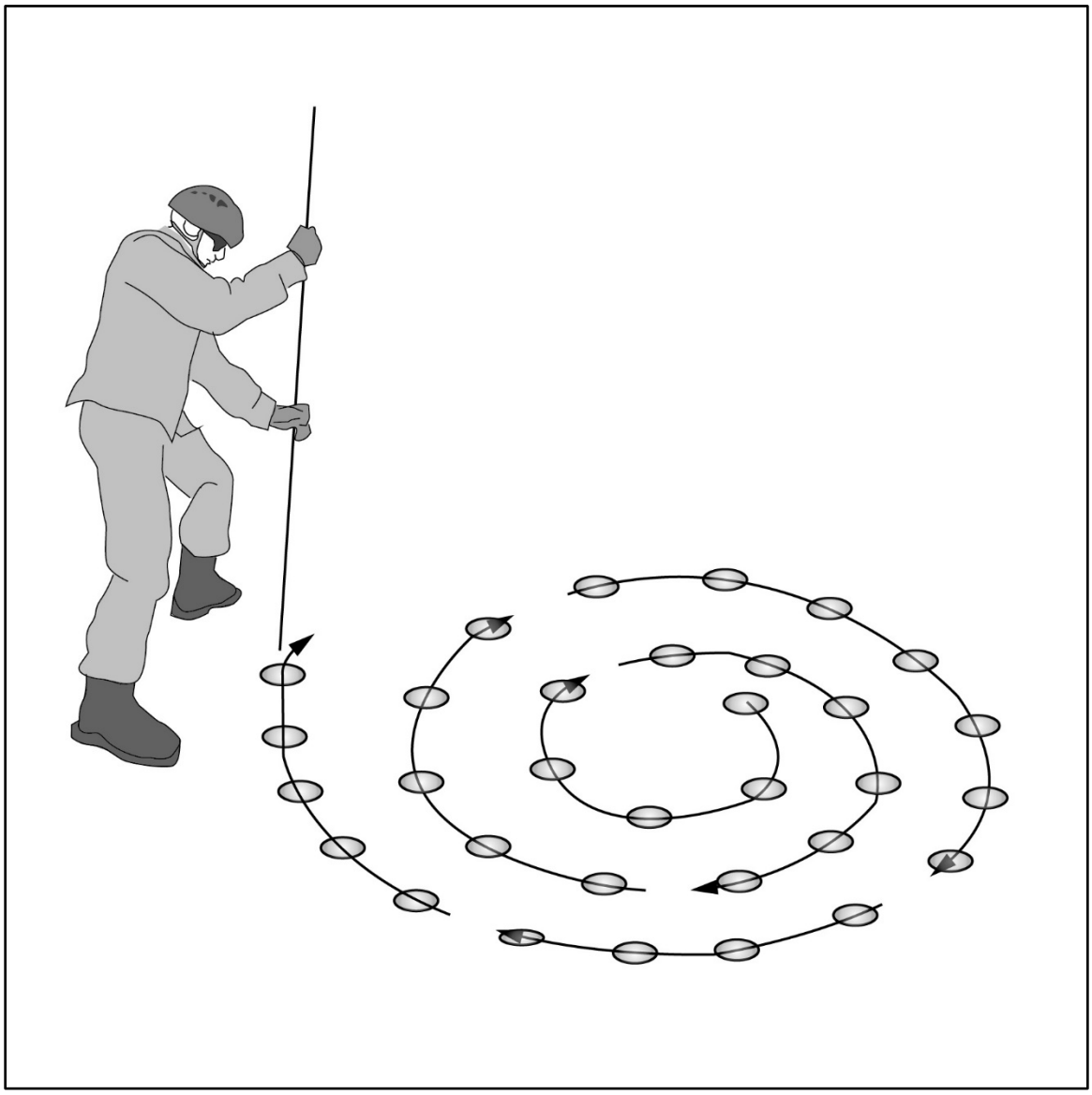


**Figure 5-10. Probing**

## SHOVELING

5-53. Upon probe strike, take 1 large step downhill, 2 steps for a deep burial (greater than 2 meters). Rescuers should excavate snow from the side so that they are not lifting snow out of a hole. They should dig towards the probe and throw the snow far away while shoveling as fast and hard as possible. If there is a large group, rotate personnel often. Those who are not shoveling in the hole should continue to move snow out of the way and widen and improve the platform the others are creating. Everyone must prepare to switch out often so that those shoveling are doing so at maximum capacity. (See figure 5-11, page 80.)

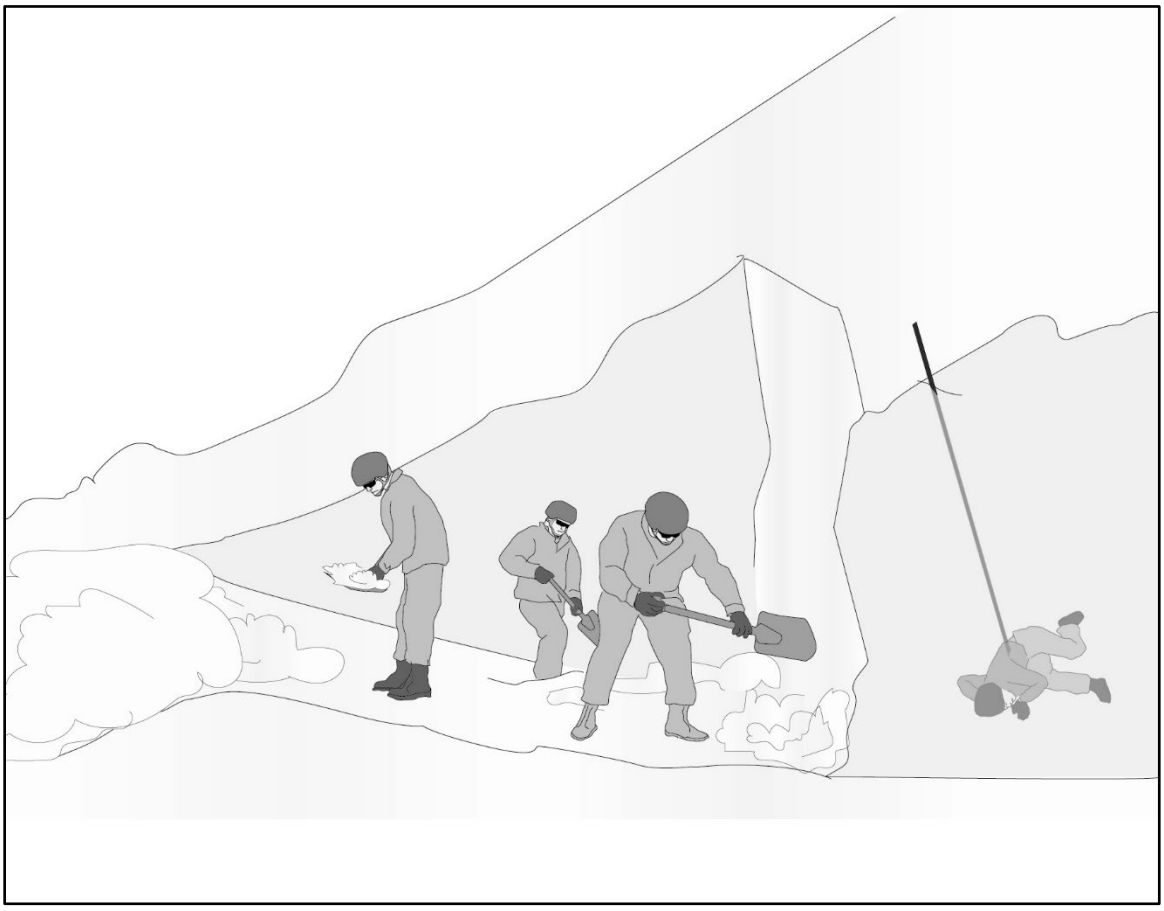


**Figure 5-11. Shoveling**

## PATIENT CARE

5-54. Work to clear the victim's airway as soon as possible. Provide first aid and CPR as required. With long burials where there is a risk of hypothermia, move the patient gently. Move the patient to safe terrain and begin planning for evacuation.

## PROBE SEARCHES

5-55. Avalanche burials longer than 15 minutes can result in permanent brain damage and death. If victims are going to be saved, it is critical that it is done quickly. If the Soldier is not wearing a transceiver, the likelihood of finding them in time for survival is small.

5-56. If transceivers are unavailable, it is likely there are no probes available either. Soldiers can use their ski poles with the basket removed to begin initial probing attempts. If there is any hope of success, searchers must focus their efforts on the most probable locations.

- Start the search from the point last seen.
- Look for equipment clues. Gloves, hats, ski poles, packs—all may give clues to the trajectory of the victim or may still be attached. Pull each out of the snow to confirm.
- Most buried victims are carried to the place of greatest deposition, usually the toe of the slide. Any terrain features that catch and hold avalanche debris, such as outside curves, are also likely locations.
- Vegetation, rocks, and other obstacles act as strainers and may catch or slow the victim.

## PROBE LINES

5-57. For body recovery of individuals without transceivers, it may be necessary to locate them using a probe line. A probe line is a systematic search, online, through the entire debris field. It is a slow process and requires many rescuers. A probe line is not appropriate when there is still an overhead avalanche hazard.

5-58. There are two distinct probing methods: coarse probe and fine probe. Coarse probing is intended to be fast, with wide spacing of probe insertions. Fine probing involves close-spaced probing with an emphasis on thoroughness. The coarse-probe technique has about a 70-percent chance of locating the victim on a given pass, while the fine probe has closer to a 100-percent chance of locating the victim.

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# Chapter 6
# Mountain Mobility

A unit's ability to maneuver through difficult and hazardous terrain provides it with access to the most tactically advantageous areas in the mountains. Units with Soldiers trained to a high level of mobility can move further, faster, and more safely through all levels of terrain. Mobility skill is the primary tool to manage risk when there is a fall hazard. Rope systems and belays can be used to mitigate fall risk during movement but require more time to complete, more technical training to accomplish, and can result in increased exposure to enemy attack. By far, the greatest combat multiplier in the mountains is high mobility skill. Units anticipating combat operations should focus on building individual movement skills over nearly all other special technical or tactical skills.

## SECTION I – INDIVIDUAL MOVEMENT TECHNIQUES

6-1. The speed at which the unit can move, the complexity of terrain they can negotiate unroped, and the violence of action they can muster as a team on the objective are all determined by the mobility of the unit's weakest members. Properly equipped units with mobility skills are more likely to outmaneuver the enemy in physically demanding and hazardous terrain. Soldiers who have been trained in mobility techniques can take advantage of terrain above operational level 2. This provides commanders with access to the highest and most difficult to reach points of domination in their areas of operation. For those untrained in mountaineering, such terrain can prove too hazardous to move in. However, units well-trained to maneuver here can take advantage of reduced combat risks during all types of combat operations by owning ground that most enemy forces cannot access, granting them overwhelming tactical advantage. As a result, individual mobility skills training should always be a high priority for units anticipating these operations.

## MOBILITY

6-2. Individual mobility comprises many factors, the most important of which are fitness and movement techniques. Soldiers can increase their mobility by practicing the movement techniques specific to negotiating rough terrain. Soldiers build proficiency by approaching movement from a skill-building perspective, whether the movement is walking, scrambling, or climbing, and regardless of whether the surface is dirt, rock, snow, or ice. The hallmarks of mobility are balance, surefootedness, and net endurance. The results are reduced likelihood of slipping or falling, reduced energy expended, increased speed, and the ability to focus on other critical tasks. A reasonable goal for Soldiers is the ability to move confidently through 3rd-class terrain unroped, even when exposed to fall hazards that would result in significant injury or death.

### BALANCE

6-3. The most important aspect of mobility is balance. Soldiers who learn to move in such a way that their body is rarely out of balance will display a higher level of surefootedness and endurance than ones who have not mastered this skill.

6-4. Moving in balance requires a basic understanding of how the human body moves, how gravity and other forces act upon it, and how to counteract them. In the beginning of skills development, Soldiers can build knowledge by paying attention to when they feel out of balance, such as when they are stepping around, over, or under small obstacles in their path. Carrying a pack or heavy tactical equipment high on the body will increase the effort required to stay in balance.

6-5. As Soldiers begin to identify when movements put them out of balance, they should begin to experiment with adjusting body position, or foot placement, to maintain the feeling of being in balance. Early in training, achieving a less out-of-balance feeling may be the best a Soldier can achieve. Through practice, this will improve.

6-6. The complexity or severity of the terrain will determine the difficulty of the movement techniques and body positions required. Techniques for 5th-class rock climbing are much less intuitive than those necessary for hiking, but the principles for building skill are the same for both, and across the spectrum of difficulty.

6-7. With enough focus and practice, Soldiers will develop enough skill that moving becomes natural and requires little effort. At that point, they can focus on other mission critical tasks, such as navigation, security, communicating, firing weapon systems, moving casualties or any other complex tasks without the distraction of trying not to fall.

### FITNESS

6-8. Soldiers develop and improve their mountain fitness through strengthening muscles that move and stabilize the body. Although strength in some large muscle groups is useful to move the body uphill against the pull of gravity, muscles used in maintaining balance are far more important. Recovering from a slip or stumble requires far more energy than just maintaining balance and footing in the first place. Well-developed supporting and stabilizing muscles prevent these slips and stumbles and reduce the burden on large muscle groups. In this way, mountain Soldiers are better at controlling corrective movements and conserving energy, which reduces fatigue and results in greater endurance over the course of a movement. (See FM 7-22 for more information on training specific muscle groups.)

6-9. Flexibility is another important aspect of fitness. Soldiers who are flexible have a greater range of movement. Soldiers with low flexibility may not be able to perform movements necessary to negotiate some obstacles. Soldiers should develop flexibility along with strength when training for mobility in the mountains.

6-10. General combat fitness does not translate to mountain fitness. Ruck marching, especially over relatively level ground, does not develop the balance and flexibility necessary for movement over rough, broken, and steep terrain. Upper body mass developed through heavy body building regimens does nothing for dismounted mobility and little for scrambling and climbing. A holistic approach to fitness is necessary. Physical training plans must balance combat fitness and mountain fitness requirements to best prepare Soldiers for combat action.

6-11. A Soldier's role within the unit should be considered when training for the physical requirements of the mountains. An advanced military mountaineer who will be responsible for regular movement in 4th- and 5th-class terrain requires a higher level of mobility than a machine gunner does.

## MOUNTAIN WALKING

6-12. Most terrain negotiated during combat operations in mountainous terrain requires only well-developed walking skills. However, this terrain is typically undeveloped, broken, steep and covered by loose dirt, rock, or snow. Surfaces are often slick. Heavy loads, nonuniform stride, and unpredictable footing challenge Soldiers moving in any of these conditions. Half of the battle for mountaineers is knowing where to step under these variable conditions to gain maximum traction, and the other half is knowing how to position their body to ensure their footing holds.

### TYPES OF TERRAIN

6-13. Typically, mountain-walking terrain is considered class 1 and 2 terrains, but these skills are equally important in terrain that is more difficult. Mountain-walking techniques provide the foundation for higher-level skills, such as climbing. They require the same level of focus and practice to master.

### MOBILITY EQUIPMENT

6-14. Quality footwear, such as mountaineering boots, reduces many risks associated with moving in mountainous terrain. Quality boots increase both mobility and security of footing and can reduce orthopedic injuries. Boots designed for mountaineering range in weight, breathability, flexibility, and in how well they interface with other equipment. The rand helps protect the toe area from sharp rock and standing water. They have a high enough upper boot to protect the wearer's ankles from sharp rock and provide joint support against rolling. They have recessed soles made of softer rubber, a protective band around the forefoot, at least a partial shank, and are constructed with abrasion and water-resistant materials. Mountain boot soles are designed for traction on dirt and slick rock alike. Their stiffer, stickier rubber soles provide a significant advantage when climbing.

6-15. Quality socks are more durable, help reduce blisters, better manage moisture, and dry faster than other materials.

6-16. Good quality insoles are critical to reducing minor foot injuries, such as blisters, during movement in rough, rocky terrain that can interfere with mission completion if they progress untreated.

6-17. Most Soldiers do not require special packs in walking terrain if they assemble their packs neatly and do not overload them.

6-18. The rucksack is the issued, modular lightweight load-carrying equipment (MOLLE) pack. The carry harness should be adjusted to the body of the Soldier carrying it. Soldiers should place heavier items close to the frame. Heavy items attached to the outside of, or higher on the pack, increase strain on the Soldier and raise the Soldier's center of gravity, increasing the effort required to stay in balance. Soldiers should remove large pouches that they usually attach to the outside of MOLLE packs to streamline the pack and reduce its likelihood of being caught on obstacles. Soldiers should use compression straps to prevent loads from shifting and throwing them off balance. They should use waist belts to support the weight on their hips and lower their center of gravity.

6-19. Mountaineering packs are designed to be slimmer, taller, and lighter than Army packs. Typically, mountaineering packs are not designed with organization and accessibility in mind but rather to consolidate loads close to the body and to make movement and balance easier. They are generally less durable than Army packs; however, crossover packs, designed for remote mountain hunting, provide an excellent middle ground. The drawback of crossover packs is the high expense.

6-20. Using assault packs when walking terrain can reduce the negative impact on Soldier mobility if loads are not too heavy. Their lack of a rigid frame means that they provide less support. If lashing items to the outside of the assault pack becomes necessary to carry all required items, then carrying a properly loaded MOLLE pack is probably less detrimental to the Soldier's mobility.

## GRASSY SLOPES

6-21. Grassy slopes are usually composed of small tussocks of growth rather than one continuous field. When ascending, step on the upper side of each hummock or tussock, where the ground is more level. When descending a grassy slope, climbers should use the traverse technique because of the uneven nature of the ground. A climber can easily build up too much speed and fall if a direct descent is attempted. When traversing, the climber's uphill foot points in the direction of travel. The downhill foot points about 45° off the direction of travel (downhill). This maintains maximum sole contact and prevents possible downhill ankle rollout.

## MOUNTAIN WALKING

6-22. Two critical skills in mountain walking are selecting foot placements and moving the body in a way that maintains balance with each step. (See figure 6-1, page 86.) These skills increase the security of foot placements and decrease slips. Surface characteristics vary greatly in mountains, and Soldiers should experiment with various features and surfaces in their operational environment. To obtain maximum traction on a given feature, Soldiers must position their bodies so that their weight pushes perpendicularly against the feature. Soldiers must reposition their body with each step to do this and should try to gain as much sole contact as possible to achieve maximum friction. As Soldiers become familiar with surface characteristics in their area of operation, they learn just how much friction is necessary for the footing to hold on various features such as the following:

- Common microfeatures that can provide greater footings are flat spots, small divots, or depressions, the uphill side of stable rocks and tussocks, rough rock features, dry spots, rough or heavily featured rock, and stable compact dirt.
- Common microfeatures that make traction more difficult to achieve and that should be avoided if possible are smooth features, loose dirt or small rocks, wet spots, and any surface covered with loose debris, such as leaves or small sticks.

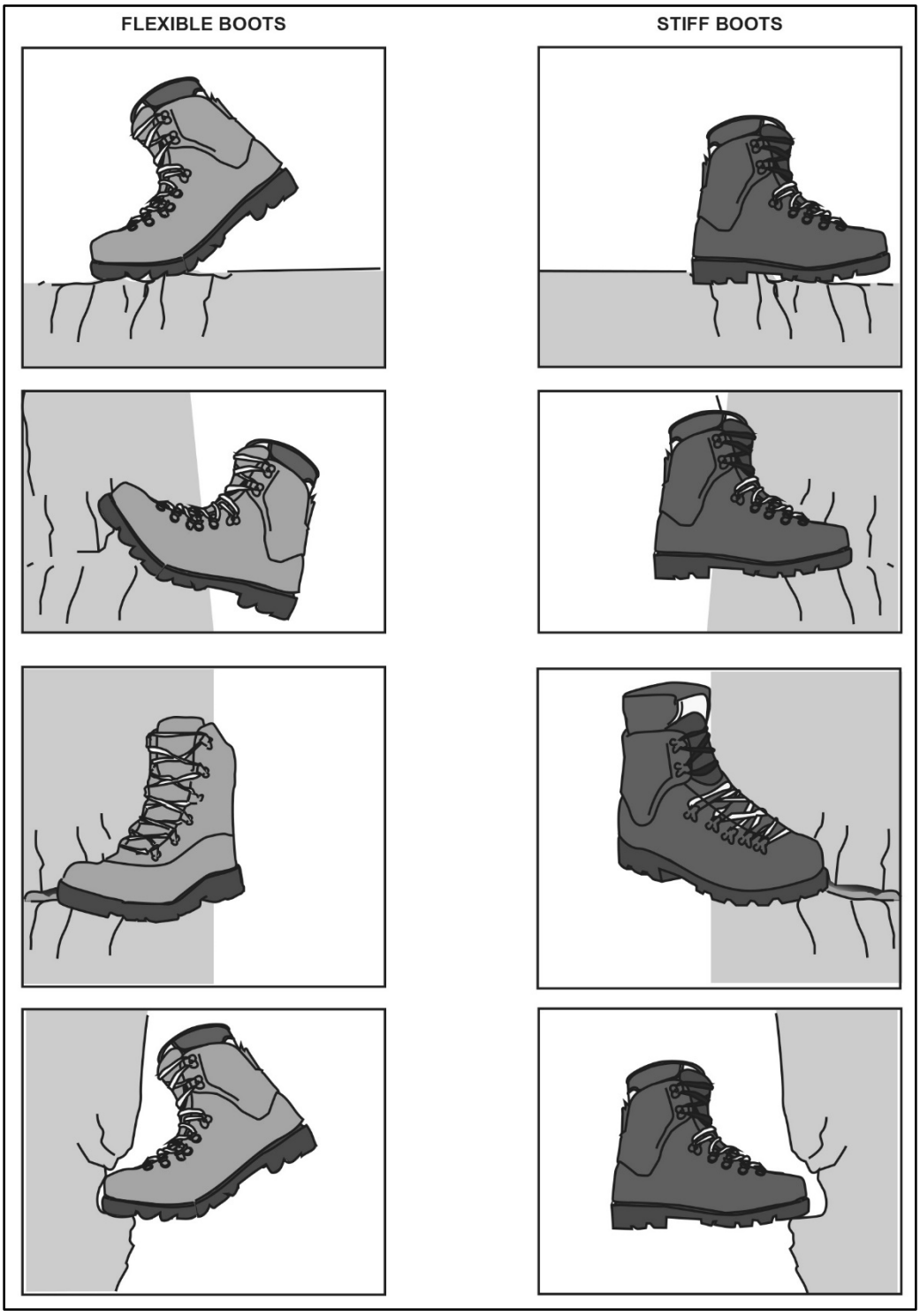



**Figure 6-1. Foot placement**

6-23. Selecting reliable foot placements is even more difficult while descending. This is primarily because they must be made dynamically (while stepping down) and often out of their ideal body position. This prevents the Soldier from testing the placement before committing weight. If a slip occurs, momentum increases the likelihood of a fall or tumble.

6-24. General techniques for ascending:

- As terrain becomes steeper, routes should adopt a traversing or switchback pattern. This involves moving diagonally up and across a slope, then turning back and doing the same in the opposite direction as necessary. This switchback pattern reduces the intensity and demand on large muscle groups, slows the onset of fatigue, and allows Soldiers to maintain situational awareness. Charging in a straight line up a steep hill is more demanding, results in more extreme fatigue and longer recovery time, and increases the likelihood of slips, falls, and injury. This technique should be avoided unless speed is critical, and all members of the group are highly fit and experienced moving this way.
- The rest step technique involves locking out the rear leg briefly with each step. This gives muscles a micro rest with each step and results in greater endurance over long movements. (See figure 6-2, page 88.)
- Pressure breathing—this technique involves breathing all the way out on the exhale to empty the lungs of air. This does two positive things. First, it ensures all carbon dioxide is pushed out of the lungs, reducing the likelihood of cramping, and making more space for oxygenated air. Second, the negative pressure created in the lungs makes it easier to pull lower pressure air into them when moving at higher altitudes.

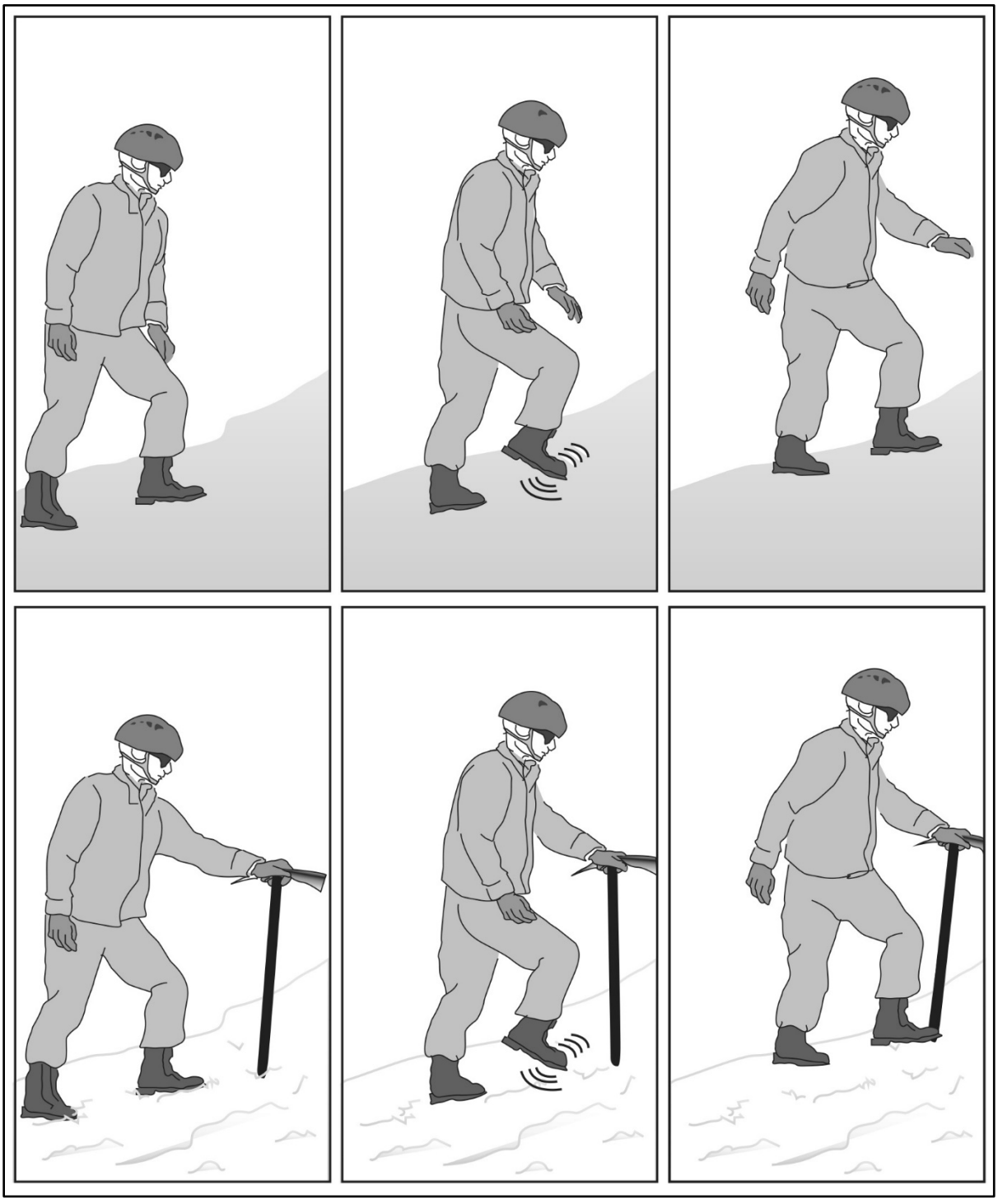


**Figure 6-2. The rest step**

6-25. General techniques for descending:

- Whenever Soldiers must use a questionable foot placement, they should identify a quick plan for how they will react prior to stepping down.

- Soldiers should ensure they bend their knees when stepping down to reduce impact on their joints. Prolonged descents often prove painful, and they could sustain long-term damage if they do not take measures to protect their joints under heavy loads.
- Poles are helpful when descending. They make it easier to stay in balance and allow the arms to absorb or reduce much of the impact on lower extremity joints. Even one pole can be very helpful.
- When Soldiers are new to walking in the mountains, it takes more focus to do so effectively. They move slower, but they benefit by moving at a rate that allows them to remain in balance without slipping and stumbling. Additionally, they improve mountain walking skills when allowed to move a little slower during training, becoming faster and more efficient in the end. Leaders should look at every dismounted movement in training as an opportunity to improve.

6-26. When a moderate pace is set, the need for rest halts decreases and the chance of personnel overheating lessens. Typically, shorter breaks taken more often are better than long breaks, especially in colder weather. However, leaders should consider fitness level, difficulty of the terrain, length of movement, speed, load, and level of fatigue when determining rest durations.

6-27. During the first half-hour of movement, an adjustment halt should be taken. Soldiers will loosen or tighten bootlaces as needed, adjust packs, and add or remove layers of clothing.

## Brush

6-28. Brush is both a help and a hindrance. Brush-filled gullies can provide routes and rally points concealed from observation; on the other hand, steep, brushy terrain is hazardous to negotiate. Cliffs and steep ravines are hidden traps, and blow downs and thickets can obstruct travel as much as manmade obstacles. When brush must be negotiated, take the most direct route across the obstacle; look for downed timber to use as raised paths through the obstacle; or create a tunnel through the obstacle by prying the brush apart, standing on lower branches, and using upper limbs for support.

## Dirt and Rocky Terrain

6-29. Surfaces comprised of mixed dirt are very common in mountainous terrain. As the terrain gets steeper and rockier, it typically becomes rougher and looser. This may require slowing the rate of movement to one that is maintainable by the less fit and skilled or overburdened members of the group. If this is not done, they are at risk of falling out or injury while struggling to catch up.

6-30. Hard ground is firmly compacted, rocky soil that does not give way under the weight of a Soldier's step. It is usually found under mature forest canopy, in low brush or heather, and areas where animals have beaten out multiple trails. When ascending, employ the rest step to rest the leg muscles.

6-31. Scree fields are comprised of loose rock approximately fist-sized or smaller, that are common in the mountains and are a challenge to ascend. The experience is like climbing sand, except that the loose rock can be rough on ankles and lower legs. Climbers should avoid ascending scree fields, if possible, as they demand the expenditure of much more energy than other surfaces. Soldiers should kick in with the toe of the upper foot so that a step is formed in the loose scree. After determining that the step is stable, the Soldier transfers weight to the upper leg, then steps up, and repeats the process with the lower foot. Traversing scree is very difficult, as the loose stones slide out from under the foot downslope with each step. On the other hand, they are often a good option for descent routes. Greater focus on maintaining balance is required since foot placements are invariably unstable. The best method for descending scree slopes is to come straight down the slope using a short shuffling step with the knees bent, back straight, feet pointed downhill, and heels dug in. When several climbers descend a scree slope together, they should be as close together as possible (one behind the other at single-arm interval) to prevent injury from dislodged rocks. Avoid running down scree as this can cause a loss of control.

6-32. Talus fields are comprised of larger rocks. Often these rocks are loose and present a hazard to Soldiers moving through them. Soldiers must choose their foot placements carefully, often testing rocks to ensure they are stable. Typically, talus is easier to ascend than scree or loose dirt, but it is still demanding physically. Often it requires occasionally using hands for balance on steeper slopes. If a talus field is particularly unstable, then the switchback travel technique may not be appropriate for larger groups to use, as the risk of Soldiers higher on a slope knocking off a rock that hits Soldiers lower on the slope is potentially high.

### SCRAMBLING

6-33. Scrambling is the act of moving over difficult or broken terrain, characterized by using mostly walking techniques but requires some use of the hands for balance or other specific climbing techniques. It is perhaps the most dangerous means of mobility in which snow and ice are not present. At the lowest level, scrambling involves simply placing a hand or hands on features periodically to help maintain balance and improve efficiency during movement. At the higher level, scrambling involves Soldiers making multiple easy rock-climbing moves, followed by several steps walking, and repeating that sequence throughout an ascent.

6-34. Typically, 3rd-class terrain is where Soldiers begin scrambling, but just exactly what terrain and terrain features require is determined largely by the mobility skill of the individual Soldier. Soldiers with low-mobility skill will need to use hands more often, especially if a fall risk is present, which will slow their movement. Soldiers with higher mobility skills need to use their hands less often for balance enabling them to move faster even when a fall risk is present.

6-35. The higher the rock-climbing skill, the more quickly, efficiently, and safely Soldiers can scramble. The best way to train Soldiers to be better at scrambling is to provide rock-climbing training. Rock climbing is easier to protect with ropes and forces Soldiers to use better movement techniques even though rock-climbing training involves steeper and more difficult terrain.

### SCRAMBLING DURING MILITARY OPERATIONS

6-36. Scrambling terrain can be some of the most dangerous terrain through which Soldiers can move. Often it is the low ground between higher terrain features or cliffs, subjecting it to falling object hazards and significant tactical disadvantage. Additionally, it can be exposed to fall hazards below.

6-37. Good reconnaissance and route planning are critical for movements through scrambling terrain. Whenever possible, small teams of advanced military mountaineers should be sent to find the best route ahead of the main body.

6-38. Maneuvering is incredibly difficult in terrain that requires a lot of scrambling. If enemy contact is a possibility, bounding overwatch must be used to ensure security during movement. Small teams may need to be sent forward to clear points of domination over the route. Sniper or machine gun overwatch positions may need to be established to cover movement through sections of terrain that is particularly exposed to enemy attack. All these security measures increase movement times significantly. (See ATP 3-21.50 for VDA-crossing TTP.)

6-39. Two-point slings should be used to secure rifles close to the body. Heavier weapon systems, such as sniper rifles and machine guns, may need to be secured to rucksacks close to the body during sustained scrambling to allow Soldiers to use their hands freely for assistance.

### SCRAMBLING CONSIDERATIONS

6-40. There are no scrambling specific movement techniques, but greater care in selecting hand and footholds is often necessary given the nature of the terrain. Possessing rock-climbing skills (discussed later in the chapter) increases the efficiency with which Soldiers can scramble. Vegetation may appear to provide good handholds but may easily pull free. Large boulders or masses of loose rock may be knocked free without warning. Groups should move in such a way that Soldiers further back in the formation are not subject to rockfall from those above. Some scrambling terrain may require simple fixed lines to aid movement. This is even more likely during descending. These sites must be identified, planned for, and established prior to the main body arriving for efficiency. (See chapter 11 for more techniques for moving on ropes.)

## CLIMBING ROCK

6-41. Climbing rock, typically 4th- and 5th-class terrain, requires a very high level of skill, especially when done for sustained periods. The probability and consequence of falls are high, even under the best conditions. Rope systems are usually necessary to protect climbers from injury or death, slowing movement and reducing tactical maneuverability.

6-42. Building rock-climbing skill increases the confidence and speed at which Soldiers can move unroped in easier terrain, even when subjected to higher fall consequence. Soldiers who possess moderate

rock-climbing skills can maneuver more safely and efficiently unroped in easy terrain. This should be the goal for level 1 mountaineers. Soldiers with high rock-climbing skills can do the same in moderate terrain. This should be the goal for level 2 mountaineers.

6-43. The basic principles of rock climbing are the same as walking in rough terrain; they are just more difficult to achieve, and the required movements less intuitive. Selecting hand and foot placements can be much more difficult, and the movements and body positions required for them to hold can be challenging to perform. Experience built through climbing terrain more difficult than would need to be accessed in military operations is the path to building rock-climbing skill.

## CLIMBING EQUIPMENT

6-44. Climbing shoes are small, lightweight, close-fitting shoes with a smooth, soft, rubber sole used by recreational climbers, which increase the precision in which weight can be applied to small rock features. They contain hook-and-loop fasteners or laces to secure to the foot, and they are designed for various levels of climbing difficulty. The tighter, stiffer, and more downcurved the toe is, the more difficult the terrain (YDS 5.9 and higher) for which they are designed. Typically, climbing shoes are not appropriate for military applications because they are much more uncomfortable to wear for long periods and unsuitable for walking even short distances. However, these are an excellent choice for advanced military mountaineers looking to improve their skills using established routes off military installations, where climbing with muddy boots may be frowned upon. A moderate climbing shoe that is comfortable for the Soldier to wear for long periods is sufficient in training and (rarely) operationally. Operationally, climbing shoes are only appropriate to small, assault climber teams that must guide or establish routes for others in the most difficult operational terrain. (See figure 6-3.)

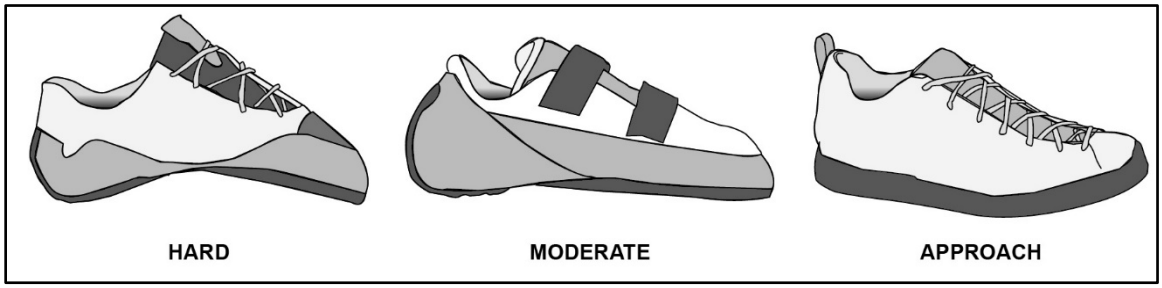



**Figure 6-3. Rock-climbing specific footwear**

6-45. The issued advanced combat ballistic helmet provides sufficient protection from head impacts during a fall and from small falling objects. However, it is not designed to absorb large impact from above, and its weight introduces substantial additional fatigue during sustained climbing. Rock-climbing helmets are very lightweight and are designed to protect the wearer against impact from falling objects but do not provide a means of mounting night vision devices. Plastic, tactical bump helmets offer a reasonable compromise for military rock climbers as they provide the best combination of top- and side-impact protection, the ability to mount night vision devices, and weight savings. Commanders must consider risks when determining headgear requirements for Soldiers during rock climbing. It is recommended that lead climbers use, at a minimum, a lighter-weight helmet. (See figure 6-4, page 92.)

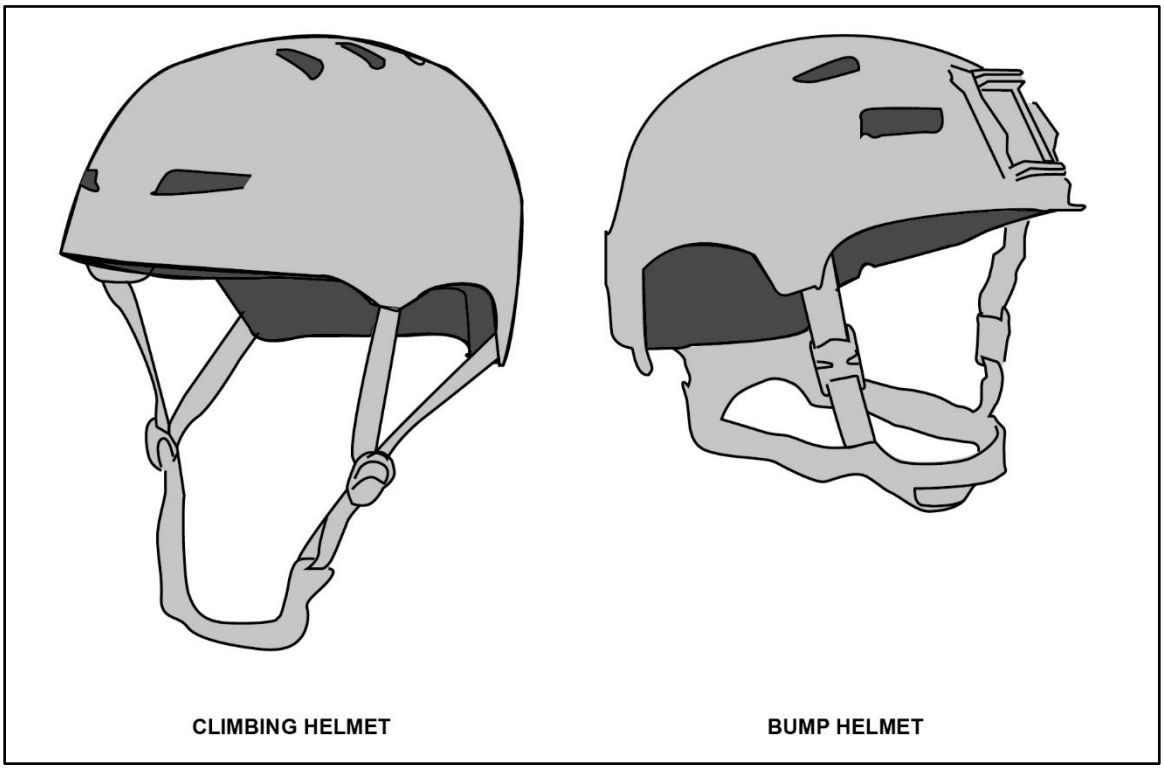



**Figure 6-4. Climbing helmets**

6-46. The issued MOLLE pack is not suited for rock climbing. Its size, empty weight, and width interfere with movements necessary for even moderate climbing. When loaded, climbing may not even be possible. Soldiers climbing sustained rock routes may require a smaller lightweight pack to carry required items (for example, water, sensitive items, communications equipment) during the climb. Whatever packs are worn should be snugged to the body, and waist straps as well as chest straps worn to reduce the load from shifting during climbing and throwing the climber out of balance.

## ROCK CLIMBING DURING MILITARY OPERATIONS

6-47. Sustained climbing in 5th-class terrain during conventional military operations is impractical. However, routes through easier terrain are often blocked by shorter sections of 4th or easier 5th-class terrain. These routes may be the only or most tactically sound approaches to points of domination for properly trained units. Small teams of advanced military mountaineers can be used to establish fixed-rope routes for lesser-trained Soldiers to use for protection during movement. Accessing these points may be required to reach enemy defensive positions, establish observation posts, or position small teams conducting reconnaissance or forward observation of fires.

6-48. Soldiers climbing 4th- and 5th-class terrain are typically unable to provide themselves sufficient local security during movement. Bounding overwatch in vertical terrain by small-specialized teams or VDA-crossing procedures must be performed by a larger unit to provide adequate security for climbing Soldiers. (See ATP 3-21.50 for more on VDA.) Small reconnaissance and surveillance teams may have to rely on careful technical route selection that provides concealment throughout the approach and the climb. Fortunately, 4th-class and easier 5th-class terrain often provide such opportunities for teams with the technical and mobility skills necessary to negotiate them.

## CLIMBING ROUTE SELECTION

6-49. Before climbing, Soldiers should scan the rock for features that indicate that climbing the route is possible. With experience, Soldiers can determine how difficult a section of rock will be for them to complete.

Climbers should begin to form a plan for climbing the route and a plan to protect themselves with a rope system (when necessary) before leaving the ground. (See chapter 10 on how to protect climbers from fall hazards.)

6-50. During military operations, the least difficult routes possible should be selected for travel. (See chapter 7 for more information on planning technical movement routes.)

## ROCK-CLIMBING TECHNIQUES

6-51. The basic principles for rock climbing are the same as those for walking in rough terrain. They are finding and selecting suitable holds and positioning the body to achieve sufficient friction for continued movement. Due to the vertical nature of the terrain, hands must be used to aid Soldiers in maintaining balance and preventing them from tipping backward off the rock.

6-52. Suspect rock-climbing holds should be tested to ensure they are secure by tapping with a hand or foot. Holds that move or shift should be avoided. This is common in undeveloped 4th- and 5th-class terrain.

### Maintaining Balance

6-53. Balance is the most important aspect of rock climbing and footwork is the foundation of balance. Good use of the feet saves energy and makes staying in balance easier. A relaxed, comfortable stance is essential. The body should be centered over the feet as much as possible. On lower angle sections of climbing, it should be positioned away from the rock face. Alternatively, it should be positioned closer to the rock face on steeper sections. This puts downward pressure on footholds, increasing their security. Smaller lower body movements are often less strenuous than larger ones, which take more effort to stay in balance.

6-54. Rock climbing usually requires the use of handholds to maintain balance. Handholds can be large jugs that allow climbers to hold nearly their whole weight or tiny crimpers that only hold a fraction of their weight. Specific handhold techniques are discussed throughout this section. New climbers commonly overuse their arms to pull themselves up the rock and burn out quickly. Tired or pumped forearms are a sign of bad footwork.

6-55. Whenever possible, three points of contact should be maintained while moving the fourth to the next hold. This can reduce the likelihood of a fall should one point of contact fail.

### Types of Contact

6-56. Though counterintuitive, often pushing rather than pulling is required during climbing. Using downward pressure involves pushing down on a feature with the hands to allow unweighting of the other hand or one foot for movement to the next hold. Using counterpressure involves pushing away from features to allow a hand or foot to be unweighted for movement. (See figure 6-5, page 94.)



**Figure 6-5. Downward or counterpressure**

6-57. Occasionally, the holds available put the climber out of balance, but repositioning the body (usually by extending a leg to the left or right) improves the climber's balance. This technique is called counterbalancing and often allows the climber greater reach. (See figure 6-6.) Often the climber can find a microfeature to touch or apply slight pressure to with the foot improving the security of the move.

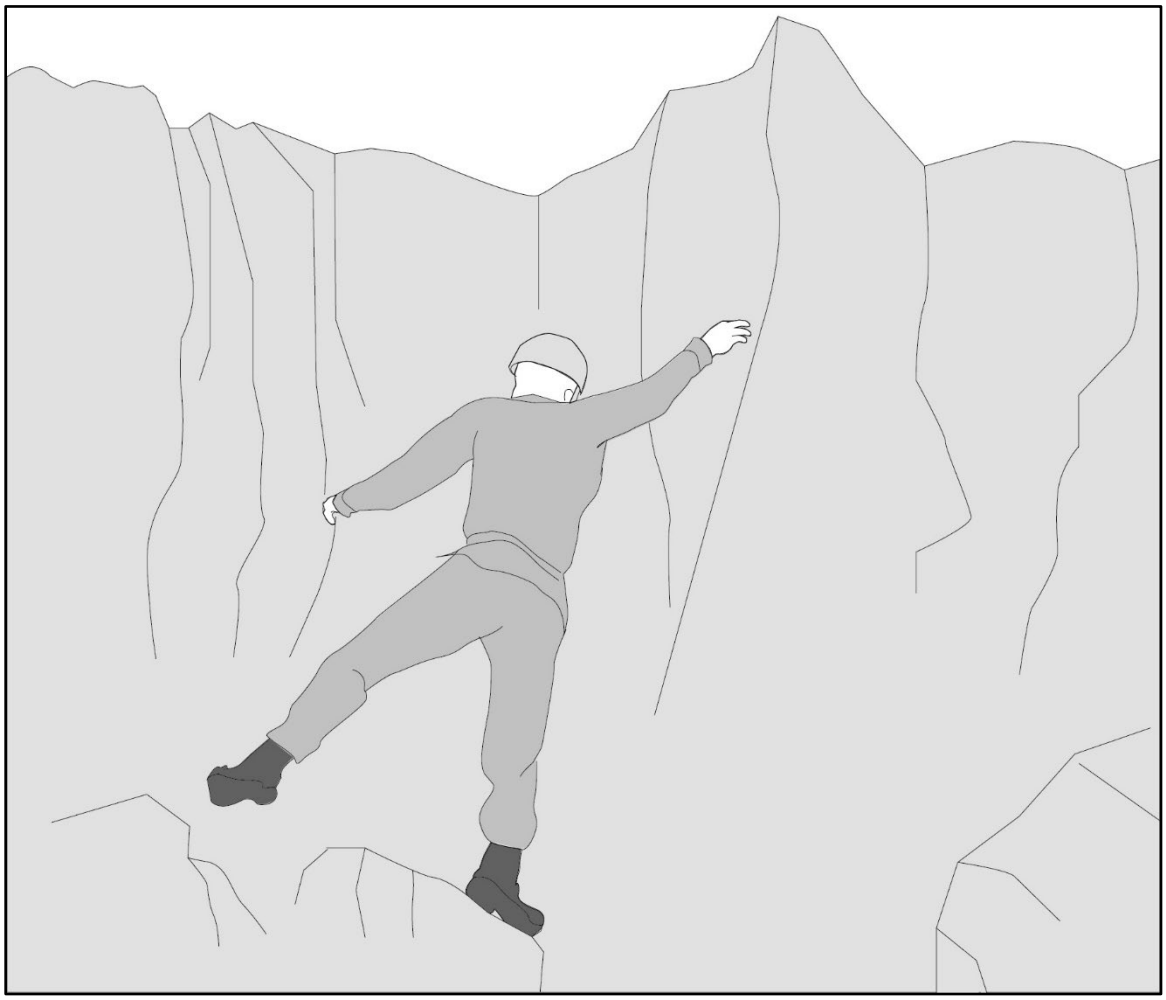


**Figure 6-6. Counterbalance**

6-58. Occasionally, the climber must switch hands or feet on a hold to make the next move. Sometimes the hold can be shared temporarily by two hands or feet, even if they are unsecure, while the lead hand or lead foot moves. Other times, the second hand or foot may need to use a temporary, perhaps less desirable hold, while the lead one moves.

6-59. Dynamic moves are sudden, explosive moves where climbers throw themselves out of balance, potentially even losing contact with the rock, to reach another hold. These moves must be calculated carefully because failing to execute them perfectly usually results in a fall.

## Slab and Face Climbing

6-60. Slabs are typically smoother, lower angle rock features. They can be large or small. Comparatively, they provide the climber with few hands and footholds and require good footwork and balancing to climb. The primary technique used to climb them is smearing with the feet. This involves placing the sole of the boot or shoe on the rock with toe facing uphill to obtain maximum contact and friction. The body is then positioned away from the rock so that the foot does not slip. The closer climbers can get to pushing perpendicular to the rock, the more friction they will create. (See figure 6-7, page 96.) Hands are usually used to help balance by pushing against the rock. Any microfeature that can be found will improve the security of climbing slabby terrain. Climbing slabby rock helps build confidence in footwork and good balance skills.

6-61. Face climbing is what is commonly associated with rock climbing. Face climbs are typically suitably featured rock faces (cliffs) where climbers employ a wide variety of basic moves to ascending. Climbers spend most of their time facing the rock, like climbing a ladder. Many footholds are small or sloped and require edging or smearing to be effective; others are larger. (See figure 6-8.) Many techniques for using handholds exist. (See figure 6-8.) Using knees should be avoided because they are more likely to slip than good footwear.

6-62. Most slab or face climbing terrain appropriate to military operations can be climbed in combat boots, mountaineering boots, or approach shoes. Moderate to difficult climbs require climbing shoes. (See figure 6-9.)

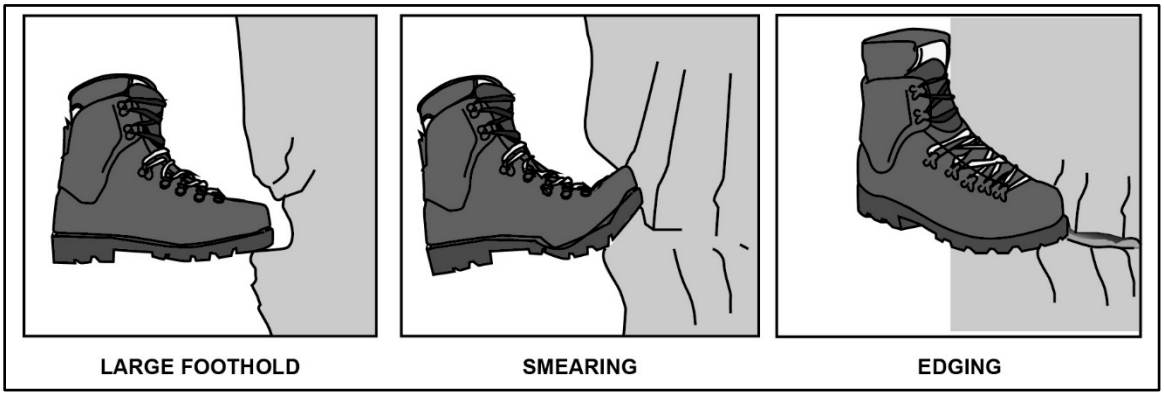



**Figure 6-7. Footholds**

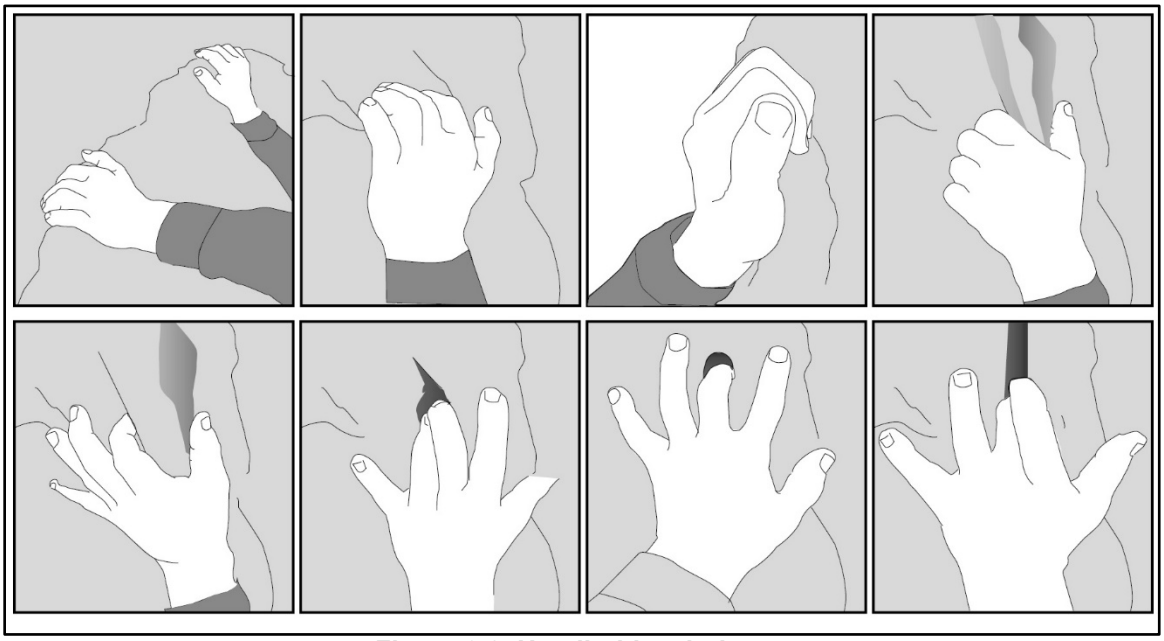


**Figure 6-8. Handhold techniques**

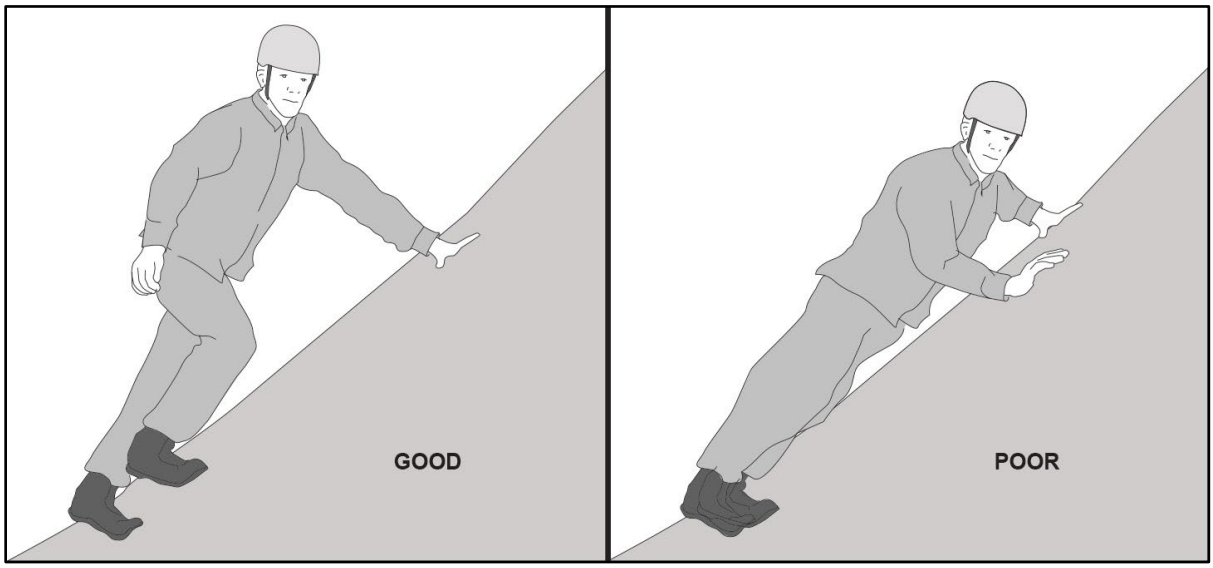



**Figure 6-9. Slab body position**

***Resting During Climbing***

6-63. Resting is critical during sustained rock climbing. Any opportunity to stand up and let go or lightly hold on with the hands should be taken. Sometimes the body or a body part can be wedged into a large crack, allowing the climber to relax. Often, the only rests available are between moves while looking for the next hold. When not actively moving, climbers should keep their weight on their skeletal system as much as possible. This means locking out legs or arms and providing muscles with a brief rest. Doing this is particularly important to preserve arm strength. Often one arm and the climbers' feet can support their weight while they shake out the other arm and hand. (See figure 6-10, page 98.)

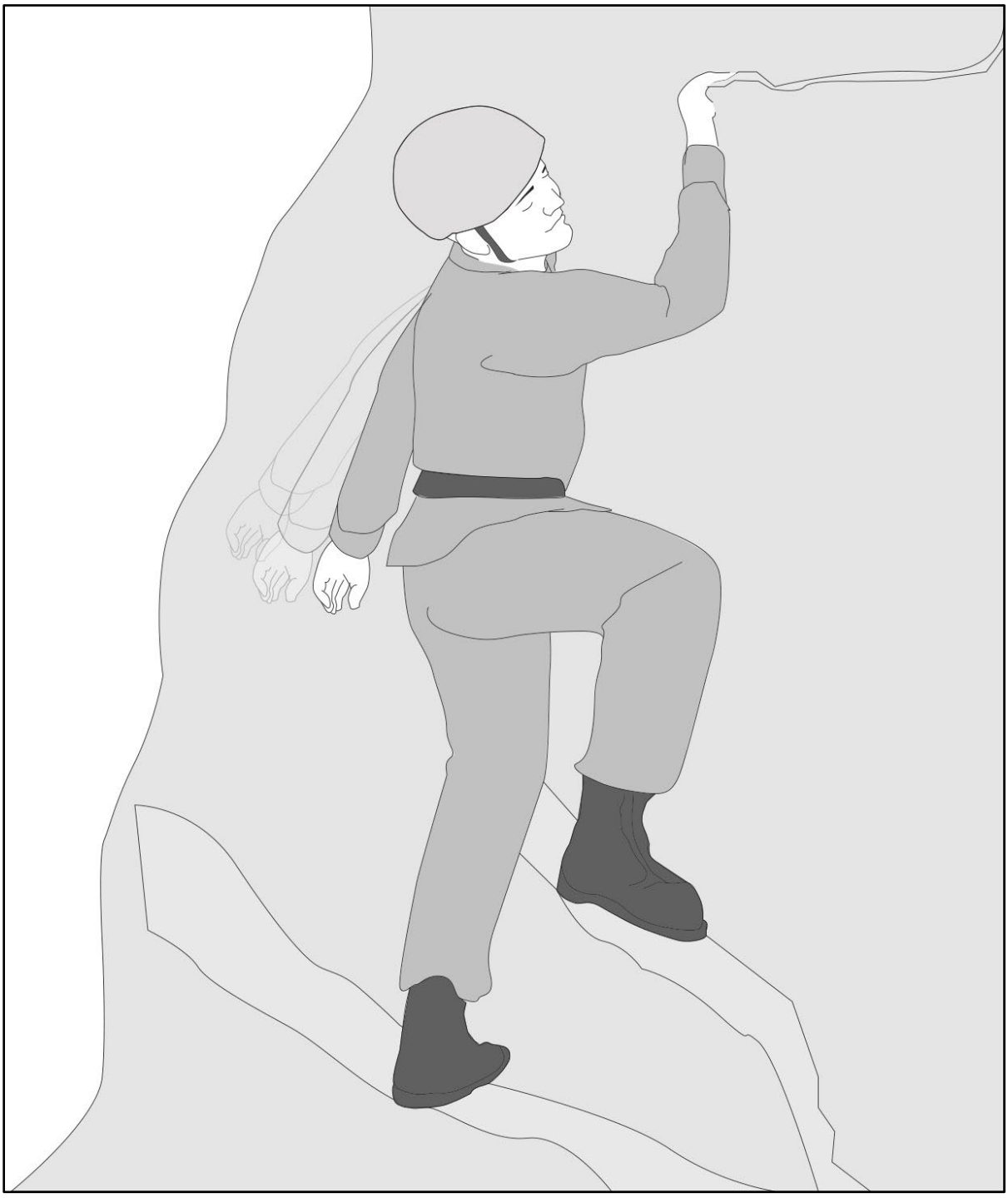


**Figure 6-10. Rest or shake out**

***Specific Moves***

6-64. Mantling involves pulling down with both arms on the edge of a ledge type feature until the chest is ledge height, then transitioning to pushing down on the ledge while walking the feet up the face below. This move is common to climbing out of a swimming pool. (See figure 6-11.)

6-65. Stemming involves placing the feet on features to the left and right of the body so that force is applied outward as well as down. Stemming is typically very stable and requires a relatively low amount of energy to maintain. (See figure 6-12, page 100.)

6-66. Underclinging involves gripping an overhanging rock feature with the hands, palm up, and pushing against a lower rock face with the feet. Underclings can be very stable but can be quite strenuous and tiring. Occasionally, underlings are the only means of getting through a section of climbing. (See figure 6-13, page 101.)

6-67. Liebacking involves using counterforce by pulling hard on a vertical or diagonal feature (such as a large flake) while pushing hard against the face of the rock. These moves are very strenuous because little or none of the climbers' weights is supported by their feet. In fact, leg muscles are being used to push away from the rock, so they are very taxing to the upper body. The climber's hands are then walked up the feature while the feet are walked up the face. Footholds on the face, however small, can be used to make liebacking easier and more secure. (See figure 6-14, page 102.)

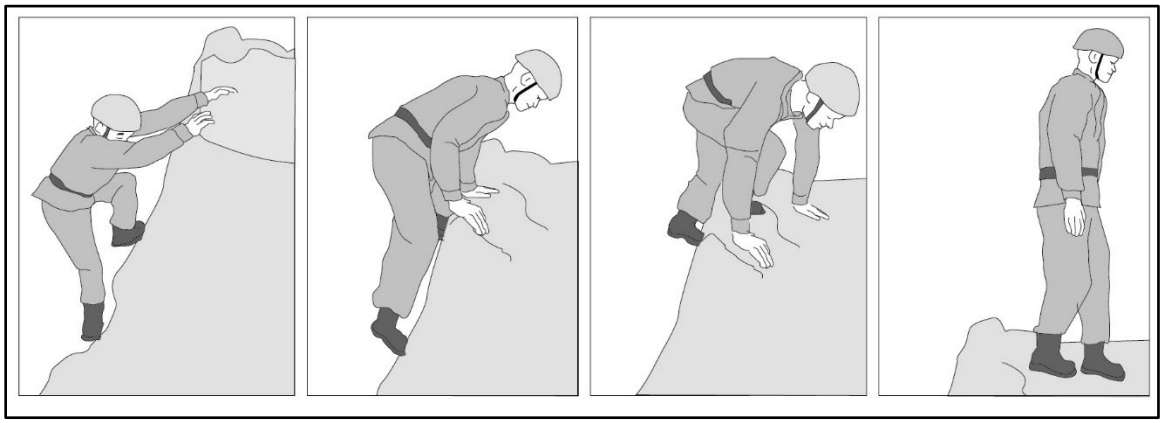


**Figure 6-11. Mantling**



**Figure 6-12. Stemming**

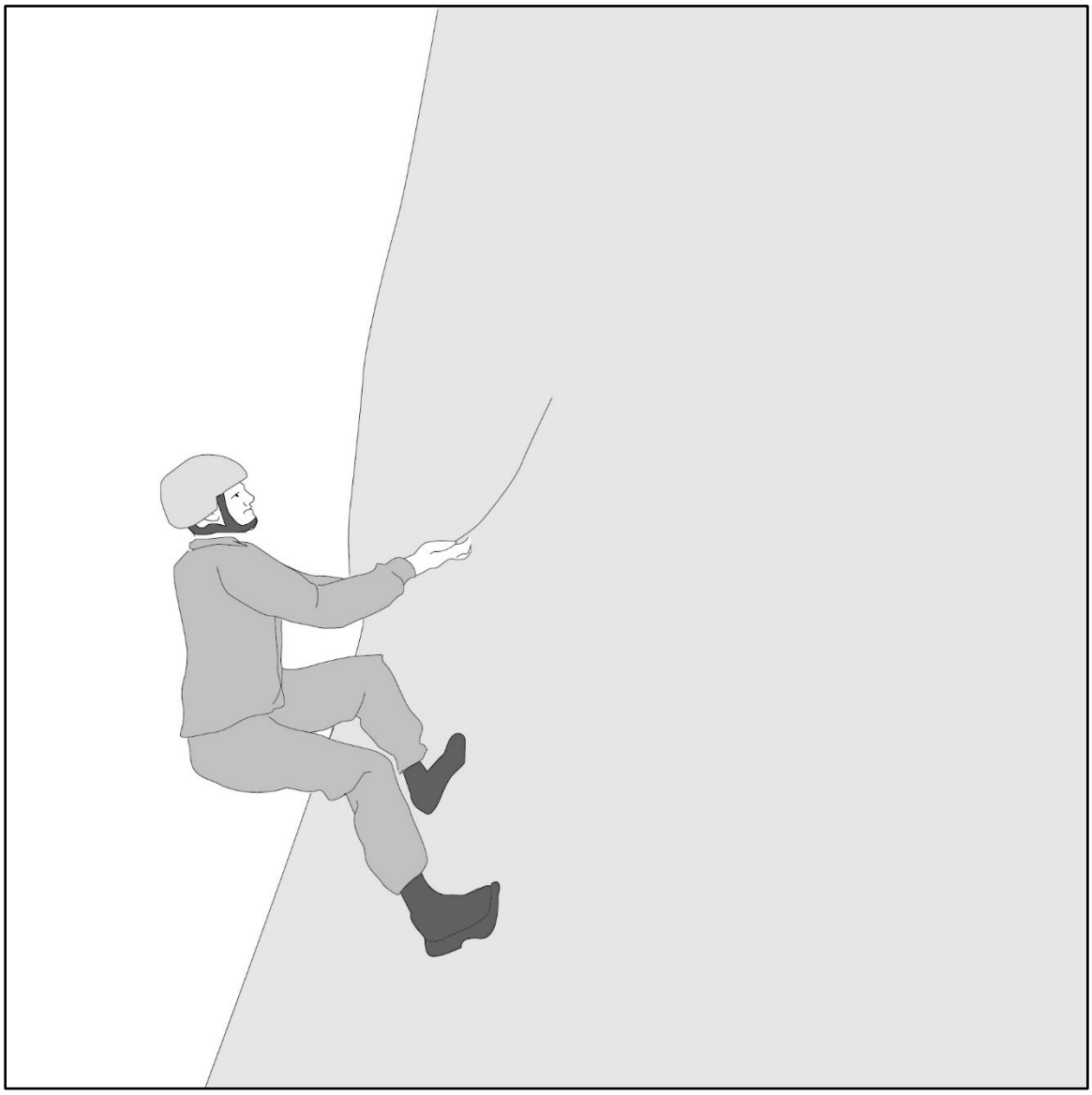


**Figure 6-13. Underclinging**

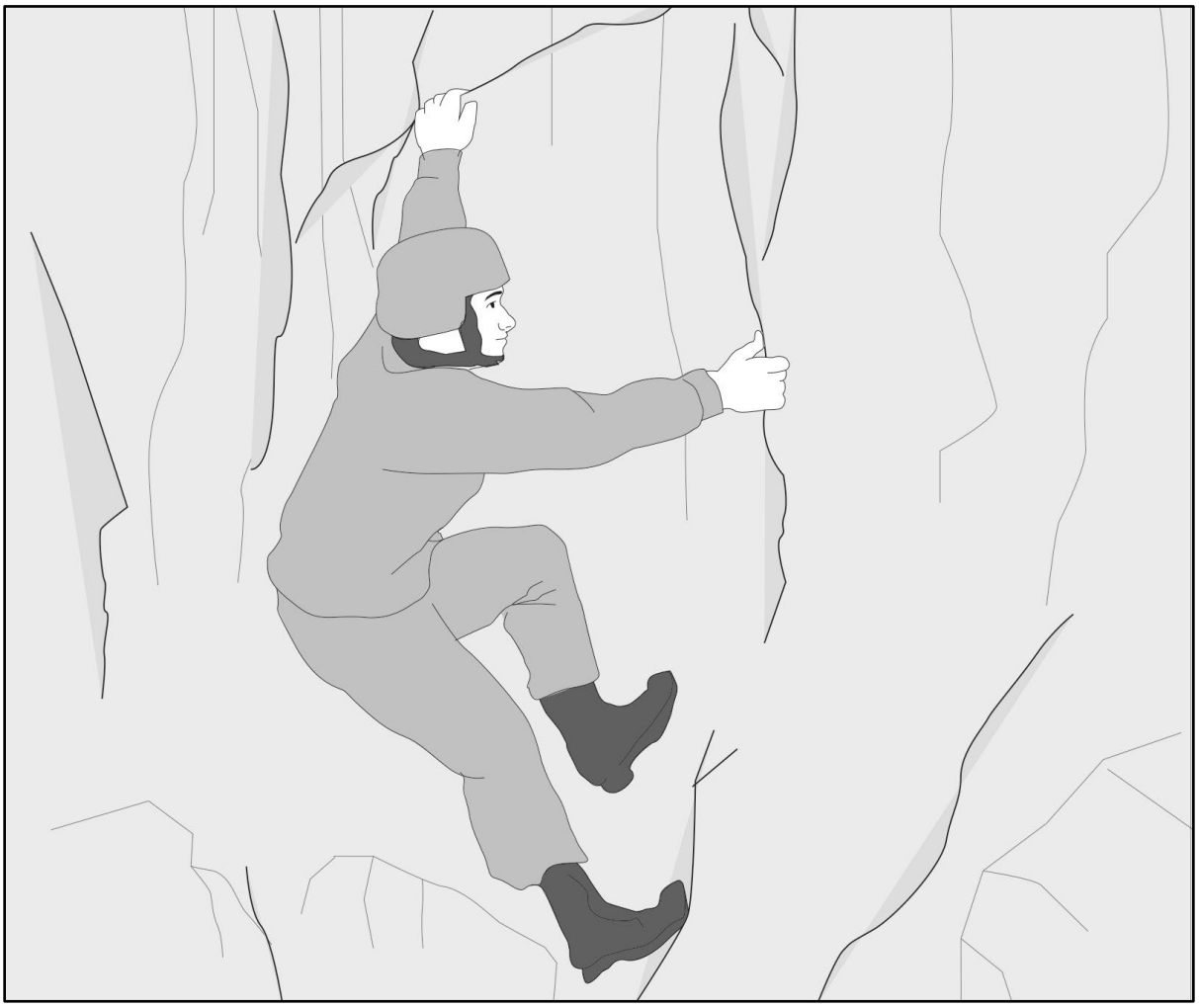


**Figure 6-14. Liebacking**

## Crack Climbing

6-68. Crack climbing requires a specific set of nonintuitive techniques that take quite a bit of practice to build proficiency in. While some climbs involving cracks can be climbed with weak or no crack technique, more difficult crack climbs require climbing shoes and good technique to be climbable. Mixed crack climbing involves using features on the rock face for footholds while using a prominent crack for handholds. (See figure 6-15.) Classic crack climbing involves moving up a prominent crack by alternately jamming hands or fingers and feet or toes and walking them up the crack. Often, one foot is placed out of the crack to the side for balance, even on a featureless face. Off-width crack climbing is the term for climbing cracks that are larger than fist and foot sized but not large enough to fit the entire body. These climbs are difficult.

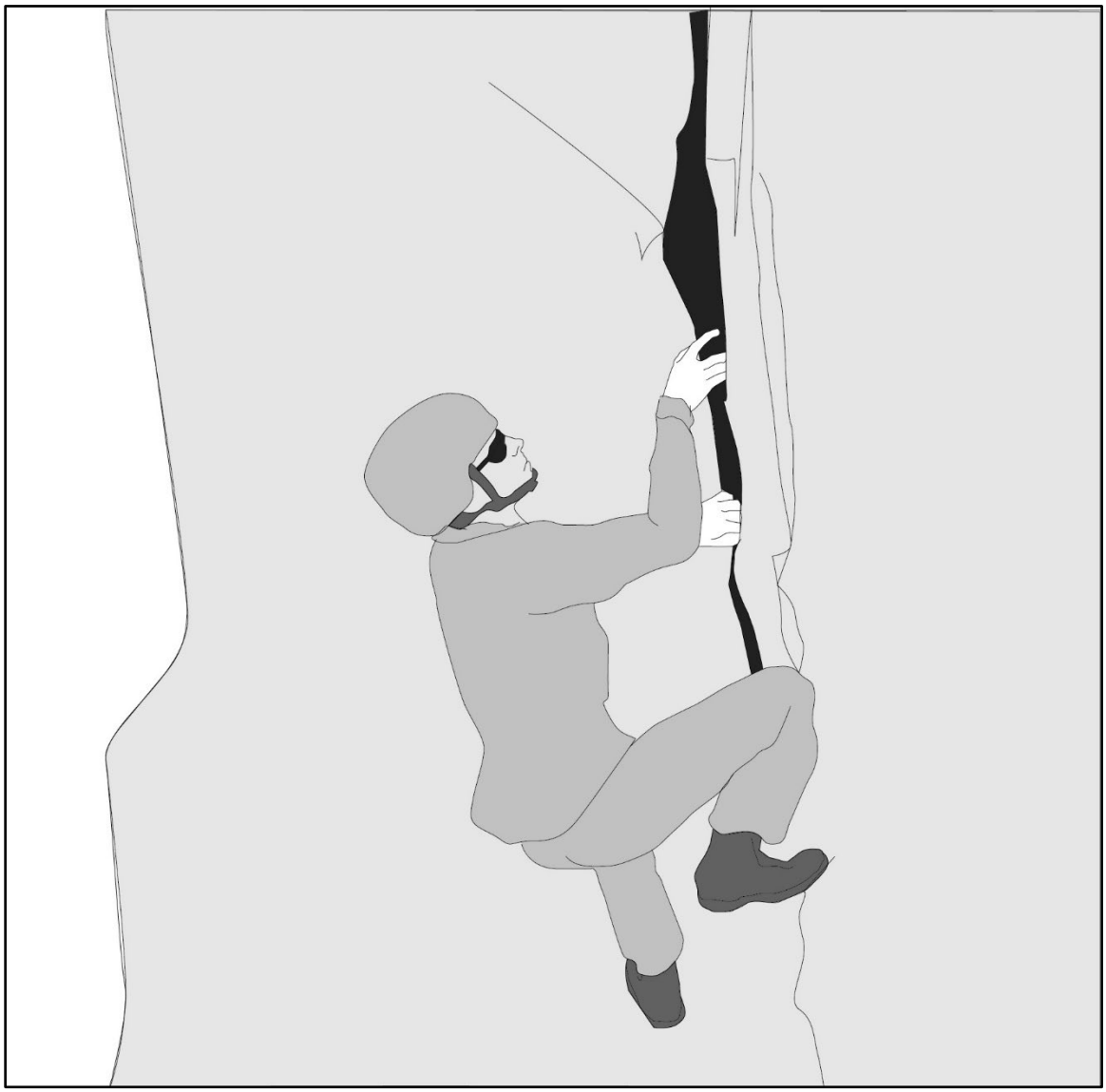


**Figure 6-15. Mixed face and crack climbing**

***Jamming***

6-69. A critical technique in climbing cracks involves placing a hand or foot into a crack and turning, twisting, or otherwise manipulating them so that they become temporarily jammed in the crack. A good jam can be achieved in a variety of ways depending on crack size, whether it has constrictions in it or not, and its position in relation to other holds on the climb. Jams can provide solid hands or footholds but are often uncomfortable or even painful. Crack size determines which jam technique to use for a given hold. Constrictions in the crack make jam holds more secure.

***Types of Hand Jams***

6-70. Hand-sized jams are the easiest to perform. The hand is inserted open into the crack and then the fingers bent exert pressure against the walls of the crack. Often turning one hand thumb down is useful. Typically, leaning to the same side adds security to a thumb up hand jam. (See figure 6-16, page 104 for variations of hand jamming.)

6-71. Fist jams are techniques necessary for cracks that are larger than those that work for hand jams. The same jamming principles apply, but climbers just insert their entire fist into the crack. (See figure 6-17 for variations of fist jamming.)

6-72. Finger jams are techniques necessary for cracks that are smaller than those that will accept a hand. The same jamming principles apply, but the climber only inserts their fingers, or parts of their fingers into the crack. Finger jamming is more difficult and can be painful for the joints. It is important to strengthen finger muscles prior to attempting to support substantial weight with finger jams to prevent joint strain. (See figure 6-18.)

***Types of Foot Jams***

6-73. Foot jams involve turning the foot so that it fits into the crack and then twisting it so that the width of the foot wedges into the crack. This can be uncomfortable but can provide very secure footholds. (See figure 6-19.)

6-74. Toe jams are used in the same manner as foot jams, but in smaller cracks. (See figure 6-20, page 106.)

***Types of Arm Jams***

6-75. Arm bars is a technique used for off-width cracks and involves inserting an entire arm into the crack and bending at the elbow to create a jam. (See figure 6-21, page 106.)

6-76. Chicken wing is a technique also used for off-width cracks and involves inserting an entire arm into the crack bent at the elbow and pushing against one wall of the crack with the hand to create a jam. (See figure 6-21, page 106.)

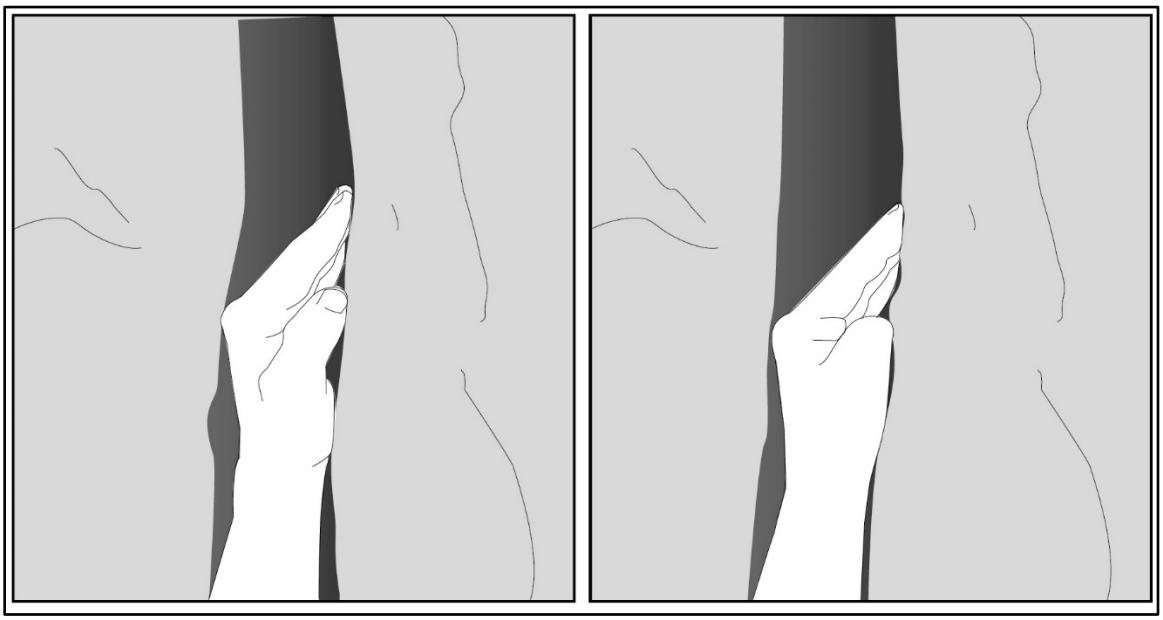


**Figure 6-16. Hand jams**

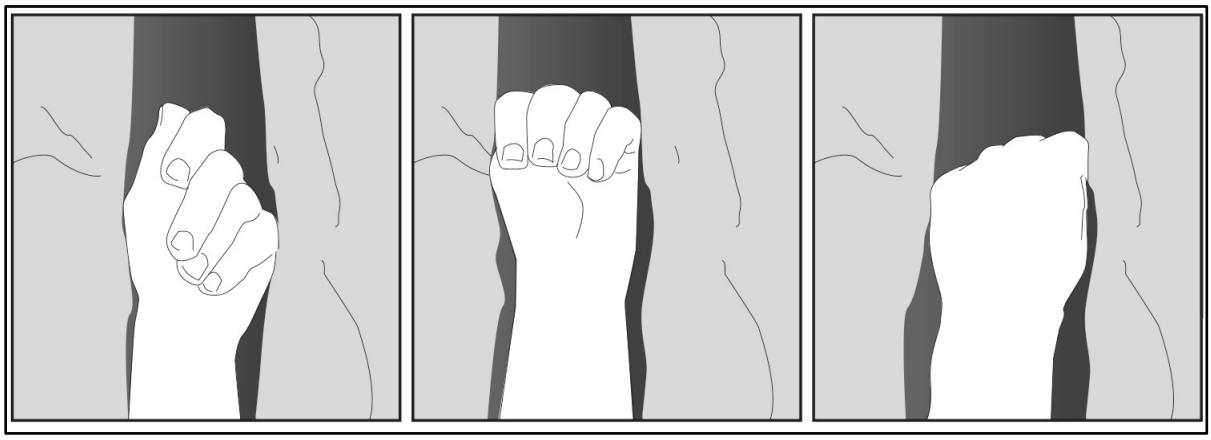


Figure 6-17. Fist jams

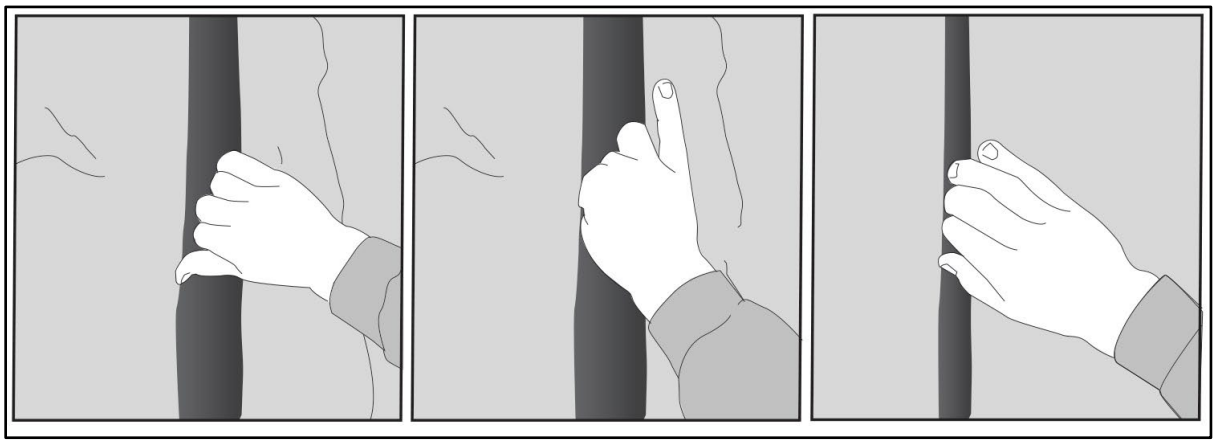


Figure 6-18. Finger jams



Figure 6-19. Foot jams



Figure 6-20. Toe jams

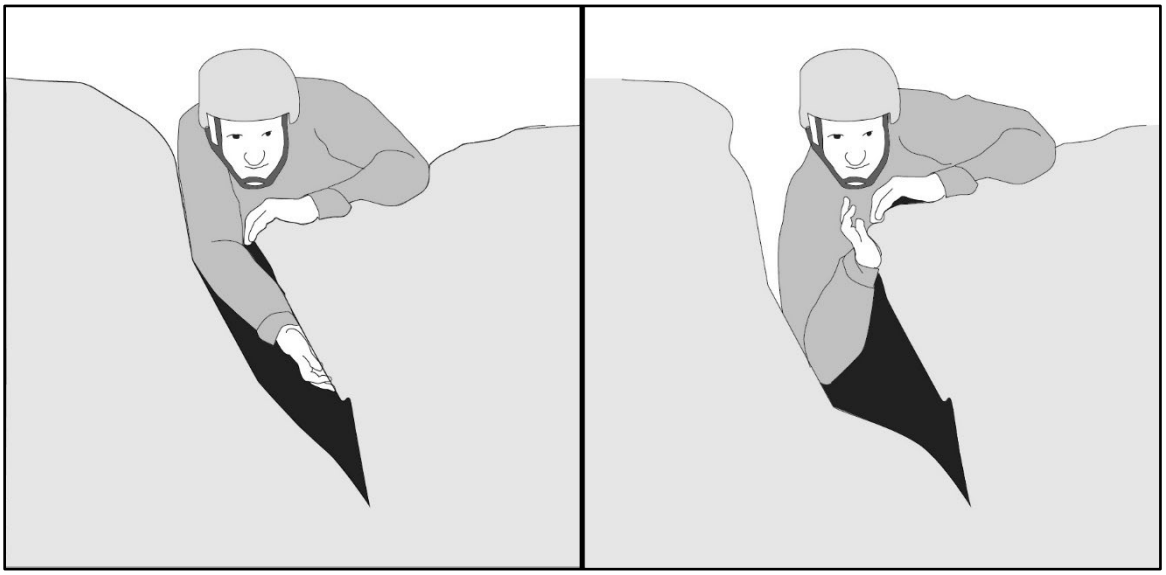


Figure 6-21. Arm bar and chicken wing

## Dihedral and Chimney Climbing

6-77. Climbing dihedrals and chimneys involves positioning the body inside a feature and using counterpressure or stemming to make upward movement. These features can often make for less strenuous climbing due to the counterpressure positions allowing for more rests. A dihedral is two rock faces that meet to form a corner, like an open book. Often there is a crack where the two faces meet. Chimneys are roughly parallel-sided features. They could be like a vertical shaft or crack large enough to accept a whole body.

6-78. Dihedrals can usually be climbed with a combination of stemming and either crack or face climbing. Dihedrals are easier and less strenuous to climb when the two faces have multiple and large features.

6-79. Chimneys are often unpleasant features to climb but provide a lot of security during movement. The basic technique for climbers is to position their body in the chimney and use counterpressure by pushing with arms, legs, and back against opposing sides. (See figures 6-22 through 6-24, pages 107 through 109, for variations in chimney climbing techniques.) Often during chimney climbing, it is necessary to attach climbing packs to the harness hanging below the climber.



**Figure 6-22. Stemming in a dihedral**



**Figure 6-23. Stemming in a chimney**

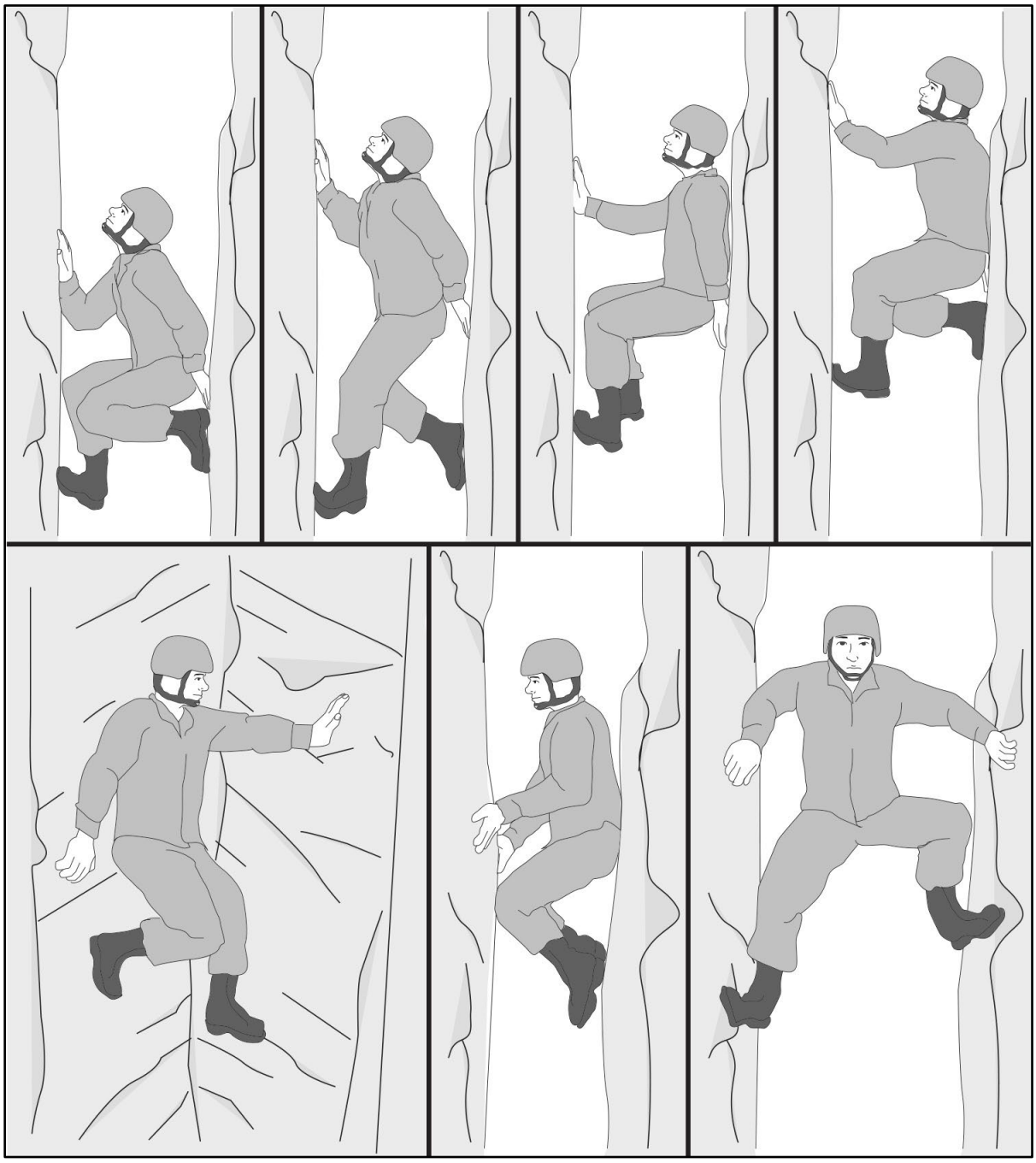


**Figure 6-24. Chimney climbing technique**

## Traversing

6-80. Traversing is moving laterally on the rock. This is often necessary because the features that make up a rock route are not always continuous or travel straight up a face. Traversing often involves a series of placement exchanges. Most traversing is done facing the rock.

6-81. Hand traversing requires a ledge, flake, other horizontal feature, or a series of horizontally oriented large handholds. Climbers' hands walk their way across the features while their feet walk their way across a face below. (See figure 6-25, page 110.)

6-82. Steep traverse is a technique often used when handholds are not as good, but decent footholds are present. Climbers lean heavily in the direction they want to move and place hands on available holds, and then walk their feet in the same direction using available footholds. Sometimes a crossover step is helpful. This technique typically requires solid side pulling, counterpressure, and counterforce skills. (See figure 6-26.)

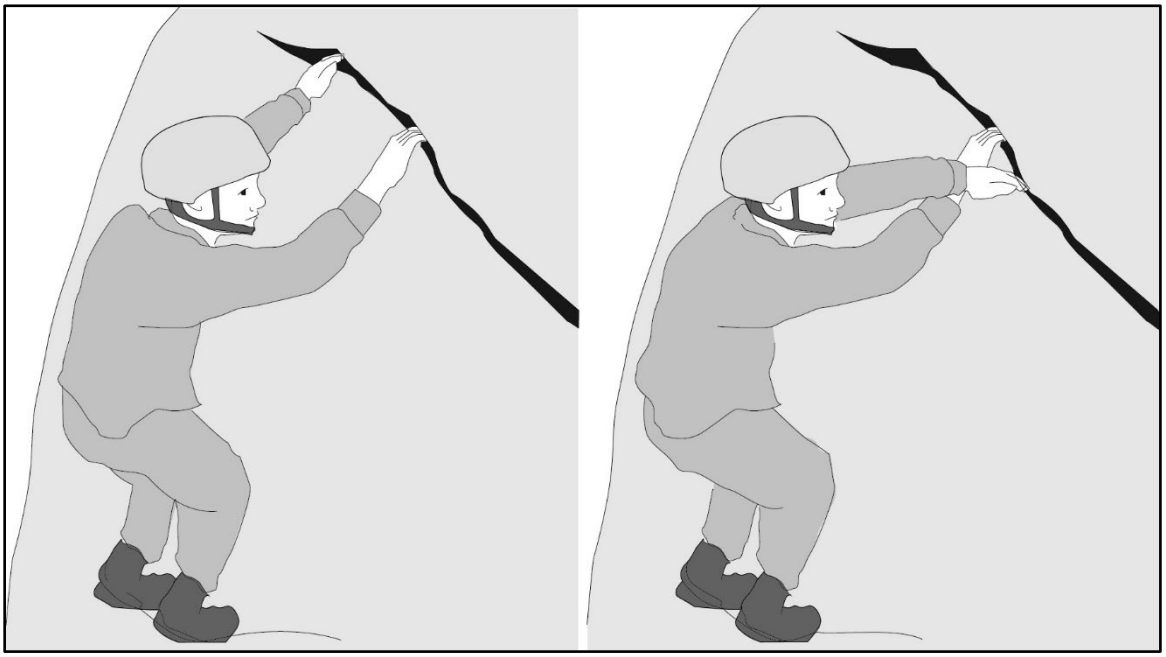


**Figure 6-25. Hand traverse**

## Topping Out or Gaining Ledges

6-83. Topping out or gaining a ledge can be one of the more challenging parts of climbing. Often low holds located near where climbers want to put their feet need to be used to get over the edge. Often, a mantling technique is effective. Most importantly, climbers should avoid laying on their belly on the edge when moving because it may be difficult to get their feel back on the rock, and they may slide off on sloped ledges. A crossover step is helpful. This technique typically requires solid side pulling, counterpressure, and counterforce skills. (See figure 6-26 for the proper technique.)

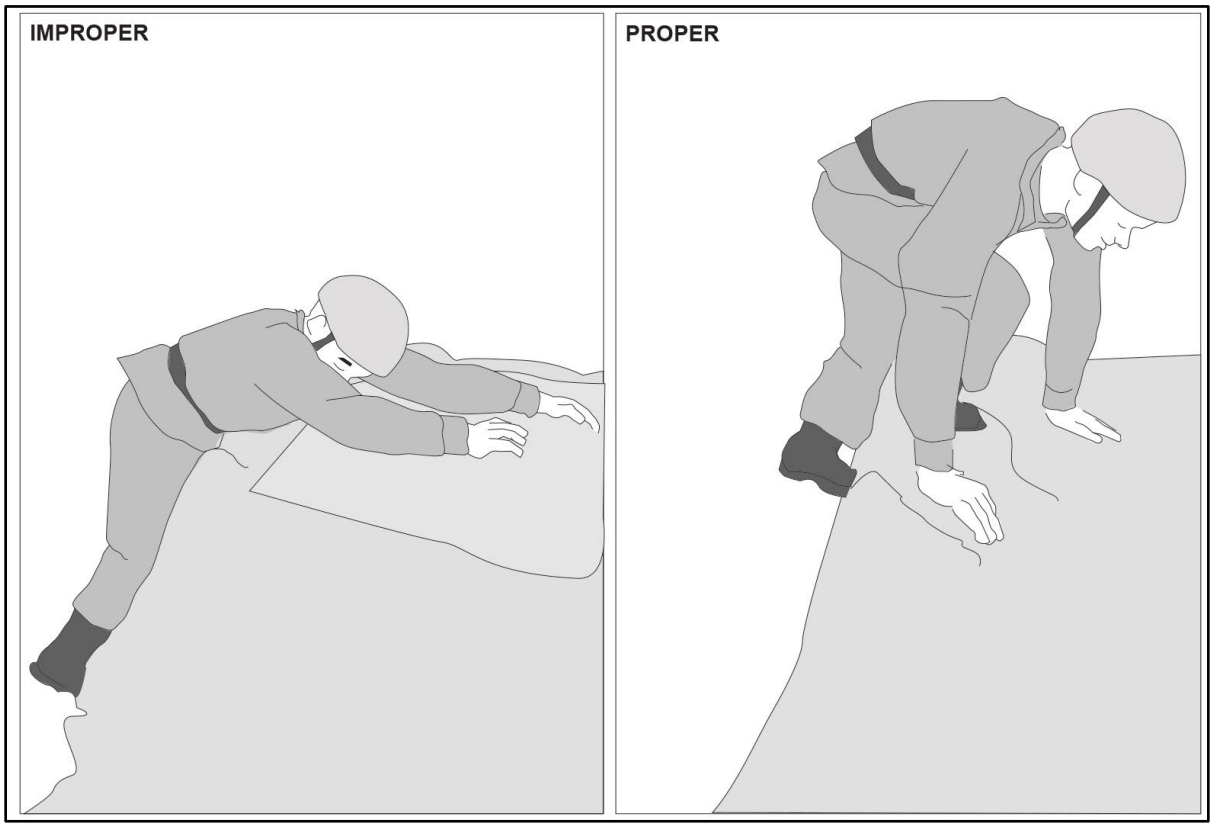



**Figure 6-26. Gaining ledges**

## Down Climbing

6-84. Down climbing is far more difficult than climbing up and takes much practice to gain proficiency. This is largely because rock features are often difficult to identify from above. They are easily obscured by other features above them or even the climber's body parts. However, down climbing is an important skill to practice, as it is often necessary to do in 3rd- and 4th-class terrain.

6-85. Facing out is a technique used on low angle rock. Climbers face out and use their hands for stability behind and below their body while moving their feet down to the next hold. (See figure 6-27, page 112.)

6-86. Walking down a slab is a technique that involves simply walking down slabby rock while maintaining maximum friction and balance. (See figure 6-27, page 112.)

6-87. Facing sideways involves climbers facing to the side and side stepping down to lower footholds while controlling and balancing their movement using handholds above. Climbers use this technique on steeper rock. (See figure 6-27, page 112.)

6-88. Facing the rock involves climbing down in the same position as the climber would use to move up the rock. Climbers lower themselves down with their arms, keeping their body away from the rock so they can see footholds below, and then transition their weight onto the next foothold. (See figure 6-27, page 112.)

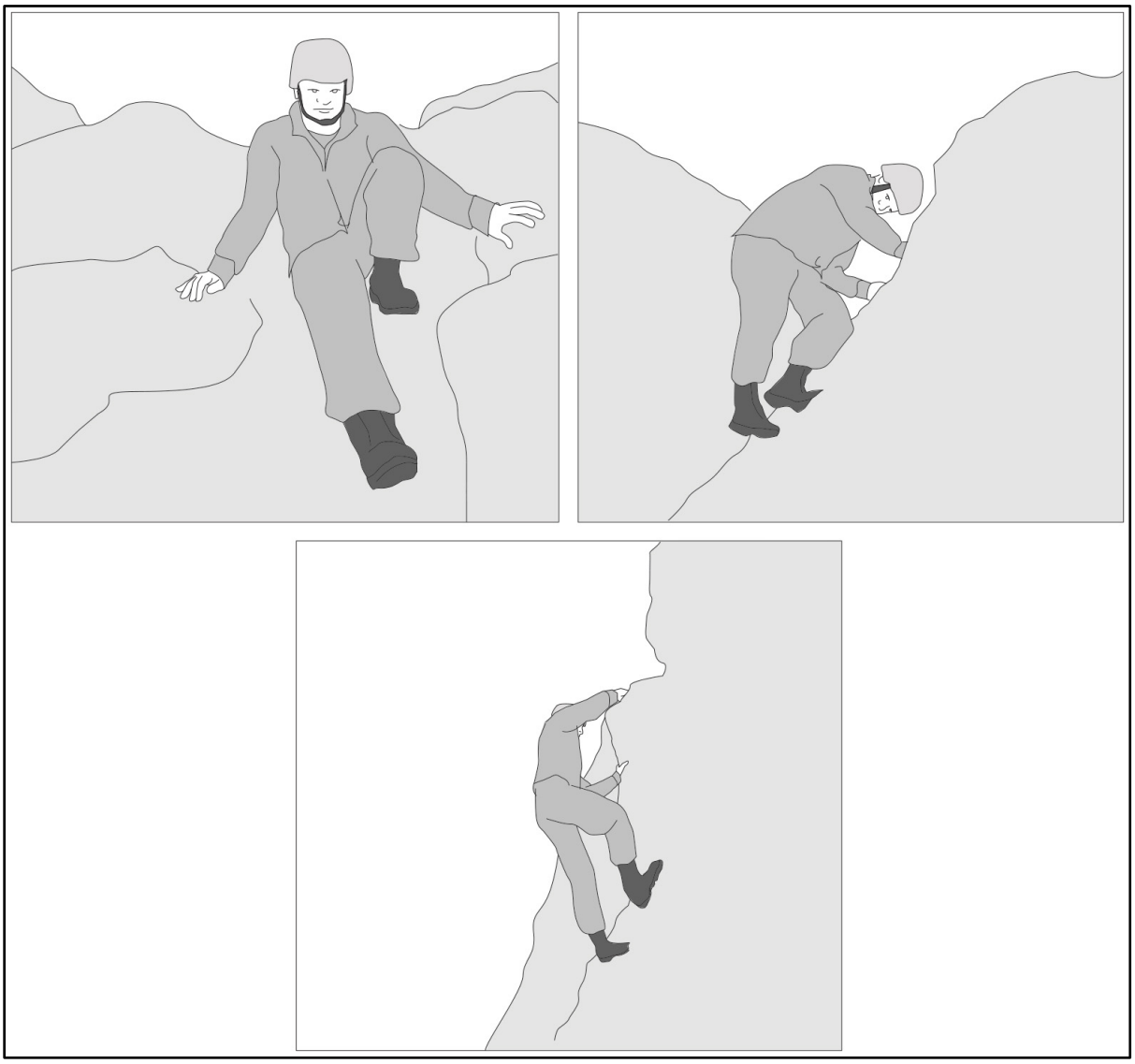


**Figure 6-27. Down climbing**

## TRAINING FOR ROCK CLIMBING

6-89. Beginner rock-climbing training is typically conducted at established climbing areas using top rope belay techniques (see chapter 10). When supervised by qualified mountaineers, this kind of rock climbing is relatively low risk and has a high payoff for developing mobility skills. One restriction is that sites do not often allow large groups to be actively engaged. Thus, climbing training should be planned along with concurrent training for smaller groups to rotate through. Route difficulty should be challenging to climbers but easy enough that they can be successful. This motivates climbers to build skills. A motivational rather than critical atmosphere is most effective when building climbing skills.

6-90. Climbing training for more advanced military mountaineers can be conducted the same way, just on more challenging routes, but should also be conducted in a multipitch setting that more accurately reproduces conditions of climbing during military operations. This setting requires the development of lead climbing and route-finding skills, which are critical to the advanced military mountaineer.

6-91. Leaders should try to learn the etiquette associated with climbing before using civilian climbing areas.

## SECTION II – MOVEMENT OVER SNOW AND ICE

6-92. Deep snow, steep powdery slopes, glare ice, and frozen waterfalls all present significant challenges to movement. The basic individual movement principles and skill development necessary for movement under other surface conditions also apply to movement over snow and ice. However, additional skills are necessary for efficiency and safety. Specialized equipment is required in even the easiest snow or ice-covered terrain.

# MOBILITY OVER SNOW AND ICE

6-93. Fitness and movement techniques are the foundation of moving through snow or up steep ice. However, identifying and selecting secure foot placements can be difficult because traction is drastically reduced. Movement without specialized equipment, such as crampons or skis, is difficult under almost all conditions above 1st-class terrain. Even when it is possible, deep snow requires a substantial amount of energy to move through unaided. Anything deeper than calf-deep snow will impede movement in even easy terrain, and a few inches of snow or a glaze of ice will make steeper terrain treacherous. Soldiers must develop the same level of skill using snow and ice equipment, which requires proficiency in an additional set of skills. Like moving over broken rocky terrain, these skills can only be developed through experience and repetition. Units that train their Soldiers to proficiency in these conditions can move faster, safer, and access terrain that others cannot.

### EQUIPMENT FOR SNOW AND ICE

6-94. Skis provide substantial floatation in deep snow and require the least amount of energy for movement. This is especially true for downhill movement where much energy can be saved over walking. There are varieties of ski systems available for movement over snow, but those most suited to military mountaineering are called alpine touring skis. The ski itself is like a downhill ski, but the binding allows the heel to release for movement over flat or uphill terrain. It can also be locked down for greater control when skiing downhill. Climbing skins are used in conjunction with skis to climb uphill. Skins are designed to slide in only one direction, providing traction in deep snow and on steep slopes. At a minimum, a stiff mountaineering boot is necessary for use with skis. In the steepest terrain, a dedicated rigid plastic ski boot may be required. Compatibility between boots and bindings must be considered. (See figure 6-28, page 114.)

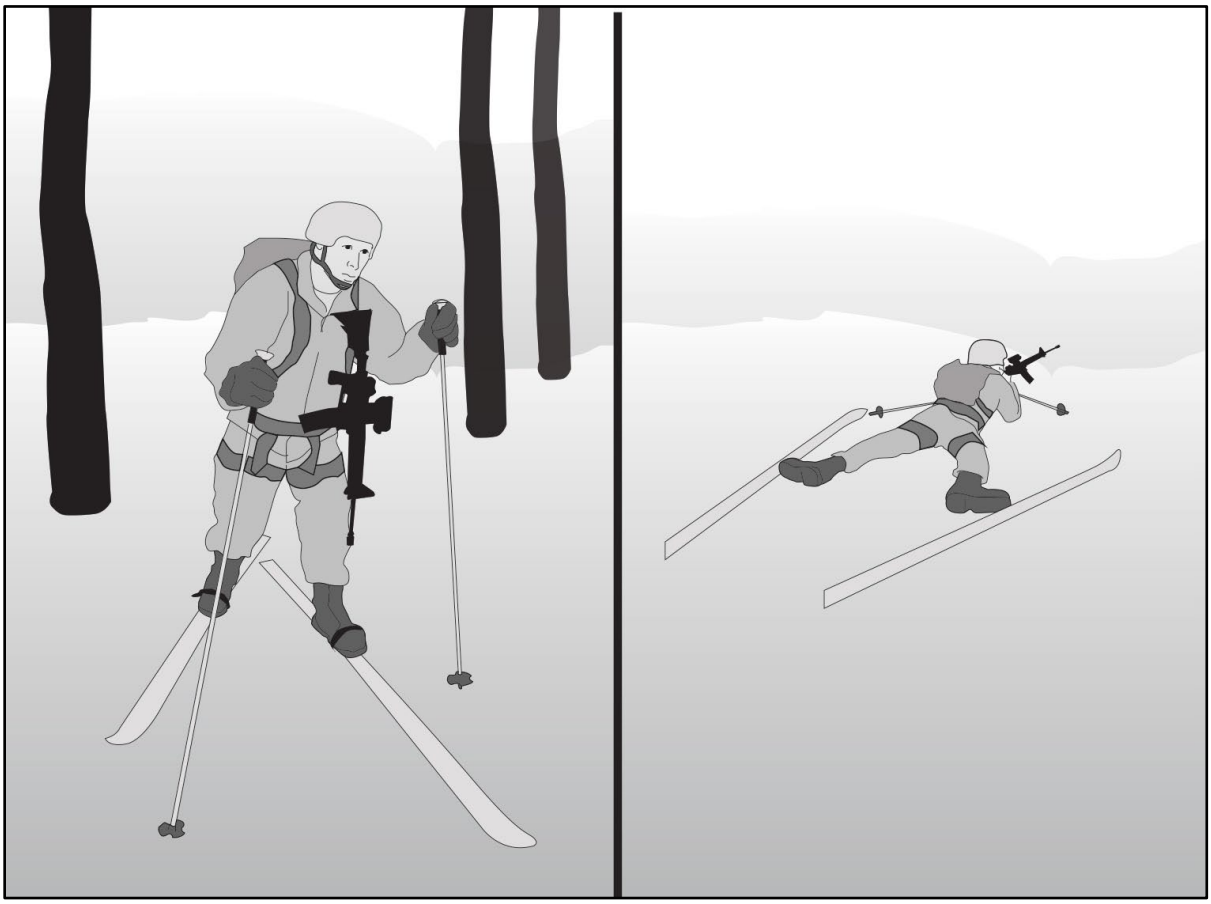


**Figure 6-28. Alpine touring skis**

6-95. Snowshoes are another tool available to Soldiers for moving over deep snow. Modern snowshoes provide sufficient floatation and traction for moving through snow on fairly steep (class 2) slopes and should be small and light enough to pack, if necessary. Snowshoes work with any boot. (See figure 6-29.)

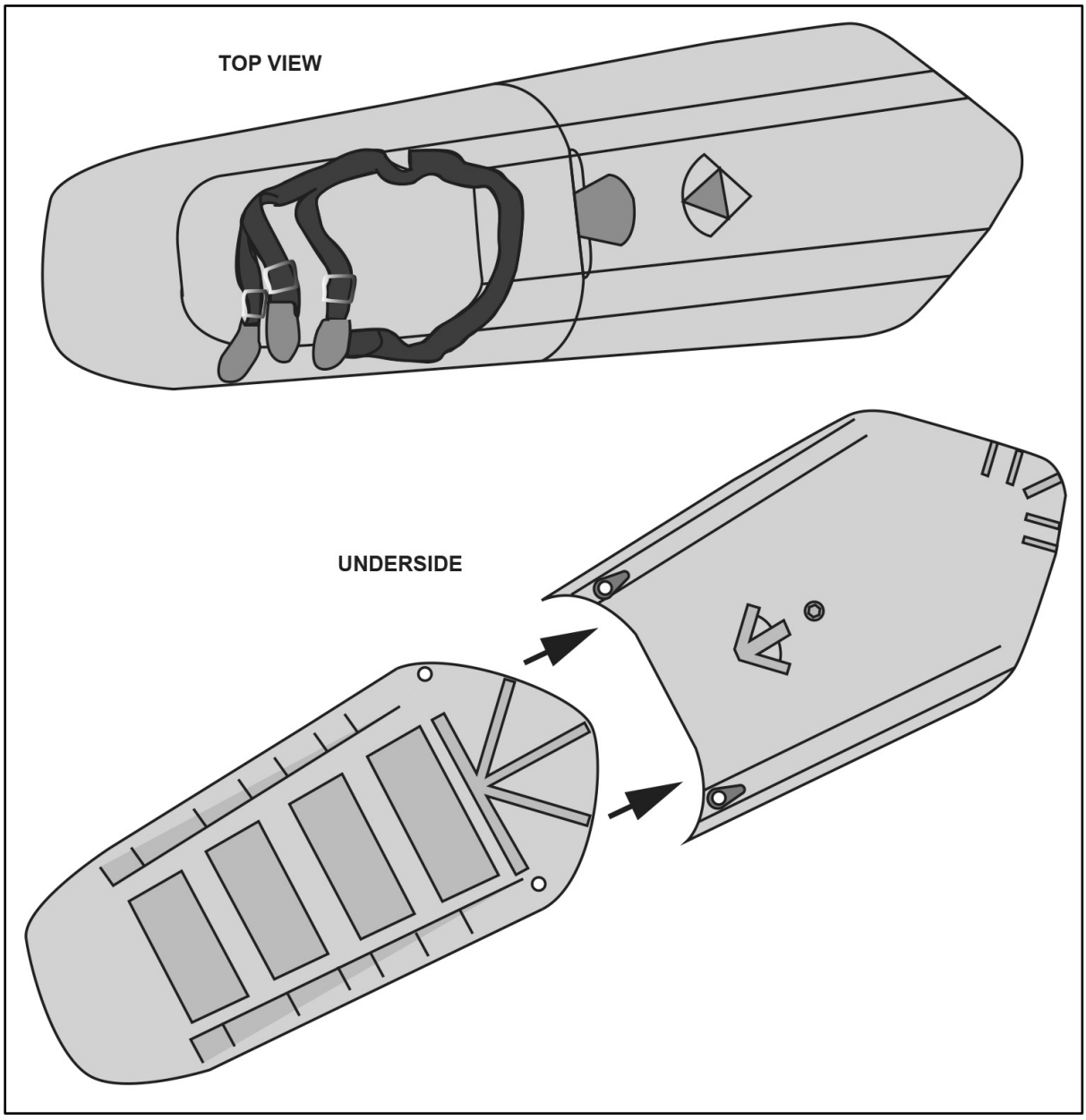



**Figure 6-29. Snowshoes**

6-96. Ski poles are typically used with snowshoes and skis to provide more lateral stability and balance. Ski poles can be used to provide excellent support for weapons systems during firing from the prone, kneeling, and standing positions.

6-97. Sleds are useful for carrying large amounts of equipment, such as bivouac equipment, heavy weapons, food and water, or other supplies. They range in size, shape, and weight, all of which should be considered before selection for military operations. Four- and ten-Soldier Ahkio-style sleds are available through the military supply system. These are designed to carry all group sustainment equipment (for example, tents, stoves, fuel) for a four- or ten-Soldier group. These come with a cover and rigid poles, convenient for dragging up and downhill. (See figure 6-30, page 116.)

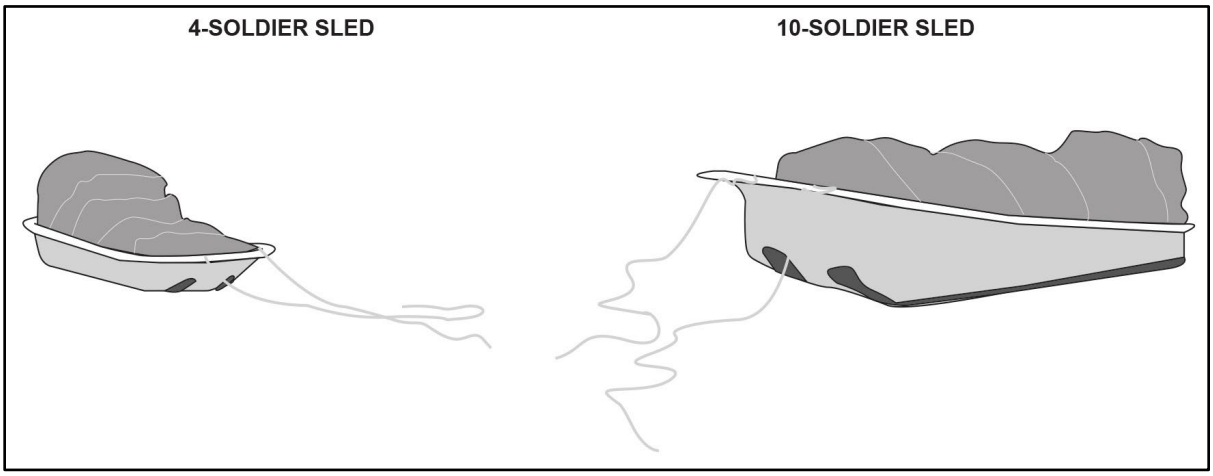



**Figure 6-30. Ahkio sleds**

6-98. Crampons attach to the Soldier's boot to provide traction on ice and snow. There are two basic types: general mountaineering crampons and ice climbing crampons. Mountaineering crampons have less aggressive points. They are designed for use in steep snow and on low-angle ice and can be used for ice climbing but are not ideal. Ice climbing crampons have points that are more aggressive and are typically more rigid. They are designed for steep ice climbing but can be used in snow and low angle ice as well. Crampons work best when paired with a stiff leather or rigid plastic mountaineering boot. They do not work well with issued cold-weather combat boots. (See figure 6-31.)

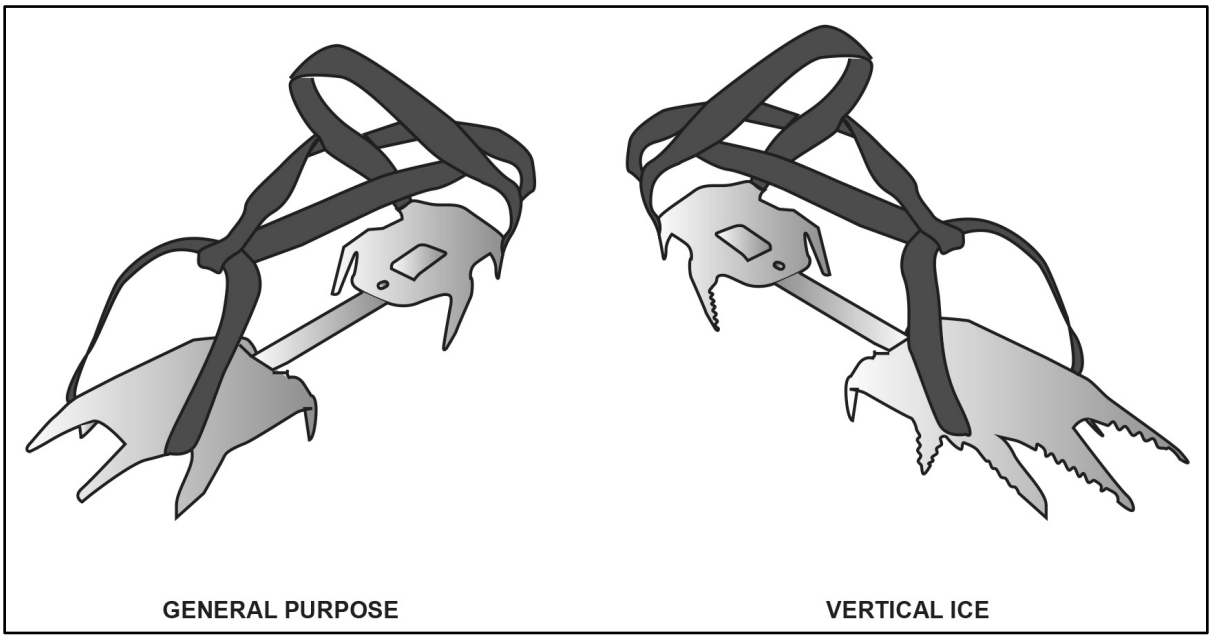



**Figure 6-31. Crampons**

6-99. Mountain axes are important tools for movement over steep snow and occasional low-angle ice. The two types of axes usually used in alpine terrain are general mountain axes and hybrid mountain axes. General axes are designed for steep snow and hybrid axes are designed for steep snow and low-angle ice climbing. Ice axes have an adze to the rear of the pick for chopping snow and ice. (See figure 6-32.)

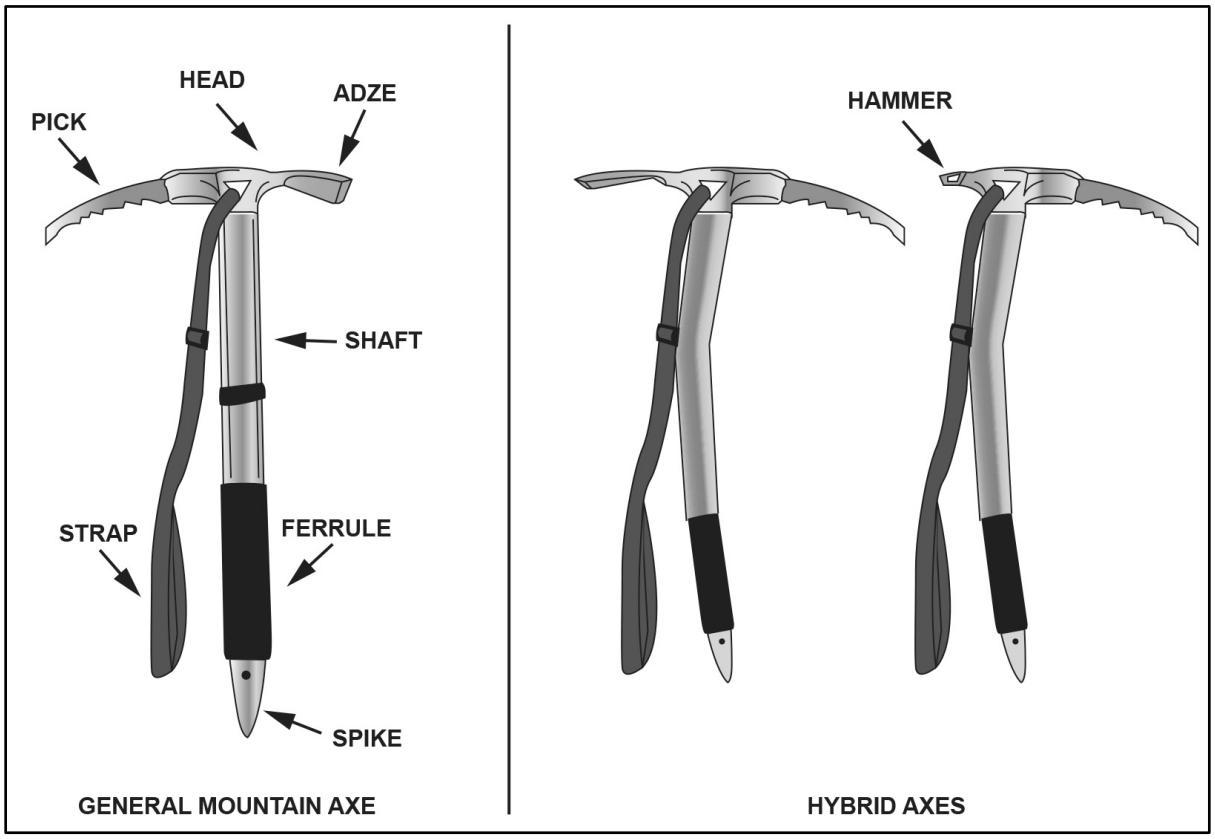



**Figure 6-32. Mountain axes**

6-100. Ice tools are modified ice axes designed for steep ice climbing. They are much more aggressive and curved to help obtain solid sticks in hard vertical ice and over bulges. They are less effective in snow than general or hybrid axes because of their short length. Ice tools can include an adze or a hammerhead. Hammers are used for placing pitons during mixed climbing. (See figure 6-33, page 118.)



**Figure 6-33. Ice tools**

## MILITARY OPERATIONS IN SNOW- AND ICE-COVERED TERRAIN

6-101. Snow and ice present many additional challenges for units that need to move in mountainous terrain. Specialized equipment, training, and experience are necessary to move in it safely and effectively. Whether the challenges are deep snow, slick slopes, or steep sections of vertical ice, they will prove substantial obstacles for unprepared units. Units anticipating operating in such terrain and conditions should train in them prior to engaging in combat operations.

6-102. Even with proper equipment and training, it is unlikely that larger units can move in terrain steeper than 2nd-class terrain without ropes due to the high risk of long sliding falls. Small teams of advanced military mountaineers should be trained to move over ice and snow and tasked with finding routes and establishing rope systems for larger units. (See chapter 11 for establishing fixed-rope systems for troop movement in steep terrain and ATP 3-21.50 for crossing VDA TTP.)

# MOVEMENT OVER SNOW

6-103. Low- to moderate-angle snow slopes found on or adjacent to valleys are primary avenues of movement for military units operating in winter conditions. Steeper slopes in gullies and passes are often the easiest routes through even steeper rocky features around them. Though challenging to move over, these often provide the best access to points of domination in alpine terrain.

6-104. Techniques for moving over snowy surfaces change IAW slope and surface conditions. Some soft snow increases physical strain but can increase the security of foot placements. During movement, breaks should be taken more frequently and for shorter durations in cold weather to assist with moisture management. This helps prevent overheating, which can cause problems once movements stop. Snow deeper than calf-height makes movement difficult without skis or snowshoes. Hard-packed snow slopes requiring special techniques and equipment or falls that could result in serious injury or death are likely.

6-105. A thorough analysis of avalanche threat should be conducted prior to moving over slopes that could be exposed to avalanche risk. Terrain at any risk for avalanche should be avoided. All Soldiers moving in potential avalanche terrain must be equipped with avalanche protective equipment and trained in its use, as well as avalanche response procedures. (See chapter 5 for more information on avalanche considerations.)

## BOOT PACKING

6-106. The boot-packing method requires the least amount of training and special equipment. The same techniques can be used in mountain walking; however, there is often less traction. During the boot-packing method, Soldiers move slower and minor slips and falls should be expected. In deeper soft snow, Soldiers should step in the tracks left by the Soldier in front of them. This packs them into hard steps and makes movement less difficult. Rotate lead Soldiers to prevent fatigue.

6-107. Crampons are strongly recommended for moving on hard-packed slopes. However, if crampons are not available, there are a few techniques to use to improve the security of foot placements. Step kicking involves kicking the toe or edge of the boot into the surface with each step creating a small depression, which improves traction. Mountain axes can be used as a third point of contact, allowing the body to gain more traction. The axe is typically held by its head in the uphill hand, with the pick to the rear (cane position). Steps can be cut into the slope using the axe's adze to improve foot placement security. (See figure 6-34, page 120.) This technique is effective for short distances but is very time-consuming.

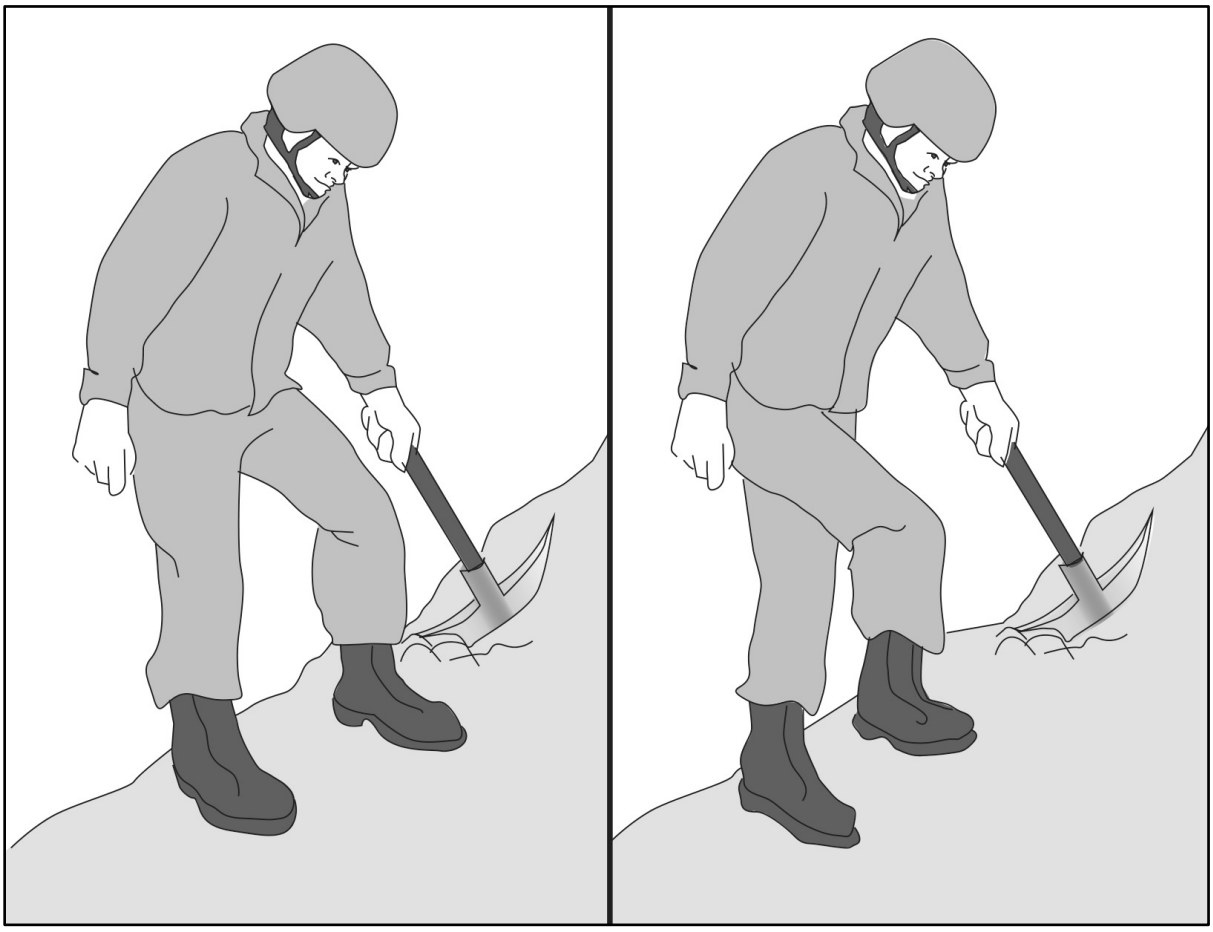


**Figure 6-34. Step cutting**

## GLISSADING

6-108. Glissading is a technique used to descend low to moderate angle slopes by sliding in the seated position and using a mountain axe as a brake. (See figure 6-35.) Glissading allows Soldiers to descend appropriate slopes very quickly and efficiently, thereby saving significant time and energy. Specific conditions are required for glissading to be appropriate. The slope should not have any obstacles (such as trees, rocks, drop offs, crevasses) in the slide path, and it should have sufficient soft snow on the surface to allow Soldiers to control the speed of the slide. Glissading should never be done on hard-packed snow or ice surfaces. Crampons should be removed prior to glissading to ensure injuries to lower extremities are not caused by a crampon becoming caught on something during the slide.

6-109. Glissading is conducted by sitting in the snow and positioning the midpoint of a mountain axe shaft against one hip with the spike in the snow. The hand on the same side as the axe holds its shaft to the hip at the midpoint. The other hand holds the top of the axe where pick, shaft and adze meet. The mountain axe pick should always face forward (away from the Soldier) to prevent injury. Soldiers then initiate the slide on their buttocks using the axe spike as a brake. To slow down, Soldiers rotate the spike downward, pressing it deeper into the snowpack and increasing friction. To speed up, Soldiers rotate the spike away from the snowpack, decreasing friction. Adequate time should be allowed between Soldiers sliding in the same glissade path to ensure a collision does not occur should a Soldier stop shortly mid-slide.



**Figure 6-35. Glissading**

## FLATFOOTING

6-110. Flatfooting is the term for numerous techniques that increase security and efficiency of movement over snow and ice slopes. These techniques involve the use of both crampons and a mountain axe. The key principle of flatfooting is to position the body so that all crampon points are embedded in the snow surface. This provides maximum security for foot placements. These techniques are particularly critical to safe movement over steep, hard-packed snow. Flatfooting with heavy loads requires greater proficiency. Flatfooting techniques are much more difficult to perform in flexible boots or with loose sloppy crampons. (See figure 6-36, page 122.)

6-111. Crampons substantially increase the security of foot placements when used properly. However, walking in them forces the Soldier's gait to change and can take some practice getting used to. They must be sized properly and snugged tight to the boot, so Soldiers' boots do not slide around in the crampon introducing instability to their foot placements.

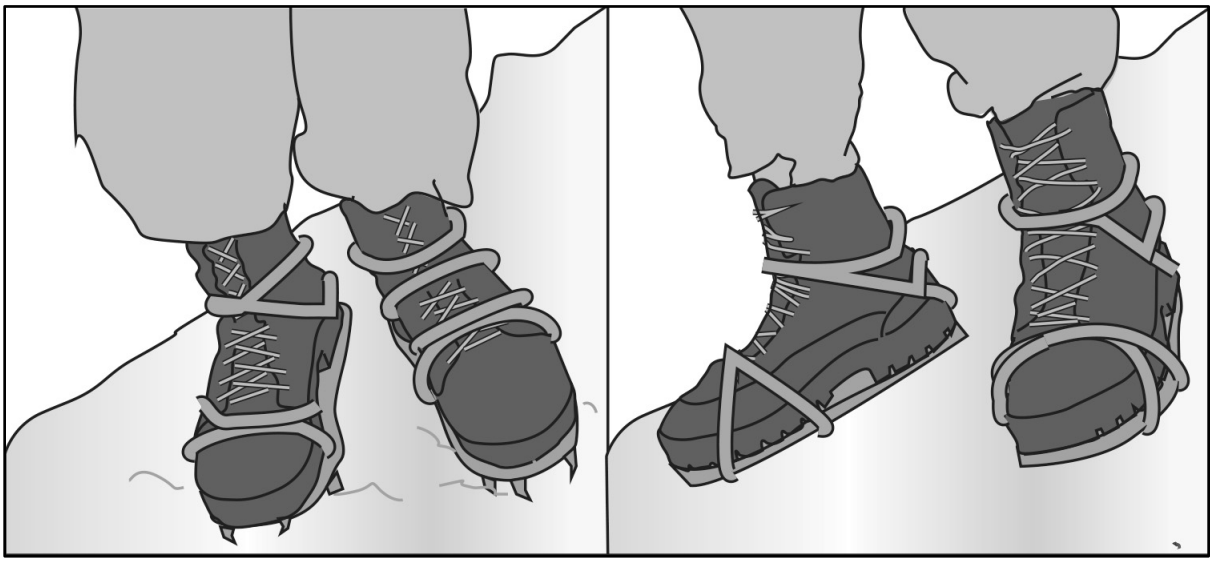


**Figure 6-36. Flatfooting**

## Ascending

6-112. Lower-angle slopes can be ascended using a diagonal traverse or switchback technique. More security can be gained from pointing the toe downhill some when placing the foot. Mountain axes or an ice tool can also be used in cane position the same way previously mentioned. (See figure 6-37.)

6-113. As terrain gets steeper, maximizing crampon point contact with the surface becomes more difficult. Footwork techniques used in rock climbing, such as edging, are very insecure when wearing crampons. They should not be used. Ankles must be rolled somewhat downhill to ensure crampon points are embedded in the surface. Turning the downhill foot so that the toe points downhill increases security by making it easier to engage the crampon points on the outside edge of the foot.

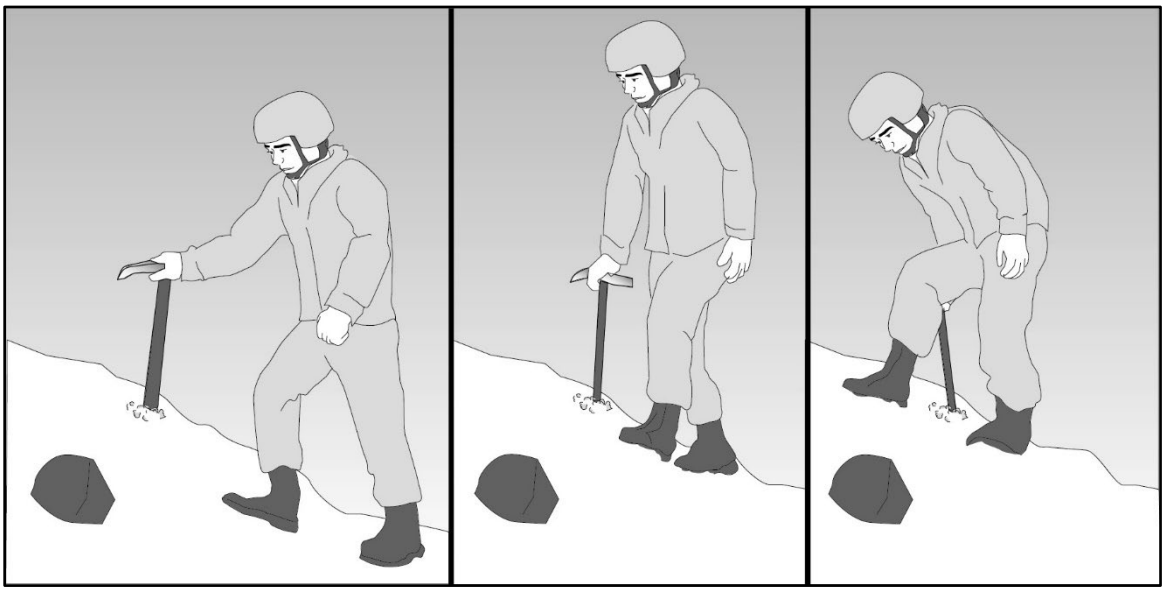


**Figure 6-37. Ice axe uses in low-angle terrain**

6-114. To obtain secure foot placements, lean the body away from the slope to increase pressure on crampon points. This becomes more important as surface conditions get firmer. Generally, it is easier to stay in balance and achieve solid foot placements by taking smaller steps. Moving diagonally up slope makes this easier to execute.

6-115. Flatfooting, using a mountain axe in a cross-body position. To perform this technique, the Soldier stands sideways to the slope. The mountain axe head is held in the downhill hand and the shaft held low in the uphill hand. The uphill foot is placed perpendicular to the slope and the downhill foot is placed similarly, but with the toe pointed downhill as much as comfort demands. The axe spike is then forced into the snowpack uphill from the feet far enough so that most of the Soldier's weight is transitioned onto it. This provides balance and security during foot movement. The downhill foot is moved across and placed above the uphill foot. If the crossover step is too awkward, it can be moved to a position just below the uphill foot, but this method is less efficient. The Soldier's weight is then transitioned onto the newly placed foot so that the uphill foot may be moved upslope. The process is then repeated, starting with replacing the axe uphill and the Soldier moves in a generally diagonal path up the slope. (See figure 6-38.)

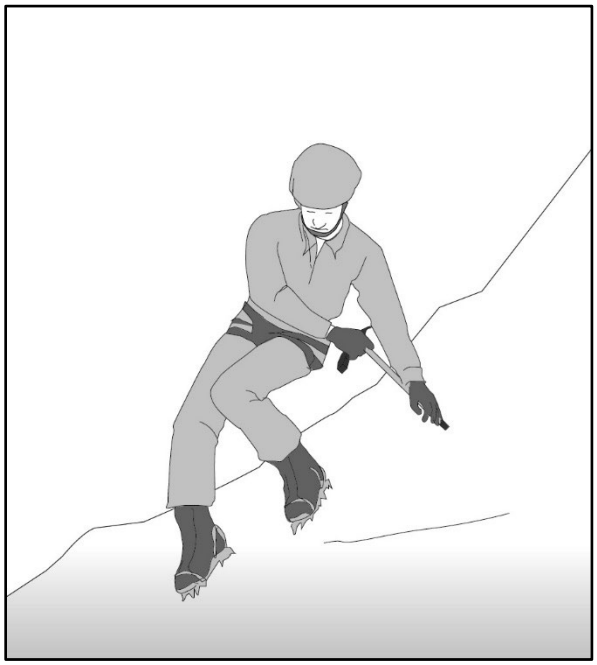


**Figure 6-38. Flatfooting with axe in cross-body position**

6-116. Flatfooting using a mountain axe in anchor position. The footwork is the same for this technique as when using the axe in a cross-body position. However, the axe is held by the shaft like a hammer and swung so that the pick is embedded into the uphill slope. The axe can then be "climbed" by walking the hands up the shaft while the feet work their way up the slope. (See figure 6-39.)

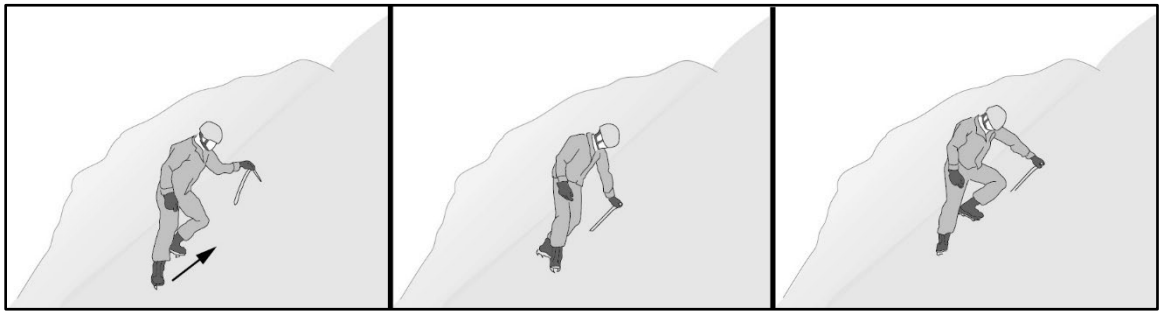


**Figure 6-39. Flatfooting with axe in anchor position**

6-117. Front pointing involves kicking into the slope with the toe of the boot so that all front crampon points become embedded in the surface. The Soldier leans forward slightly locking the ankle so that the sole of the foot is held perpendicular to the slope. If the heel is too low or too high, or only the large front points are embedded, then the foot placement will be less secure and may fail. The Soldier stands up on the placement using hands or mountain axe for balance and repeats kicking in with the other foot higher on the slope. This process is repeated as the Soldier generally moves straight up the slope. The front-pointing technique is very effective and allows for faster movement in steep terrain but is more physically taxing. The Soldier's calf muscles become fatigued quickly using this technique. The front-pointing technique is most effective for ascending short, steep sections of terrain. (See figure 6-40.)

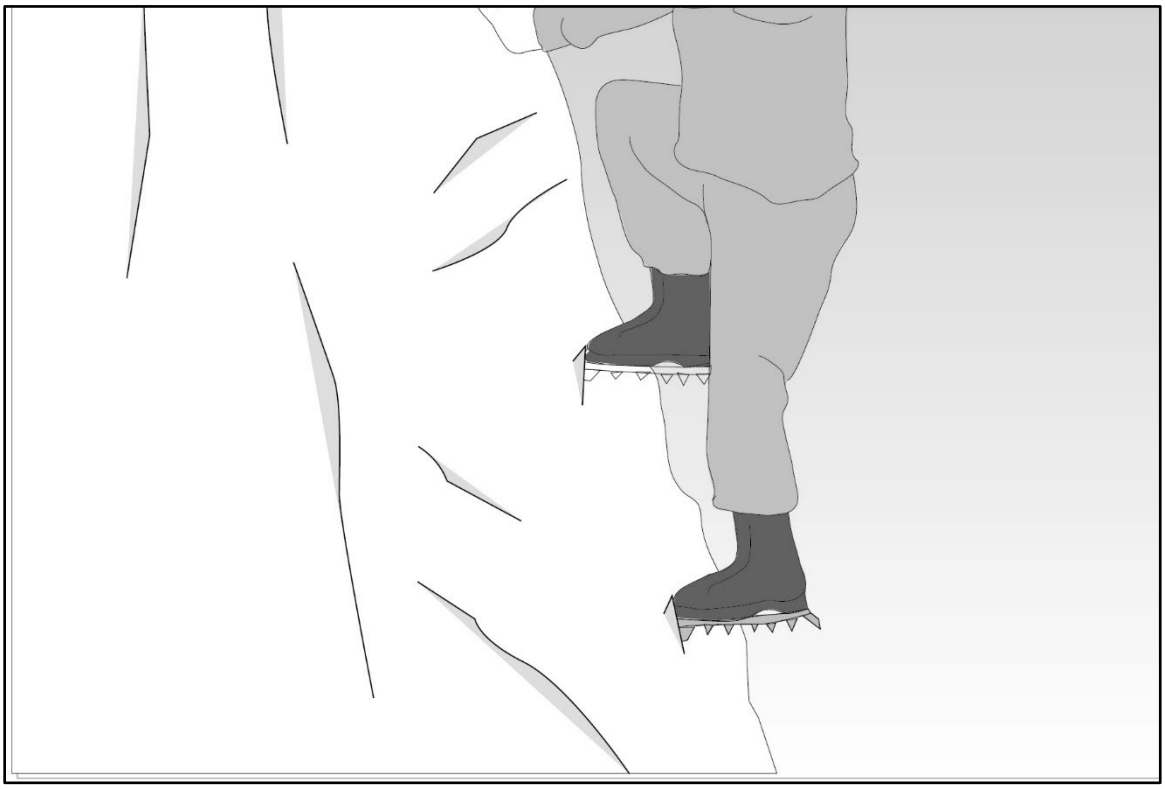


**Figure 6-40. Front pointing**

6-118. Front pointing with a mountain axe in dagger positions involves Soldiers holding the axe by the head with the adze and thumb facing them. The pick is then forced into the slope in a hammer-fist motion (high dagger). Once placed, Soldiers walk their feet up the slope, using front pointing as high as they can go. A low dagger technique can be used to allow climbing higher than a high dagger allows by transitioning the hand to the top of the axe head and pushing down on it for balance. The process is then repeated, moving straight up the slope. (See figure 6-41.)

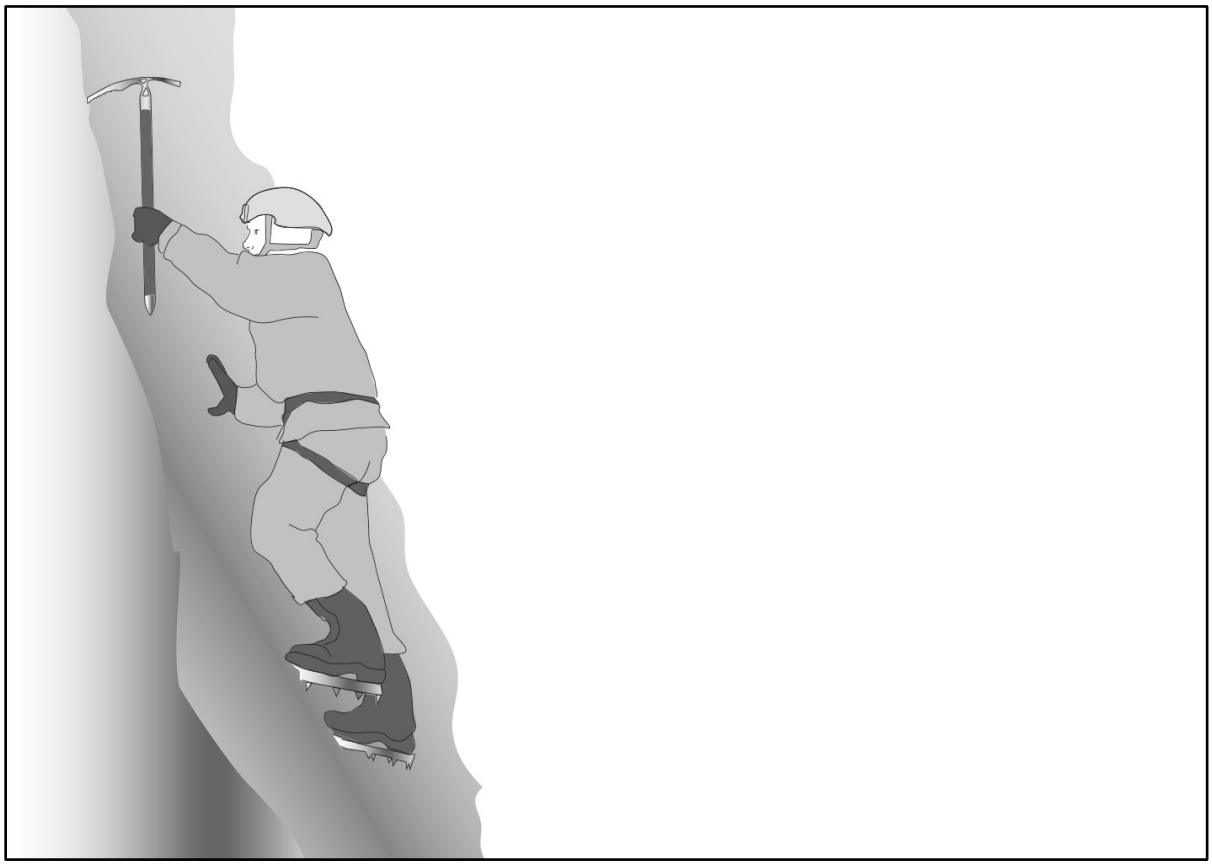


**Figure 6-41. Front pointing with axe in dagger positions**

6-119. Front pointing with mountain axe in anchor position involves holding the axe by the shaft and swinging it like a hammer so that the pick is embedded into the slope higher above the Soldier. The axe is then used as holds for both hands as Soldiers climb the slope with their feet using front pointing. (See figure 6-42.)

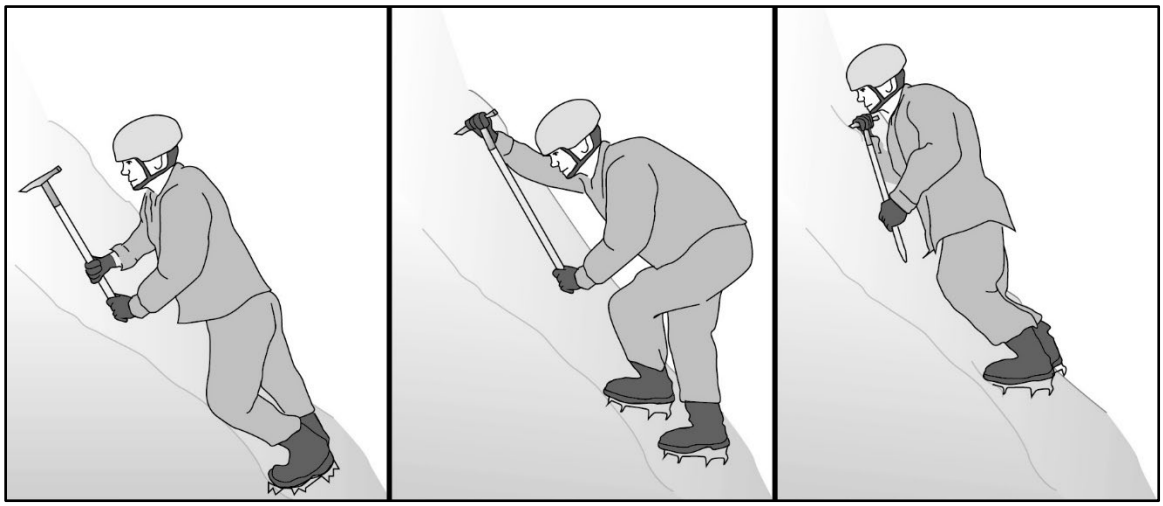


**Figure 6-42. Front pointing with axe in anchor positions**

6-120. Front pointing using mountain axe as in ice climbing involves holding the axe by the shaft and swinging it like a hammer so that the pick is embedded into the slope as with anchor position. However, in this technique the Soldier only uses the axe for holds with one hand. The other hand is placed to push against the slope for balance. (See figure 6-43.)



**Figure 6-43. Front pointing using axes in ice climbing**

## Descending

6-121. Slips and slides should be considered very likely on moderate to steep terrain, especially if surface conditions are hard. Rope systems may be used to mitigate the risk of injury, but they do not make movement faster or easier. Efficient movement requires good flatfooting skills.

6-122. Moderately steep slopes can be descended by simply using a diagonal traverse or switchback pattern down the slope. This may require rolling the ankle more than usual to force all crampon points into the snow. The downhill foot can be turned so that the toe points downhill to reduce strain and add security during movement. The mountain axe is used in any of the positions described above to aid with balance and prepare the Soldier for self-arrest. Edging technique is ineffective; Solders should not attempt this technique. (See figure 6-44, page 128.)

6-123. Steeper slopes require descent facing downhill and relying heavily on a mountain axe for balance and security. Soldiers must bend their knees to lower their center of gravity and position their weight over their crampons. Depending on the slope angle and surface hardness, the mountain axe should be used in one of the positions described below:

- Using the mountain axe in cross body position, while driving the spike into the slope behind the feet is a very secure method of moving down steep slopes when executed properly. During movement, most of the weight is supported by the mountain axe and the feet are moved forward in short deliberate steps. In hard surface conditions, crampons need to be stomped into the ground to ensure points are set. Weight is then transitioned over the feet, the axe moved down and reset. (See figure 6-44, page 128.)
- In addition to the positions already discussed, the mountain axe can be used in support position while descending. This is when it is carried in one hand, head oriented uphill and pick facing down, while the Soldier moves down the slope facing downhill. The axe is held in this position so that the Soldier can quickly plant the pick into the snowpack for security, as necessary. If this is done, the axe provides a handhold to assist in making one or two moves that are more difficult. This can be repeated for longer sections that are more difficult than necessary. (See figure 6-44, page 128.)
- If more security is needed, then the Soldier can transition to using the axe in the anchor position, allowing both hands to grip the axe and a more secure pick placement. (See figure 6-44, page 128.)

6-124. Using the mountain axe in cross body position, while driving the spike into the slope behind the feet is a very secure method of moving down steep slopes when executed properly. During movement, most of the weight is supported by the mountain axe, and the feet are moved forward in short deliberate steps. In hard surface conditions, crampons need to be stomped into the ground to ensure points are set. Weight is then transitioned over the feet; and the axe moved down and reset.

6-125. In addition to the positions already discussed, Soldiers can use the mountain axe in its support position while descending. Soldiers carry the axe in one hand, head oriented uphill and pick facing down, while moving down the slope, facing downhill. The axe is held in this position so that the Soldier can quickly plant the pick into the snowpack for security, as necessary. Carrying the axe this way provides a handhold to assist in making one or two moves that are more difficult. This can be repeated for longer sections that are more difficult, as necessary. (See figure 6-44, page 128.)

6-126. If more security is needed, the Soldier can transition to using the axe in the anchor position, allowing both hands to grip the axe for a more secure pick placement.

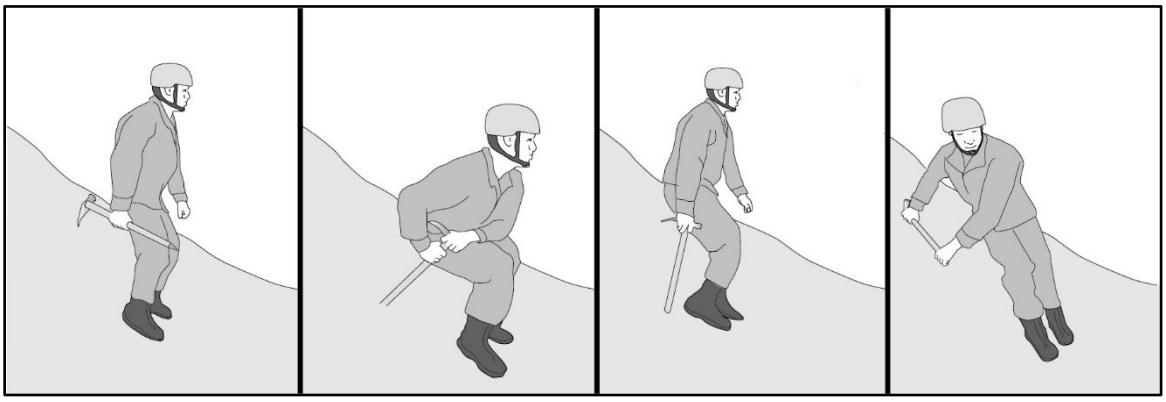


**Figure 6-44. Descending steep slopes**

## SELF-ARREST

6-127. Self-arrest is a technique intended to stop a short fall before it turns into a long, sliding, tumbling fall. Soldiers that will be moving on moderate to steep snow slopes unroped must be issued a mountain axe at a minimum and trained to proficiency in self-arrest techniques. There is little margin for error in executing self-arrest on steep slopes with firm surface conditions. Self-arresting should not be considered an adequate protective measure when slipping and falling risk is determined to be likely. Good movement skills are still the primary risk mitigation for moving unroped.

6-128. Soldiers should carry the axe in the cane position with the pick to the rear in the uphill hand. The instant Soldiers fall, they must commit to self-arresting immediately. The technique is executed by bringing the mountain axe into position at the center of chest, with the hand on its head and pick facing away. The lower hand moves to a position low on the axe shaft. The Soldier then uses body weight and violence of action to drive the pick into the snowpack. This must be done in seconds and if the axe is not centered under the body, it is difficult to apply adequate force to achieve this. The less aggressive and curved design of the ice axe pick is meant to prevent it from biting into the surface too well, where momentum would cause it to be ripped out of the falling Soldiers' hands. Rather, it is designed to stop the Soldier gradually. For this reason, picks that are more aggressive like those found on tools meant for ice climbing are less effective for this. If crampons are not worn, the Soldier can also dig toes into the snowpack to assist stopping the slide. Careful attention must be paid not to allow the spike of the axe to dig into the snow while sliding. If this happens, the Soldier could be flipped over backwards and thrown into a tumble. Recovering from a tumbling is unlikely. (See figure 6-45.)

6-129. When self-arresting with crampons on, Soldiers must bend their knees during the slide, so the crampon points do not catch and cause a tumble. Legs must remain bent until sliding has stopped. Front points can then be planted to reduce the likelihood of a slide resuming.

6-130. To self-arrest while sliding on the back, the Soldier must bring the axe into position at the center of the chest, then roll in the direction of the axe head until on the stomach, and then drive the pick into the snow.

6-131. To self-arrest headfirst face down, the Soldier must reach downhill to the same side as the axe head, plant the pick, pivot the body around the pick, and swing the legs downhill.

6-132. Self-arrest headfirst, on the back, is the most difficult. Here, the Soldier must plant the pick, twist and roll toward the pick, swing the legs downhill, and roll the chest toward the pick.



**Figure 6-45. Self-arrest**

## SNOWSHOES AND SKIS

6-133. Snow deeper than calf height typically requires more floatation than crampons provide for efficient movement to be possible. Skiing is the most efficient technique for moving over deep snow but requires substantial training to become proficient. Snowshoeing is less efficient but is relatively easy for Soldiers to learn.

6-134. Moving in snowshoes provides good floatation and traction in deep snow. Poles should be used to maintain balance while moving. More practice is necessary if the terrain is rough, rocky, or strewn with obstacles. Soldiers should practice with operational loads to proficiency.

6-135. Skiing involves using climbing skins on flat terrain and while ascending. Heels are released during movement. Traversing or switchback techniques should be used when ascending slopes. Poles should be used to help with balance, especially when carrying a pack. Slopes can be descended slowly with skins on, or skins

can be removed for rapid decent. Well-trained skiers can move very quickly in steep terrain. The historical effectiveness of ski troops is well documented.

# ICE CLIMBING

6-136. Ice climbing is demanding and requires specialized equipment and techniques. Waterfall ice develops in the bottom and along the steep sides of drainages, such as gullies and couloirs. (See figure 6-46.) Alpine ice can develop in the same areas or in glacial features that are more open. (See figure 6-47.) These terrain features may provide the easiest routes for ascending and descending steep mountains.

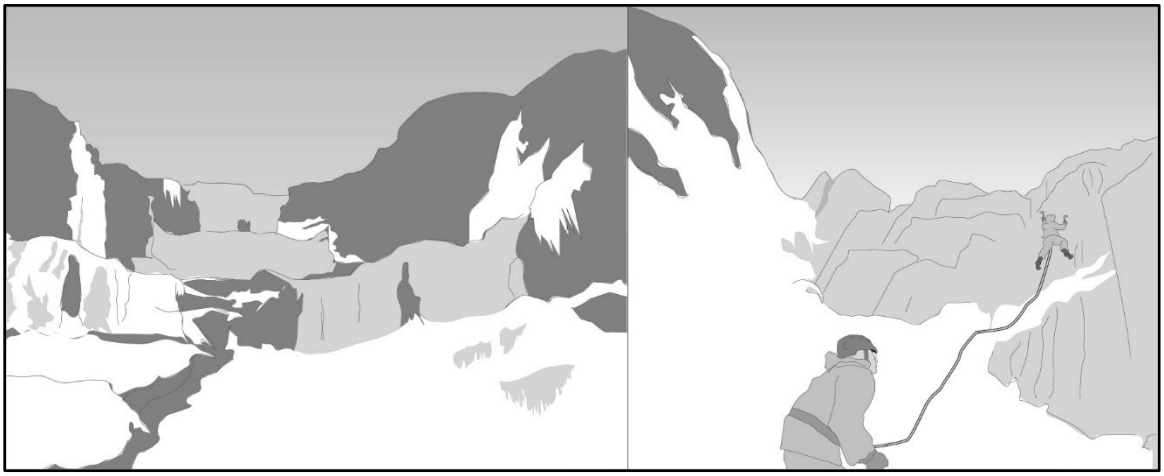


**Figure 6-46. Waterfall ice**



**Figure 6-47. Alpine ice**

6-137. All the hazards associated with rock climbing exist for ice climbing, as well as additional ones, including avalanches and icefalls. Icefall is always a real threat to ice climbers and personnel located below them. This is particularly true during warmer temperatures as hanging ice features can break off and fall naturally. Ice climbers are at higher risk of injury during a fall due to the sharp tools and crampons used in climbing. Even short falls can result in a tool accidentally puncturing the climber's body, or a crampon catching on a feature during the fall and causing lower extremity injuries.

6-138. Climbing ice usually requires the use of rope systems for protection even when climber's skills are high due to the consequences of falling.

## ICE CLIMBING DURING MILITARY OPERATIONS

6-139. Sustained climbing in 5th-class terrain during conventional military operations is impractical, especially when covered in ice. However, routes through easier terrain are often blocked by short sections of low or steep angle waterfall ice. These routes may be the only or most tactically sound approaches to points of domination for properly trained units. Small teams of advanced mountaineers can be used to establish fixed-rope routes through this terrain for lesser-trained Soldiers to use for protection during movement.

6-140. Typically, Soldiers climbing ice are unable to provide themselves with sufficient, local security during movement. Bounding overwatch in vertical terrain by small-specialized teams or VDA-crossing procedures must be performed by a larger unit to provide adequate security for climbing Soldiers. (See ATP 3-21.50 for more on VDA crossing.) Small reconnaissance and surveillance teams may have to rely on careful technical route selection that provides concealment throughout the approach, the climb, and the top out. Fortunately, the terrain in which ice develops often provides such opportunities for teams with the technical and mobility skills necessary to negotiate it.

## ICE CLIMBING ROUTE SELECTION

6-141. Before starting to climb, Soldiers should study the face of the ice flow for features that indicate that climbing the route is possible. With experience, Soldiers can determine how difficult an ice flow will be for them to climb and how reliable protection placements will be. Climbers should form a plan for climbing and protection using rope systems (when necessary) before leaving the ground. (See chapter 10 for how to protect climbers from fall hazards.)

6-142. During military operations, the least difficult routes possible should be selected for travel. (See chapter 7 for more information on planning technical movement routes.)

## BASIC ICE CLIMBING TECHNIQUES

6-143. Compared to rock climbing, ice climbing movement techniques are relatively simple. The most difficult part is learning how to place tools and crampons into the ice so that they hold the climber's weight, and then moving in balance so as not to dislodge them or waste energy. The keys to efficient ice climbing are a reliable and secure tool, crampon placements, and staying in balance during movement.

6-144. Complicated movement techniques are rarely necessary in ice climbing.

### Using Ice Tools

6-145. The purpose of the tools in ice climbing is to provide climbers with handholds to hang from while moving their feet and for maintaining balance while moving the body. Whenever possible, each tool placement should be secure enough to hold the climber's entire body weight.

6-146. Modern ice tools should be held loosely by the grip, with the heel of the hand wedged into the hook or stop at the bottom of the shaft. This feature allows the climber to hang without squeezing. When done properly, the climber's weight can be held with just moderate pressure from two or three fingers around the grip. (See figure 6-48.)

6-147. Some force must be used when swinging ice tools, but how they are swung is more important than how hard it is. Placing tools starts with positioning the climber's hips close to the ice creating space to swing the tool. This becomes more important as the ice gets steeper. The tool is swung in an overhead arc with a flick of the wrist as the pick is about to strike the ice.

6-148. Ideal tool placements are as high as the climber can comfortably reach and as close to the centerline of the body as possible. Low features, or small depressions, are the best targets for tool placements. If a placement is not secure enough after one swing, climbers should swing again aiming for the same spot until they are confident that it will hold their entire weight.

6-149. Ice tools can be removed from the ice by gently tapping upward on the adze or hammer to loosen the pick in the ice. If the tool is too low in relation to the upper body, it can be gripped by the head and wiggled up and down to loosen.

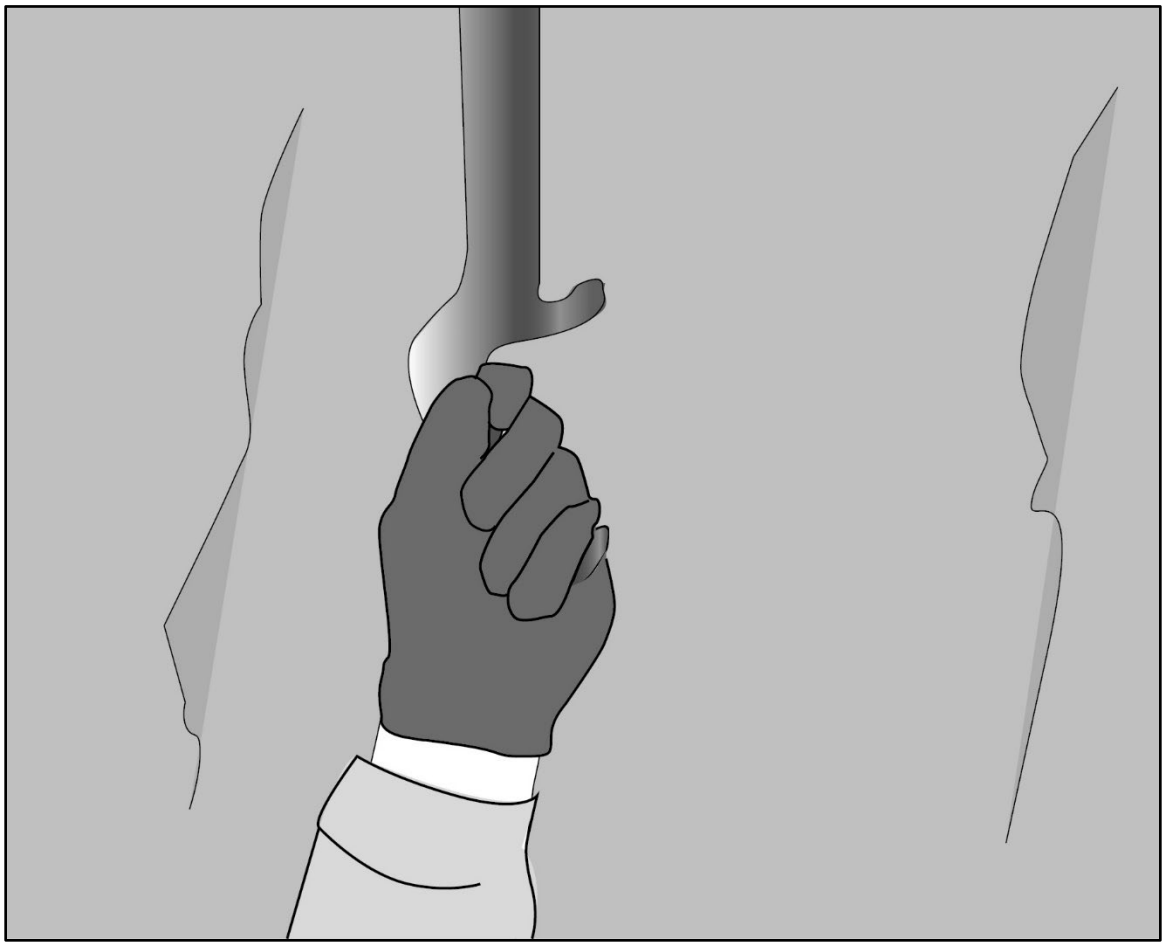


**Figure 6-48. Ice tool grip**

## Using Crampons

6-150. Crampons must be sharp, correctly sized, and tight. Vertical ice or technical crampons are preferred, but not always necessary.

6-151. Crampon placements on low-angle ice are used in the same manner as flatfooting with occasional front pointing. The hard surface of the ice requires more effort to ensure crampon points are set securely in the ice before committing weight to them. Edging techniques are insecure on ice.

6-152. When using crampon placements on moderate and steeper ice flows, front pointing is used exclusively. Climbers must move their lower body away from the ice during crampon placement. Good front point placements are those in which all front points are in solid contact with the ice and the foot is perpendicular to the surface. (See figure 6-40, page 124.) Low spots in the ice, the top of small features sticking out of the ice, and the tops any step-like features are the easiest spots to place crampons. Climbers must ensure that the sole of their boot remains perpendicular to the surface of the ice (for example, heel is not too high or too low), or front points may lever out of the ice.

## Body Positioning and Moving Efficiently

6-153. The basic body position for ice climbing is a triangle, with crampons placed about shoulder width apart, and tools placed in a staggered vertical pattern close to the centerline of the body. Body weight should be centered under the higher ice tool. This puts the climber in balance. The climber must resist the urge to place tools parallel with each other or wide in relation to the body. When this is done, the position causes the

climber to become out of balance during tool removal, causing the climber's body to open or swing toward the remaining tool placement. (See figure 6-49.) This could cause a fall.

6-154. The basic movement sequence starts from the position described in this paragraph. (See figure 6-50.) Climbers hang from a high tool placement and walk their feet up the ice as high as they can go. They return to a stable stance and push their body upward with their legs. Once erect, the low tool is removed. Climbers then place it as high as possible as close to the centerline of the body, and the sequence is repeated.

6-155. With practice, the above sequence becomes more fluid, and steps are combined for efficiency. However, focusing on this sequence helps new climbers to learn what being in balance feels like. Once they develop basic proficiency, they can adjust the technique for their body type and can better negotiate more complex ice features.

6-156. Occasionally, moving diagonally left or right of the high tool is necessary or more efficient than straight up above the climber. In this case, the high ice tool is placed as high as necessary in the direction of travel. Climbers then adjust their feet laterally back into line with the high tool to maintain balance, then climb their feet up as previously described. With practice, the lateral foot movement can be skipped, and climbers can just climb toward their high tool and back into position.

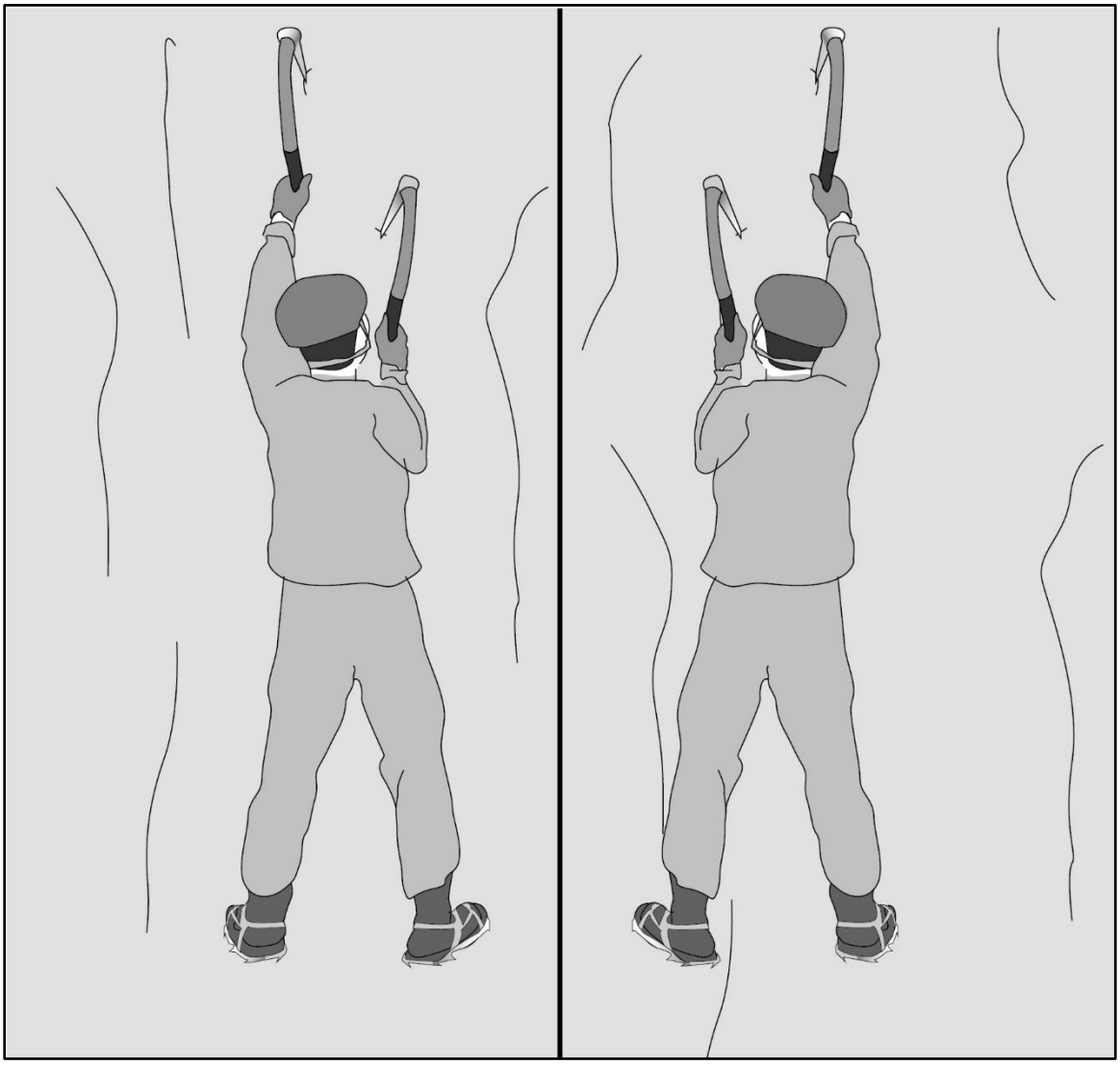


**Figure 6-49. Basic body position**

### Special Moves

6-157. Stemming is the same as in rock climbing and provides the same benefits. The opportunity to do this is created by a groove feature running vertically up and down the ice. Climbers kick their crampons diagonally into the sides of the feature for very secure foot placements. Stemming makes climbing steep ice much easier.

6-158. Climbing over ice bulges is challenging because maintaining a high tool for balance is not always possible. The high tool must be placed low in relation to the body on a horizontal feature. Feet must then walked up the lower face as close to the lip of the bulge as necessary for the climber to step onto the top of it. Crampon placements can be difficult because the bulge may block the climbers' line of sight with their feet. This series of movements is strenuous for the arms because it forces the climber to lean back away from the ice more than normal so as not to topple forward. (See figure 6-50.)

6-159. Traversing is challenging because it requires the climber to move deliberately out of balance and then back into balance with each move. The lead hand places a tool far to the side in the direction of travel. The climber then makes a short move in that direction. The rear tool is then moved into a new position closer to the centerline of the body. The climber then moves toward the lead tool again until it is close to the centerline of the body. The lead tool is then moved to a position further in the direction of travel and the sequence repeats. (See figure 6-50.) Another more advanced technique involves leap frogging the tools across the ice face to provide successive high tool placements. This requires changing hands on the high tool with each move and passing the rear tool to the lead hand before the next tool placement is made. With either technique, there is a strong likelihood that a tool could be pulled sideways and out of the ice. The climber must always pull straight down when traversing.

6-160. Down climbing ice is tricky but can be done on lower angle ice by Soldiers with strong skills. Down climbing steep ice is very difficult since the ice flow usually blocks the climbers' view of their feet and transitioning over bulgy features during descent may prevent climbers from even positioning their body to make effective crampon placements.

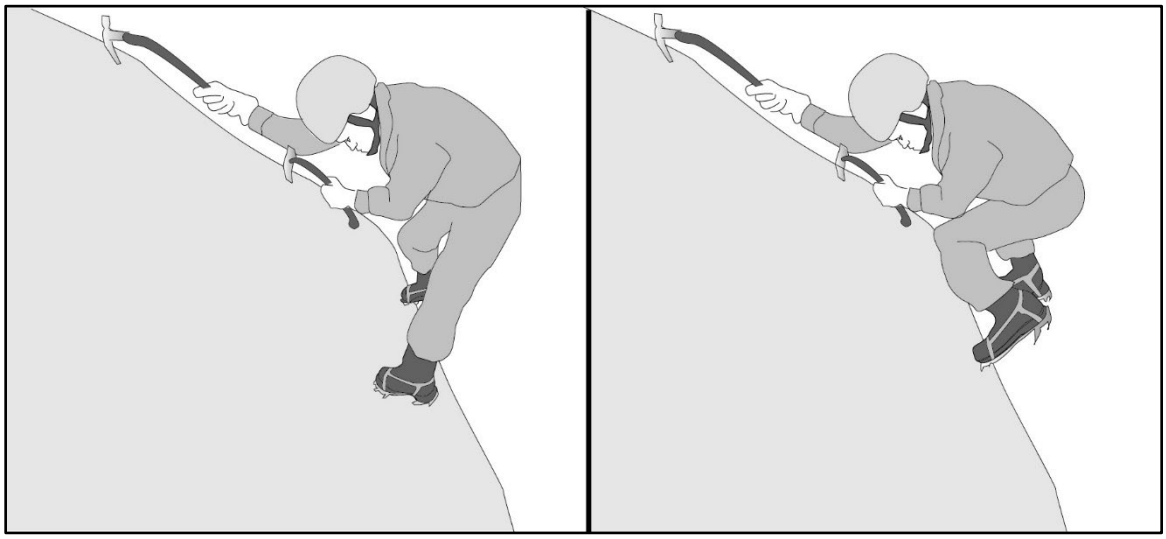


**Figure 6-50. Climbing over bulges**

## MIXED CLIMBING CONSIDERATIONS

6-161. Mixed climbing involves climbing terrain that is made up of both rock and ice features. Ice tools are used as described earlier in ice features but are also used to hook rock features or wedge into cracks. This kind of 5th-class climbing requires very high rock and ice climbing skills.

6-162. Climbing difficult mixed routes is impractical for military operations. However, easy to moderate mixed climbing (3rd- and 4th-class) is often necessary in alpine terrain. At the very least, transitioning back and forth between climbing low angle ice and snow and scrambling on rock in a cold environment is often necessary.

### TRAINING FOR ICE CLIMBING

6-163. Beginner ice climbing training is typically conducted at established climbing areas using top rope belay techniques (see chapter 10, section III). When supervised by qualified mountaineers, this kind of ice climbing is typically moderate risk and high payoff for developing mobility skill for small numbers of participants, if sufficient time is allotted. Top rope ice climbing sites are typically small or spread out. Training large groups effectively is difficult without special manufactured ice-climbing facilities. This is primarily due to the cold-weather environment in which ice develops. Ice climbing training should be planned along with concurrent training for smaller groups to rotate through. Route difficulty should be challenging for climbers, but easy enough that they can be successful. This motivates climbers to improve their skills. A motivational rather than critical atmosphere is most effective when building climbing skills.

6-164. Climbing training for more advanced military mountaineers can be conducted the same way, just on more challenging routes, but should also be conducted in multi-pitch settings that more accurately reproduces conditions of climbing during military operations. This setting requires the development of lead climbing and route-finding skills critical to the advanced military mountaineer.

6-165. Leaders should try to learn the etiquette associated with climbing before using civilian climbing areas.

## SECTION III – LOAD MANAGEMENT FOR MOBILITY

6-166. Overburdened Soldiers cannot move safely or efficiently in steep unstable terrain. The amount of weight Soldiers carry and how they carry it directly affects their ability to move safely and efficiently. The heavier the load carried; the greater the Soldier's capability is reduced. This results in slower movement and the potential for injury in rough or steep terrain. Unbalanced or loosely packed loads have the same effect.

# LOAD MANAGEMENT

6-167. ***Load management*** **is the act or strategy of planning and packing loads to reduce negative impacts on Soldier physical performance**. Excessive loads reduce movement speed, increase the likelihood of orthopedic and lower back injury, and significantly increase the risk of falling in high-consequence terrain.

# PLANNING

6-168. When planning packing lists, leaders must consider the level of mobility necessary during movement first. Once identified, loads should be reduced IAW it. Commanders should consider modifying requirements for the protective posture for Soldiers operating in difficult terrain. When Soldiers must move dismounted in mountainous terrain, plate carriers, lower profile armor plates, and lower profile tactical load-bearing harnesses can allow them to move further, faster, and more efficiently, resulting in increased maneuver capability. Trends of past enemy engagements in a unit's area of operation should be considered to determine if ammunition and other munitions requirements could be reduced. Equipment used infrequently must be considered for reduction or removal entirely from standard packing lists. "Ounces equal pounds," and units that try to carry equipment for every contingency are less mobile and less effective in rugged terrain. (See chapter 4 for general load management guidance.)

6-169. Sleds should be used when heavy loads must be carried over snow-covered terrain. Their use reduces Soldier fatigue and allows for rotating load-bearing responsibilities throughout a movement. Additionally, Soldiers can then drop most of their load when contact with the enemy is made while retaining essential survival items in their pack.

6-170. In steeper less stable terrain, packs should be loaded with heavier objects lower than normal to assist with balance by lowering the Soldier's center of gravity. Heavy or loose items should not be attached to the outside of packs, as they could shift and cause a fall.

# SCRAMBLING AND CLIMBING LOAD MANAGEMENT

6-171. Load planning for Soldiers who need to climb rock or ice is a difficult task. The difficulty of the climbing they must conduct, protective systems needed to prevent fall injury, and fitness must all be considered before packing lists are developed. Leaders must be open to developing different packing lists for different teams IAW the mobility level their mission requires. It is likely that only items necessary to the mission may be carried out to make easy climbing feasible. Lead climbers, who are at risk of long falls, may only be able to carry what is necessary to fulfill their role during the climb (for example, finding routes in technical terrain and establishing protective systems for follow-on troops). Any additional equipment they may need might need to be cached, hauled through the terrain, or carried by follow-on personnel.

6-172. Climbers may require smaller packs that allow for greater range of motion when climbing. Occasionally it is necessary for them to attach their pack to their harness, hanging below, or between the legs.

6-173. Weapons must be slung on the back or to the side of the pack during sustained climbing. Lead climbers may need to leave weapons behind or carry smaller weapons, such as pistols, during particularly difficult sections of climbing to reduce fall risk. Follow-on Soldiers who are protected by rope systems would then carry their weapon through the section.

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## Chapter 7

# Navigation in Mountainous Terrain

The goals, strategies, and tools available to Soldiers for navigation in mountainous terrain are no different from other types of terrain. However, mountainous terrain makes using those tools to stay on course much more difficult. Additionally, straying off course while navigating in this terrain can prove extremely hazardous and detrimental to mission success. The difficulty of planning routes and calculating movement timelines also increases significantly with the steepness and complexity of terrain. Soldiers and leaders who learn how to mitigate these challenges effectively can not only successfully navigate in mountainous terrain but also better use the terrain for cover and concealment.

## SECTION I – MILITARY LAND NAVIGATION IN NONTECHNICAL MOUNTAINOUS TERRAIN

7-1. Navigation is the process of determining one's present position, locating a target objective, and selecting and following a route between these two points. Navigation consists of three distinct stages: orientation, navigation, and route finding.

7-2. Orientation is simply figuring out exactly where one is. Using a map, compass, and identifiable terrain features, assisted by an altimeter and GPS, is the foundation of good orientation.

7-3. Navigation determines the objective's location and the direction from the Soldier's starting point to the objective. The same skills and equipment used in orientation are essential for good navigation.

7-4. Route finding is picking the best line of travel IAW METT-TC (I); mission, enemy, terrain and weather, troops and support available, time available, civil considerations, and informational considerations, and the commander's intent. Good route finding in mountainous terrain requires solid terrain analysis, clear priorities for route selection, an understanding of group members' levels of fitness and mobility skill, unit capabilities for technical movement, and mission-specific requirements. Examples of priorities for route selection are navigability of terrain, tactical advantage and disadvantage throughout the movement, concealment throughout, fatigue reduction, and required speed of movement.

7-5. Perhaps the single, most important factor in navigation through mountainous terrain is the ability to identify and analyze terrain. Navigators must be able to create an accurate mental model of the terrain to be moved through from a map or satellite imagery. The more skilled they are at this, the more effective they will be at avoiding hazards, selecting tactically advantageous or concealed routes, and planning paths that minimize fatigue. This ability can only be developed effectively through route planning and movement in such terrain. Skill at land navigation in level terrain does not necessarily translate to skill in mountainous terrain. (See TC 3-25.26 for more information on general navigation techniques.)

## NAVIGATIONAL EQUIPMENT

7-6. The following equipment should be considered for use when planning for or navigating in mountainous terrain:

- Maps and protractors.
- Imagery (satellite, aerial, or surface taken).
- Compasses.
- Altimeters.
- GPS devices.

### MAPS AND PROTRACTORS

7-7. Ideal topographical maps for mountain navigation are those of sufficient scale and detail to depict terrain features accurately. This may require using larger-scale maps usually requested for military operations and

may require carrying more map sheets to cover all terrain in any operation. For larger-scale maps, a smaller contour interval can make terrain analysis easier.

## SATELLITE AND AERIAL IMAGERY

7-8. Additional imagery of complex terrain can be very useful to a navigator for route planning. However, top-down satellite imagery often is not as useful as topographical maps. Aerial or surface photographs of specific terrain features can be incredibly useful for finding and planning routes through complex terrain.

## COMPASSES

7-9. The lensatic compass is most used and can be employed in a variety of ways for either day or night navigation. It can be used as an effective tool for navigating the mountains. The primary benefits of a lensatic over adjustable declination compasses are durability, inclusion of a mil-radian scale, and availability in the military supply system.

7-10. Ideal compasses for navigation in mountainous terrain are ones that have an adjustable declination. The user can adjust the compass to compensate for the difference between magnetic and grid north. This eliminates the conversion step usually required when obtaining navigational azimuths, thereby reducing time and probability of math errors. These types of compasses also usually come with illuminated north-seeking arrows, built-in protractor, and even magnifying glasses incorporated into the design. They are typically lighter than traditional military compasses and are the most widely used compasses by mountaineers. These compasses typically do not include scales in mil-radians and are usually plastic in construction, making them less durable than metal compasses.

## ALTIMETERS

7-11. Altimeters are valuable pieces of navigational equipment used by experienced navigators in mountainous terrain. They are rarely used in flatter terrain types. Most Soldiers have not been exposed to them or trained in their use. Altimeters provide navigators with elevation information for their location without requiring GPS satellite signal. This information turns contour lines on a map into reliable linear features that can be followed, used as progress markers during movement, or as known points when they intersect with other clearly identifiable linear terrain features.

7-12. Modern altimeters are most commonly digital and typically come in wristwatch form, though they are available as stand-alone digital devices. Battery life must be considered when using these devices. Nonelectronic analog altimeters are also available, typically as stand-alone devices. Digital altimeter devices also have a digital compass feature. Most mountaineers use digital watch altimeters.

7-13. Altimeters use a barometer incorporated into their design to measure the weight of air above the device. Since air pressure drops uniformly as elevation is gained, it can be used to read altitude by means of the altimeter's scale or digital display, marked in feet or meters of elevation above sea level.

7-14. Changes in the weather are usually accompanied by air pressure changes, which are reflected in the altimeter. As the air pressure drops due to the approach of inclement weather, for instance, the displayed elevation rises by a corresponding amount. This means that a barometric pressure change of 1 inch of mercury equals roughly 1,000 feet of elevation. If the altimeter displays an elevation gain of 300 feet, a loss of barometric pressure of 0.3 inch has occurred, and bad weather should be expected.

7-15. Because the altimeter is sensitive to changes in air pressure, it must be recalibrated whenever a point of known elevation (summits, saddles, stream-trail intersections, survey monuments, and so forth) is reached. This is especially important when weather fronts are moving rapidly through the area.

7-16. Altimeters are currently available in the military supply system. (See appendix C for national stock numbers.)

## GLOBAL POSITIONING SYSTEMS

7-17. The GPS is a highly accurate tool that can calculate user location by using a satellite constellation system. It can determine the latitude, longitude, and elevation of the user. Location information is also displayed in military grid coordinates.

7-18. The GPS provides precise steering information, as well as position locations. The receiver can accept many checkpoints entered in any coordinate system by the user and convert them to the desired coordinate system. The user then calls up the desired checkpoint, and the receiver displays direction and distance to the checkpoint. The receiver can also compute the approximate travel time to the next checkpoint.

7-19. Because the GPS does not need visible landmarks to operate, it can provide position (accurate to within 5 meters) in darkness or on featureless terrain. GPS also does not compound navigational errors as compass use can.

7-20. GPS devices and satellites communicate via radio waves, so anything that blocks light reduces or blocks the effectiveness of the signals. The more unobstructed the view of the sky, the better the system performs. Although the GPS can be used in any terrain, it performs best in more open areas, such as the desert. Heavy cloud cover and precipitation, such as snow or rain, can interfere with or block GPS signals.

7-21. Because the GPS requires horizon-to-horizon views for good satellite reception, its utility can be limited in the mountains. Canyons, deep valleys, saddles, and steep mountainsides are all problematic. Good locations to get satellite reception are high points or wide-open areas, such as ridgelines, spurs, summits, plateaus, and wide valleys.

7-22. When using GPS in regions with questionable surveying and mapping products, the operational datum of the local maps must be reconciled with the datum used in navigational and targeting systems. Identify the spheroid and datum information on the pertinent map sheets and then check that the GPS receiver has the compatible datum loaded. If not, then contact the intelligence staff office for updated datum or maps. Otherwise, the GPS will show different locations than those on the map.

7-23. Cold temperatures (50°F and below) and high elevations will adversely affect the GPS's operation due to the batteries and the liquid crystal diode screen freezing. Soldiers can improve battery life and overall performance by placing the GPS inside their parka or coat.

7-24. The best use of the GPS is to supplement, back up, or verify the accuracy of other navigational techniques. GPS should never solely be relied on to navigate in mountainous terrain.

# NAVIGATIONAL TECHNIQUES

7-25. When planning movement through mountainous terrain, all possible techniques should be considered for use. Typically, the best approach is a combined use of all the above tools to identify and navigate efficiently IAW the mission and commander's intent. No single technique is a universal solution to every situation. Navigating requires putting varied emphasis on tools at different times along the route. The one skill used in mountain navigation that remains critical is terrain analysis and association.

## DEAD RECKONING

7-26. Because of the complex nature of mountainous terrain, dead reckoning is usually of limited value on most movements. Broken or sheer terrain can make it impossible to follow a precise azimuth for any significant distance. Furthermore, doing so may put significantly more strain on personnel as it may require traveling up and down or boxing around numerous large terrain features. The compass is generally employed more to support terrain association and to orient the map than as a primary navigational aid. Dead reckoning can be a useful and necessary tool under certain conditions, such as periods of limited visibility. Heavy fog, snowy, or whiteout conditions may prevent the use of other more effective techniques. Using dead reckoning under these conditions requires the development of a detailed limited visibility navigational plan. This plan must be followed precisely to prevent wandering off course into potentially hazardous terrain.

## TERRAIN ASSOCIATION

7-27. Terrain association is the process of creating a mental model of what terrain features look like from what is depicted on a map so that they can be identified and used to guide navigation during movement. This skill is critical in mountainous terrain. Once proficiency is developed, navigation in terrain of significant relief can be easier than in flatter terrain, because every feature stands out as a landmark.

7-28. The most efficient way to increase skill and proficiency with terrain association is through practice navigating in areas of significant relief. The mnemonic SOSES (shape, orientation, size, elevation, slope)

approach to considering terrain features is especially valuable in mountainous terrain association and should be practiced extensively (see TC 3-25.26). Terrain identification and association training should be incorporated into all land navigation training for Soldiers who are likely to operate in mountainous terrain.

7-29. Terrain association allows Soldiers to identify navigational aids while planning to ensure the navigator does not stray off course. The following are some examples of navigational aids:

- Checkpoints are easily identifiable terrain features to either side of a route, or linear features crossing a route, which are used to determine distance traveled. These can be hilltops, saddles, streams, or ridgelines, to name a few. Manmade features are less reliable due to lack of permanence. Checkpoints are typically used to mark the end of a leg of a route.
- Handrails are easily identifiable linear features that run parallel with the navigator's route, or leg of a route. They can be roads, streams, valleys, draws, or even distant ridgelines. During movement, they can be paralleled to a checkpoint or the objective. Navigational corridors are very large handrail features, such as valleys.
- Attack points are easily identifiable features within 200 meters of an objective where area navigation ends and point navigation starts. Attack points should be located on a feature that is easy and quick to navigate to, such as a hilltop or prominent feature. From the attack point, the navigator can slow down movement speed to increase navigational accuracy for the final short movement into the objective. Often, it is best to use dead reckoning from the attack point to ensure navigational accuracy is maintained.
- Expanded objectives are large features that contain the actual objective, such as a large hill. The navigator can easily navigate to the hill from far off and then reorient to move to the precise objective.
- Catching features and elevation backstops are used to provide a limit of advance to prevent navigators from overshooting their objective. Some examples of catching features include stream, draw, elevation, or even movement time.

## ALTIMETER NAVIGATION

7-30. Altimeters help the navigator in several ways. They aid in orientation, in computing rates of ascent or descent, during resection, and in weather prediction.

7-31. Altimeters allow any elevation line on a map to be used as a linear feature. Navigators can plan the legs of their route that run perpendicular to elevation lines. Navigators can then easily track progress as they ascend or descend by referencing their current elevation during movement. In the same way, elevation lines provide checkpoints and catching features to ensure the navigator does not ascend or descend too far. Navigators can also plan the legs of their route to run parallel to elevation lines on large terrain features. The navigator only needs to ascend or descend to the desired elevation, then turn, and follow it toward the objective or next checkpoint. Again, this is done by checking the altimeter occasionally to ensure they stay at the desired elevation while moving.

7-32. Altimeters can confirm terrain association assumptions during movement. Anytime navigators are standing on an easily identifiable terrain feature, they can cross-reference data displayed on the altimeter with the terrain feature they think they are on using a map. If both numbers match, then the navigator is at the correct location.

7-33. Altimeters are also useful in reestablishing navigators' locations if they are unsure of it via modified resection. This is done by obtaining a back azimuth to their location from an easily identifiable terrain feature, then drawing it on a map. Wherever that line crosses the contour line corresponding to the elevation, their altimeter reads their location.

7-34. Most altimeters allow the user to track and record elevation related data, such as ascent and descent rates, as well as overall elevation gain and loss. This data can help leaders more accurately plan route movement times in the future.

7-35. Altimeters can be used as barometers to assist in weather prediction. Although GPS provides triangulated altitude, it does not use a barometer to do so and, therefore, cannot monitor weather. Altimeter weather prediction only works if the altimeter remains in a static position for a significant period (for example, several hours or more). Most digital devices have a barometer function, allowing the user to track

the increase and decrease in pressure. These indicate changing weather conditions, whereas no or little increase or decrease indicates stable weather trends.

# ROUTE PLANNING

7-36. Careful map reconnaissance, knowledge of the enemy situation, terrain analysis of the operational area, and an accurate assessment of the unit's capabilities are all key parts of the planning process. Route planning in the mountains proves to be difficult, and often the original route selection changes during movement due to the restrictive nature of this terrain. Always use METT-TC (I) to maximize advantages of routes used in military operations and carefully weigh costs and benefits of route decisions. Additionally, weather and surface conditions impact route decisions greatly.

## MISSION FACTORS

7-37. The mission and commander's intent must be considered when planning routes in the mountains. Establish priorities for route characteristics IAW their impact on the mission. Some common examples of route selection priorities are navigability of terrain, tactical advantage or disadvantage throughout the movement, concealment throughout, fatigue reduction, and required speed of movement. For example, if a strong security posture is required, speed may need to be sacrificed in favor of moving through tactically advantageous terrain that is more difficult. In other circumstances, the opposite may be true. Ultimately, route planners must possess a clear understanding of how their route selection decisions may affect the mission.

## ENEMY SITUATION

7-38. There are several factors to consider when assessing the enemy's capabilities. Some of which include range of weapons, effectiveness of indirect fires, level of mobility and capabilities in mountainous terrain. If the enemy force is better prepared to maneuver in the mountains, they have a marked advantage, and route selection must be scrutinized.

## TERRAIN FACTORS

7-39. Topographic map reconnaissance provides the primary source of information concerning the area of operations. A 1:25,000 map depicts greater detail than a 1:50,000 map and should be used whenever possible. Because examining the micro terrain is important for mountain operations, even larger-scale maps are desirable. Higher detailed nonmilitary maps may be useful, if available. Aerial, oblique angle, and photographs give details not always shown on maps (crags and overhangs). Sketch maps supplement other sources of information, but they should not be relied on for accuracy since they are seldom drawn to scale. Along with sketch maps, verbal descriptions, documented information gathered from units previously in the area, or published sources, such as alpine journals or civilian climbing guides, may help. Forest service, logging, and mining company maps provide additional information, often showing the most recent changes to logging trails and mining access roads. Standard military topographic maps are generally accurate graphic depictions of the operational area.

7-40. Ensure map marginal information is reviewed for each new map used. The legend may contain mountain-specific symbols. Ensure map datum matches GPS datum, if used.

7-41. Enemy capabilities and recent activity in the area provide important information for determining concealed routes.

7-42. OAKOC should be used to analyze mountainous terrain during route planning. Typically, considering OAKOC from the enemy's perspective is important. Additionally, mountain-specific hazards, such as falling rock or ice, loose, slick or ice-covered footing, avalanche threat, crevasse presence, and fall hazard, should all be considered when selecting routes.

- Observation and fields of fire—in mountainous terrain, the easiest lines of movement are often exposed to observation from great distances. Good analysis of potential enemy positions and activity must be considered prior to using open or silhouetting terrain for movement.
- Avenues of approach—when route planning, it is important to consider avenues of approach to positions that dominate terrain a route may run through. There is usually high ground around Soldiers in the mountains. Easily accessible dominating terrain is the most threatening to units on the move.

- Key terrain—when selecting routes, key operational terrain must be identified. Often key terrain is easier and allows nontechnical movement through and around very difficult terrain. These features are more likely to be observed by the enemy from positions that dominate them.
- Obstacles—broken rocky terrain, ice-covered slopes, cliff bands, rivers, ravines, and avalanche terrain can easily restrict or halt movement. These obstacles often require tactical movement techniques to maintain effective security (for example, traveling and bounding overwatch). Technical mobility skills, equipment, and systems for safe movement are also a result. If the terrain is severe or restrictive enough, VDA-crossing techniques may need to be employed to ensure unit security during certain legs of the route, which are a substantial operational undertaking.
- Cover and concealment—often folded and broken terrain provides good cover and concealment, even though it is more difficult to move in and maintain command and control. Draws, gullies, couloirs, and ravines often provide great concealment from a distance but also may contain water, loose rock, thick vegetation, and may be exposed to the hazard of falling objects or observation from high ground above.

7-43. Other resources may greatly assist in selecting appropriate routes in mountainous terrain. Open-source mapping programs developed for mountain navigation provide useful tools for route finding and planning. Some provide detailed slope angle imagery that can help determine difficulty of movement, and valuable avalanche risk information that is not easily identified on a topographical map. In cases of extreme terrain complexity, advanced military mountaineers may need to be tasked with route finding or reconnaissance missions just to identify the possibility of a route existing through a given area.

7-44. Terrain also has a huge impact on the effectiveness of communications systems. Many terrain features block or reduce communications ranges in the mountains. The capabilities of the group's radios must be considered. Routes may need to be adjusted to ensure line of sight with higher or adjacent units is maintained, or to periodically gain high points to hit communications windows.

## TROOPS FACTORS

7-45. Route planners must have a solid understanding of the fitness, mobility skills under load, tactical movement proficiency, technical proficiency, and morale of their group members to adequately plan routes through the mountains. These factors determine what terrain is passable, passable with protective systems, or impassable, and how much time is required to do so.

## CONSIDERATIONS FOR WINTER CONDITIONS

7-46. Winter route planning can be far more difficult than in other seasons. This is primarily due to the presence of more difficult snow-laden and ice-covered surfaces. Cold temperatures and the additional hazards that come with accumulated snow and ice may also present some challenges. Even just a few inches of snow or occasional icy patches significantly slow movement, especially if the correct equipment is not used. Soldiers operating in these conditions should be issued special equipment necessary for moving over ice and snow IAW surface conditions. Movement times and risk of injury increase significantly in steeper terrain if the correct mobility equipment is not used. See chapter 6 for a detailed description of this equipment and its uses. Some of these techniques require significant practice to achieve proficiency, and the level of proficiency increases as the severity of the terrain and conditions increases.

7-47. The following must be considered when planning routes in winter conditions:

- Weather conditions affect the chosen route. During calm weather, a Soldier's rate of movement is significantly faster than during periods of inclement weather. In windy conditions, routes on the leeward side of terrain features are usually preferred, so long as they do not pose an avalanche risk.
- Avalanche danger zones must be identified by map review and data gathered during route planning. Routes should not be planned through avalanche danger areas unless necessary for the mission. In that case, experienced personnel should conduct in-depth analysis of avalanche risk prior to movement.
- Vegetation can aid or hinder movement. Thickly forested areas usually have a deep snowpack. Trees provide shelter from the wind, but footing can be less reliable due to brush and small trees holding up a layer of snow that collapses when weighted, making movement arduous. Avalanches are still possible on forested slopes with an angle of 30° to 45°.

- Lower angled snow-covered water features can provide valuable navigation aids and easy movement routes, especially if personnel are proficient skiers. Runoffs sometimes provide the only feasible routes through steep, thickly vegetated terrain.
- Individual movement abilities affect rate of movement, limit choice of terrain, and route. All personnel must be proficient in the mobility skills (for example, crampon use, snowshoeing, or skiing) required by the surface conditions. Greater fitness is required to move in winter conditions than other seasons.
- Moisture output during movement should be considered when planning routes in cold temperatures. The rate of movement and the strenuousness of ascending slopes directly increase sweating, which can have a significant impact on the ability for personnel to stay warm when they stop movement. More frequent, shorter breaks should be planned, as opposed to fewer longer breaks, to reduce the need to up-dress and down-dress, and help personnel shed heat periodically.

7-48. The following conditions and characteristics of cold weather and mountainous regions make accurate navigation difficult:

- In winter, short hours of daylight, fog, snowfall, blizzards, whiteouts, and drifting snow, especially above tree line, drastically limit visibility. At times, an overcast sky and snow-covered terrain create a phenomenon called flat light, which makes recognizing irregularities in the terrain extremely difficult.
- Heavy snow may completely cover existing tracks, trails, outlines of small lakes and similar landmarks. Because the terrain looks quite different in winter from that in summer, Soldiers must pay careful attention when identifying landmarks, both on the ground and from aerial photographs.
- Avoid handling maps, compasses, and other navigation instruments in low temperatures with bare hands. Exposing bare skin to these conditions increases the risk of frostbite. (See chapter 3 for information on cold-weather injuries.)
- Maintaining pace count is extremely difficult in winter and mountain environments. Thick vegetation and rough, steep slopes hamper attempts at accurate pace counts.

7-49. Whenever there is a possibility of extremely limited visibility during movement, a whiteout navigation plan should be developed ahead of time and disseminated to every Soldier in the patrol. They should include numerous checkpoints and record the distance, azimuth, and end elevation for each leg. Guidance should be disseminated regarding rendezvous and rally points procedures. The easier the terrain each leg covers, the easier the plan is to follow blind. Waypoints can be entered manually into most GPS devices as well for those low-visibility circumstances where they can still connect to satellites. Note that accuracy may be negatively affected by fog or precipitation even if they do function. (See table 7-1 for an example.)

**Table 7-1. Whiteout navigation card, example**

| *Point* | *Grid 19T Elevation* | *Elevation* | *Elevation +/-* | *Azimuth* | *Distance* | *Leg Time* |
|---|---|---|---|---|---|---|
| Start Point | 021312 756466 | 150 meters | +150 meters | 33 degrees | 2.5 kilometers | 1:00 |
| Checkpoint 1 Trail Junction | 047411 763891 | 300 meters | +45 meters | 99 degrees | 0.5 kilometers | 0:15 |
| Checkpoint 2 Stream | 050763 765271 | 345 meters | +75 meters | 110 degrees | 4.3 kilometers | 1:15 |
| Checkpoint 3 Ridge High Point | 085430 749519 | 420 meters | -220 meters | 330 degrees | 2.2 kilometers | 0:20 |
| Checkpoint 4 Objective | 094052 767046 | 200 meters | N/A | N/A | N/A | 2:50 |
| **Legend**: N/A–not applicable | | | | | | |

## TIME CONSIDERATIONS

7-50. Movement in mountainous terrain requires a lot more time than in many other terrain types. Route planners must understand how all the factors above affect the rate of their group's movement so that they can

make route selection decisions that meet mission timelines. Accurately predicating movement times can only be achieved through building experience by moving in a wide range of mountainous terrain under a wide variety of conditions. Ideally, experience is developed through realistic unit training in similar terrain.

7-51. Movements in mountainous terrain are often measured in time rather than distance units because elevation gain, elevation loss, and surface conditions can be bigger factors. To do this, first measure the map distance. This distance plus one-third is a good estimate of actual ground distance. Add 1 hour for each 1,000 feet of ascent or 2,000 feet of descent to the time required for marching a map distance.

7-52. Computing movement rates in the mountains is extremely difficult, especially when there is snow cover. Since snow can be expected in the mountains for most months of the year, units should have some experience in basic snow travel. The following rates are listed as a guide (see table 7-2). Rates are given for movement over flat or gently rolling terrain for individuals carrying a rifle and loaded rucksack.

**Table 7-2. Time-distance formulas**

| *Movement Technique* | *Unbroken Trail* | *Broken Trail* |
|---|---|---|
| On foot (no snow cover) | 2.0 to 3.0 kph (cross-country) | 3.0 to 4.0 kph (trail walking) |
| On foot (less than 1 foot of snow) | 1.6 to 3.2 kph | 2.0 to 3.2 kph |
| On foot (more than 1 foot of snow) | 0.4 to 1.2 kph | 2.0 to 3.2 kph |
| Snowshoeing | 1.6 to 3.2 kph | 3.2 to 4.0 kph |
| Skiing | 1.0 to 5.6 kph | 4.8 to 5.6 kph |
| Skijoring | N/A | 3.0 to 24 kph |
| **Legend**: kph–kilometers per hour, N/A–not applicable | | |

7-53. Combined Soldier loads that exceed 50 pounds per Soldier can be expected to slow movement significantly in mountainous terrain. Given the increased weight of extra ammunition for crew-served weapons, basic military mountaineering gear, and clothing for mountain travel, it becomes obvious that Soldiers will carry weights well over that 50-pound limit. Units should conduct cross-country movements in the mountains with the expected rucksack and tactical load out to develop more accurate movement time data.

7-54. Deep snow significantly reduces movement speeds and requires either snowshoes or skis to be practical for anything but the shortest movements.

## SECTION II – NAVIGATION IN TECHNICAL MOUNTAINOUS TERRAIN

7-55. Technical terrain is defined as terrain that requires ropes and specialized mountaineering equipment to increase security and reduce the consequences of falling. Navigation on this type of terrain can be very difficult. Safe travel requires careful analysis and a greater level of experience. Given the capability, however, units can own and operate in areas that may be off limits to the enemy.

# RECONNAISSANCE

7-56. For small teams with advanced skills, the variable nature of technical terrain makes detailed reconnaissance an invaluable tool. Although Soldiers must be particularly skilled at decision making and on-the-fly problem solving, information obtained during reconnaissance can greatly reduce the challenges of navigation.

7-57. Collecting information about the terrain before initiating movement is helpful to determine special equipment needs as well as movement techniques that may be required. Turnaround points, egress routes, and contingency plans should be identified to account for changing timelines, weather conditions, or unexpected enemy presence. Visually observing the terrain from as many angles as possible with the use of optics aids the mountaineer to identify specific features, such as cracks, ledges, cliff bands, and other landmarks, for travel. It may be used to determine rock quality and identify the presence of objective hazards.

7-58. When a physical recon is not practical, several tools assist the mountaineer with interpreting terrain and identifying potential routes. A combination of sources is best.

7-59. Maps can be used to assess terrain, establish distances, elevation, and general timelines. They are helpful for identifying key landmarks and potential weaknesses in the terrain that may allow for travel. Maps may not be up to date and may not always accurately reflect the ever-changing mountain landscape. Usually, micro terrain is not well represented on a military map, especially in mountainous terrain.

7-60. Satellite imagery is useful for identifying specific objective hazards, degree of cover and concealment, and for visualizing possible routes through steep terrain. If the imagery is recent, it may provide supplemental information if using an older map to verify the terrain and hazards. Imagery may also identify terrain that is not always identified on a map, for example, a scree or talus field.

7-61. Photos taken before or during movement are helpful for detailed technical navigation and can be used for future reference. They are particularly useful for remembering locations of small landmarks, intersections, and exposed or hazardous sections of terrain. Keep in mind that ridges and faces in photos often appear steeper than they are.

7-62. Using time estimating tools, such as the Munter method (see appendix B, section III), can assist in making accurate timelines in nontechnical terrain. However, timelines through technical terrain are difficult to accurately calculate, and extra time must be allotted to these sections. The timeline is determined based on the accuracy of the information collected, the conditions, and the skill and ability of the unit. The more experience an individual has moving in technical terrain, the more accurate their time estimations.

# ROPED MOVEMENT TECHNIQUES

7-63. Using roped movement techniques is an important decision that greatly affects the speed and efficiency of an element in technical terrain. Techniques described in chapter 10, such as fixed ropes, lead climbing, simultaneous climbing (known as simul-climbing), and rappelling may be necessary. Techniques are dictated by the terrain, weather, conditions, skill level, equipment available, and the tactical situation. Terrain that varies in difficulty may require the group to change movement techniques often to maintain efficiency. The best options create a balance of speed and security.

# ROUTE FINDING

7-64. Individual mobility skills play a huge factor in determining the feasibility of movement in technical terrain. Good route finding requires continually assessing terrain in relation to the climbing skill of team members. Information gathered during reconnaissance can often be inaccurate or incomplete once in the terrain and requires quick decision making and problem-solving ability.

7-65. Keep established landmarks in sight and move through terrain that allows for protection when and where fall hazards exist. Prioritize ridges and buttresses rather than faces and gullies when possible. This reduces exposure to rockfall and keeps Soldiers in position to observe the surrounding terrain. Gullies often look easier but are more difficult to assess and have looser terrain and generally more objective hazard.

7-66. A common route-finding mistake is climbing rock that appears easy but is loose or does not offer solid anchors or good options for protection, when other options are available. Another is misinterpreting the difficulty level of the terrain and climbing to the point where reversing direction becomes too difficult. Recognizing when one is “off route” early in the process is the key to avoiding serious injuries and major time delays. Any of these mistakes, when combined, can quickly lead to mission failure.

7-67. Soldiers must have experience with both success and failure when navigating in technical terrain to build the foundation of experience required to be effective on complex missions in the mountains. Time spent focused on planning, analyzing terrain, and executing technical movements while managing risk is invaluable to both the individual Soldiers and the unit.

7-68. Soldiers should be familiar with using collective data on established climbing routes found in guidebooks and online resources (see appendix B). Soldiers can train stateside and develop many of these critical skills, while intentionally selecting objectives within their ability level and with reasonable margins of safety. These resources contain route descriptions that include approach and decent information, rock quality, recommended rope strategies, topos, photographs, and more.

7-69. Commanders must understand that these skills take time to develop and that a degree of investment is necessary to create mountain Soldiers capable of such tasks.

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## Chapter 8

# Knot Tying and Rope Management

The rope is a vital piece of equipment to the mountaineer. It is used to address many of the problems and hazards encountered in the mountains. When climbing, rappelling, or building rope installations, the mountaineer must know how to utilize and maintain this equipment. Misuse can cause serious injury or death. This chapter discusses equipment, terminology, knots, hitches, rope management techniques, care, and maintenance.

## SECTION I – TYPES OF ROPE, WEBBING, AND CARABINERS

8-1. Mountaineering equipment is engineered to be lightweight but strong enough to provide a wide margin of safety. Each item is tested to high standards. In most cases, user error is to blame when this equipment fails. Soldiers should regularly check and inspect mountaineering equipment. Equipment should be replaced when there is any obvious damage, or it has exceeded the manufacturer's lifecycle recommendation.

8-2. All mountaineering equipment used in training should be constructed and tested to a recognized standard. The International Climbing and Mountaineering Federation, or Union des International Alpine Association (UIAA), is the certifying body that defines the standards for mountaineering and climbing equipment. This safety commission develops the standards for mountaineering and climbing equipment recognized throughout the world. In Europe, the European Conformity, or Conformité Européene (CE), and the European Committee for Standardization establish standards across all industries. They publish standards that align with the UIAA standards for all climbing and mountaineering equipment produced in Europe. The United States has no specific standards, but American manufacturers have their equipment tested to receive UIAA certification. Any equipment used for mountaineering should be marked with either the UIAA safety label or the CE standard that it meets.

### ROPES AND CORDS

8-3. Ropes and cords are Soldiers' lifelines in the mountains. Soldiers should understand the types of ropes and cords and their applications. All ropes and cords used in mountaineering and climbing today are constructed with the same basic configuration. The construction technique is referred to as a kernmantle rope, which is a rope constructed with a load-bearing core of twisted synthetic fibers and a protective outer sheath of interwoven synthetic fibers. The core of fibers provides the strength of the material, which is protected by a woven sheath like parachute cord. (See figure 8-1.)

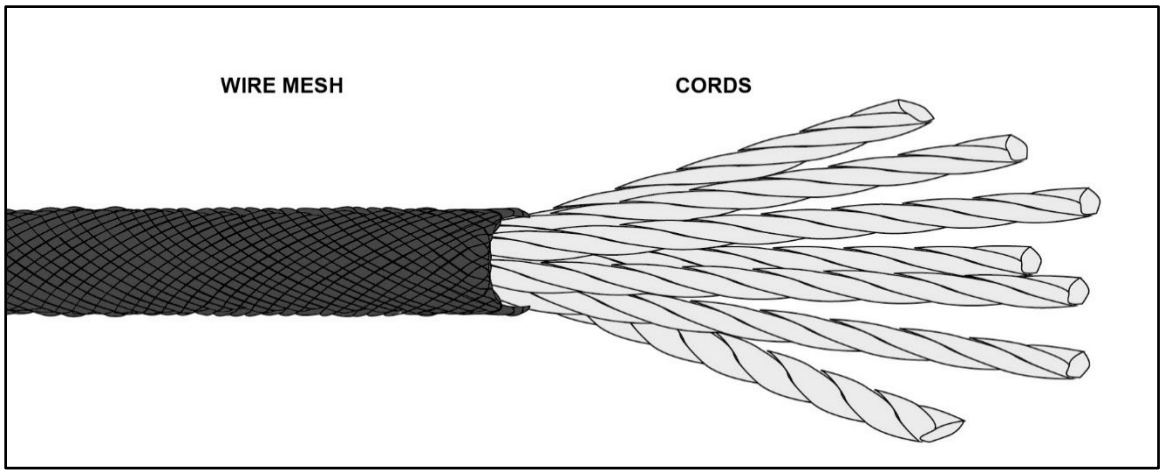



**Figure 8-1. Kernmantle rope construction**

8-4. There are many types of fibers and ropes that each have unique characteristics, making them suitable for specific tasks. The two main categories of rope are static and dynamic. Military mountaineers need to be able to differentiate between the two and know how each rope should be used.

### STATIC ROPE

8-5. A static rope is a kernmantle rope designed for minimal stretch under load, primarily used for hauling, lowering, and anchor systems construction. It has a core (kern) that is laid straight, giving it low stretch (2 to 8 percent). They are constructed with a tightly woven sheath (mantle) and are more durable than dynamic ropes. Static ropes are preferred for rappelling, rescue operations, load hauling, and rope installations. They should never be used in situations where the rope is shock loaded (for example, lead climbing). Typical diameter for static rope is between 9 and 11 millimeters (mm). Static rope is issued in 600 feet (183 meters) spools. While the minimum tensile strength for static ropes for military use is 4,500 pounds, the recommended working load is often 25 percent of the actual strength of that rope. The tensile strength for the 9.5 mm-issued low-stretch kernmantle rope is approximately 6,000 pounds. The length needed is dependent on the specific task being conducted. A 45-meter (150 feet) static has been the standard military length since the introduction of nylon ropes, but some tasks or obstacles may require a longer rope. The length of rope over 100 meters is a challenge to carry and manage.

8-6. The military purchases black static ropes to prevent a static rope from being mistaken for a climbing rope; however, static ropes are manufactured in all colors and patterns. A rope of unknown history or construction should not be used for any application.

### DYNAMIC ROPE (CLIMBING ROPE)

8-7. A dynamic rope is a kernmantle rope designed to stretch and absorb force, primarily used to protect climbers from fall injuries. All climbing should be protected with dynamic ropes. Even short falls on static rope can cause serious injury. Standards for climbing ropes are established by the UIAA, and all climbing ropes should be certified.

8-8. Dynamic ropes come in various diameters, but for most military applications, 9 to 10 mm provide a good compromise of durability and weight. The climbing ropes issued in the assault climbing team kits (ACTKs) are 60-meters long but can be cut shorter to meet mission or training requirements. Military climbing ropes are usually produced with olive drab or tan sheaths.

### CORD

8-9. Cord is thinner in diameter than rope. All cord is static and constructed in the same kernmantle structure as larger rope. It is used for constructing anchors, as well as most components in technical rope systems. Military mountaineering applications work best when Soldiers use 6- to 7-mm diameter cord. It is issued to units on a 200-meter spool and then cut down. It is commonly used in two configurations. Most mountaineering tasks can be accomplished with these two lengths. Units that conduct operations that require ascending a rope or extensive glacier travel may cut additional cords to length for specific tasks:

- Cordelette—6-meters long, any appropriate joining knot for anchor construction and general use.
- Prusik cord—1.8-meters long, joined with a double fisherman's bend, for friction hitches.

## WEBBING AND SLINGS

8-10. Webbing is a flat or tubular nylon material that ranges in widths from 9 to 25 mm and has many uses in mountaineering. (See figure 8-2.) This material comes on a spool; it can be cut to a desired length for various purposes. It can be joined or presewn to form slings.

8-11. Slings are presewn or tied loops of webbing. (See figure 8-3, page 152.) A sling is often attached to a harness to act as a personal safety, to extend a rappel device, or attach to a fixed rope. A sling rigged with two carabiners is a runner. Lead climbers use runners to clip the climbing rope to pieces of protection. Most sewn slings are 60 cm and are usually made of nylon.

- Sewn slings are made in several lengths: 30 cm, 60 cm, 120 cm, and 180 cm.
- Sewn slings are also manufactured with high-strength, low-stretch materials. These are lighter than nylon, do not absorb water, and are more resistant against UV deterioration. However, they are very

static, exhibit very low-melting points, and are not recommended for use as personal safeties or friction hitches.

8-12. If sewn slings are unavailable, tubular webbing can be used to create tied slings. Tubular webbing can be cut to length 175 cm (69 inches) and joined with a water knot to create a sling that is 60 cm (24 inches). Tied slings can be used for any task as sewn slings but require additional inspection. Tied slings can also be untied and retied around anchors and are more adjustable than sewn slings. Tubular webbing can also be used to create expedient harnesses.

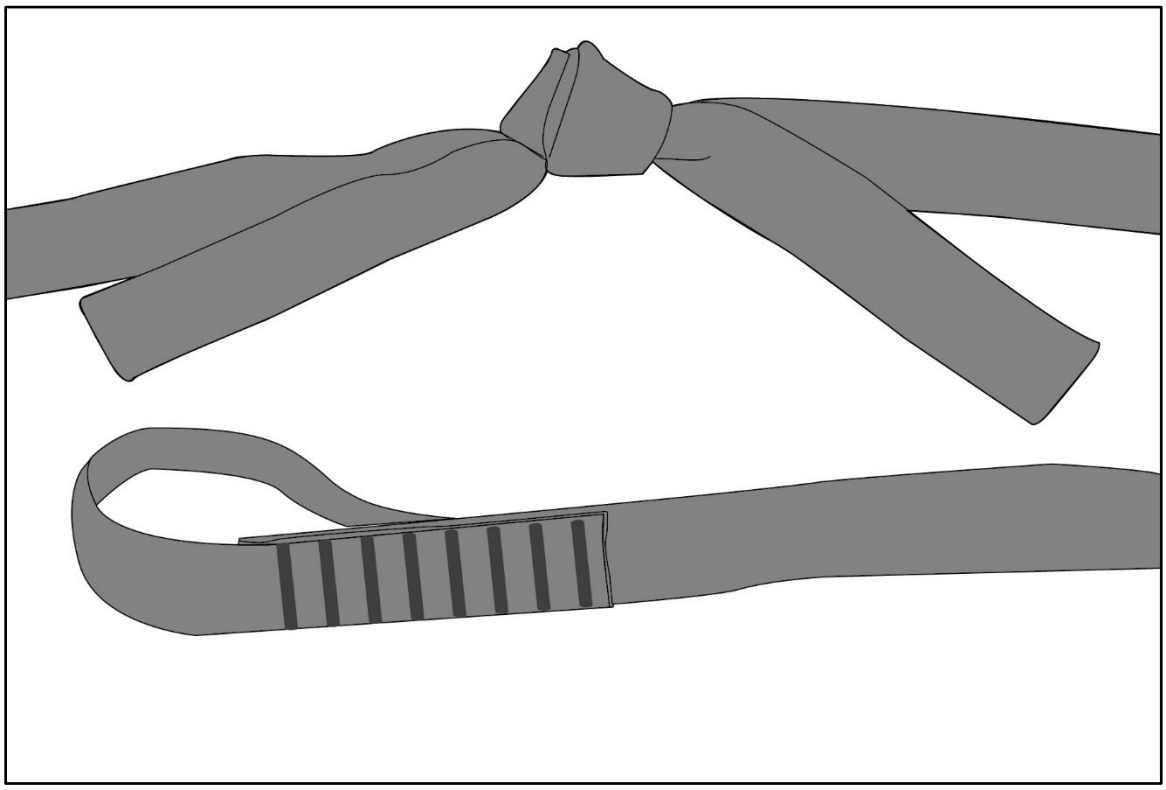


**Figure 8-2. Types of webbing: tubular joined with a knot and a sewn webbing**

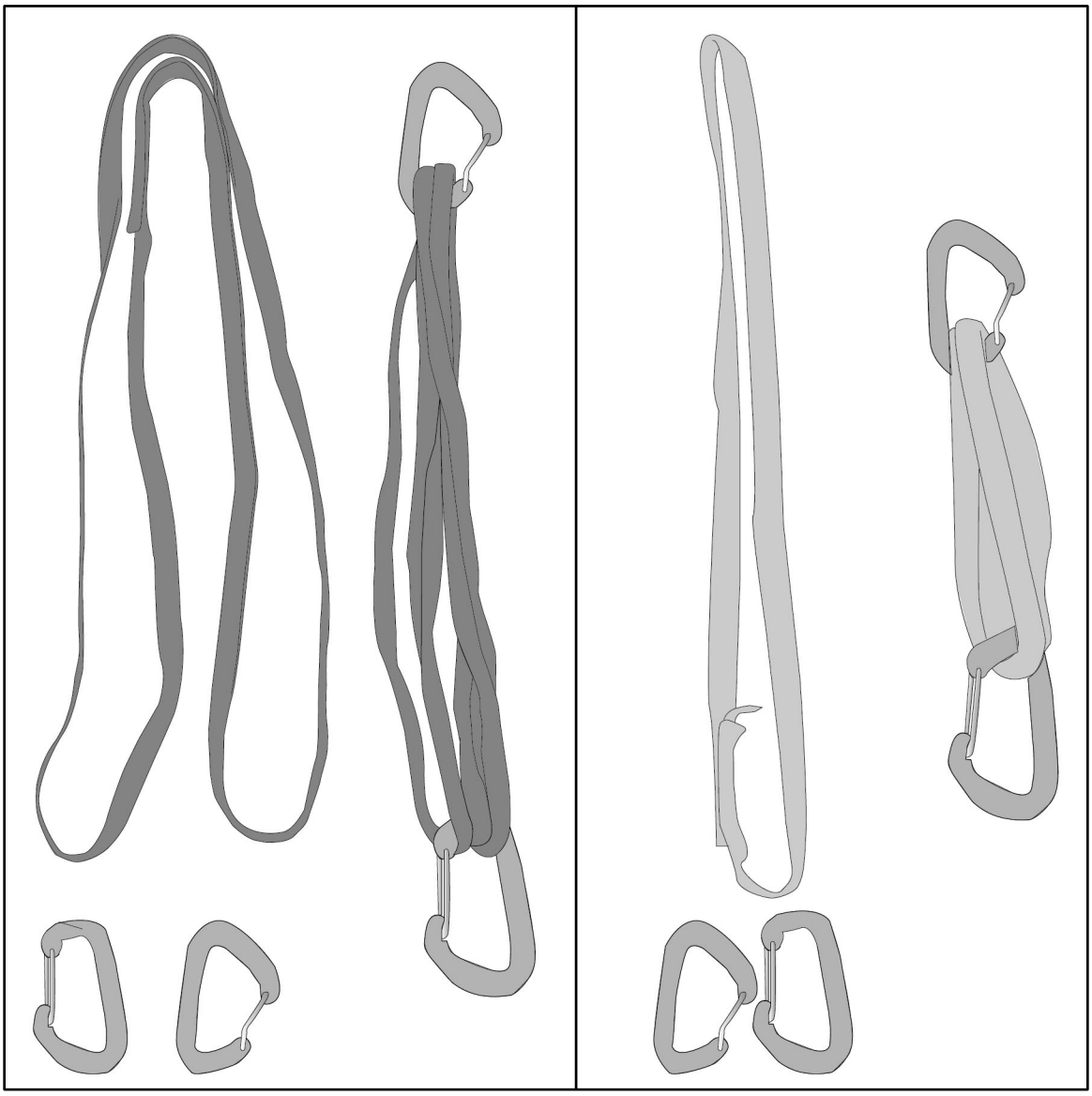


**Figure 8-3. Slings and runners**

# CARABINERS

8-13. A carabiner is a D-shaped or oval-shaped metal link, with one spring-hinged side, that is used in mountaineering as a connector between soft materials and to capture a freely running rope. A carabiner is one of the most versatile pieces of equipment available to the mountaineer. This simple piece of gear is the critical connection between anchors, ropes, and mountaineers. (See figure 8-4.)

8-14. Most carabiners are constructed of aluminum. Carabiners are produced in several different shapes. Oval carabiners were once popular for general mountaineering because their symmetry makes them good for many purposes. Most carabiners used today are offset D-shaped carabiners, which offer the best compromise of weight to strength and ease of clipping and racking. (See figure 8-4.)

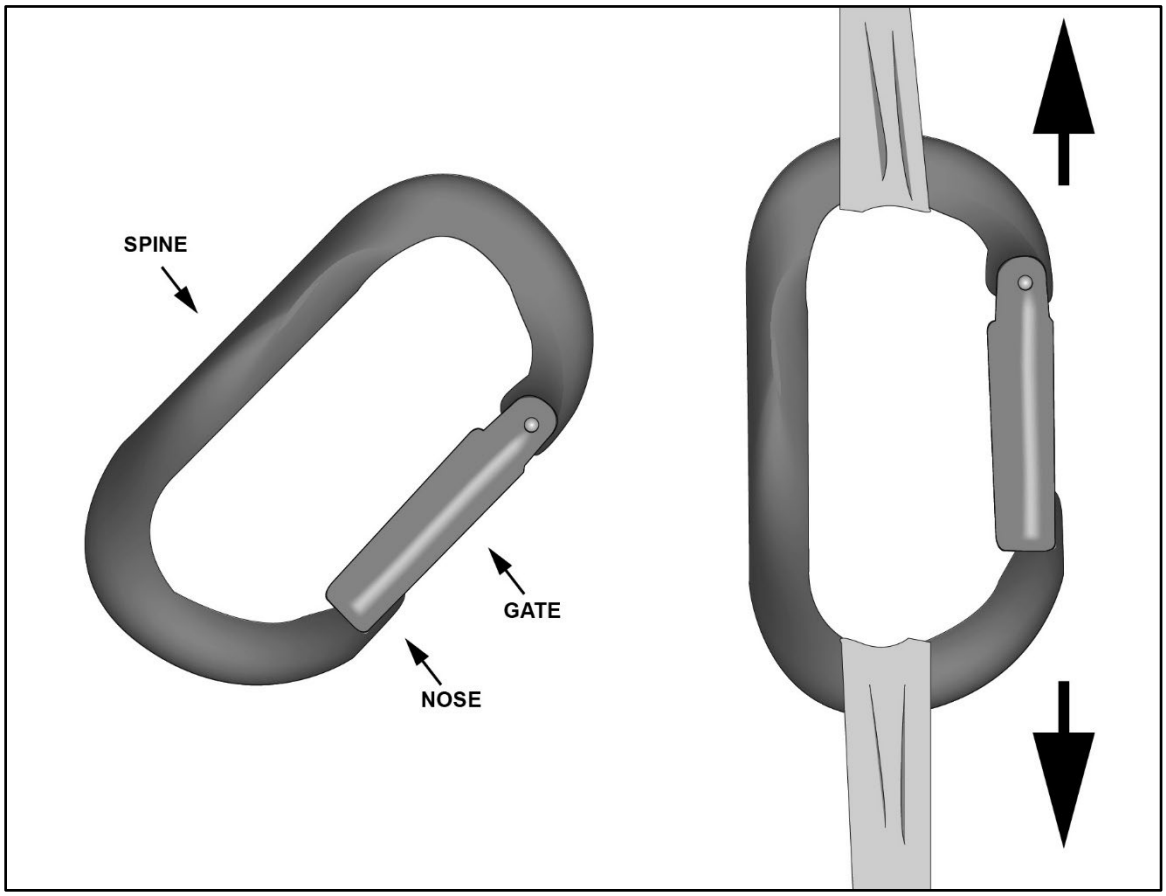



**Figure 8-4. Carabiner components**

8-15. A carabiner's design allows it to be loaded in opposite directions along the spine. (See figure 8-4.) When loaded improperly, the strength of a carabiner is reduced significantly. When using a carabiner, care should be taken to avoid cross loading the carabiner across the gate and spine and to avoid tri-loading. (See figure 8-5, page 154.)

8-16. There are two types of carabiners used in mountaineering: the locking carabiner and the nonlocking carabiner.

## LOCKING CARABINERS

8-17. Locking carabiners feature a barrel-shaped sleeve that prevents the gate from opening. They are used where an accidental carabiner opening could cause system failure. Any live load should be attached to an anchor with a locking carabiner. Locking carabiners are used for rappel hook ups, personal safeties, and the primary attachments in most rope systems. (See figure 8-5, page 154.)

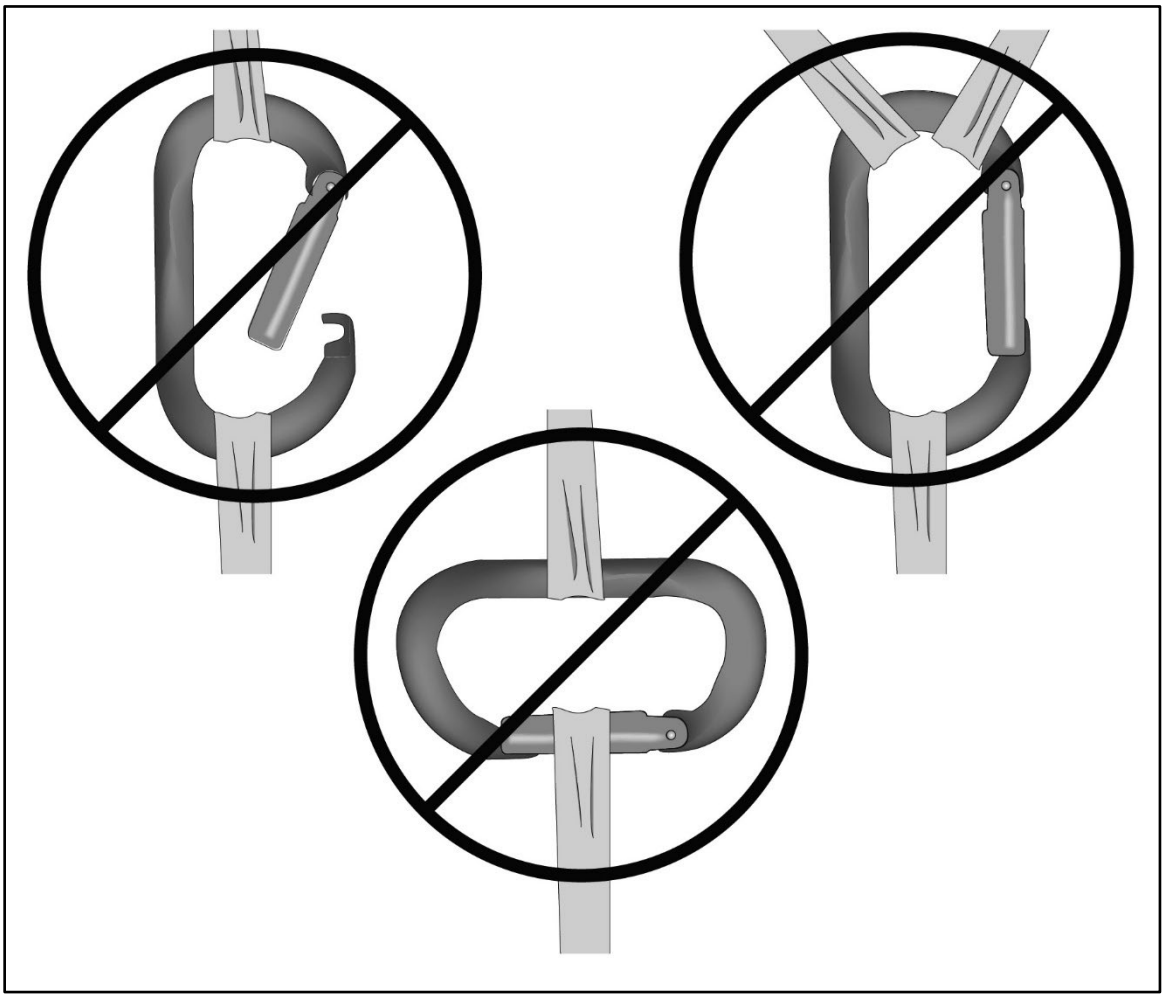


**Figure 8-5. Improper carabiner loading**

### NONLOCKING CARABINERS

8-18. Most carabiners do not lock. Locking mechanisms add weight and slow the manipulation of carabiners. Nonlocking carabiners are used in most mountaineering applications. They should be used where there is more than one attachment and accidental gate opening will not cause system failure.

## SECTION II – BASIC TERMINOLOGY

8-19. Understanding basic terminology is important when learning how to tie knots. The terms explained in this section are the most common in military mountaineering. (See figure 8-6, page 156.)

### RUNNING END

8-20. A running end is the loose or working end of the rope.

### STANDING END

8-21. The standing end is the static, stationary, or nonworking end of the rope.

## BIGHT

8-22. A bight of rope is a bend in the rope in which the standing end is parallel to the running end and the rope does not cross itself.

## LOOP

8-23. A loop is a bend of the rope in which the rope crosses itself. When the running end crosses over the top of the standing end, it is an overhand loop. When the running end crosses under the standing end, it is an underhand loop.

## TURN

8-24. A turn wraps around an object, providing 360° contact.

## ROUND TURN

8-25. A round turn wraps around an object one and one-half times so that the running and standing end are parallel. A round turn is used to hold an anchor or knot in place.

## HALF HITCH

8-26. A half hitch is a turn with the running end crossing over the standing end.

## TAIL

8-27. The tail is the excess portion of the running end of the rope when the knot is completed. If a knot requires an overhand safety, the length of the tail is measured from the safety knot to the end of the rope. A safety knot is a backup knot tied to prevent a primary knot from slipping loose.

## DRESSING

8-28. Dressing a knot is arranging all the knot parts, removing unnecessary kinks, twists, and slack so that all rope parts of the knot are secured and tight.

## SETTING

8-29. Setting a knot is removing all unnecessary slack from the knot. This ensures that the knot is tight and minimizes the chances of the knot becoming untied.

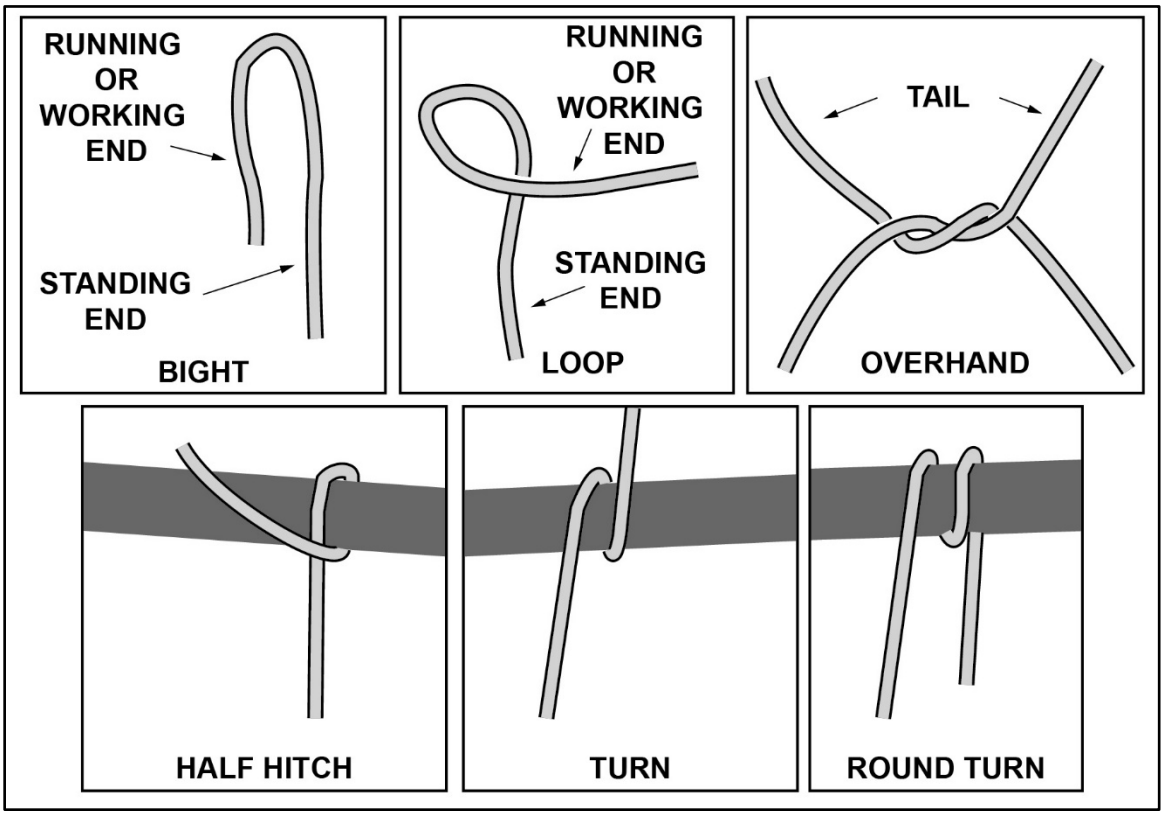



**Figure 8-6. Examples of rope-tying terminology**

## SECTION III – KNOT TYING AND CONSIDERATIONS

8-30. The term knot is commonly used to describe numerous categories. A knot is the fixed portion of a rope that has been manipulated around itself, another object, or both during the process of being tied for some purpose. Sometimes it is referred to as a "hard knot" since its condition will remain intact until actively untied. Knots are self-contained and self-supporting and do not need another object or rope to maintain its integrity. Hitches are not considered knots. Yet, for simplicity, they are generalized into a single category. Knots should never be considered permanent. It is possible that they can loosen or become less secure under certain conditions. Knots should be inspected regularly. Many knots can accomplish the same task; therefore, it is important to understand these considerations when choosing the appropriate knot to tie.

# TYPES OF KNOTS

8-31. There are several broad types of knots that are used in mountaineering. Military mountaineers should be familiar with the following types and terms at a minimum.

### BENDS

8-32. Bends are used to join the ends of rope, cord, or webbing. When tied correctly, they are considered safe and strong enough for many applications. Specific joining knots should be used for certain situations and applications. Take care to learn the purpose of each joining knot and to have a clear understanding of where, when, and why to use each one.

### HITCHES

8-33. Hitches are like knots but are tied around another object or rope. Without an object like a carabiner or another rope, a hitch would not retain its form and fall apart.

### FRICTION HITCHES

8-34. A friction hitch is a type of hitch tied with webbing or cordage around a rope that can be moved easily while no force is applied to it but cinches and becomes fixed when tensioned. Friction hitches grip the rope while under load, but they can be moved along the rope when unloaded. There are several friction hitches, each with different applications. Using the wrong friction hitch can be dangerous or create additional problems.

### LOOP KNOTS

8-35. Loop knots are used to create fixed or adjustable loops in rope or webbing. Some loops are directional to prevent the distortion of a knot when loaded.

### SPECIALTY KNOTS

8-36. These knots do not fit the above criteria but are still useful to know. They may only serve one specific purpose for mountaineering.

## KNOT TYING CONSIDERATIONS

8-37. There are several factors to consider when selecting knots for use or training. Military mountaineers do not need to be able to tie every possible knot that can be used in mountaineering. They just need to be able to tie an appropriate knot for each application they may face in their duties. When selecting knots for use in mountaineering rigging, selecting simpler knots that are easier to tie, untie, and inspect are preferable to complex specialty knots, even if the complex knot is a little more effective. When considering teaching knot tying techniques to Soldiers and new military mountaineers, knots that are easier to teach and learn are preferred, as are multipurpose knots. Ultimately, the number and complexity of knots that military mountaineers may need to be proficient with increases as the scope and complexity of their technical mountaineering responsibilities and duties increase.

### STRENGTH

8-38. Introducing a knot reduces the rope's strength by a quarter to almost half of its original strength. Certain knots retain more strength than others do. This depends on knot structure. (See table 8-1 for some examples of the remaining rope strength associated with common knots.)

**Table 8-1. Knotted kernmantle rope retained strength (single strand)**

| *Type of Knot* | *Rope Strength* |
|---|---|
| No knot | 100 percent |
| Clove hitch | 60 to 65 percent |
| Water hitch | 60 to 70 percent |
| Figure eight | 75 to 80 percent |
| Overhead | 60 to 65 percent |
| Bowline | 70 to 75 percent |
| Two half hitches | 60 to 70 percent |

### EASE OF TYING OR UNTYING

8-39. Choosing a knot based on its strength alone is not always the best choice. Using knots that are easy to tie and teach are ideal. The ability to untie knots after being loaded is important for the reuse and recovery of that material.

### EASE OF INSPECTION

8-40. Efficiently inspecting knots is important to ensure they have been tied properly and safely. Choosing knots that are difficult to inspect or that can easily be tied incorrectly heightens the chance of human error and increases risk.

### CONSERVATION OF MATERIAL

8-41. Using as little material as possible is the desired end state in knot tying. Some knots use more material than others do even if they accomplish the same purpose. It is important to recognize this when choosing the appropriate knot for a given application.

## KNOT TYING TECHNIQUES

8-42. More knots exist that are useful to military mountaineering. It is not feasible to include them all in this training circular. Those presented below were selected to cover the full range of military mountaineering applications as simply as possible. Versatility, ease of tying, untying, and teaching were the primary factors considered for selection.

### OVERHAND SAFETY KNOT

8-43. An overhand safety is commonly used in conjunction with other knots to make them more secure. Some knots loosen when subject to varying tension and therefore need a backup. (See figure 8-7.)

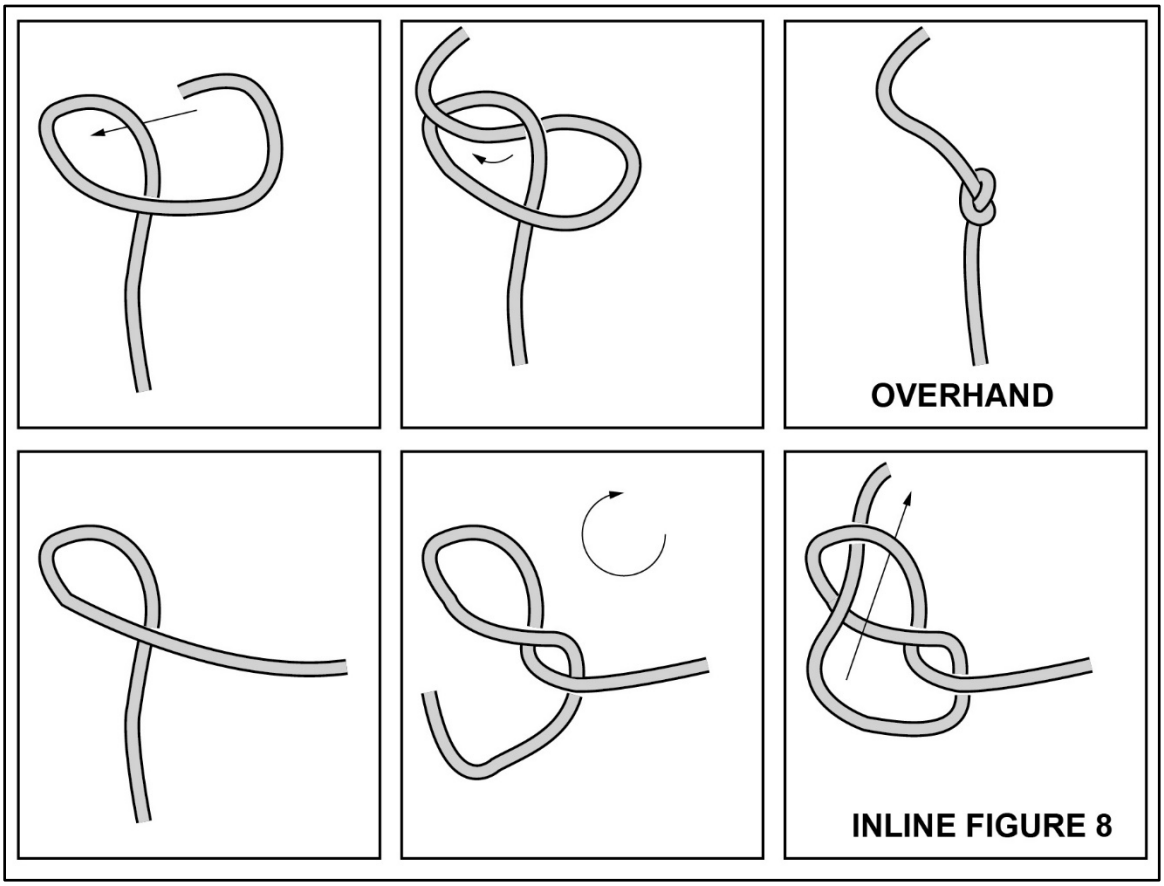



**Figure 8-7. Overhand and inline figure eight**

### INLINE FIGURE EIGHT

8-44. The inline figure eight is a common initial step in tying figure-eight family knots. (See figure 8-7.)

### FIGURE-EIGHT SLIP KNOT

8-45. The figure-eight slip knot forms an adjustable bight in a rope. (See figure 8-8.)

## Tying the Knot

8-46. Refer to the following steps to tie a figure-eight slip knot:

- STEP 1. Form a 12-inch bight at the end of the rope.
- STEP 2. Hold the center of the bight in the right hand. Hold the two parallel ropes from the bight in the left hand about 12 inches up the rope.
- STEP 3. With the center of the bight in the right hand, twist two complete turns clockwise.
- STEP 4. Reach through the bight and grasp the running end of the rope. Pull another bight (from the running end) back through the original bight.
- STEP 5. Pull down on the standing end of the rope and dress the knot down.
- STEP 6. If the knot is to be used in a transport tightening system, secure the adjustable bight with a half hitch.

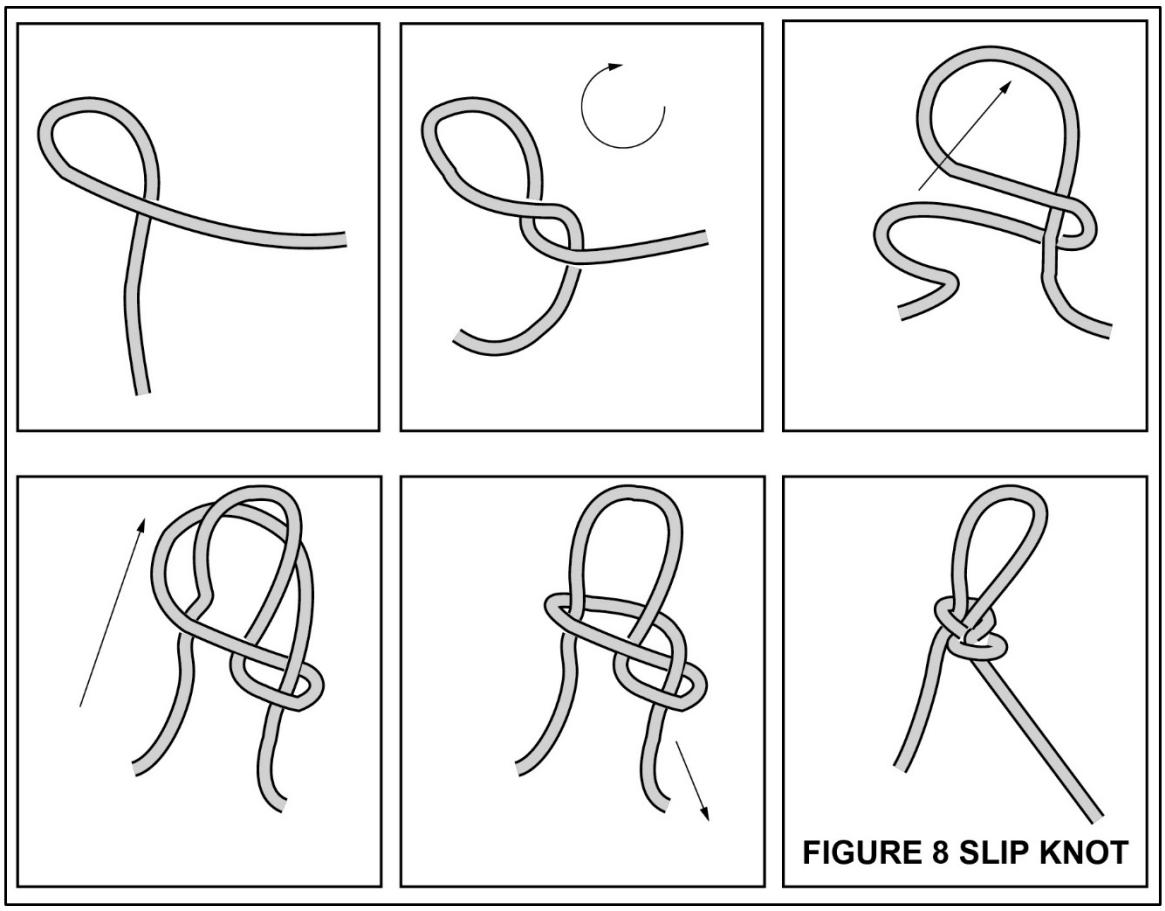



**Figure 8-8. Figure-eight slip knot**

## Checkpoints

8-47. The following must be true for the knot to be correct:

- The knot is in the shape of a figure eight.
- Both ropes of the bight pass through the same loop of the figure eight.
- The sliding portion of the rope is the long working end of the rope.

## FIGURE EIGHT ON A BIGHT (FIGURE-EIGHT LOOP)

8-48. The figure eight on a bight is used to form a fixed loop in a rope. (See figure 8-9.) In certain situations or systems, this knot can be tied with two bights to form two fixed loops (double figure eight on a bight). This is achieved by folding the cord or rope to form two bights and prior to tying the figure eight.

### Tying the Knot

8-49. The following steps are used to tie the figure eight on a bight:

- STEP 1. Form a bight in the rope about as large as the diameter of the desired loop.
- STEP 2. With the bight as the working end, form a loop in rope (standing part).
- STEP 3. Wrap the working end around the standing part 360° and feed the working end through the loop. Dress the knot tightly.

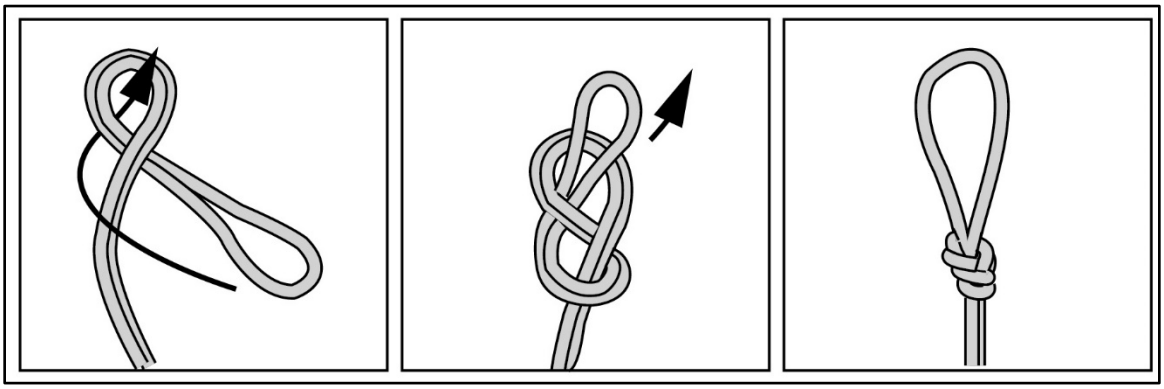


**Figure 8-9. Figure eight on a bight**

### Checkpoints

8-50. The following must be true for the knot to be correct:

- The loop is the desired size.
- The ropes in the loop are parallel and do not cross over each other.
- The knot is tightly dressed.

## FIGURE-EIGHT RETRACE (REROUTED FIGURE EIGHT)

8-51. The rerouted figure-eight knot produces the same result as a figure-eight loop. However, by tying the knot in a retrace, it can be used to tie into a harness or fasten the rope to objects. (See figure 8-10.) It is also called a figure-eight retrace. This is the preferred method to tie into a climbing rope.

### Tying the Knot

8-52. The following steps are used to tie a figure-eight retrace:

- STEP 1. Tie an inline figure-eight knot, leaving a long enough running end to go around the object or through the harness, and then back through the knot. Leave this knot loose to allow the rope to be routed back through itself easily.
- STEP 2. Take the running end and place it through the attachment point on a harness or around an anchor.
- STEP 3. With the running end, insert the rope back through the loop of the knot in reverse.
- STEP 4. Retrace the knot around the wrap and back to the standing part.
- STEP 5. Remove all unnecessary twists and crossovers; dress the knot down.

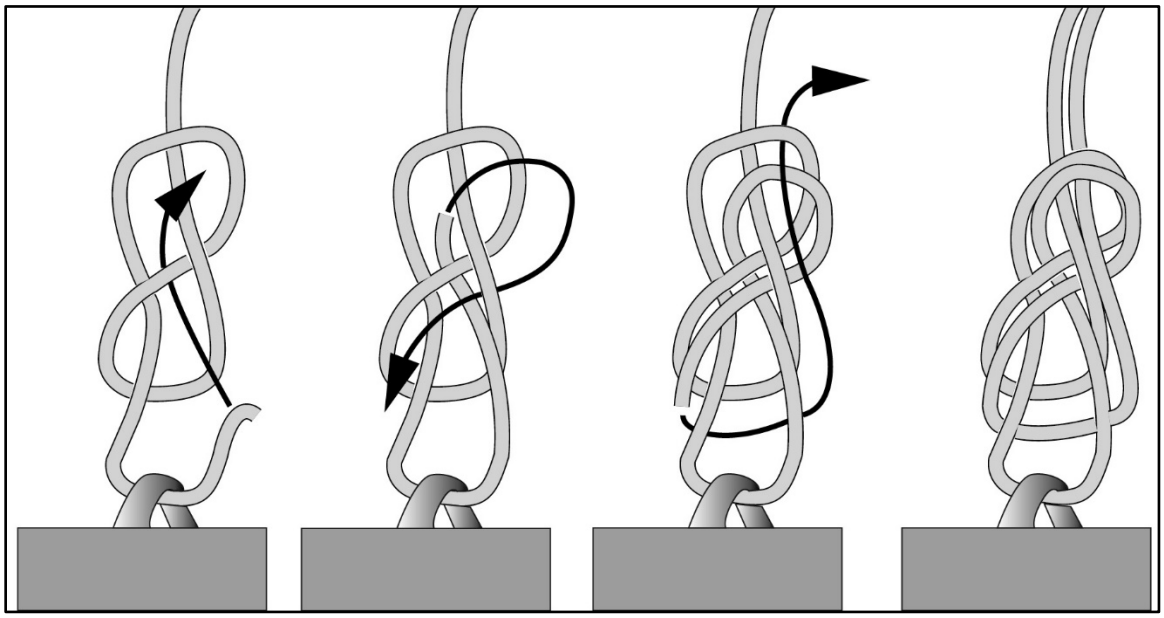


**Figure 8-10. Rerouted figure-eight knot**

### Checkpoints

8-53. The following must be true for the knot to be correct:

- A doubled rope runs side by side in the shape of a figure eight.
- The knot forms a fixed loop around a fixed object or harness.

## TWO-LOOP FIGURE EIGHT

8-54. The two-loop figure eight is used to form two adjustable, fixed loops in a rope. (See figure 8-11, page 162.) This knot is useful because it forms two independent loops that are easily adjustable to different lengths.

### Tying the Knot

8-55. The following steps are used to tie a two-loop figure eight:

- STEP 1. Using a doubled rope, form an 18-inch bight in the left hand with the running end facing the left.
- STEP 2. Grasp the bight with the right hand and make a 360° turn around the standing end in a counterclockwise direction.
- STEP 3. With the working end, form another bight, then place that bight through the loop just formed in the left hand.
- STEP 4. Hold the bight with the left hand, and then place the original bight (moving toward the left hand) over the knot.
- STEP 5. Dress the knot down.

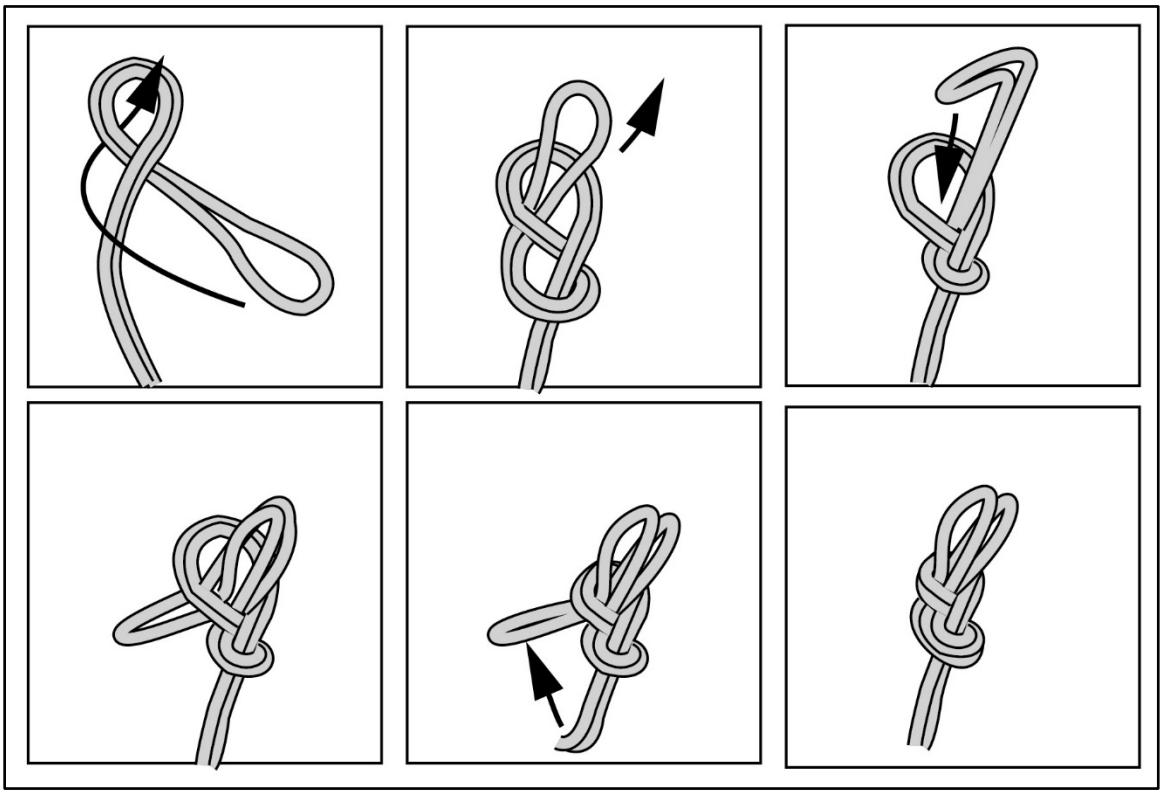


**Figure 8-11. Two-loop figure eight**

### Checkpoints

8-56. The following must be true for the knot to be correct:

- There is a double figure-eight knot with two loops that share a common locking bar.
- The two loops must be adjustable by means of a common locking bar.
- The common locking bar is on the bottom of the double figure-eight knot.

## DIRECTIONAL FIGURE EIGHT

8-57. The directional figure-eight knot forms a single, fixed loop in the middle of the rope that lays back along the standing part of the rope. (See figure 8-12.)

### Tying the Knot

8-58. The following steps are used to tie a directional figure eight:

- STEP 1. Create an overhand loop, with the loop facing the opposite direction of the finished knot.
- STEP 2. With the overhand loop formed, tie a figure-eight knot around the standing part.
- STEP 3. When dressing the knot down, the running end and the bight must be together.

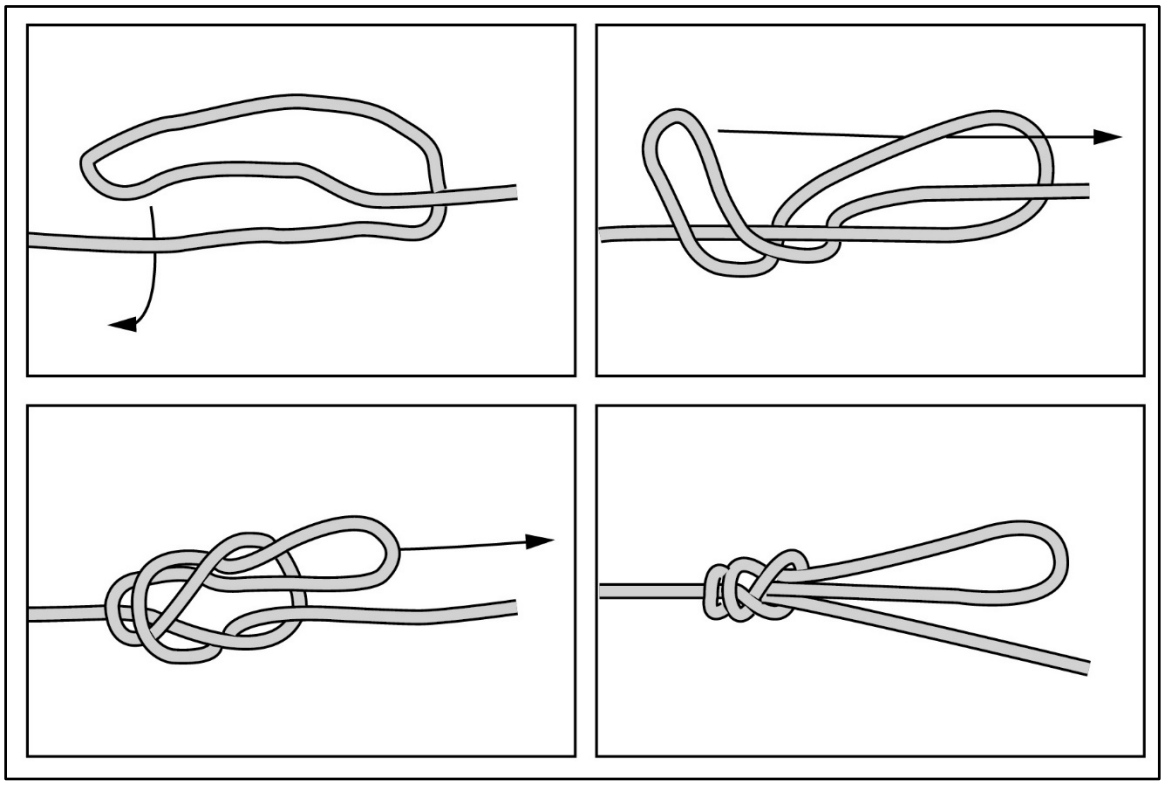


**Figure 8-12. Directional figure eight**

### Checkpoints

8-59. The following must be true for the knot to be correct:

- The loop should be large enough to accept a carabiner but no larger than a helmet-size loop.
- The tail and bight must be together.
- The figure eight is tied tightly.

## ALPINE BUTTERFLY

8-60. The alpine butterfly knot forms a single, fixed loop in the middle of the rope. (See figure 8-13, page 164.) The knot can be loaded in either direction or is easy to untie after use.

### Tying the Knot

8-61. The following steps are used to tie an alpine butterfly knot:

- STEP 1. Take a bight of rope and twist it 360°.
- STEP 2. Using the end of the bight, bring it up and back toward the two standing ends that exit at the back of the twisted bight just created. Careful to avoid untwisting the bight while doing this.
- STEP 3. Bring the bight back through the portion of the twisted bight that created a hole where the first twist in the bight is located. Pull the bight through that hole.
- STEP 4. Next dress down and tighten the knot.

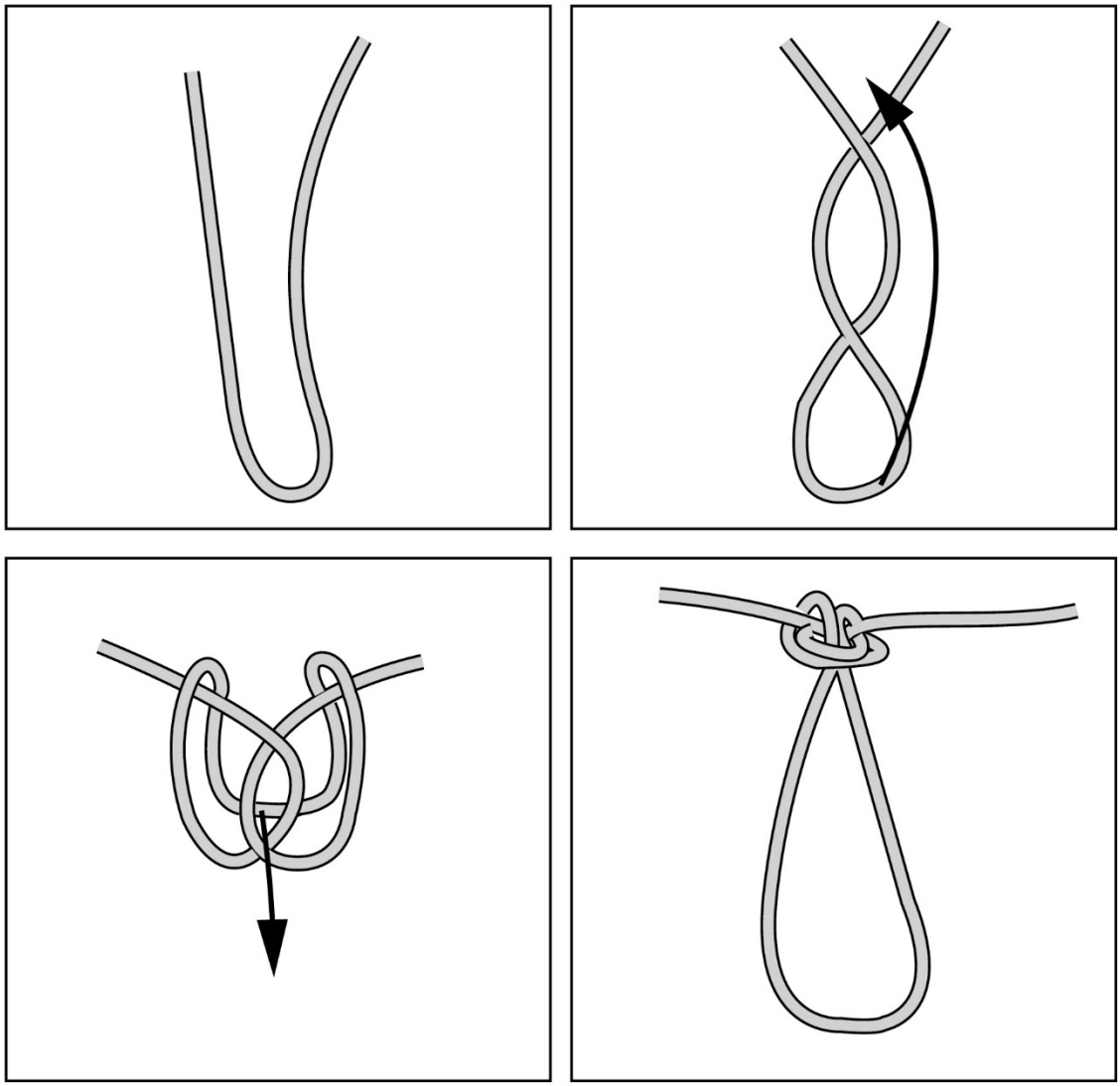


**Figure 8-13. Alpine butterfly knot**

### Checkpoints

8-62. The following must be true for the knot to be correct:

- The knot should have a bight of rope exiting two opposing bights of rope.
- The opposing bights should be clean and untwisted.

## FIGURE-EIGHT BEND

8-63. The figure-eight bend is used to join the ends of two ropes of equal or unequal diameter up to a 5-mm difference. (See figure 8-14.) This joining knot should be the primary knot used to join cord. It can be untied after loading, which allows the material to be used for other applications.

### Tying the Knot

8-64. The following steps are used to tie a figure-eight bend:

- STEP 1. Form a bight in the running end of the rope.

- STEP 2. With the other hand, grasp the running end (short end) and make a 360° turn around the standing end.
- STEP 3. Place the running end through the loop just formed creating an inline figure eight.
- STEP 4. Route the running end of the other rope back through the figure eight starting from the original rope's running end. Trace the original knot to the standing end.
- STEP 5. Remove all unnecessary twists and crossovers. Dress the knot down.

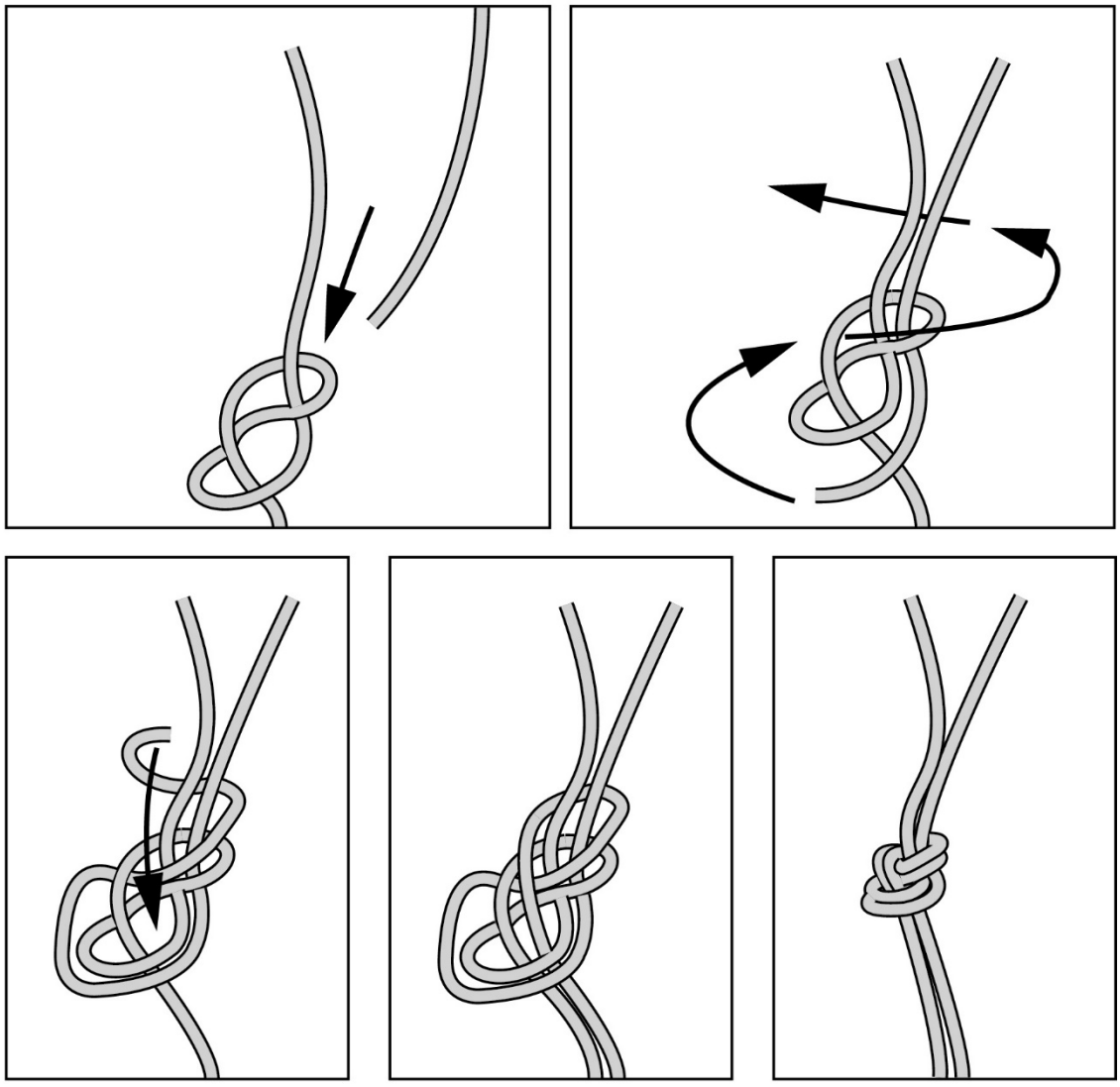


**Figure 8-14. Figure-eight bend**

## Checkpoints

8-65. The following must be true for the knot to be correct:

- There is a figure eight with two ropes running side by side.
- The running ends are on opposite sides of the knot.
- There is an approximate 4-inch tail.

## WATER KNOT

8-66. The water knot is used to attach the ends of webbing. (See figure 8-15.) The water knot is also known as a ring bend or tape knot.

### Tying the Knot

8-67. The following steps are used to tie a water knot:

- STEP 1. Tie an overhand knot in one of the ends.
- STEP 2. Feed the other end back through the knot, following the path of the first strand in reverse.
- STEP 3. Draw tight and pull all the slack out of the knot. The remaining tails must extend at least 4 inches beyond the knot in both directions.

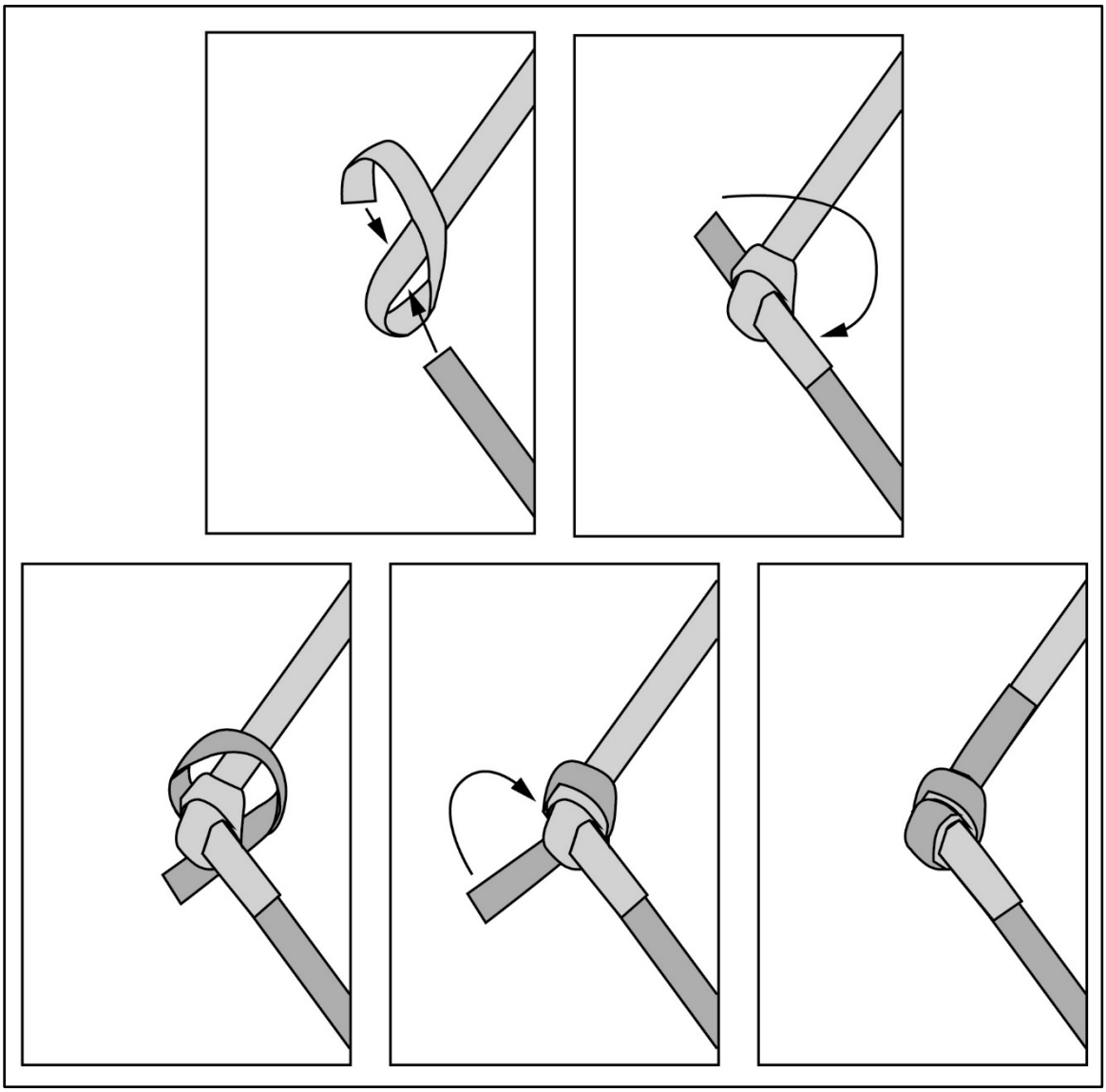


**Figure 8-15. Water knot**

### Checkpoints

8-68. The following must be true for the knot to be correct:

- There are two overhand knots, one retracing the other.
- There is no slack in the knot, and the working ends come out of the knot in opposite directions.
- There is an approximate 4-inch tail.

## FLAT OVERHAND

8-69. The flat overhand is used for joining two ropes that are being used to rappel. (See figure 8-16.) Additionally, it is used as a stopper knot at the end of the ropes to prevent Soldiers from rappelling off the end of the ropes.

### Tying the Knot

8-70. The following steps are used to tie a flat overhand:

- STEP 1: Hold both strands 24 inches from the end of the ropes.
- STEP 2: Tie an overhand knot with both strands.
- STEP 3: Dress the knot down, ensuring there are no twists in the knot, and it is hard to touch.
- STEP 4: Lastly, ensure that there is a minimum 18-inch tail for both strands of rope.

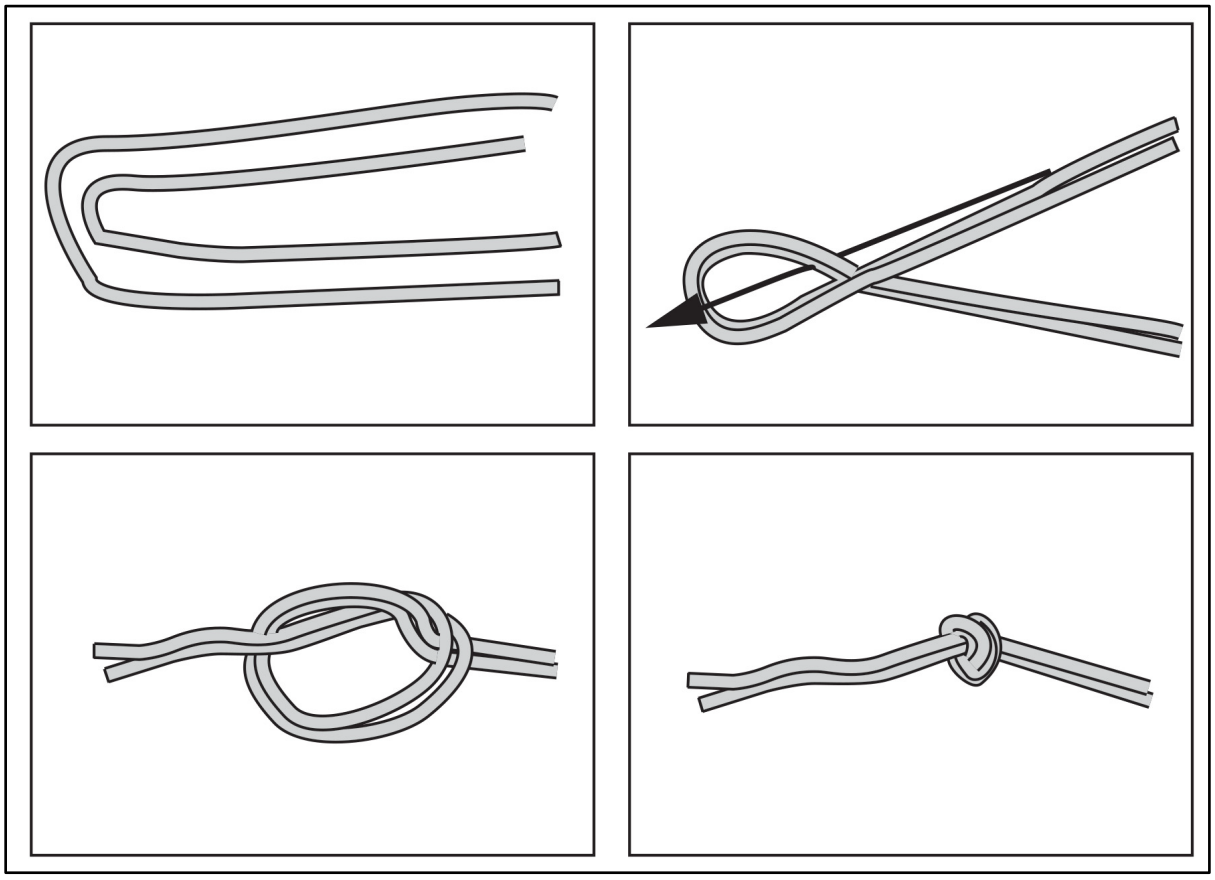


**Figure 8-16. Flat overhand**

### Checkpoints

8-71. The following must be true for the knot to be correct:

- A double overhand dressed without twists.
- Minimum 18-inch tails.

- Knot should be hard to the touch, not loose, or sloppy.

## DOUBLE FISHERMAN'S KNOT

8-72. The double fisherman's knot is used to join the ends of a rope of the same diameter. (See figure 8-17.) Once loaded, it can become very difficult to untie. Avoid using this knot if it must be untied after use.

### Tying the Knot

8-73. The following steps are used to tie a double fisherman's knot:

- STEP 1. With the working end of one rope, tie two wraps around the standing part of another rope.
- STEP 2. Insert the working end (step 1) back through the two wraps and draw it tight.
- STEP 3. With the working end of the other rope, which contains the standing part (steps 1 and 2), tie two wraps around the standing part of the other rope, routing the wraps in the opposite direction as the first knot (the working end in step 1). Insert the working end back through the two wraps and draw tight.
- STEP 4. Pull on the opposing ends to bring the two knots together.

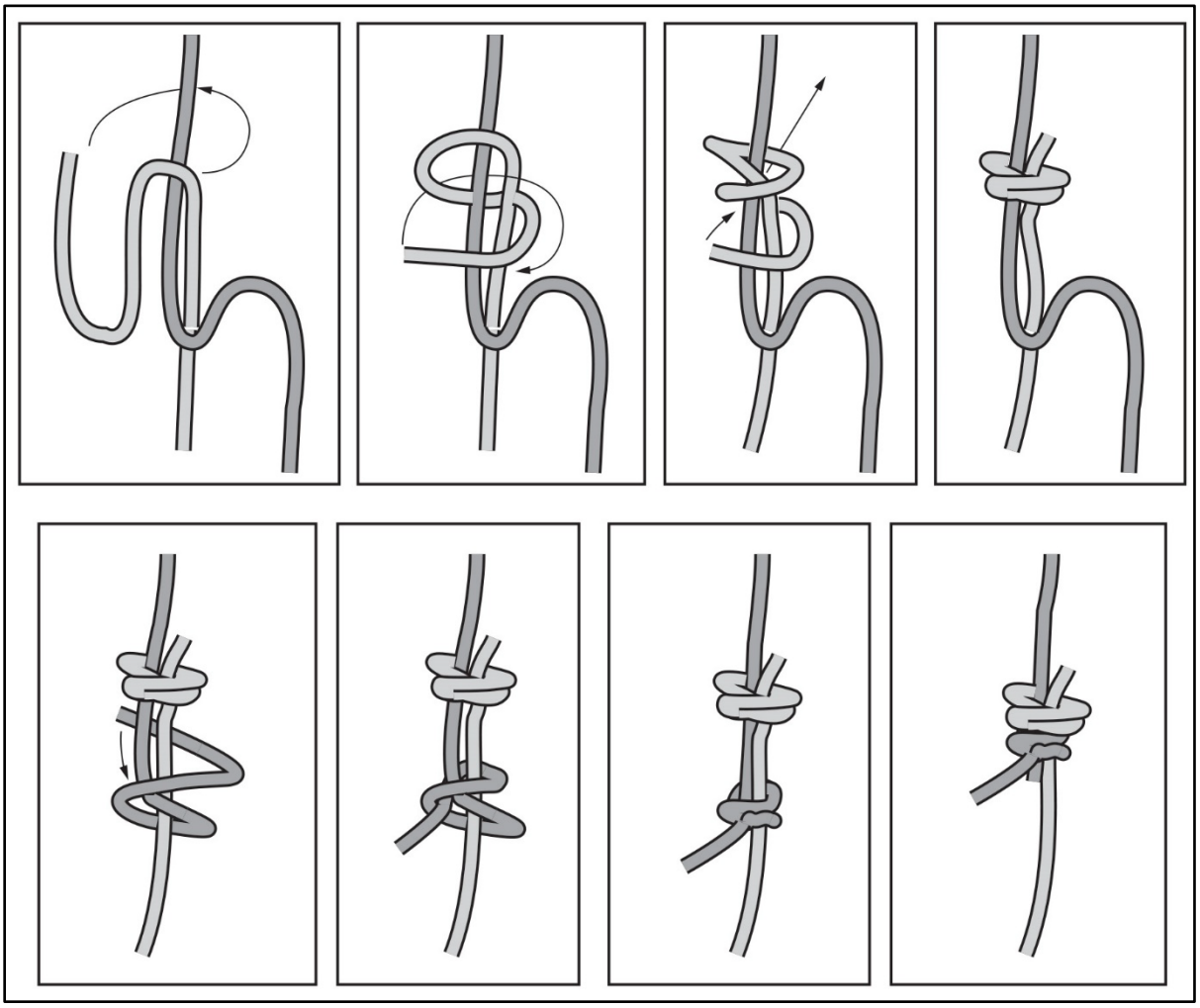


**Figure 8-17. Double fisherman's knot**

### Checkpoints

8-74. The following must be true for the knot to be correct:

- Two double overhand knots securing each other as the standing parts of the rope are pulled apart.
- Four rope parts on one side of the knot form two X patterns; four rope parts on the other side of the knot are parallel.
- Ends of rope exit knot opposite each other with approximately 4-inch tails.

## SQUARE KNOT

8-75. The square knot is used to join the ends of rope of equal diameter while under tension. (See figure 8-18, page 170.) This joining knot should only be used when it is impossible to tie a more secure joining knot like the figure-eight bend or double fisherman's knot.

### Tying the Knot

8-76. The following steps are used to tie a square knot:

- STEP 1: Holding one working end in each hand, place the working end in the right hand over the one in the left hand.
- STEP 2: Pull it under and back over the top of the rope in the left hand.
- STEP 3: Place the working end in the left hand over the one in the right hand and repeat step 2.
- STEP 4: Dress the knot down and secure it with an overhand knot on each side of the square knot.

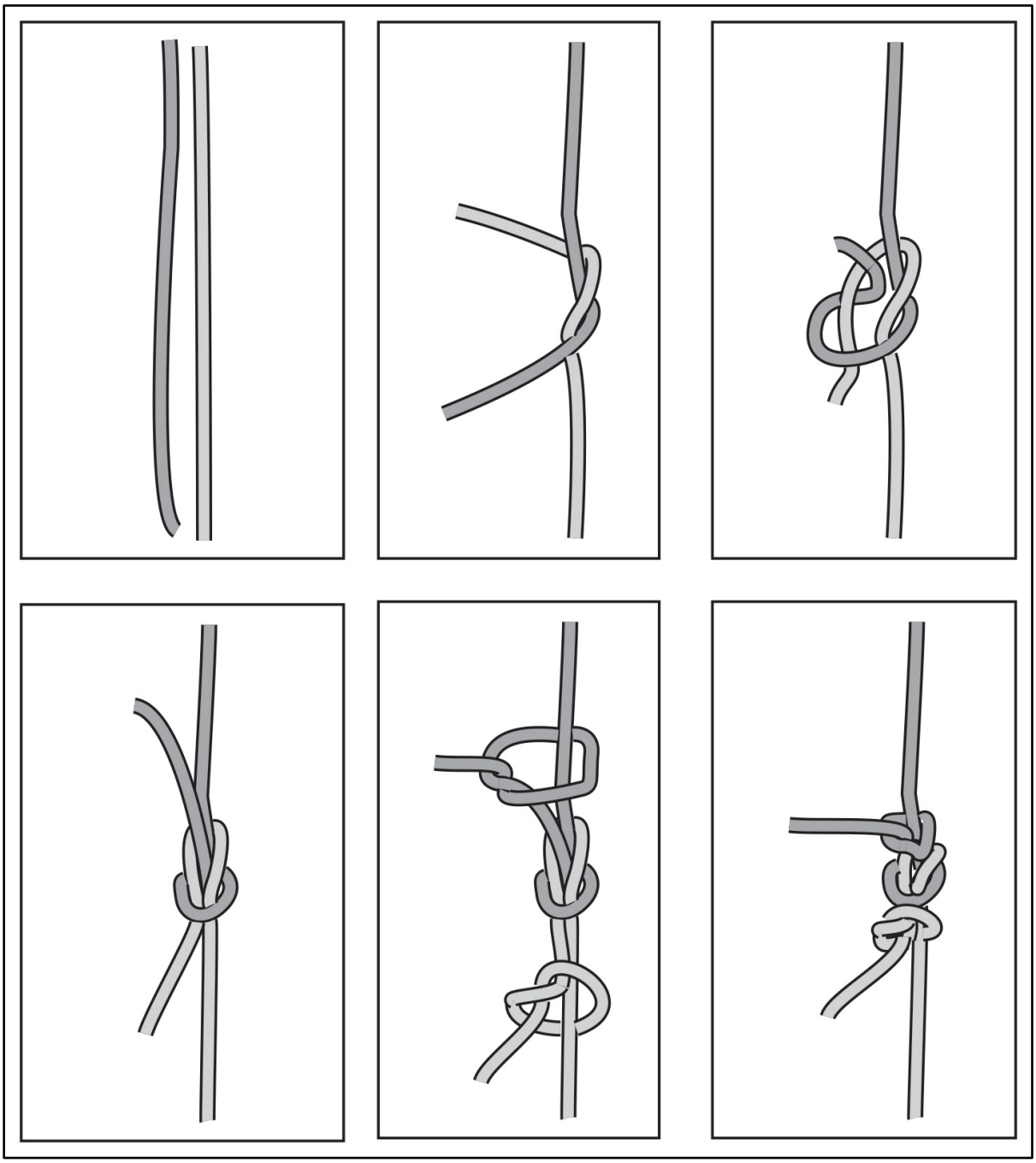


**Figure 8-18. Square knot**

## Checkpoints

8-77. The following must be true for the knot to be correct:

- There are two interlocking bights.
- The running end and standing part are on the same side of the bight formed by the other rope.
- The running ends are parallel to and on the same side of the standing ends with 4-inch minimum tails after the overhand safeties are tied.

## BOWLINE

8-78. The bowline is used to tie the end of a rope around an anchor. It may also be used to tie a single fixed loop at the end of a rope. (See figure 8-19.)

### Tying the Knot

8-79. The following steps are used to tie a bowline:

- STEP 1. Bring the working end of the rope around the anchor, from right to left (as the climber faces the anchor).
- STEP 2. Form an overhand loop in the standing part of the rope (on the climber's right) toward the anchor.
- STEP 3. Reach through the loop and pull up a bight.
- STEP 4. Place the working end of the rope (on the climber's left) through the bight and bring it back onto itself. Now dress the knot down.
- STEP 5. Form an overhand knot with the tail from the bight.

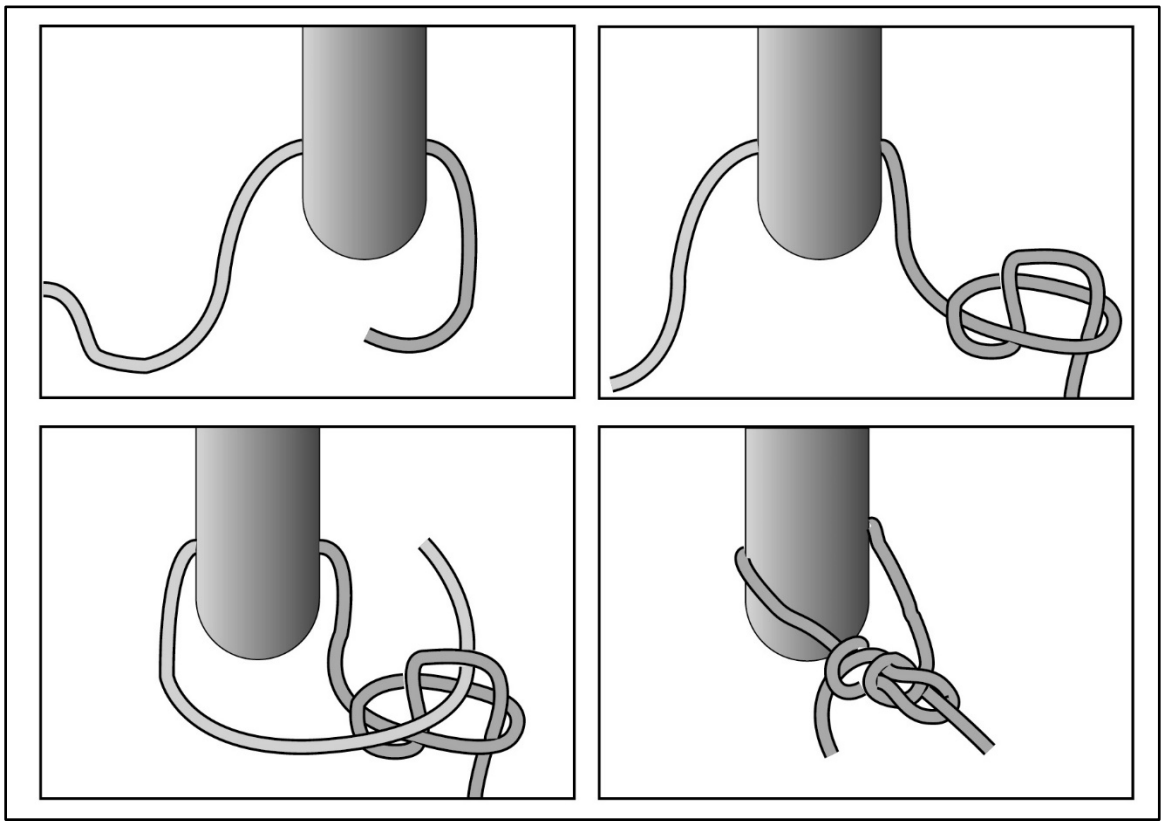


**Figure 8-19. Bowline knot**

### Checkpoints

8-80. The following must be true for the knot to be correct:

- The bight is locked into place by a loop.
- The short portion of the bight is on the inside and on the loop around the anchor (or inside the fixed loop).
- There is an approximate 4-inch tail after tying the overhand safety.

## TRIPLE BOWLINE (THREE-LOOP BOWLINE)

8-81. The triple bowline is used to tie the middle or a bight of rope around an anchor. (See figure 8-20.)

### Tying the Knot

8-82. The following steps are used to tie a triple bowline:

- STEP 1. Form a bight. Route the bight around the anchor.
- STEP 2. With the right thumb facing toward the body, form a doubled loop in the standing part by turning the wrist clockwise. Lay the loops to the right.
- STEP 3. With the right hand, reach down through the loops and pull up a doubled bight from the standing part of the rope.
- STEP 4. Place the running end (bight) of the rope (on the left) through the doubled bight from left to right and bring it back on itself. Hold the running end loosely and dress the knot down by pulling on the standing parts.
- STEP 5. Safety it off with a double overhand knot.

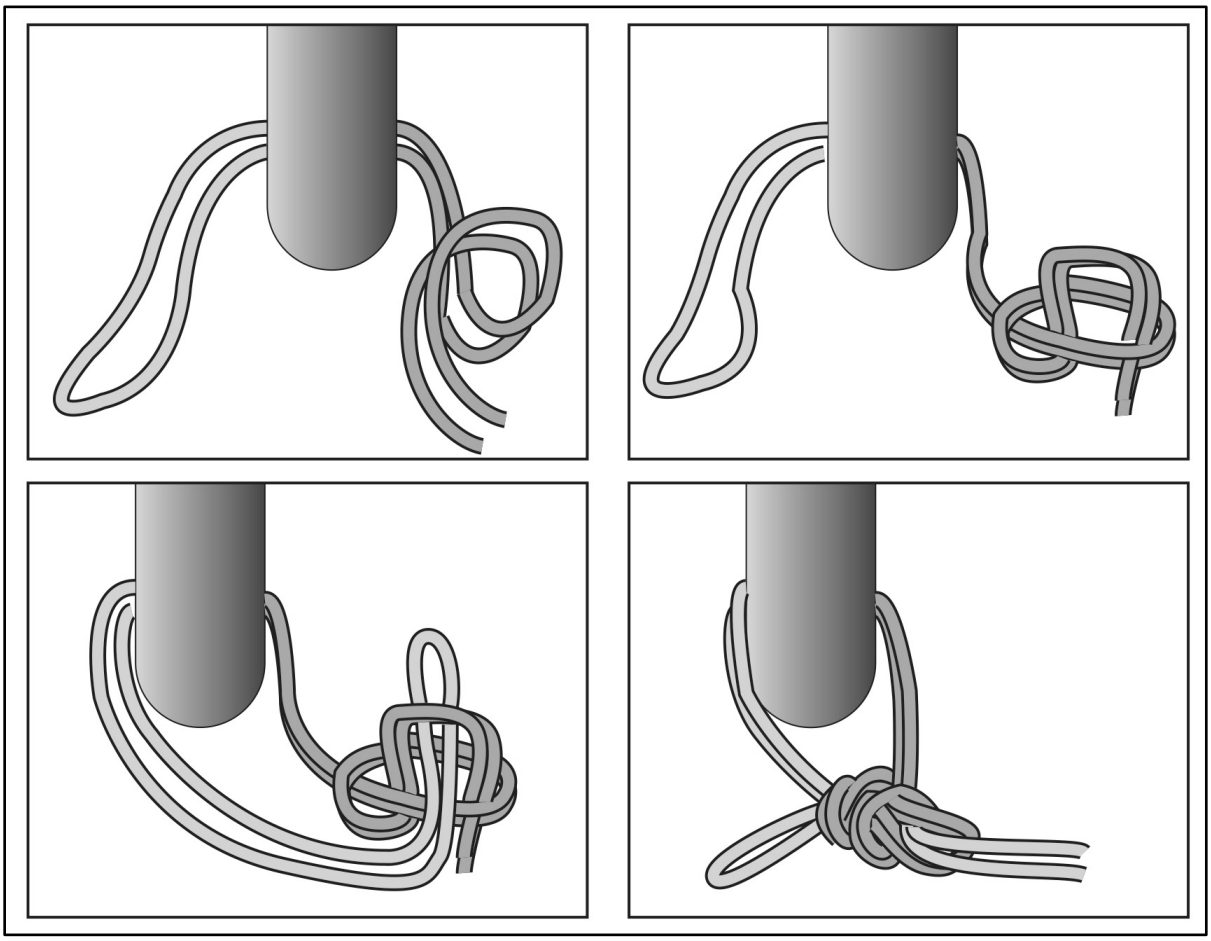


**Figure 8-20. Triple bowline**

### Checkpoints

8-83. The following must be true for the knot to be correct:

- There are two bights held in place by two loops.
- The bights form locking bars around the standing end.

- There is an approximate 4-inch tail (bight) after the double overhand safety knot is tied.
- The running end (bight) must be on the inside of the fixed loops.

## BOWLINE ON A BIGHT (TWO-LOOP BOWLINE)

8-84. The bowline on a bight is used to form two fixed loops in the middle of a rope. (See figure 8-21.)

### Tying the Knot

8-85. The following steps are used to tie a bowline on a bight:

- STEP 1. Form a bight in the rope about twice as long as the finished loops will be.
- STEP 2. Form an overhand loop with both strands.
- STEP 3. Pass the bight up through the loop.
- STEP 4. Fold the bight, passing the entire knot through, until the bight is around the standing ends.
- STEP 5. Dress the knot down so that the bight is tight around the standing ends, and the loops are adjusted to the desired size.

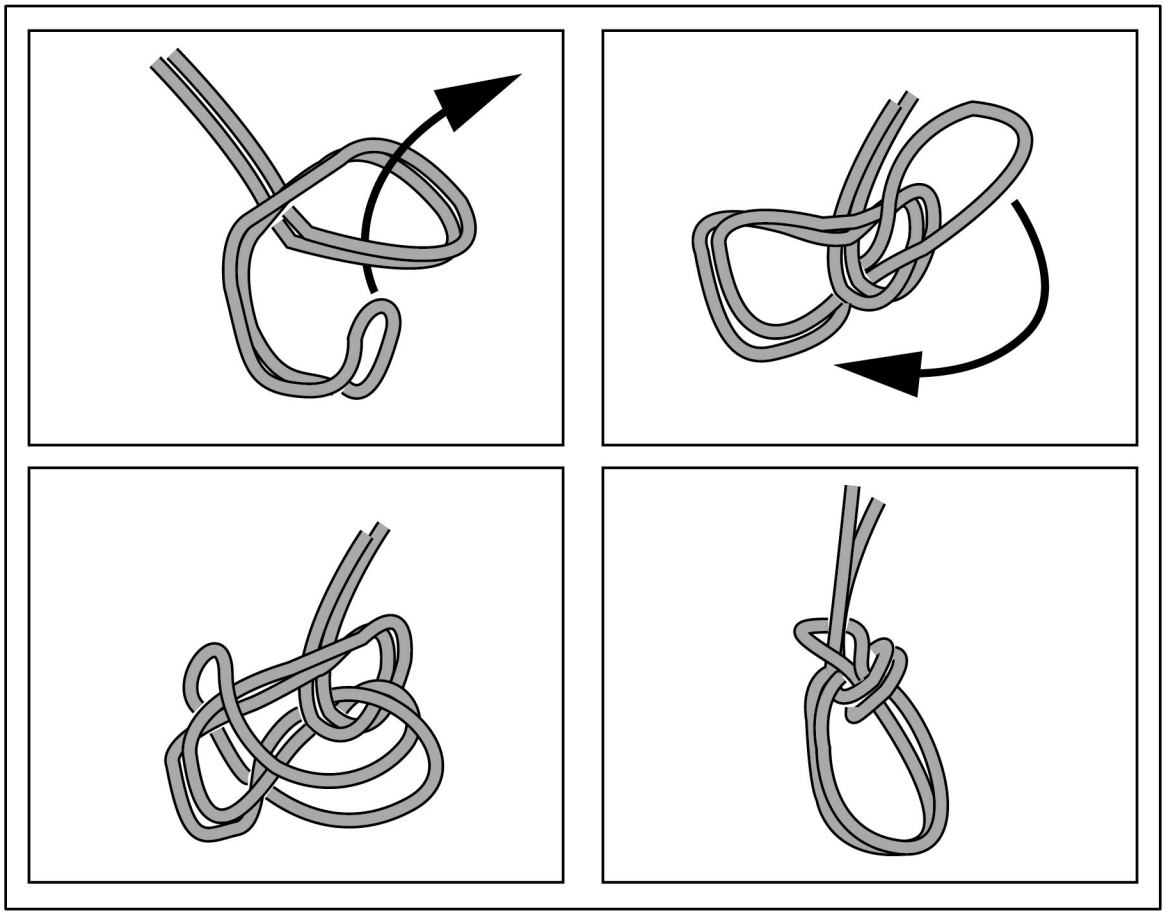


**Figure 8-21. Bowline on a bight**

### Checkpoints

8-86. The following must be true for the knot to be correct:

- There are two fixed loops that will not slip.
- There are no twists in the knot.
- A double loop is held in place by a bight.

## GIRTH HITCH

8-87. The girth hitch is used to attach a cord or sling to an anchor or piece of equipment. (See figure 8-22.) The hitch is also used to attach a sling to a harness.

### Tying the Knot

8-88. The following steps are used to tie a girth hitch:

- STEP 1: Form a bight.
- STEP 2: Bring the running ends back through the bight.
- STEP 3: Cinch the knot tightly.

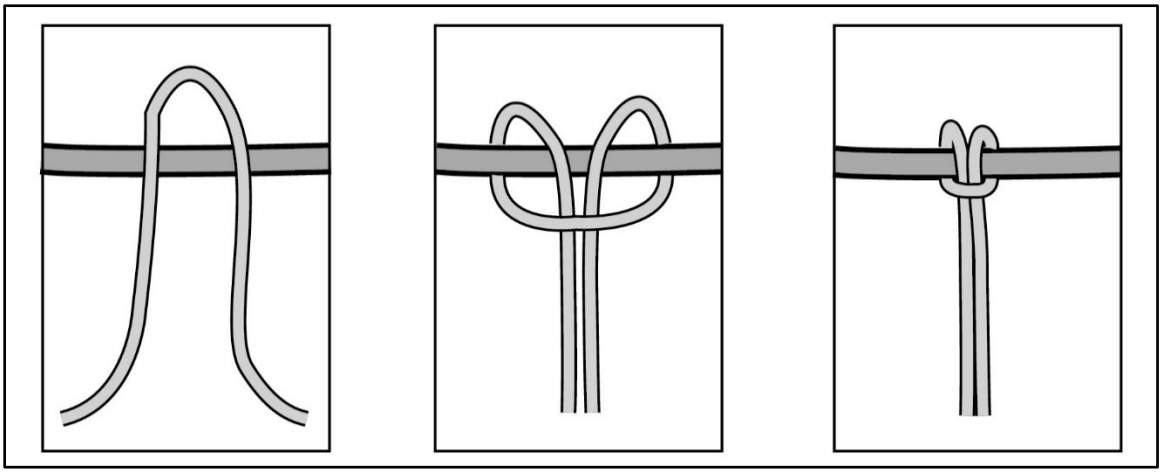


**Figure 8-22. Girth hitch**

### Checkpoints

8-89. The following must be true for the knot to be correct:

- Two wraps exist with a locking bar running across the wraps.
- The knot is dressed tightly.

## PRUSIK

8-90. The prusik is a friction hitch that can be loaded in either direction. When force is applied to this friction hitch, it is very difficult to move or loosen. It can be tied with the middle or end of a cord.

### Tying the Knot

8-91. The prusik can be tied with a cordelette to an installation rope. An installation rope is the primary load-bearing rope or strand in a rope system. A minimum of three turns should be used for this knot. The closer in diameter the cordelette is to the installation rope, the more turns may be required for the knot to function. Ideally, there should be a 3-mm difference in diameter between the cordelette and installation rope. Always check to see if the prusik grabs prior to operation.

#### *Middle-of-the-Rope Prusik*

8-92. The following steps are used to tie a middle-of-the-rope prusik (see figure 8-23):

- STEP 1. Double the cord, forming a bright, with the working ends even. Lay it over the installation rope so that the closed end of the bight is below the installation rope and the remaining part of the rope (working ends) is the closest. Spread the working end apart.
- STEP 2. Reach down through the 12-inch bight. Pull up both working ends and lay them over the installation rope. Repeat this process twice more, making sure that the working ends pass in the

middle of the first two turns. Now there are six turns and a locking bar working across them on the installation rope.

- STEP 3. Dress the wraps and locking bar down to ensure they are tight and not twisted.

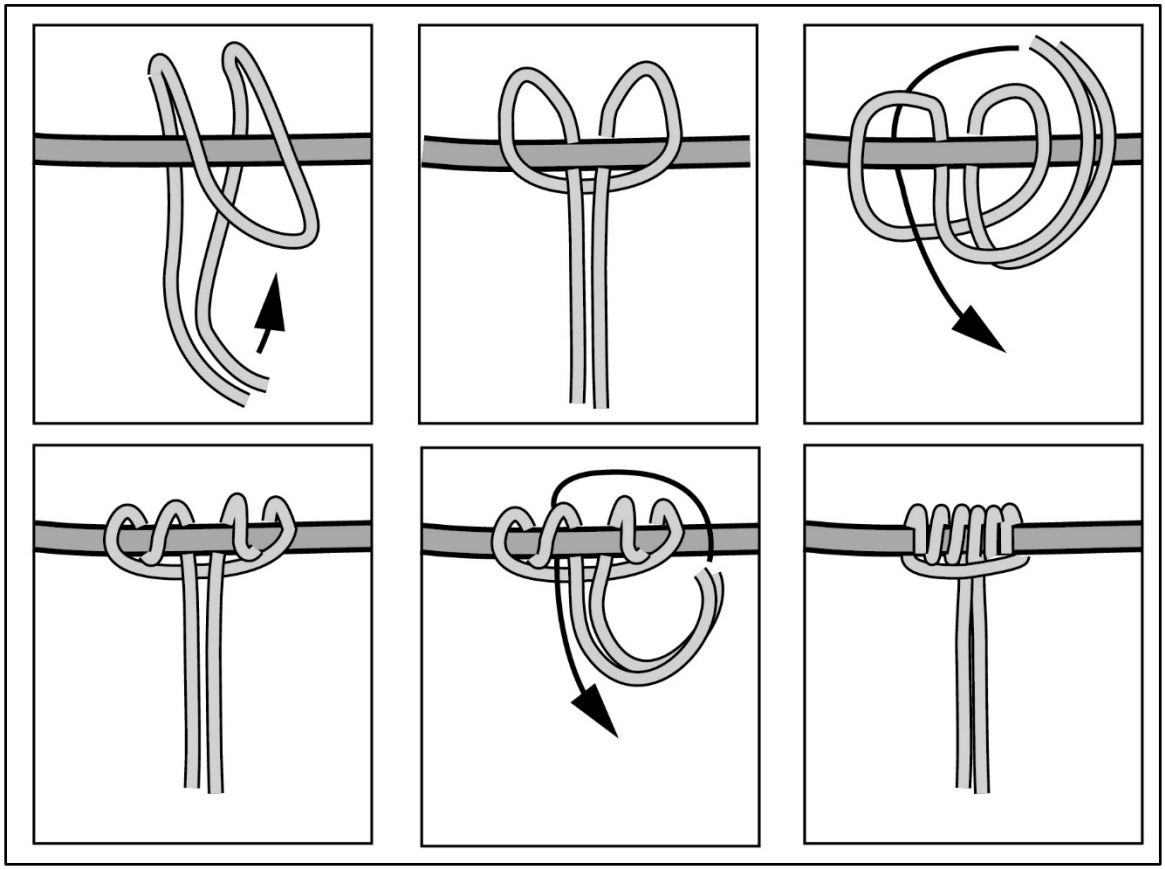


**Figure 8-23. Middle-of-the-rope prusik knot**

***End-of-the-Rope Prusik***

8-93. The following steps are used to tie an end-of-the-rope prusik (see figure 8-24, page 176):

- STEP 1. Take approximately 1 meter of cord and place it over the installation rope.
- STEP 2. Form a complete round turn in the rope.
- STEP 3. Cross over the standing part of the cord with the working end of the cord.
- STEP 4. Lay the working end under the installation rope.
- STEP 5. Form a complete round turn in the rope, working back toward the middle of the knot.
- STEP 6. There are six turns and a locking bar running across them on the installation rope. Dress the wraps and locking bar down. Ensure they are tight, parallel, and untwisted.
- STEP 7. Finish the knot with a bowline with the tail, ensure both strands have tension on it and running end of the prusik knot cannot be pulled through and undo the knot.

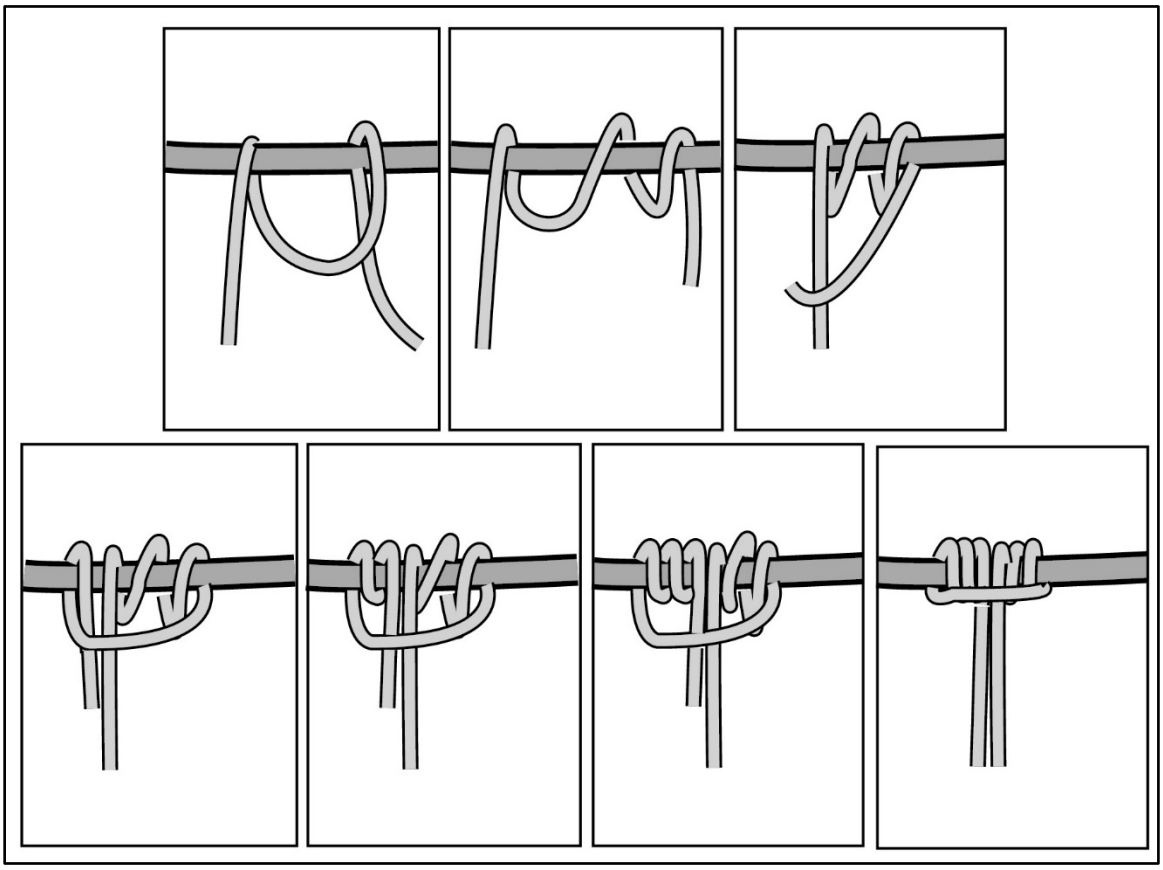


**Figure 8-24. End-of-the-rope prusik knot**

## Checkpoints

8-94. The following must be true for the knot to be correct:

- Six complete turns with a locking bar.
- The knot is tight and dressed down with no ropes twisted or crossed.
- The end-of-the-rope prusik hitch should be closed out with a bowline to prevent slipping.

## AUTOBLOCK

8-95. The autoblock creates a friction hitch that is releasable even when force is applied. (See figure 8-25.) This knot is used as a hands-free backup for rappelling and lowering.

## Tying the Knot

8-96. The following steps are used to tie an autoblock knot:

- STEP 1. Begin with a joined length of webbing or cord about 24-inches long. A presewn sling is also acceptable.
- STEP 2. Offset the joining knot, keeping it close to one end of the loop. If using sewn webbing, treat the sewn portion as the knot.
- STEP 3. Begin wrapping the clean portion of material around the rope. Create a minimum of three complete turns.
- STEP 4. Secure both bights into a locking carabiner that is attached to the harness and lock it.
- STEP 5. Ensure the autoblock grabs the rope by testing it prior to use. Smaller diameter ropes may require more than four wraps.

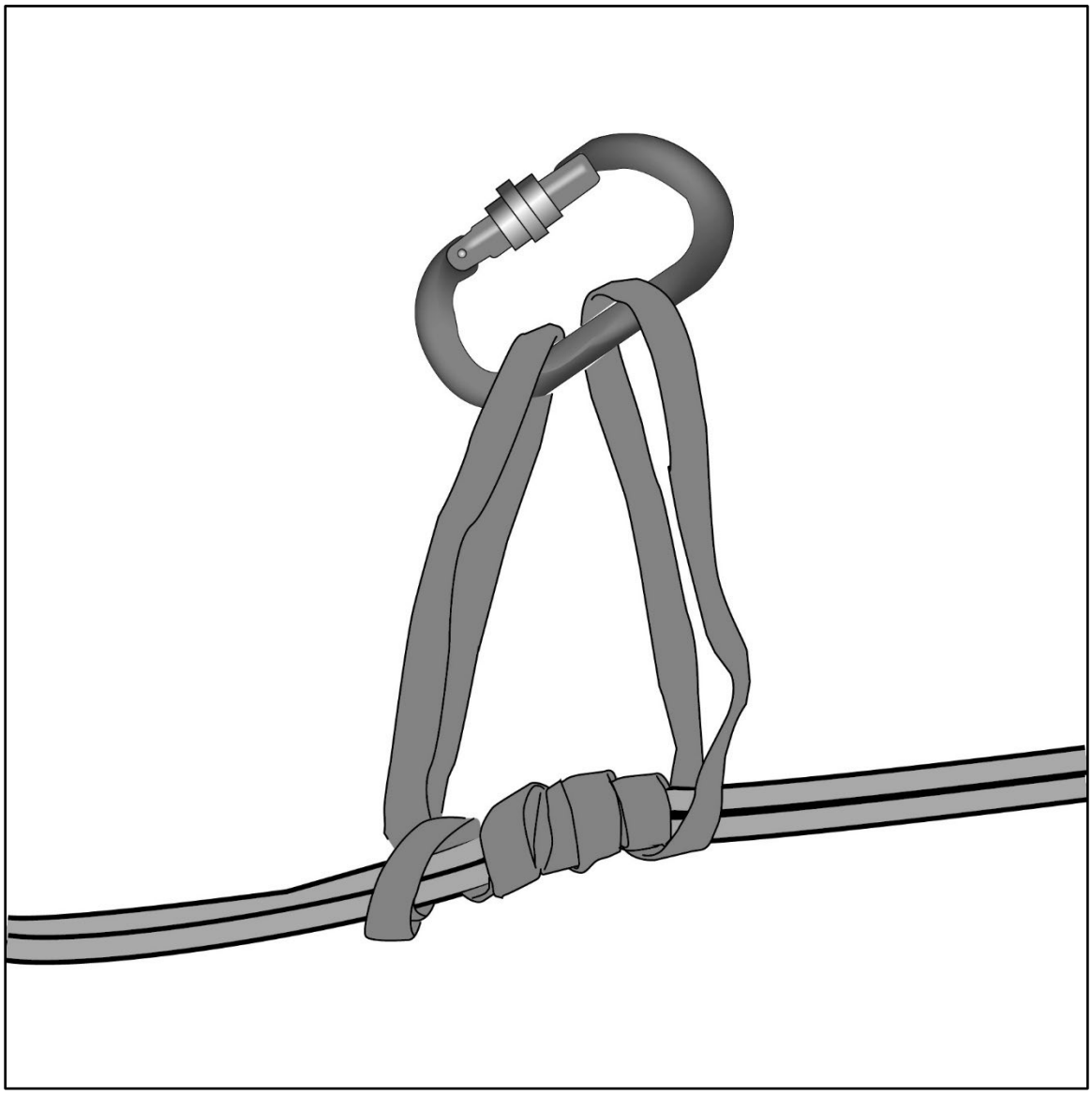


**Figure 8-25. Autoblock knot**

### Checkpoints

8-97. The following must be true for the knot to be correct:

- Both bights of the joined material are secured into a locking carabiner.
- There is a minimum of three turns.
- The joining knot, tails, or sewn portion is not incorporated into any of the wraps or in the carabiner.

## KLEMHEIST

8-98. The klemheist is a friction hitch. Like the prusik, it is difficult to move or loosen while force is being applied. It is easier and quicker to tie than the prusik. It is also easier to loosen and move after applying force than the prusik. It cannot be loaded in both directions. (See figure 8-26, page 178.)

### Tying the Knot

8-99. The following steps are used to tie a klemheist (see figure 8-26):

- STEP 1. Using a cordelette or webbing offsets the ends by 12 inches. Find the center of the rope and form a bight. Lay the bight over the installation rope.
- STEP 2. Wrap the tails of the cordelette around the installation rope back toward the direction of pull. Create at least four complete turns.
- STEP 3. With the remaining tails of the cordelette, pass them through the bight (see step 1).
- STEP 4. Dress the knot down tightly so that all wraps are touching.

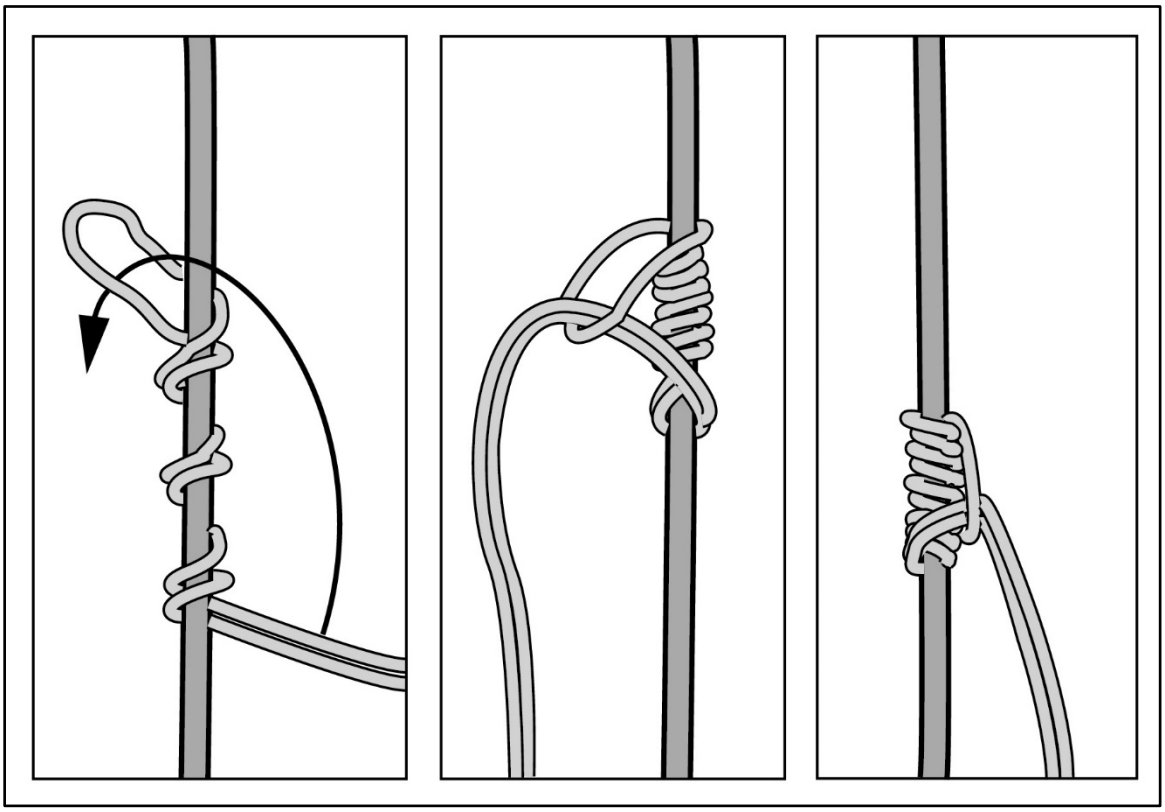


**Figure 8-26. Klemheist hitch**

### Checkpoints

8-100. The following must be true for the knot to be correct:

- The bight is opposite the direction of pull.
- All wraps are tight and touching.

## BACHMANN HITCH

8-101. The Bachmann hitch is a friction hitch that is easily released and reset. (See figure 8-27.) The carabiner acts as a handle to help move the friction hitch along the rope.

### Tying the Knot

8-102. The following steps are used to tie a Bachmann hitch:

- STEP 1. Find the middle of a cordelette and insert it into a carabiner.
- STEP 2. Place the carabiner and cordelette next to the installation rope.
- STEP 3. With the two ropes parallel from the carabiner, make two or more wraps around the climbing rope and through the inside portion of the carabiner.

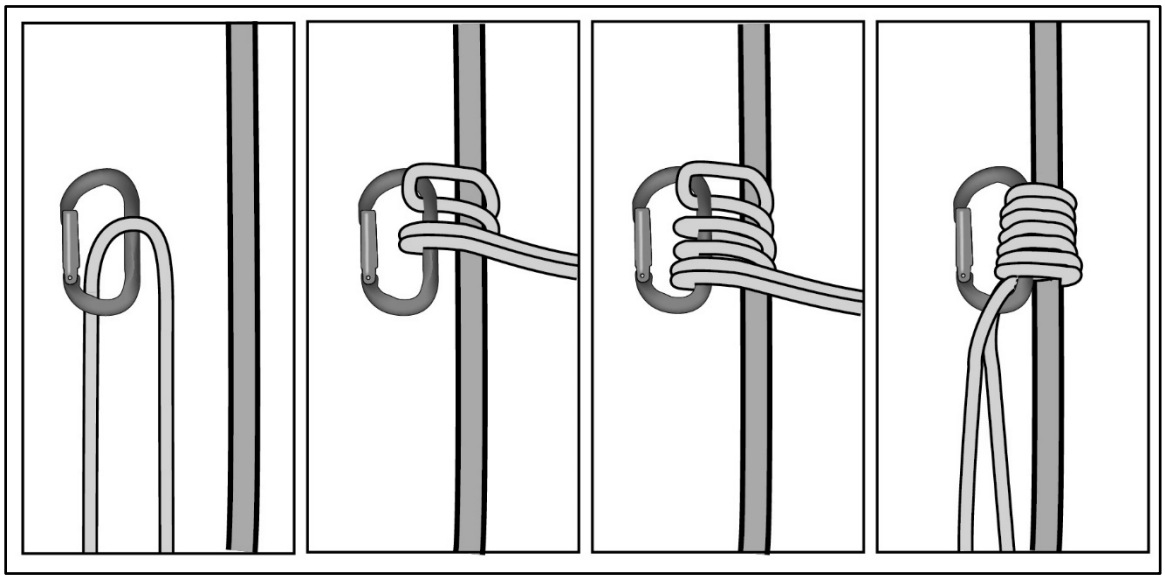


**Figure 8-27. Bachmann hitch**

### Checkpoints

8-103. The following must be true for a knot to be correct:

- The bight of the climbing rope is at the top of the carabiner.
- The two ropes run parallel without twisting or crossing.
- Two or more wraps are made around the long climbing rope and through the inside portion of the carabiner.

## CLOVE HITCH

8-104. The clove hitch is an anchor knot that can be used in the middle of the rope as well as at the end. (See figure 8-28, page 180 and figure 8-29, page 181.) This hitch is easily adjustable after it has been tied and it uses a little rope.

### Tying the Knot

8-105. There are two versions of the clove hitch: the middle-of-the-rope clove hitch and the end-of-the-rope clove hitch.

#### *Middle-of-the-Rope Clove Hitch*

8-106. The following steps are used to tie a middle-of-the-rope clove hitch (see figure 8-28, page 180):

- STEP 1. Hold the rope in both hands, palms down with hands together. Slide the left hand to the left approximately 10 inches.
- STEP 2. Form a loop away from and back toward the right.
- STEP 3. Slide the right hand approximately 10 inches to the right. Form a loop inward and back to the left hand.
- STEP 4. Place the left loop on top of the right loop. Place both loops over the anchor and pull both ends of the rope in opposite directions.

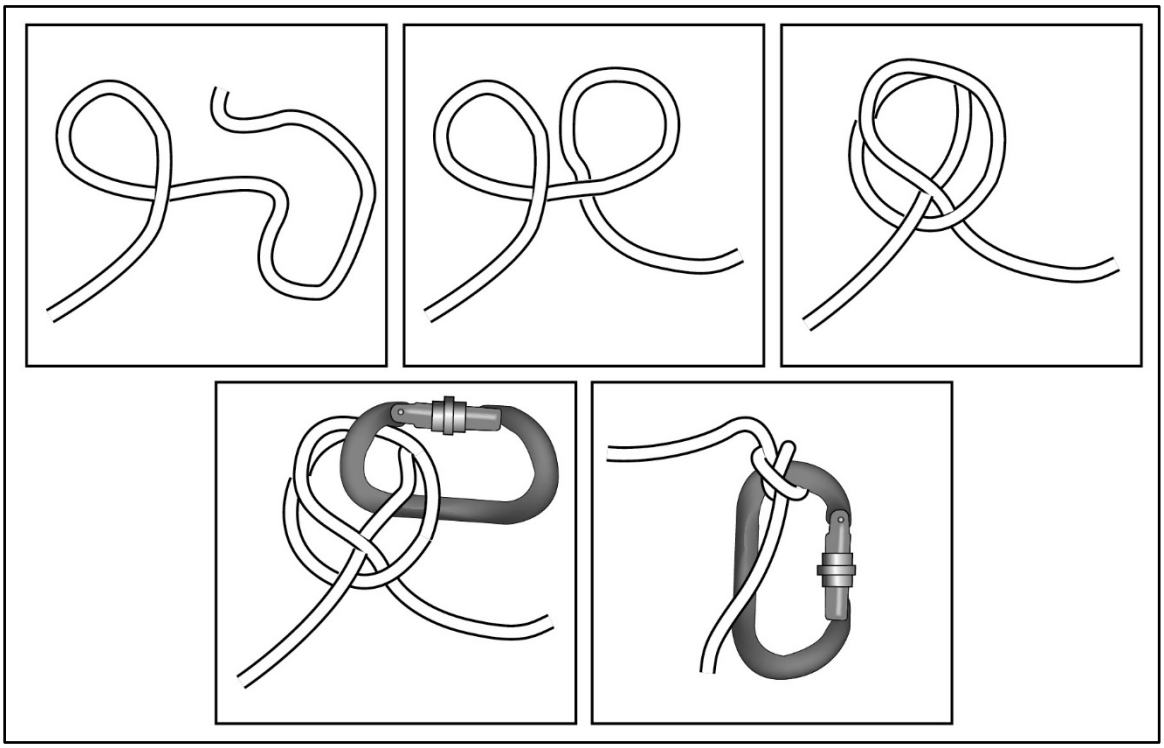


**Figure 8-28. Middle-of-the-rope clove hitch**

***End-of-the-Rope Clove Hitch***

8-107. The following steps are used to tie an end-of-the-rope clove hitch (see figure 8-29):

- STEP 1. Place approximately 30 inches of rope over the top of the anchor. Hold the standing end in the left hand. With the right hand, reach under the horizontal anchor, grasp the working end, and bring it inward.
- STEP 2. Place the working end of the rope over the standing end (to form a loop). Hold the loop in the left hand. Place the working end over the anchor to the left of the loop.
- STEP 3. With the right hand, reach down to the left-hand side of the loop under the anchor. Grasp the working end of the rope. Bring the working end up and outward.
- STEP 4. Dress down the knot.

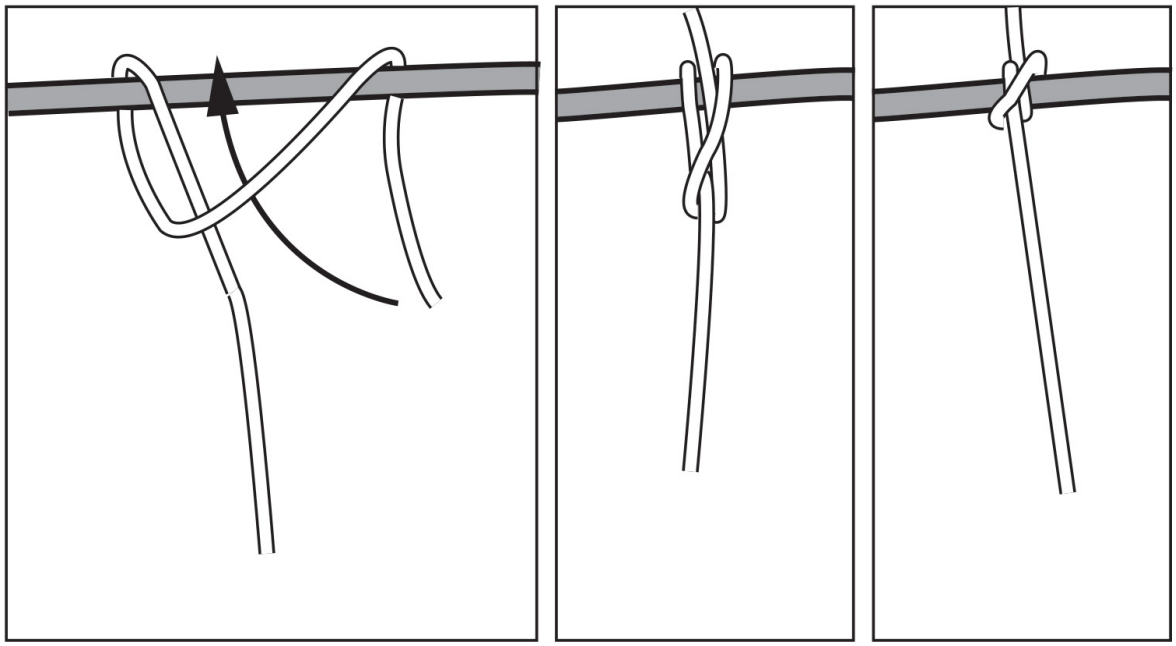


**Figure 8-29. End-of-the-rope clove hitch**

### Checkpoints

8-108. The following must be true for the knot to be correct:

- The knot has two round turns around the anchor with a diagonal locking bar.
- The locking bar is facing 90° from the direction of pull.
- The ends exit l80° from each other.
- The knot has more than a 4-inch tail remaining.

## MUNTER HITCH

8-109. The Munter hitch is used to form a mechanical belay. (See figure 8-30, page 182.) The Munter hitch produces friction, reducing the force required to hold a fall. It can be used to belay a climber going up or to lower a climber or load down.

### Tying the Knot

8-110. The following steps are used to tie a Munter hitch:

- STEP 1. Hold the rope in both hands, palms down about 12 inches apart.
- STEP 2. With the right hand, form a loop away from the body toward the left hand. Hold the loop with the left hand.
- STEP 3. With the right hand, place the rope that comes from the bottom of the loop over the top of the loop.
- STEP 4. Place the bight that has just been formed around the rope into a locking carabiner. Secure the locking carabiner.
- The carabiner is locked.

### Checkpoints

8-111. The following must be true for the knot to be correct: A bight passes through the carabiner with the close end around the standing or running part of the rope.

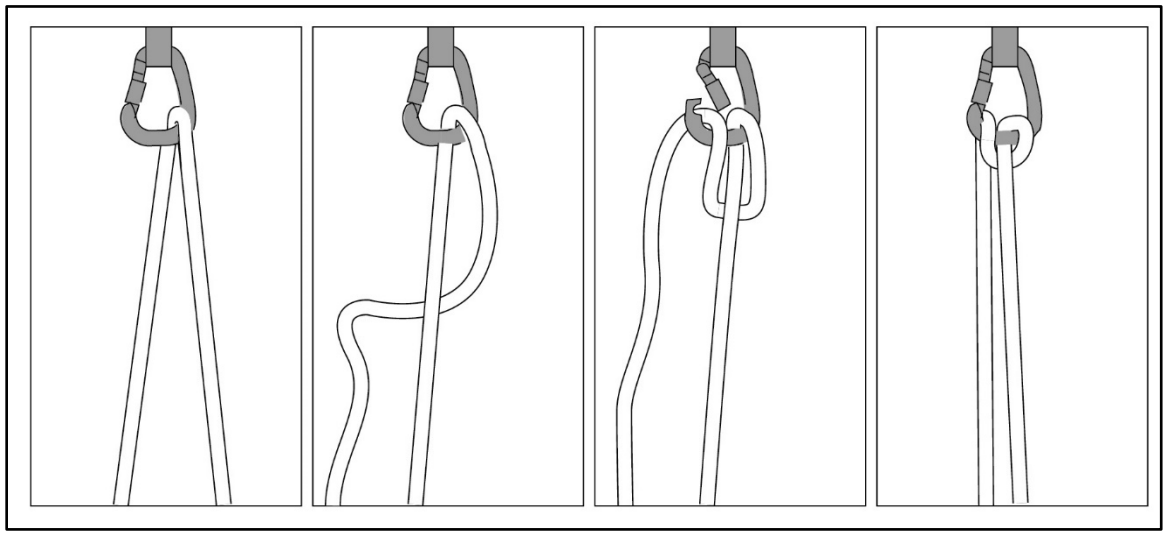


**Figure 8-30. Munter hitch**

## SUPER MUNTER HITCH

8-112. The super Munter hitch is used to form a high-friction lower. (See figure 8-31.) The knot produces more friction with an additional wrap. Mountaineers use the super Munter hitch to lower very heavy loads.

### Tying the Knot

8-113. The following steps are used to tie a super Munter hitch:

- STEP 1. Hold the rope in both hands, palms down about 12 inches apart.
- STEP 2. With the right hand, form a loop away from the body toward the left hand. Hold the loop with the left hand.
- STEP 3. With the right hand, place the rope that comes from the bottom of the loop over the top of the loop.
- STEP 4. Place the bight that has just been formed around the rope into a locking carabiner.
- STEP 5. Take the brake strand or the strand not exiting the carabiner into the bight and pass it under the knot and carabiner. (**A *brake strand* is the strand of a rope system that controls the rate at which a load is lowered or a rappeller descends**.) Then bring it back up to form another bight. Take this bight and place it into the locking carabiner. Secure the carabiner.

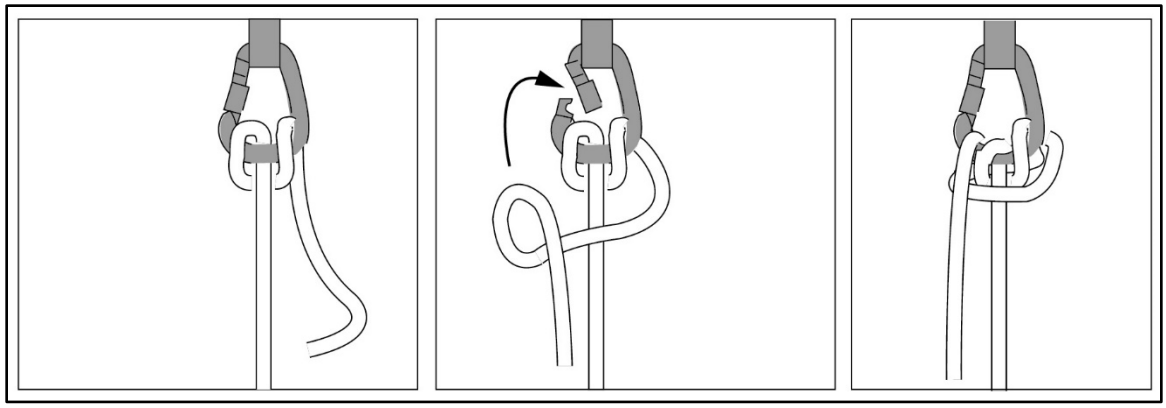


**Figure 8-31. Super Munter hitch**

### Checkpoints

8-114. The following must be true for the knot to be correct:

- A bight passes through the carabiner, with the closed end around the standing or running part of the rope.
- An additional opposite bight is wrapped around the same strand as the first.
- The carabiner is locked.

## MUNTER MULE KNOT

8-115. The mule knot is used to create an easily releasable anchor knot in conjunction with a Munter hitch. (See figures 8-32 and 8-33, page 184.) This knot is used in systems where there is a need for releasability. The mule knot can be used to tie off a belay or lower to go hands free.

### Tying the Knot

8-116. The following steps are used to tie a Munter mule knot:

- STEP 1. Place a Munter hitch into a locking carabiner.
- STEP 2. With the brake strand of the Munter, create an overhand loop and place onto the load strand of the Munter hitch.
- STEP 3. Bring a bight through the overhand loop, capturing the load strand creating a slipknot.
- STEP 4. Dress the slipknot down against the Munter hitch.
- STEP 5. Pass the tails through the bight of the slipknot.
- STEP 6. Dress the bight to 4 to 6 inches.

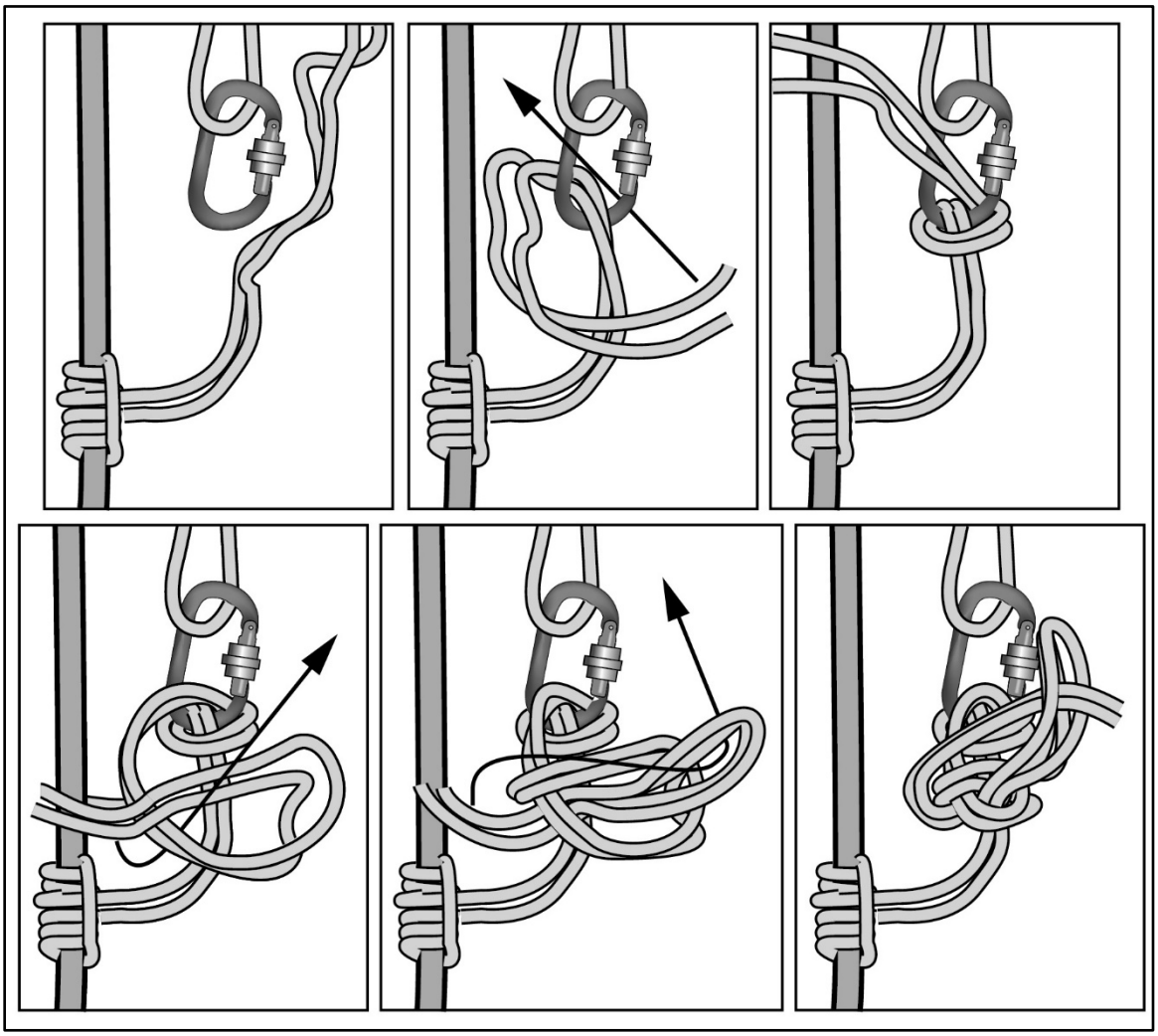


**Figure 8-32. Munter mule knot using cord**

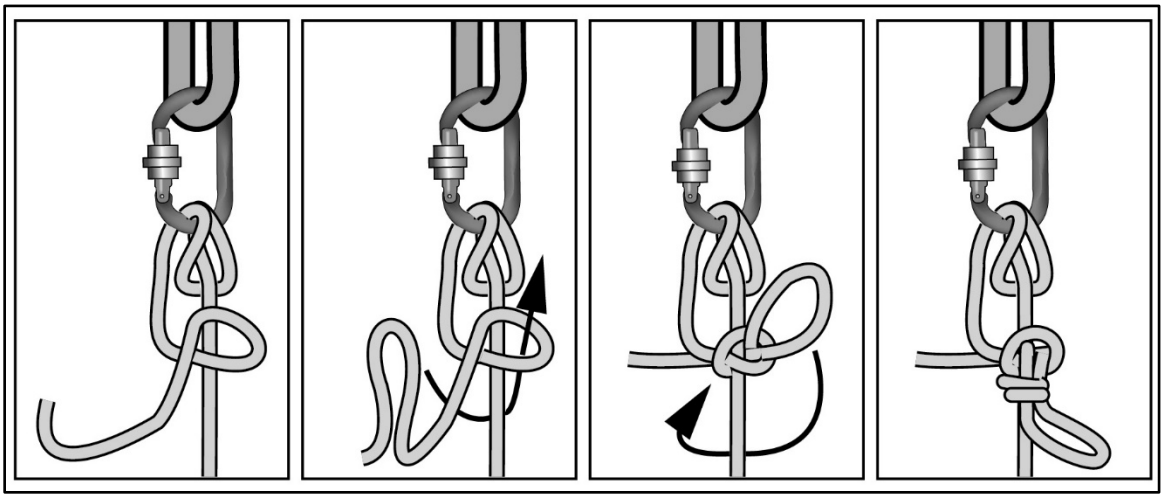


**Figure 8-33. Munter mule knot using installation rope**

### Checkpoints

8-117. The following must be true for the knot to be correct:

- A bight passes through the carabiner, with the closed end around the standing or running part of the rope.
- An additional opposite bight is wrapped around the same strand as the first.
- The carabiner is locked.

## GARDA HITCH

8-118. The garda hitch (ratchet knot, alpine clutch) is a special-purpose knot, which allows rope to travel in one direction but not the other. The garda hitch is primarily used for hauling systems or rescue. (See figure 8-34.) The knot works in only one direction, and it cannot be reversed while under load.

### Tying the Knot

8-119. The following steps are used to tie a garda hitch knot:

- STEP 1. Place a bight of rope into the two nonlocking carabiners (which works best with two alike carabiners). D-shaped carabiners are the most effective.
- STEP 2. Take a loop of rope from the nonload side and place it down into the opposite carabiner so that the rope comes out between the two carabiners.

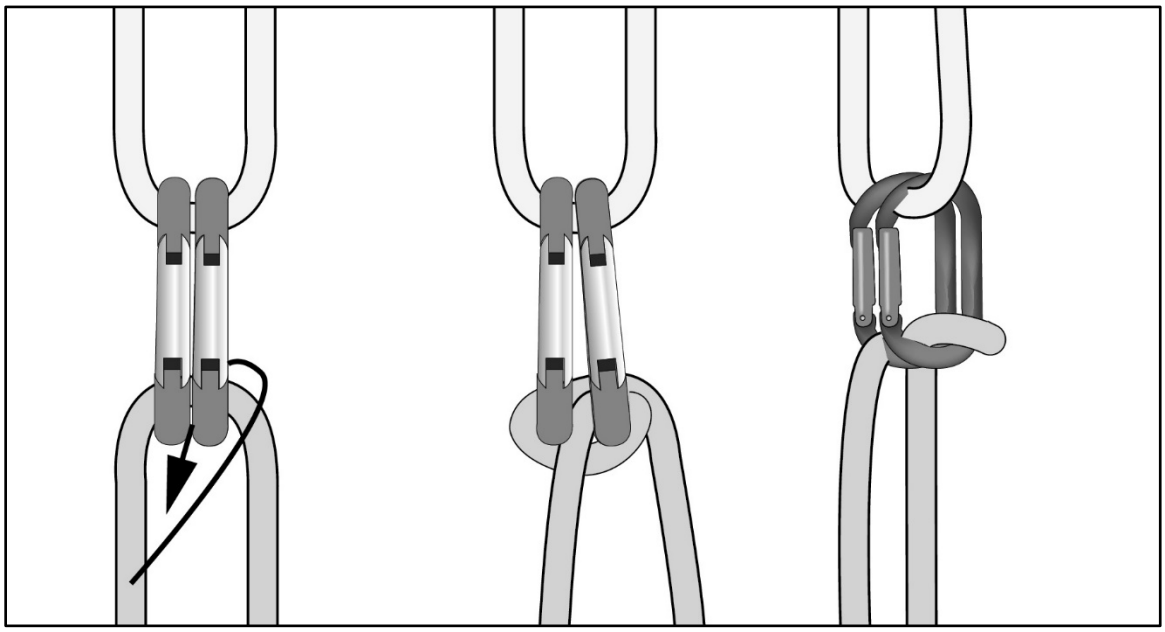


**Figure 8-34. Garda hitch**

### Checkpoints

8-120. The following must be true for the knot to be correct:

- When properly dressed, rope can only be pulled in one direction.
- The knot will not fail when placed under load.

## BIG HONKING KNOT

8-121. The big honking knot (BHK) is used to bring together strands of rope from multiple anchors to create a master point. (See figure 8-35, page 186.) It is often used in institutional top rope and rappel anchors. The BHK is a strong, secure knot that can handle repeated use, yet is still easy to untie.

## Tying the Knot

8-122. The following steps are used to tie a BHK:

- STEP 1. Equalize all the strands from the anchor points, then fold back approximately 24 inches of the bight that is created.
- STEP 2. Tie a double overhand or figure-eight knot with all the strands.
- STEP 3. Check that all loops are fixed. The loop that exits behind the knot, toward the anchors, should be secured, either with a carabiner to one of the anchor legs or by passing the knot through the loop adding extra security.

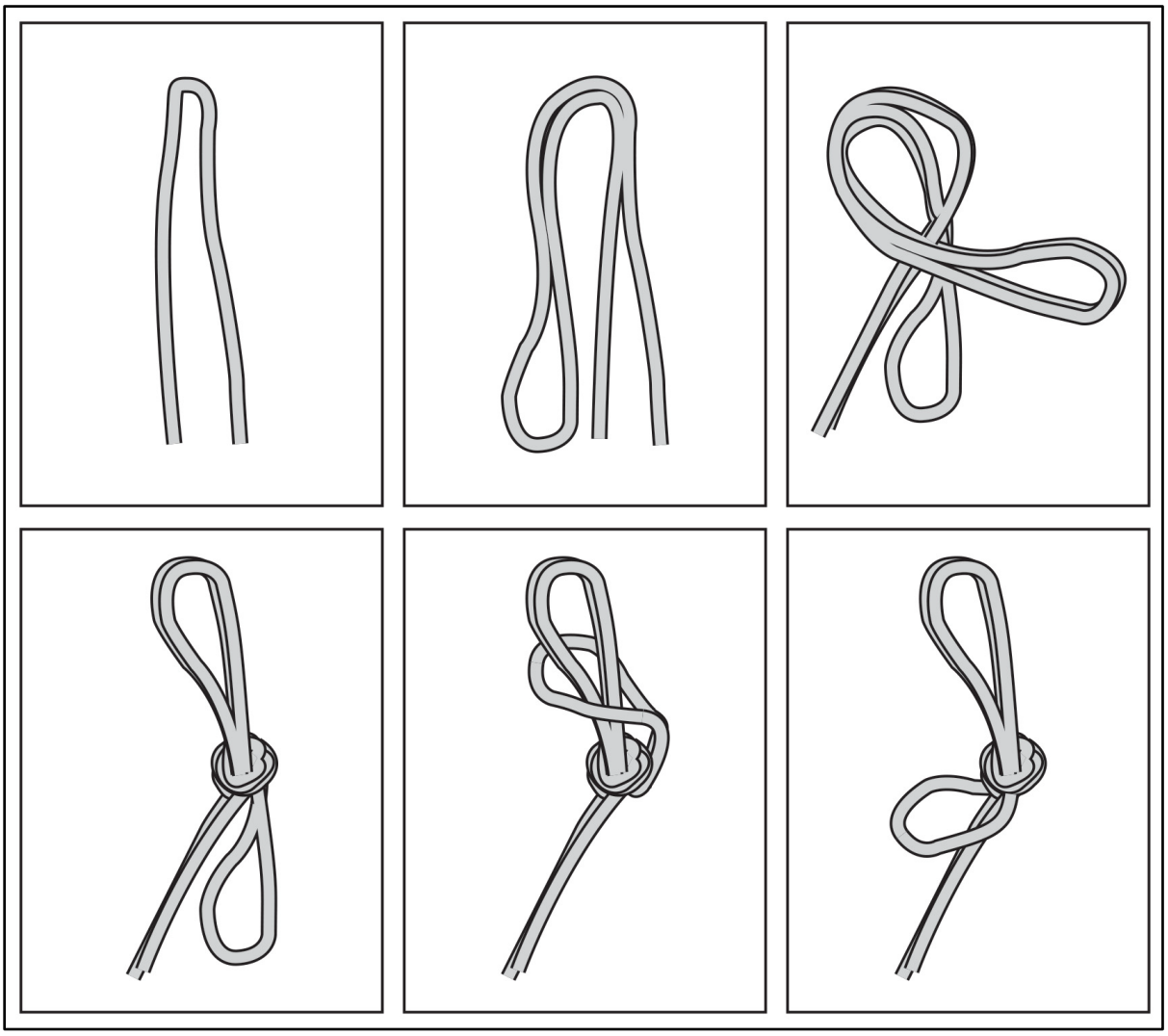


**Figure 8-35. Big honking knot**

## Checkpoints

8-123. The following must be true for the knot to be correct:

- There are two fixed loops that exit away from the anchors.
- Four strands of rope should exit together from the back of the knot toward the anchors.
- Two of the strands in the back form an additional fixed loop.
- This fixed loop should be secured by a carabiner attached to a leg of the anchor or the knot should be passed through this loop to ensure it cannot be pulled back through the knot.

## FIELD EXPEDIENT HARNESS

8-124. The field expedient harness creates a seat harness out of tubular webbing used for climbing or rappelling. (See figure 8-36, page 188.) This improvised harness is more secure than the rappel seat and will not come loose while climbing. The field expedient harness can also be used in rescue to secure a patient not wearing a harness. Either 1- or 2-inch tubular webbing is acceptable for use.

### Constructing the Harness

8-125. The following steps are used to tie a field expedient harness:

- STEP 1. Find the middle of a 25-foot section of tubular webbing and form a bight.
- STEP 2. Pass the bight between the legs from rear to front and pull it up to beltline level.
- STEP 3. Wrap the right and left tails of webbing around each respective leg from rear to front ensuring that the tails do not cross over one another.
- STEP 4. Pass the tails through the bight at belt level and wrap them back onto themselves.
- STEP 5. Wrap the remaining lengths of webbing around the body above the hips and continue to wrap in the opposite directions until enough is remaining to tie a square knot with safeties.
- STEP 6. Join the tails together just above the hip offset from front of the body on either side of the body using a square knot with overhand safeties.

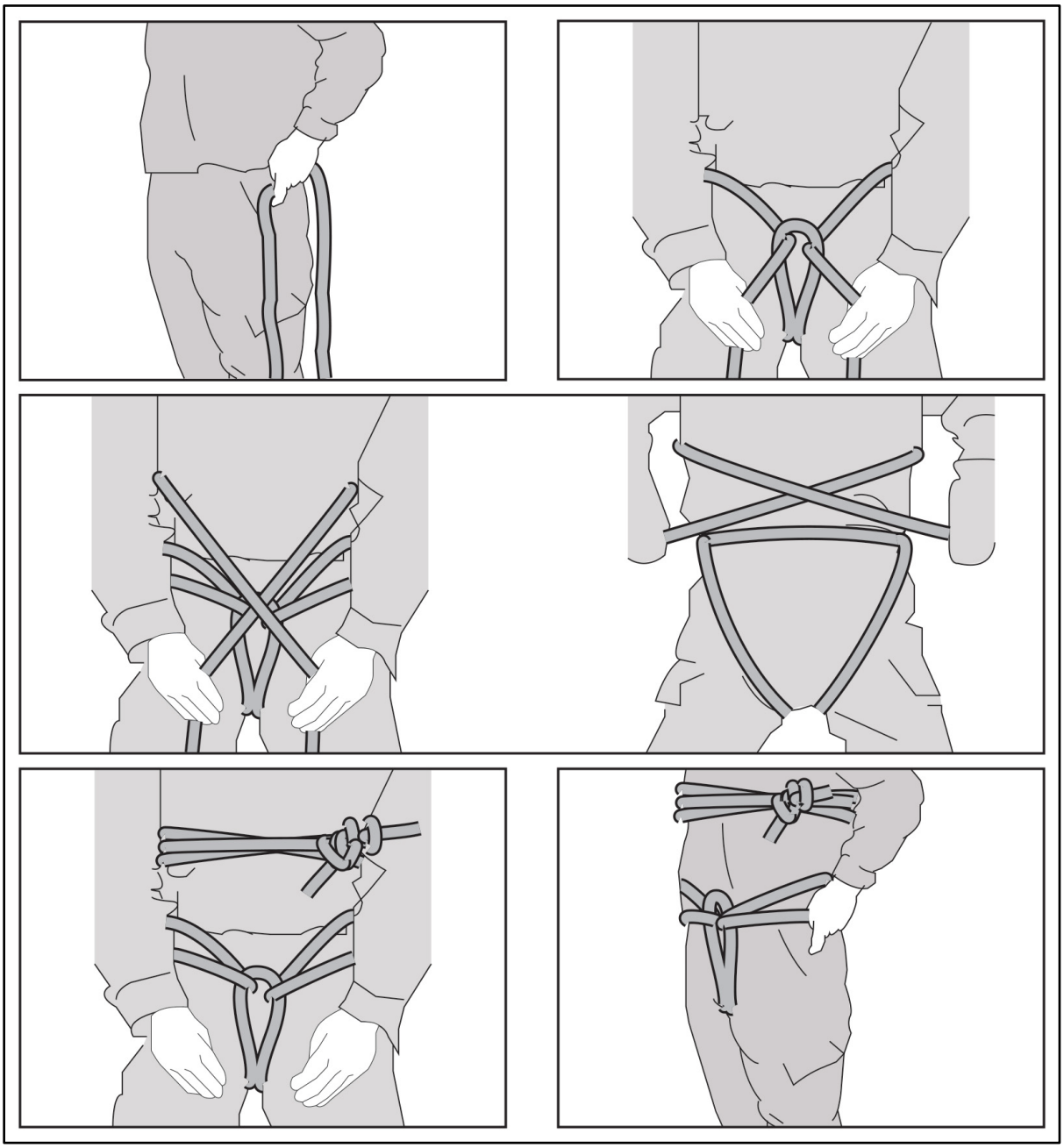


**Figure 8-36. Field expedient harness**

## Checkpoints

8-126. The following must be true for the knot to be correct:

- Webbing does not cross between the legs.
- Tails are passed through the diaper portion to create leg loops in the same direction.
- Minimum one full wrap around the body above the hips.
- Secured on one hip with a square knot. Safeties are only tied around the last strand around the waist.
- Square knot is far enough to the side that anything tied or clipped into the harness does not hit the square knot.

## SECTION IV – ROPES: PREPARATION, CARE, INSPECTION, COILING, CARRYING, AND THROWING

8-127. The service life of a rope depends on the frequency of use, applications (rappelling, climbing, rope installations), speed of descent, surface abrasion, terrain, climate, and quality of maintenance. Ropes may fail if misused, placed over sharp edges, or not properly inspected prior to use.

# PREPARING ROPES

8-128. The mountaineer must select the proper rope for the task to be accomplished according to type, diameter, length, and breaking strength. It is important to prepare all ropes before departing on a mission. Avoid rope preparation in the field.

### PACKAGING

8-129. New rope comes from the manufacturer in different configurations, boxed on a spool in various lengths, or coiled and bound in some manner. New ropes should be carefully unspooled or uncoiled to avoid kinks and prevent tangling.

#### Coil

8-130. **A *coil* is a secure configuration of rope that allows for easy transport without tangling**.

#### Precut

8-131. Precut ropes are usually packaged in a protective cover, such as plastic.

### SECURING THE ENDS OF ROPE

8-132. If still on a spool, the rope must be cut to the desired length. All ropes fray at the ends unless they are bound or seared. Both static and dynamic rope ends are secured in the same manner. The ends must be heated to the melting point to attach the inner core strands to the outer sheath. By fusing the two together, the sheath cannot slide backward or forward. Ensure that this is only done to the ends of the rope. If the rope is exposed to extreme temperatures, the sheath could be weakened, along with the inner core, reducing overall tensile strength. The ends may also be dipped in enamel or lacquer for further protection.

# CARE AND MAINTENANCE

8-133. The rope is a climber's lifeline. The rope must be maintained and used properly. Climbers should use the following general guidelines when handling ropes:

- While in use, do not allow the rope to touch sharp edges. Rope is cut more easily when under tension. If the rope must be used over a sharp edge, pad the edge for protection and inspect often.
- Never allow one rope to continuously run over another. The friction causes the nylon to melt.
- Never leave a rope knotted or tightly stretched for longer than necessary. Doing so reduces the strength and life of the rope over time.
- UV radiation (sunlight) tends to deteriorate nylon over long periods. This becomes important if rope installations are left in place for months.
- Do not step on or drag ropes on the ground unnecessarily. Small particles of dirt grind between the inner strands slowly cutting them.
- All ropes should be washed periodically to remove dirt and grit and rinsed thoroughly. Army-issued rope washes are made from short pieces of modified pipe that connect to any faucet. Pinholes within the pipe force water to circulate around and scrub the rope as the Soldier slowly feeds it through the washer.
- Ropes should not be stored wet. Dry wet ropes by uncoiling and hanging them in large loops off the ground. Never dry a rope with high heat or in direct sunlight.
- When not in use, ropes should be loosely coiled and hung on wooden pegs rather than nails or other metal objects. Storage areas should be relatively cool with low-humidity levels to prevent mildew

or rotting. Rope may also be loosely stacked and placed in a rope bag and stored on a shelf. Avoid storage in direct sunlight, as the UV radiation deteriorates the nylon over long periods.

- Inspect the rope before each use for frayed or cut spots, mildew or rot, or defects in construction (new rope).
- Do not mark ropes with paints or allow them to touch oils or petroleum products. Some of these weaken or deteriorate nylon.
- Never subject the rope to high heat or flame. Heat and flame significantly weaken rope.
- Never use a mountaineering rope for any purpose except mountaineering.
- Each rope should have a corresponding rope log DA Form 5752-R (*Rope Log [Usage and History]*), which is also a safety record. On the form, annotate use, terrain, weather, application, number of falls, dates, and so on. Annotate each time the rope is used on the form. DA Form 5752-R is authorized for local reproduction on 8 1/2- by 11-inch paper.

# INSPECTION

8-134. Ropes should be inspected before and after each use, especially when working around loose rock or sharp edges.

- Although the core of the kernmantle rope cannot be seen, it is possible to damage the core without damaging the sheath. Check a kernmantle rope by carefully inspecting the sheath before and after use while the rope is being coiled. When coiling, be aware of how the rope feels as it runs through the hands. Immediately note and tie off any lumps or depressions felt.
- Damage to the core of a kernmantle rope usually consists of filaments or yarn breakage that results in a slight retraction. If enough strands rupture, a localized reduction in the diameter of the rope results in a depression that can be felt or even seen.
- Check any other suspected areas further by putting them under tension (the weight of one person, approximately 185 pounds standing on a prusik tensioning system is about maximum). This procedure emphasizes the lump or depression by separating the broken strands and enlarging the dip. If a noticeable difference in diameter is obvious, retire the rope immediately.
- Many dynamic kernmantle ropes are quite soft. They may retain an indentation occasionally after an impact or under normal use without any trauma to the core. When damage is suspected, patiently inspect the sheath for abnormalities. Damage to the sheath does not always mean damage to the core. Inspect carefully.

# COILING AND CARRYING ROPE

8-135. Use the butterfly or mountain coil to coil and carry the rope. Each is easy to accomplish and results in a minimal number of kinks, twists, and knots later during deployment.

## BUTTERFLY COIL

8-136. The butterfly coil is the quickest and easiest technique for coiling. (See figure 8-37.)

### Coiling

8-137. To start the butterfly coil, grasp both ends of the rope and begin back stacking, ensuring the ends of the rope are not buried at the bottom of the stack. Find the center of the rope and form a bight. With the bight in the left hand, grasp both ropes and slide the right hand out until there is approximately one arm-length of rope. Place the doubled rope over the head, draping it around the neck and over the shoulders. Ensure that it hangs no lower than the waist. Soldiers ensure the rest of the doubled rope is in front of them and continue making doubled bights and placing them over the head in the same manner as the first bight. Coil alternating from side to side (left to right, right to left) while maintaining equal-length bights. Continue coiling until approximately two arm-lengths of rope remain. Remove the coils from the neck and shoulders and hold the center in one hand. Wrap the two ends upwards around the coils with a minimum of three complete wraps, ensuring that the first wrap locks back on itself.

### Tie Off and Carrying

8-138. Take both strands from the tails of the rope, forming a double bight and pass it through the apex of the coils. Pull the loose ends through the doubled bight and dress it down. Ensure that the loose ends do not exceed 2 meters. In this configuration, the coiled rope is secure enough for hand carrying or carrying in a rucksack or for storage. To carry on the body, place the butterfly coil on the back, with one tail over each of the shoulders, bring back directly under the arms and wrap at least once around the body, ensuring to capture all the coils. Secure the ends with a square knot, which does not need overhand safeties. (See figure 8-37 for a farmer's tie off.)

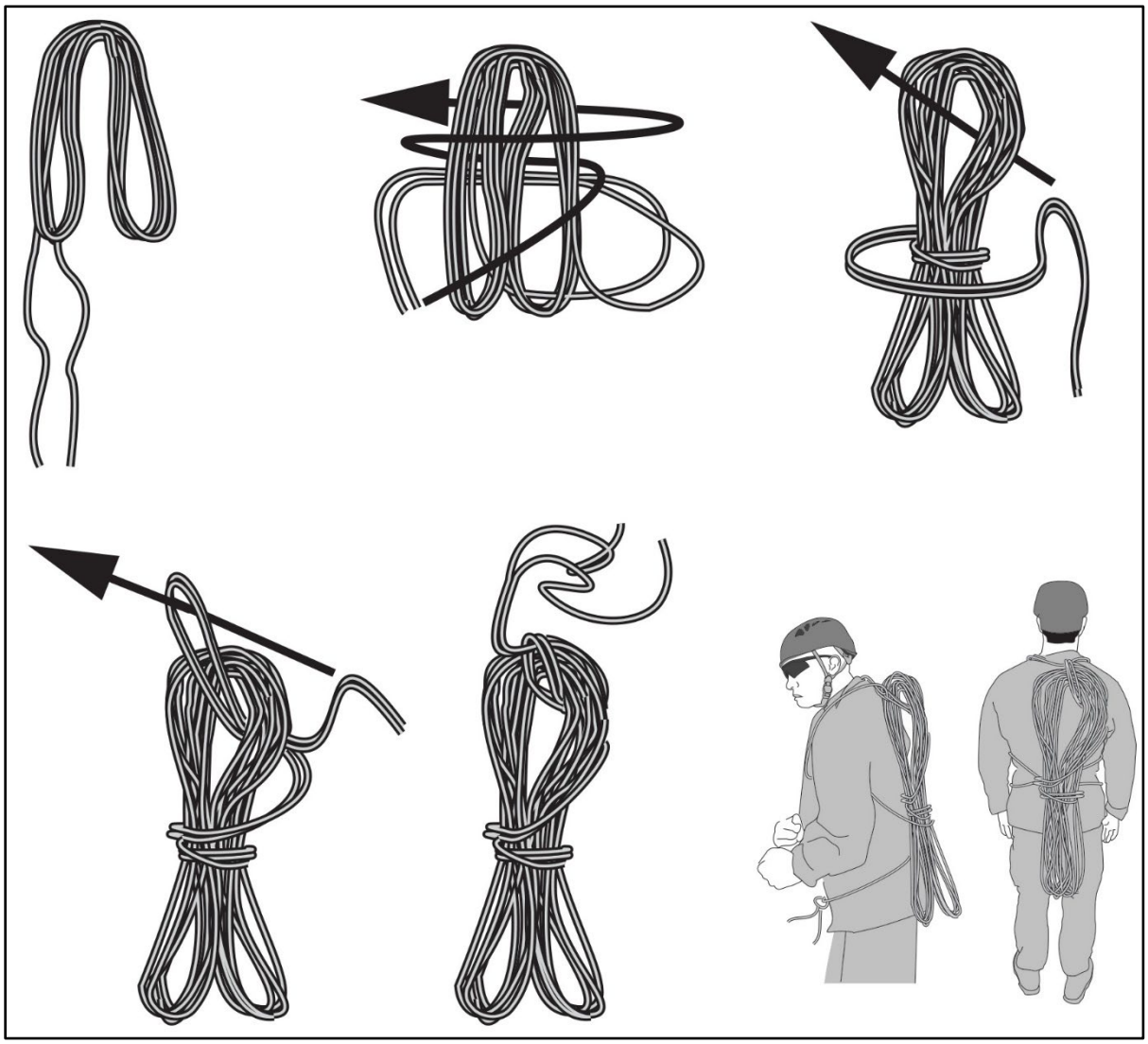


**Figure 8-37. Butterfly coil with farmer's tie off**

## MOUNTAIN COIL

8-139. To start a mountain coil, grasp the rope about 1 meter from the end with one hand. Run the other hand along the rope until both arms are outstretched. Grasping the rope firmly, bring the hands together, forming a loop, which is laid in the hand closest to the end of the rope. This is repeated, forming uniform loops that run in a clockwise direction, until the rope is completely coiled. The rope may be given a one-quarter twist as each loop is formed to overcome any tendency for the rope to twist or form figure eights.

8-140. To finish the mountain coil, form a bight about 30-cm long with the starting end of the rope and lay it along the top of the coil. Uncoil the last loop and, using this length of the rope, begin making wraps around the coil and the bight, wrapping toward the closed end of the bight. Make six to eight wraps to adequately secure the coil, and then route the end of the rope through the closed end of the bight. Pull the running end of the bight tight, securing the coil.

8-141. The mountain coil may be carried in either the pack (by forming a figure eight), doubling it and placing it under the flap, or by placing it over the shoulder and under the opposite arm, slung across the chest. (Figure 8-38 shows how to coil a mountain coil.)

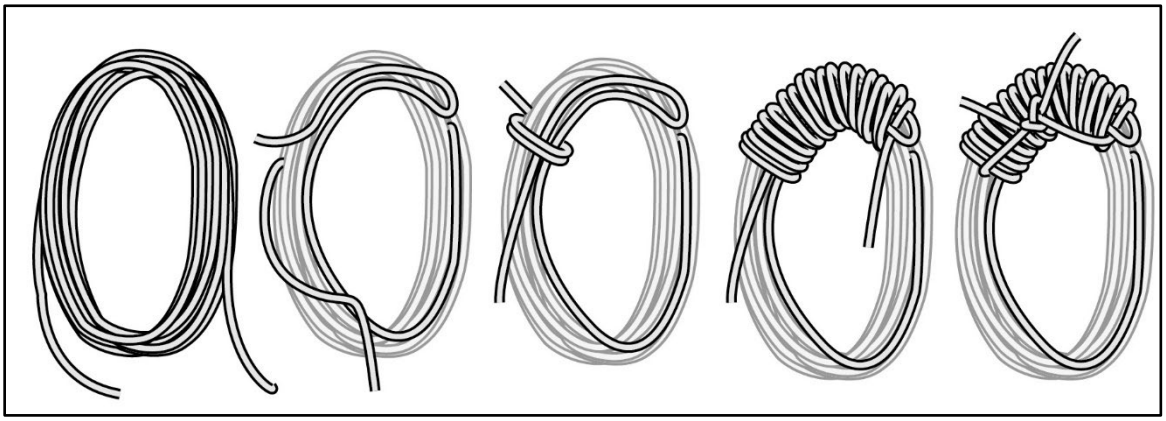


**Figure 8-38. Mountain coil**

### COILING CORDS AND SLINGS

8-142. Length of cord, webbing, or rope less than 8 meters may be coiled so that they can be hung from the harness. Hold the ends of the cord or the joining knot in the left hand. Coil the doubled rope into 6- to 8-inch loops until an approximate 12-inch bight is left. Wrap that bight around the coil, ensuring that the first wrap locks on itself. Wrap until there is just enough bight left to feed through the bights formed at the top of the coil. Dress it down tightly. Now the piece of rope or webbing may be hung from a carabiner on the harness or attached to a gear sling and slung over the shoulder. The same can be done with slings.

### UNCOILING, BACK STACKING, AND STACKING

8-143. When the rope is needed for use, it must be uncoiled and back stacked on the ground properly to avoid kinks and snarls. Choose a location that is clear of sharp rocks, sticks, or other items that could damage the rope or cause snarls when deploying the rope. Also, avoid wet or muddy areas. When these locations are unavoidable, using a tarp, poncho, or rope bag to place under the rope when stacking can provide protection.

8-144. Untie the tie off and lay the coil on the ground. Single back stack the rope to minimize kinks and snarls. (This is also useful when moving the rope a short distance and coiling is not desired.) Take one end of the rope in the left hand and run the right hand along the rope until both arms are outstretched. Next, lay the end of the rope in the left hand on the ground, ensuring that the standing end of the rope is laid off to the side and is not buried under the stack. With the left hand, regrasp the rope next to the right hand and continue laying the rope on the ground.

8-145. The rope should be laid or stacked in a neat pile on the ground to prevent it from becoming tangled and knotted when throwing the rope, feeding it to a lead climber, and so on. This technique can also be started using the right hand.

## THROWING THE ROPE

8-146. Before throwing the rope, it should be back stacked to prevent it from tangling during deployment. The bottom end of the rope should be anchored to prevent complete loss of the rope over the edge when it is thrown. Several techniques can be used when deploying a rope.

8-147. If the cliff is steep enough, it may be unnecessary to throw the rope. Back stack the rope down the cliff face. The rope is less likely to be carried by the wind or to be caught in trees. It is more likely to be hung up on ledges and shrubs on the face than when thrown. The rope should be thrown at a low angle and blocky terrain.

8-148. To throw the rope, take the strand on the top of the stack and begin to create butterfly coils in the dominant hand. Create enough coils so that there is sufficient weight to carry the rest of the rope down when it is thrown. It is time consuming and almost never necessary to coil the entire length of rope to throw it. The rope is best thrown underhand and slightly up and out from the edge. Throwing the rope too high could cause it to be hung up in tree branches. At a training site where there may be people below, the thrower should confirm that no one is below and sound off with the following warning as they throw: ROPE.

8-149. When windy weather conditions prevail, adjustments must be made. In a strong crosswind, the rope should be thrown angled into the wind so that it lands on the desired target. The stronger the wind, the harder the rope must be thrown to compensate. If the wind is too strong, sometimes it is best to single back stack the rope in a pack. The first Soldier who descends the rope should guide it down the fall line. During the descent, the rope is stacked in such a way that it exits cleanly from the pack to avoid becoming tangled. Another technique is to coil the rope freely on the shoulders of the first Soldier, allowing it to easily uncoil as the Soldier descends.

8-150. This Soldier needs to incorporate a hands-free backup during the rappel to allow stopping and using both hands to manage the rope, if necessary.

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## Chapter 9

# Anchor Selection and Construction

Understanding anchors is an important fundamental that must be understood early in the path to becoming a military mountaineer. An anchor is the point where manufactured equipment for mountaineering meets the surface of the earth. Great varieties of natural features are found in different operational environments that a Soldier could use to construct an anchor. Anchors are found in all rope systems and are built in many ways. This chapter gives Soldiers the tools to assess terrain for the suitability of anchor construction for a wide variety of rope systems. This chapter also exposes Soldiers to the principles of anchor construction that ensure they are building solid anchors in a wide variety of terrain for many different purposes. Anchor selection in mountainous terrain requires a certain degree of knowledge and substantial experience. Most mountaineering accidents occur at the anchor. Inexperienced Soldiers should stick to selecting anchor features that are obviously stronger than necessary and choose simple rigging techniques with which they are familiar.

## SECTION I – GENERAL PRINCIPLES: SINGLE AND MULTIPOINT

9-1. An anchor for military mountaineering is a fixed object to which a rope system is secured and is of sufficient size, weight, and security to suspend the weight of or arrest the fall of an attached load. It is a point in the operational environment, which a rope installation is attached, providing more than enough resistance to a directional pull. Rope systems can be used for moving casualties and equipment. Some, like rappels or fixed ropes, are used for aiding movement. Technical rope systems provide the tools for addressing many of the challenges posed by mountainous terrain. Anchor selection and evaluation together form the foundation of all systems.

9-2. Considerations for selecting a natural feature to construct an anchor are its location and ability to resist any forces that are placed upon it. The anchor should be above any intended rope pathways. This reduces the pendulum effect on any loads attached to the anchor. Another important facet of anchor location is its proximity to the edge. In some situations, having the anchor a short distance away from the edge creates a platform to work on. In other situations, such as setting a top rope, it is best to have the anchor near the edge. This aspect of anchor building can be challenging as the strength of natural features, such as rocks, trees, roots, and boulders; can be difficult to judge. Soldiers must err on the side of caution and leave no doubt that an anchor is strong enough for its intended purpose. If there is any doubt about a single-point anchor's strength or security, then additional anchor components should be constructed and incorporated until sufficient strength and security are achieved to ensure that anchor failure cannot occur. The strength of an anchor should never be in question.

9-3. Anchors in mountaineering should be loaded in a steady and slow manner. Avoid bouncing as much as possible as it could weaken the integrity of the natural object being used. Sometimes slack can generate in various types of rope systems and cause an anchor to be shock loaded. It is best to avoid any circumstances that may lead to this as shock loading results in very high forces on the anchor.

## SINGLE-POINT ANCHORS

9-4. Single-point anchors are the simplest in mountaineering and serve as the building blocks for more complicated anchors. If a single feature, object, or piece of equipment is to be used as an anchor, there must be no doubt that it is both strong enough and secure enough to hold if shock loading were to occur. The same goes for all rigging used in building the anchor. Correctly tied master points, locking carabiners, and double nonlocking carabiners opposite and opposed must be used for all points of connection. (See figure 9-1, page 196.)

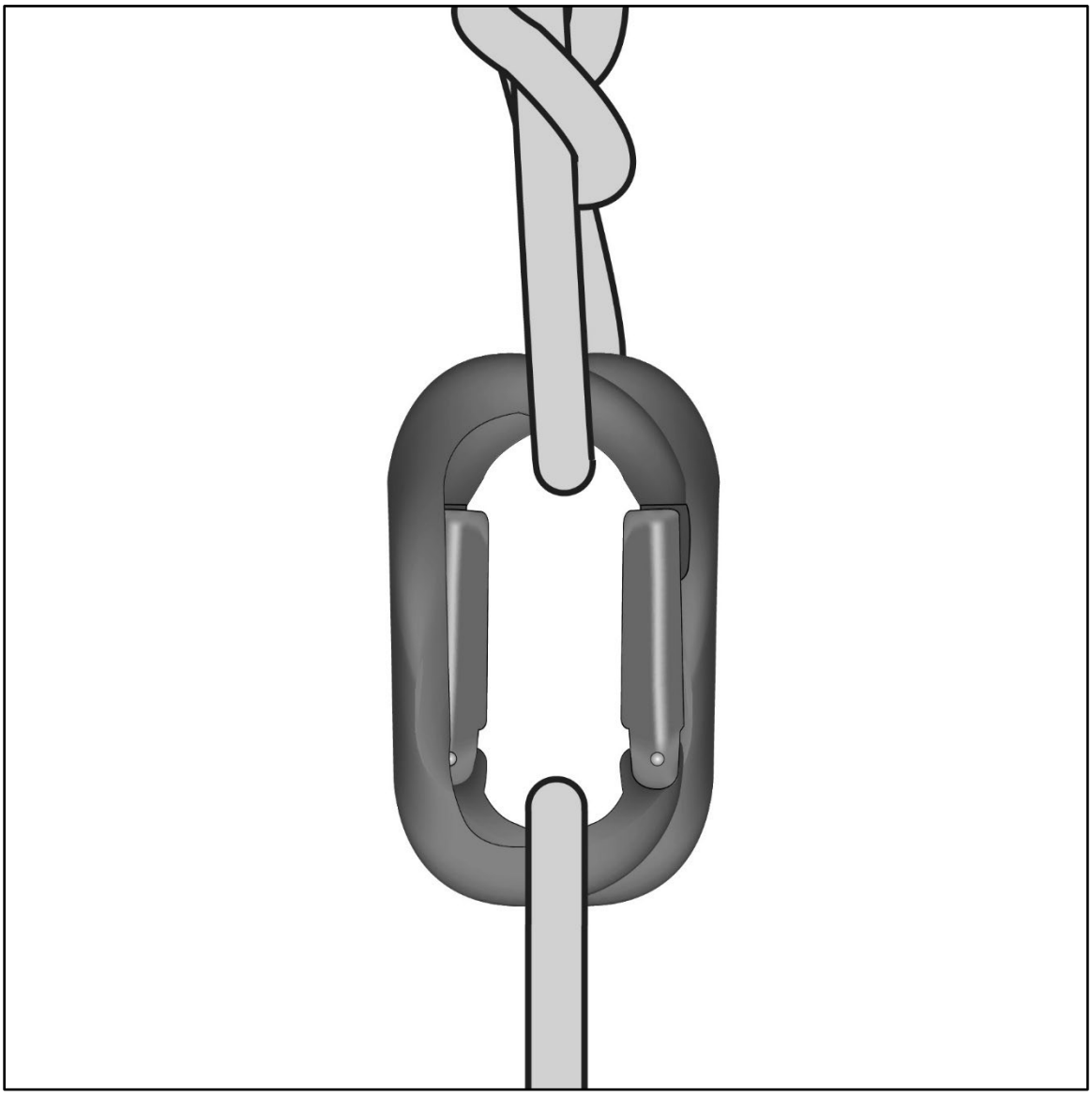


**Figure 9-1. Opposite and opposed carabiners**

9-5. If using opposite and opposed carabiners in place of a locking carabiner, ensure they are properly configured. (See figure 9-1.)

9-6. Single-point anchors are created by simply tying cordage or webbing around something of sufficient strength to form an adequate anchor.

9-7. There are three basic methods of attaching webbing slings to single-point anchors: single loop (drape) with the webbing joined around the anchor, basket hitch (wrap), and the girth hitch. (See figure 9-2.)

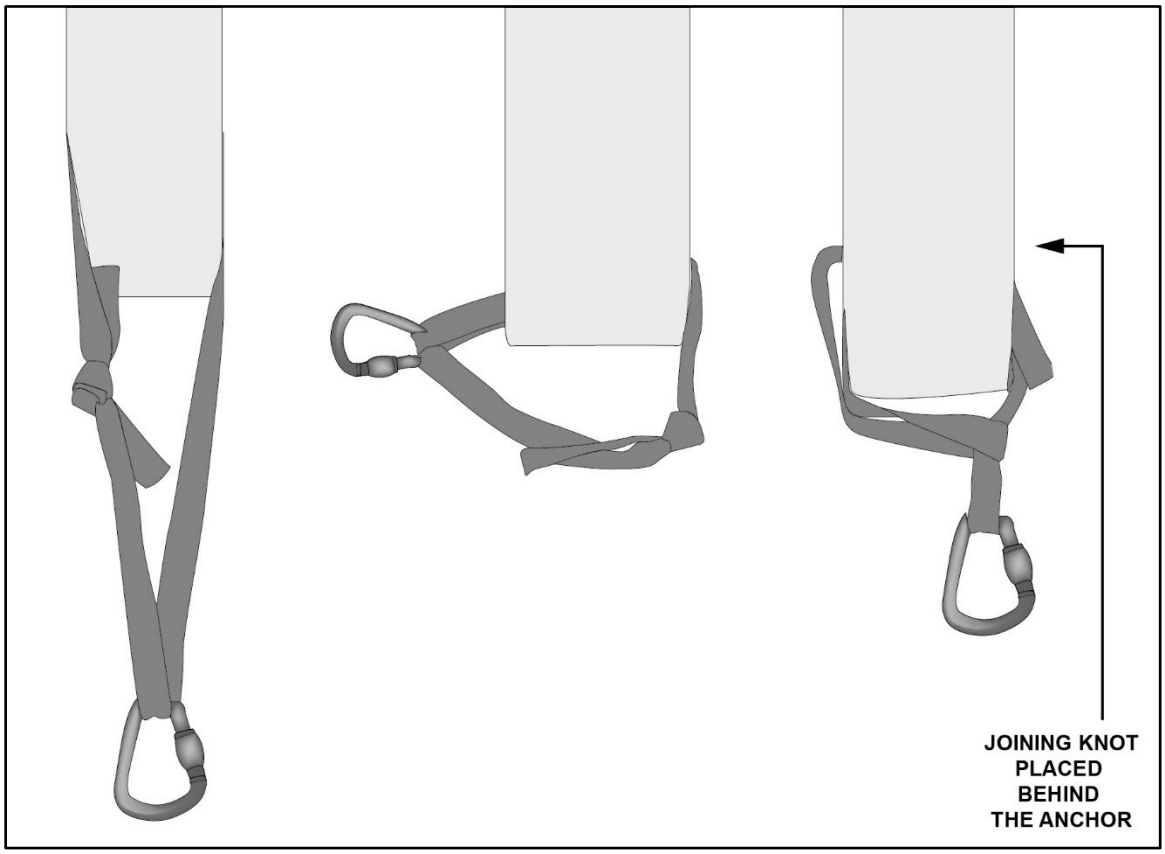



**Figure 9-2. Single-point webbing anchors: single loop, double bight, and girth hitch**

9-8. There are two basic methods to create single-point anchors using joined cordelette. They are the basket hitch and master point. (See figure 9-3, page 198, and figure 9-4, page 199.)

9-9. A cordelette can also be doubled before tying a basket hitch. This keeps the attachment point closer to the anchor. Round turns can also be added around the anchor to hold the anchor in place. Certain specific situations require this (for example, a high redirect). (See figure 9-3, page 198.)

9-10. A knot can be incorporated in the basket hitch to create a master point. A master point is the loop created from the knot that is incorporated into the anchor. It serves as an attachment point for carabiners for building rope systems or belays. This can be created by creating a fixed loop with a figure-eight or overhand knot.

9-11. The master-point technique should be used if there is any chance the material could be cut on sharp rock edges when the cord is wrapped around a rock. The knot isolates the individual strands creating redundancy so if an individual strand were to break, the entire anchor would not fail.

9-12. A master point is also useful for creating a clean and easily identifiable working point for use with multiple carabiners.

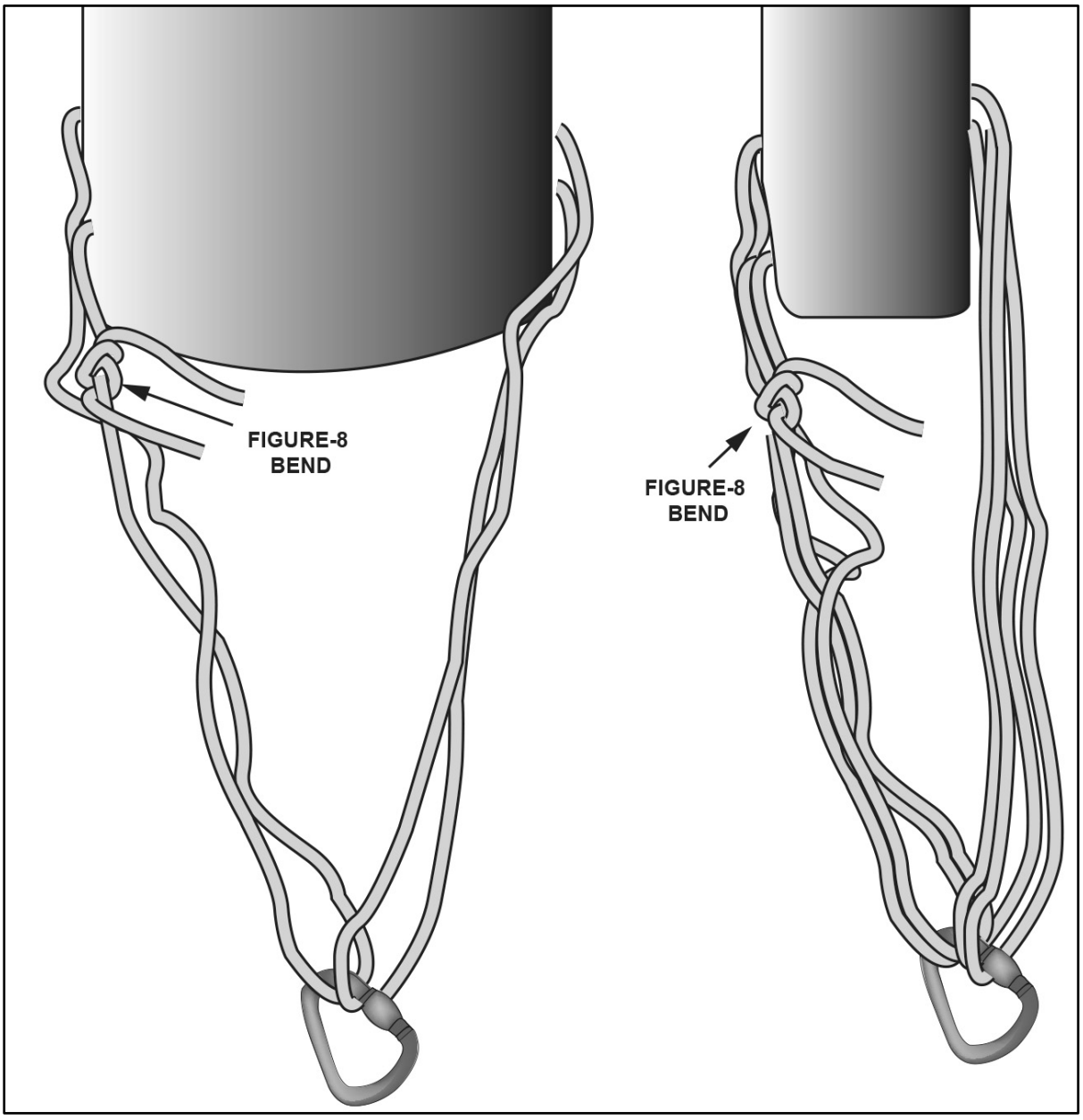



**Figure 9-3. Single and double basket hitch**

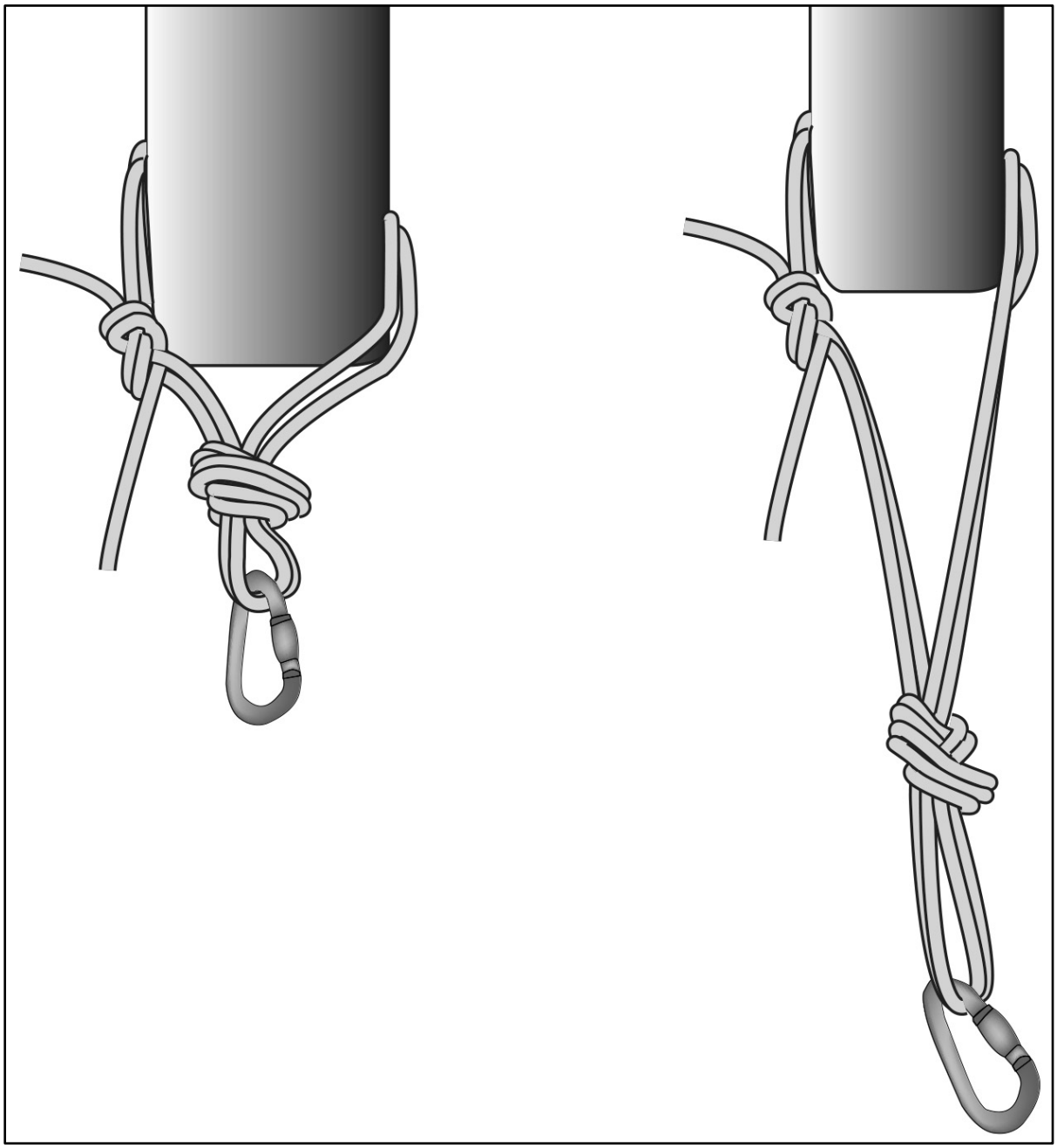


**Figure 9-4. Single and double basket hitch with master point**

# MULTIPOINT ANCHORS

9-13. Multipoint anchors are more than one fixed object joined with technical rigging to form an anchor system capable of suspending the weight or arresting the fall of an attached load. They become necessary as suitable single-point anchors become scarce. This not only provides greater anchor strength but also adds redundancy or backup because of the multiple components. Multipoint anchors are used frequently in mountaineering. It requires a strong understanding of anchoring principles, creativity, and experience applying them in the field to ensure adequacy.

## ANGLE CONSIDERATIONS

9-14. When using only two anchor points, it is extremely important to recognize the angle that is created. Imagine holding two ends of a rope with a 5-gallon water can in the middle. It would be very difficult to hold the can up with the rope straight at 180°. It would be much easier to support the weight of the water can if the two rope ends were almost touching in the middle. As the angle between anchor components increases, so does the force that is felt by each anchor. (See figure 9-5.)

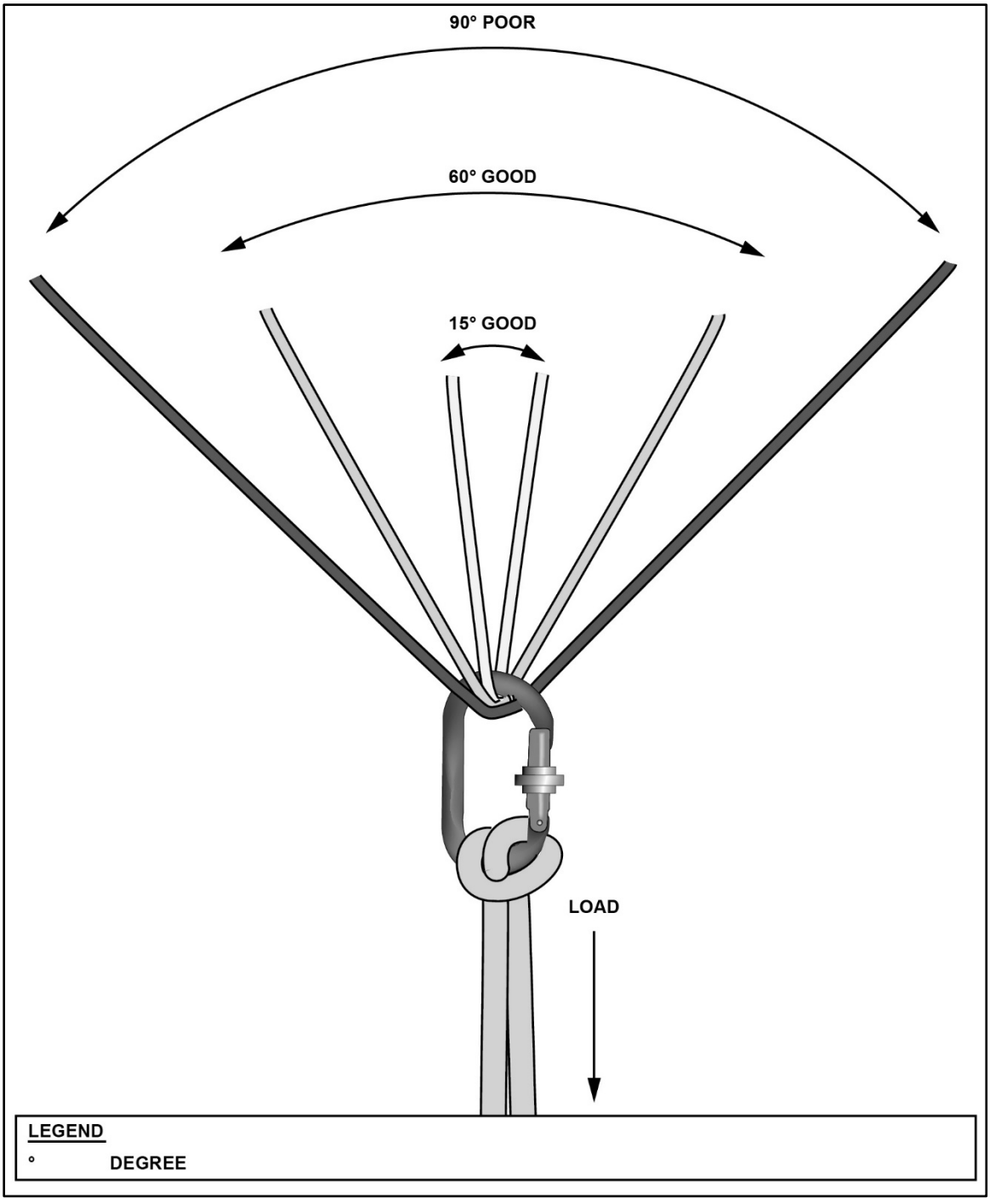



**Figure 9-5. Ideal angle required between anchor points to reduce force**

## SELF-EQUALIZING ANCHORS

9-15. A self-equalizing anchor is a multipoint anchor comprised of adjustable strands from each anchor component to a shared attachment point that allows for maximum load sharing even when direction of pull changes during use. (See figure 9-6, page 202.) Self-equalizing anchors are rarely necessary in mountaineering as the direction of pull rarely changes, and there is the possibility of extension and shock loading if a component fails.

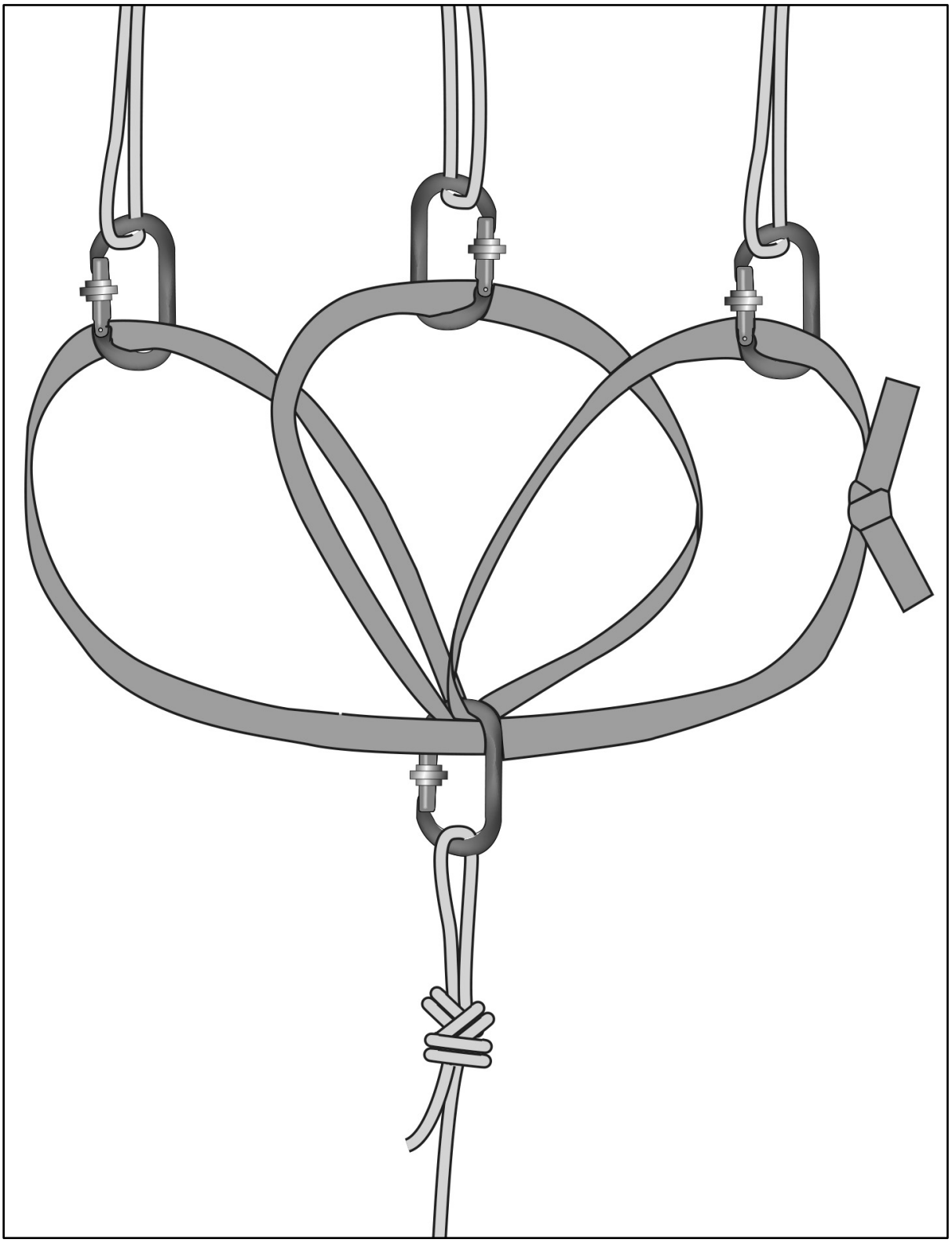


**Figure 9-6. Self-equalizing anchor**

## PRE-EQUALIZED ANCHORS

9-16. A pre-equalized anchor is the preferred type of multipoint anchor used in mountaineering. The anchor distributes the weight of the load among each individual anchor component using fixed and independent strands. (See figure 9-7.) Multipoint anchors orient all strands together pointing in the direction that the anchor will be loaded. A pre-equalized anchor prevents extending and shock loading the anchor if an individual component fails. An anchor is pre-equalized by tying a master point using an appropriate loop knot in the webbing or sling.

9-17. The mnemonic EARNEST-H can be used as a guide to build optimal and efficient multipoint anchors. Multipoint anchors should be—

- E—equalized: Each component of the anchor shares the load evenly. Nonlocking carabiners are typically acceptable links between soft materials here.
- A—angle: The angles between the strands of individual components should not exceed 90°, if possible. The goal is to minimize multiplying forces as shown in figure 9-7.
- R—redundant: The entire anchor system is not reliant on a single anchor component. Rigging of the cord is such that if a single strand breaks or is cut, the entire anchor would not fail. Redundancy is achieved by tying a master point.
- NE—no extension: If one leg of the anchor does fail, the anchor does not extend, causing shock load to the rest.
- S—solid: This is the big picture look at the anchor system. Ensure that there are no problems with how the individual segments work together, that the larger feature comprising the anchor is strong and secure, and that the whole thing is appropriate for the intended anchoring application. Anchor components should not all be placed in the same feature.
- T—timely: This is meant to remind mountaineers to remember efficiency when building anchors. The fastest and simplest anchor system to build that meets the above criteria is the best.
- H—high: This is not required, but if it can be achieved while meeting all the above criteria, then it is strongly recommended. Anchors with master points between waist and shoulder height make operating any attached system significantly easier and more efficient.

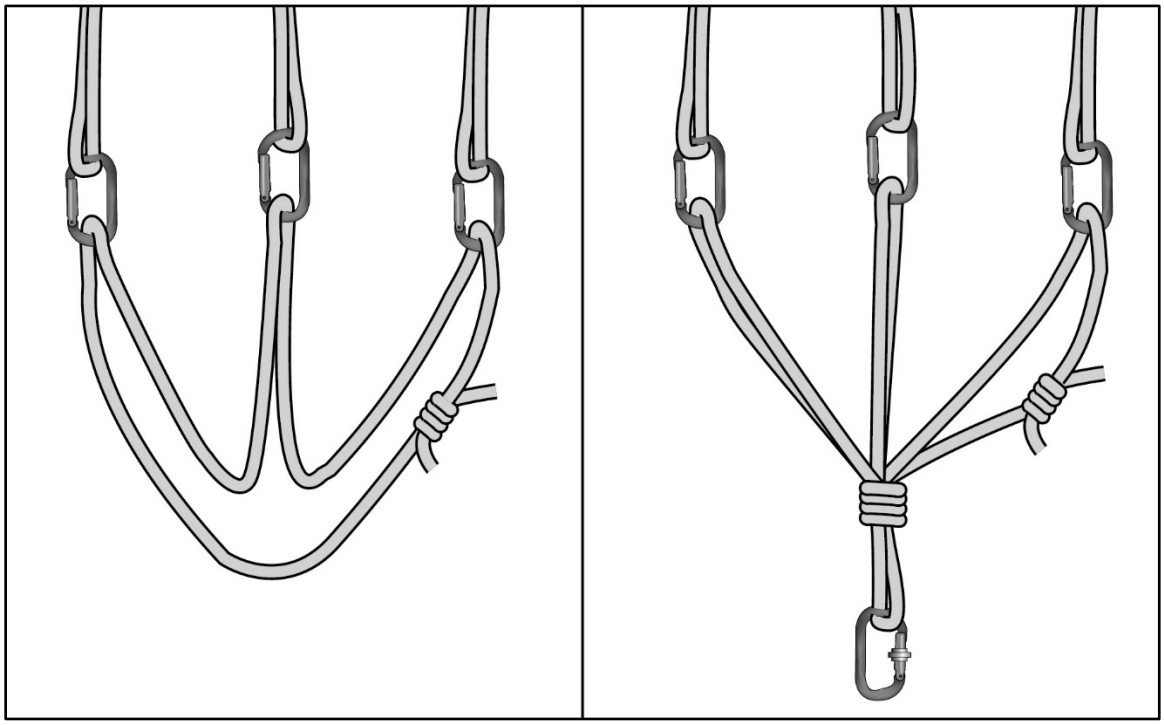


**Figure 9-7. Pre-equalized anchor**

## SECTION II – TREES

9-18. Tree anchors should be considered for use first. They are usually strong and often simple to construct with minimal use of equipment. Trees are already in place and simply require a method of attaching the rope. However, they should be carefully studied and evaluated for stability and strength before use. Sometimes the rope is tied directly to the anchor, but under most circumstances, a cord or sling is attached to the tree and then the climbing rope is attached to the sling with a carabiner.

# CONSIDERATIONS

9-19. The following are considerations for using trees as anchors for mountaineering rope systems:

- In rocky terrain, trees usually have a shallow root system. This can be evaluated by pushing on the tree to see how well it is rooted. If there is concern that a tree may be pulled over when loaded, another anchor should be selected. If this anchor is the only option, the rope should be anchored as low as possible to reduce leverage.
- When evaluating a tree for suitable strength, strive for a diameter at the base of the tree of at least 8 inches.
- In the summer months, it may be easy to determine if a tree is alive. The best indicator can be leaves. However, even trees that have fallen over may still grow leaves if they are still partially rooted. Ensure that a concentrated effort is made to evaluate the tree.
- In the winter, certain trees do not have leaves. This may make it difficult to establish if they are alive. Look at the tree trunk for signs of extensive rot, woodpecker holes, or fungus growing on the tree trunk. Trees that have no leaves in the winter can still be checked to see if they are alive. The tree will have buds at the ends of small twig branches that will turn into next year's leaves. Major deformities, cracks, or damage are also an indicator that the tree may not be a viable anchor.
- Use padding on soft, sap-producing trees to keep sap off ropes and slings.

# ROPE ANCHORS

9-20. The climbing or installation rope can be tied directly to the tree anchor using several different techniques. (See figure 9-8.) This requires less equipment but also sacrifices some rope length to tie the anchor. The rope can be tied to the anchor using an appropriate anchor knot, such as a bowline or triple bowline. Round turns can be used to help keep the rope in position on the anchor and reduce the likelihood of it slipping on the trunk.

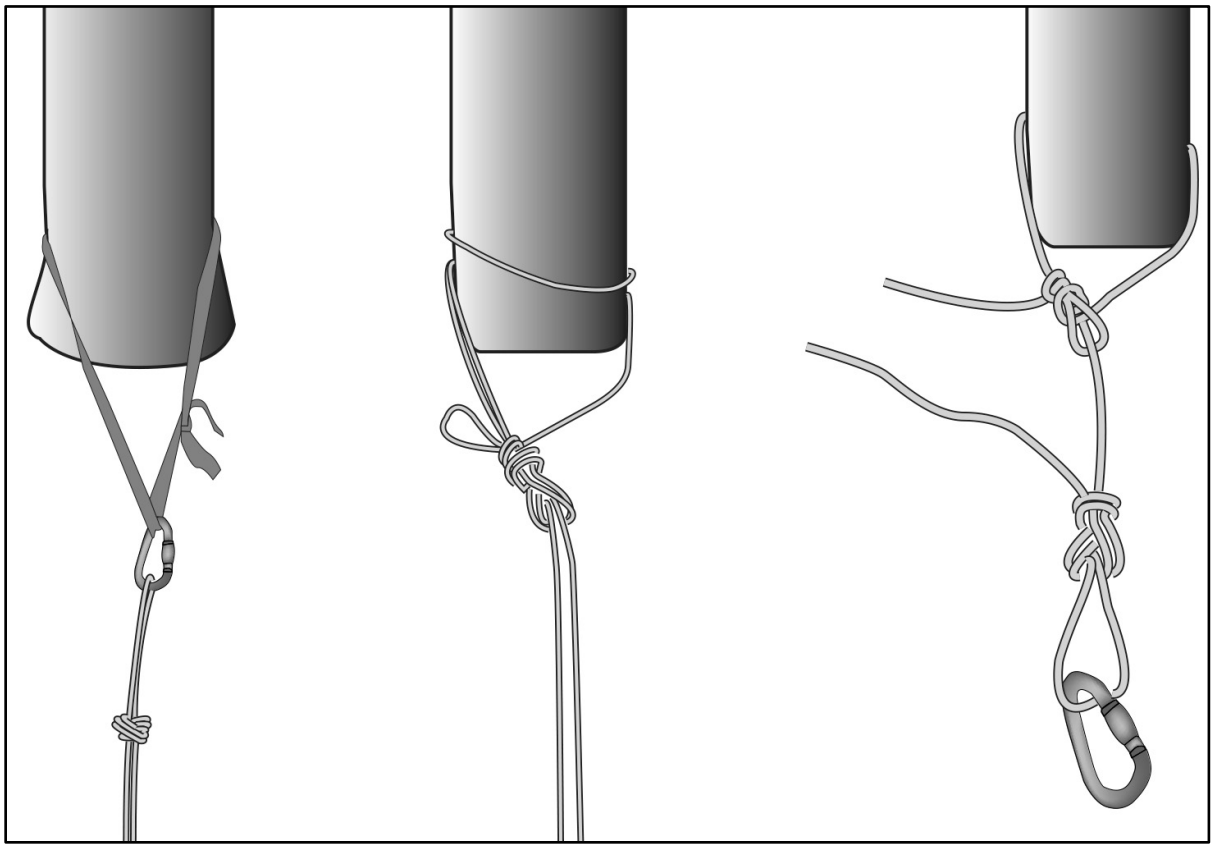


**Figure 9-8. Anchoring a rope to a single-point tree anchor**

# HIGH-STRENGTH TIE OFF (TENSIONLESS HITCH)

9-21. A high-strength tie off is a single-point anchoring method that retains maximum installation rope strength and releasability, using multiple-round turns around the anchor object to create friction, and securing the end back to itself ensuring no force is applied to any component knots or carabiners. It is used to anchor the rope on high-load installations used for bridging and traversing. (See figure 9-9, page 206.) The wraps of the rope around the anchor absorb the tension of the installation and keep the tension off the knot and carabiner. The anchor is usually tied with a minimum of three wraps, more, if necessary, to absorb the tension. A smooth anchor may require several wraps, whereas a rough barked tree might only require a few. The rope is wrapped from top to bottom without crossing strands so that it can be untied under tension, if desired. A fixed loop is placed into the end of the rope and attached loosely back onto the rope with a locking carabiner.

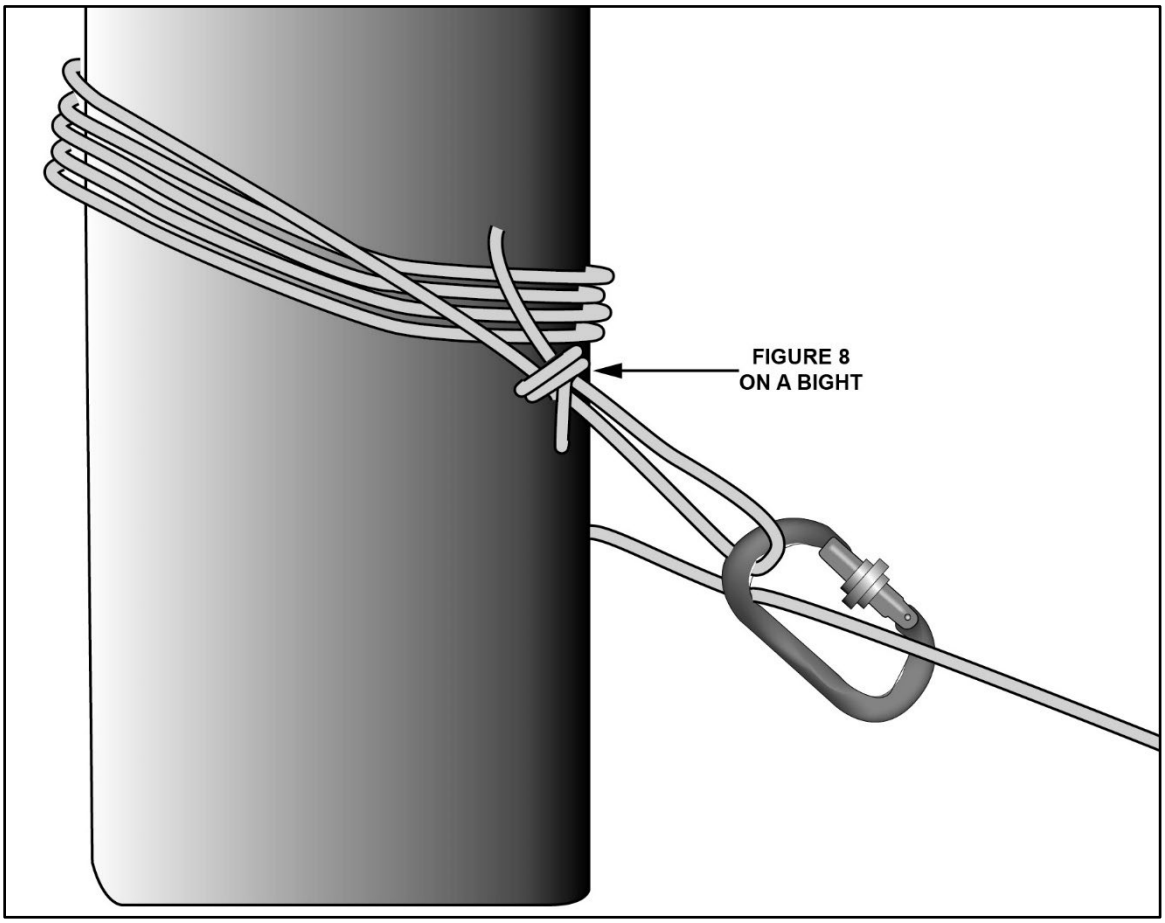



**Figure 9-9. High-strength anchor**

## MULTIPOINT TREE ANCHORS

9-22. When there are multiple tree anchors available that do not meet the criteria for a single-point anchor, then multiple trees should be used. Using multiple anchors incorporates redundancy in case one anchor fails. The same principles for multipoint anchors apply for trees and all other anchors. If using only two trees for anchors, then the angle created between the two trees should be less than 90° as described in paragraph 9-14, page 200.

## BUSHES AND SHRUBS

9-23. Bush and shrub anchors are not recommended for use unless there are no other options, and a technical task cannot be avoided. An advanced-level mountaineer should be present to evaluate the rigging and strength of the anchor. They are constructed by equalizing many small bushes and shrubs together into a master point using cordelettes, slings, and anchor ropes. As with trees, the anchoring rope is placed as low as possible to reduce leverage on the anchor. All vegetation should be healthy and well rooted to the ground. It cannot be overstated that the strength and security of bush and shrub anchors cannot be easily assessed for strength.

# SECTION III – ROCK ANCHORS

## BOULDERS AND ROCK PROTRUSIONS

9-24. Boulders and rock protrusions make ideal anchors. (See figure 9-10.) Rock features should not be used as anchors if they can be moved by pushing or kicking it or sound hollow or detached when tapped. The

surface a boulder rests upon should be inspected to ensure the boulder does not slide when force is applied to it. Rock protrusions should be a solid mass of rock. Crumbly or loose rock formations are not typically sufficient anchors. Talus and scree fields are an indicator that the rock in the area is not solid. All areas around the rock formation that could cut the rope or sling should be padded. It is also wise to consider the consequences if the rock were to dislodge.

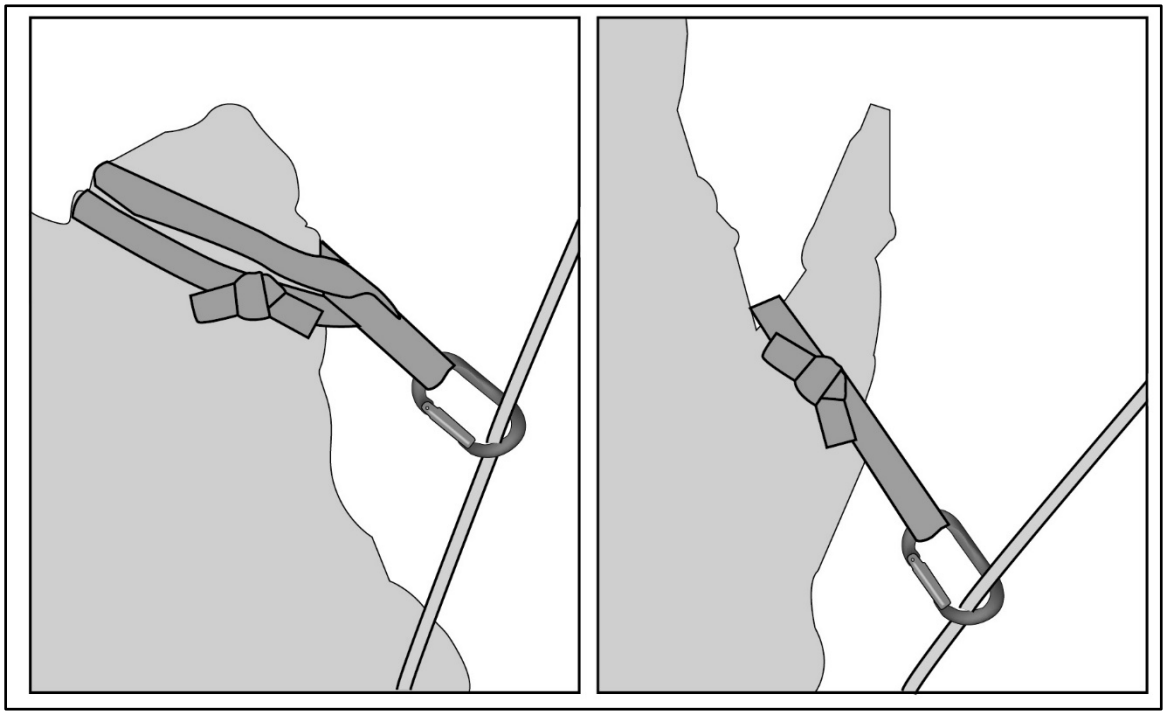


**Figure 9-10. Boulders and protrusions used as anchors**

# CHOCKSTONES

9-25. A chockstone is a rock that is wedged in a crack that narrows downward. (See figure 9-11, page 208.) Chockstones should be checked for strength, security, crumbling and should always be tested before use. All chockstones must be solid and strong enough to support the load. They must have maximum surface contact and taper with the surrounding rock to remain in position. Chockstones are often directional; they are secure when pulled in one direction but may pop out if pulled in another direction.

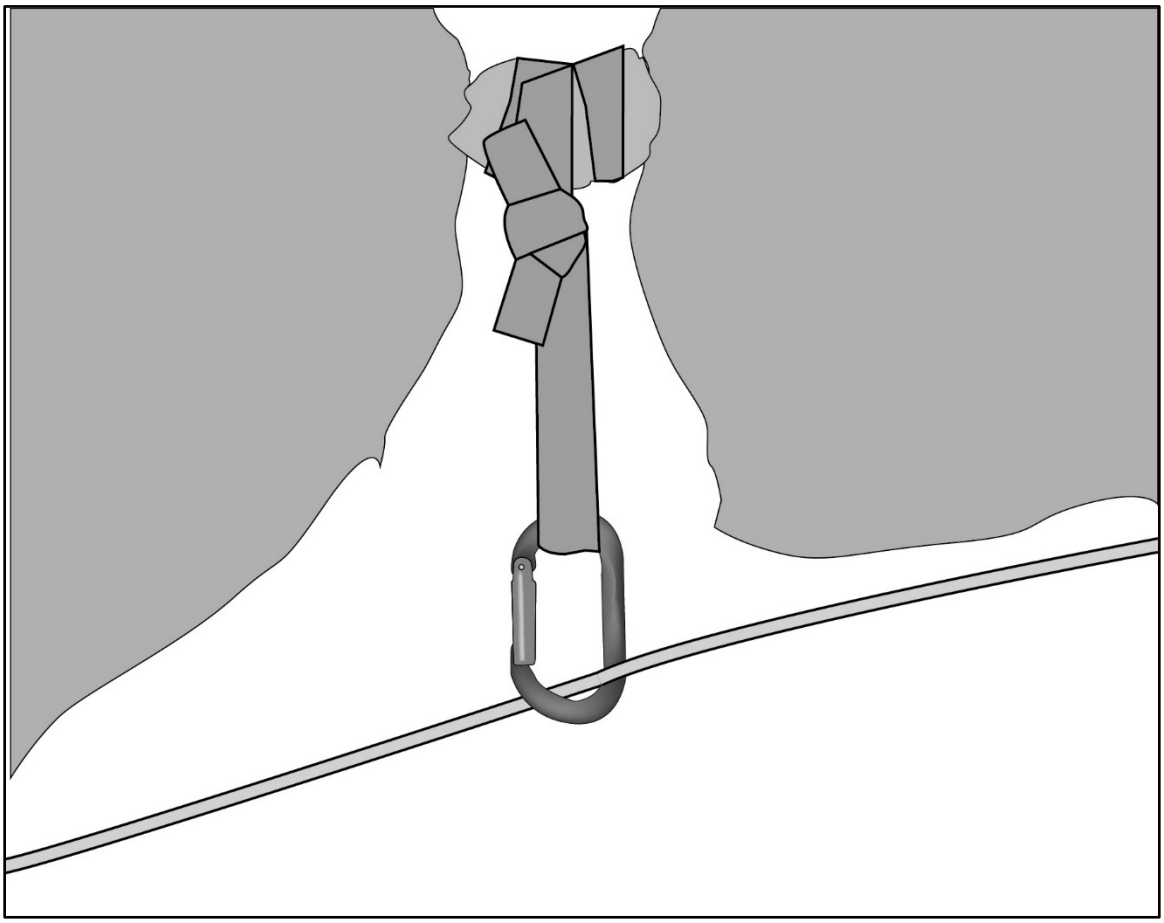


**Figure 9-11. Chockstone used in a construction**

# TUNNELS, ARCHES, AND PINCH POINTS

9-26. Tunnels and arches are holes formed in solid rock. If viable, they provide one of the more secure natural anchor points as they can be pulled in any direction (See figure 9-12.) A natural anchor is a natural fixed object (such as a tree, rock formation, or ice formation) to which a rope system can be secured and is of sufficient size, weight, and security to suspend the weight of or arrest the fall of an attached load. A sling is threaded through the opening hole and secured with a joining knot or girth hitch. The load-bearing hole must be strong and free of sharp edges (pad, if necessary). A pinch-point anchor is used the same way as arches or tunnels; it is just formed by a pinch point between two large boulders, allowing a sling or cordelette to be tied around it. Boulders comprising a pinch point need to be large enough and secure enough to ensure they do not move when a force is applied. Sometimes a little digging in snow or earth provides a pinch-point anchor where no other options are available.

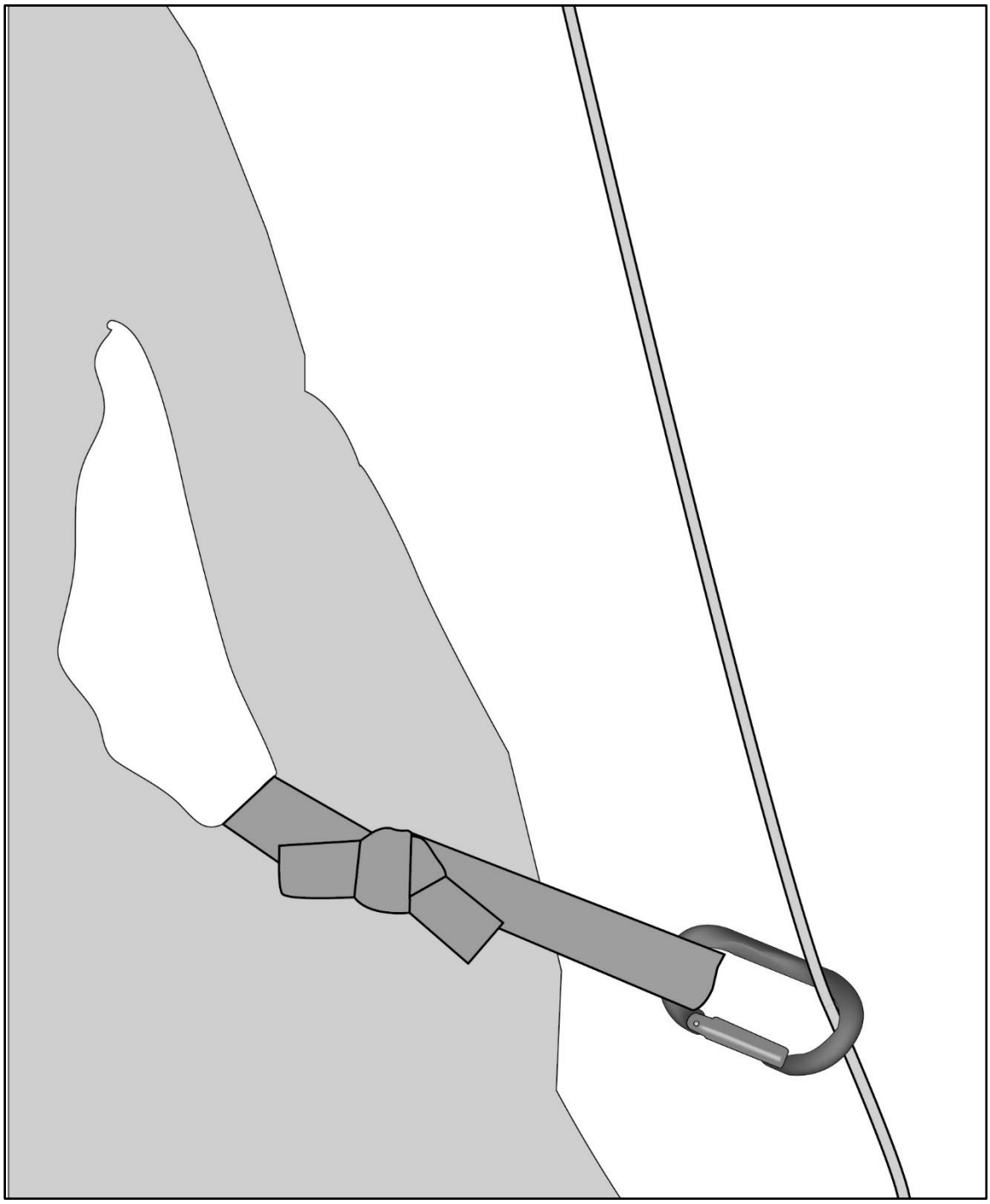


**Figure 9-12. Natural tunnel or hole in the rock**

# ARTIFICIAL ROCK PROTECTION

9-27. Artificial rock protection is anything used to protect a climber or anchor a rope system and is not part of the natural environment. The evolution of artificial protection started with handmade pieces of metal called pitons. Now there are several companies that manufacture various lightweight artificial protection. There is fixed and removable protection. Fixed protections are bolts and pitons; they are left in the rock for future use

and can be difficult to remove. Removable protection refers to spring-loaded camming devices (known as cams), chocks, and other specialty protection that is easily recoverable after use.

9-28. Artificial protection is used to construct anchors in various ways. Anchors may be comprised of a combination of artificial protection and other objects, such as a tree or a boulder. The combinations are endless. However, when building anchors made with only artificial protection, multiple pieces are required. No single piece of artificial protection is considered adequate to comprise an anchor. A minimum of two components are needed to provide redundancy in the case of bad placement, poor rock quality, or any other factor causing a piece to fail.

# PITONS

9-29. Pitons have been in use for over 100 years. Although still available, pitons are not used as often as other types of artificial anchors due primarily to their impact on the environment. Most climbers prefer to use other artificial anchors rather than pitons because they do not scar the rock and are easier to remove. Pitons still have a place in military mountaineering since they are a relatively light, cheap, and expendable yet extremely strong and secure anchor option when placed properly. They are particularly useful during rocky alpine descents, when an ice axe with a hammer is already carried and natural rappel anchors are scarce.

9-30. One piton is not considered strong or secure enough to serve as a single belay or system anchor. When establishing an anchor using multiple pitons, they should be placed in different cracks or features. A single piton can also be combined with other viable natural anchoring methods, if available.

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***Note***. Properly placing pitons requires significant practice to master, which should be conducted in training scenarios involving backup systems to protect the trainee should a placement fail.

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## ADVANTAGES AND DISADVANTAGES

9-31. Some advantages with using pitons are—

- Depending on type and placement, pitons can support multiple directions of pull.
- They are less complex than other types of artificial anchors.
- Pitons work well in thin cracks where other types of artificial anchors do not.

9-32. Some disadvantages with using pitons are—

- During military operations, the distinct sound created when hammering pitons is a tactical disadvantage.
- Due to the expansion force of emplacing a piton, the rock could spread apart or break, causing an unsafe condition.
- Pitons are more difficult to remove than other types of artificial anchors.
- Pitons leave noticeable scars on the rock. They are prohibited in most established climbing areas.
- Pitons are easily dropped if not tied off when being used.

## PITON PLACEMENT

9-33. Properly positioning or placing pitons is critical. (See figure 9-13 for examples of piton placement.) Usually, a properly sized piton for a rock crack will fit one-half to two-thirds into the crack before being driven with the piton hammer. This helps ensure the depth of the crack is adequate for the size piton selected. As pitons are driven into the rock, the pitch or sound that is made will change with each hammer blow, becoming higher pitched as the piton is driven in.

9-34. Test the rock for soundness by tapping with the hammer. Driving pitons in soft or rotten rock is not recommended. When this type of rock must be used, clear the loose rock, dirt, and debris from the crack before driving the piton completely in.

9-35. While it is being driven, attach the piton to a sling with a carabiner (an old carabiner should be used, if available) so that if the piton is knocked out of the crack, it is not lost. The greater the resistance overcome while driving the piton, the stronger and more secure the anchor is. The quality of the rock around the crack a piton is placed into also greatly affects the strength and security of the anchor. The piton should not spread the rock, thereby loosening the placement.

9-36. Sometimes a piton cannot be driven completely into a crack because the piton is too long. Although this is not optimal, occasionally there are no other options. Instead of attaching to the piton hole, webbing should be attached to the shaft with a girth hitch as close to the rock face as possible to reduce leverage on the piton. (See figure 9-14, page 212.)

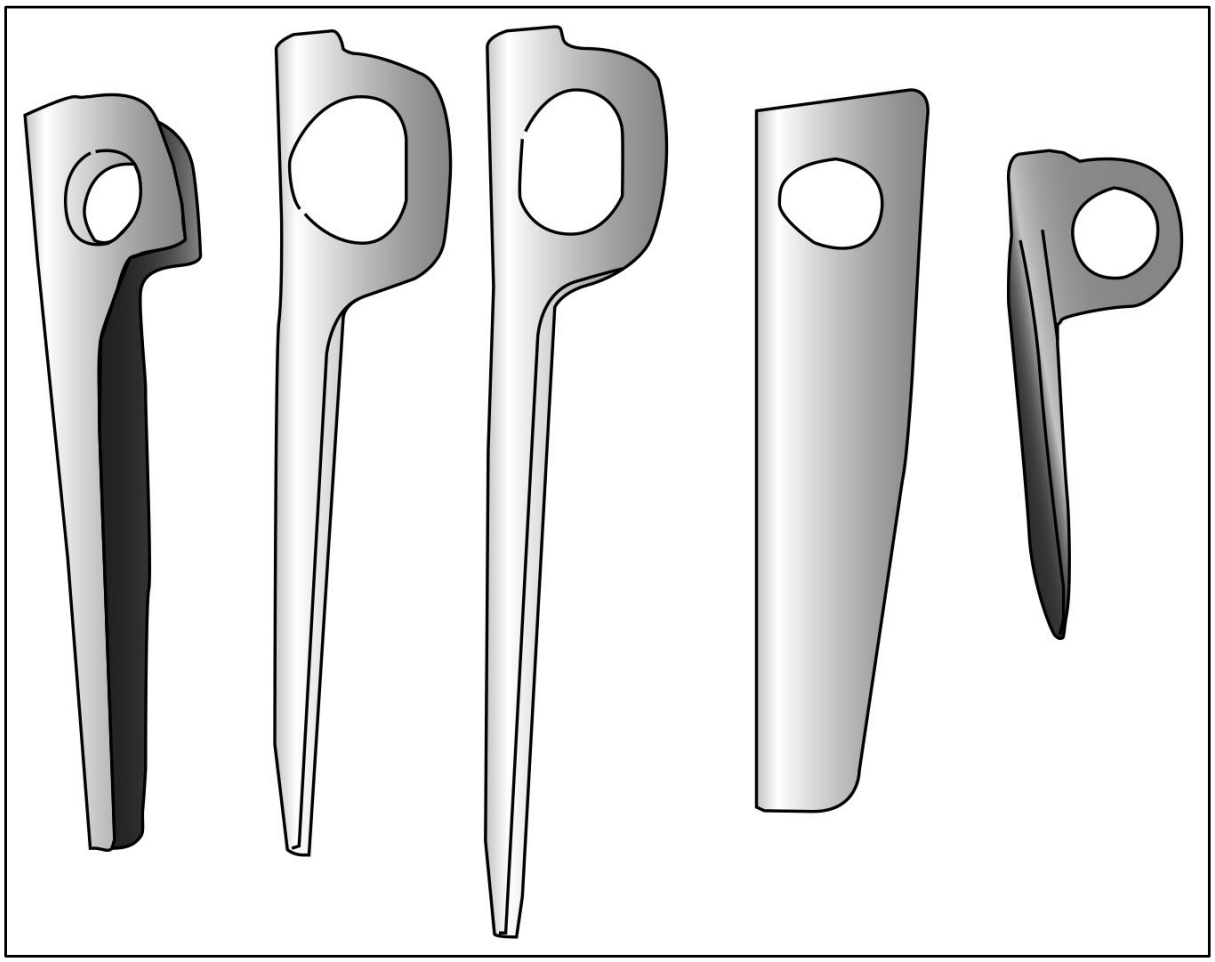


**Figure 9-13. Examples of piton**

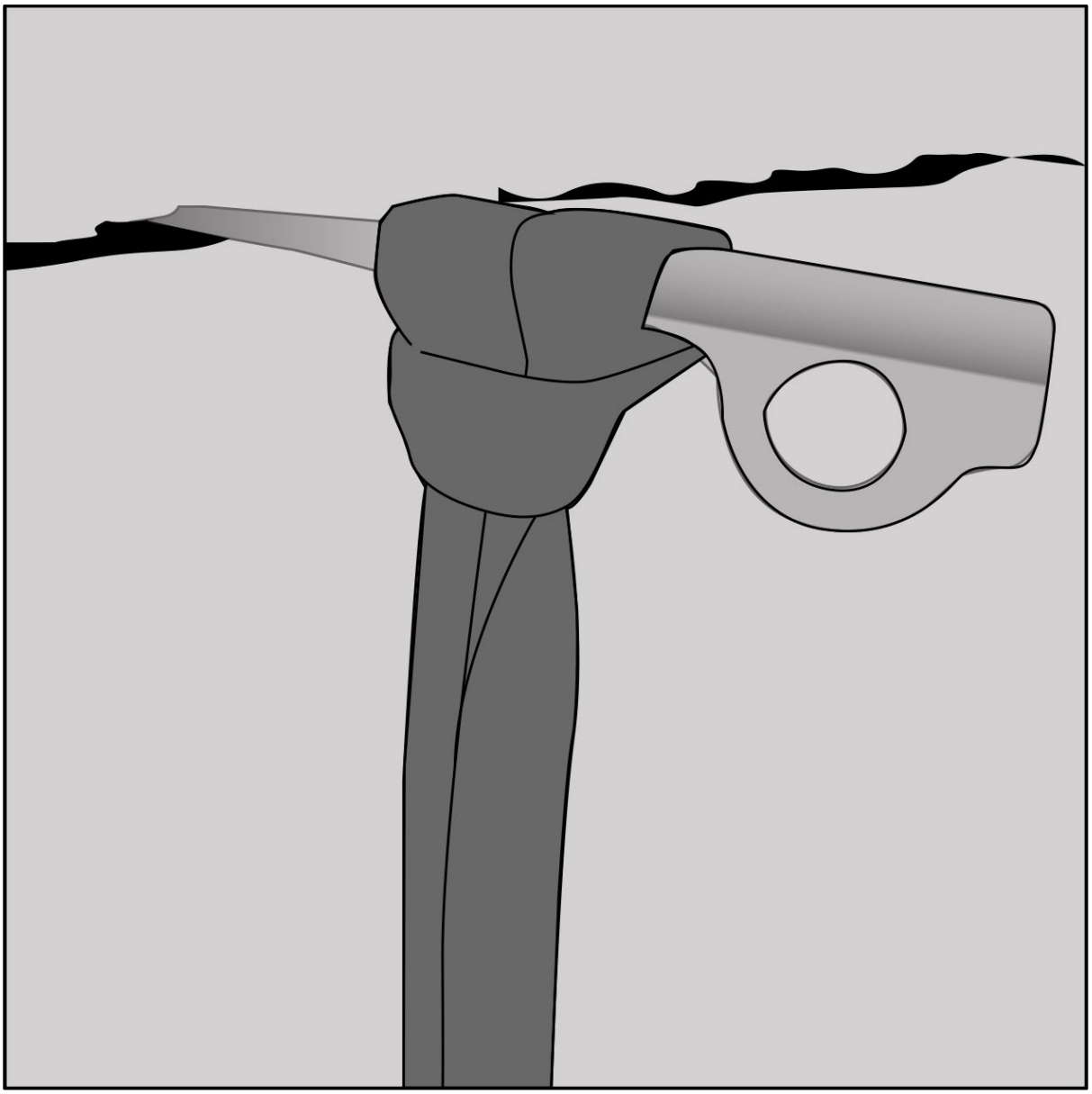


**Figure 9-14. Hero-loop**

## REMOVING PITONS

9-37. Attach a carabiner and sling to the piton before removal to reduce the likelihood of dropping and losing it. Tap the piton firmly along the axis of the crack in which it is located. Alternate tapping from both sides while applying steady pressure. Pulling out on the attached carabiner eventually removes the piton. (See figure 9-15.)

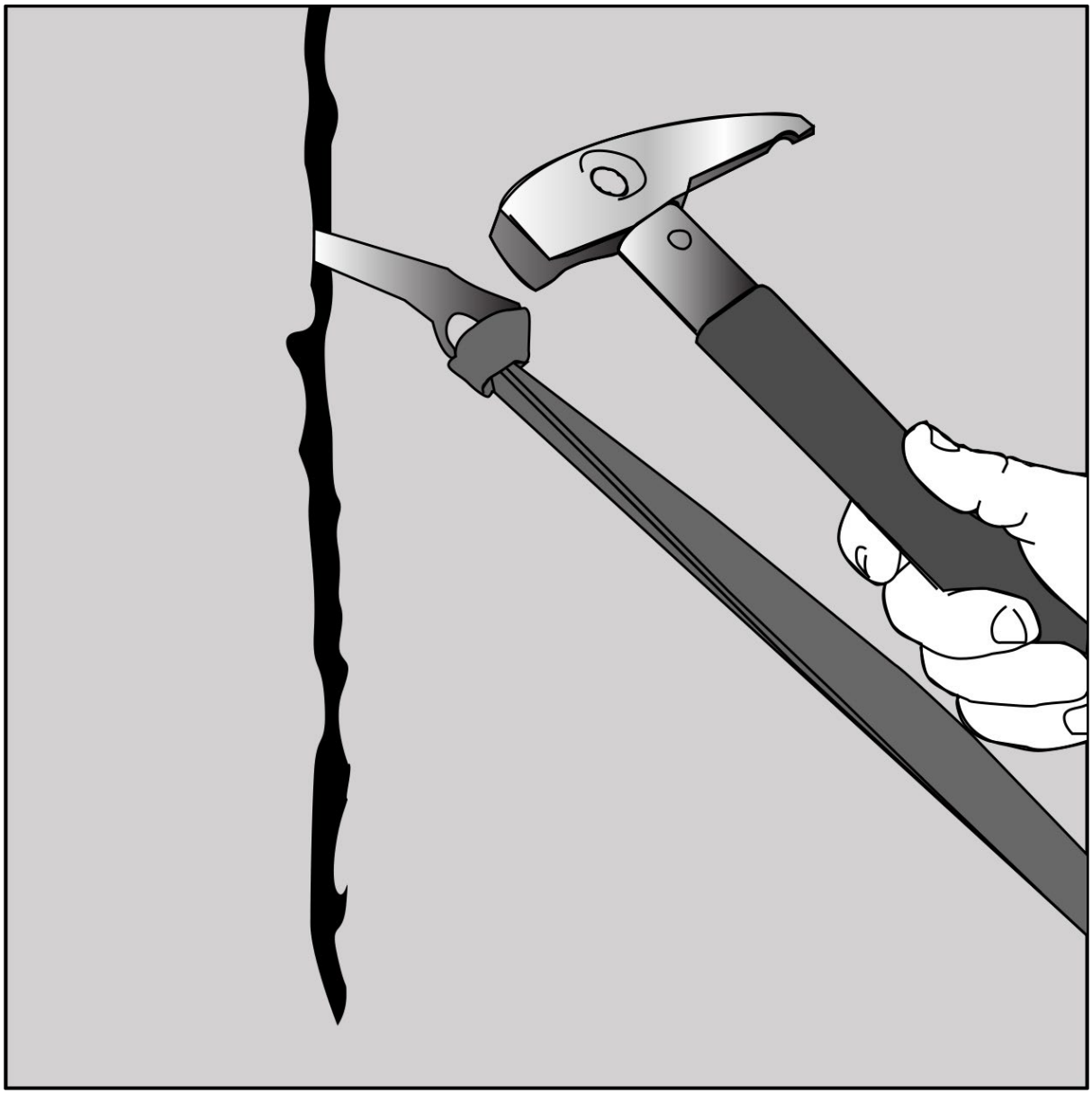


**Figure 9-15. Piton removal**

## REUSING PITONS

9-38. Soft iron pitons that have been used, removed, and straightened may be reused, but they must be checked for strength. In training areas, pitons already in place should not be trusted since the weather loosens them in time. Also, they may have been driven poorly the first time. Before use, test them as described above and drive them again until certain of their soundness.

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***Note***. Fixed artificial anchors, such as pitons and bolts, are not widely accepted for use in all areas because of the scars they leave on the rock and the environment. They are often left in place and are unnatural fixtures in the natural environment. For training, consider local laws and courtesies for each area of operation.

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# BOLTS

9-39. **A *bolt* is a type of rock protection or anchoring component comprised of an expansion bolt or glue-in shaft attached to a hanger to which a carabiner can be attached**. Bolts are often used in fixed-rope installations and in aid climbing where cracks are not available. Bolts provide one of the most secure means of establishing protection.

9-40. Some bolts have rings attached for easy retrievable rappelling, clip-in points for top rope climbing, chains to aid in establishing tope rope climbing anchors, or other special-purpose attachment points.

9-41. There are two primary types of bolts: expansion bolts and glue-in bolts. Both involve drilling a hole into a rock face, cleaning out dust and debris, and inserting a bolt. The difference is in how the bolt is secured in the hole:

- Expansion bolts use a sleeve that expands as it is tightened. The sleeve expands against the walls of the hole to prevent it from coming out. (See figure 9-16.)
- Glue-in bolts are held in place by a high-strength adhesive. Glue-in bolts are used in softer, porous rock, such as sandstone. Delicate rock, like sandstone, may not be strong enough to support expansion bolts. Its porous structure allows the glue to expand deep into the rock around the original hole. (See figure 9-17, page 216.)

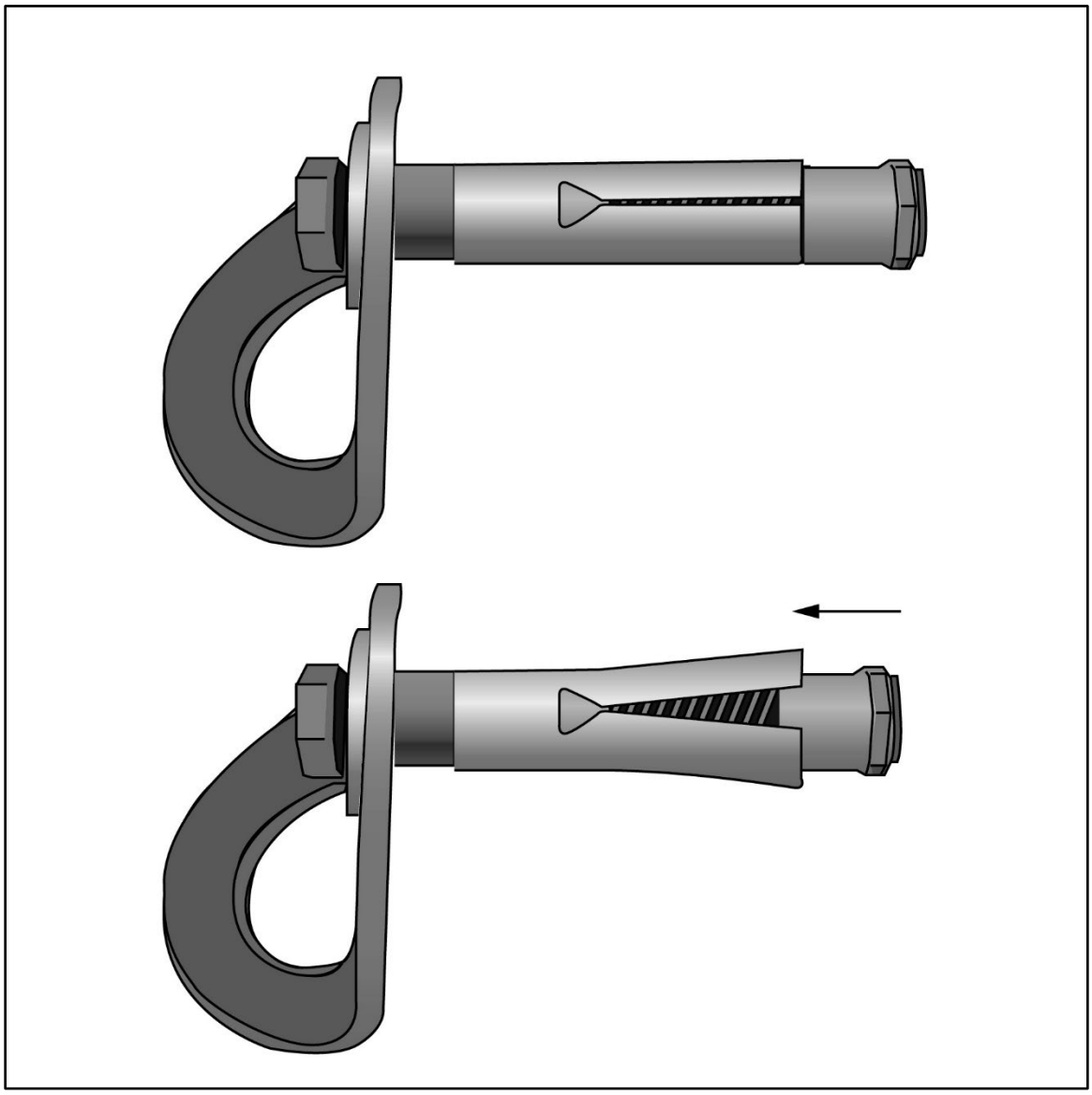


**Figure 9-16. Expansion bolt**

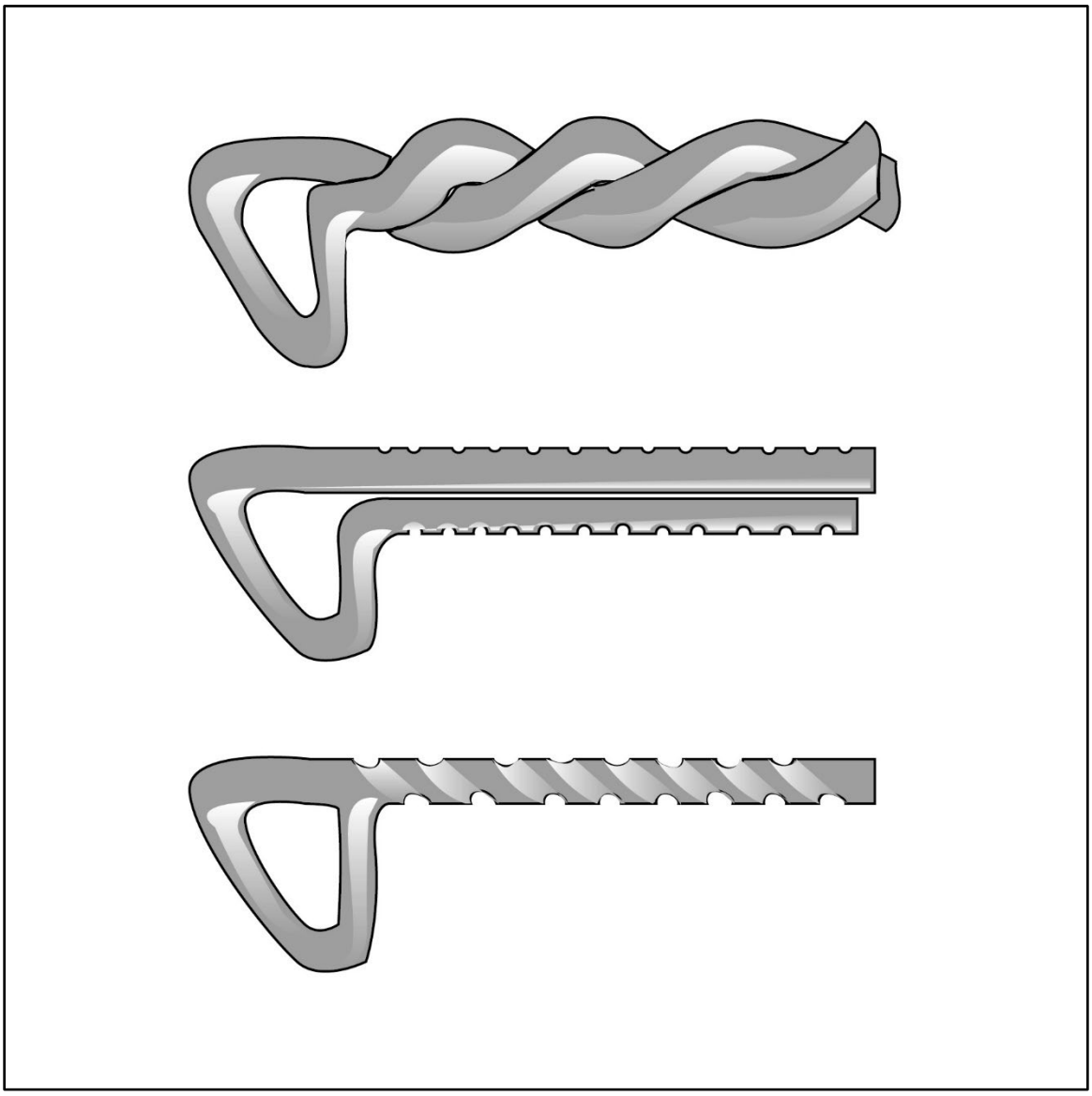


**Figure 9-17. Glue-in bolt**

## ADVANTAGES AND DISADVANTAGES

9-42. Some advantages of using bolts in anchor construction are—

- Extremely strong and secure when installed properly.
- Very easy to use for climbing protection when already installed.
- Very easy to use in multipoint-anchor construction when already installed.

9-43. Some disadvantages of using bolts in anchor construction are—

- Extremely time consuming to install relative to other artificial anchoring devices.
- Require the mountaineer to use both hands and hang during installation.
- Require special, relatively heavy tools (for example, drills, hammers, wrenches) to install.
- Noisy to install.

### INSTALLATION AND USE

9-44. There are enough differences in bolts available on the market that mountaineers should refer to manufacturers' instructions for installing bolts. Installing bolts permanently alters the rock. The climbing community has strong ethics regarding the placement of bolts. Ethics and regulations vary regionally, but in all areas, it is unacceptable to add bolts to existing climbs. Any bolting should be done with the consensus of the climbing community.

9-45. When using existing bolts as climbing protection or as part of an anchor system, mountaineers should inspect them for anything indicating compromise. The first thing that should be inspected is the rock on which it will be placed. Bolts are only as strong and secure as the quality of the rock. The hanger should not be rusty or loose. Loose hangers can indicate the bolt being insecure, or the hole has not been drilled deep enough to secure the hanger to the rock's face. If the nut holding a hanger can be tightened to a point, then it is viable. If it keeps spinning, the bolt should not be used or at the very least backed up with additional protection.

9-46. Many chock picks (sometimes referred to as nut-tools) have a hex cut out in them that can be used like a wrench to tighten loose bolts. A chock pick is used in lead climbing to aid a follow-on climber in removing protection. (See figure 9-18.)

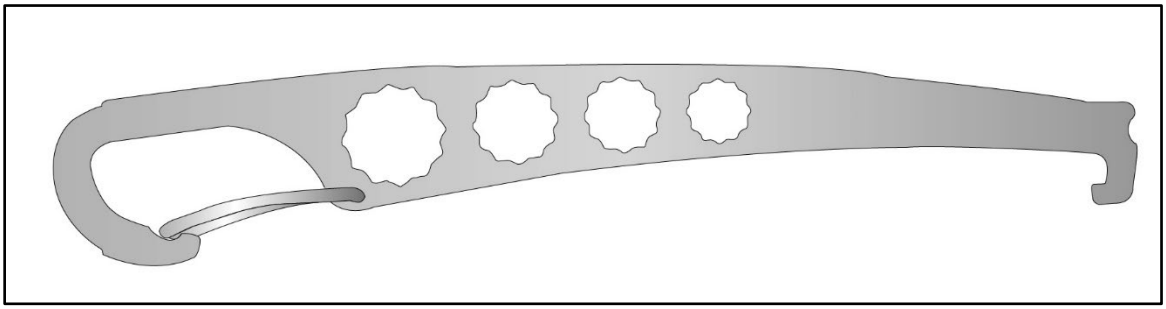


**Figure 9-18. Chock pick**

## CHOCKS

9-47. The principles for using devices commonly called chocks, nuts, or stoppers are the same as with chockstones above. They are designed to work in smaller cracks, easier to place, and more secure. (See figure 9-19, page 218.) The direction of pull must be considered carefully when using chocks.

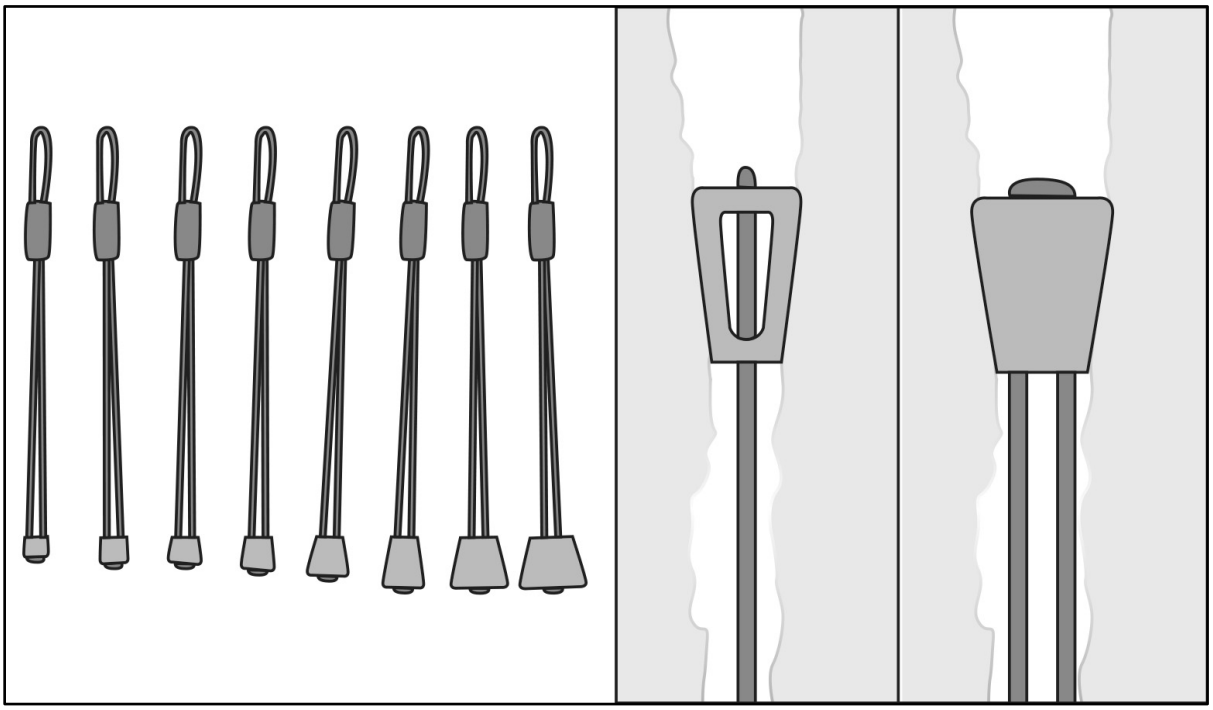


**Figure 9-19. Chocks**

## ADVANTAGES AND DISADVANTAGES

9-48. Using chocks in anchor construction has the following advantages:

- Tactically quiet installation and recovery.
- Usually easy to retrieve and, unless severely damaged, are reusable.
- Light to carry.
- Minimal rock scarring as opposed to pitons.
- Sometimes can be placed where pitons cannot (expanding rock flakes where pitons would further weaken the rock).

9-49. Using chock in anchor construction has the following disadvantages:

- May not fit in thin cracks, which may accept pitons.
- Often provide only one direction of pull.
- Practice and experience are necessary to become proficient in proper placement and removal.

## PLACEMENT

9-50. The principles of placing chocks are to find a crack with a constriction at some point, place a chock of appropriate size above and behind the constriction, and set the chock by gently jerking down. Maximum surface contact with a tight fit is critical. Chocks are usually good for a single direction of pull.

9-51. Avoid cracks that have crumbly (soft) or deteriorating rock, if possible. Some cracks may have loose rock, grass, and dirt, which should be removed before placing the chock. Look for a constriction point in the crack, and then select a chock to fit it.

9-52. When selecting a chock, choose one that has as much surface area as possible in contact with the rock. A chock resting on one small crystal or point of rock is likely to be unsafe. A chock that sticks partly out of the crack is avoided.

9-53. All chocks used for lead climber protection should include a soft material extension, such as a runner, to prevent the rope from wiggling the chock out of placement.

9-54. Chocks must be lightly tugged on to set them so that they do not fall out of placement. Weighting the placement helps to keep the protection in position. A carabiner often provides enough weight.

# CAMMING DEVICES

9-55. Camming devices are designed for building anchors in parallel-sided cracks where chocks are ineffective. There are several different types, but they all work by changing from a downward force to an outward force when loaded. This force creates enough friction that the device cannot move, even when no constriction in the crack is present. Camming devices increase force on surrounding rock as downward force is applied. Due to this, care should be taken to inspect the security of the rock on which they are placed.

9-56. Camming devices become even more secure when placed above a constriction. If the lobes slip during loading, they cannot exit the crack.

9-57. Cams are the most used camming devices in mountaineering. They have advantages and disadvantages and require extensive practice and experience to place and use properly.

## SPRING-LOADED CAMMING DEVICES

9-58. Cams are the most versatile and widely used artificial rock anchoring devices available to mountaineers. Although there are several types of cams, the modern design consists of two sets of lobes that oppose each other and rotate from one or two axles, connected to a trigger mechanism on a single, flexible stem that runs perpendicular to the axle. Attached to the axle is a presewn connection sling. They are designed to work in parallel-sided cracks where a chock would just slide down.

9-59. Cams come in a wide variety of sizes to fit cracks from 0.5 inches to over 21 inches. Each unit has an expansion range that enables it to function properly within a certain width of cracks. It may be necessary to carry many sizes depending upon the route, mission, and intended use. Most come with color-coded slings to help the user select the correct size for use.

9-60. Three quality camming devices equalized together are required to establish an adequate anchor. An exception is two large camming devices perfectly placed in solid rock with constrictions below them. A single camming device is usually placed for intermediate lead-climbing protection. Suboptimal placements or rock features require additional pieces to achieve an acceptable anchor.

## ADVANTAGES AND DISADVANTAGES

9-61. The advantages of using cams in anchor construction are listed below:

- They are much faster to place and remove, for creating anchors or as points of protection while lead climbing.
- They require only one hand to place, so the mountaineer can hold on to the rock with the other.
- They are easy to insert and remove when placed properly.
- They can be more forgiving than other anchor devices if the direction of pull changes.
- They provide many possibilities for rigging multipoint anchors.
- They do not damage the surrounding rock.

9-62. The disadvantages of using cams in anchor construction are listed below:

- They can wiggle or walk out of proper placement, resulting in a compromised anchor, or in a stuck camming device that is difficult or impossible to remove.
- They are much more expensive compared to other types of anchors.
- They can be heavy and bulky to carry.
- They have the potential to generate enough outward mechanical force to damage the surrounding rock and compromise the anchor when loaded.

## PLACEMENT

9-63. To place cams, find a uniform, parallel spot in the crack where the rock is clean and solid. Retract the lobes by pulling back on the trigger. Gently insert the camming device and release the trigger so the lobes expand to fit the crack. The spring mechanism works to hold the camming device in place. Ideally, the lobes

should be open between 10 percent and 80 percent of full expansion. (See figure 9-20 and figure 9-21, page 222.)

9-64. Avoid overcamming, which can make the unit difficult or impossible to remove, or undercamming, which results in too little surface area contact and reduced stability. The unit should also be placed deep enough to not break the edge of the crack but not so deep that the trigger mechanism cannot be reached.

9-65. Orient the stem to point in the direction from which the camming device is loaded.

9-66. Inspect the final placement to ensure the angle of the lobes in relation to each other is even and within the acceptable range.

9-67. An extension using a runner may be added between the camming device and climbing rope to reduce likelihood it walks out of position during lead climbing.

9-68. Single cam placements can be used for fall protection while lead climbing. Multiple cam placements can be equalized together with cordage or webbing to create load-bearing anchors.

9-69. To remove cams, simply pull the trigger mechanism and gently remove the device.

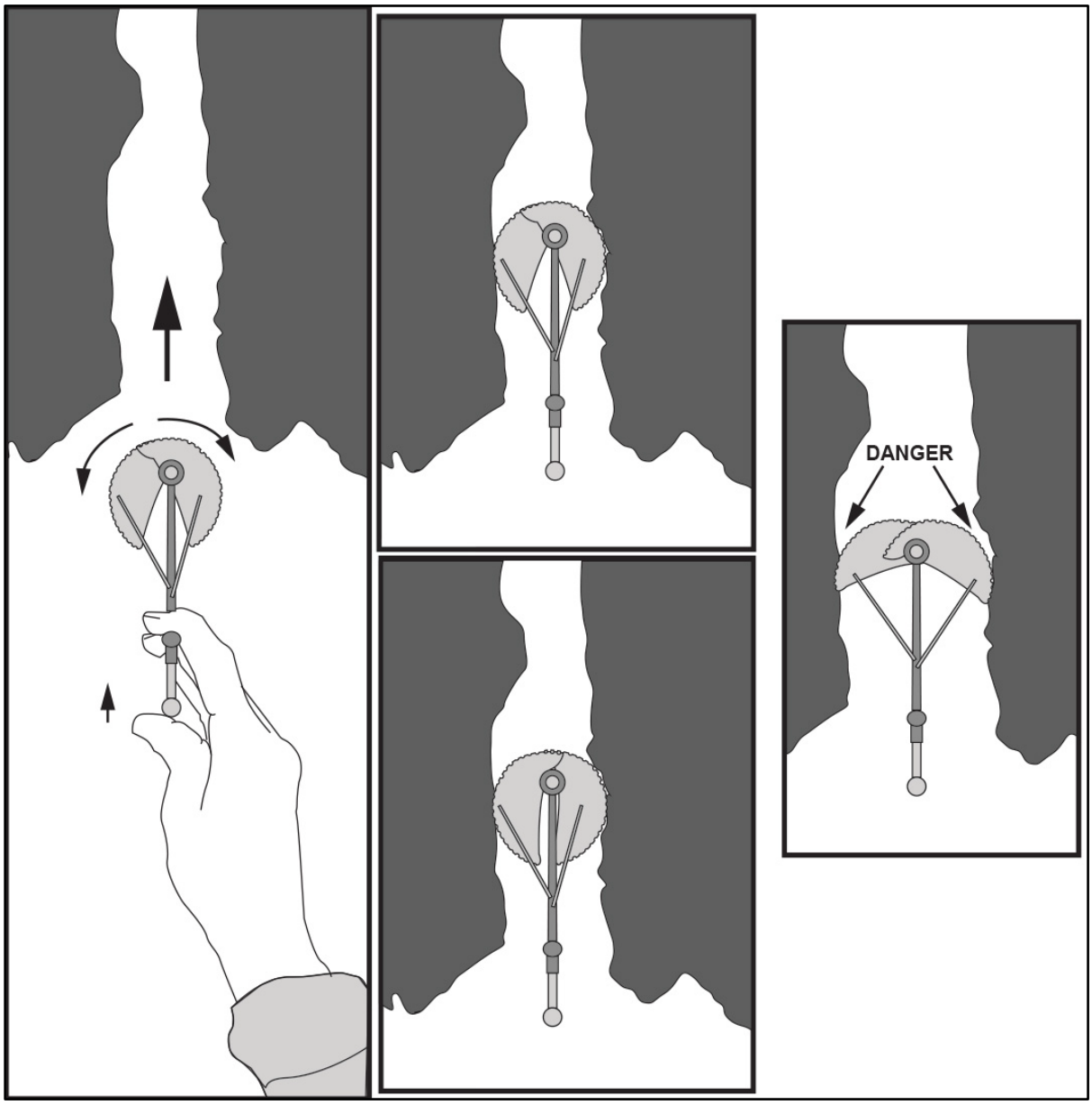



**Figure 9-20. Spring-loaded camming device placement**

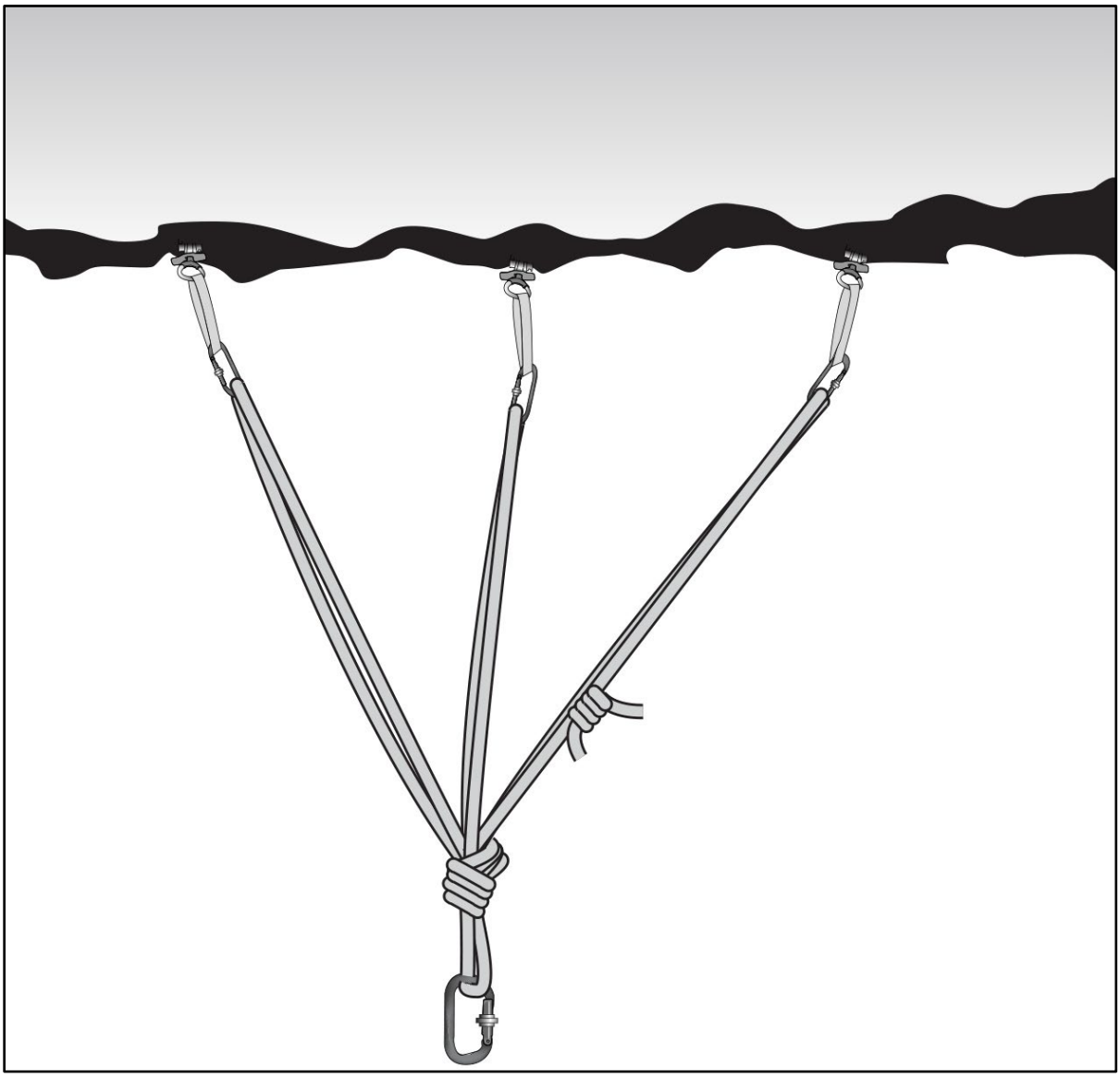


**Figure 9-21. Cord anchor with multiple points**

## SECTION IV – ICE ANCHORS

9-70. Fall protection and anchors can be constructed in alpine or waterfall ice using specialized ice screws. Occasionally, natural ice features can be found allowing anchor construction without them.

# TYPES OF ICE ANCHORS

9-71. Ice anchors consist of ice pillars, ice screws, and V-threads. Except for the case of large ice pillars, ice anchors should incorporate two or more anchor points to be strong and secure enough.

# ICE PILLARS, ICE SCREWS, AND V-THREADS

9-72. Ice pillars often form in steep alpine terrain. It is sometimes possible to pass a length of cordage or webbing around the whole mass of ice and create a single-point anchor in the same fashion as a rock protrusion or tree. (See figure 9-22.) Ice pillars should be totally frozen to the ground, comprised of dense,

crack-free ice, and greater than 1 foot in diameter to use as a single-point anchor. Smaller pillars may be used as part of multi-point anchors.

9-73. Occasionally, ice pillars can be created in ice features, such as sufficiently thick ice curtains where there is a hollow space behind, and a hole can be broken through a thin section with a mountain ax. Then an anchor can be established as above. Care must be taken not to damage the selected ice mass when creating a hole.

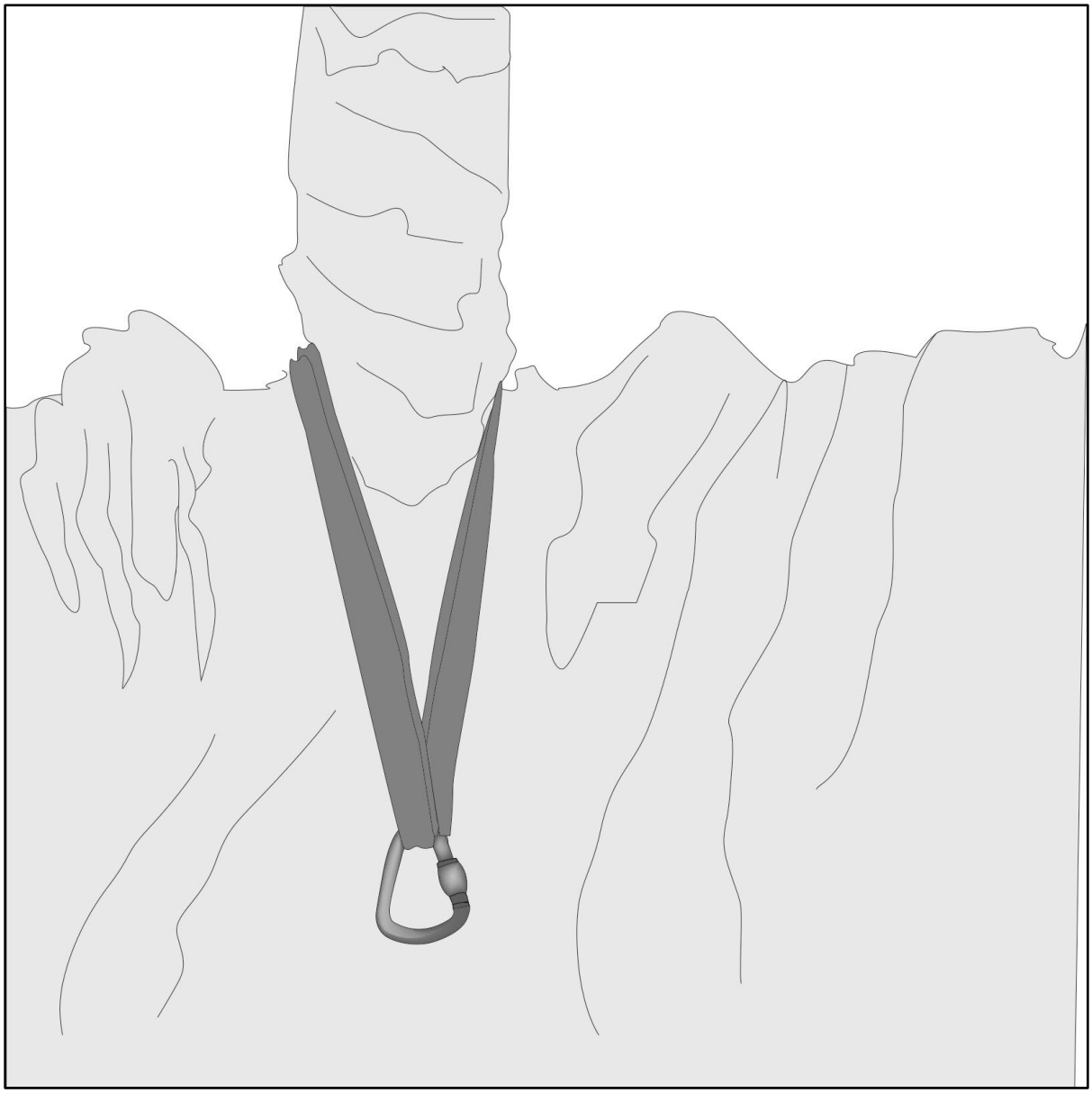


**Figure 9-22. Ice pillar**

## ICE SCREWS

9-74. The ice screw is the most common type of ice protection. An ice screw is a threaded tubular screw with teeth on the end. Some screws have longer hangers or handles, which allow them to be easily twisted into position by hand. Ice screws come in various lengths for use in various ice thicknesses. Newer ice screws come manufactured with a twist knob on the hanger for easier placement.

9-75. The security of an ice screw is determined by the quality of the ice in which it is placed. The thicker and denser the ice is, the stronger it is. Thinner ice, aerated ice, or ice with air pockets is weak; mountaineers should avoid this sort of ice. Deep, thick ice is generally bluish in color, while ice that has air pockets is often white in color. It takes significant experience to judge the strength of ice, but even a novice can learn much about ice quality by the resistance felt when placing the ice screw. Air pockets are felt as a reduction in resistance. The more resistance, the denser the ice. The longer the core grows as it is screwed in, typically the better the ice. (See figure 9-23.) Evaluate the integrity of the ice structure. If possible, avoid fracture lines, the apex of ice bulges, and ice blocks that are not attached to a main flow.

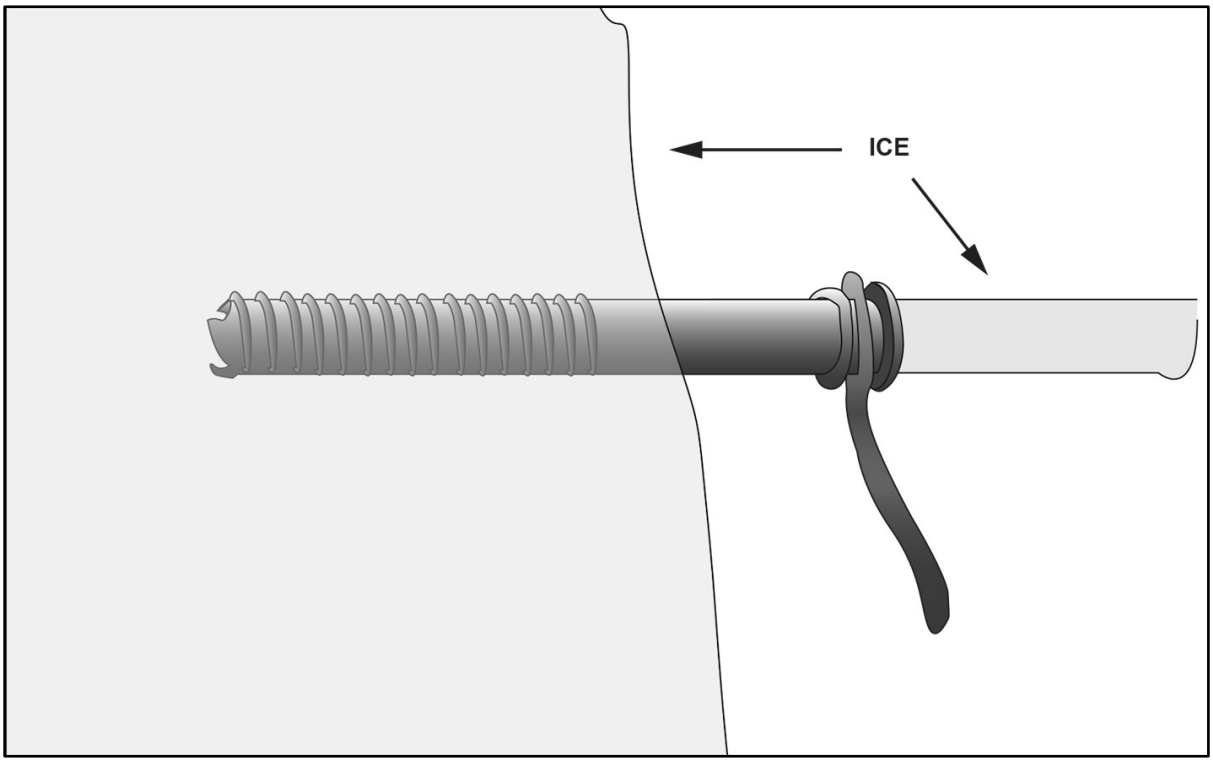



**Figure 9-23. Long ice core protruding from screw indicates good ice quality**

9-76. One ice screw in quality ice is sufficient to protect a lead climber. Two or more ice screws must be placed in quality ice to create a secure anchor. (See figure 9-24.) The same principles apply for creating multipoint anchors for ice screws. If the ice quality is suboptimal, then additional screws should be incorporated.

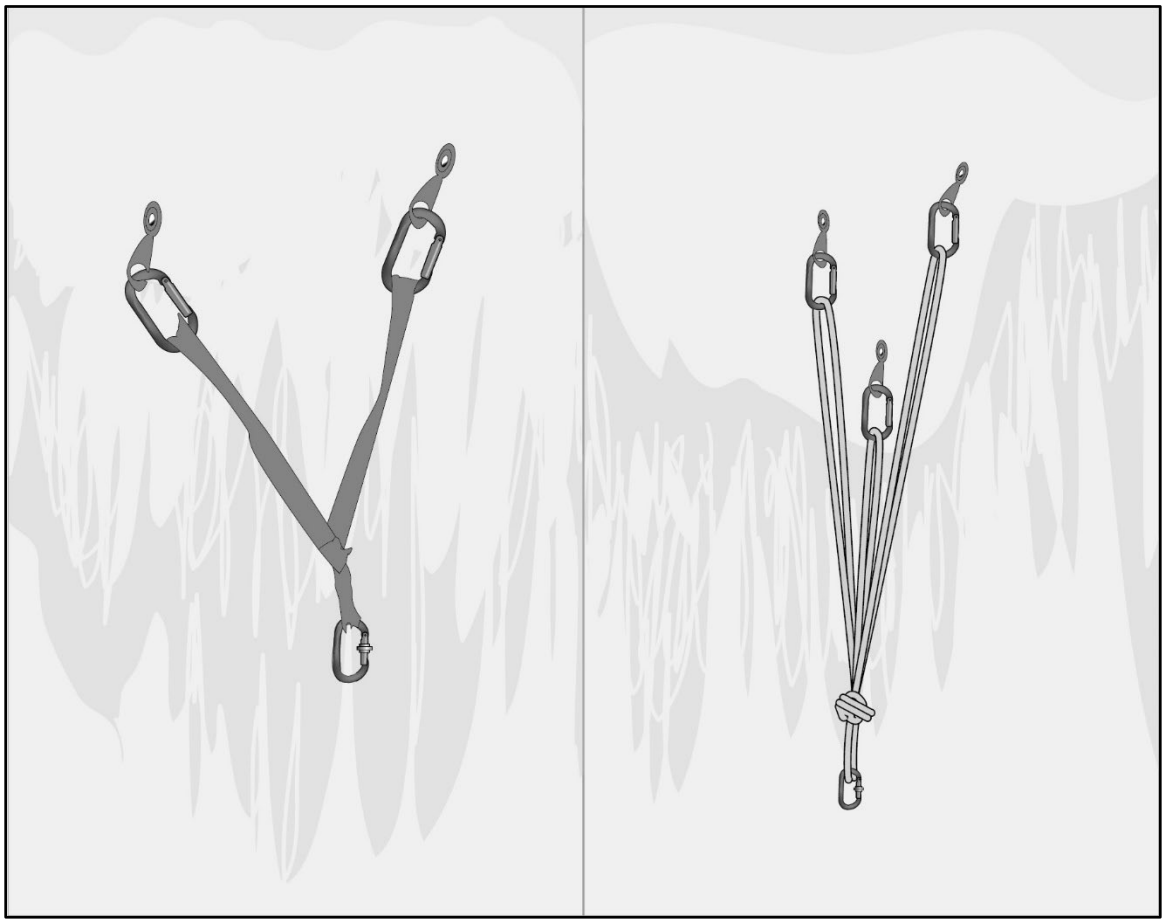


**Figure 9-24. Multipoint ice anchor construction**

## Advantages and Disadvantages

9-77. The advantages of using ice screws in anchor construction are that they—

- Can be placed almost anywhere in an ice flow.
- Can be placed with one hand.
- Fastest protection to place in ice.

9-78. The disadvantages of using ice screws in anchor construction are that they—

- Are bulky and difficult to carry in large numbers.
- Require difficult and tedious maintenance to keep sharp because of the double angle and curvature of the teeth.
- If not removed and cleared correctly, ice can freeze in the core of the screw, rendering it useless.

## Placement

9-79. Ensure all rotten ice is cleared away from the surface.

9-80. Hold the hanger end of the screw, and press teeth against the surface at an approximately 90° angle to the ice with a twisting motion. An acceptable range is +/–20°. (See figure 9-25, page 226.) Typically, several twists are necessary to get it started. The screw is started when it does not fall out of the ice. This is more easily done at about waist level for leverage, especially if the footing is poor.

9-81. Once started, fold out the screw's knob or handle, and twist in a circular motion clockwise until the hanger is tight to the ice. Fold knob or handle down and out of the way. Avoid overturning the screw once it

has become tight. If the screw is tight and the hanger is not pointed downward, back the screw out enough to achieve a downward hanger. The screw should be tight and secure; the threads in contact with solid ice are what absorb any force placed on the screw.

9-82. Clip a carabiner to the hanger, then incorporate into a multipoint anchor or clip rope when lead climbing.

9-83. Remove the ice by folding out the knob or handle and spinning counterclockwise. Clear any ice out of the tube so that it does not freeze.

9-84. Melting of the ice around a screw must be considered. The effective time or strength of an ice screw placement are limited. The screw will heat from solar radiation, or the ice may crack or soften. Solar radiation can be nearly eliminated by covering the screw with ice chips once it has been emplaced. If repeated use is necessary for one installation, such as top roping, the screws should be inspected frequently and relocated when necessary. When an ice screw is removed, the ice that has accumulated in the core of the screw must be cleared immediately.

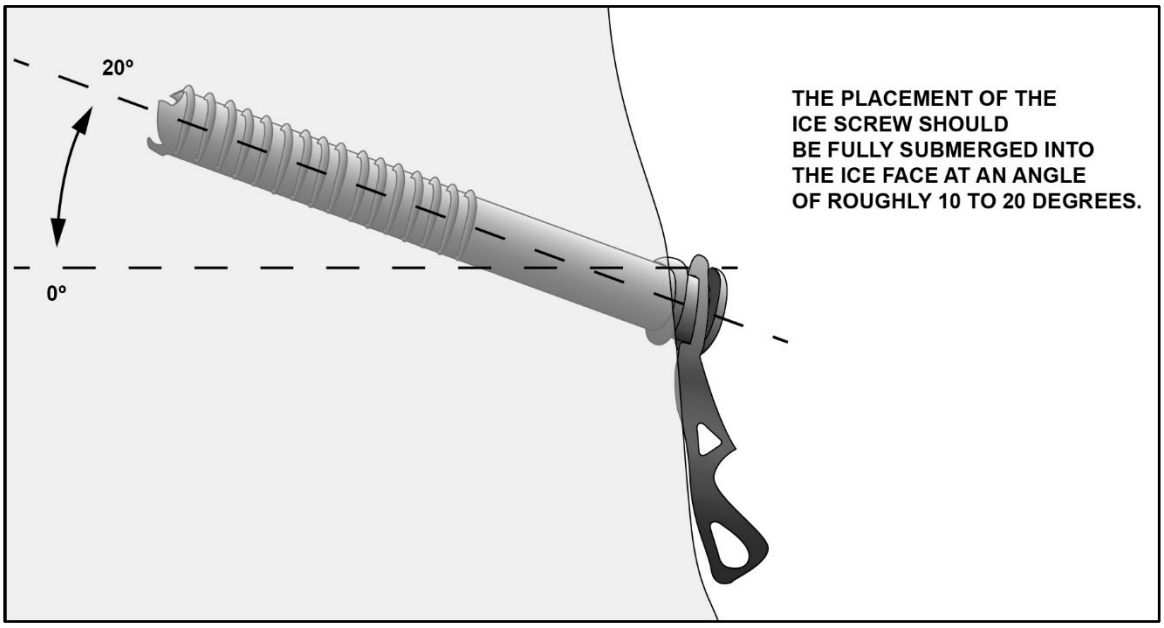



**Figure 9-25. Ice screw placement**

## V-THREADS

9-85. An ice anchor can be improvised using one long screw. This is particularly useful when the climber is short on ice screws or does not want to leave ice screws behind while rappelling. V-threads are common in fixed rope construction in snow and ice. Vertical or horizontal V-thread anchors can be created depending on the nature of the ice flow. Multiple V-thread anchors may be created and joined to create a secure ice anchor when ice quality is suboptimal. (See figure 9-26.)

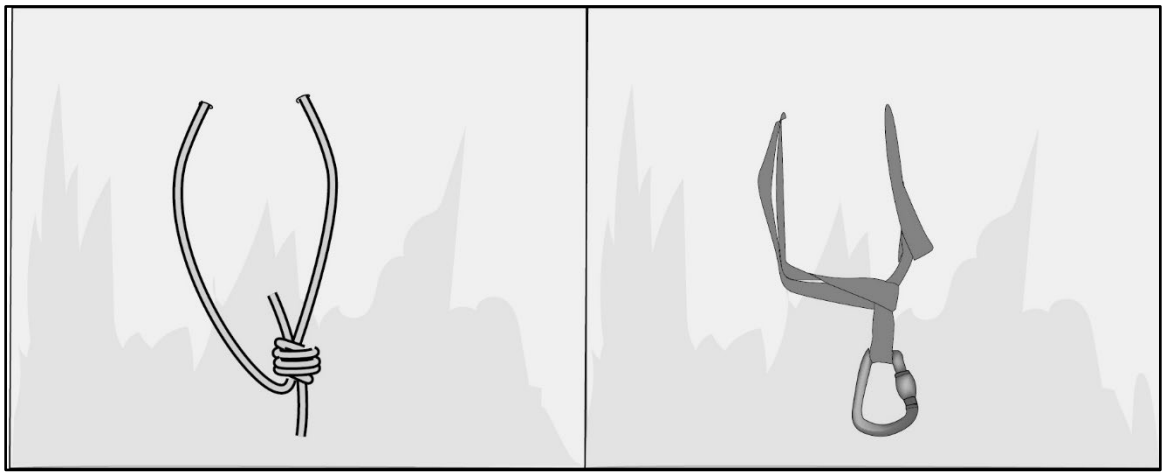


**Figure 9-26. V-thread anchors**

## Advantages and Disadvantages

9-86. The advantages of using V-threads in anchor construction are that—

- They can be placed almost anywhere in an ice flow.
- They require very little to build many of them.
- Their gear placed in the ice is expendable.

9-87. The disadvantages of using V-threads in anchor construction are—

- Compared to other ice anchors, it takes a long time to construct, and two are necessary for a strong and secure anchor.
- They require a fair amount of experience to use appropriately.

## Placement

9-88. Place a long (19+ cm) ice screw into quality ice at a 60° angle to the ice face, and then remove it, creating a borehole the length of the screw.

9-89. Use the length of this ice screw to measure how far away from the first hole (either vertically or horizontally) a second hole should be bored.

9-90. Bore another 60° angle hole in the opposite direction as the first so that it intersects the first at the back of the hole, creating a roughly triangular column of ice.

9-91. Pass a piece of cordage or webbing through the tunnel created and tie it off with an appropriate knot to complete the anchor. Usually a V-thread tool is used to fish the cordage or webbing out of the hole.

9-92. V-thread tools can be made from a wire coat hanger by cutting the length of wire, bending one end into a small hook and the other into a handle (See figure 9-27, page 228.)

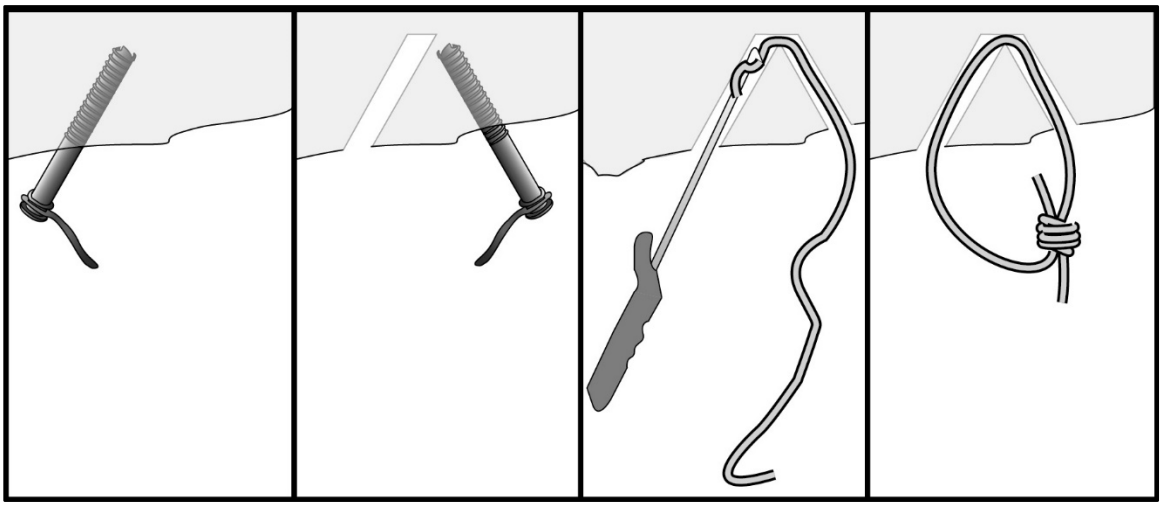


**Figure 9-27. Constructing a V-thread anchor**

## SECTION V – EARTH ANCHORS

9-93. Using improvised earth anchors becomes necessary when naturally existing anchors, such as trees, are unavailable. These anchors are created using materials that are readily available. The strength of these anchors depends on the material used, the depth, and the density of the earth in which they are placed. The art of constructing and placing good earth anchors requires a great deal of practice and experience. It is especially important to load earth anchors in a slow and steady manner. It is also important to ensure the direction of the pull is low and does not pull up on any component of the earth anchor.

# DEADMAN ANCHOR

9-94. A deadman is an effective means of building an anchor in earth or snow when there are no other natural anchors available. A deadman is constructed by digging a trench perpendicular to the direction of pull and placing a lengthy solid object with a sling or cordelette attached into it. A thinner slot is cut into the ground in the direction of pull and bisecting the trench to form a T-shape. The attached cordelette or webbing is then routed through this slot in the direction of pull.

9-95. The object is then buried. A rope or rope system can then be attached to it. The strength of a deadman anchor is determined by the density of soil it is placed into. The security of it is determined by the depth of the trench. Objects such as lengthy rocks, sticks, poles, and mountain axes can be buried.

# PICKET HOLDFAST

9-96. A picket holdfast can be constructed in the absence of suitable existing anchors. It requires three suitable pickets that can be made from sturdy sticks at least 3 inches in diameter and 3-feet long. The pickets can also be improvised from sturdy metal stakes or poles, if available. It is best to sharpen one end of each wooden stick or picket, so they are easily driven into the ground. (See figure 9-28.)

9-97. Next, drive the pickets in line with the load a safe distance from the edge. Drive the pickets approximately 2-feet apart from each other at a 45° angle leaning away from the edge. The pickets should be driven into the ground at least half their total length.

9-98. Attach the rear picket at its base with a cord. Then attach the other end at the top of the middle picket. Using a clove hitch here will make it easy to adjust so there is equal tension on the pickets.

9-99. Repeat this process from the middle picket to the front picket, then attach a cord to the front picket at its base and create an attachment point for the anchor.

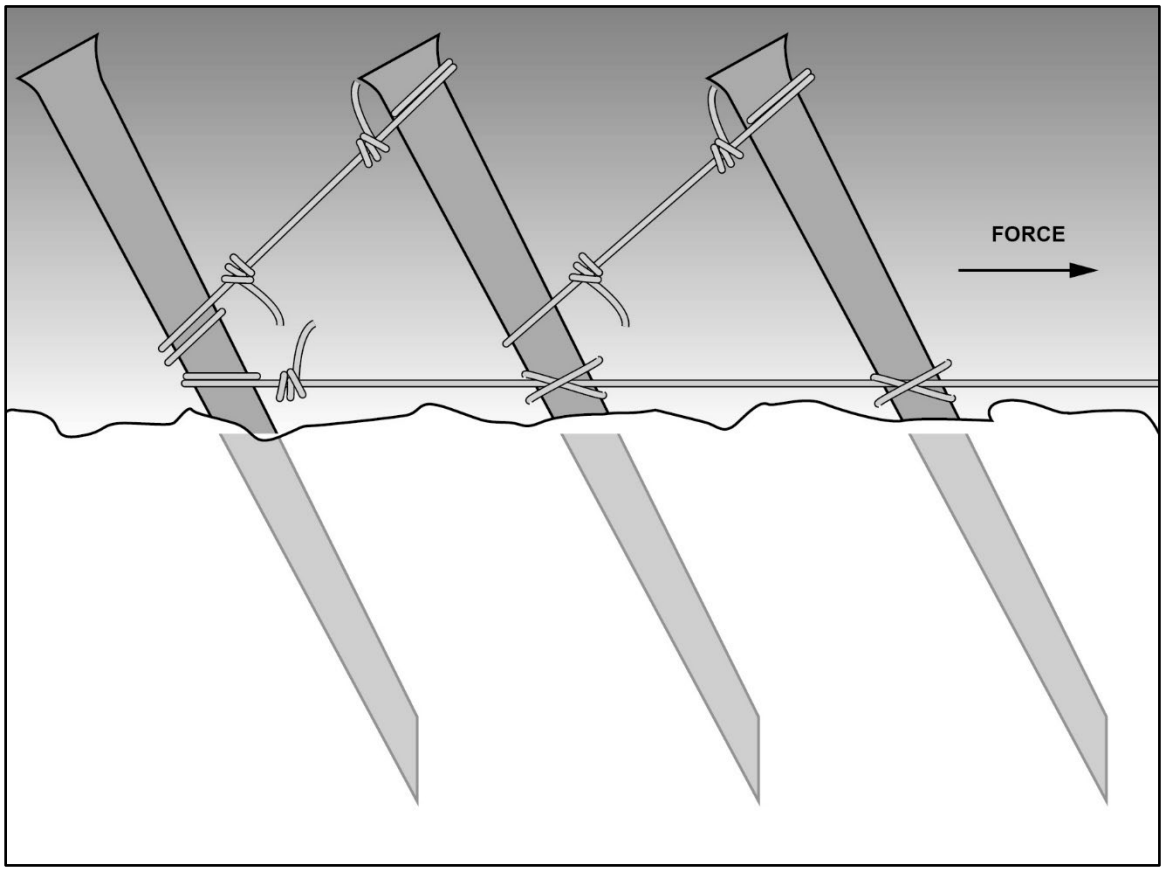



**Figure 9-28. Picket holdfast**

## SECTION VI – SNOW ANCHORS

9-100. Snow anchor effectiveness is determined by the density of the snow into which they are built. Two or more snow anchor points can be equalized into a multipoint anchor if strength and security are questionable.

# PICKETS AND ICE AXES

9-101. Pickets and ice axes may be used as snow anchors. The picket should be driven into the snow at 10° to 15° off perpendicular from the lower surface. If the picket cannot be driven in all the way to the top hole, the carabiner should be placed in the hole closest to the snow surface to reduce leverage. The picket may also be tied off with a short loop of webbing or rope girth hitched low on the picket. (See figure 9-29, page 230.)

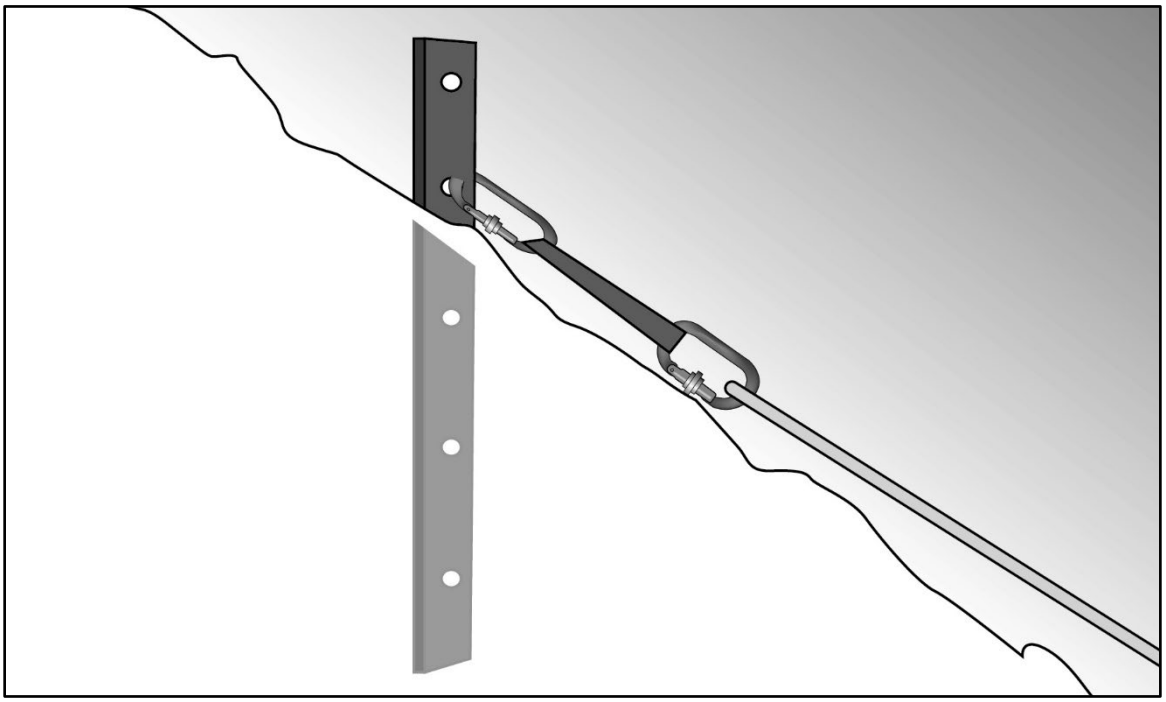


**Figure 9-29. Snow picket placement**

9-102. When the snowpack is loose or it is suspected that a single picket cannot act as a sufficient anchor, then use multiple pickets if available. (See figure 9-30.) If the snow picket goes into the snow with ease, consider placing it in the deadman orientation to maximize strength and surface contact. If the snow picket requires pounding to place in vertically, the placement is most likely solid. The same general principles apply to constructing this multipoint anchor as any other. Ensure that each picket shares the load equally. They can be placed in succession similarly to the picket holdfast described in section V in this chapter or in a reverse V-shape shown in figure 9-31, page 232. If the snow is extremely loose, it may be better to build a deadman anchor that is dug in quite deeply where there is firmer snow.

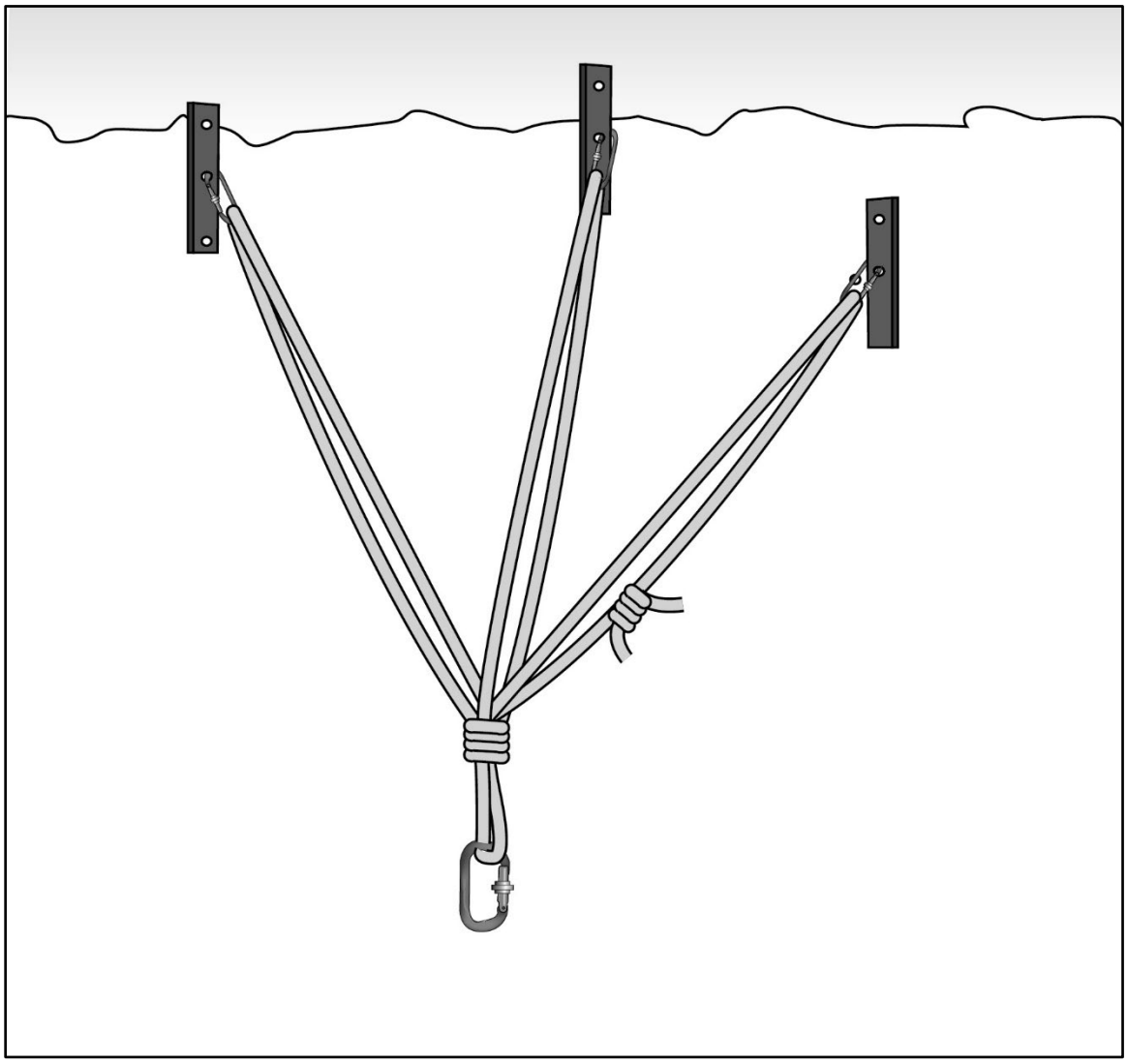


**Figure 9-30. Multipoint snow anchor**

9-103. In softer snow conditions, both snow pickets and mountain axes can be used effectively in constructing a deadman anchor in the same fashion that they are constructed in earth (described in paragraphs 9-93 through 9-99, page 228). Longer objects, such as skis, can be used for increased strength. (See figure 9-31, page 232.) Snow density determines strength, and depth of the deadman determines security. Deadman anchors are the most reliable compared to all other techniques described. (See figure 9-31, page 232.) This is the most simple and reliable improvised snow anchor that can be used in a variety of snow conditions.

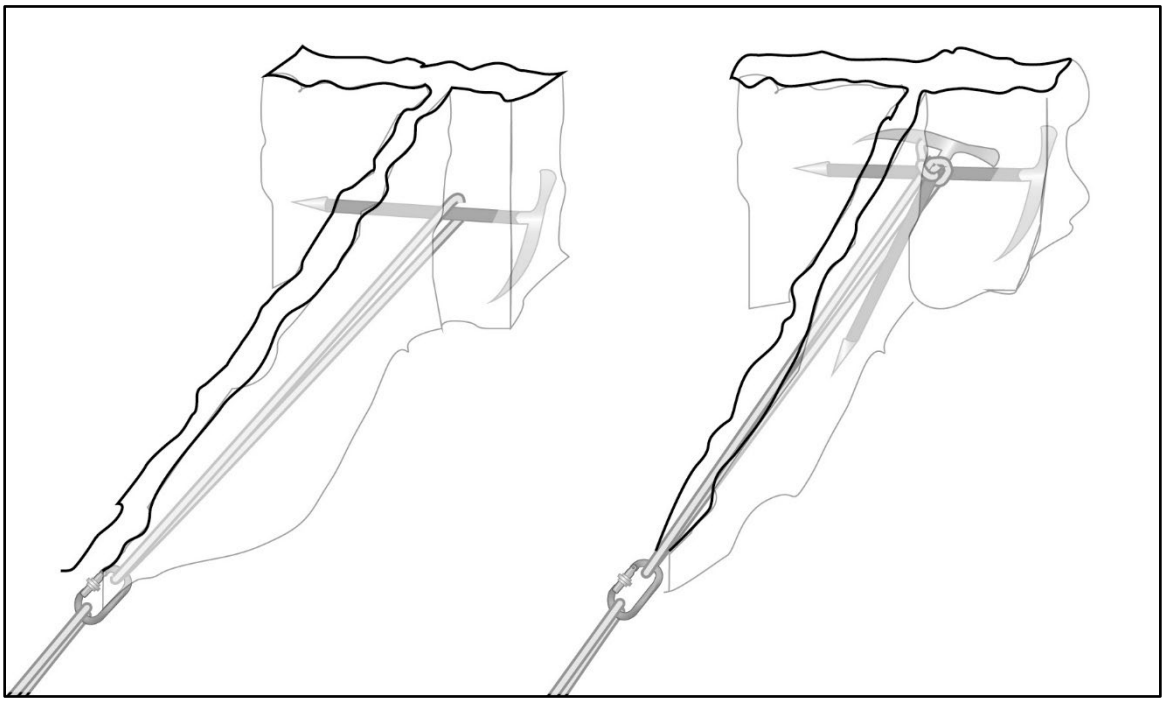


**Figure 9-31. Deadman anchor/T-trench anchor in snow with ice axe**

# BOLLARD ANCHOR

9-104. This is an artificial anchor shaped generally like a horseshoe. (See figure 9-32.) It is formed from either ice or snow and constructed by either cutting with an ice axe or stamping with the boots. When constructed of snow, the width should not be less than 10 feet. In ice, this width may be narrowed to 2 feet, depending on the strength of the ice. The length of the bollard should be at least twice the width. The trench around the horseshoe should be stamped as deeply as possible in the snow and should be cut not less than 6 inches into the ice after all rotten ice is removed. The backside of the anchor must always be undercut to prevent the rope from sliding off and over the anchor.

9-105. This type of anchor may be used for fixed ropes or rappels. It must be inspected frequently to ensure that the rope is not cutting through the snow or ice more than one-third of the length of the anchor. If it is, a new anchor must be constructed in a different location.

9-106. A horseshoe anchor constructed in snow is always precarious; its strength depends upon the prevailing texture of the snow. For dry or wind-packed snow, the reliability of the anchor should always be suspected. The backside of the bollard can be reinforced with ice axes, pickets, or other equipment for added strength. A snow-T trench is an example of a horseshoe anchor. (See figure 9-31.)

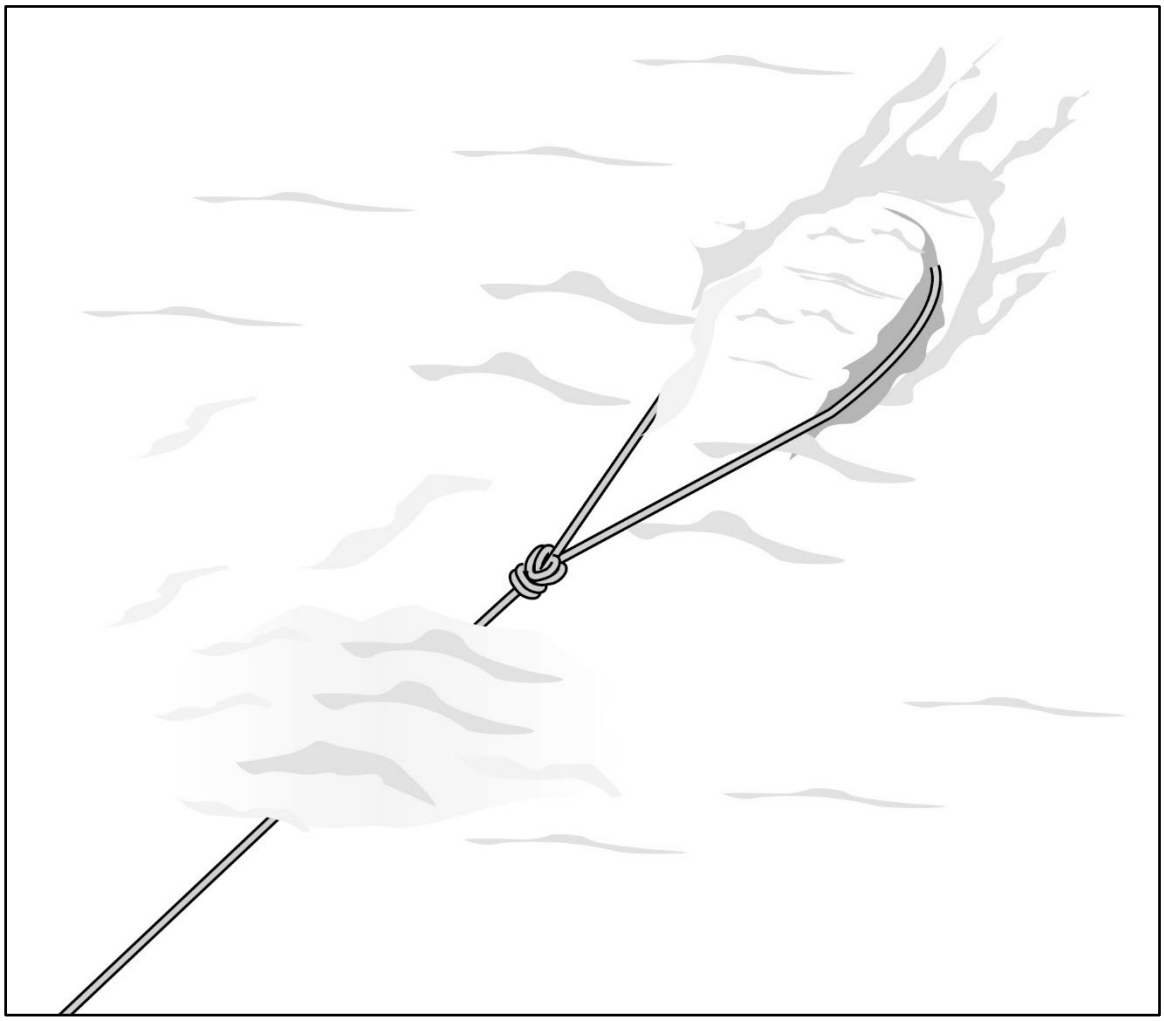


**Figure 9-32. Snow bollard anchor**

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## Chapter 10

# Rope Systems for Climbing

There is an inherent risk to moving in the mountains. Much of the terrain is high consequence, where a misjudged foothold, a loose rock, a slip, trip, or fall can kill. However, troops fighting in the mountains are often exposed to greater risk by not being able to move through the terrain. Examples exist throughout history. Modern examples include the assaults on Riva Ridge and Monte la Difensa in Italy, both examples of failed conventional assaults, where defensive positions in the heights were taken by assaults through more difficult terrain. More recently, the Indians retaking hilltops in the Kargil Conflict display all the same principles. Successful offensive operations in the mountains require troops who can move in difficult terrain and under poor conditions. The alternative is costly, often unsuccessful attacks where the defenders hold significant tactical advantage. To manage the risk involved with movement through these types of terrain, Soldiers must be trained in a variety of rope systems for climbing.

## SECTION I – RISK MITIGATION

10-1. Fighting in the mountains requires exposure to mountain hazards. The mountain environment is defined by its hazards and difficulties. Often, the control measures used to address one hazard increase the exposure to another. Installing or using ropes to protect against a fall increases movement time and increases the exposure to compromise by enemy forces.

## MANAGING RISK

10-2. Managing risk in the mountains is a dynamic process, where the most appropriate measures for managing risk change with the terrain and situation.

10-3. Control measures target either the consequence or the likelihood of an incident. Protective equipment, such as a helmet to protect against rockfall, only reduces the consequence. The likelihood of being hit by rockfall is addressed by avoiding areas of loose rock and routing Soldiers so that they do not travel above one another.

## REDUCING THE LIKELIHOOD OF A FALL

10-4. The mountaineer has several technical tools for managing fall hazards. However, while the consequence of a fall can be reduced, it cannot be eliminated. Even a short fall while rock climbing can cause severe injury. To manage the risk, target factors that will reduce the likelihood of a fall.

### JUDGEMENT

10-5. The safety of a mountaineer comes from the ability to read the terrain. Judge the rock, snow, or ice, and see where it can be climbed and where it cannot. This includes identifying features and weaknesses that can be linked together. Judgement is developed through time spent climbing in a controlled environment and through experience and mentorship.

### TECHNIQUE

10-6. Soldiers must possess the physical ability to make the moves, use footholds, and maintain balance as each move is made. As with judgement, climbing technique is the product of extensive training.

### LOAD

10-7. Increased Soldier load rapidly increases the difficulty of climbing, even in easy terrain. Operations in the mountains are subject to the mindset that occupying high terrain requires more equipment for sustaining life than at lower elevations. However, to maintain maneuverability, the Soldier's load must be reduced.

Soldiers conducting offensive operations, reconnaissance patrols, or any maneuver in high-consequence terrain need to travel light.

### FOOTWEAR

10-8. Proper footwear will enhance the military mountaineer's ability to move safely and efficiently through the rugged terrain found in the mountains. (See chapter 4 for footwear considerations.)

### ROPE

10-9. Ropes are used to reduce the consequence of a fall. Ropes can be fixed in place to manage or reduce the consequences of a fall (see chapter 11) or can be used to provide belays (see section III in this chapter).

## SECTION II – CONSIDERATIONS FOR MOVING UNROPED

10-10. Moving unroped is the fastest and most efficient method of moving through terrain. It requires little equipment and is quiet. Team members can move together, making communication quiet and easy. In instances where the greatest hazard is not falling, but rock or icefall, impending severe weather threat, enemy observation, or failing to meet an operational timeline, moving unroped may be the safest way to move. (See figure 10-1.) Moving unroped in terrain above 3rd-class should only be done after thorough risk analysis has been conducted and speed has been identified as a critical control measure for managing overall operational risk.

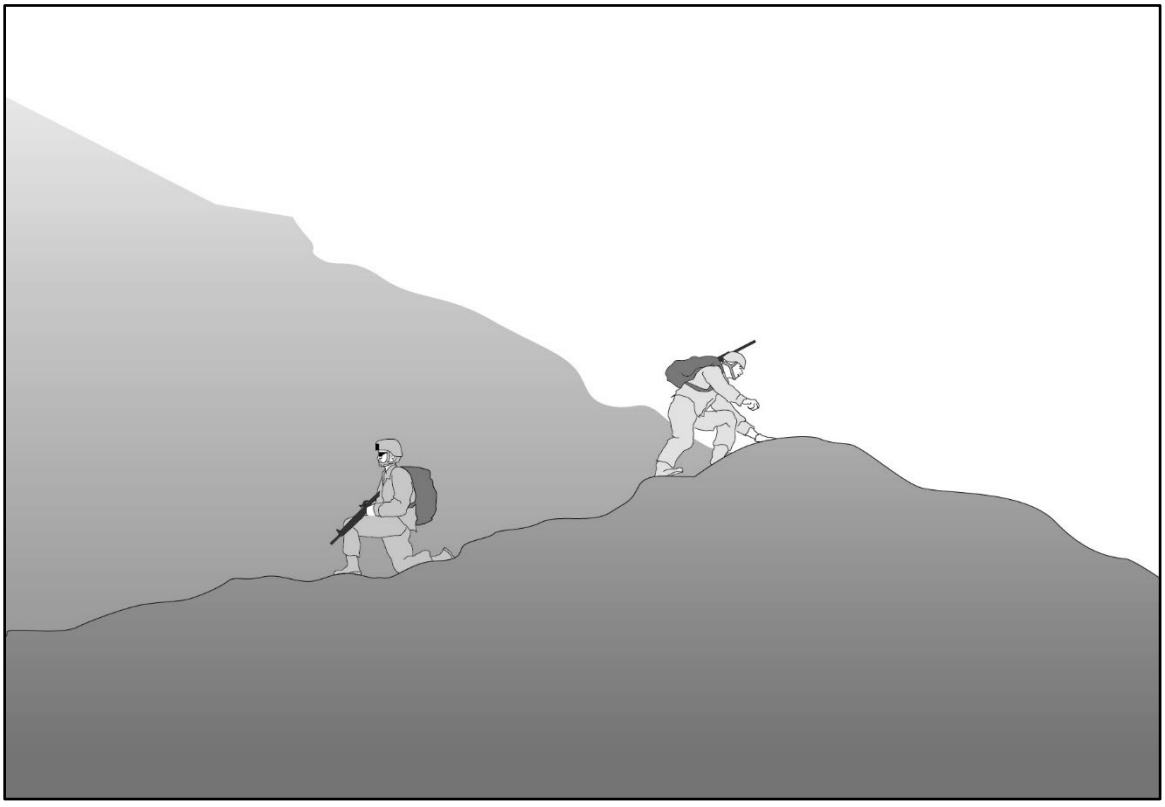


**Figure 10-1. Soldier moving unroped**

10-11. Moving unroped should only be done in 4th-class terrain or lower. It should never be considered in 5th-class terrain.

10-12. Moving unroped exposes Soldiers to very high consequences in the event of a fall and could have catastrophic results including death. A rescue or body recovery in this terrain would likely become its own

operation. Moving unroped should not be the default choice. The risk of a fall must be balanced against the other hazards. If the choice is made, there are measures to manage the risk.

- Target likelihood—maximize the use of every control measure to reduce the likelihood of a fall. Everyone in the team should have good movement skills. Loads should be reduced to the essentials. The team should be wearing appropriate footwear for climbing.
- Conservative route selection—the difficulty of the route must be within the comfort zone of the entire group. It is necessary to have the ability to adjust to a more conservative movement strategy, which requires harnesses to be worn and rope accessible.
- Route planning—use all available tools to build route plans. Often, climbing unroped goes badly not because a route is too difficult, but because a climber ends up off route in more difficult terrain.
- Pace—climb at a slow, deliberate pace. An easy pace allows full focus on the movement.
- Attention—keep attention focused on the climbing. Every foothold and handhold are critical. Stop often and assess the terrain ahead. Do not commit to features to which a Soldier cannot back off.
- Communication—a nontechnical risk management tool is coaching. Communicating a hazard focuses awareness on the hazard. During a movement, check in with group members and reassess their comfort with the risks at rest halts and decision points.
- Descent plan and tools—down climbing is more difficult than climbing up. Always have a multilayered descent plan and a rope and equipment to get down.
- For most units, there is limited terrain where climbing unroped may be appropriate. Average combat loads are heavy and issued combat boots are poorly suited for climbing. Limited steps of 3rd-class terrain, without exposure, are the upper limit for most units, and even then, should be assessed and managed carefully. Without individual mobility training and teams selected for their movement proficiency, there is a high risk of someone falling.

**WARNING**

- **Never climb unroped in 5th-class terrain.**
- **Climbing unroped in 4th-class terrain requires high skill, extensive experience, and superior confidence. Unroped climbing is only an option when the need to move quickly due to exposure to enemy or environmental hazards exceeds the risk of an unroped fall.**
- **Unroped climbing is a high-risk activity that requires a deliberate risk mitigation process and commander approval.**

## SECTION III – BELAYED CLIMBING

10-13. **A *belay* is a system of using a rope as a backup in steep terrain to arrest a Soldier's fall should one occur**. This section will discuss an overview of various strategies for using ropes and belays.

# TYPES OF BELAYED CLIMBING

10-14. When terrain is too dangerous to move unroped, a team will transition to belayed climbing. Belayed climbing is usually done in a party of two, with each climber tied into one end of the rope. One team member is always anchored and providing a belay for the other.

### TOP ROPE CLIMBING

10-15. Military mountaineers are first introduced to top rope climbing. Top rope climbing is where the rope is run through an anchor at the top of a climb and kept relatively snug to avoid longer falls. It is a training tool used to teach climbing technique. (See section IV for more information on top rope climbing.)

## LEAD CLIMBING

10-16. As military mountaineers progress, they are later introduced to lead climbing. ***Lead climbing*** **is climbing a route while attached to the end of a rope to place devices in rock, ice, or snow for fall protection with a belayer located below**. When lead climbing, one climber leads climbs, placing protection and clipping the rope through it as they go. The belayer (sometimes referred to as the second) belays and is prepared to catch a fall. Lead climbers climb to another secure stance, build a solid anchor, and then belay second climbers as they climb to the new stance. Each length of climbing is called a pitch, which is a section of a climb that comprises the distance between two belay stations, which can be up to a standard rope length (60 meters) on easy ice and snow. In more broken rock, it may be just 10 to 15 meters, to minimize rope drag and aid communication.

10-17. Lead climbing provides security for both members of the party. Leaders accept more risk because they are climbing above their protection. Any fall will be well past the last piece of protection they placed before the rope begins to come tight, so it is still imperative that leaders have good movement skills. The second has a top rope unless the route traverses. The overall security of the team is good. The team always has a solid attachment, and the belays can be placed in sheltered stances, with solid anchors. (See section V for more information on lead climbing.)

10-18. Most climbers will protect themselves with belays in 5th-class terrain. In 3rd- or 4th-class terrain, in darkness or bad weather, belayed climbing is the most conservative strategy for protecting the team and provides the greatest margin of safety.

## AID CLIMBING

10-19. If the climbing is too difficult for the leader, ***aid climbing*** **is a climbing technique in which standing on or pulling oneself up via devices attached to fixed or placed protection is used to make upward progress**. (See figure 10-2.) Aid climbing is when climbers use anchors and protection to support their weight as they climb. In a recreational setting, climbers on big walls may do extensive aid climbing, with webbing ladders called etriers (or aiders) that can be clipped to pieces of rock protection and climbed, and daisy chains or webbing tethers, to hang from. Aid climbing can also be as simple as pulling on pieces of protection to get through difficult sections of what would otherwise be a free climb.

10-20. Aid climbing is slow. It may take hours to climb one pitch. Aid climbing requires significantly more rock protection. An aid rack may have three times the equipment used by leaders to protect themselves. Advanced military mountaineers should be familiar with aid climbing but expect to improvise the tools to make it happen.



**Figure 10-2. Aid climbing**

## Simul-climbing (Running Belay)

10-21. ***Simul-climbing*** **is a belay technique involving two Soldiers climbing simultaneously while attached to the ends of a rope which runs through the fall protection**. It is a variation of belayed climbing, where leaders continue to climb rather than stopping to belay the second. Second climbers climb simultaneously, removing protection as they go. Leaders continue to climb while trying to keep a few pieces of protection between the two climbers at all times. If one falls, they may pull their teammate off their stance, but they will be caught eventually, counterbalanced through the protection with the other climber. Simul-climbing is faster than belayed climbing and useful for covering easy ground quickly. (See figure 10-3, page 240.) Simul-climbing provides more security than soloing. Climbers may find it necessary to shorten ropes between 20 and 30 meters to help with communication and prevent rope drag.

10-22. When both climbers are moving together, both share the consequence of a fall. Climbers should only use simul-climbing where a fall is unlikely and with partners of similar ability. If rockfall or icefall is a

concern, it is not appropriate because the second is exposed to anything dislodged by the leader. Simul-climbing is best suited for easy alpine ridges where rocks fall off the feature. Simul-climbing is an appropriate technique for easy climbing, 3rd class through easy 5th class, with well-matched partners.

10-23. Simul-climbing is a technique used when the environmental or tactical situation presents a greater threat than the fall hazard. Simul-climbing sacrifices some level of fall protection to gain speed of movement.

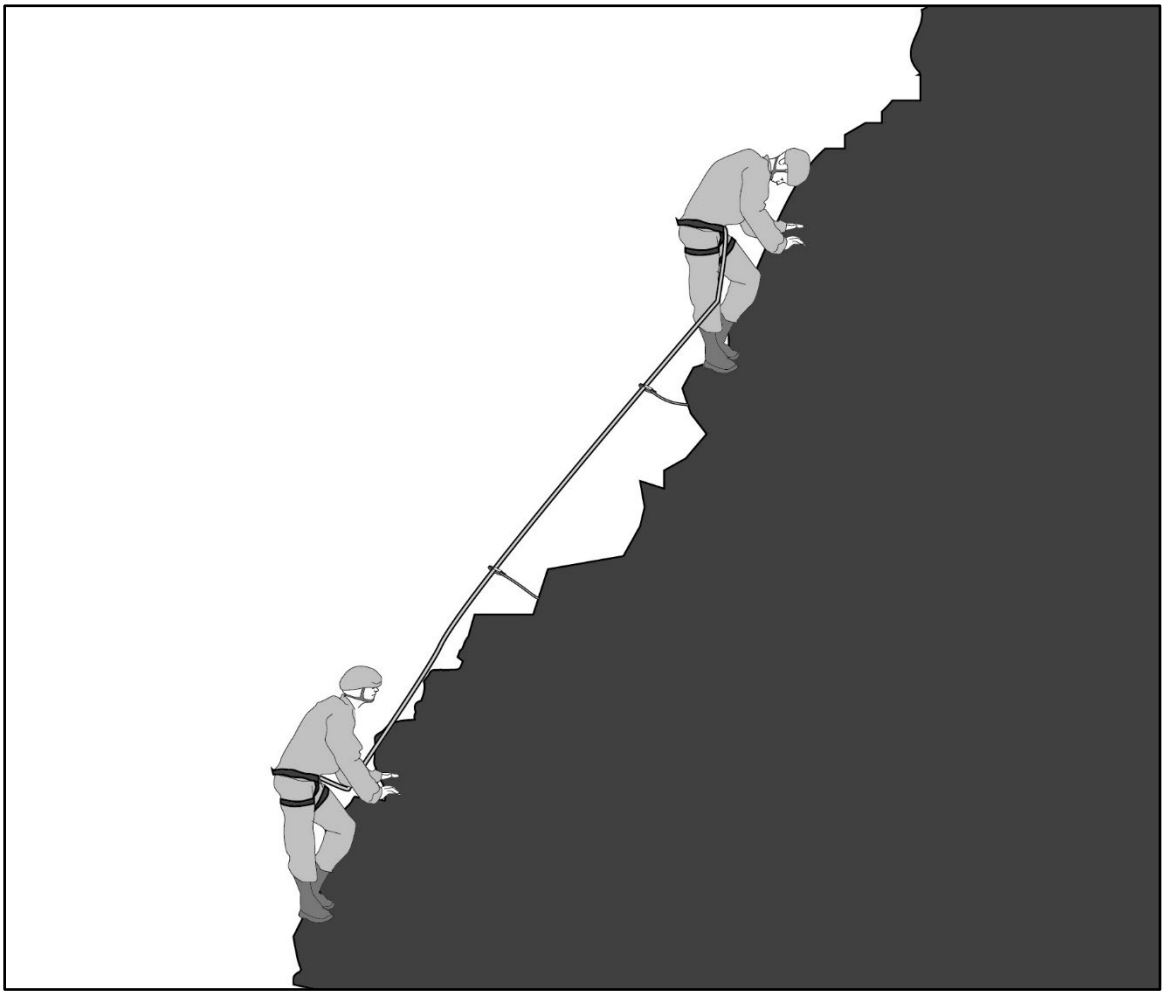


**Figure 10-3. Simultaneous climbing: two Soldiers climbing together with intermediate protection from falling**

**WARNING**

- **Only highly experienced advanced or master military mountaineers are qualified to simul-climb. They should only simul-climb in terrain that is well below their ability level, when speed is needed due to enemy contact, or when environmental hazards outweigh the risk of a long-roped fall.**
- **Simul-climbing is a high-risk activity that requires a deliberate risk mitigation process and commander approval.**

## Short Roping

10-24. Short roping is a technique that may have some use in training military mountaineers. (See figure 10-4, page 242.) Short roping is used by more experienced mountaineers for protecting less experienced Soldiers in easy but exposed terrain. The climbing rope is shortened to just a few meters, and the leader holds the rope close to the other's harness and the two move together. Short roping cannot arrest a fall. It manages risk by putting the senior mountaineer close to the other climber, where the senior mountaineer can coach and model. If someone slips, leaders pull the rope connected to their harness to prevent the slip from becoming a fall. The only anchor is the senior mountaineer's stance. Short roping is appropriate only in terrain where leaders are confident climbing unroped and do not need their hands to climb.

10-25. Short roping has limited application for military mountaineers. Short roping requires practice and the leader's full attention. In an operational environment, the military mountaineer's focus must be forward, looking for upcoming hazards or enemy contact. All Soldiers operating in the mountains, especially those working in small teams, should have the mobility skills to move in easy terrain.

**WARNING**

- **Only highly experienced master military mountaineers are qualified to short rope. They should only use short rope as part of a formal risk management process that identifies short roping as the appropriate risk mitigation method for the circumstances of the movement.**
- **Short roping is a high-risk activity that requires a deliberate risk mitigation process and commander approval.**

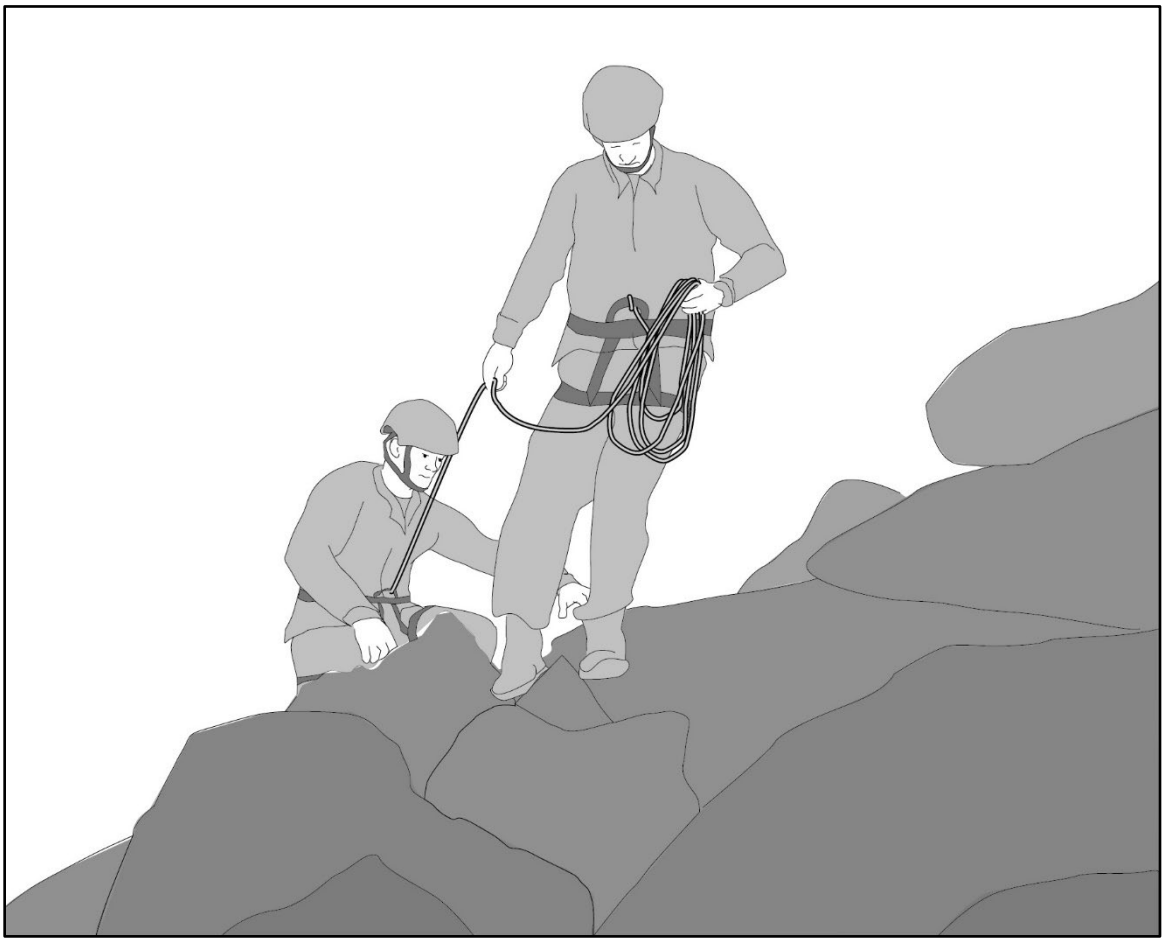


**Figure 10-4. Short roping**

## Short Pitching

10-26. Experienced leaders often combine short pitching with short roping as they manage less experienced Soldiers in 4th-class terrain. It is used when leaders need to use their hands to climb and cannot provide security with a short rope. Leaders place others in a safe position, and then scramble up the more technical section to a stance. From above, they can anchor or brace themselves to provide a belay as they climb. Often, because 4th-class terrain is more stepped, with plenty of ledges and stances, the leader can use simpler belay techniques and anchors than when rock climbing in 5th-class terrain and use a much shorter rope.

10-27. Most of the military mountaineer's time is spent avoiding the steepest and most difficult terrain. Operationally, they are more likely to use terrain where short pitching and simul-climbing would be most efficient. The techniques used in short pitching are faster than belayed climbing in longer pitches. A shorter rope helps with communication and fast transitions.

10-28. Short pitching requires training and practice in techniques to become safe and efficient. These techniques may not be as commonly practiced as other belay techniques, but they still have a place in alpine terrain, with good stances, and in positions where the second will not be stuck, hanging from the belay.

10-29. Hasty belays may be necessary during short pitching where anchoring options that are more substantial are not available. (See figure 10-5.) These involve leaders using their own body, positioned in a good stance, as the anchor or partial anchor. Ideally, the leader is also attached to a back-up anchor of some type, even if it does not meet the usual standards for a climbing anchor. This technique should only be used

by experienced advanced military mountaineers when operationally necessary or when no other secure anchoring or belaying technique is possible.



**Figure 10-5. Hasty belay**

## Shortening the Rope

10-30. When climbing in variable terrain, most pitches are short. This type of terrain is usually associated with 4th-class terrain. A full-length climbing rope is often too long and slows every transition with extra rope management. Teams may choose to carry shorter ropes if the terrain can be descended easily without long rappels, or they may choose to shorten their full-length climbing rope. Ropes are typically shortened for simul-climbing, short roping, and short pitching.

## Kiwi Coil

10-31. The Kiwi coil is the most common method of shortening a rope for climbing. (See figure 10-6, page 244.) After a climber ties into the end of the rope, the rope is coiled in a circular fashion, and then put over the shoulder of the climber. To secure this coil, a bight is run through the belay loop and around the coils. The bight is then tied off to the strand going to the other climber with an overhand on a bight, and a carabiner secures the bight to the harness. After the rope is shortened, team members can begin movement and adjust the length between them as necessary. Since the climber is tied into the end and the rope was shortened towards the other climber, it is easy to adjust the distance between climbers. This distance between climbers is usually dictated by the terrain. To lead a longer pitch, the coils can be removed from around the body. To stay closer to one another, the rope can be shortened.

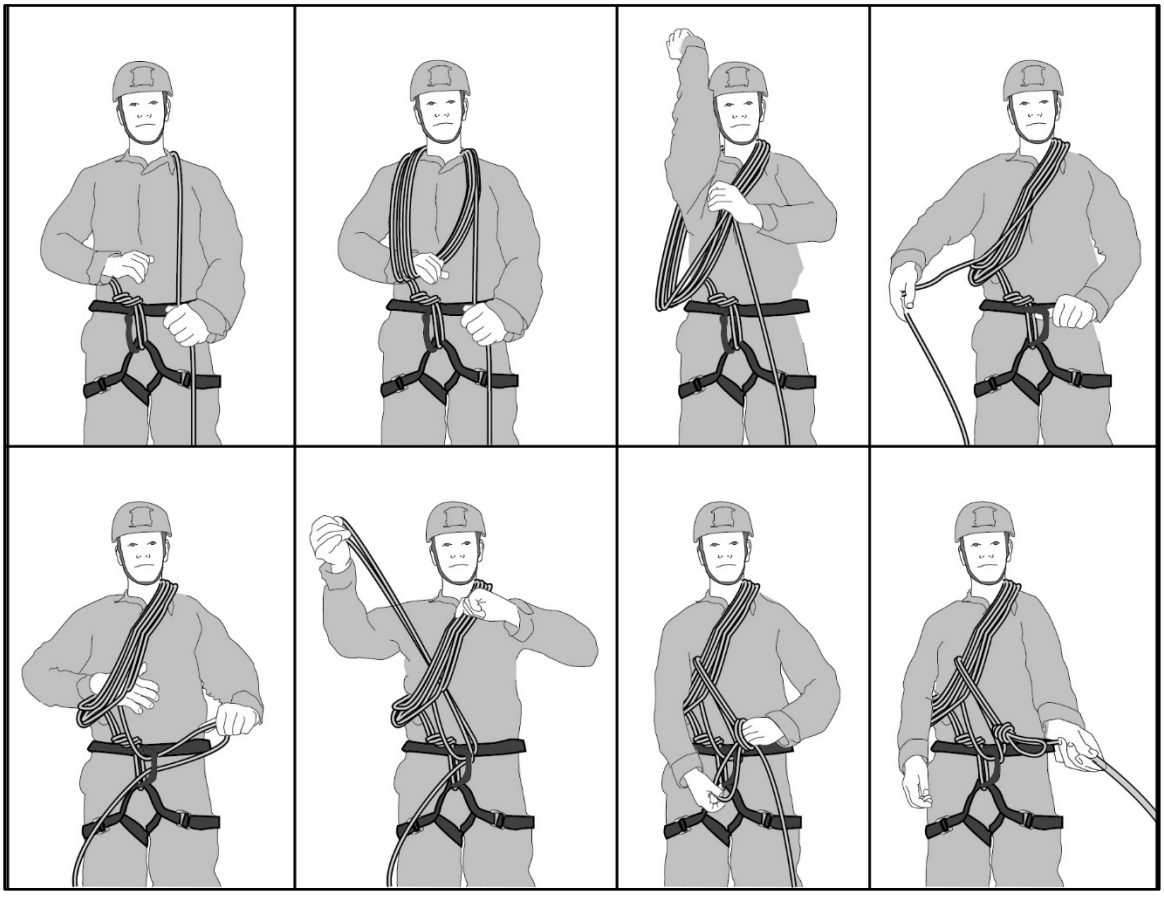


**Figure 10-6. Kiwi coil**

# OPERATIONAL CONSIDERATIONS

10-32. The various strategies and techniques described above for moving while roped will compromise speed and security. In a training environment, safety and conservative decision making must be the primary focus. As military mountaineers progress in their training, they may be exposed to alpine terrain above tree line. Weather and environmental hazards can pose a greater threat than falling. Each strategy for protecting the movement of the team is a compromise that should match the difficulty of terrain and the consequence of a fall. It should not expose the team to greater risk from another hazard. For combat operations, military mountaineers may need to compromise on protection and belays even further. Speed, stealth, and the ability to react are critical if enemy contact is expected.

## SECTION IV – TOP ROPE CLIMBING

10-33. A top rope is a belay in which both rope ends are on the ground and the rope runs up to the top of the cliff (or climb) and passes through a pre-established anchor point. This enables one Soldier to climb while the other Soldier belays. The belayer keeps the rope tight to prevent the climber from falling more than a short distance. This system also enables the belayer to lower the climber back down to the ground after completing the climb. (See figure 10-7 for an example of top rope climbing.)



**Figure 10-7. Top rope climbing**

10-34. A top rope is a training tool. It allows Soldiers to learn the fundamentals of tying in and belaying and to practice individual climbing techniques without the consequences of a long leader fall or unroped fall. It allows one instructor to coach and supervise both the climber and the belayer. It also facilitates learning the climbing technique because all participants can observe one another.

# EQUIPMENT CONSIDERATIONS

10-35. The UIAA develops safety and testing standards for mountaineering equipment. Equipment used for any mountaineering training should meet these standards as outlined in chapter 8 and appendix C.

## HELMETS

10-36. Helmets will protect a Soldier from rockfall and debris. They also offer some protection from impacts in a swinging fall. Climbing helmets are lightweight and certified to standards set by the UIAA.

10-37. Most units do not have access to climbing helmets. The combat helmet, while not rated or designed for impact protection from rockfall or in climbing falls, is already issued to most Soldiers and provides adequate protection.

## HARNESS

10-38. There are many types of climbing harnesses. Harnesses must be made and tested to UIAA standards, and users must ensure that wear and use conforms to manufacturer recommendations. The high-angle mountaineering kit (HAMK) is issued to units where most Soldiers have no formal mountaineering training. The harness that was selected for the HAMK (see figure 10-8), is a harness with a single, reinforced tie-in portion. It is a simpler harness than most recreational climbing harnesses. It is one-size fits all and easy to put on and inspect. It has one gear loop on the left side, which can be used to rack equipment. When worn, it should be tight around the waist, with the leg loops snug enough to take some of the force while falling or sitting into the harness.

10-39. If harnesses are not available, tubular webbing can be used to make field expedient harnesses, although this is not preferred. Soldiers must ensure their seats are tied correctly, and military mountaineers acting as safeties must carefully inspect several more points. This introduces several more points for human error.

10-40. The rappel seat (Swiss seat) should not be used as a climbing harness as it is not designed for this purpose. In addition to being uncomfortable, it quickly loosens with repeated loading and unloading.



**Figure 10-8. High-angle mountaineering kit harness tie-in**

## ROPE

10-41. Dynamic ropes are used for all climbing training. Dynamic ropes stretch and reduce the peak impact force felt by a climber in a fall. Falls while top roping should not generate as much force as a lead fall; however, if slack develops in the belay, such as from a stuck rope or slow belayer, there is potential for generating significant force.

10-42. Top rope training puts significant wear and tear on ropes. New climbers fall often, and because a rope may be used on the same climb for the entire day, there may be significant wear in the same sections of rope. Heavy-duty climbing ropes in the 10-mm range are recommended for top rope training. The 10.2-mm dynamic rope included in the ACTKs provides good durability.

# PREPARATION

10-43. Advanced and master military mountaineers should plan and supervise mountaineering training that involves roped climbing and rappelling. They advise the commander on training requirements, priorities, and equipment needs, as well as plan, organize, and conduct training.

### SITE RECONNAISSANCE

10-44. Visit the training area before the scheduled training date and conduct a rehearsal or walkthrough with key personnel. This will help proof the plan, identify hazards, and develop controls. It is also an opportunity to save time with set up by identifying anchors and cleaning the area of loose rock or other hazards ahead of time.

### TIME MANAGEMENT

10-45. Ensure the training plan provides ample time to cover movement, set up, demonstrations, and training time. Extra time for contingencies is often needed.

### COMMUNICATION

10-46. All key personnel should have reliable communication with each other to communicate changes to hazards or conditions or to coordinate the response to emergencies.

### PARTICIPANT-TO-INSTRUCTOR RATIO

10-47. Ensure an adequate number of trained personnel are available to effectively supervise the given number of participants. In cases where there are only one or two trainers working with a much larger group, it may be necessary to limit the number of Soldiers being trained at one time.

### ORGANIZATION OR PLACEMENT OF KEY PERSONNEL

10-48. Critical points must be identified, and key personnel must be placed or distributed to facilitate supervision of the training site.

### EMERGENCY AND MEDICAL EVACUATION PLANS

10-49. Emergency and MEDEVAC plans must include special equipment and must consider the nature of the terrain in the training area. These plans must be rehearsed to ensure the viability of the plan.

# TRAINING SITE CONSIDERATION

10-50. The following are important considerations when managing a top rope training site.

### EASE OF ACCESS

10-51. The top of the cliff must be accessible to safely establish the anchors and hang ropes. Otherwise, a climb may have to be led prior to rigging. The bottom of the cliff must be easily accessible for the group and have adequate space to safely move around and store equipment.

### LENGTH OF CLIMBS

10-52. The length of the climbs must be less than half the length of the available ropes. Longer climbs can be used by joining two ropes together but is more complex and should be avoided, if possible, when working with beginners.

### DIFFICULTY

10-53. Ensure the difficulty of climbing is appropriate for the Soldiers. A common mistake is to use climbs that are too difficult for Soldiers to learn the basic movement skills and establish confidence. It is best to have a variety of difficulty levels available.

### DISTANCE BETWEEN CLIMBS

10-54. Climbs should be far enough apart so that climbers are not falling on or swinging into other climbers; however, they should not be so far apart that supervision and control are hindered. With climbs in close proximity, the instructor can often maintain adequate supervision of more than one climb.

## TRAINING SITE ANCHORS

10-55. Anchors at training sites are built stronger and more redundant than others used in climbing. A top roping anchor is used for long durations of time and is often out of the user's sight. It either is loaded frequently, with climbers falling or as each climber is lowered back down to the ground. Extra care should be taken to avoid sharp edges and add padding where necessary.

### LOCATION OF ANCHORS

10-56. Anchors should be located directly above the climb. If the anchor is not above the climb, during a fall climbers will pendulum, swinging across the face until they are in line with the anchor. This is more pronounced the closer to the top the climber gets.

### CONSTRUCTION OF ANCHORS

10-57. Anchors must be strong and redundant. Developed climbing areas often have bolted anchors at the top of climbs. A top roping anchor can be built with these with a cord as for other applications. (See figure 10-9.) Locking carabiners may be substituted for non-locking carabiners to ensure that the anchor is secure, even if it is checked only a few times during the training day. If anchors are unavailable at the cliff edge or are not in line with the top of the climb, static rope can be used to extend anchors out over the edge of the cliff and create a master point that is in line. Anchor ropes should be at least 9.5 mm in diameter.

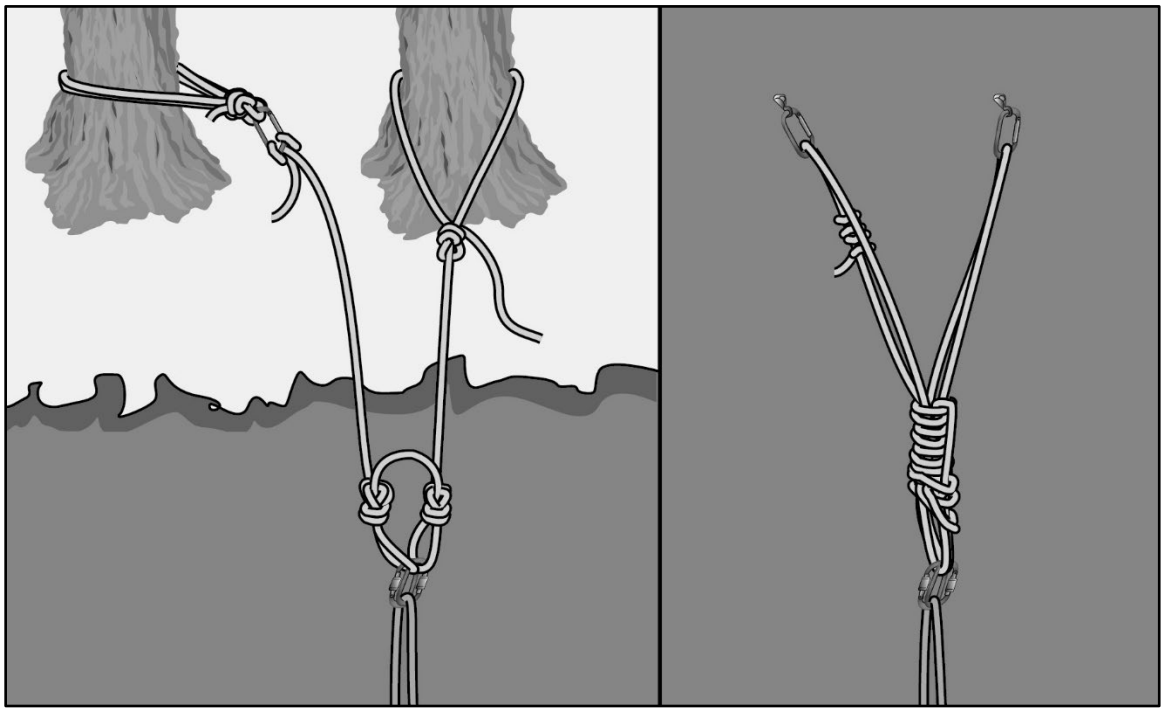


**Figure 10-9. Top rope climbing set up**

## INSPECTIONS

10-58. Inspection is one of the most critical components of any technical mountain training event. Many accidents can be attributed to lack of inspection or instructor error during the inspection process. Level 2 or

higher military mountaineers should inspect all rigging. The site should be organized in such a way that participants are unable to climb or proceed towards edges or dangerous terrain without first being inspected. Trainers must have a clear, logical sequence to follow when conducting inspections, whether it is anchor points, harnesses, tie-ins, rappel hook ups, or other. These should be conducted hands-on, not viewed from a distance.

# TOP ROPE BELAY

10-59. Top rope training develops two main skills. One is the individual mobility skill of the climber. The other is belaying. Belaying is the most important for safe training.

## POSITIONING THE BELAYER

10-60. The best position to catch a fall is directly below the anchor. The belayer will be pulled straight up and not off-balance. However, belayers should be offset enough so that the climber will not fall on them. They should also be positioned so that the rope will not interfere with climbers as they climb the route or entangle the climber in the event of a fall. The belayer should be protected from hazards, such as falling rock or ice. They should be placed into a protected feature under a roof or bulge or offset out of the path of any falling objects.

## ANCHORING THE BELAYER

10-61. Anchoring belayers can keep them from being pulled off their stance during a fall. It is not always necessary, but the decision not to anchor should be deliberate. It is recommended that the belayer is anchored when—

- Belayers are inexperienced and may lose control of the belay if they are pulled up.
- The climber severely outweighs the belayer.
- It is necessary to keep them from being pulled into hazards and obstructions.

## BACK-UP BELAYER

10-62. Using back-up belayers can achieve several things. Back-up belayers improve the overall security of the climbers, since it decreases the likelihood that a Soldier could be dropped to the ground. Back-up belayers help to convey the importance of the belay when learning is first taking place and keeps additional Soldiers occupied and focused when unit trainers are working with large numbers of participants. To provide a back-up belay, one Soldier stands just behind the primary belayer, on the brake-hand side, and keeps additional control of the rope while making sure not to interfere with the primary belayer's movements.

## BELAYING WITH A TUBE-STYLE DEVICE

10-63. A belay device acts as a brake on the climbing rope by applying friction to it. The device, plus the belayer's braking hand, keeps tension on the rope in the event of a fall and helps protect the climber at the other end. It is an essential device for climbing safety.

10-64. Tube-style devices are the most used belay devices. (See figure 10-10.) They are lightweight, simple, and do not twist the rope. The brake position with a tube-style device is down, with the brake hand below the device, creating two sharp bends in the rope that provide the necessary friction. Attention must be paid to the belay technique, as there is very little friction outside of the brake position.

- Place a locking carabiner into the tie-in portion of the harness or into the belay loop. Thread a bight of the climbing rope through the tube slot of the device opposite the side of the keeper loop. Attach both the bight of rope and the keeper loop to the carabiner and lock the gate.
- To take in the rope, grasp the brake strand a few inches from the device and with the thumb pointed towards the device. Reach out and place the guide hand on the load strand with the thumb pointed up. Pull down with the guide hand and up with the brake hand simultaneously until the brake strand is approximately 1 foot away from the waist. Return the brake strand immediately to the brake position (below the device). Move the guide hand down to the brake strand just underneath the brake hand and slide the brake hand back to within a few inches from the device. Reach back up to the load strand with the guide hand and repeat.
- Never let go of the brake strand. The climber's life depends on it.

- To lower the climber, remove all slack from the system. Hold the brake strand in the brake position with both hands, and feed rope slowly back through the device until the climber is safely on the ground. (See figure 10-11, page 252.)

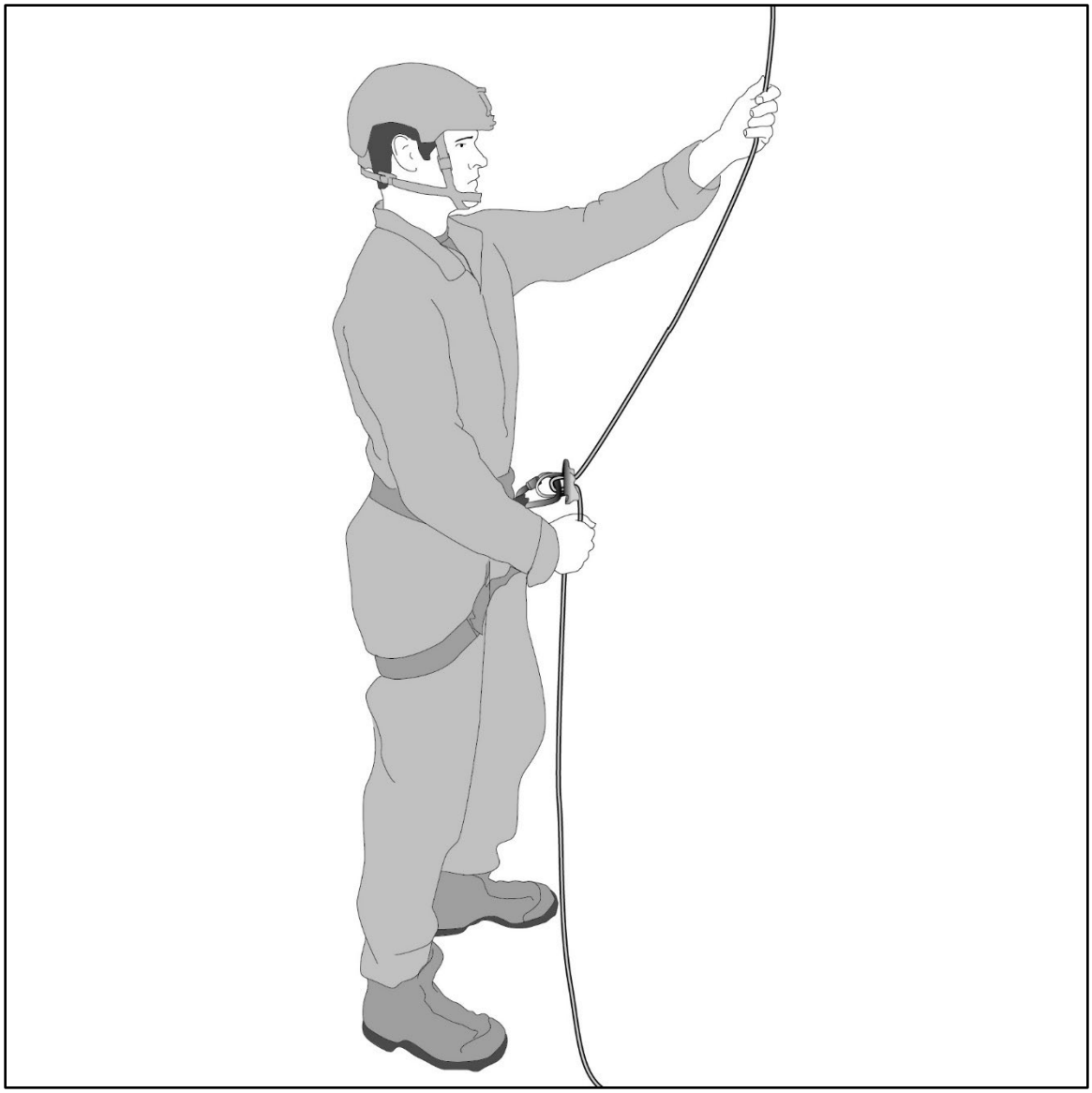


**Figure 10-10. Top rope belay with tube-style device**

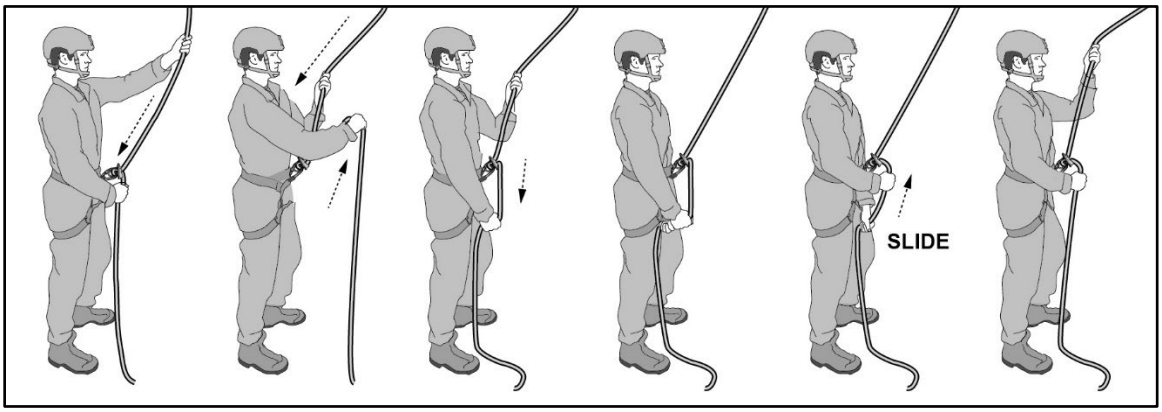



**Figure 10-11. Tubular device belay action**

## BELAYING WITH A MUNTER HITCH

10-65. The Munter hitch is rarely used for top roping, but for units that are not fielded mountaineering kits, it provides an adequate belay. It has the advantage of requiring no extra equipment and maintaining a sufficient level of friction to stop a fall with the brake strand in a variety of positions. Its main disadvantage is that it twists and kinks the rope.

- Place a locking carabiner into the tie-in portion of the harness. Tie a Munter hitch in the climbing rope and clip it into the carabiner for either a right-hand or a left-hand brake. Lock the carabiner.
- To take in rope, grasp the brake strand with the brake hand a few inches away from the Munter hitch and with the thumb pointed up. Pull down with the guide hand and up with the brake hand simultaneously until the brake hand is just below the guide hand. With the guide hand, grasp both ropes just above the brake hand, and then slide the brake hand back down to its original place, a few inches from the Munter hitch. Reach back up the rope with the guide hand, and repeat.
- During a fall, the bight of the Munter hitch will pass from the brake side of the carabiner to the guide-hand side. The hitch creates enough friction for the belayer to easily hold the climber's body weight. The brake position for the Munter hitch is with the brake strand and the load strand parallel.
- Never let go of the brake strand.
- To lower the climber back down, place both hands on the brake strand and feed the rope slowly back through the Munter hitch until the climber is safely on the ground. (See figure 10-12.)

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***Note***. Do not put the brake hand too close to the Munter hitch. Fingers caught in the Munter hitch could cause a mountaineer to lose control of the brake, dropping the climber.

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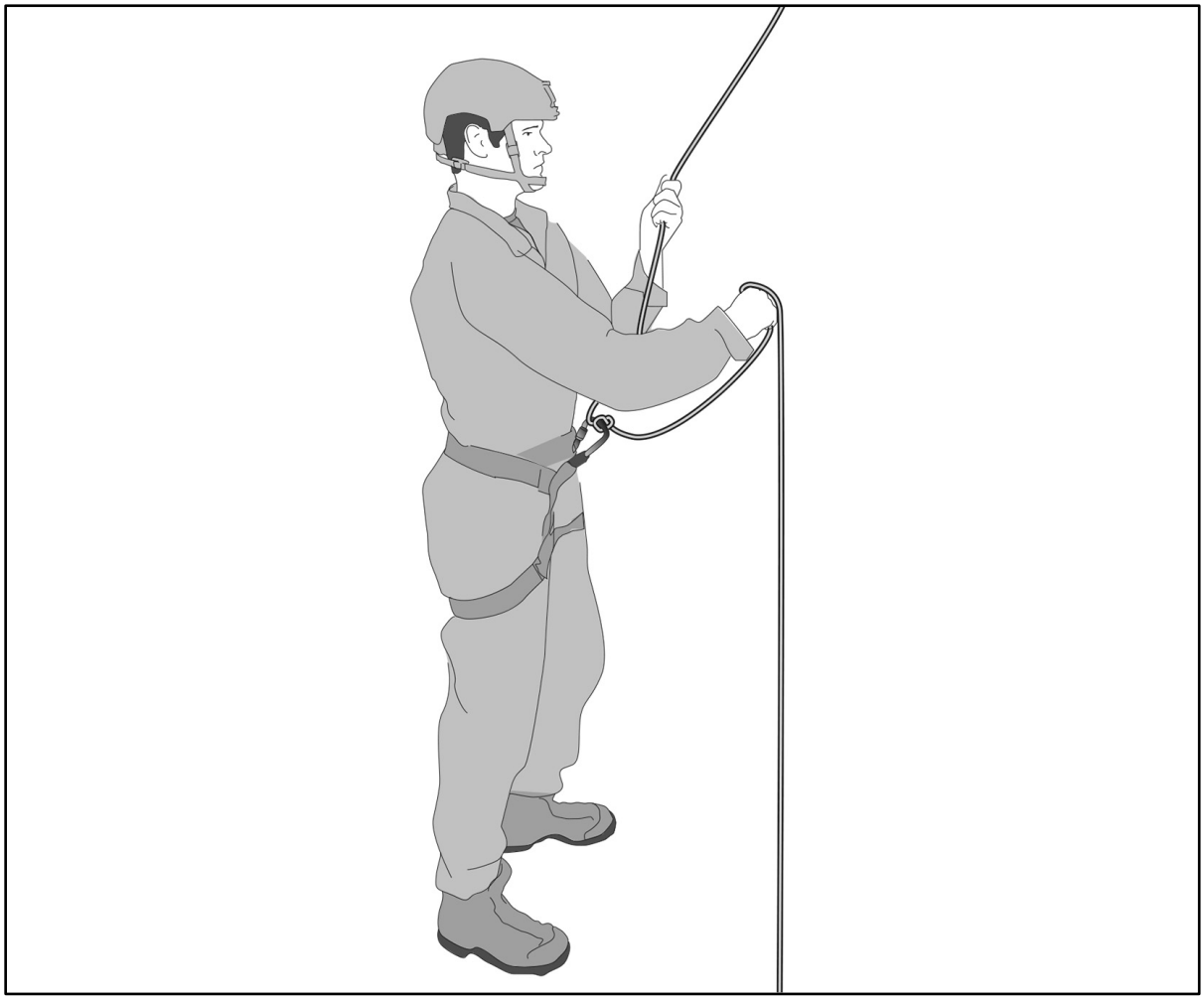


**Figure 10-12. Munter belay technique**

# CLIMBING COMMANDS

10-66. Using standardized verbal climbing commands is a necessary safety protocol to ensure both members are ready before any actions are taken. Commands while top roping also teach proper communication before introducing lead climbing, where communication may occur over a much longer distance. Clear communication minimizes the chance of human error and helps to ensure safe operation of the belay. All commands must be preceded by the other Soldier's first or last name, like a radio transmission, to gain the other Soldier's attention. This is especially important at training sites where there are multiple top rope climbs set up nearby to avoid confusion.

10-67. Units and schoolhouses should develop their own SOPs to determine appropriate commands. Consider the following when choosing these terms:

- Avoid using terms that sound alike or may be confused with another word (for example, GO, SLOW, and WHOAH may sound like NO and vice versa).
- Avoid using words that are not definitive (for example, GOOD is a vague term that does not define any specific action).

10-68. Table 10-1, page 254 lists common terms that are widely used. To manage risk and avoid confusion, consider these commands as the bare minimum associated for top rope climbing. Units or schoolhouses may add additional commands if they feel they are necessary to help further mitigate risk.

**Table 10-1. Climbing commands**

| *Belayer* | *Climber* | *Command Description* |
|---|---|---|
| | THAT'S ME | This command is said when the climber feels tension from the rope as the belayer takes all the slack out of the system. This command is intended to let belayers know that they have tension to the climber and the rope is not caught somewhere. |
| BELAY ON | | This command is given when all slack between the climber and belayer has been taken out of the rope, and the belayer has control of the break strand with at least one hand. |
| | SLACK | The climber may use this command to release some tension in the rope. This may be necessary in situations where the rope may be caught on a flake of rock and the climber can safely adjust it. |
| | TAKE | This command is used to tell the belayer to take in more rope. It is also used when there is unwanted slack in the system, climbers have reached the top of the climb and are preparing to be lowered down, or if they feel they may fall and would like additional tension. |
| ROCK or ICE | ROCK or ICE | This command is used to describe any falling object. Anyone can use this command, when necessary. |
| I'VE GOT YOU | | The command is given when the climber reaches the top or needs to be lowered for any reason. The belayer will say TAKE, place two hands on the brake strand, and then give the command. |
| | ON YOU | Once climbers sit back into their harnesses and are ready to be lowered, they will give the belayer this command. The belayer should never begin to lower the climber until this command is given. |
| | BELAY OFF | Once climbers are safely on the ground and have good footing, they will give this command to let the belayer know they can take them off belay. |

## SECTION V – LEAD CLIMBING

10-69. Lead climbing is where a roped team has one climber take the lead while the other climber follows. While ascending the route, the lead climber periodically connects the rope to protection for safety in the event of a fall. This protection can consist of permanent bolts to which the climber clips quick draws, or removable protection, such as nuts and cams. One of the climbers below the lead climber acts as a belayer. The belayer gives out rope while the lead climber ascends and stops the rope when the lead climber falls or wants to rest.

10-70. In military mountaineering, the primary mission of a roped climbing team is to fix a route with some type of rope installation to assist movement of less trained personnel in the unit. This duty falls upon the most experienced climbers in the unit, usually working in two- or three-man groups or teams. Even if the climbing is for another purpose, roped climbing should be performed whenever the terrain becomes difficult and exposed.

10-71. Units or schoolhouses should develop their own SOPs for lead climbing commands and establish alternative means of tactically communicating actions while lead climbing. Examples of climbing commands are described in table 10-1 in the top rope section.

# EQUIPMENT CONSIDERATIONS

10-72. The ACTK contains the equipment necessary for lead climbing operations and includes mountaineering harnesses, chocks, and cams in a wide variety of sizes, locking and nonlocking carabiners, dynamic climbing rope, webbing and accessory cord, ascenders, and belay devices. The specific use of this equipment is described in chapters 8 and 9.

10-73. The snow and ice mobility kit (SIMK) is designed to outfit a platoon with safety and mobility equipment for operations in snow- and ice-covered mountainous terrain. This kit will be required if moving through this type of terrain and the specific use of this equipment is described in chapters 6 and 15.

## HELMETS

10-74. As outlined in chapter 6, lighter weight or climbing-specific helmets offer several advantages and are recommended for lead climbers.

## HARNESS

10-75. The ACTK contains three basic mountaineering harnesses. These harnesses are a bare minimum, and lead climbing in any type of field expedient harness is not recommended. Lead climbing requires much more gear than general mountaineering tasks, so harnesses with additional features can increase efficiency and functionality. (See figure 10-13.) Typical features of harnesses well-suited for lead climbing are—

- Adjustable leg loops with buckles.
- Four or more gear loops designed to hold extra gear.
- Thick and durable padding increases comfort when spending a long time in the harness.
- Extra lumbar padding helps to stabilize the lower back and waist.

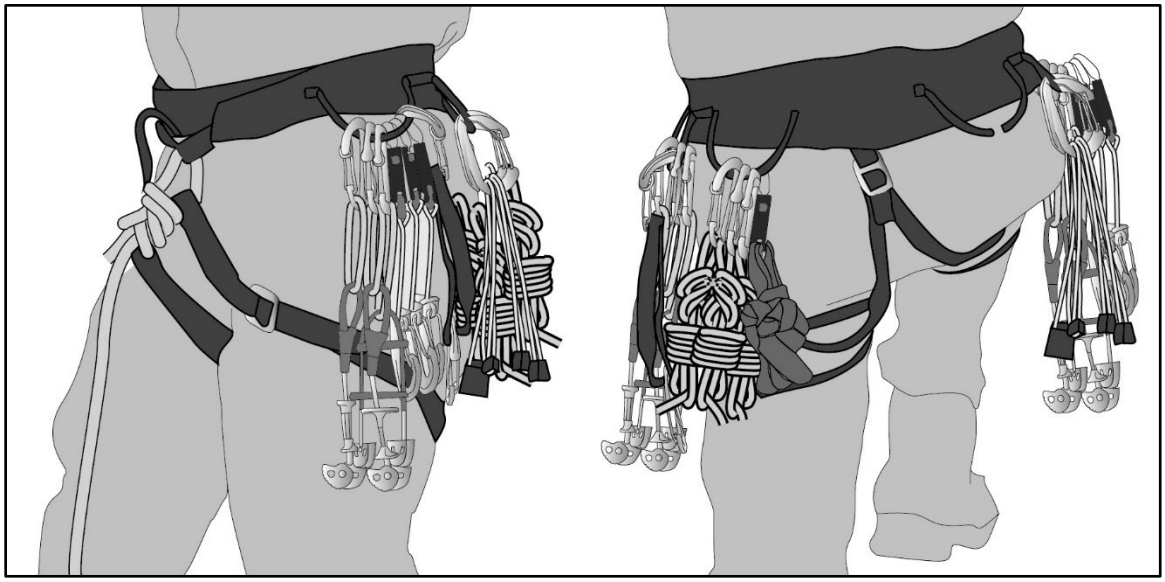


**Figure 10-13. Climbing harness tie-in and equipment racking**

## ROPE

10-76. Lead climbing can be protected by different rope systems. The UIAA develops safety and testing standards for mountaineering equipment. It sets standards for three different types of climbing rope: single ropes, half ropes, and twin ropes.

### Single Ropes

10-77. Single ropes are the most common type of climbing rope. Diameters can range from 8.9 to 11.1 mm.

### Half Ropes

10-78. Half ropes are a set of two ropes that are clipped separately into points of protection. This reduces friction and rope drag during long wandering routes and serves as a second rope for longer rappels. The disadvantage to half ropes is the increased complexity required for both the climber and belayer to manage these ropes separately. The diameters for half ropes can range from 8 to 9 mm. Half ropes are used for a party of two in wandering alpine terrain, on rock, or on ice.

### Twin Ropes

10-79. Twin ropes are also a set of two ropes, but both strands are clipped into each point of protection and managed as one rope. Diameters for twin ropes range from 7 to 8 mm. Twin ropes are primarily used on routes needing two ropes for rappels.

***Note***. Some ropes may hold more than one, or all, of these certifications, which can add to confusion during rope selection. Weight, versatility, and durability should be the primary considerations. In most cases, lightweight, single ropes offer the best balance of these factors.

## PROTECTION

10-80. The amount of protection the lead climber brings depends upon the character of the climber and the skill of the lead climber. In easy alpine terrain, the rack may be just a few pieces of rock gear to protect exposed steps and make simple anchors. Protecting sustained, multipitch rock may require a rack of doubles, two sets of the entire size range of cams.

10-81. The presence of pre-established anchors or bolts found in some commonly used training areas are some of the biggest variables in protection. Climbing a route that has bolts placed for protection, known as sport climbing, provides security and allows the climber to carry less equipment. Sport climbing is useful for training purposes only. Sport climbing provides a safe way to introduce climbers to lead climbing and allows more experienced climbers to work on climbing terrain that is more difficult without having to place traditional protection.

10-82. In winter and alpine environments, ice screws must be incorporated.

## ROCK SHOES

10-83. Rock shoes are specialized pieces of equipment that are only necessary when moving through difficult technical terrain. The practical application of this equipment is limited operationally but can greatly enhance climbing training and should be utilized when building Soldiers' skillset in rock climbing. These specialized shoes provide more friction, support, and precise footwork, allowing the Soldier to move more effectively through the terrain. (See figure 10-14.) It is a common misconception that climbing is about upper-body strength. Climbing requires a lot of upper-body strength, but the legs typically propel the climber up the wall. The reason Soldiers fall while learning how to rock climb is typically some failure of their foot placement. While lead climbing, especially when learning, rock shoes are invaluable in managing risk by increasing the security of foot placements and reducing the likelihood of a fall.

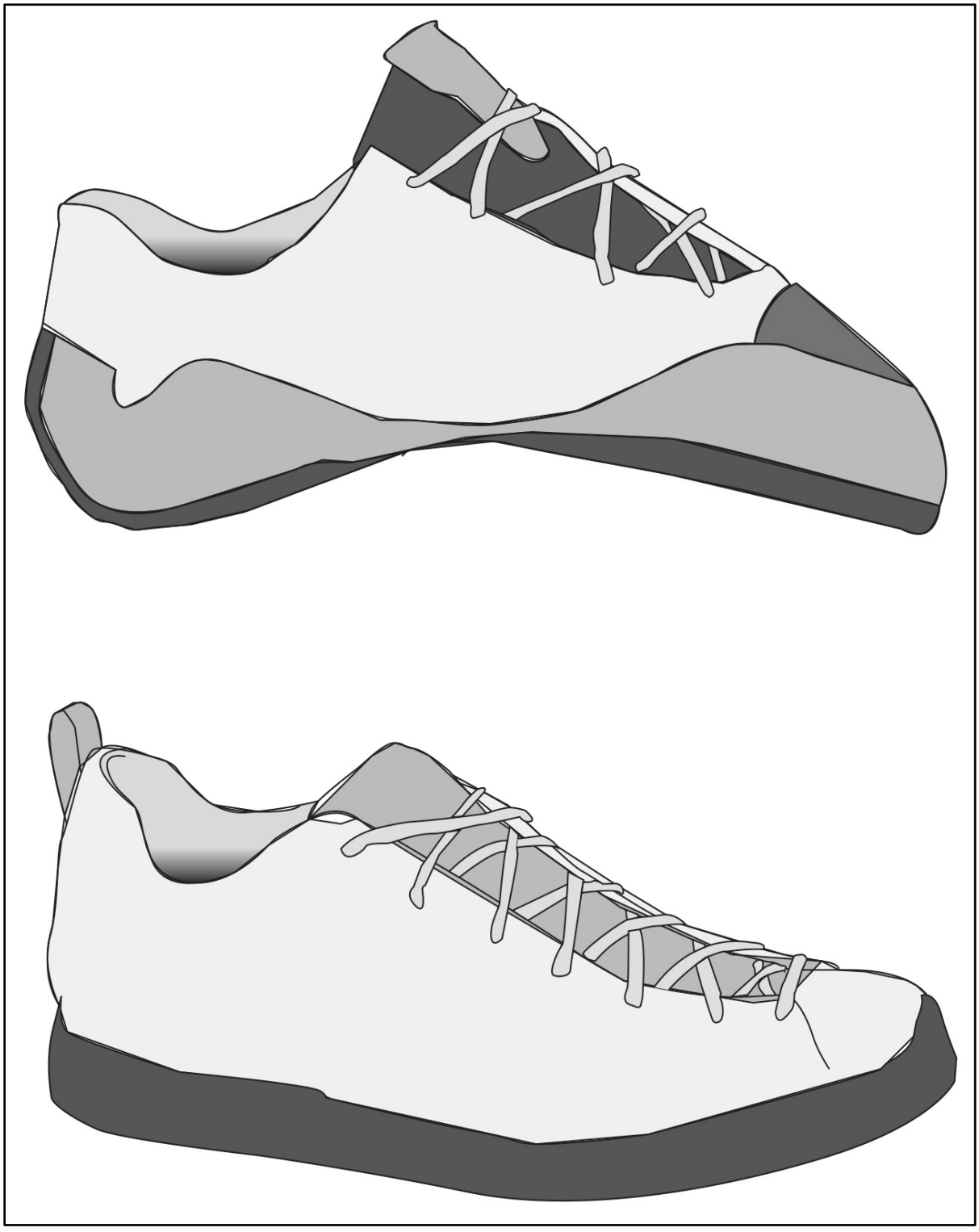


**Figure 10-14. Rock-climbing shoes**

# BELAYING A LEAD CLIMBER

10-84. Belayers must first identify a place to stand when belaying that is free from rockfall or other objective hazards they can trip over or be pushed into. Belayers must also achieve an adequate stance or brace their body positions to help absorb the energy from a lead fall. They should consider attaching themselves to an anchor near the ground to help prevent being pulled off their stance and losing control of the belay. (See figure 10-15.) The climbing rope should then be back stacked, and both climber and belayer will tie into the appropriate ends of the rope.

10-85. The best position to catch a fall is directly below the first piece of protection. Belayers will be pulled straight up and not lose their balance. However, they should be offset enough so that the climber will not fall directly on them. The belayer should be positioned so that the rope does not interfere with the climber as they climb the route, and they do not become entangled in it in the event of a fall.

10-86. As the leader climbs, the rope is fed out ensuring that climbers have full freedom to move, and they are not hindered by the rope. Ensure that there is always a slight sag in the rope, but no more. Anticipate the climber's movements and be prepared to feed rope out quickly when protection is being clipped. If belayers cannot see the climber, they must feel the climber through the rope. Unless the climber says otherwise, the belayer can slowly give slack on the rope as the climber proceeds on the route. The belayer should keep just enough slack in the rope so the climber does not have to pull it through the belay. If climbers want a tighter rope, they can call for it. If belayers notice too much slack developing in the rope, they should take in the excess rope quickly. It is the belayers' responsibility to manage the rope, whether by sight or touch, until the climber tells them otherwise.

10-87. To catch a fall, immediately drop the guide hand down next to the brake hand and lock the rope off in the brake position. Bend the knees slightly to help absorb the impact.

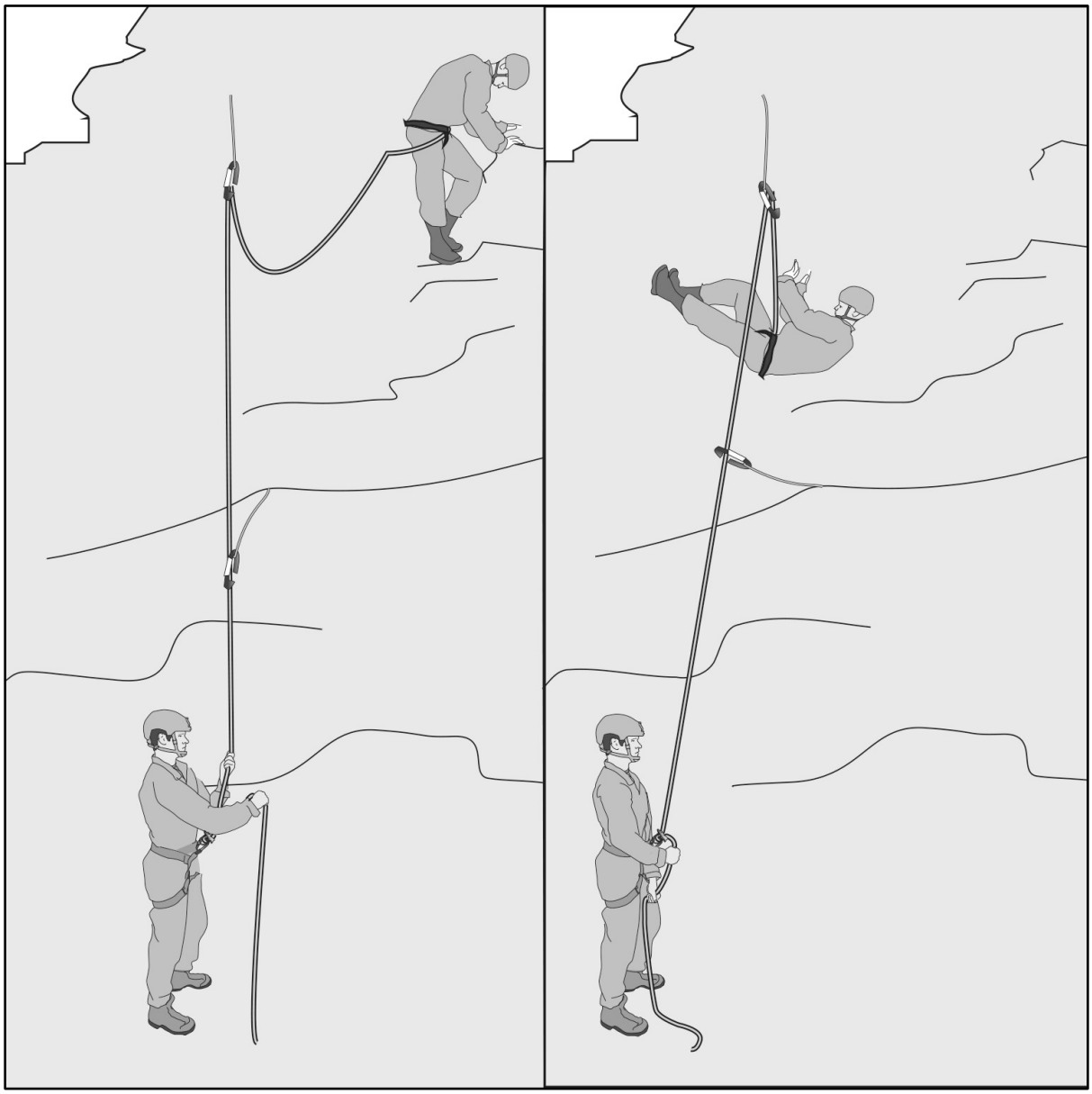


**Figure 10-15. Belaying the lead climber**

# LEAD CLIMBER

10-88. Lead climbers have a lot to consider while climbing. **A *lead climber* is the first climber to negotiate a route, for whom a top belay is not possible, and who assumes the most risk of injury in a fall**. They should spend sufficient time reviewing the various techniques available for protecting themselves and their followers before selecting one, as well as preparing their equipment for efficient use before beginning a climb.

## RACKING

10-89. The protection the lead climber brings with them is referred to as the rack. The term racking is simply the process a climber goes through to prepare the equipment for climbing. Racking should be organized so the right gear can be found and accessed quickly. Equipment should be spread out between a gear sling over

the shoulder and the gear loops on the harness. The specific location and order of placement of the protection falls to personal preference, but there should be a logical sequence to the process.

## CLIMBING

10-90. The procedures for conducting a lead climb with a group of two are relatively simple. The most experienced individual is the lead climber or leader. Leaders are responsible for selecting the route. They must ensure that the route is well within their climbing ability and that of the second climber ("second"). The lead climber carries most of the climbing equipment to place protection along the route and set up the next belay. The leader must also ensure that the second has the necessary equipment, such as a chock pick, to remove any protection that the leader may place.

10-91. The leader is responsible for emplacing protection frequently enough and in such a manner that if either the leader or the second should fall, their fall is neither long enough nor hard enough to result in injury. The leader must also ensure that the rope is routed so that it can run freely through the protection placements, thus minimizing friction, or rope drag.

10-92. The other member of the climbing team, the second, is responsible for belaying the leader, removing the belay anchor, and retrieving the protection placed by the leader between belay positions (also known as cleaning the pitch).

10-93. The leader continues the route until either a designated belay location is reached, or the near end of the rope is reached. At this position, the leader sets an anchor, connects to the anchor, and says OFF BELAY. The belayer remains attached to the anchor until the command BELAY ON is given.

10-94. Leading a difficult pitch is the most hazardous task in roped climbing. Lead climbers may be exposed to potentially long, hard falls. They must exercise keen judgment in selecting routes, placing protection, and routing climbing rope through the protection. Every effort should be made to keep the climbing line as direct as possible to the next belay to allow the rope to run smoothly through the protection with minimal friction. Protection should be placed whenever the leader feels it necessary to prevent hazardous situations and before moving past a difficult section.

## PLACING PROTECTION

10-95. Generally, protection is placed from one stable position to the next. If the climbing is difficult, protection should be placed more frequently. If the climbing becomes easier, protection can be placed farther apart, saving hardware for difficult sections. On some routes, an extended diagonal or horizontal movement, known as a traverse, is required. As leaders begin this type of move, they must consider the second's safety as well as their own. The potential fall of the second will result in a pendulum swing if protection is not adequate to prevent this. The danger comes from any objects in the swinging path of the second.

## REDUCING ROPE DRAG; USING RUNNERS

10-96. No matter how direct the route, the climber often encounters problems with rope drag through the protection positions. Rope drag is caused when there are exaggerated changes in direction of the rope between carabiners attached to protection that creates excessive friction. Minimal rope drag is an inconvenience; severe rope drag may pull the climber off balance, inducing a fall. When belaying the second, rope drag can be mistaken for the climber, causing the belayer to not take in the necessary slack. This can potentially result in a serious fall. To prevent this, the placements should be extended by using runners, when necessary, so the rope creates a smooth, almost straight line as it passes through the carabiners. (See figure 10-16.) Do this by attaching an appropriate-length runner to the protection to extend the rope connection in the necessary direction. The runner is attached to the protection while the rope is clipped into a carabiner at the opposite end of the runner. Extending placements with runners allows the climber to vary the route slightly while the rope continues to run in a relatively straight line.

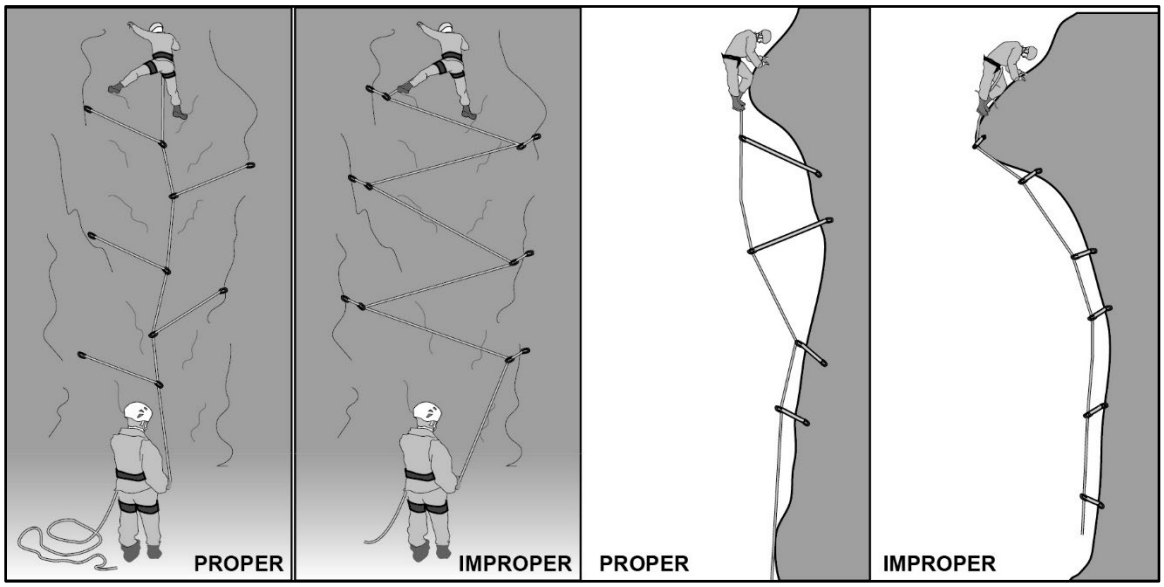



**Figure 10-16. Use of runners to extend and reduce rope drag**

10-97. Not only is rope drag a hindrance, but it can also cause undue movement of protection as the rope tightens between any out of line placements. Rope drag through chock placements can be dangerous. As the climber moves above the placements, an outward or upward pull from rope drag may cause correctly set chocks to pop out, even when used correctly. Passive protections, like chocks, are especially prone to wiggling loose as the rope pulls on the cable attachment. All wired chocks used for leader protection should be extended to reduce the chance of the rope pulling them out. (See figure 10-17, page 262.)

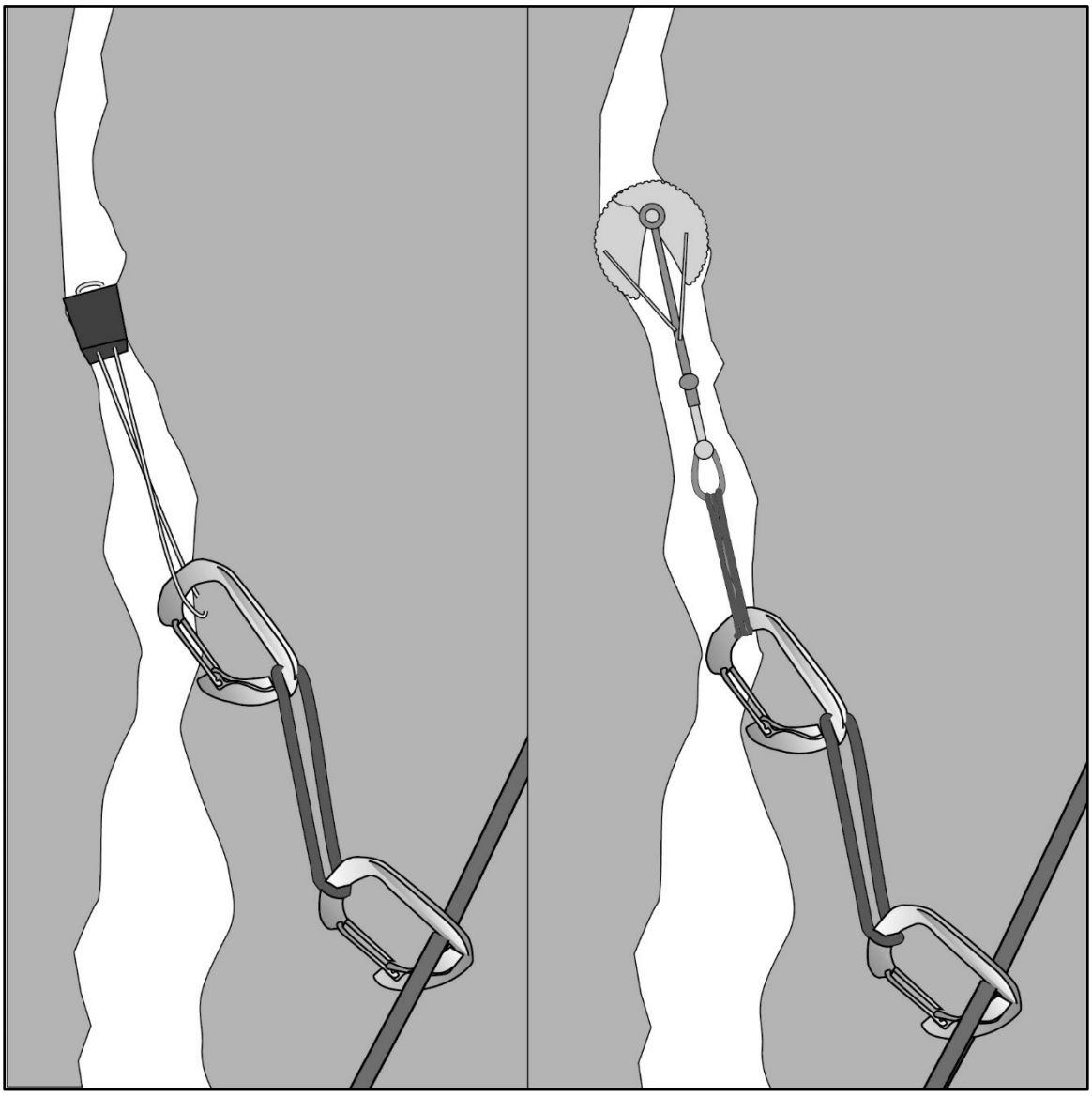


**Figure 10-17. Proper extension of cams and chocks using runners**

## CLIPPING TECHNIQUE

10-98. Clip the climbing rope into a point of protection by reaching down and grabbing the rope between the thumb and index finger. Use the middle finger to stabilize the carabiner at the protection or runner, and use the thumb and index finger to clip the rope in. Alternately, the rope can be held between the middle and index finger and clipped in as shown in figure 10-18. Ensure the gate of the carabiner faces out (not towards the rock), and the rope is clipped in the direction of travel to prevent the rope from potentially becoming unclipped in a fall. Recreational climbers typically do all their clipping while hanging onto rock holds as much as they can; however, as a Soldier not worried about preserving the free climbing style, simply grab the point of protection and hang onto it while clipping the rope and runner into it. This may provide better temporary hold or provide a much-needed rest.

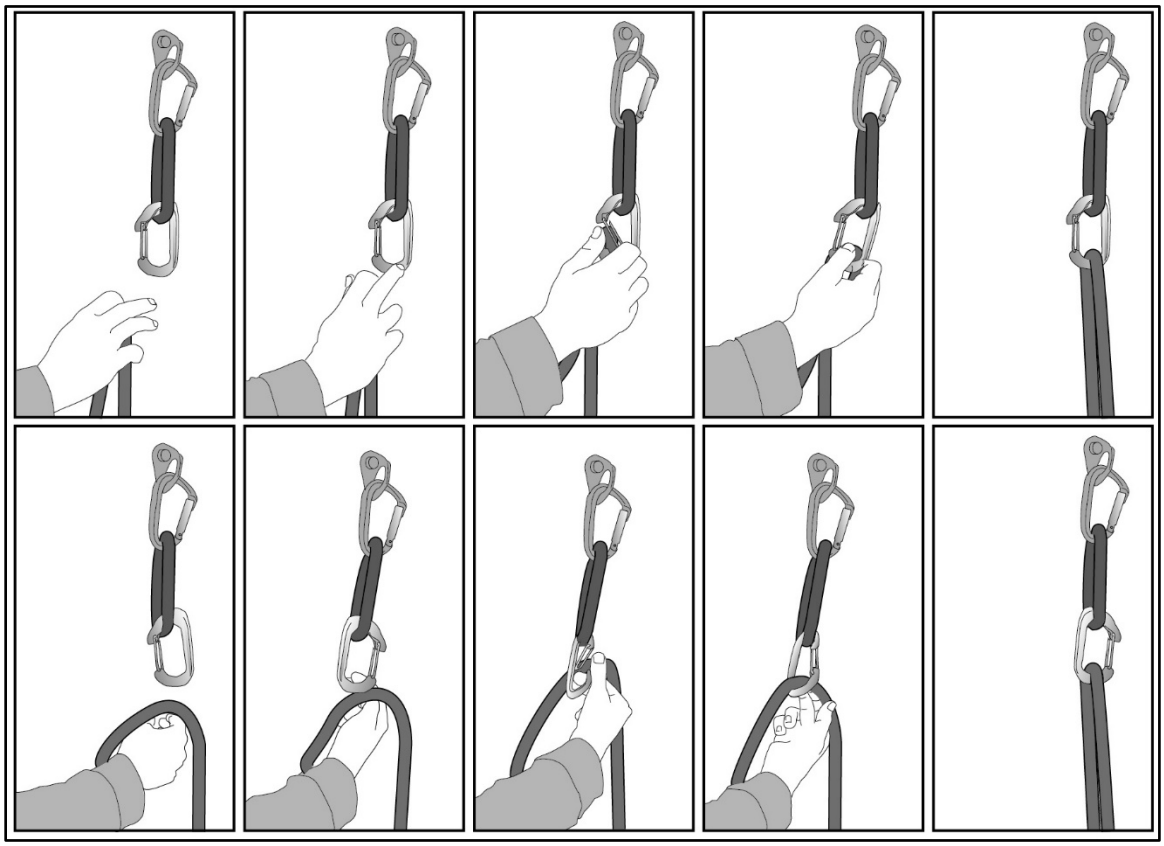


**Figure 10-18. Proper clipping techniques**

## BELAYING A SECOND CLIMBER

10-99. Typically, one climber takes the lead while belayed from below, moves up the route to the next ledge or desired spot, and then sets up a new anchor and belay. This distance between these belays is known as a pitch. The length of a pitch is limited to the length of available rope and convenient, suitable to belay positions.

10-100. In most cases, the leader attaches to the anchor with either separate sling material or by using the climbing rope with a clove hitch and locking carabiner. Using a clove hitch in the climbing rope itself has the distinct advantage of allowing more room and material to fine tune the distance between the anchor and the cliff edge to enable better communication with the climber below. The leader then uses the command of OFF BELAY. Once the belayer has removed the belay, enabling the rope to run freely, the belayer would use the command BELAY OFF. The leader then pulls in all the remaining rope until it is tight with the second. Once an appropriate belay is set up, the leader uses the command BELAY ON letting the second know that it is safe to climb.

10-101. Many techniques can be used to belay the second, depending upon the terrain, difficulty of the climbing, availability of anchors, and likelihood or consequences of a fall. The second is essentially on a top rope, with a snug rope being maintained throughout the climb.

## INDIRECT BELAYS

10-102. An indirect belay occurs when a leader is anchored and belays the second off the harness with either a Munter hitch or tube-style belay device. While this does work, it has several drawbacks. It can oftentimes be quite awkward in the event of a fall that pulls the belayer down towards the ground or if there is a climber who is struggling and hanging excessively on the rope. The belayer is forced to hold the rope in the brake position with much or all the climber's weight pulling in a downward direction on the harness. Additionally,

should belayers need to tie off the climber and escape the belay for any reason, several steps would be required to free themselves from the system. For these reasons, this technique is only preferred when using an anchor that is suspected to be weak. With a weak or bad anchor, belayers' bodies, in this case, act as the primary anchor with the other simply backing them up. Once again, a good, braced position is necessary. The preferred technique otherwise is to always use direct belays.

## DIRECT BELAYS

10-103. Belaying directly off the anchor allows any forces to be transmitted solely to the anchor so that the belayer is not pulled in any direction and cannot become trapped in the system should problems arise. Direct belays are also generally more comfortable and give the belayer freedom to move while maintaining control of the brake rope. This can be done either using a Munter hitch or using a plaquette-style belay device in guide mode. In either case, the first step is for the climber to attach to the anchor and shout, OFF BELAY. Pull the remainder of the rope up until the second shouts, THAT'S ME. Then use one of the following belay methods: the Munter hitch or the autolocking tubular device in guide mode.

### Belaying with the Munter Hitch

10-104. Using a Munter hitch as a belay is quick, easy to tie, and can be used to easily lower the second back down, if necessary. It is an alternative in case a Soldier does not have a belay device. Attach a locking carabiner to the anchor master point, pull the slack out of the rope to the climber below, and tie a Munter hitch with the climbing rope. (See figure 10-19.)

10-105. Place the guide hand on the load strand and the brake hand on the brake strand a few inches away from the Munter hitch, ensuring both thumbs are pointing towards the anchor. To take in rope, hold firmly and slide both hands towards each other until they meet. With the guide hand, grab both strands of rope just beneath the brake hand, then slide the brake hand back up to within a few inches of the Munter hitch. Slide the guide hand back down and repeat. Care should be taken to ensure that the brake hand does not get so close to the Munter hitch that a thumb or finger could be sucked in and pinched during a fall.

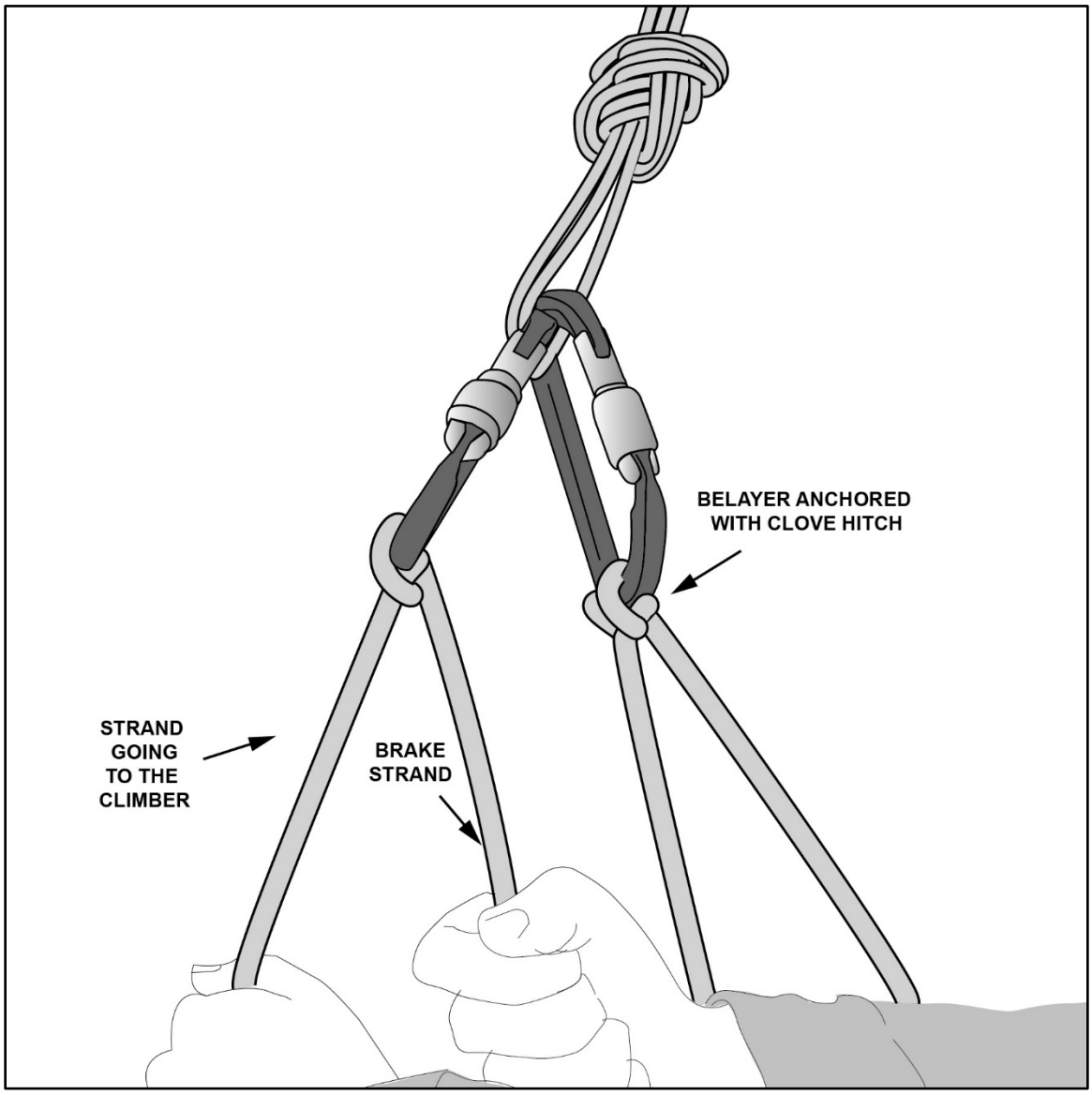



**Figure 10-19. Belaying using a Munter hitch**

## Autolocking Tubular-Style Device

10-106. The tube-style belay or rappel devices issued in the Army mountain kits can be used in guide or autolocking mode. To use this device in autolocking mode, a locking carabiner is clipped through the metal loop and attached to an anchor. A bight of rope is then fed into the device, with the climber's strand on top, and a second "braking" locking carabiner is clipped through the device's carry wire and the bight of rope. One locking carabiner is used to attach the device itself to the anchor, and a second is used as a braking carabiner after the rope is fed through the device. The shape and orientation of the device allows rope to pass smoothly through it in one direction, but lock off in the opposite direction, being pinched around the stock of the braking carabiner. (See figure 10-20, page 266.)

10-107. To use the device, attach it to the anchor with a locking carabiner in the appropriate spot. Then feed a bight of rope into the device, paying close attention to the diagram on its side. Clip an additional locking carabiner around both the rope and the keeper, ensuring again that the brake strand is between the Soldier's body and the load rope. Pull down on the load rope to make sure it is rigged correctly and locks off in the

correct direction before shouting ON BELAY. To take in rope with a device in guide mode, use the same technique described above for the Munter hitch.

10-108. One advantage of these devices over the Munter hitch is that they do not require holding power on the part of the belayer because they lock off automatically, oftentimes allowing the belayer to multitask at the anchor. They can also be used when using half or twin ropes or when belaying two seconds simultaneously on two separate ropes. They are particularly useful in these situations or if the climbing is difficult and the second is expected to be hanging a lot. A disadvantage is that since it only allows rope to pass through in one direction, giving "slack" or lowering a climber back down requires additional training.

***Note***. Never use a device in standard tube-style mode to belay directly off the anchor.

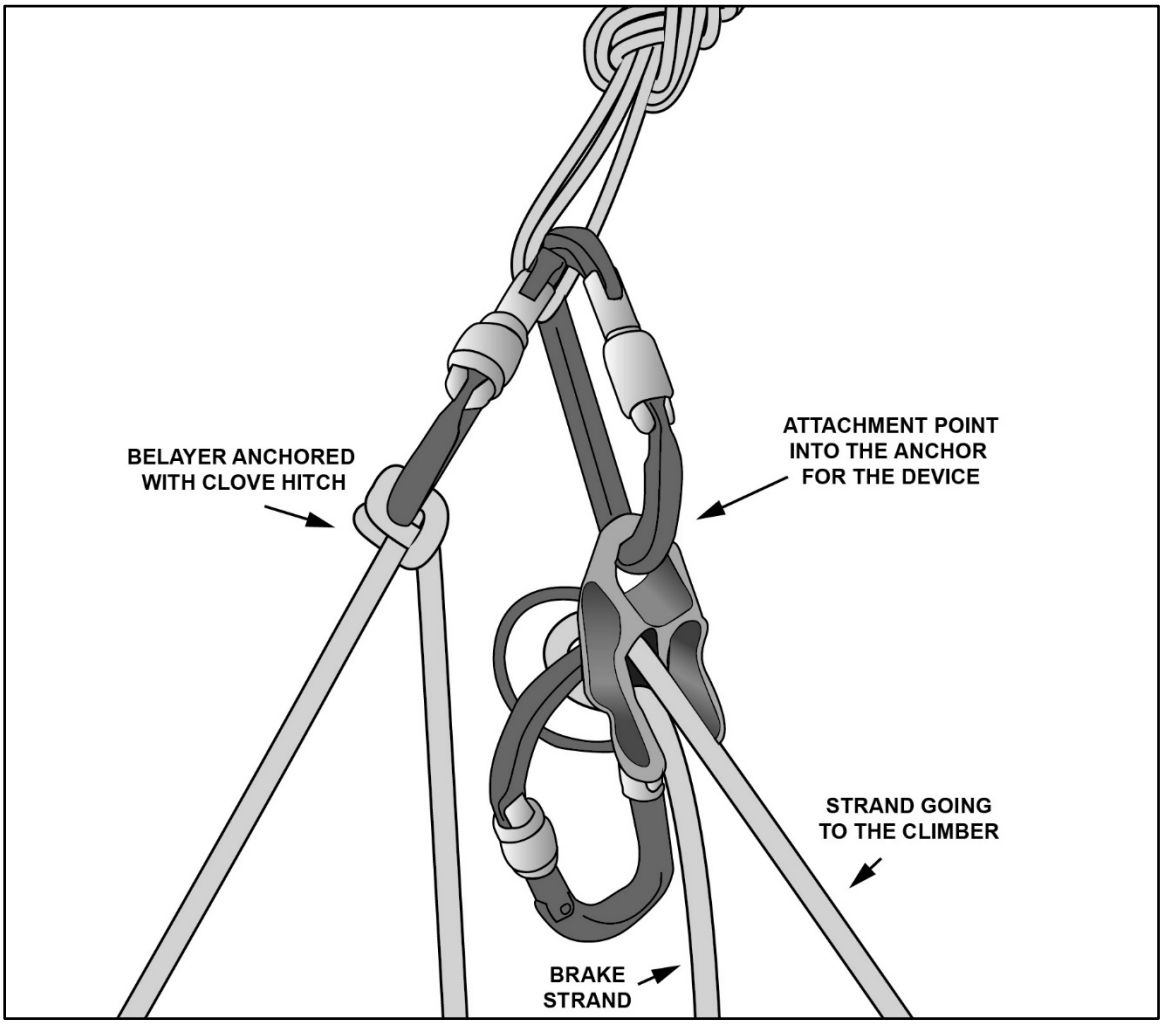



**Figure 10-20. Belaying a climber using an autolocking device in guide mode**

## ROPE MANAGEMENT WHILE BELAYING

10-109. Pay careful attention to ensure that rope taken in when belaying the second is stacked or coiled neatly to make the belay transition easy and to ensure that it does not fall down the cliff and become tangled or caught.

### On Ledges

10-110. On small or large ledges, it is usually possible to stack the rope in a neat pile as it is pulled through the belay. This allows for an easy transition and for smooth rope feeding.

### At Hanging Stances

10-111. At hanging belay stances, it may be necessary to stack the rope back and forth over the tie-in strand as the Soldier pulls rope through the belay. If this is done, the rope should be looped back and forth in large bights (not so long as to becoming caught on things below). If the second becomes the new leader for the next pitch, these bights should start big and gradually become smaller. This allows the rope to feed out without becoming tangled during the next lead. If the original leader leads the next pitch, the rope may have to be restacked over the second's tie-in strand when they reach the anchor. Another option is to stack the rope back and forth over a leg or foot. However, feet tend to get shifty when belaying during a long lead, which can lead to dropping the rope where it could possibly become stuck or jammed below.

## Rope Tug Commands

10-112. Sometimes yelling cannot be heard when the climber and belayer are far apart. This is especially true in windy conditions or if the climber is around a corner, above an overhang, or at the back of a ledge. It may be necessary to use a series of tugs on the rope in place of the standard voice commands. To avoid any possible confusion with interpreting multiple rope tug commands, use only one. Rope tug commands may also have a tactical application where noise discipline is particularly important. Units or climbing teams should develop their own SOPs for rope tug commands. These commands should always be discussed and confirmed prior to a climb.

## Training Considerations for Lead Climbing

10-113. Due to the high consequences involved, advanced and master military mountaineers must plan and supervise mountaineering training that involves lead climbing. They advise the commander on training requirements, priorities, and equipment needs, as well as plan, organize, and conduct training. Lead climbing training is particularly demanding of trainers and supervisors. For inexperienced climbers, a 2:1 ratio is often required. Supervision of climbing training must be thorough and deliberate. A large part of this supervision is inspecting every component of the rope system. The ability to balance the rigid process of supervision and inspection with the soft skills of mentorship and coaching can help maximize the safety and value of the training.

10-114. Assess the mental readiness of the climber. The fear of heights is real and is not something that can be ignored. A Soldier becoming panicked while lead climbing can create hazardous situations and may dissuade the Soldier from continuing further climbing training.

10-115. Consider climber skill when selecting routes for training. Climbs should be challenging but achievable with a couple of tries. Routes for new climbers should not exceed intermediate difficulty (see appendix A for more on climbing classification). A common mistake is to place Soldiers on climbs that are too difficult, steep, or strenuous, where they cannot first focus on the processes. Established bolted climbs are often an excellent place to begin lead climbing training. Traditionally protected routes can be attempted after proficiency has been achieved with these. For initial training, the length of climbs is ideally less than half the length of the available ropes to allow quick transitions to rappel and maximize repetitions. These shorter lengths also make it easier for the supervising trainer to ascend next to the climber when necessary.

10-116. Soldiers should already be proficient at placing protection, clipping ropes into protection, belaying leaders, belaying follow-on climbers, and constructing multipoint anchors. These skills can often be practiced on the ground in advance.

10-117. Mock lead training is a useful tool to prepare Soldiers for lead climbing. Mock leading occurs when a Soldier climbs a route on top rope while also leading up with another rope. This allows the Soldier to focus on placing protection, clipping, and managing the rope on lead with the security of having a top rope as backup in case of a fall.

## SECTION VI – ALPINE BELAY TECHNIQUES

10-118. In broken alpine terrain, with secure stances, and no chance of second climbers falling and hanging from a belay, hasty techniques may provide adequate protection for the team. Safety should never be compromised for the sake of speed. Use of standard belay techniques should be used if there is any question as to security.

# BODY BELAYS

10-119. Body belays can sometimes be used on short sections of less steep terrain where a fall is unlikely and there is a good, braced belay stance of which to take advantage. To create a body belay, simply run the rope around the body at the waist to create friction, with the chest facing the direction of pull. The load rope is at one hip and the brake strand is in the opposite side hand. To take in rope, pull in on the load rope with the guide hand and out with the brake hand. Grab both ropes above the brake hand with the guide hand and slide the brake hand back towards the body. To brake, pull the brake hand up and across the chest. The body belay can be used in either the sitting or standing position; however, the sitting position offers a lower center of gravity and is preferred. It can also be used with an anchor or without. The advantage of the body belay is its speed and simplicity for belaying short sections where a climber is moving quickly. However, there are disadvantages as well. Because the force of a fall is dissipated as friction against belayers' bodies, serious rope burns can occur to the body and hands, possibly causing them to lose control of the belay. It also generates less braking force and causes more slippage than other techniques, causing the climber to fall farther. For this reason, it is only used on low-angle easy terrain. The belayer must have a good, braced position and must keep the rope tight. (See figure 10-21.)



**Figure 10-21. Hip belay**

# SHOULDER BELAY

10-120. A shoulder belay is a way to add a level of friction to the rope as the belayer pulls it tight with a climber below. The shoulder belay shares many of the advantages and disadvantages listed above for the body belay. The level of friction created with this method is relatively low and should only be used on short steps where there is no risk of the climber hanging from the belay in a fall. A classic example of terrain where the shoulder belay is appropriate is a short, steep step where the belayer can stand directly above the climber below. The rope is routed under the arm, over the opposite shoulder, and down to the opposite hand and is kept tight with the climber below. The belayer's body creates friction on the rope and acts as the anchor at the same time. A shoulder belay is fast to create, but it is only suitable on rare occasions. (See figure 10-22, page 270.)

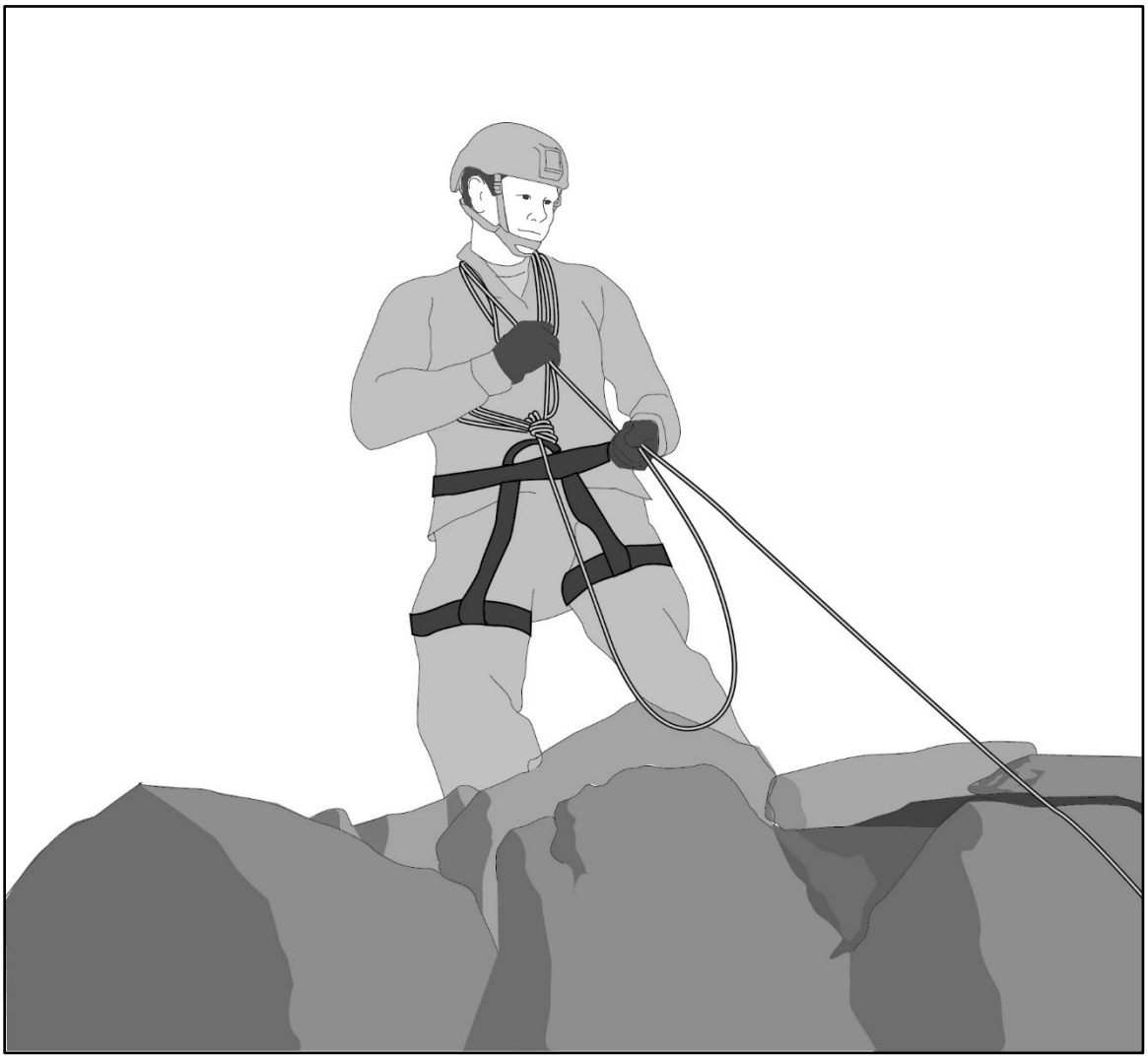


**Figure 10-22. Shoulder belay**

10-121. A terrain belay can be used when there is a feature that the rope can go around and create enough friction to arrest a fall or lower a load. The natural feature must be solid and not have sharp edges. Terrain belays are an effective means of belaying a climbing partner, but they require good judgement. When using a boulder or horn of rock, the belayer must ensure the rope will not slide off the rock in the event of a fall and that the rock is wedged securely. Trees are another good example of a natural object that can be used as a terrain belay. (See chapter 9 for more information on tree selection.) (See figure 10-23.)

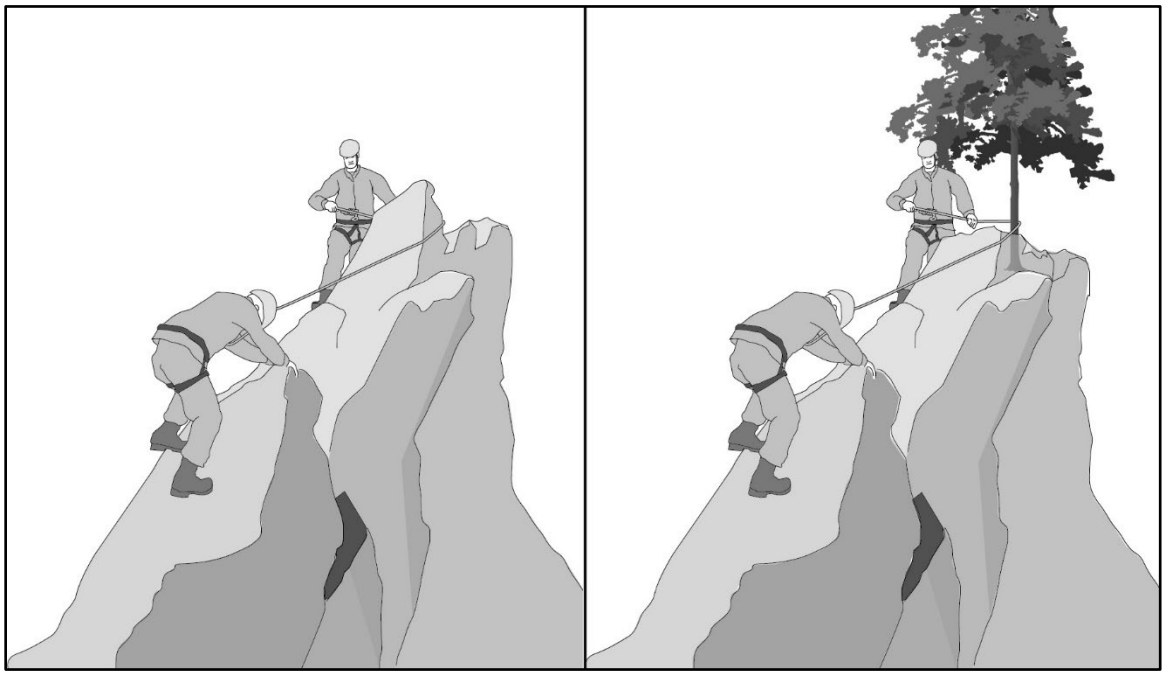


**Figure 10-23. Terrain belay**

## SECTION VII – CLIMBING IN A TEAM OF THREE

10-122. Level 2 mountaineers are trained to work as a team of two. There are numerous examples of when it may be beneficial to work and move as a team of three. Moving as a team of three has added complexity and much more challenging rope management at each belay. To progress into managing two ropes, a climber must first become proficient in managing one.

10-123. It is good for military mountaineers to have options for roped travel through terrain with changing hazards. The mountaineer must constantly assess terrain and hazards and fluidly adapt the technique to mitigate those hazards as best as possible. Time is always against mountaineers, and efficient transitions from one roped movement style to the next are important. A mountaineer should not default to using one style of movement for all types of terrain and should know how to properly apply different roped movement techniques to different terrain.

# CATERPILLAR

10-124. Caterpillar technique is usually the first technique learned for managing a party of three. The lead climber and second climber tie into the ends of one rope. The second also ties into another rope with the third climber. The leader leads as usual, clipping protection, and then builds an anchor and belays the second. Rather than cleaning the protection, the second climbers remove their rope and clip the second rope into the protection. Once the second climber is anchored, the leader then belays the third climber.

10-125. Climbing while using the caterpillar technique is often slower than other techniques. It can take the party twice as long to cover a pitch in some situations but is the simplest method of managing a party of three. It builds on the skills already used for two-party climbing, with only slightly more complex rope and station management. This technique also reduces the workload on the following climbers.

# END ROPING

10-126. In easy terrain, two climbers can tie into the end of the same rope. One ties into the end of the rope, the second attaches with a cow's tail and a bight of rope long enough that they can move up and down independent of the climber below. (See figure 10-24, page 272.) It is tied with an overhand on a bight loop

with a 30-cm bight. This bight should be far enough from the other climber that the two do not interfere with each other as they climb, usually about 4 meters. The second attaches to the cow's tail with a clove hitch around two opposite and opposed locking carabiners. This is almost as fast as climbing in a party of two. Rope management is simple for the leader and no different from climbing in a party of two. The two followers can be clove hitched into the anchor on the rope between them, securing them both. The followers can also coach and assist each other with the climbing.

10-127. This is only appropriate in easy terrain, where there is little risk of a fall. It is used primarily in 4th-class terrain.

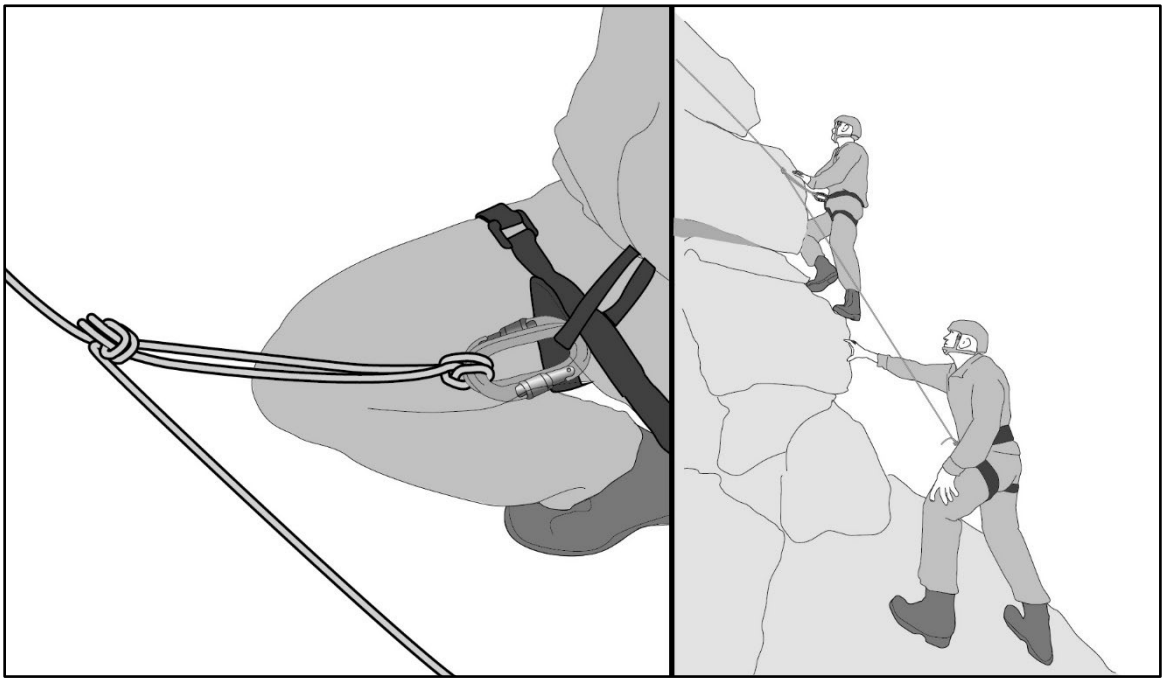


**Figure 10-24. Clipping to a cow's tail and end roping**

***Note***. When attaching to a rope to climb, the preferred method is to be tied directly into the rope. Locking carabiners can unlock and open if they are not being monitored, and while climbing, they may end up in a position where they can be cross loaded. When clipping into a rope to climb, it should be with two lockers, opposite and opposed, and with a knot that secures around the carabiners to keep them oriented correctly.

# PARALLEL

10-128. For parallel technique, the lead climber ties into both ropes and the two followers tie into the other ends. The leader leads on one strand, clipping it into the protection. The second rope can either be clipped into the protection as well, clipped into just specific pieces as directional, or routed on a separate line, depending on the terrain and the hazards. (See figure 10-25.) At the anchor, the leader sets up to belay the two followers.

10-129. Belay devices with a guide mode (plaquette or autolocking) can be used to belay two climbers, on two ropes, simultaneously. For rock climbing, with little rockfall hazard, both followers often climb together, offset enough so that they do not fall onto each other. Where loose rock is a concern or when ice climbing, this must be managed differently, often one climber climbing at a time, either for the whole pitch, or bounding from sheltered stance to sheltered stance. (See figure 10-26.)

10-130. Rope management is more difficult with two ropes and two climbers moving simultaneously. Organization at the belays requires additional thought, ensuring that the followers are anchored in a manner that the ropes are not twisted, and both strands feed up from them.

10-131. The parallel technique is used frequently. In steep terrain, it is often the fastest way to move as a party of three. However, to avoid complications, it requires mastery of the basics and practice.

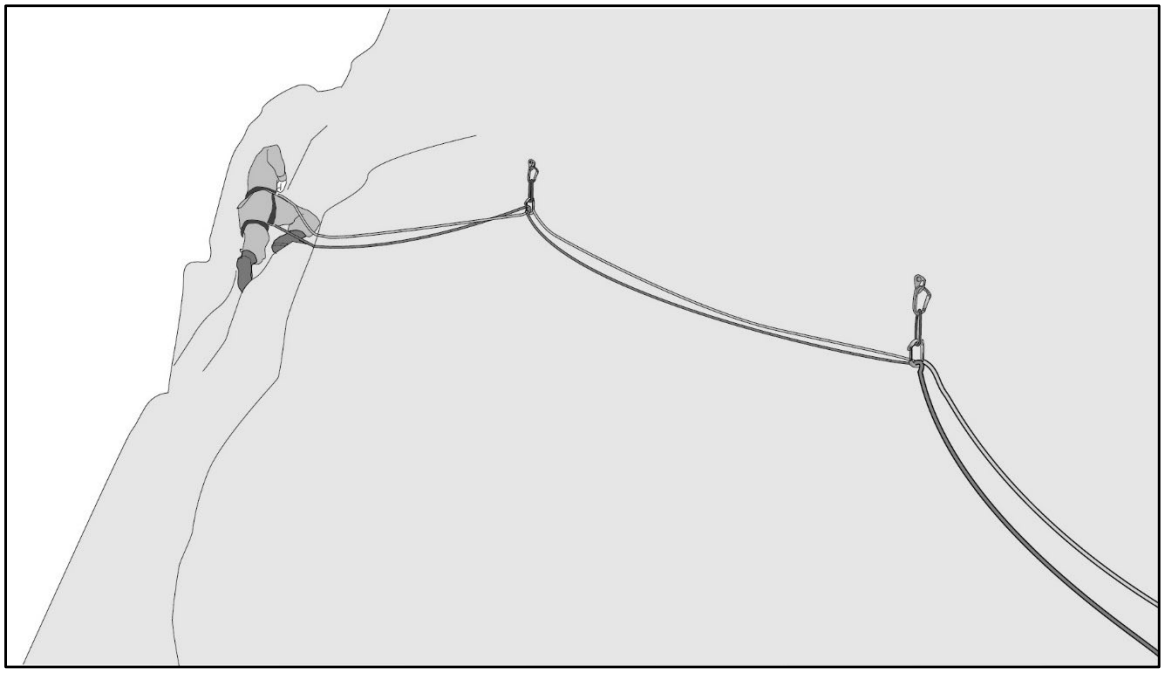


**Figure 10-25. Parallel climbing two stands**

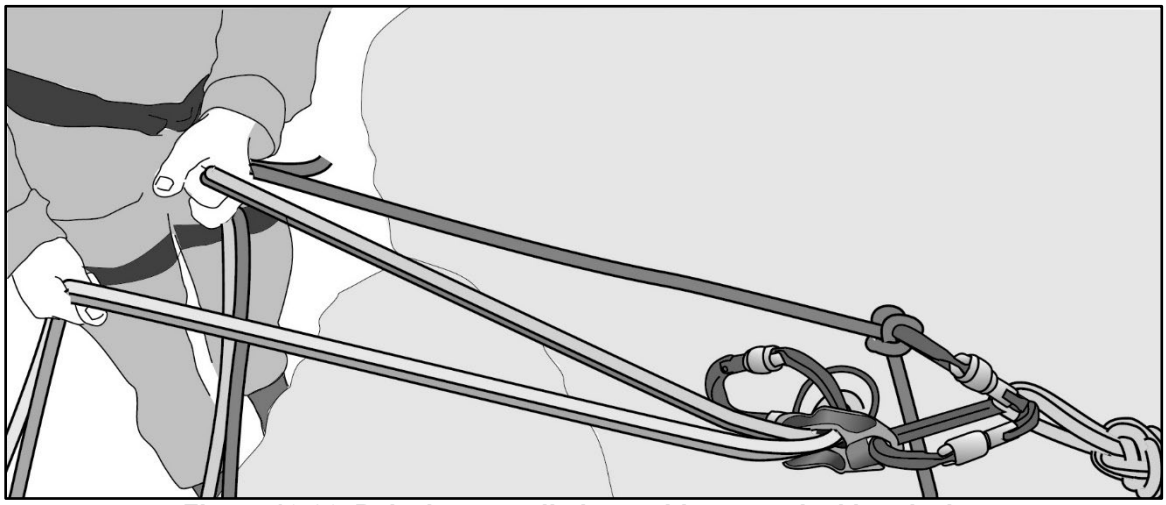


**Figure 10-26. Belaying two climbers with an autolocking device**

# FIXED STRANDS

10-132. It is also possible for leaders to fix the strand of rope they led onto the anchor at the top. This frees up leaders from any belaying responsibilities and allows them the ability to provide security, if necessary. This concept of the leader fixing strands of rope after leading a pitch provides many options for moving Soldiers through terrain. Leaders are not limited to just fixing the strand of rope they led on. They can pull

up the rope, fix the middle, and have two strands for others to ascend if the rope reaches. The leader could trail another rope and fix it in another location after having reached the top. Having second climbers ascend rather than climb removes any possibility of a second not being able to reach the top due to a lack of climbing ability. The second would then ascend the rope rather than climb on belay. It is not appropriate in all terrain due to various terrain hazards. The weighted rope can dislodge loose rock. The rope is easily damaged or cut if it runs over a sharp edge while the followers ascend. (See chapter 11 for more information on ascending ropes.)

## Chapter 11

# Fixed Ropes

Fixed ropes are an important part of military mountaineering as they facilitate the movement of Soldiers through rugged terrain. Fixed ropes allow large groups of Soldiers to safely access terrain that provides tactical advantage over the enemy. They have proven useful in past conflicts. During World War II, they were successfully used during Operation Neptune (commonly referred to as D-day) and the famous assault on Riva Ridge by the 10th Mountain Division. Proficiency in using fixed ropes allows units to overcome mobility limitations and, therefore, achieve greater lethality in mountainous terrain.

## SECTION I – BASIC FIXED-ROPE TECHNIQUES

11-1. A fixed rope is any rope system attached to at least one anchor that can be used to improve security and efficiency of movement through difficult terrain that subjects Soldiers to a fall hazard. They can be used for ascending, descending, or traversing across steep terrain in which a fall hazard exists. They may simply provide Soldiers with a handhold through a short section of steep terrain or as complex as hundreds of feet of broken hazardous terrain involving numerous sections that prevent attached Soldiers from being able to fall. They can be used to assist the movement of small teams to large units. They allow units to overcome mobility limitations and access tactically advantageous terrain.

## FIXED-ROPE CONSIDERATIONS

11-2. Fixed ropes should be used whenever a group of Soldiers cannot move safely through a section of terrain unroped. Fixed ropes are usually the most efficient means of protecting groups larger than team sized, especially if the groups have not received advanced military mountaineering training. Common factors contributing to the necessity of building fixed ropes are fall hazard, slippery surfaces, limited visibility, heavy loads, low mobility skills, and fatigue.

11-3. The two basic types of fixed-rope systems are simple fixed ropes and fixed ropes with intermediate anchors. Both types have applications in every class of terrain. Simple fixed ropes are anchored only at the top, can only be used by one Soldier at a time, and require a straight path of movement from bottom to top. Fixed ropes with intermediate anchors have multiple anchors and rope sections, allowing more Soldiers to move on them simultaneously and the path to change directions. Each type is determined by route and availability of anchors along it, the number of Soldiers to use the system, and the type of available equipment to attach to it.

11-4. All types of fixed ropes are built from the top down over, or through, terrain obstacles. However, fixed rope installation teams may need to ascend terrain using other techniques prior to building a fixed-rope system. (See chapter 10.)

11-5. Units planning to use fixed ropes must establish installation teams capable of locating routes, moving safely through various terrain obstacles, and building a variety of installations. They should be led by advanced military mountaineers but may be assisted by basic military mountaineers. These teams should be experienced in building fixed ropes in the type of terrain to be negotiated, equipped appropriately for the task, and familiar with the capabilities of the Soldiers who use them.

11-6. In a tactical environment, any terrain that requires a fixed rope should be considered a VDA, which is steep terrain that puts a unit moving through it at significant tactical disadvantage. The process for establishing even the simplest fixed rope comes at the cost of time and exposure to enemy attack. Adequate security must be established prior to deploying the installation team. In complex terrain, security teams may need to be adjusted or leap-frogged forward if fixed-rope systems cover large pieces of terrain. Emplacing security teams in a complex terrain may require high-mobility skills as well as substantial time. Typically, it is best to approach fixed-rope terrain from above because security is more easily established on higher

ground. But that is rarely possible. Units that anticipate building fixed-rope systems for movement in a combat environment should be well-rehearsed in crossing VDA TTP. (See ATP 3-21.50.)

# SIMPLE FIXED ROPES

11-7. A simple fixed rope is a rope that is anchored at the top of steep terrain that can be used to increase safety or efficiency of movement up or down. The method of anchoring the rope is determined by anchor features available but can be as simple as a bowline tied to a tree or as complex as a multipoint anchor established with rock-climbing gear. The principal benefit of simple, fixed ropes is their simplicity and speed of construction.

11-8. Simple fixed ropes are typically established by one mountaineer climbing the obstacle, dragging a rope, and then anchoring it at the top. They can also be established by approaching the top of a steep obstacle by some other means, anchoring a rope, and lowering the other end down for others to use.

11-9. Some important considerations for using simple fixed-rope systems are that they must follow a path straight up the terrain feature, the attachment technique is appropriate to reduce fall risk, and they allow for a large enough loading and unloading platform to manage the site safely. Using a friction hitch or mechanical progress capture to attach to the rope provides increased security during movement.

## EASY TERRAIN

11-10. Short 2nd- or 3rd-class slopes with low fall consequence can be negotiated using simple fixed ropes without the necessity of attaching to the rope. Soldiers using the fixed rope simply grasp the rope with the thumb downward and use it in a hand-over-hand fashion to assist with balance. (See figure 11-1.) This technique is appropriate when there is an increased likelihood of fall but low consequence. Usually this means short slopes that Soldiers could easily negotiate normally, but slippery conditions, fatigue, or heavy loads increase the chance of a fall. Knots can be added to increase the security of Soldiers moving on the rope, making it less likely their hand slips on the rope.

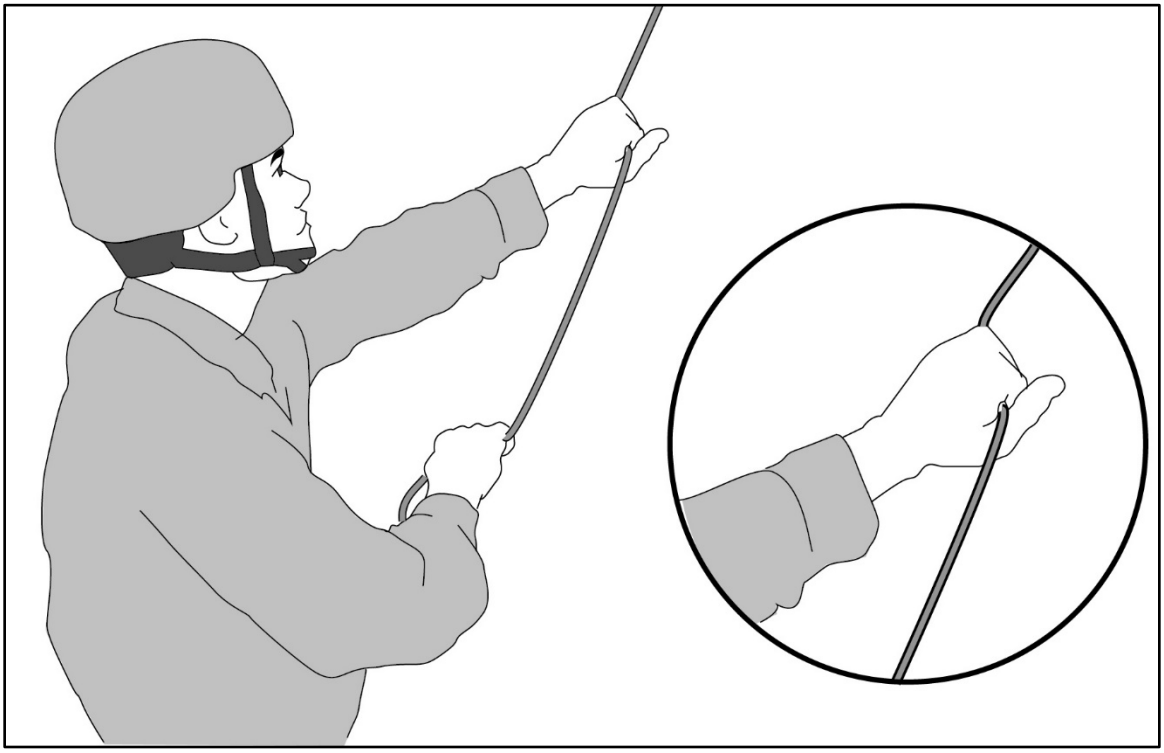


**Figure 11-1. Simple fixed rope use in easy terrain**

## MODERATE TERRAIN

11-11. Short sections of steep 3rd or 4th class with higher fall consequence can be negotiated by attaching to simple fixed ropes with a progress capture, such as a prusik or other mechanical rope-grabbing device. This technique requires Soldiers to wear some type of harness. A significant drawback to this technique is that it takes a lot of time to move a group of Soldiers. Only one Soldier can move at a time on a rope, and time is lost during attachment and detachment. (See figure 11-2, page 278.)

### Prusik Technique

11-12. A common technique involves tying a prusik on the rope with a cordelette, then tying a fixed loop in the other end of the two tails. Clip the fixed loop to the harness with a locking carabiner. The optimum length of the attachment is one outstretched arm.

11-13. Ascend the fixed rope by using the legs to climb the slope and the rope as a handhold for balance, sliding the prusik up to capture progress and prevent fall in case of a slip.

11-14. The prusik technique is recommended only on simple fixed ropes without intermediate anchor points because friction hitches cannot be easily or safely transitioned past intermediate anchors.

### Mechanical Ascender Technique

11-15. It is also possible to use a rope-grabbing device, such as a mechanical ascender, to create a progress capture for Soldiers moving on fixed ropes. These devices are easier and faster to use but require every Soldier to carry a piece of equipment that has limited uses. They should be used when fixed rope ascents are planned for large groups in moderate terrain.

11-16. Mechanical ascenders are devices shaped like a handle that can be attached to a rope by means of a toothed cam. It can slide in one direction on a rope but not the other. When weighted, the camming mechanism activates and grips the rope. Soldiers can attach ascenders to their harness and slide them along fixed ropes during movement, capturing their progress and preventing a fall during a slip (see figure 11-2, page 278). Ascenders should never be dynamically loaded as their teeth could damage the rope. Ascenders are included in the Army ACTK, but Solders can use other similar ascenders to ascend fixed ropes. Some are much lighter but are less easy to use. Advanced military mountaineers should familiarize themselves with the options available and units should obtain those best suited to the mountaineering tasks they must perform.

11-17. To use a mechanical ascender, attach it to the fixed rope. Then girth hitch a sling to the harness and clip it to the ascender with a locking carabiner. (See figure 11-2, page 278.)

11-18. Ascend the fixed rope by using the legs to climb the slope and the ascender as a handhold for balance, sliding it up to capture progress and prevent fall in the case of a slip.

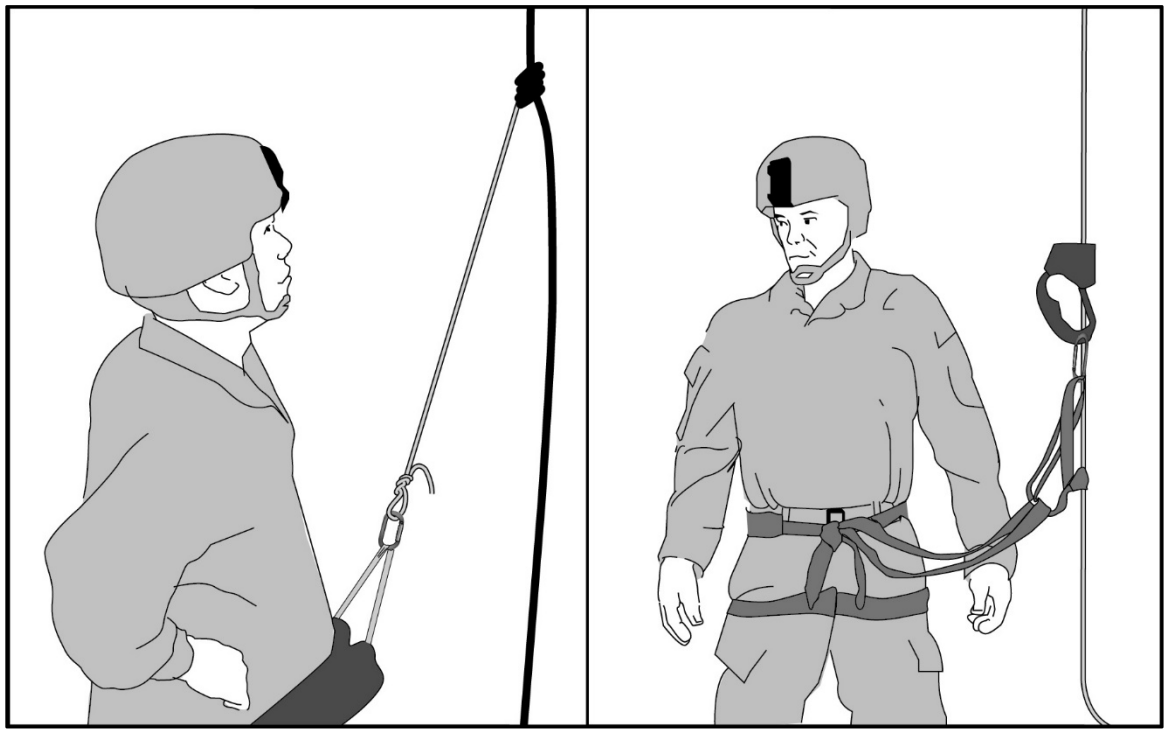


**Figure 11-2. Simple fixed-rope attachments in moderate terrain**

### VERTICAL TERRAIN

11-19. Moving on simple fixed ropes in terrain where significant sections are very steep or vertical requires rigging that is more complex. These rigging techniques provide secure attachment to the rope and aid movement up the rope. (See paragraphs 11-36 through 11-52, pages 282 through 286, for more information on ascending techniques.)

## FIXED ROPES WITH INTERMEDIATE ANCHORS

11-20. Larger or more complex sections of steep terrain require fixed ropes with intermediate anchors to ensure adequate safety and efficiency of movement. This may involve various sections of 3rd, 4th, or even 5th-class terrain. The principal difference between simple fixed ropes and fixed ropes with intermediate anchors is the use of intermediate anchor points to create independent sections and changes in direction of travel. This allows the movement route to follow the easiest, safest, and most efficient path. This type of fixed rope is commonly used along exposed ridges and narrow mountain passes.

11-21. Advanced or master military mountaineers with substantial experience are required to establish fixed ropes with intermediate anchors, but they can be assisted by basic military mountaineers.

### FIXED-ROPE CONSTRUCTION WITH INTERMEDIATE ANCHORS

11-22. The primary guiding principles for building a fixed rope with intermediate anchors are that they provide adequate fall prevention while maximizing the speed at which Soldiers can move using them.

#### Path

11-23. Establishing a fixed rope with intermediate anchors starts with thorough terrain analysis and route finding. When selecting a path for the rope, mountaineers must consider the anchor options available, difficulty of movement on the route, and any other objective hazards present. The characteristics of the Soldiers who use the fixed rope are also useful information. Particularly, what their mobility and technical skill levels are and what equipment they have for attaching to the rope.

### Intermediate Anchors

11-24. Terrain and vegetation determine the equipment mountaineers need to build the fixed rope. Heavily vegetated terrain or broken rocky terrain may only require cordelettes, slings, and carabiners. Slabby or steep rock faces require cams, nuts, and other lead climbing protection to build anchors. Intermediate anchors must be built robust enough to support the weight of a fall by the number of Soldiers who will move on each section at a given time. When possible, anchors should be built at about waist height in places where good footing is possible so that transitioning past anchors is easier for Soldiers moving on the fixed rope (See figure 11-3 for common methods of attaching ropes to single component anchors.)

### Rope Section Slack

11-25. Fixed-rope sections do not have a standard amount of slack. There should be enough slack to allow Soldiers to follow the easiest path through terrain without adding fall risk. Sometimes a lot of slack is necessary to go around an obstacle or steep section. This is usually better than running a tighter rope over these things, because going around is easier, which reduces the chance of a fall. Other times, a section may need to be tight to reduce fall distance, such as traversing across a cliff on a narrow ledge.

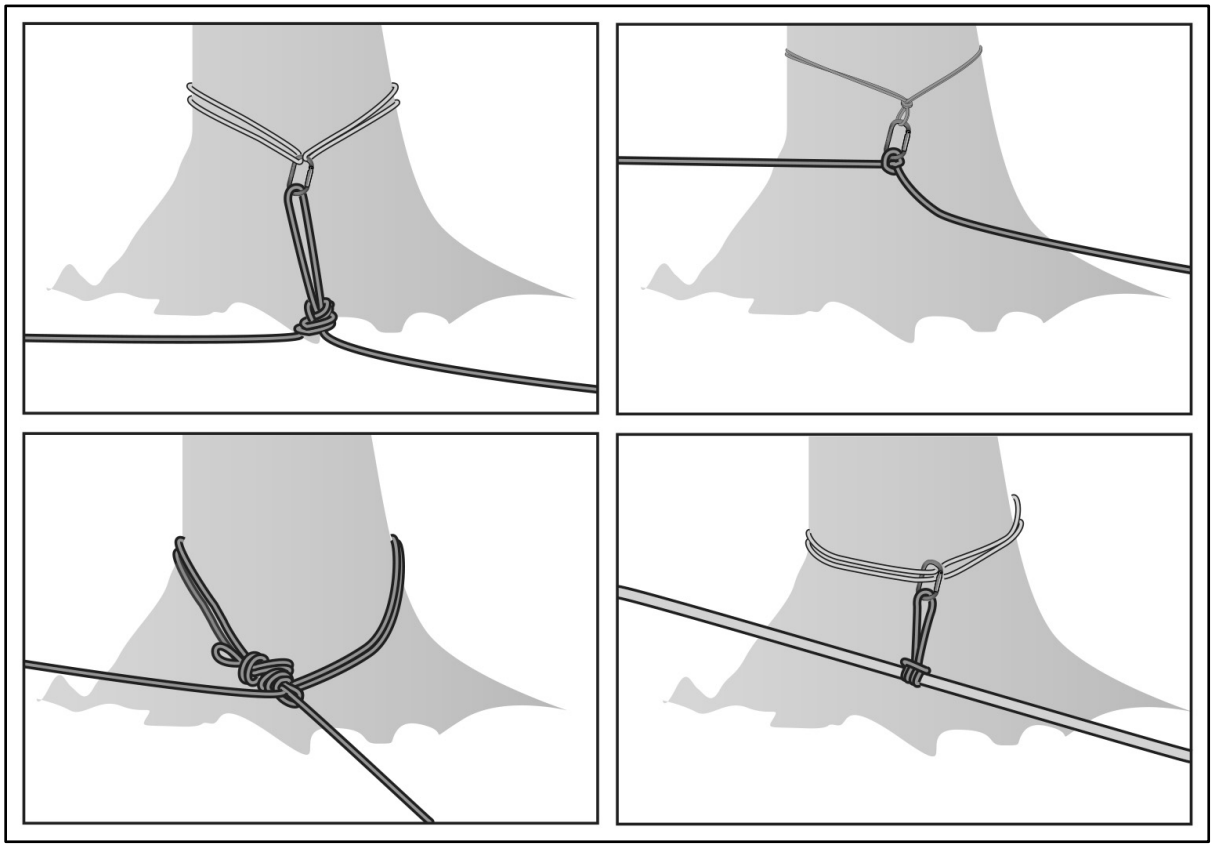


**Figure 11-3. Intermediate anchors in moderate terrain, example**

## Attachment and Movement

11-26. The method for movement on fixed ropes with intermediate anchors is as important as how they are constructed. Two primary methods exist for use in steep terrain: the two personal safeties method and the ascender-carabiner method. Choosing between the two is a tradeoff between not carrying heavier single-purpose items and having more security during movement. The two personal safeties method requires no special equipment but cannot eliminate fall risk for a Soldier. The ascender-carabiner method prevents falling but requires each Soldier to carry a piece of equipment that has little other use. Both techniques have their place, and both must be considered for use when planning fixed-rope movements.

## Two Personal Safeties Method

11-27. This method involves having two separate girth hitched slings attached to the tie-in portion of the harness with a single nonlocking carabiner in each. The carabiners are then attached to the fixed rope. Always keep the two carabiners attached to the rope unless they move past an intermediate anchor. To move past an intermediate anchor, clip one carabiner at a time above the anchor. When both carabiners are above the anchor, continue movement. (See figure 11-4.)

11-28. The two personal safeties method is appropriate for situations where the fall consequence is high, but the likelihood is low. It can be used up to 4th-class terrain under good conditions (such as good surface conditions, moderate mobility skills, light loads, well-rested, high visibility) provided that intermediate anchors are appropriately spaced to prevent serious fall injury. Since falls using this method are only stopped by the last anchor a Soldier passed, there is always a chance of injury. This should be considered carefully before choosing it.

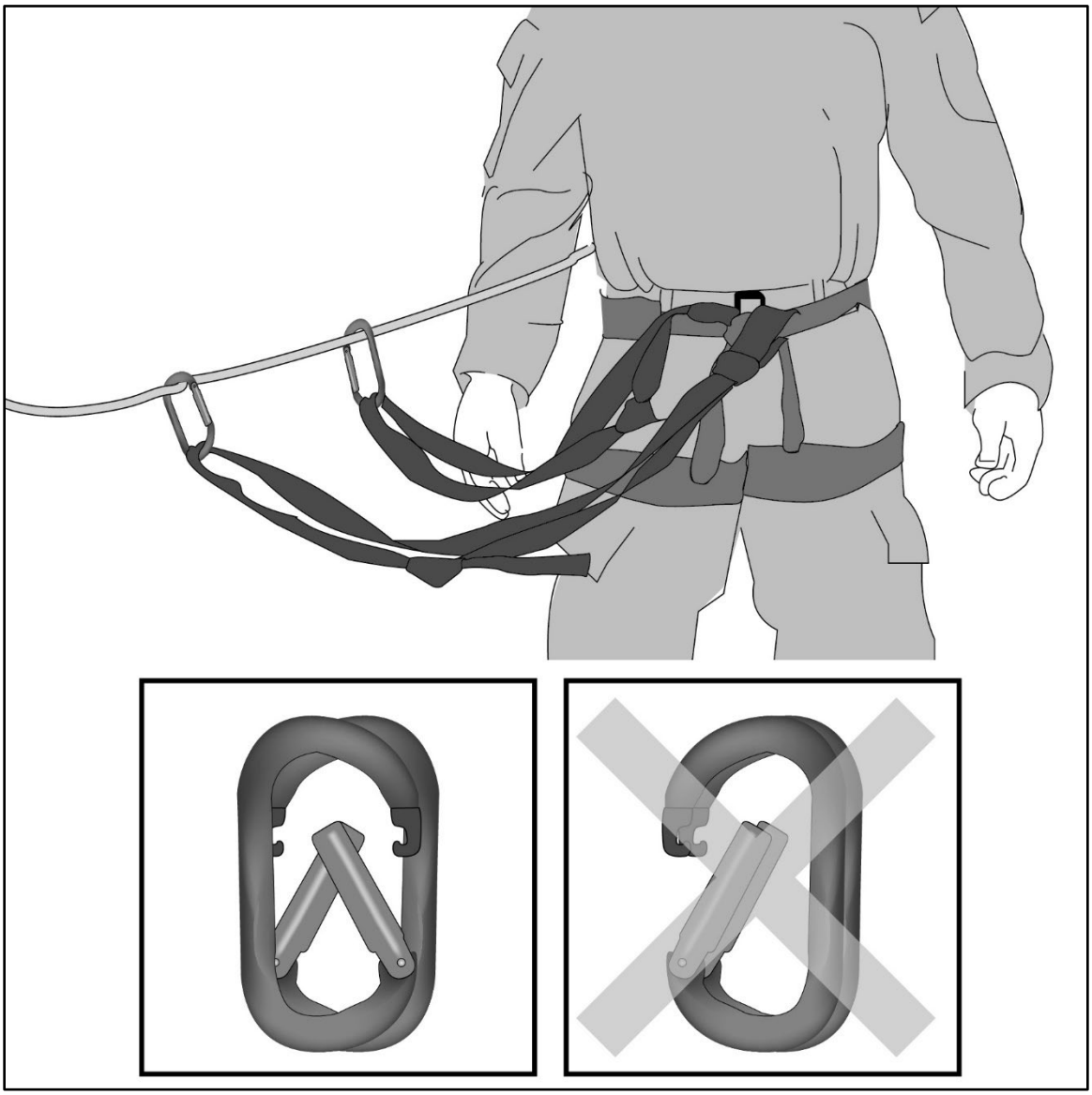


**Figure 11-4. Two personal safeties attachment**

## Ascender-Carabiner Method

11-29. The ascender-carabiner method is the fastest and most secure way to travel up very steep fixed ropes. It is preferred when fall risk is substantial or sections of the fixed rope are long, because the ascender captures the Soldiers' progress as they move.

11-30. To use this technique, girth hitch two slings into the harness. Clip one nonlocking carabiner into one extension. Clip a mechanical ascender to the other extension with a locking carabiner.

11-31. Ascend in the same manner as with simple fixed ropes. To move past the intermediate anchor, clip the nonlocking carabiner above the anchor, and then move the ascender to above the carabiner on the fixed rope. (See figure 11-5.)

11-32. This method is appropriate when both fall consequence and likelihood are high. It can be used in terrain up to 4th class under any conditions. It is the best method when surface conditions are slippery, loads are heavy, mobility skills are low or Soldiers are fatigued, during low visibility, and when intermediate anchors cannot be established to prevent fall injury.

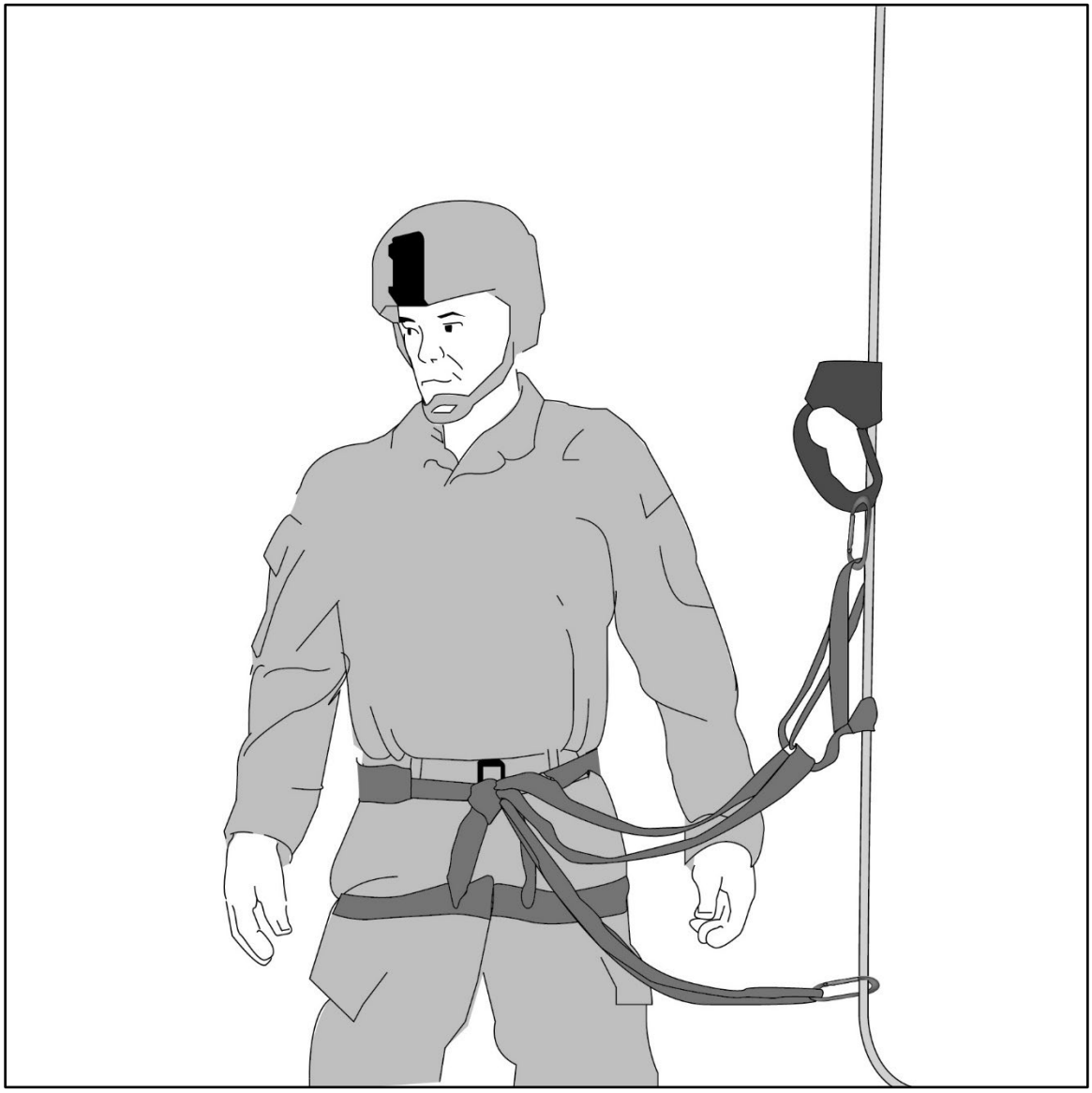


**Figure 11-5. Ascender-carabiner method**

# FIXED ROPES IN VERTICAL TERRAIN

11-33. Fixed ropes are sometimes necessary for moving in vertical terrain during complex rescue operations or other special operations in permissive or nontactical environments. They are rarely practical for tactical operations, given their extreme exposure to enemy observation and direct fire. However, vertical terrain is not always avoidable during combat operations, and there are historical examples of their use during pivotal cliff assaults. Vertical terrain is the most extreme example of VDA. Soldiers moving on vertically fixed ropes require well-established overwatch security since they are totally exposed and can do little but ascend the fixed rope.

11-34. Moving on fixed ropes in vertical terrain requires Soldiers to possess the equipment and skills necessary to ascend rope, relying entirely on their attachment to it to prevent fall. Efficient ascending requires specialized equipment.

## CONSTRUCTING FIXED ROPES IN VERTICAL TERRAIN

11-35. Fixed ropes in vertical terrain are constructed in the same fashion as moderate terrain; however, they take greater technical rope skills, experience with complex anchoring, and time to establish. With fixed ropes in moderate terrain, it would be ideal for the installation team to approach the route from the top and build the system top-down. However, this is rarely possible. Typically, they must be established from the bottom up by advanced military mountaineers employing lead climbing techniques to get the rope to the top. This process is time-consuming and inherently risky.

## ASCENDING TECHNIQUES

11-36. Many situations may require a Soldier to ascend a rope in very steep or vertical terrain. Soldiers must be prepared and equipped to do so when operating in 4th- and 5th-class terrain. Typically, ascending rope is a more efficient technique than climbing for moving followers over hard climbing terrain, to include those members of small assault climber teams.

11-37. The techniques described below are for single strands of rope, so it is imperative that appropriate measures are taken to pad the rope near sharp edges. Whenever Soldiers plan to ascend vertical terrain, they should use mechanical ascenders to achieve maximum safety and efficiency during movement.

11-38. Ascending techniques are also key skills used in rescue operations, self-rescue during crevasse fall, and whenever rappellers find their rope does not reach the ground.

### Prusik Ascent

11-39. Two prusiks can be used to ascend rope. One prusik is tied to the fixed rope using a cordelette at approximately forehead height. A fixed loop is tied in the hanging tails to create an attachment point at about waist level. This is then secured to the harness with a locking carabiner. Another prusik is tied to the fixed rope at about waist level. The hanging tails are then tied to one or both feet using any appropriate knot to form a foot stirrup. (See figure 11-6.)

11-40. The upper prusik serves as the “progress capture,” during ascent, by holding the Soldier up, while the lower friction hitch serves as the “progress” or makeshift foothold. During movement, the lower hitch is slid up as high as possible while hanging from the upper hitch. Soldiers then stand up on the lower hitch, pushing down and behind them with their leg, while sliding the upper hitch as high as possible. They then rest in the harness from the upper hitch and continue. Safety knots should be tied in the fixed rope below the lower hitch and attached to the harness with a locking carabiner every 10 to 15 feet. This provides a backup against failure of the friction hitch to grab. This technique should be considered an improvised technique for use when ascending is not expected.

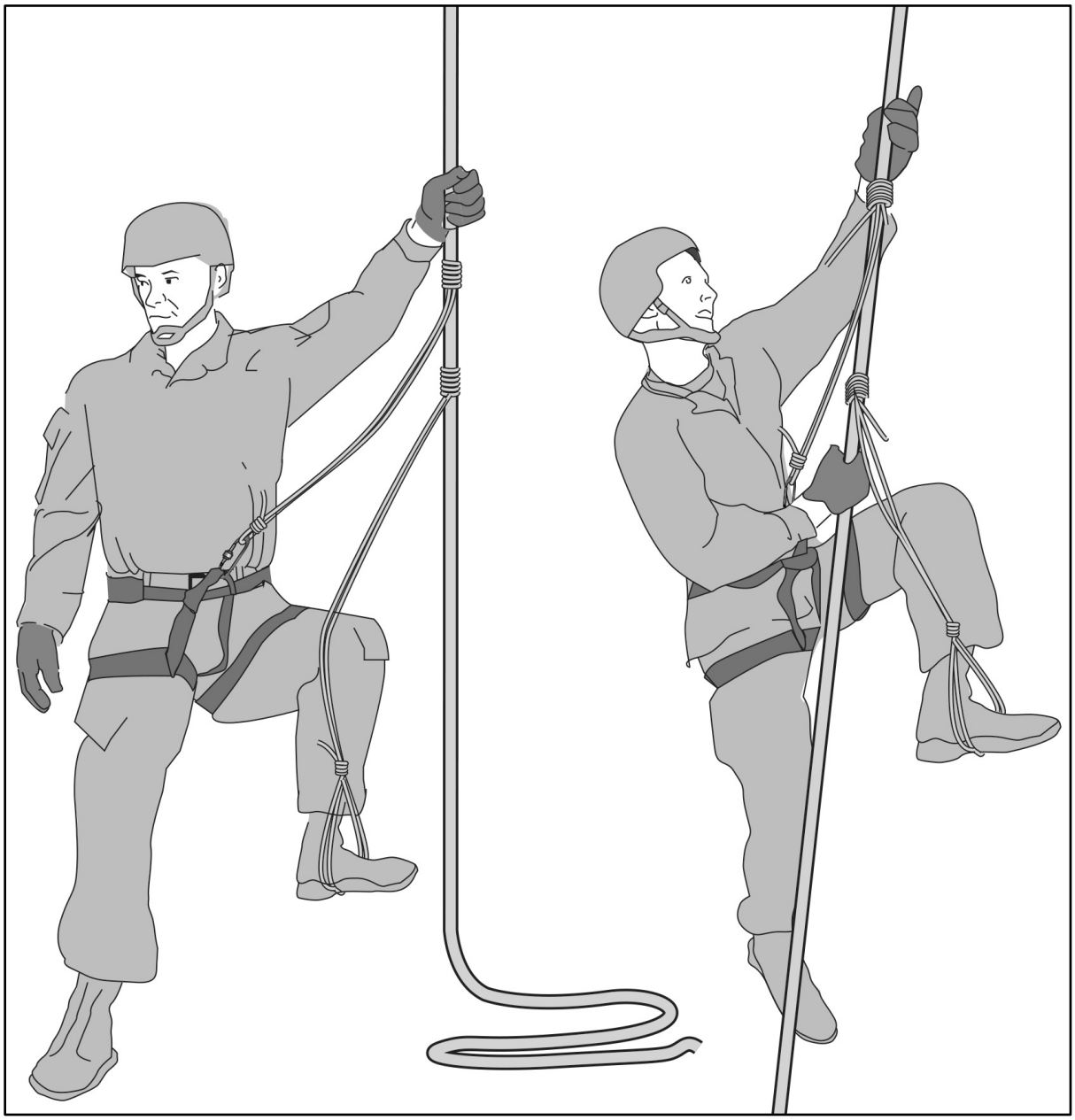


**Figure 11-6. Prusik ascent**

## Prusik Ascender Method

11-41. Mechanical ascenders are a one-directional device used to capture progress along a rope and assist climbers as they ascend steep, vertical, or free-hanging terrain. They can be substituted for one or both hitches described in prusik ascent. They make ascending efficient and fast.

11-42. To use an ascender as a progress capture, attach it to the rope at about head height. Girth hitch a sling or cordelette to the harness, and then use a locking carabiner to secure the other end to the bottom of the ascender, forming an arm-length extension between them. Commonly, a nonlocking carabiner is clipped around the rope through the top of the ascender for added security. This prevents the device from twisting off the rope.

11-43. To create the progress with an ascender, attach it to the rope at about waist height. Girth hitch or use any carabiner to attach a sling or cordelette to the bottom of the carabiner and tie it to one or both feet using any appropriate knot. The movement process is the same as described above for prusik ascent.

11-44. There are dozens of devices available that work the same as an ascender. Ensure the rope type and diameter are appropriate for the device used, as most mechanical devices have a specified range of acceptable use. Read all manufacturers' instructions to ensure safe use.

11-45. Stopper knots should be tied in the fixed rope below the lower hitch or device and attached to the harness with a locking carabiner every 10 to 15 feet. This provides a backup against the rope grabs slipping. This technique should be used when ascending is planned but not enough ascenders are available for Soldiers to be issued two.

## Double-Ascender Method

11-46. This technique is extremely efficient once it has been practiced. It is a recommended technique for ascending long distances. An etrier or cordelette forming a foot stirrup is hung off each ascender with a locking carabiner. Both ascenders are then placed on the rope. A cordelette or sling also hangs off each ascender and is girth hitched to the user's harness, creating two attachment points to the rope. (See figure 11-7.)

11-47. To use the system, the Soldier places a foot in each etrier (or stirrup) and slides the upper ascender up the rope. This upper ascender is easier to move because the Soldier's weight is on the lower ascender. The lower ascender is moved up next, while the upper ascender supports the Soldier's weight. Sometimes it is necessary to slightly release the camming mechanism before moving an ascender.

11-48. It is also recommended to tie back-up knots periodically in the same manner as prusik ascent.

11-49. This technique is the most efficient and is recommended for use whenever ascending is a planned movement technique.



**Figure 11-7. Double-ascender ascent**

## SPECIAL TECHNIQUES AND CONSIDERATIONS

11-50. There are too many considerations for using and improving fixed ropes to cover them all in this training circular. However, the following techniques should be considered for use with fixed ropes.

### Weapon Management

11-51. Unless enemy attack is imminent, weapons should be slung to the rear, allowing Soldiers to scramble more easily in difficult terrain. Heavier weapons, such as sniper weapon systems, mortars, and machine guns, may need to be attached to the top of rucksacks.

## Improving Steps

11-52. Soldiers are less likely to fall and move more quickly if they have good footing. Hard snow is especially easy to carve steps into and can allow Soldiers to move with less exertion on their calf muscles. Carving steps should be done first in steeper sections and, as time allows, in other areas too. Platforms can also be made where Soldiers are transitioning past intermediate anchors. If a Soldier can easily stand near an intermediate anchor, they can clip around it much faster. This greatly lessens the time required for the group to navigate terrain where objective hazards may be present.

## Etriers or Slings at Difficult Steps

11-53. The hanging of a sling or etrier (for use as a hand or foothold) where there is a difficult step can help reduce fall potential and increase speed of the group. An etrier is a short ladder that can be made from any piece of rope or cord and creates an artificial step in a place where there is no natural feature to step on. The etrier can be hung off an intermediate anchor or its own anchor. (See figure 11-8.)

## Caving Ladders

11-54. Manufactured ladders can be useful for large steps and crevasse negotiation. They also enable Soldiers to navigate challenging terrain in the dark, much easier than if they had to search for hand and foot placements. Some are constructed of materials that can be rolled up for transport. While they may make the ascent of a blank wall easier, they are cumbersome to carry.

## Cables and Via-Ferrata

11-55. If terrain is to be repetitively used for access to higher points for something semi-permanent such as an observation post, it may be in the unit's best interest to build a via-ferrata style system for access. A via-ferrata works similarly to a fixed rope with intermediate anchors, except it uses cable instead of rope. Using cable reduces the need for constant inspection and greatly increases durability. They are much more time consuming to build, but it may be the most feasible option if a unit uses a piece of terrain for an extended period. Given the cable's rigidity, the attachment method used by Soldiers needs to provide the stretch to lessen fall forces. This equipment can be found on the civilian market. Another component of a via-ferrata-style system is the addition of metal ladder style and foot and handholds. These are for areas and routes that will see traffic over a long time, making the use of soft materials impractical.

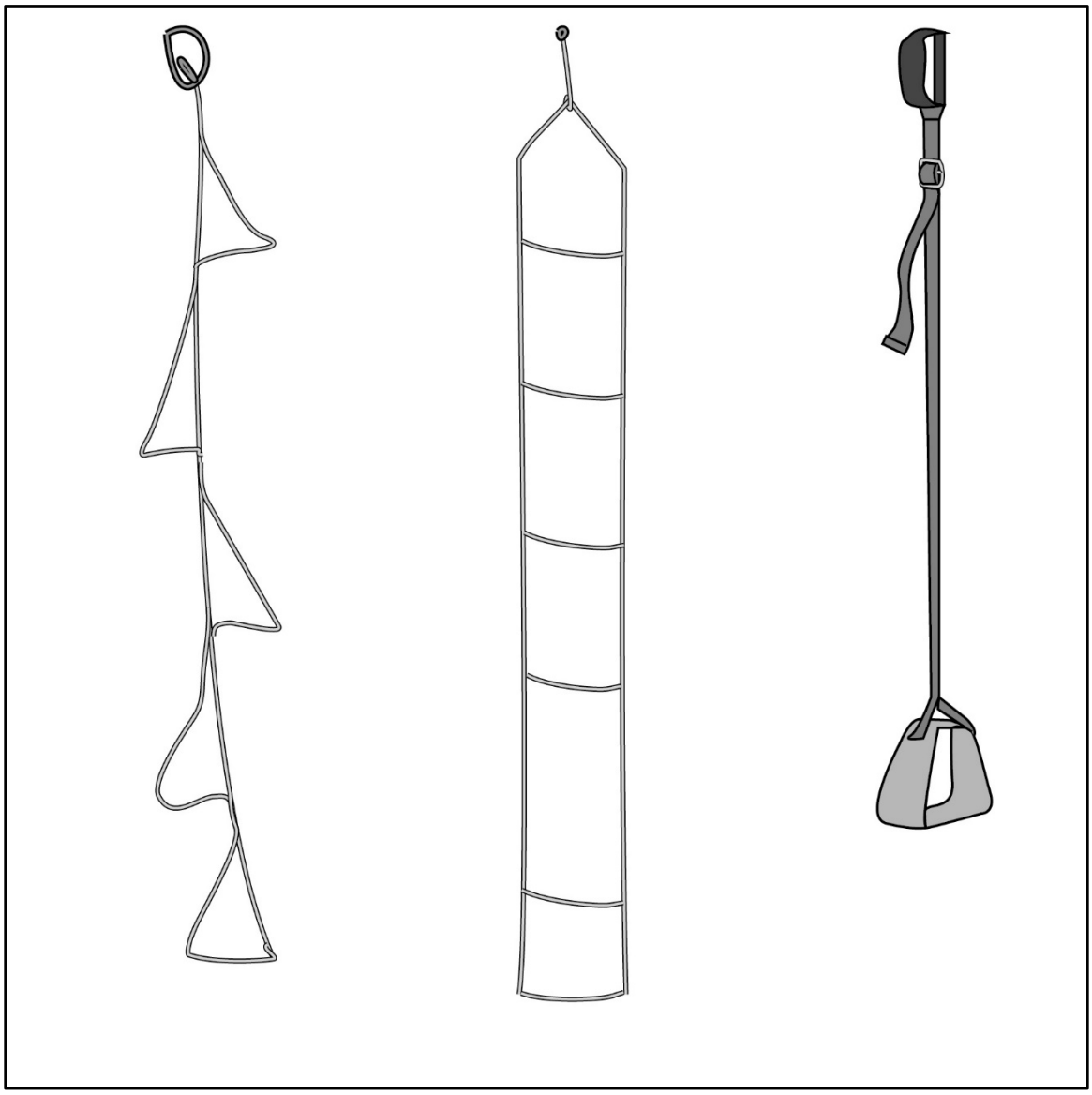


**Figure 11-8. Etrier styles**

## SECTION II – TYPES OF RAPPELLING

11-56. Rappelling is a method of descending steep terrain using a rope and a means of creating friction to control the rate of descent. This provides Soldiers with a safe way to descend terrain that would otherwise expose them to very high fall risks.

11-57. If the descent distance is greater than a rope length (for example, multipitch), multiple, simple fixed lines can be linked together with anchors at the top and bottom of each rope. Soldiers can then rappel from anchor to anchor and transition from rope to rope until they reach the ground. This method requires many resources and numerous personnel to establish and manage safely.

11-58. Small teams with fewer resources must use the one or two ropes they can carry to rappel the whole group from one anchor to a lower one, then retrieve the rope, and repeat the process until the ground is reached.

# RAPPELLING FUNDAMENTALS

11-59. Rappelling is a quick method of descent, but it can be extremely dangerous. The dangers include anchor failure, equipment failure, and individual error. Carefully select anchors in a mountainous environment. In a mountain environment, take great care to load the anchor slowly and to ensure that no excessive stress is placed on the anchor. To ensure this, prohibit bounding while rappelling; Soldiers should slowly descend. Soldiers should avoid dragging their feet when moving backwards towards the edge as this causes rockfall.

11-60. Soldiers rappelling with weapons should sling them on the back or to the side when wearing packs. Soldiers carrying particularly heavy weapons, such as machine guns, sniper rifles, or mortars may need to strap them to the top of their pack and use additional techniques described below to make rappelling less difficult.

## RAPPEL SITE SELECTION

11-61. Selecting the rappel point depends on factors, such as mission, cover, route, anchor availability, and edge composition (for example, avoiding those with loose or jagged rocks). The anchor selected should leave no doubt that it will work for its intended purpose.

11-62. Rappel ropes anchored at waist level or above make transitioning over the edge much easier and reduce the likelihood of Soldiers stumbling or falling. Stumbles and falls are likely to increase the risk of rope damage on sharp rock as well as increase force exerted on anchors.

11-63. Rappel sites with suitable loading and off-loading platforms should be selected. Ideally, they are flat and allow for anchoring far enough away from the edge that Soldiers do not need to be attached to an anchor to prevent accidentally falling off the edge. If this is impossible, use fixed-rope techniques described in section I when approaching the rappel point. A staging area large enough to hold the group in a safe place nearby is also desirable.

## INSTALLATION CONSIDERATIONS

11-64. The two major factors in deciding how to attach a rappel rope to an anchor are whether the rope needs to be retrievable from the bottom and whether redundancy in rappel rope strands is necessary for safety. Both characteristics cannot be achieved at the same time.

11-65. In an operational environment, or during advanced military mountaineering training, ropes must be retrievable. This is because there is presumably no other feasible way to negotiate the vertical obstacle, or the group would be using it. All people and equipment must rappel, and the rope must be recovered for future use. This means that the rope cannot be fixed to the top anchor when the last Soldier begins rappelling.

11-66. When training basic rappelling, retrieving ropes is not necessary. Appropriate rappel sites for inexperienced rappellers should include access between the top and bottom by some other safe means for set up and breakdown. This allows for a greater safety margin by using two fixed independent strands for rappel ropes. Not only does this add redundancy to the system, but also using two strands replicates typical rappelling in an operational environment.

11-67. Anchors that support the maximum force rappellers could exert should be established as described in chapter 9. All rigging should be inspected by a qualified advanced military mountaineer, at a minimum.

## RETRIEVABLE RAPPELS

11-68. Retrievable rappels can be established using appropriate single-point anchors (such as a tree, boulder, horn of rock) using only the rope, or they can be attached to cordelettes, or webbing tied around the anchor feature. If other materials are used, then they cannot be retrieved from the bottom.

11-69. Multipoint anchors require additional materials to establish. This material cannot be retrieved from the bottom.

11-70. The minimum necessary equipment should be used in building retrievable rappel anchors.

### Half-Rope Length

11-71. The simplest and most common method is to just run one end of the rope around anchor feature, and then double back stack it until the middle of the rope is around the anchor feature. This ensures both strands are the same length. Tie a stopper knot at the bottom end with both strands leaving 12- to 18-inch tails. This prevents accidentally rappelling off the end of the rope. The ropes are then thrown or back stacked over the edge.

11-72. Sometimes the rope cannot be routed directly around the anchor. The rope can then be back stacked so that the middle of the rope passes through the attachment point for an anchor made from cordelette or webbing or clipped to it using a locking carabiner.

11-73. If a rope could be cut, it is possible to make the system redundant for all but the last rappeller. This system is established in the same manner as above, but once complete a BHK is tied close to the anchor with both strands. This creates two fixed independent strands and adds redundancy to the system. Before the last Soldiers begin to rappel, they simply untie the BHK, and the system is retrievable again.

### Full-Length Rope

11-74. Full-length rappels require two standard-length ropes. Route the end of one rope around or through the anchor point and tie a flat double overhand with the ends of both ropes joining them. Double back stack the ropes and tie a stopper knot as described above. Using a flat overhand to join the rappel ropes reduces the likelihood of the knot being stuck in vegetation of rock features during retrieval.

11-75. Full-length rappels can be made redundant for all but the last rappeller in the same manner as is described above.

### Rappel Rope Retrieval

11-76. Once all Soldiers have reached the bottom and any stopper knots have been untied, the rope can be retrieved by pulling one strand. The other strand travels up to the anchor and falls. If there are any knots in it, they can become jammed in the anchor and prevent rope retrieval. It is a good idea to get excess personnel away from the area prior to pulling in case any loose rocks are dislodged above.

11-77. When pulling the rope on a multipitch rappel, it is a good idea to route the end being pulled through the next anchor, so the rope is less likely to be dropped.

## RAPPELS WITH FIXED STRANDS

11-78. Whenever a threat of the installation rope being cut is identified, two fixed independent strands should be used. Two strands add redundancy and reduce the likelihood that a fall may occur in a cut rope incident. Installations with two fixed independent strands are typically the standard for rappelling training whether a hazard has been identified.

### Half-Rope Length

11-79. If using a single anchor, anchor the middle of the rope to it with a bowline knot. If using a pre-equalized multipoint anchor, tie a fixed loop in the middle of the rope, and attach it to the anchor with two opposing locking carabiners.

### Full-Rope Length

11-80. Anchor the rappel ropes by tying a bowline knot with the top ends of both ropes.

11-81. Situations may arise where the distance of anchors from each other, or the distance of the anchors from the rappel point, requires using a second rope to construct an anchor, or extend the anchor master point closer to the loading platform, allowing for the maximum amount of rope to be utilized for the rappel. In this case, tie a fixed loop with the top ends of both ropes, and clip it to the anchor system master point using two opposing locking carabiners.

## RAPPEL INSTALLATION SPECIAL TECHNIQUES

11-82. There are a few problems that mountaineers should be prepared to solve related to rappelling. The common problems are damaged ropes, short ropes, and the threat of a rope being cut when retrievability is necessary.

### Damaged Rope

11-83. Ropes occasionally become damaged but may need to be used until they can be replaced following an operation. Mountaineers must be familiar with how to safely use damaged ropes for rappelling.

11-84. First, tie an overhand knot, isolating the damaged spot in the rope. The rope can then continue to be used for many mountaineering tasks. However, the knot in the rope prevents Soldiers from rappelling past.

11-85. If a retrievable rappel is necessary, the damaged rope can be used as follows. The rope is back stacked around the anchor as usual. A fixed bight is tied in the damaged strand near the anchor. That bight is then clipped to the nondamaged strand with a locking carabiner. When loaded, the carabiner fits snug to the anchor like a slip knot. (See figure 11-9.) Both strands of rope are thrown or back stacked off the cliff.

11-86. Soldiers can then rig for rappel using only the nondamaged strand and descend the obstacle.

***Note.*** Rappelling on a single strand creates less friction.

11-87. Once all Soldiers have rappelled, the damaged strand, or tagline, can be pulled to retrieve the rope. The nondamaged strand travels up through the carabiner, around the anchor and back down. More care should be taken when pulling the rope because it is more likely to become hung up using this technique. This technique also works when a full-length rappel is necessary and one of the ropes is damaged near the middle.

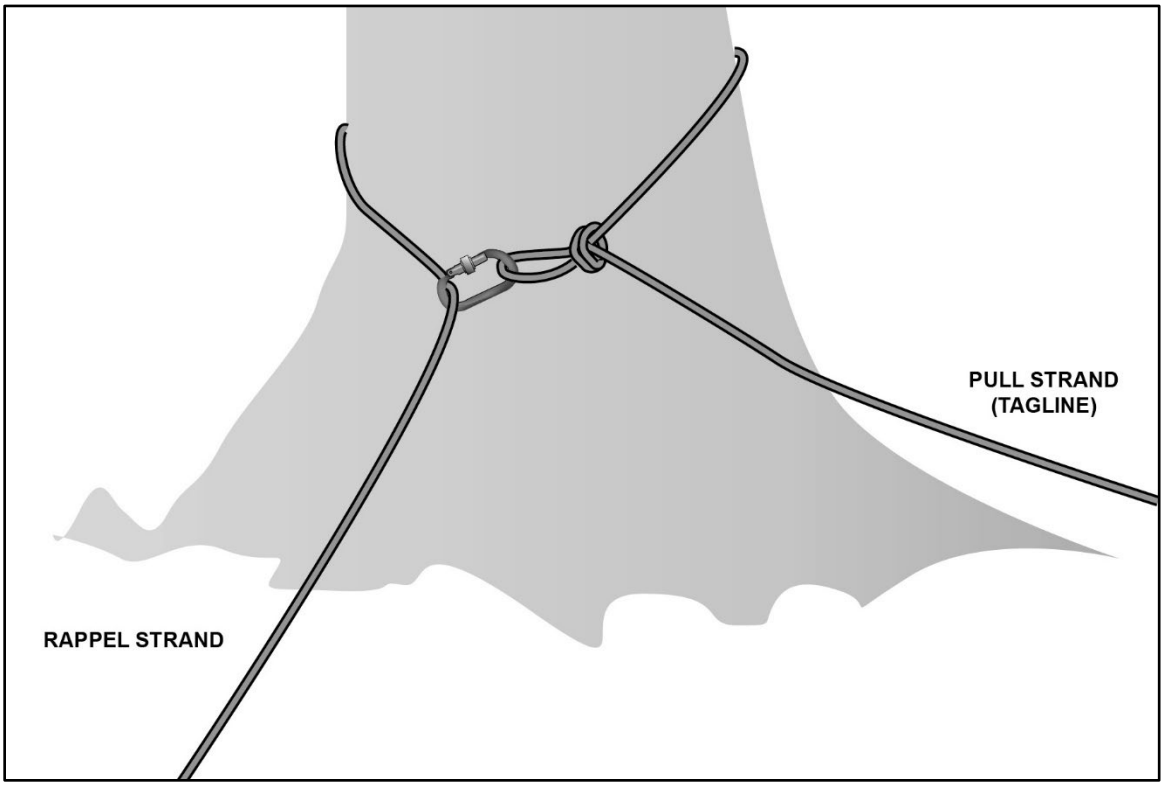



**Figure 11-9. Tagline retrievable rappel using a tagline**

### Short Rope

11-88. Sometimes a group may only have one rope that is not long enough to reach the bottom of a cliff, and the rope cannot be retrieved because the cliff is taller than a half-rope length.

11-89. If the group has enough cordelettes or shorter sections of rope, it can solve the problem. To do so, one end of the rope is lowered until it is on the ground. Cordelettes are then joined by a single strand to the other end until they reach the ground.

11-90. The installation is then rigged to be retrievable with a tagline (as described in paragraphs 11-83 through 11-87, page 290). Soldiers can then rappel on the strand of static rope. When personnel are at the bottom, the end with the cordelettes can be pulled to retrieve the rope. Take more care when pulling the rope because it is more likely to become hung up using this technique.

11-91. Small units can use this technique to reduce the weight of rope they need to carry. Rather than carry two full-sized ropes to rappel a full-rope length, they can carry one rope and a 6- or 7-mm tagline that is cut the same length from a spool, or plan to use joined cordelettes that are spread out amongst their members.

### Threat of Cut Rope Using a Retrievable System

11-92. Some situations may require a retrievable rappel, but a threat to the rope is identified (such as sharp rock or falling rock hazard) that cannot be mitigated by simply padding an edge. This problem can be resolved by one of two methods.

11-93. The first involves establishing the retrievable rappel system described above, and then attaching a tube-style device and locking carabiner tight to the anchor. This effectively fixes both strands. All but the last Soldier conducts the rappel with fixed strands. The last Soldier uses the attached device and rappels carefully as normal. This limits the exposure of all but one Soldier to the threat of cut rope. The rope can be pulled from below as previously described.

11-94. The second involves establishing the retrievable rappel system described above, and then tying a big knot close to the anchor with both strands fixing them. All but the last Soldier conducts the rappel with fixed strands. The last Soldier unties the knot and rappels carefully as normal. This limits the exposure of all but one Soldier to the threat of cut rope. The rope can be pulled from below as previously described.

## RAPPELLING TECHNIQUES

11-95. Different situations call for different rappel attachment techniques. They vary in how much friction they produce, the security in which the rappeller is attached to the rope, and whether they allow the rappeller to go hands free. The consequence of falling determines the type of attachment to the rope. Terrain severity determines how much friction is required to control descent. Whether or not other tasks need to be conducted mid-rappel determines the need for a hands-free brake.

11-96. During rappelling, the body generally forms an L-shape with the feet shoulder-width apart, legs straight, and buttocks parallel to the ground. When carrying equipment or additional weight, a modified L-shape is used with the legs slightly lower than the buttocks to compensate for the additional weight. The rappeller's back is straight. Rappellers never let go of the ropes with their brake hand until the rappel is complete. Rappellers should keep their feet flat against the surface they are rappelling down and their weight fully on the rope throughout the rappel.

### Hasty Rappel

11-97. The hasty rappel technique is only used on low-angle slopes. Its primary advantages are that it is simple to learn and execute and requires no specialized equipment. However, take care not to underestimate the terrain being negotiated. Application of this technique in terrain that is too steep can have deadly consequences. The level of rappeller surefootedness determines the severity of terrain for which this technique is appropriate. Gloves can be worn to prevent rope burns.

11-98. Facing slightly sideways to the anchor, rappellers place the ropes horizontally across their back, under their armpits, and palm up. The hand nearest to the anchor is the guide hand, and the other is the brake hand. Bending the rope around the body increases friction. (See figure 11-10, page 292.)

11-99. While moving, Soldiers should keep their legs as perpendicular to the slope as possible, leaning into the rope. This increases the security of foot placements and reduces the likelihood of a slip and fall.

11-100. To stop, rappellers rotate their body to face uphill and bring their brake hand across the front of their body to their opposite shoulder.

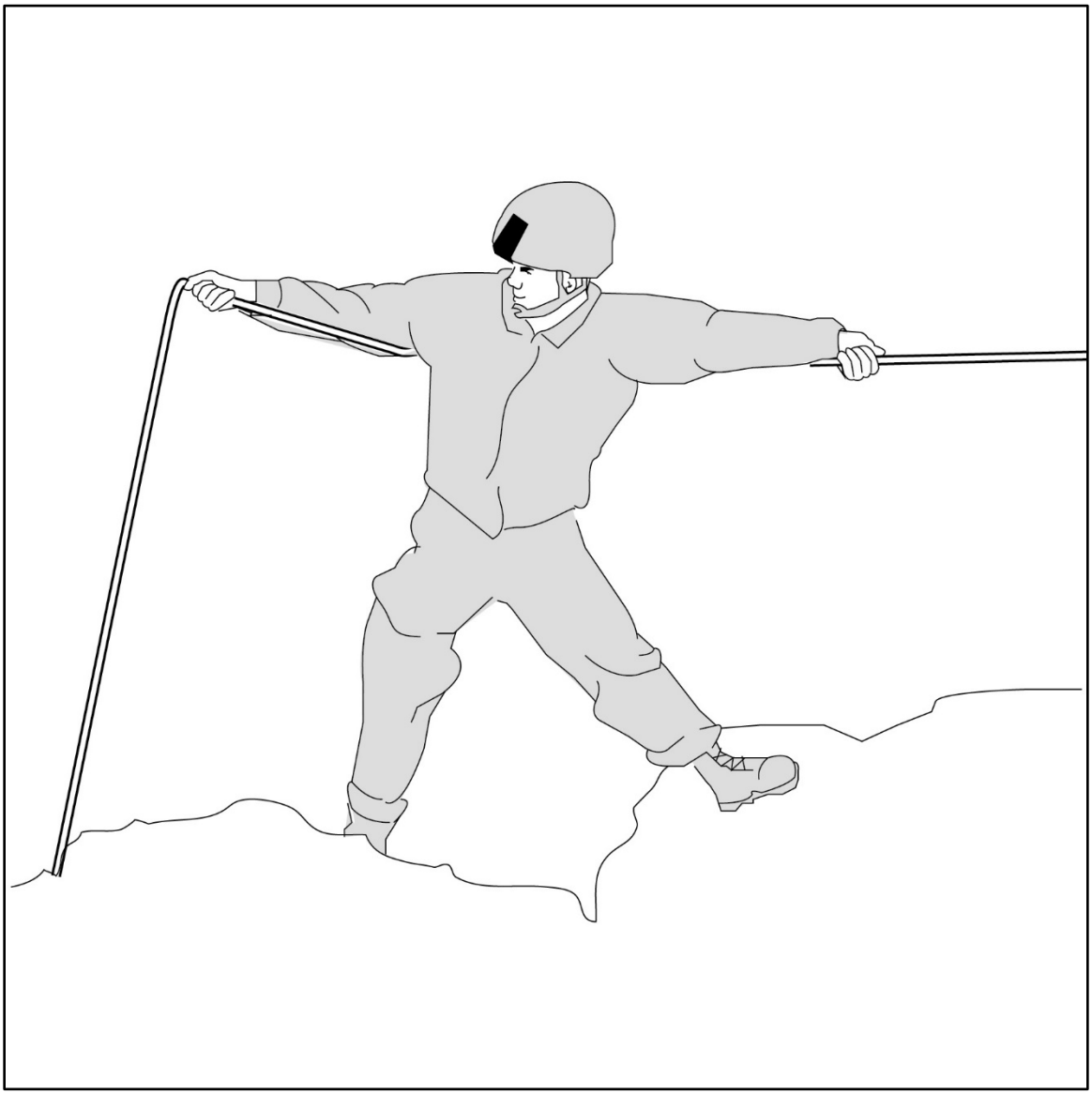


**Figure 11-10. Hasty rappel**

## Munter Hitch Rappel

11-101. This method provides adequate friction and control and is the simplest and easiest method of rappelling to establish on steep terrain when without a standard rappel device. Most often, it is used as a backup for when a more efficient device is lost or forgotten.

11-102. The drawback of using a Munter hitch is that it twists the rope, causing snarl at the bottom that makes future use difficult. An experienced Soldier can separate the strands with the brake hand and counter the twist of the rope as it feeds through the hitch to lessen this effect. It is not recommended to have multiple Soldiers rappel on the same rope using this method. Twisting is lessened if the rappel is on steep terrain and the strands

do not touch the ground. This allows the twists to undo themselves. Twisting becomes more of a problem if the terrain is at a low angle, and the rope is mostly lying on the ground.

11-103. To use this technique, attach a locking carabiner into a harness. Then tie a Munter hitch in both strands of the rappel rope and place it in the locking carabiner. (See figure 11-11.)

11-104. Descent is controlled in the same way as with the devices described above.

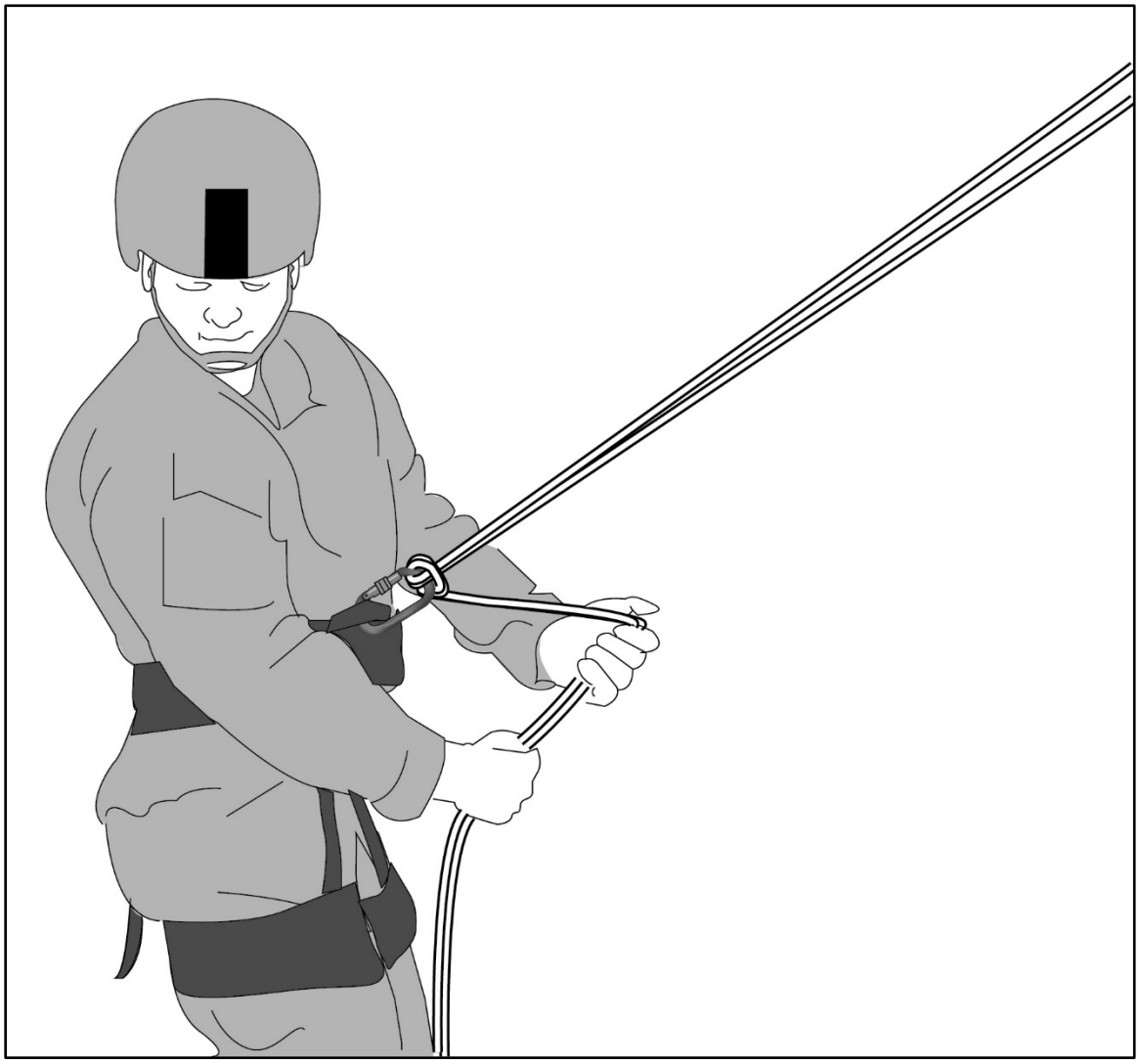


**Figure 11-11. Munter hitch rappel**

## Figure-Eight Descender

11-105. Using a figure-eight descender provides a secure attachment to the rappel rope and adequate friction for use in steep-to-vertical terrain.

11-106. The advantage of these is that they work well with both larger diameter ropes and static or low-stretch ropes. The disadvantages are that they are less versatile, heavier, and bulkier than tube-style devices, which serve multiple mountaineering purposes.

11-107. To rig the device for descent, pass a double bight through the large opening, and then around the smaller one. Then attach the figure eight to a harness using a locking carabiner through the small opening. (See figure 11-12, page 294.)

11-108. Soldiers assume a typical L-shaped position while rappelling and control their rate of descent with the brake strand by slowly feeding slack from below them toward the device. Two hands should be used on the brake strand, positioned in front of the body below the device.

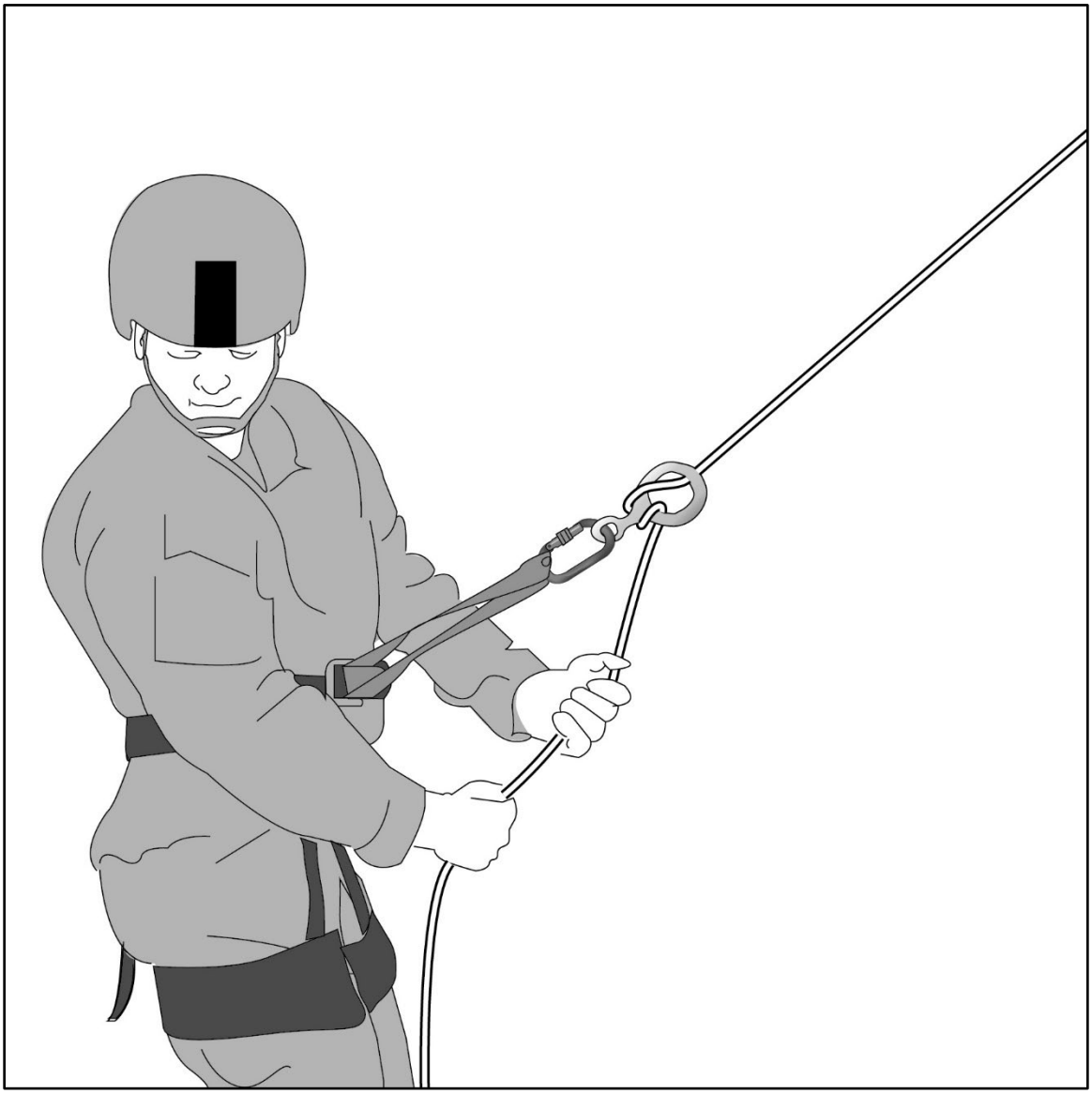


**Figure 11-12. Figure-eight descender**

## Tube-Style Devices

11-109. Using a tube-style device provides a secure attachment to the rappel rope and adequate friction for use in steep to vertical terrain.

11-110. Most climbing teams use these. The advantages are that they can be used for both belaying and rappelling with one or two ropes. They are compact and lightweight. They do not twist the ropes as much as figure-eight descenders. The disadvantages are that they do not work as smoothly when used with static or low-stretch ropes due to the more tightly woven rope sheath and stiffer feel. They also do not typically work well on ropes larger than 11 mm in diameter.

11-111. To rig the device for descent, pinch the rappel rope into a double bight, and then pass one through each hole in the tube starting on the side without a wire hanger. Clip a locking carabiner through the wire hanger and both bights of rope. Then attach the device to a harness with a locking carabiner so that the brake strands are oriented down or toward the intended brake hand. (See figure 11-13.)

11-112. Descent is controlled in the same way as with figure-eight descenders.

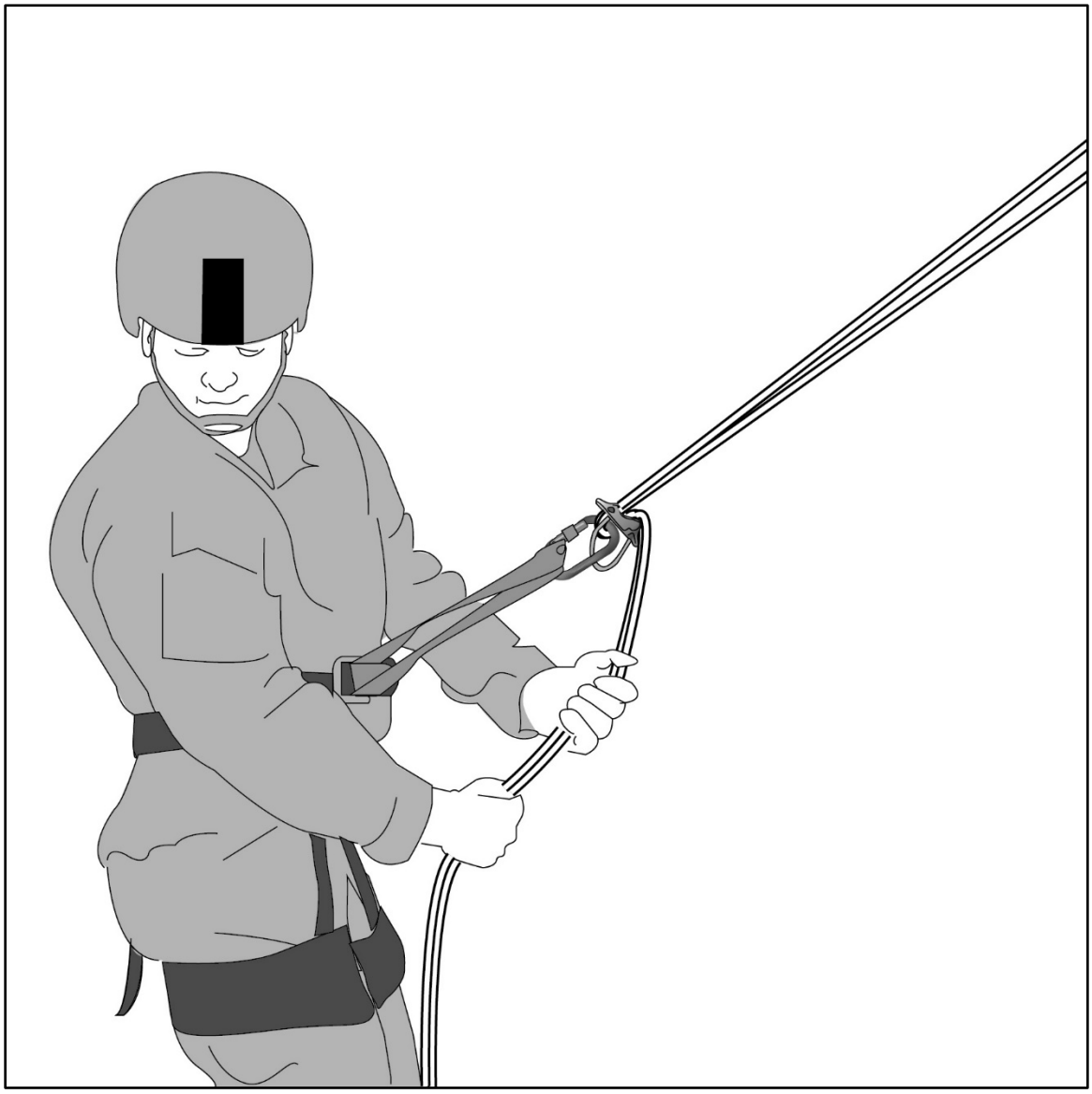


**Figure 11-13. Rappelling with a tube-style device**

## Extending Rappel Devices

11-113. Using an extension moves the rappel device away from the body. This makes it easier to keep two hands on the brake strands. It also reduces the chance of straps or clothing from being caught in the device and stopping rope from feeding through it. This results in the rappeller becoming stuck on the rope, unable to descend, and requires advanced skills to fix. Wearing bulky cold-weather clothing or tactical load-bearing harnesses increase the likelihood of this occurring. Extending the device allows for the use of a hands-free backup.

11-114. To extend a device, create an extension by girth hitching a sling to the harness. Insert the rappel ropes into the device as described above and clip them into the extension with a locking carabiner. A basket hitch can also be used to create a shorter extension. Under most circumstances, it is recommended to use an extension when rappelling in mountainous terrain because it makes controlling descent easier and less fatiguing to the core when heavy loads are carried. Rappels using the Munter hitch technique cannot be extended.

### *Hands-Free Backup*

11-115. A hands-free backup is a rigging technique, involving friction hitches or mechanical devices that prevent a load from falling should control of a brake strand be lost. To establish a hands-free backup, tie an autoblock around the rappel ropes below the device, and attach it to the climber's harness with a locking carabiner. (See figure 11-15, page 300.) Any time an autoblock is used, it must be tested to ensure it grabs before starting the rappel. If it does not, more wraps should be added until it does.

11-116. This allows Soldiers to perform other tasks mid-rappel. The most common example is the first rappeller needing to untangle the rope on the way down. During rappelling, Soldiers must prevent the autoblock from engaging and stopping their downward progress with one hand while the other feeds rope to the device. To engage the autoblock, the Soldier ceases minding the autoblock and it will engage, forcing the rappel rope into the brake position. When Soldiers are ready to continue rappelling, they resume control of the brake strands with both hands and disengage the autoblock. Descent can then continue.

11-117. Using an autoblock can provide a backup in case Soldier drops the brake strand. However, it is not the best back-up technique for large groups of rappellers to use given the additional time it takes to establish, manage, and untie from the rope.

### *Rucksack Support*

11-118. An extension can be used to make rappelling with heavy rucksacks easier. (See figure 11-14.) This is done by rigging for rappel with an extension. Then Soldiers can girth hitch a sling to the frame of the pack and attach it to the locking carabiner in their rappel device using any carabiner. This allows the device to support some of the weight of the pack and reduce core fatigue while the Soldier rappels.

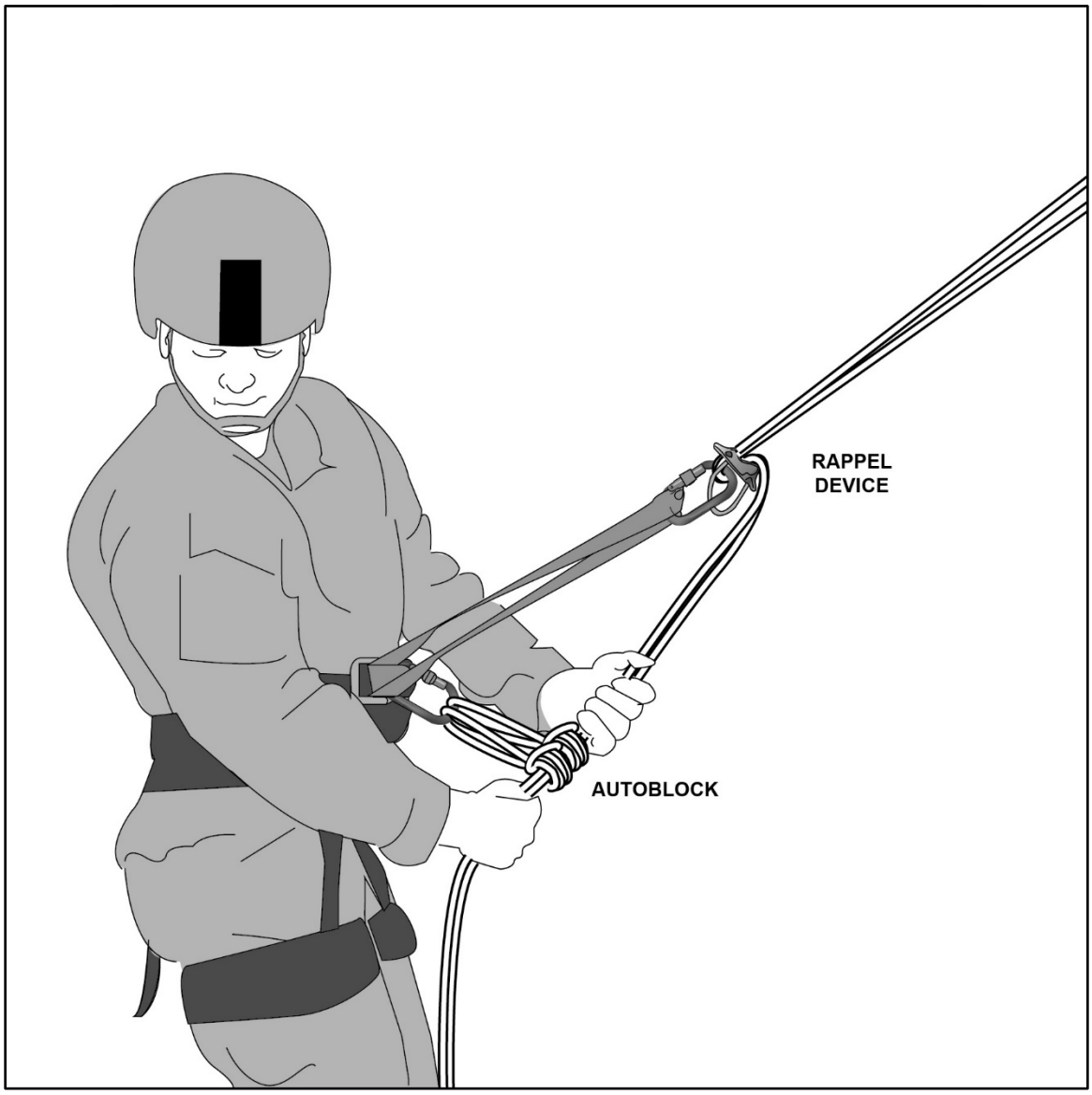



**Figure 11-14. Extended device and hands-free break**

## Belaying Rappellers

11-119. The fireman's belay can be used to prevent rappellers from falling should they lose control of the brake strand. This technique involves a Soldier loosely holding the rappel rope and watching the rappeller from the bottom. If the rappeller falls, the Soldier pulls on the rope hard. This forces the device to brake and stop the rappeller's fall. When the rappeller regains footing and control of the brake strand, tension is released, allowing them to continue rappelling.

## RAPPEL SITE OPERATION

11-120. Because of the inherent dangers of rappelling, special care must be taken to ensure safe and successful descents.

11-121. High-consequence rappel sites must be established and managed with the supervision of a qualified advanced military mountaineer or higher.

## Duties and Responsibilities of the Rappel Site Supervisor

11-122. An experienced mountaineer should be overall in charge of any movement on a rope system. This person ensures safety checks are completed and that there is a plan for the flow of personnel onto and off the system and is the one responsible for the entire event.

11-123. Duties of rappel site supervisors are as follows:

- Ensures that the anchors are sound, and the knots are properly tied.
- Ensures that loose rock and debris are cleared from the loading platform.
- Allows only one Soldier per rappel point on the loading platform at a time and ensures that the rappel point is run orderly.
- Ensures that each Soldier is properly prepared for the rappel: helmet with chinstrap fastened and harness or rappel seat is correct (if required). They ensure that the rappeller is hooked up to the rope correctly and is aware of the proper braking position.
- Ensures that the proper signals or commands are used.
- Dispatches each Soldier down the rope.
- Ensures the ropes will pull nicely when the rappel is retrieved; gets the joining knot past the edge, if necessary.
- Ensures safety lines or personal safeties for rappel site personnel are established and Soldiers remain clipped to them when necessary.

## Communication

11-124. Radio communication from the top to the bottom should be used to ensure all ropes touch the ground and someone is providing a fireman's belay before the rappeller commits to the rappel.

11-125. Loud voice commands for anything other than warning of falling objects should be discouraged, as they are unnecessary and tactically inappropriate. However, if they are used in training, they should be clear, concise, and understood by all participants.

11-126. Soldiers can determine if the rappeller ahead of them is clear of the rope by testing it for tension. If someone is still attached to the rope, then the rope will be tight. If it is slack, the next rappeller can hook up.

## Increasing Speed and Efficiency

11-127. All Soldiers should prepare themselves for rappelling at a staging area a short distance from the rappel site. Ideally, all harness and rigging other than attachment to the rope is conducted there, prior to arrival at the site. This will make rappelling groups more efficient.

11-128. The simplest method of speeding up rappelling is to instruct all rappellers to introduce slack into the system when they reach the bottom. This can be done by pulling slack through their device, or rappelling a couple steps further than necessary, and then stepping back toward the cliff. This will allow the next Soldier to hook up while they are unhooking from the system.

11-129. Rappel devices and locking carabiners may be collected and stacked on the ropes by the site supervisor prior to beginning rappelling. Soldiers then only need to attach their extension to the device before rappelling.

11-130. Retrievable rappels during tactical operations or advanced military mountaineer training can be sped up by establishing the rappel as usual, then tying a BHK knot in the ropes near the anchor. This fixes both strands. Soldiers can now rappel on each strand, doubling the rate that Soldiers can descend. This technique may not be appropriate if sharp rocks are present on the rappel route.

## MULTIPITCH RAPPELLING

11-131. Descent routes during tactical operations and advanced military mountaineer training often involve a series of rappels to reach the bottom. This requires additional techniques to ensure safety and efficiency of descent. The distance between anchor points is called a pitch.

11-132. When conducting multiple rappels, the standard technique of extending the device should be used and the first Soldier down should use an autoblock for backup. Additionally, a second locking carabiner

should be placed in each rappeller's extension sling. They will use this to attach themselves to the next anchor point prior to detaching from the rappel rope to allow the next rappeller to descend. In this way, they remain safely attached to the rappel rope or an anchor point. Once the first rappeller is safely anchored below, preferably out of the way of possible rock or ice fall, they fireman belay the remaining rappellers one at a time down to this point. Once the last Soldier is secured to the second anchor point, the rope is pulled, and the next pitch is rigged for rappel.

11-133. Soldiers can stack devices rigged for the rappel prior to the first one leaving, or each can hook up independently in turn. Typically, the most experienced members rappel first so that they can establish the next rappel anchor down. Stacking devices allows the leader to inspect all other Soldiers' hookups prior to leaving, reducing the chance of error.

11-134. The most difficult aspect of multipitch rappelling is when descending into unknown or unfamiliar terrain. The first Soldier down must effectively manage the ropes during the descent and have the necessary equipment for establishing the next anchor point. If adequate anchor points are found before nearing the ends of the rope, the decision must be made whether to use it or continue lower in hopes of finding something further down. Although it is most efficient to gain the maximum distance from each rappel, if a safe anchor point cannot be found lower, it will become necessary to ascend the ropes, taking much more time.

## SECTION III – ASCENDING AND DESCENDING TRANSITIONS

11-135. Many situations exist during which advanced military mountaineers must be able to change direction of travel while hanging from a fixed rope. The direction change can be planned or unplanned and involve single-strand or double-strand systems. Whenever mountaineers' duties or tasks may require them to make hanging transitions, they should use single-strand systems that allow them to use safer special equipment and techniques. However, they should also be prepared to transition from rappelling to ascending on two-rope systems using equipment routinely carried.

11-136. Transitioning while hanging on a rope should only be done by level 2 or higher mountaineers who have received formal training in ascending and descending transition techniques.

# TECHNIQUES

11-137. Conducting transition techniques without special equipment is not recommended. Not using the appropriate equipment will require mountaineers to transition alone and uninspected, utilizing a complex series of rigging steps while at risk of catastrophic fall. This situation should be avoided whenever possible and only attempted by mountaineers who are experienced in ascending and descending and load-transfer techniques.

# SPECIAL EQUIPMENT

11-138. Mechanical ascender—see paragraphs 11-15 through 11-18, page 277 for more description. Whereas these devices are not necessary for other fixed-rope movement situations, they should always be used when hanging transitions are planned.

11-139. Assisted braking device (ABD)—the ABD allows mountaineers to change direction without changing primary attachment to a fixed rope. It can be used with single-rope systems for belaying, rappelling, or capturing progress during ascending. The ABD uses a toothless cam to grip the rope when loaded. Rope can be pulled through it to capture progress or allowed to move in the opposite direction under the control of a release lever providing variable friction. ABDs are not recommended for use in a winter environment because they can get jammed up with snow and fail to work properly. (See figure 11-15, page 300.)

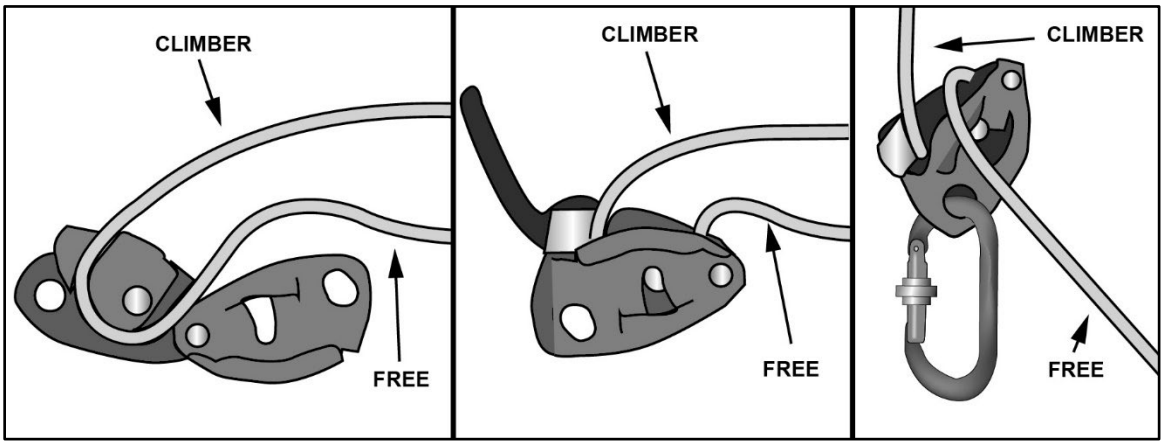



**Figure 11-15. Assisted braking device**

## TRANSITIONS ON SINGLE-STRAND SYSTEMS

11-140. The following situations require or are likely to require ascent or descent transitions while hanging:

- Descent route finding or reconnaissance. Obstacles such as overhanging cliffs longer than a rope length can prevent continued descent. Mountaineers may need to descend numerous possible routes before finding the best way down. When dead ends are discovered, they must ascend back up before trying the next path down.
- Top-down fixed rope establishment when a mountaineer realizes that their path is a dead end and must ascend to re-route the rope on a different descent path.
- Confined space reconnaissance. This involves descending into wells, tunnels, or shafts to look for caches or evidence of enemy activity, and then ascending back to the surface after.

11-141. Whenever an ascent or descent transition is considered likely, then a single strand of fixed rope should be used. This allows the use of an ABD and mechanical ascender to establish the safest and most efficient transition possible.

### Rapid Ascent and Descent Method

11-142. This fixed-rope attachment method allows mountaineers to either travel up a rope and then transition to descent, or descend a rope and transition to ascent, all while remaining safely attached to the rope.

#### *Transitioning from Ascent to Descent*

11-143. Route the fixed rope through the ABD properly, then attach an ABD to the harness with a locking carabiner. Attach an ascender to the rope above it with a cordelette or other long material hanging from it. Use this material to create a fixed loop for a foot stirrup. (See figure 11-16.)

11-144. Ascending—to use the system, place one hand on the ascender and one on the free strand of rope. Place one foot into the foot stirrup. The foot used should be on the same side as the hand on the ascender. Pull down on the ascender while simultaneously standing up in the foot stirrup and pulling rope slack up through the ABD. Once the rope is tight, sit down and the ABD will grip the rope and capture progress. Slide the ascender back up to full arm's length away and repeat. It is helpful to push both down and back with the leg when using the foot stirrup to keep body weight forward.

11-145. Ascending (variation)—the pull strand of rope can be redirected into a carabiner attached to the ascender to change to a downward pull as shown below; however, this can limit the amount of vertical gain with each movement. (See figure 11-17, page 302.)

11-146. Stopping on the rope—back-up stopper knots should be tied in the fixed rope close to the ABD whenever the mountaineer stops on the rope for a period. This is especially true if the rope is unweighted.

11-147. Transitioning—to transition to descent, the mountaineer only needs to disconnect the ascender and stow it.

11-148. Descending—descent by rappel can then be conducted using the already attached ABD. Follow the manufacturer's instructions for use. (See figure 11-16.)

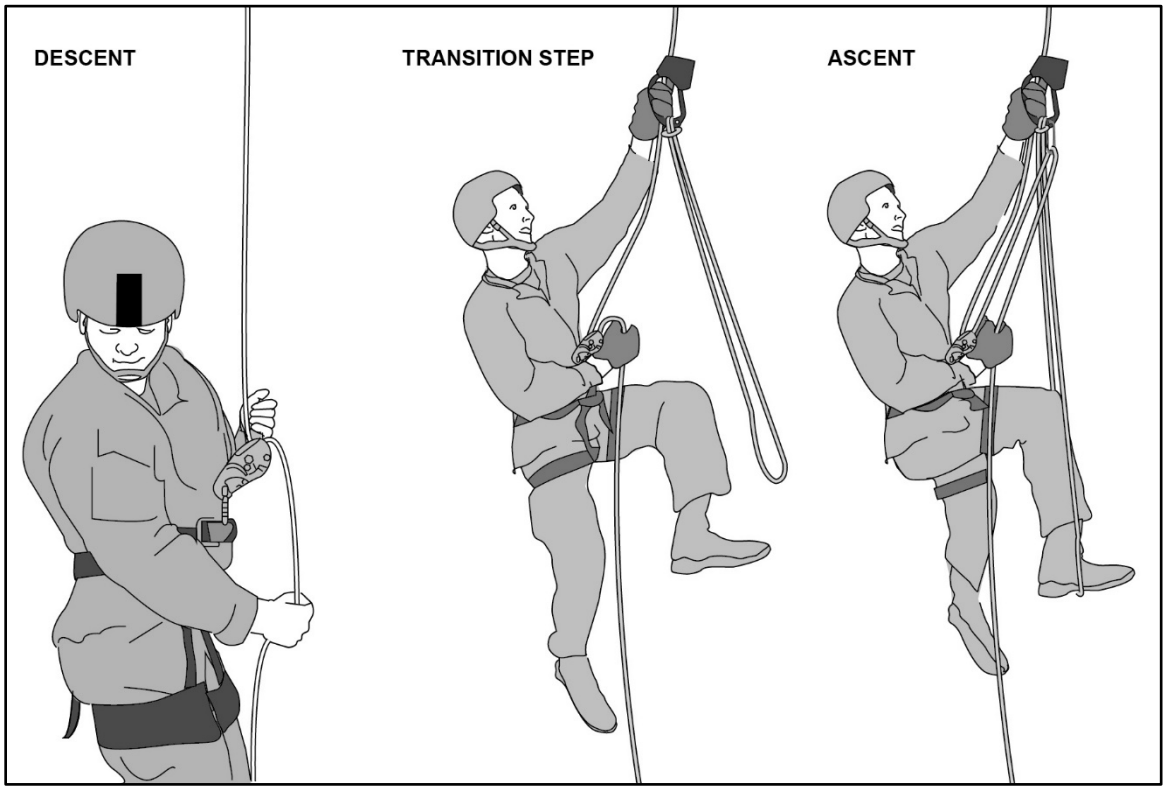



**Figure 11-16. Rapid ascent and descent method**

***Transitioning from Descent to Ascent***

11-149. Route the fixed rope through the ABD properly, then attach it to the harness with a locking carabiner.

11-150. Descending—rappel using the ABD.

11-151. Stopping on the rope—back-up stopper knots should be tied in the fixed rope close to the ABD whenever the mountaineer stops on the rope for a period. This is especially true if the rope is unweighted.

11-152. Transitioning—to transition to ascent, the mountaineer only needs to attach an ascender with a hanging foot stirrup to the fixed rope.

11-153. Ascending—ascending can be conducted using the methods described in paragraph 11-154 or 11-155.

## Improvised Rapid Ascent and Descent Method

11-154. The same process for transitioning from ascending to descending, or descending to ascending, can be used if either piece of specialized equipment is not available (the ascender or ABD) using other commonly carried equipment. The ascender can be replaced with a prusik, and a carabiner attached to a fixed loop tied close with the tails. The tails are then used to create the foot stirrup. The ABD can be replaced with a belay or rappel device that can be used in autolocking mode. The device is attached to the Soldier's harness in autolocking mode (see figure 10-20, page 266, for rigging techniques); then the brake strand is routed through a carabiner attached to an ascender (or prusik, as described above in this paragraph).

11-155. These improvised techniques require extensive practice before use, as they are somewhat more complex to rig and more difficult to operate during ascending. Soldiers employing them should use back-up attachments to the rope throughout the transition process to prevent a fall should a rigging mistake be made.

## TRANSITIONS ON TWO-STRAND SYSTEMS

11-156. The following situations require an unplanned transition from rappelling to ascending while hanging on a double-strand system:

- The rappel ropes do not reach the ground, and there are no anchors available from which to establish another rappel pitch. Often, it is not possible to see if the ropes reach the ground due to overhanging terrain until it is too late. The rappeller must then ascend back to the top.
- Occasionally during multipitch rappelling, the lead mountaineer misjudges anchor possibilities below and rappels past the last viable anchor on the pitch. This requires ascending back up to that anchor before the rest of the group can rappel down and the next pitch can be rigged.

### Prusik Ascent Method

11-157. Mountaineers can transition to ascending from rappelling using the prusik ascent technique described in this chapter.

11-158. Descending—ensure stopper knots are tied in the rappel ropes. Use a basket hitch to extend the device and an autoblock for a hands-free backup. A shorter extension will make transitioning easier.

11-159. Stopping on the rope—when mountaineers realize they cannot reach the ground, they should engage their autoblock and look for anchors that can be used to establish another rappel pitch. If none are available, or they must ascend to reach one, they will need to transition to ascent.

11-160. Transitioning—to transition to ascent, mountaineers should tie a fixed loop a few feet below their autoblock with both rappel ropes and clip it to their harness using a locking carabiner. This serves as a backup for the whole transition process. The progress capture can then be tied around both ropes above the rappel device and attached to the harness with a locking carabiner. Once double-checked, mountaineers then release the autoblock and rappel until the progress captures prusik entirely supports their weight. The rappel device and autoblock can now be disconnected from the rappel ropes and stowed. The mountaineer then attaches the progress prusik to the rappel ropes below the progress capture and establishes a foot stirrup.

11-161. Ascending—ascending is conducted as with prusik ascent. Back-up knots should be tied every 10 to 15 feet and attached to the harness prior to untying the previous ones.

### Other Methods

11-162. Additional techniques for transitioning from rappelling to ascending exist. Some are more efficient but heavily dependent on specific circumstances and available special equipment. It is not feasible to cover them all in this training circular. Seek additional formal mountaineering training to expand upon the techniques covered above.

## OTHER TRANSITION SITUATIONS AND TECHNIQUES

11-163. Other more complex situations requiring ascent and descent transitions, such as climber rescue, are more involved and beyond the scope of this chapter. To obtain formal training or other specific transition-related problems that advanced military mountaineers may expect to encounter in the performance of their duties, consult with qualified mountaineering instructors.

11-164. Opportunities for formal training are available from one of the Army's three mountain training organizations by unit request (see chapter 2).

11-165. An experienced level 3 mountaineer should supervise all sustainment and improvement training on these transition techniques.

# Chapter 12
# Hauling and Lowering Techniques

Mountain warfare requires moving Soldiers, weapons, and equipment up, over, and down steep, rugged terrain. It is vital that Soldiers understand the principles and fundamental concepts of hauling and lowering heavy loads both efficiently and safely.

## SECTION I – HAULING TECHNIQUES

12-1. Mountain operations involve many situations that require hauling systems. A hauling system is a technical rope system used to move a load up steep or vertical terrain comprised of rigging that generates increased mechanical advantage (MA) and captures progress. Properly using hauling systems allows Soldiers to move heavy loads through terrain obstacles that would have been impossible to overcome otherwise. Common situations requiring these systems are equipment recovery, resupply, and rescue operations. Choosing the right system for a given situation requires understanding the principles of MA, categories of systems, and solid judgement.

## MECHANICAL ADVANTAGE

12-2. **A *mechanical advantage* is a reduction in the force required to move a load, which comes at the cost of time and distance**. **Specific rope rigging techniques in mountaineering generate mechanical advantage.** During hauling operations, MA can be created using a rope through several rigging techniques. The advantage gained reduces the amount of force that is necessary to move a load vertically. This makes hauling heavy loads easier. When choosing and constructing a hauling system, the goal is to use the lowest level of MA to move the load. As MA increases, efficiency and load sensitivity decrease. Efficiency is lost throughout the system anytime the rope touches a surface (including the edge of the cliff), moves through carabiners or pulleys, and rubs on itself in the system. Load sensitivity is the ability of the Soldier pulling on the rope to feel what is happening to the load on the end of the rope. For example, a Soldier pulling a heavy load up a slope by hand will know immediately if the load becomes stuck on an obstacle. However, a Soldier moving the load using a high level of MA would not feel this until there was a large amount of tension in the system. This is important when moving casualties or sensitive equipment. These systems require time, materials, and personnel to construct and operate. The intent is not to make easy work of moving the load. The lowest level of MA is desired to maximize load sensitivity, efficiency, and time.

12-3. The more MA a rope system produces, the less efficient it will be. For example, a Soldier operating a 5:1 system only needs to exert 1/5 of the pulling force to move the load. However, that Soldier will need to pull 5 feet of rope through the system for the load to move 1 foot. A balance between work and efficiency must be achieved when selecting an appropriate MA for a given situation.

## HAULING SYSTEM COMPONENTS

12-4. The hauling system has five basic components. Understanding how they work to move the load together (see the list below) allows Soldiers to achieve greater efficiency during hauling:

- Anchors—the anchors required for hauling a heavy load must be unquestionable (see chapter 9). Anchors should be located away from the edge of the slope or cliff to maximize the platform and working space.
- Load—the equipment, weapons, or casualty to be hauled up the terrain.
- Load strand—rope that serves as the connection to the load.
- Pull strand—rope to which pulling force is applied.
- Progress capture (ratchet)—hauling systems require a method of maintaining lift distance gained. A progress capture will only allow one-way rope movement and will maintain tension on the mainline. This may be because the hauler needs to move to the edge for communication or simply because the system has collapsed completely, and pulleys need to be reset. Progress captures can be created

using friction hitches, such as a prusik, or mechanical devices, such as a rope grab or pulley with a built-in ratchet. Some plaquette and ABDs may be used, but they may cause an increase in friction.

- Moveable friction hitch or rope grab device (tractor)—these friction hitches or devices allow the system to collapse toward the anchor, and then are reset outward toward the load to allow continual hauling. Take care with respect to rope-grab devices with teeth. Over tensioning a stuck load with these devices can tear the sheath of the rope.
- Force—hauling systems are multipliers of force. They are expressed in terms of output versus input (for example, 2:1 and 3:1). This means that when Soldiers pull on the haul strand, the unit of force they exert is multiplied throughout the system until it reaches the load. When appropriate, multiple Soldiers may be used on the haul strand to increase the initial force put into the system.

12-5. Static or low-stretch ropes should be used for hauling operations whenever possible. Dynamic ropes are less efficient due to increased rope stretch.

# MECHANICAL ADVANTAGE CALCULATION

12-6. It is vital that Soldiers constructing and operating hauling systems understand how to calculate MA. This ensures systems are constructed correctly and that Soldiers understand the forces they are applying. Memorizing rope systems does not constitute deliberate decision making or guarantee the correct solution to a problem. It is difficult to calculate all the factors that take away from MA. However, we can easily calculate the ideal MA to make decisions.

12-7. To calculate the ideal MA of a constructed system, the tension method—or T-Method—is used. This method assigns one unit of tension, identified as T, to the pull strand of the system. That unit is then followed through the system to the load. To calculate the theoretical MA, compare the amount of tension the load receives to the initial input of tension. (See figure 12-1 and figure 12-2, page 306.)

12-8. Static or low-stretch ropes should be used for lowering operations whenever possible. When dynamic ropes are used, care should be taken to preload the system prior to edge transfer due to increased rope stretch.

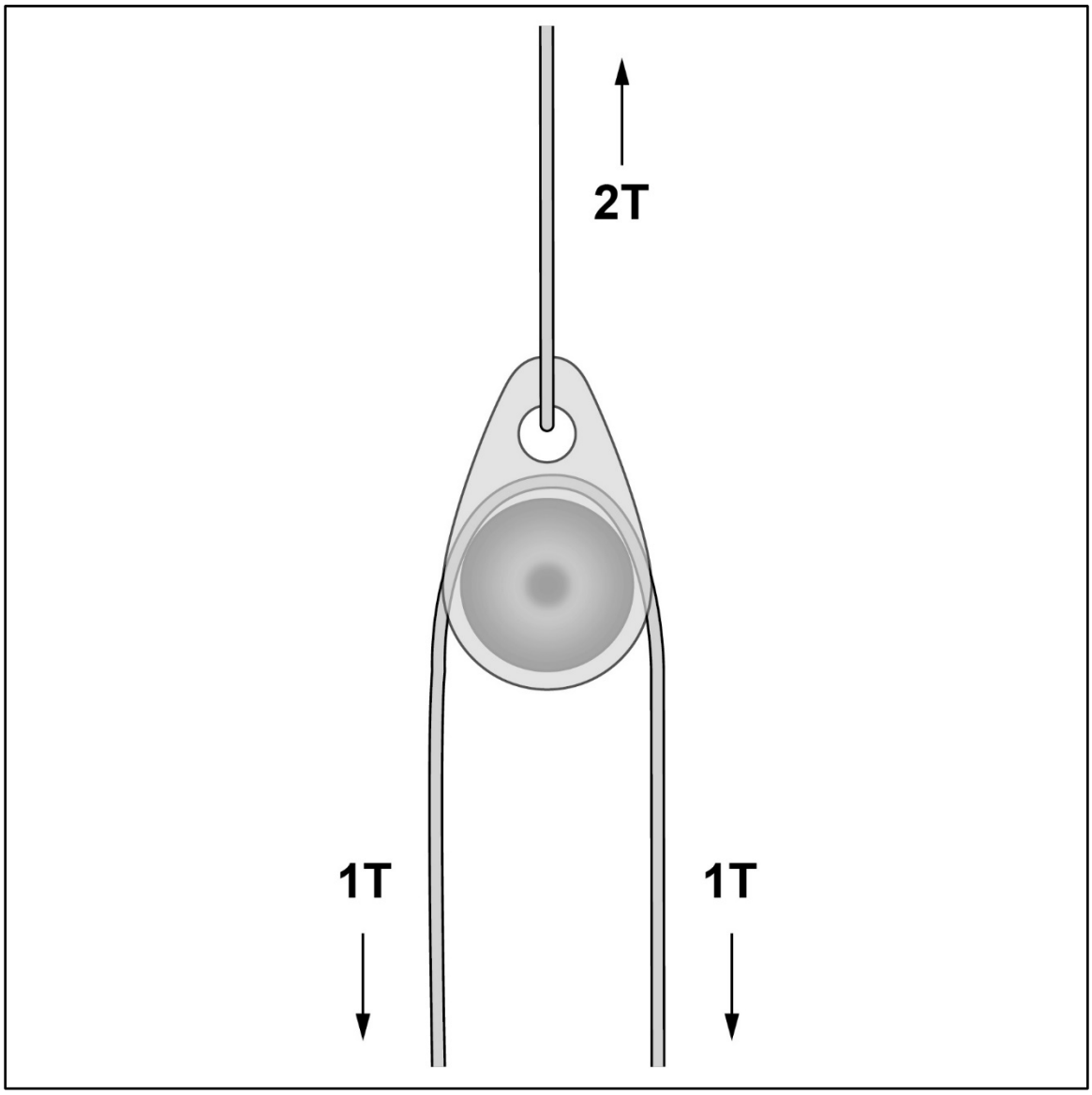



**Figure 12-1. T-Method for simple 2:1 system**

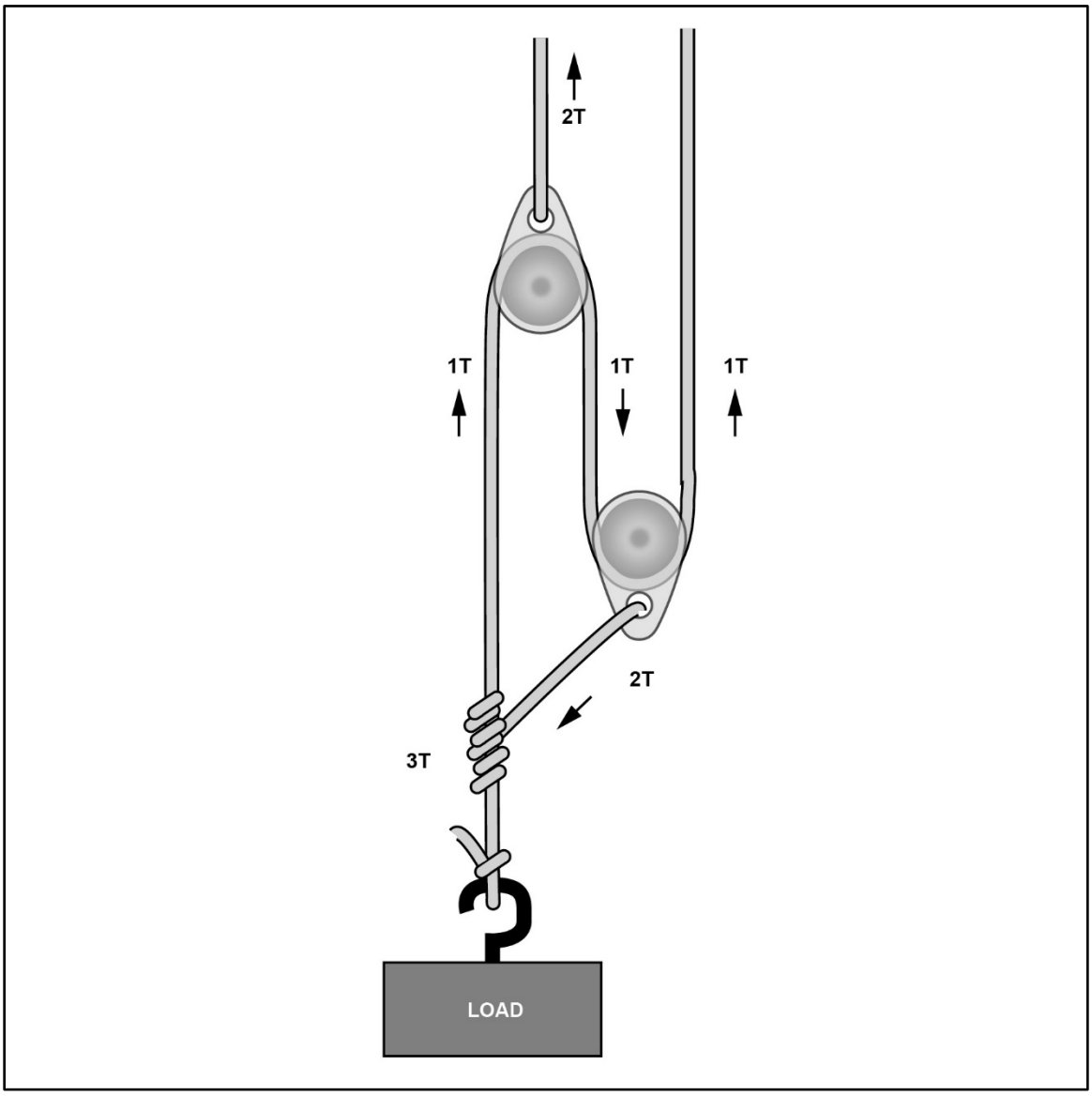



**Figure 12-2. T-Method for simple 3:1 system**

# CATEGORIES OF HAULING SYSTEMS

12-9. The three categories of hauling systems are simple, compound, and complex.

## SIMPLE HAULING SYSTEM CHARACTERISTICS

12-10. Simple hauling systems can be identified by the following characteristics:

- One rope moving continuously and alternately between fixed and traveling pulleys.
- Any traveling pulleys move toward the anchor at the same speed.
- Examples are simple 1:1, 2:1, 3:1, and 5:1 systems. (See figures 12-3 and 12-4, and figure 12-5, page 308.)

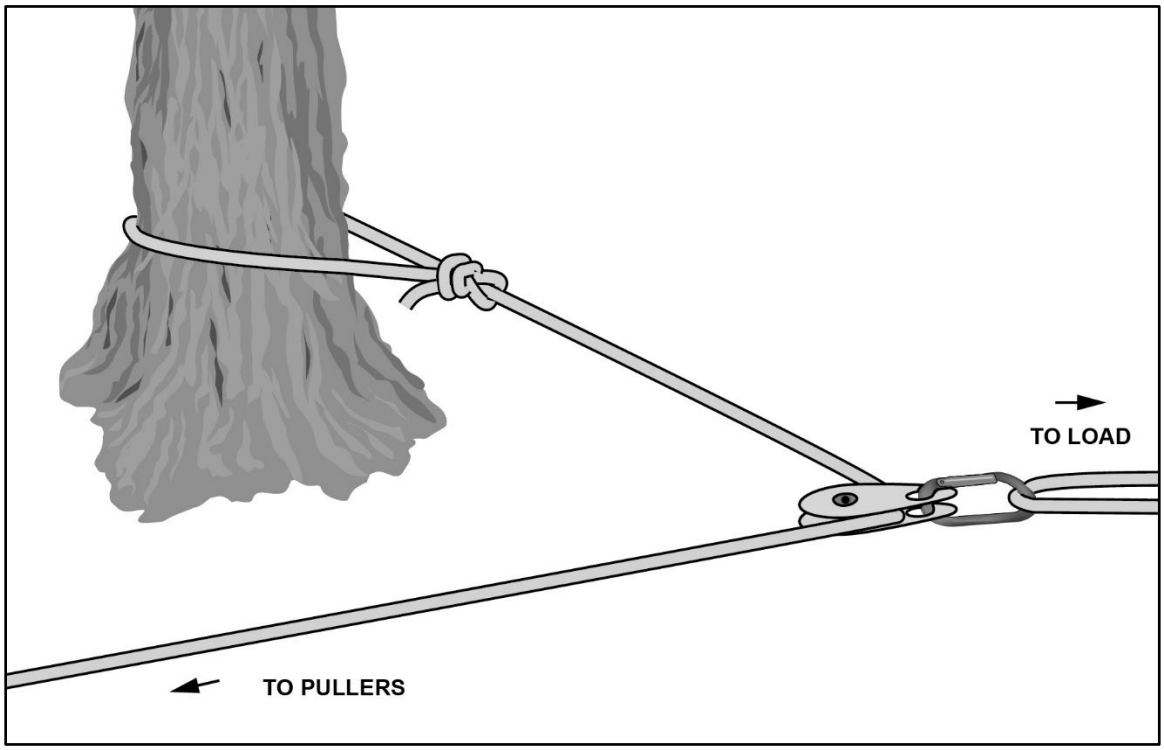



**Figure 12-3. Simple 2:1 hauling system**

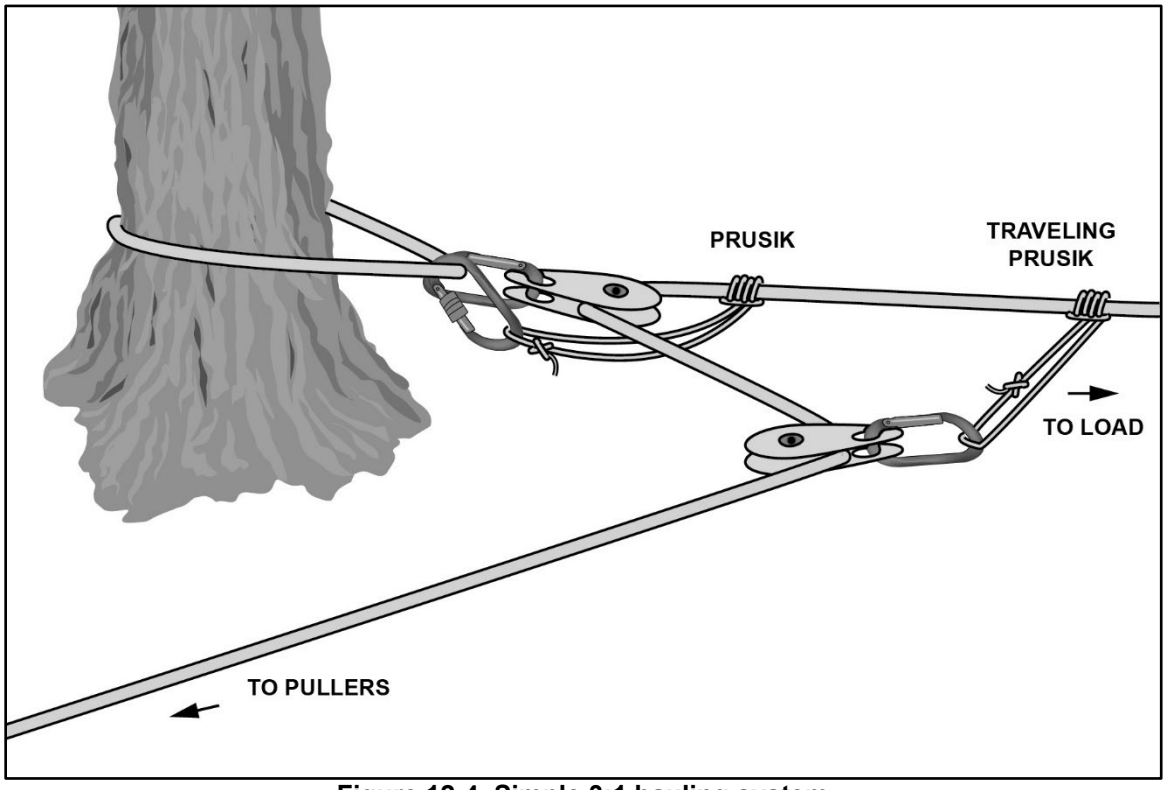



**Figure 12-4. Simple 3:1 hauling system**

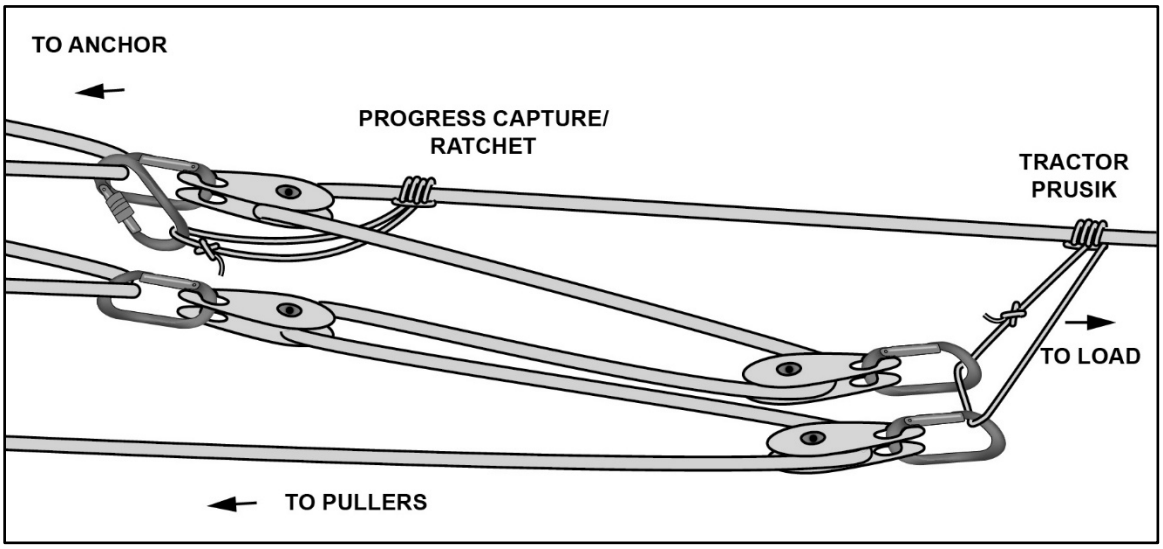



**Figure 12-5. Simple 5:1 hauling system**

## COMPOUND HAULING SYSTEM CHARACTERISTICS

12-11. Compound hauling systems can be identified by the following characteristics:

- One simple system acting on another simple system.
- Any traveling pulleys move toward the anchor at different speeds.
- Examples are compound 6:1 and 9:1 systems. (See figures 12-6 and 12-7.)

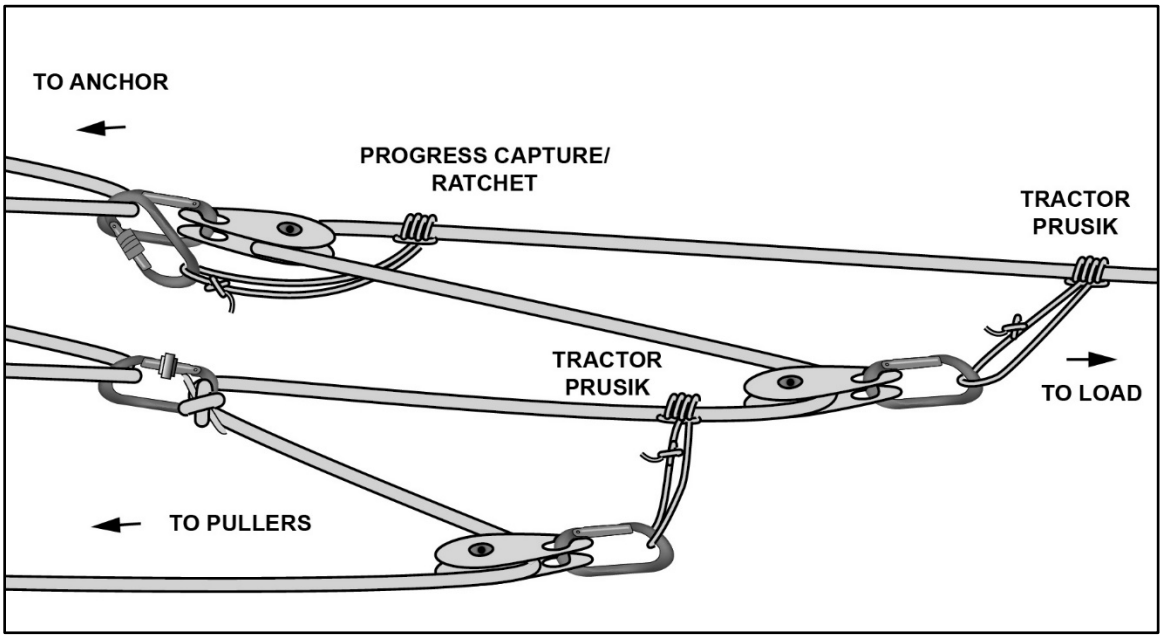



**Figure 12-6. Compound 6:1 hauling system**

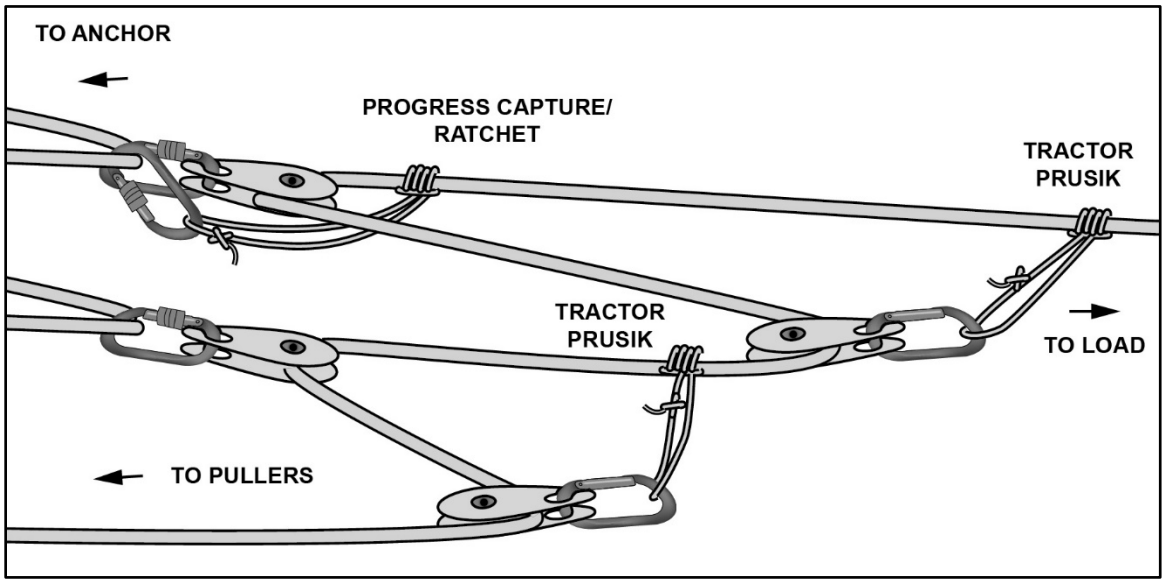



**Figure 12-7. Compound 9:1 hauling system**

### COMPLEX HAULING SYSTEM CHARACTERISTICS

12-12. Complex hauling systems can be identified by the following characteristics:

- Systems that do not fit into either category.
- Examples are complex 5:1 and 7:1 systems.
- These systems have limited practical application for military operations and, therefore, are beyond the scope of this training circular.

## TECHNIQUES TO REDUCE FRICTION

12-13. Friction reduces efficiency of rope movement and can drastically reduce MA. It is important to identify points of friction within the system and strive to reduce them. Efficiency is lost throughout the system anytime the rope touches hardware. Friction can be minimized by using pulleys. Pulleys are used to change direction in rope systems. Pulleys should be small, lightweight, and rated for mountaineering applications. They should accommodate the largest diameter of rope being used. Pulleys are made with several bearings, different-sized sheaves (wheels), and metal alloy side plates. (See figure 12-8, page 310.) Always avoid plastic pulleys. The side plate should rotate on the pulley axle to allow the pulley to be attached at any point along the rope. For best results, the sheave diameter must be at least four times larger than the rope's diameter to maintain high rope strength. Pulleys with side plates designed to accommodate prusik knots are referred to as prusik minding pulleys. These pulleys are designed with tolerances that allow the ropes to run through them but block the passage of a prusik hitch, preventing it from being caught in the pulley.

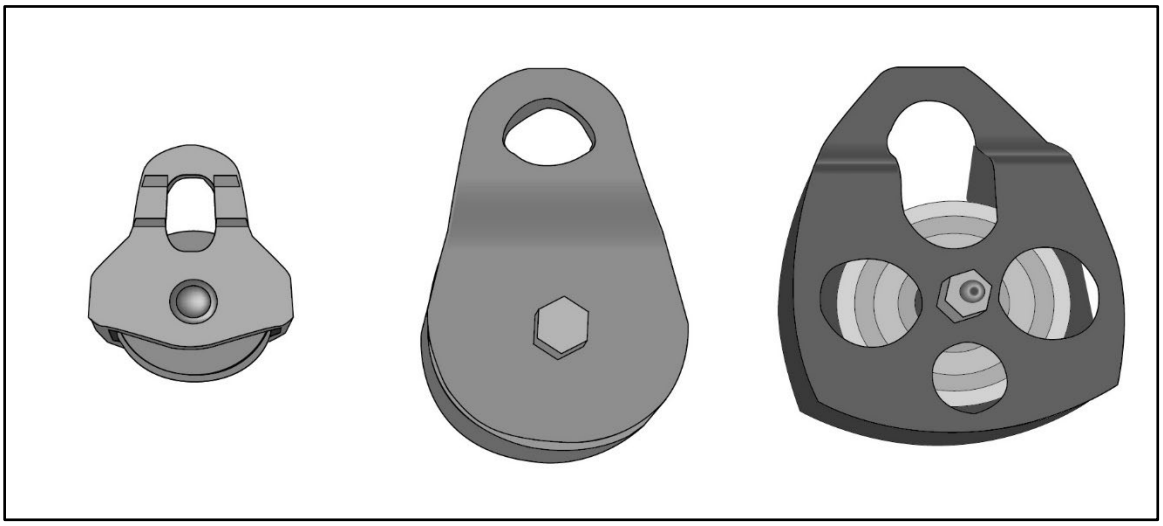


**Figure 12-8. Types of pulleys**

12-14. Pulleys are estimated to be approximately 90-percent efficient, while carabiners are considered only 60-percent efficient. The difference between a system that uses pulleys at direction changes and the same system that only uses carabiners is significant. If the team only has a few pulleys, they should be used at the direction changes closest to the system's haul strand. Pulleys in these locations will maximize the force put into the system initially and carry 90-percent efficiency farther through the system.

12-15. Friction also occurs where the mainline contacts the edge of the slope or cliff. If a suitable anchor can be found near the edge, this friction point can be minimized. The mainline can be lifted and routed through a high directional at the top of the slope or cliff to reduce rope contact and friction at the edge. (See figure 12-9.)

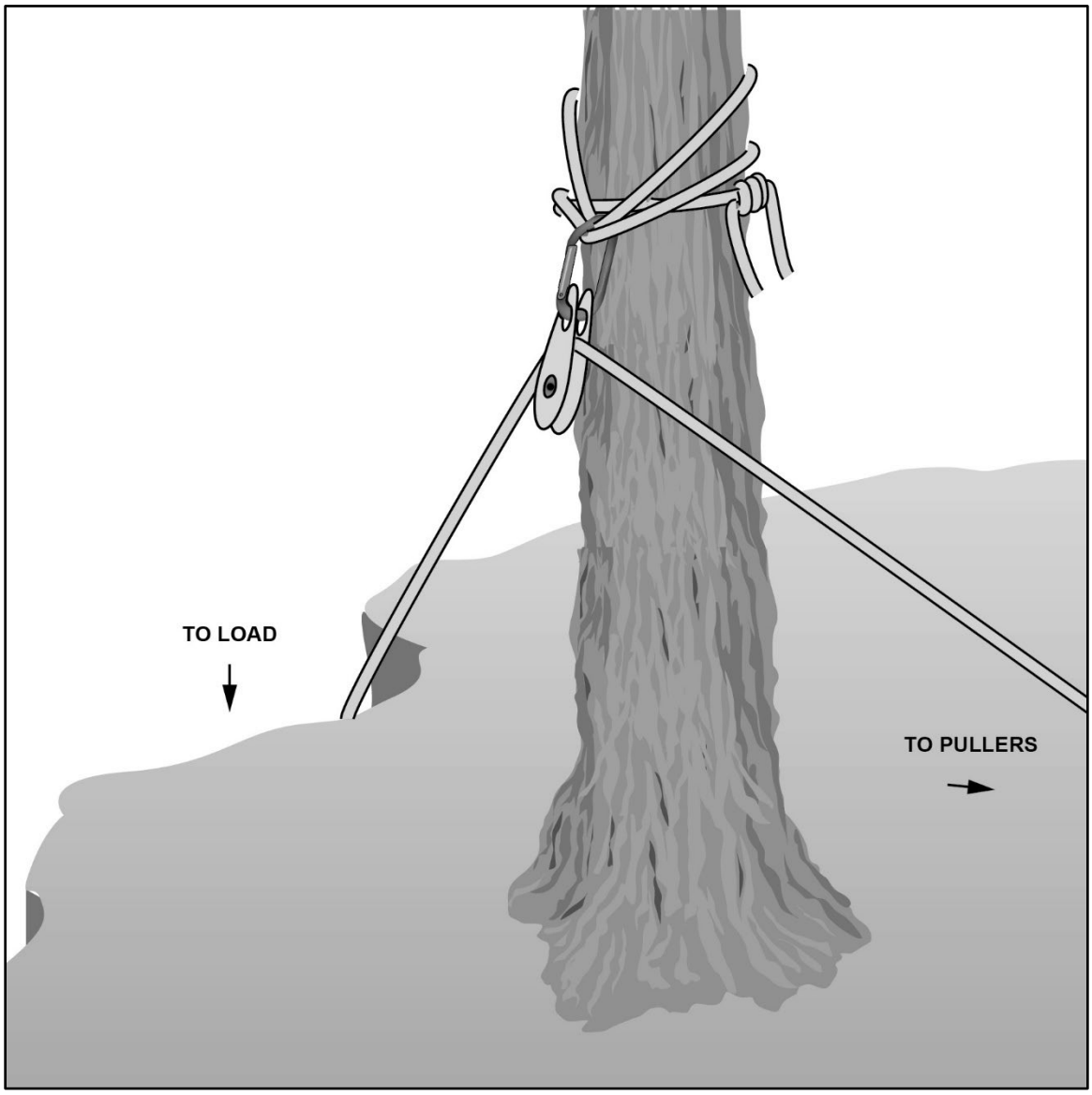



**Figure 12-9. High directional**

# VERTICAL HAULING AND A-FRAME

12-16. The vertical hauling line is an installation used to move heavy equipment and supplies up vertical or near-vertical terrain. The vertical haul line is constructed to eliminate the friction caused by the loads contacting the terrain, rope friction at the cliff edge, and to increase the efficiency of moving loads. Although no real theoretical MA is gained, the function of the system is to reduce the friction against terrain. This system is more of a permanent installation and is most often used on a main supply line. The description below is generalized and based on concepts. Soldiers should seek further instruction and training prior to system use.

12-17. The first and most important task is to determine where to construct the vertical hauling line. (See figure 12-10, page 312.) The site must have a top anchor that is secure enough to hold the system and load. Loading and unloading platforms should be easily accessible, natural platforms that provide a safe working area. Most sites will require the construction of an A-frame at the cliff edge to suspend the load away from

the cliff face. The site should also have sufficient clearance to allow for space between the slope and pulley rope for easy hauling of equipment.

12-18. A-frames should be secured to an anchor behind the edge. (See figure 12-11.) A master point is created in the apex of the A-frame, the leg bottoms joined with cord and dug into the ground. (See chapter 13 for A-frame construction.) A rope is joined into a continuous loop and placed into a pulley in the master point so that the loop reaches the base of the cliff. The A-frame is positioned so that it is leaning out over the edge. This allows loads to hang freely during hauling. Loads are attached to the rope and hauled upward to the cliff top. This specific system requires time and experience to construct and operate. It should only be used if other options are unavailable.

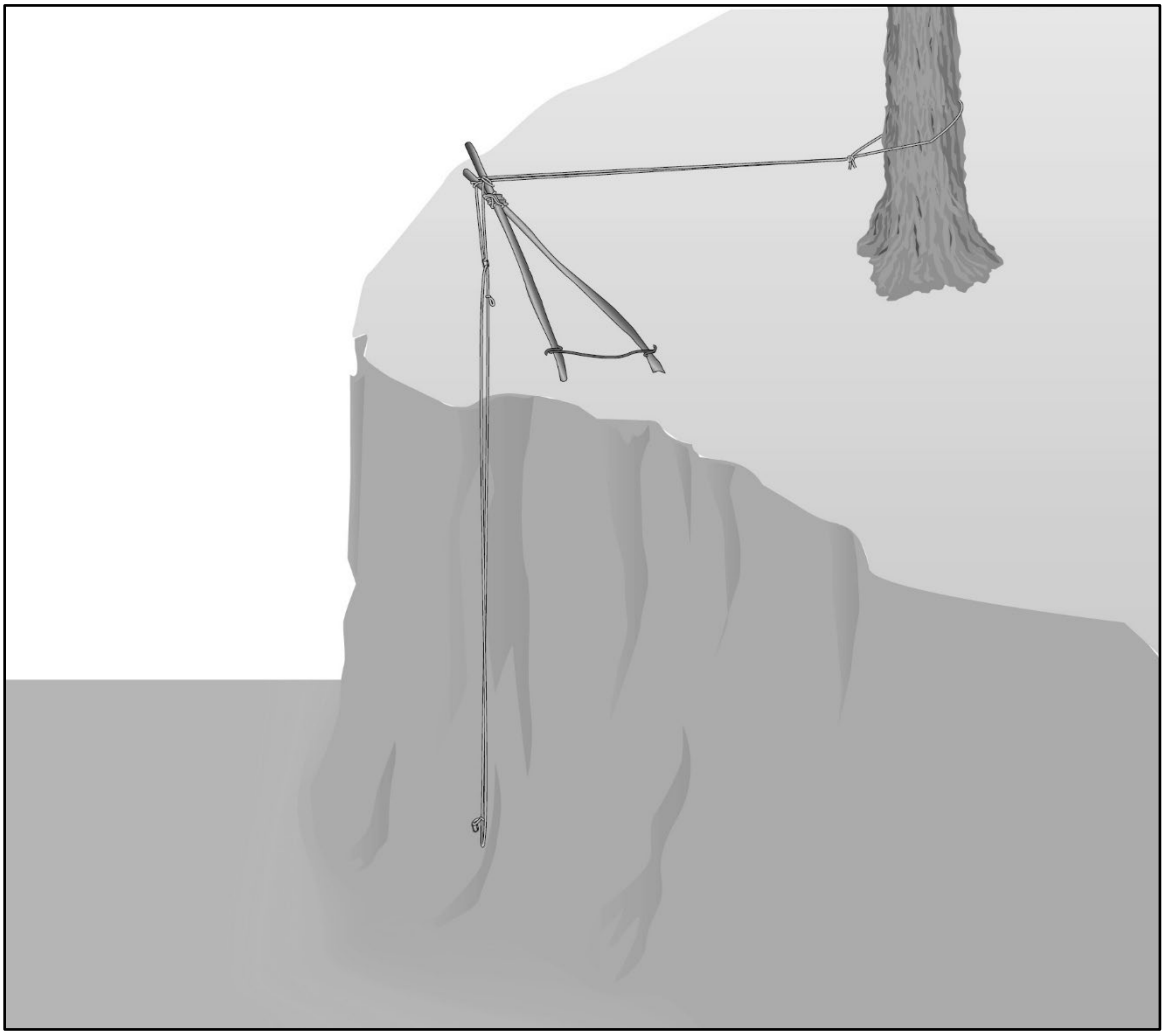


**Figure 12-10. Vertical haul line**

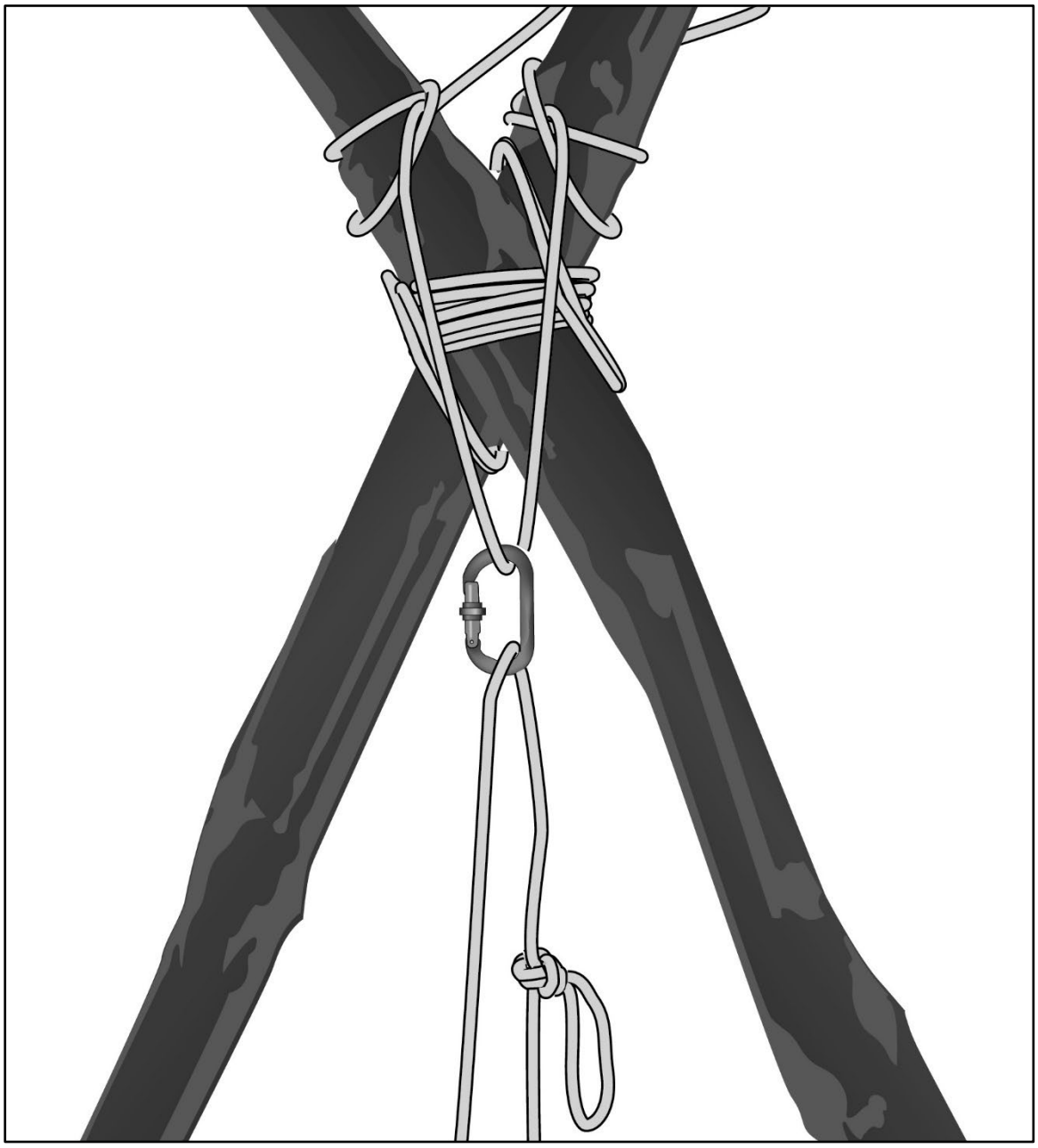


**Figure 12-11. A-frame or master point**

# REDIRECTED HAULING SYSTEMS

12-19. Some situations may require redirecting the hauling system away from the pathway of the load. This is done when the characteristics of the terrain allow for more work or pull space in an alternate or perpendicular direction. It can be achieved by first routing the load strand through an anchor to change direction. From this point, the hauling system can be constructed as before but using the more optimal workspace. This workspace makes pulling easier. When sufficient rope is available, longer systems can be constructed, reducing the number of resets needed during operation. A second technique involves constructing the hauling system in line with the load strand, but then redirecting just the hauling strand through a change in direction at the anchor. This can also be built upon with the use of piggybacked systems.

# OFFSET COMPOUND HAULING SYSTEMS

12-20. Offset compound hauling systems involve attaching a second, separate hauling system to the haul strand of the first system. This technique allows for creating systems that collapse at relatively the same time, which minimizes resets. It also allows the haul team to operate further back from the edge increasing workspace. This technique requires sufficient rope length to construct. (See figure 12-12.)

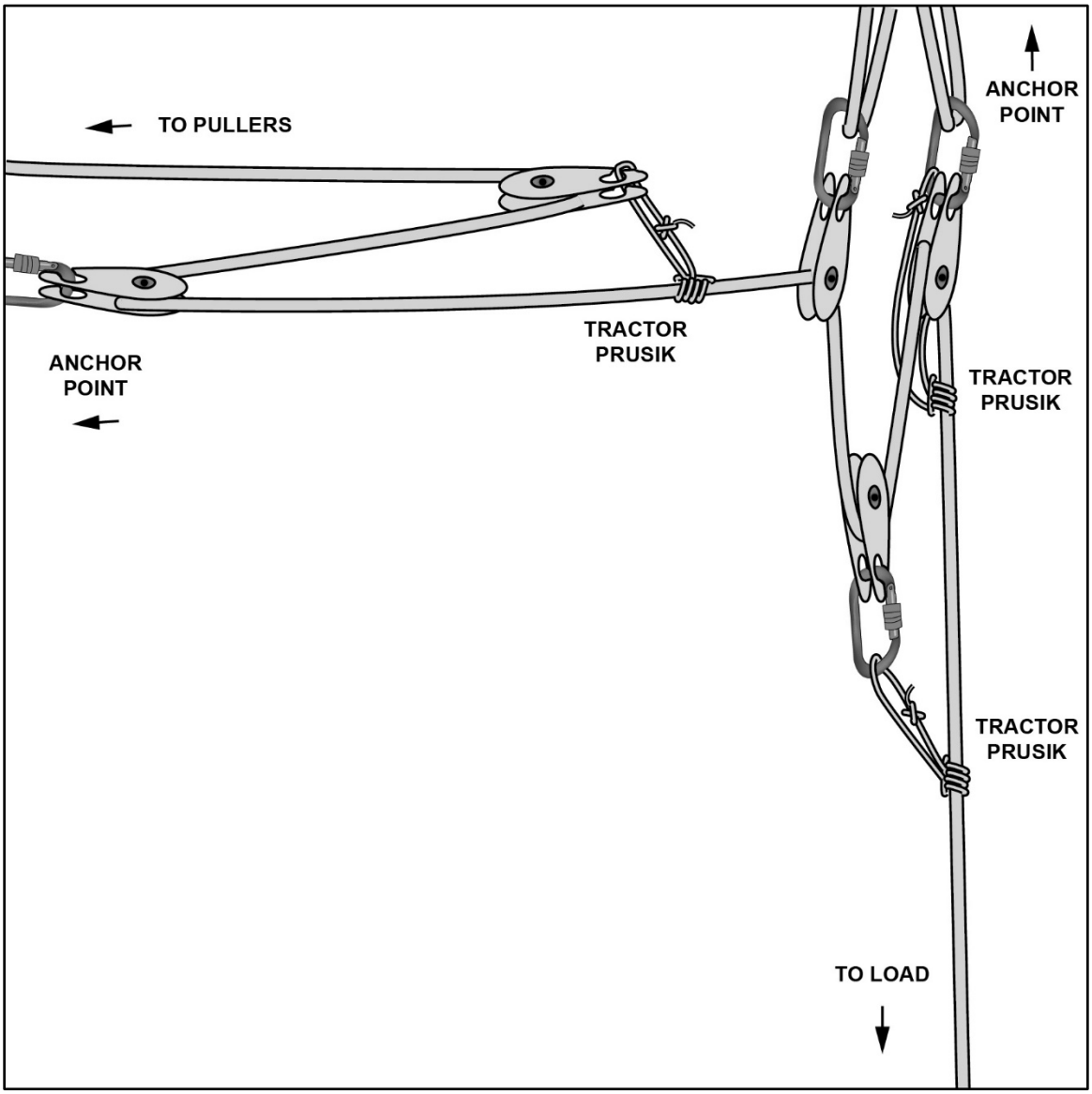



**Figure 12-12. Redirected and offset compound hauling system**

12-21. Operating and constructing hauling systems require training, experience, and judgement. Soldiers must understand both the advantages and disadvantages of using MA to apply these skills correctly. Efficiency can be improved by making practical and simple changes during operation when conditions change.

## SECTION II – LOWERING TECHNIQUES

12-22. **A *lowering system* is a technical rope system used to move a load down steep or vertical terrain in a controlled fashion using friction hitches or mechanical devices**. These sorts of systems are used to control the speed of descent for personnel or equipment using rope. They are an integral part of both high- and low-angle rescue. (See chapter 15.) Lowering a victim or a load is always preferred over hauling if the terrain and situation allows. No two situations are identical. Each new situation will dictate which lowering techniques and systems are appropriate. Understanding basic lowering concepts is key to achieving a safe and efficient solution to the problem.

# LOWERING CONCEPTS

12-23. There are many devices and techniques available depending on the weight of the load. The bottom line for any lowering system is that enough friction must be created to safely control the descent of the load. Different terrain demands different methods of creating friction. When the terrain is steep and broken, selecting a device or technique that provides varying levels of friction is preferred.

12-24. All lowering systems should be closed by securing the free end of the rope (the end not attached to the load). This prevents lowering the load off the end of the rope if the distance of the lower versus the length of rope is misjudged.

12-25. When lowering Soldiers, a hands-free backup for the system should be used. (See figure 11-15, page 300.) This can be achieved in multiple ways. Hands-free backups provide additional measures of protection against human error and allow the Soldier or team operating the lowering system flexibility while controlling the brake strand.

# TECHNIQUES AND DEVICES FOR CREATING FRICTION

12-26. There are numerous ways to create friction for lowering. The least technical solution to safely lower the load is the goal. Three basic methods are the terrain feature, Munter hitch, and redirected belay device.

### TERRAIN FEATURE

12-27. This method involves simply wrapping the rope attached to the load around a natural object, such as a tree or boulder. (See figure 12-13, page 316.) The number of wraps depends on the amount of friction desired. This technique is used for gentle, low-angle terrain, when speed is needed, or when equipment is in short supply. It also provides variable friction but may often require more than one Soldier on the brake strand to operate safely.

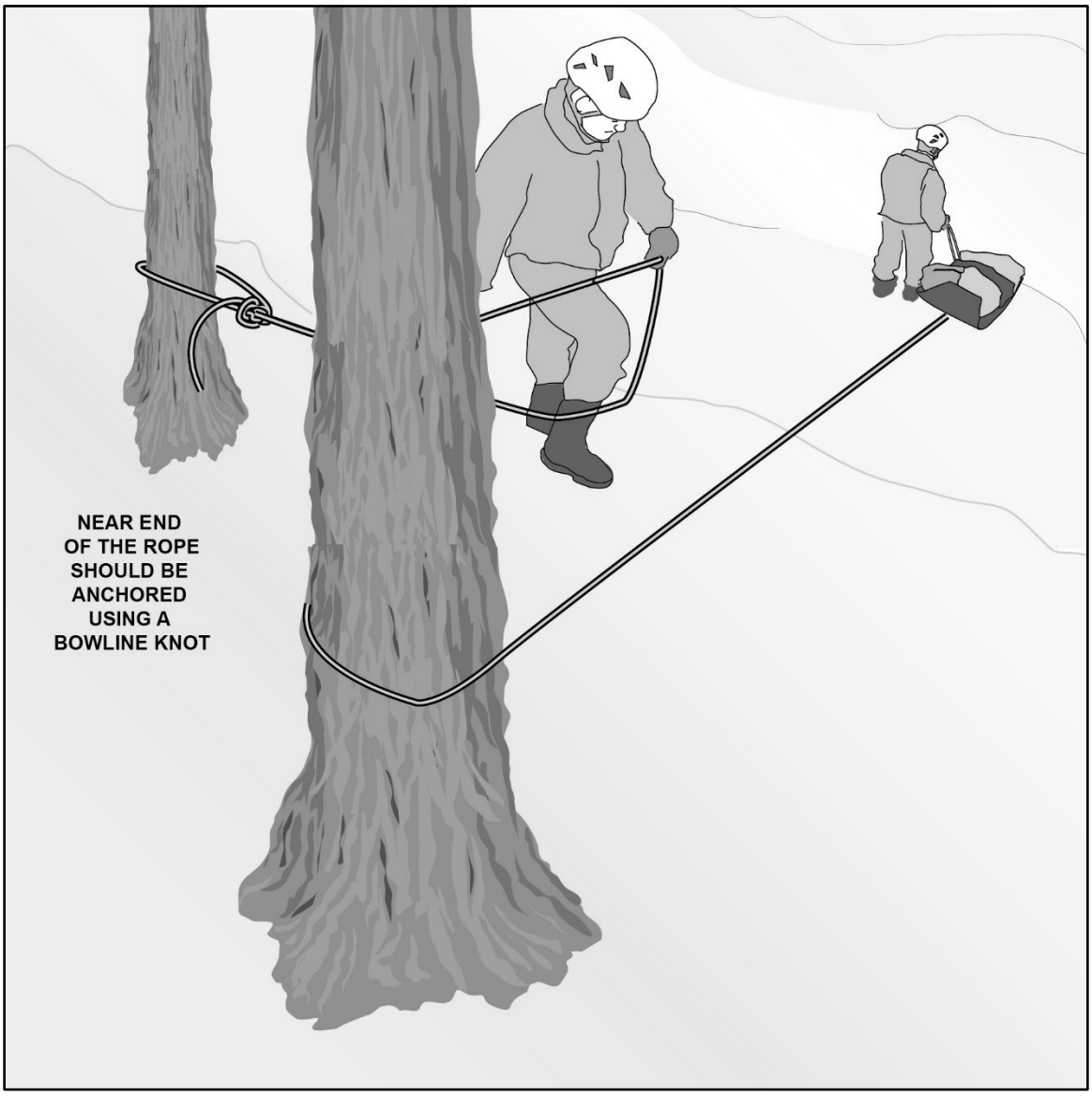



**Figure 12-13. Terrain lower**

## MUNTER HITCH

12-28. The Munter hitch provides enough friction for a one-person load. The Munter hitch can be easily converted to a super Munter if more friction is desired. (See figure 12-14.)

***Note.*** Take care not to open the gate of a fully loaded carabiner. This could cause potential failure of the carabiner.

12-29. The super Munter provides an enormous amount of friction; it is used for lowering only. In most circumstances, the super Munter provides more friction than needed. Therefore, its use is limited to when a single Soldier is lowering a heavy load.

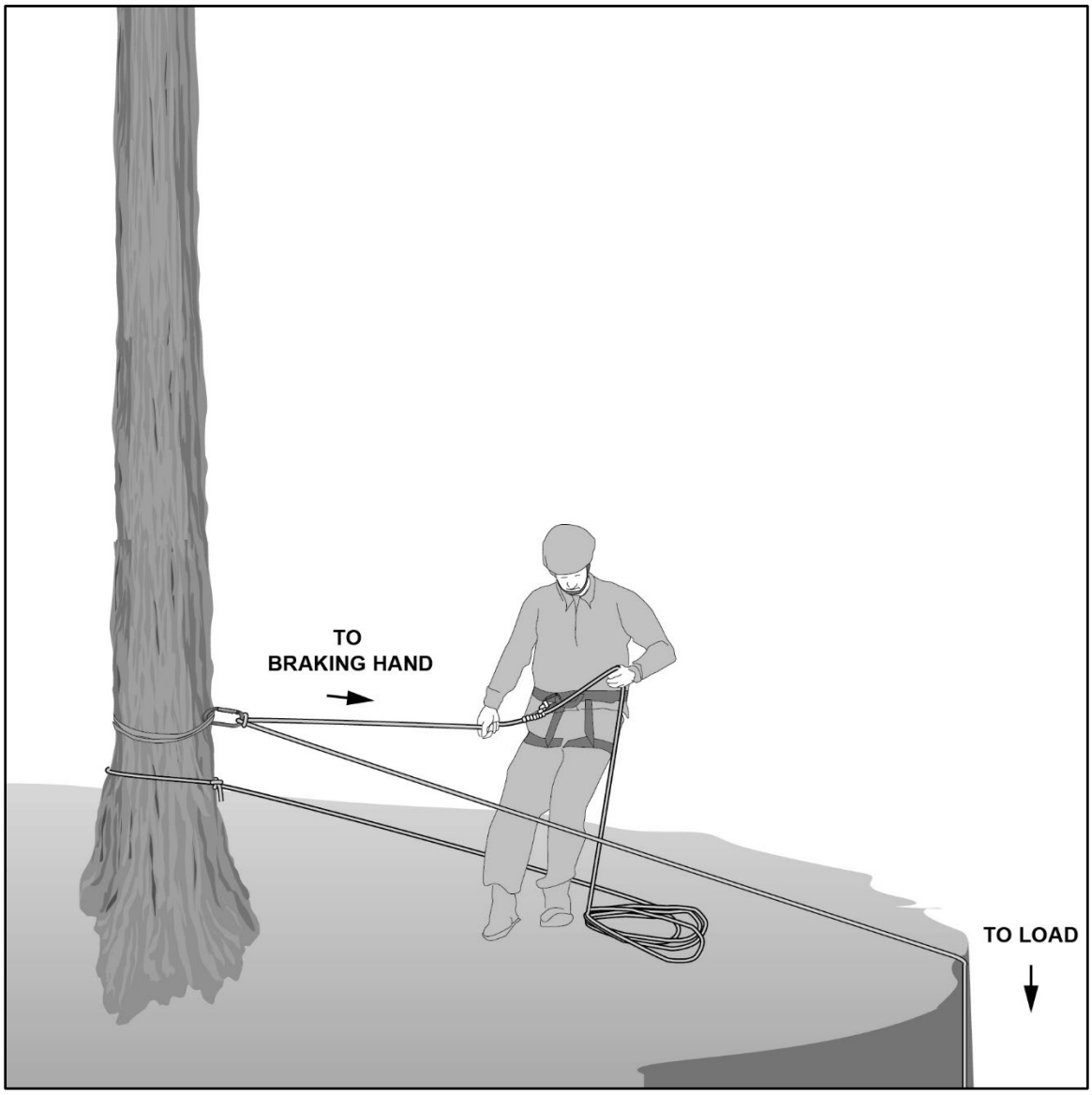



**Figure 12-14. Munter hitch**

## REDIRECTED BELAY DEVICE

12-30. A redirected belay device provides enough friction for up to two people and causes fewer twists in the rope than a Munter hitch. (See figure 12-15, page 318.)



**Figure 12-15. Redirected belay device**

# TECHNIQUES FOR CREATING HANDS-FREE BACKUP

12-31. Hands-free backups are an important component of lowering systems. They provide a critical element of safety when Soldiers are being lowered. There are two main options for creating hands-free backups: a friction hitch on the load strand or friction hitch on the brake strand.

12-32. Friction hitches on the load strand are used when the Soldier operating the lowering system does not have a harness on. (See figure 12-16.) This can be achieved by tying a prusik with the middle of a cordelette to the lowering rope, then clipping a fixed loop tied with the tails to the master point of the anchor. If the backup must be releasable, a releasable knot such as a Munter mule can be used instead of a fixed loop. Deciding which technique to use is based off the terrain and the situation. Soldiers must be careful to keep the prusik close to the Munter hitch during the lower so that it does not grab the lowering rope and stop the operation unintentionally. They must also ensure that the wraps of the prusik do not become loose. This could prevent the prusik from automatically gripping the rope if control of the lower is lost. This requires careful operation from a single rescuer or the assistance of a second Soldier to mind the prusik.

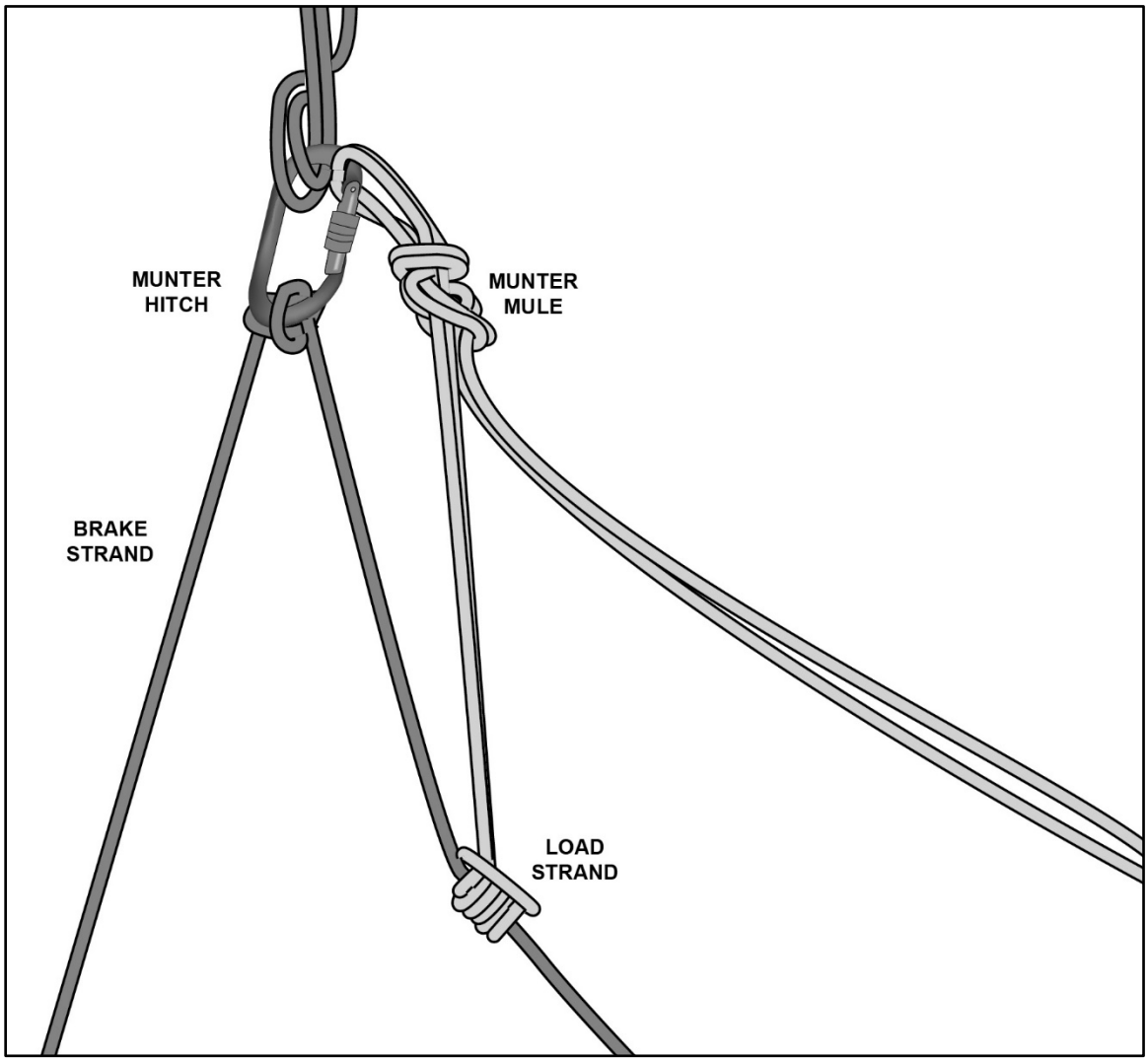



**Figure 12-16. Friction hitch on load strand (releasable)**

12-33. Friction hitches on the brake strand require the Soldier operating the lowering system to be wearing a harness. (See figure 12-17, page 320, and figure 12-18, page 321.) The preferred technique is an autoblock in a carabiner attached to the belay loop of the harness. This technique allows for Soldier flexibility in knot passes and load transfers for operation when moving away from the anchor toward the edge for better visibility and communication. Friction hitch backups on the brake strand are simpler to manage and preferred when a harness is available.



**Figure 12-17. Friction hitch on brake strand of Munter hitch**

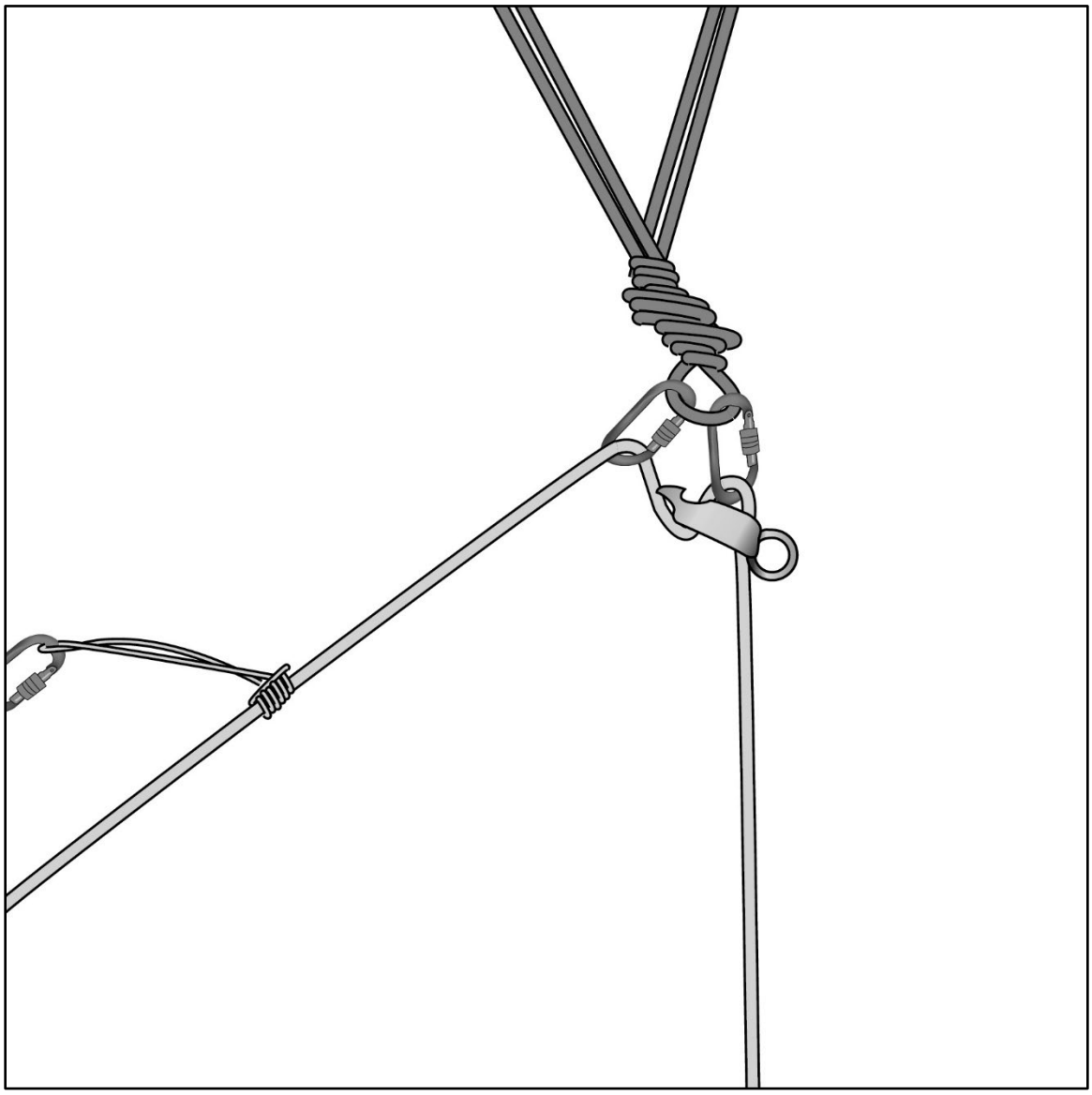


**Figure 12-18. Friction hitch on brake strand of redirected belay device**

# CONCEPTS FOR PASSING A KNOT

### Knot Pass Special Note

- A wide array of situations require a knot pass. It is not feasible to cover them in-depth in this training circular.
- The conduct of a safe knot pass with a lowering system under tension can be complicated and technical. It should be conducted or overseen by a level 2 mountaineer.
- Seek qualified instruction to gain proficiency in the skills mentioned below.

12-34. Situations arise when a knot must be passed through the lowering system. This can occur when there is a damaged section of the rope that has been isolated with a knot or when ropes have been joined to lower longer distances. If passing a knot is necessary, it is usually conducted or overseen by a level 2 mountaineer. It is preferable to construct the lowering system to facilitate passing the knot prior to beginning the lower. (See figure 12-19.)

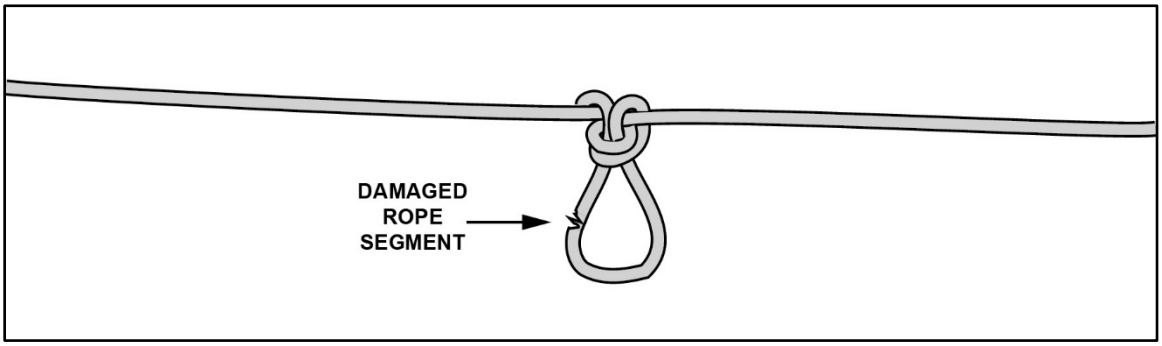



**Figure 12-19. Isolating a damaged section of rope**

12-35. The simplest way to pass the knot occurs when the terrain and situation facilitate safely unweighting the lowering system temporarily. This is generally in low-angle terrain where most of the load is resting on the ground. This unweighting enables creates enough slack to place a new friction hitch or device behind the knot, and then remove original friction hitch or device from in front of the knot, so that lowering can continue.

12-36. If the terrain and weight of the load do not allow the lowering system to be safely unweighted, a weighted load transfer is required to pass the knot. These techniques are best learned with formal hands-on training and should only be conducted by level 2 and 3 mountaineers.

12-37. The construction and operation of lowering systems requires training, experience, and judgement. Soldiers and leaders must understand what they are doing and why they are doing it. Strive to use the right amount of friction for the terrain, situation, and load.

## Chapter 13

# Mountain Stream Crossing

In 480 BC, Persian King Xerxes constructed a pontoon bridge that spanned a mile and a quarter across the Hellespont. After a previous failure to take Greece, the king weighed the options of either finding alternate routes to the north that added months to his expedition or pinpoint potential water crossing locations for his army. Xerxes insisted on the fastest and most direct route across the Aegean inlet for his 300,000 men. While negotiating the linear obstacle involved massive resources and engineering, it would save precious time for his army to reach their objective.

## SECTION I – MOUNTAIN STREAM FUNDAMENTALS

13-1. A mountain stream crossing is essentially an approach to negotiating a potentially swift and cold waterway that Soldiers may encounter in the mountains. Learning to cross small streams forms a foundation of skills for personnel to manage larger streams and rivers, where consequences could be far more hazardous.

13-2. In an operation involving the crossing of a stream or river, the actual crossing itself is a means, not an end sought. The purpose is for designated units to conduct a crossing to establish security on the far bank to protect remaining personnel. This operation should be conducted economically and with minimal loss of momentum.

13-3. There are limits on the safe use of the techniques discussed in this chapter. Not all mountain rivers or streams will be fordable with these techniques. If a water obstacle is too wide, swift, or deep, an alternate route should be used. It may require using aircraft transport if engineer support is unavailable. Reconnaissance of questionable crossing sites is essential. This chapter covers the techniques for crossing mountain streams that have a depth generally not exceeding waist level.

13-4. Stream crossings should not be taken lightly. The force of flowing water may be extremely great and is most often underestimated. All rivers and streams are obstacles to movement. They should be treated as danger areas and avoided whenever possible. When rivers or streams must be crossed, there are many techniques that the small-unit leader may choose from, depending upon the type of stream, its width, speed of the current, and depth of the water. This activity should be rehearsed prior to execution in the operational environment.

### RECONNAISSANCE

13-5. Performing a site survey of potential crossing locations (map, photo, or aerial) may not always reveal that a water obstacle exists. In a swamp, for example, unfordable sloughs may not show on the map, and they may be concealed from aerial observation by a canopy of vegetation.

13-6. Site selection is extremely important once Soldiers determine that they must make a crossing. Elevated positions offer an optimal vantage point from which to analyze a large area of possibilities. This is sometimes better than a hundred close views from a riverbank. Select the site selection before the main body arrives and examine the site around a similar time of day that the crossing will be conducted.

13-7. A suitable crossing site should have specific characteristics. A river crossing site should limit exposure to observation, facilitate the installation team crossing (if necessary) or swimming with ropes, and minimize drowning hazards. Care must be taken to avoid an installation team crossing upstream of rapids, waterfalls, or fallen trees in the river. For dry features, such as gorges or ravines, the site should facilitate the installation team's descent and ascent crossing while minimizing any falling hazards that exist. While dry crossings are preferred to wet crossings for speed and safety factors, they can become locations for an enemy to place landmines and improvised explosive devices.

13-8. The time of day is an important factor. Recent precipitation or increased temperatures could cause water levels to rise as glaciers or snow-covered peaks begin to melt. Early morning crossings are preferred, as the cooler night temperatures usually reduce the melt from snow and ice. A morning crossing also allows clothing items to dry throughout the day. Whether a crossing is made in daylight or in darkness depends on

the need for concealment, proficiency of troops, nature of the terrain, characteristics of the water obstacle, enemy disposition and capabilities (such as minefields on far banks), and the need for speed.

13-9. A crossing point should be chosen where the river widens. The sudden width of the channel normally yields a shallow depth. Avoid sharp turns in the river or a narrowing choke point in the river or stream since the water is likely to be deep and have a strong current on the outside of the bend for curves.

13-10. Many mountain streams, especially those fed by glacier runoff, contain sections with numerous braided channels. While often shallower than a main river, this changing landscape offers little in the way of cover and concealment of exposed personnel. Shoals, or partially submerged sandbars, can act like quicksand depending on the riverbed composition.

13-11. Riverbanks should be low enough to accommodate for easy entry and exit from the water. Banks that are tall and steep may require employing installations such as hasty rappels (see figure 11-11, page 293) or simple fixed ropes (see figure 11-2, page 278).

13-12. Logjams and other large obstructions present their own hazards. Floating debris, while often hung up in shallow spots, can potentially hit personnel in the water. Water flowing around logjams creates riverbed erosion and swift waters. If crossing upstream of logjams, ensure that Soldiers are far enough away to react and do not become entangled in branches beneath the water surface.

13-13. When possible, cross with ample overwatch in place for support and with an approach that offers minimal detection by enemy forces.

## PREPARATION OF TROOPS AND EQUIPMENT

13-14. Special considerations should be taken for personnel and the items they carry for the mission. Water can weigh personnel down, as can the uniform posture when dealing with submerged equipment. Most of the preparation should happen long before entering the water, with only special considerations executed in a short halt prior. Preparation should include—

- Water-sensitive items. Wrap radios, binoculars, documents, maps, and any extra clothing in waterproof bags (trash bags also work well), if available. These bags also provide additional flotation, should Soldiers find themselves in deeper water than expected. Pack these dry clothing items on top, along with other necessary items (such as munitions, sensitive items, and machine gun tripods) quickly before getting into the water.
- Uniform. If the tactical situation permits, a crossing can be made with minimal clothing. Once on the far side, Soldiers can change into dry clothing. Normally, a complete uniform is worn. Unblouse boots and untuck shirts. Ensure all pockets are buttoned or closed. If water has a point of entry, ensure that it has an easy way to exit. Trapped water can weigh down personnel who may need to swim at a moment's notice. Socks and boot insoles can be removed and stowed. Once on the far bank, boots can be drained, and wet socks replaced.
- Load-carrying equipment and body armor. Unbuckle fighting load carrier or other modular equipment and be prepared to remove, if necessary. It is difficult to remove a buckled harness in the water during an emergency.
- Helmets can be removed and stowed, but if Soldiers fall in water with debris, the helmet protects their head from impacts.
- The rucksack should be worn well up on the shoulders and snug, so it does not flop around and cause imbalance. The waist and chest straps must be unbuckled so Soldiers can rid themselves of the rucksack if they are swept off their feet and must resort to swimming. Securing everything inside the pack will help if it needs to be discarded. It is easier to find one large pack than several smaller items.
- Weapons should be secured to the pack or slung over the shoulder.

# SECTION II – CROSSING TECHNIQUES

13-15. Several techniques and methods exist to successfully negotiate water obstacles. Variables that can influence the most optimal crossing style are water depth and speed, confidence around water and swimming

proficiency, riverbed surface, daylight or night crossing, and resources available. When available, a dry crossing is always preferred.

13-16. In this section, we will discuss three different variations that work well for mountain stream crossings: the individual crossing, team crossing, and belayed crossing.

# INDIVIDUAL CROSSINGS

13-17. Whenever possible, and when the degree of experience permits, streams should be forded individually for a speedier crossing. (See figure 13-1.) The average Soldier should be able to cross most streams with mild to moderate currents and water depths of not much more than knee-deep using proper techniques. An advantage to the individual crossing is that there is nothing to recover once Soldiers have performed the crossing. A disadvantage is the time of exposure for the individual and time invested for the element to negotiate the water obstacle.

13-18. The water depth at a suitable crossing site should be about knee height or below, and the water's speed should be mild to moderate. The velocity of the water and the presence of debris are used to determine the effect, if any, on the ford's condition. Currents are categorized as—ν Swift (more than 1.5 meters [5 feet] per second). ν Moderate (1 to 1.5 meters [3 to 5 feet] per second). ν Slow (less than 1 meter [3 feet] per second).

13-19. Individuals should look upstream for obstacles, and pick up a good athletic stance, angling their body slightly perpendicular to the current. Adjust to a more parallel stance and lean upstream if the current is stronger.

13-20. Pick a location slightly downstream to the Soldier's position. Traveling at 90° causes Soldiers to fight the current rather than work with the flow of water as much as possible. Always lead off with the downstream foot and take small steps while keeping the feet close to the ground. Avoid moving one foot before securing the other foot, and do not cross legs. This will decrease the likelihood of moving water throwing the Soldier off balance. Additionally, it will allow the Soldier to explore the riverbed for obstacles such as holes, rocks, shoals, or debris for optimal management. If a sizeable rock is found, Soldiers should always step on the upstream side of it. Water cresting the top and sides of rocks picks up speed, digging around and on the downstream side. The integrity of these rocks is unknown and could roll downstream at any time.

13-21. For added stability, using a third contact point is encouraged. A long stick or staff, ice axe, or tree limb could be used. By placing the end of the third point as upstream as possible, Soldiers can create a tripod, while exercising a body position described above to create a streamlined signature. The third point can be useful as a probe, searching for obstacles and depth.

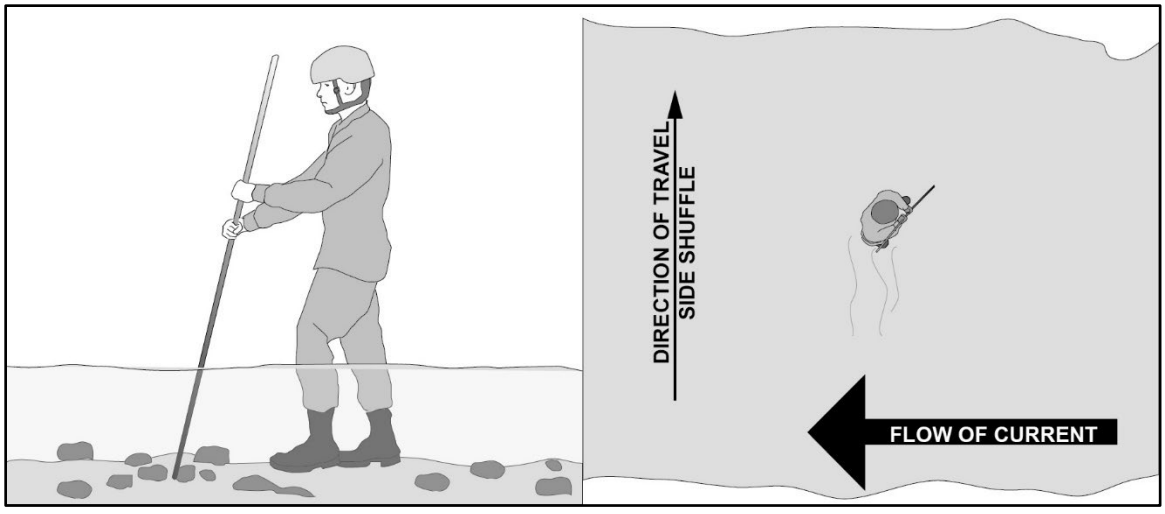



**Figure 13-1. Individual crossing**

# TEAM CROSSINGS

13-22. When the water level begins to reach thigh deep, or anytime the current is too swift for personnel to safely perform an individual crossing, a team crossing may be used. With each of these methods, have a leader call each step. One advantage to the team crossing is reduced exposure time for higher concentration of personnel, and there is no equipment to recover once Soldiers have performed the crossing. Disadvantages for all team crossings include a lack of interval for free movement and negotiation of riverbed makeup. Additionally, the close concentration of personnel makes them an easy target for direct or indirect enemy fires. The speed at which Soldiers can move fire teams and squads is that of a singular unit.

## CHAIN CROSSING

13-23. Two or more individuals cross arms with each other and lock their hands in front of themselves. (See figure 13-2.) The line formed faces the far bank. The largest individual should be on the upstream side of the line to break the current for the group, leaning upstream, into the current. The line formed will then move across the stream using the same principles as for individual crossings but with the added support of each other. The team still moves at a slight downstream angle, stepping off with the downstream foot in the lead. If the formation begins to degrade, avoid trying to excessively hang onto personnel who have lost control. In that scenario, the alternative of swimming is the safest.

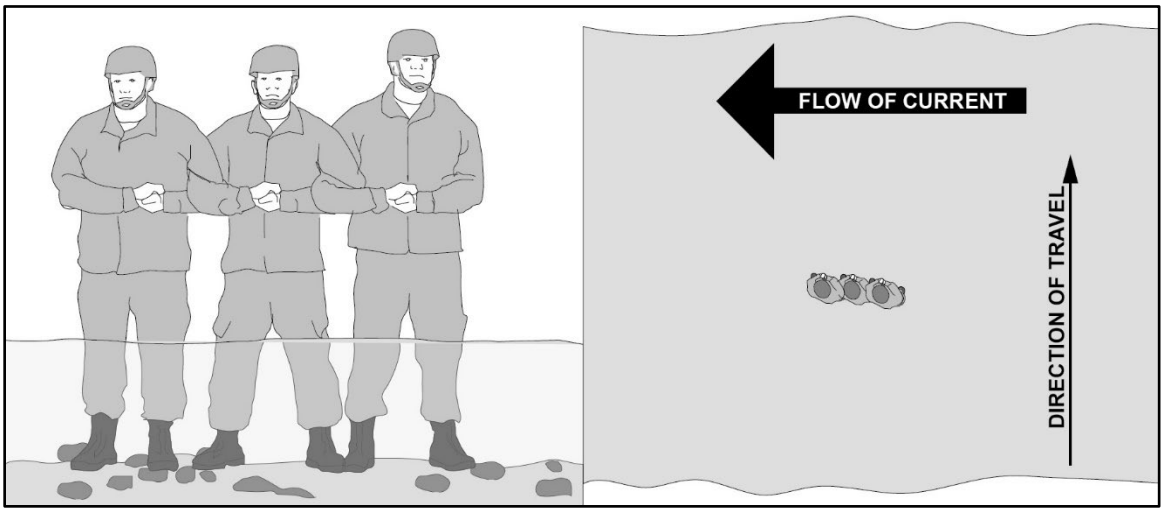



**Figure 13-2. Chain method for stream crossing**

## CHAIN CROSSING (CONGA VARIATION)

13-24. All personnel in the team face into the current, with their hands grasping clothing or gear just behind the shoulders of the person on their upstream side. The largest individual should be on the upstream side of the line to break the current for the group, leaning upstream, into the current. The line formed will then move across the stream using the same principles as for individual crossings but with the added support of each other. The team still moves at a slight downstream angle, stepping off with the downstream foot in the lead. If the formation begins to degrade, avoid trying to excessively hang onto personnel who have lost control. In that scenario, the alternative of swimming is the safest. (See figure 13-3.)

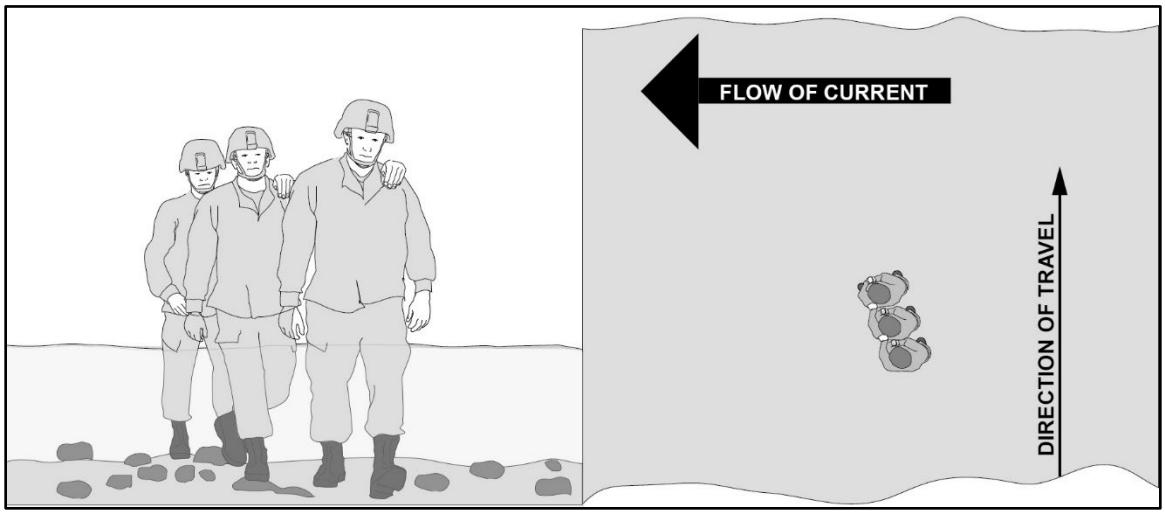



**Figure 13-3. Insert side view, top view, and traveling**

### WEDGE OR DIAMOND TEAM CROSSING

13-25. Three or more individuals form a wedge, with the largest individual upstream to break the current for the group. Cross arms behind the back or rucksack and grasp the upstream individual, developing structured support. Subsequent personnel widen the wedge with smaller personnel or casualties filling the middle portion. Maintain an interval that supports free movement without tripping on other personnel. The wedge formed has the added support of each other. Move across the stream using most of the same principles as for individual crossings but all facing upstream. The team still moves at a slight downstream angle, stepping off with the downstream foot in the lead stepping together as one unit. If the formation begins to degrade, avoid trying to excessively hang onto personnel who have lost control. The alternative of swimming is the safest in that scenario.

## BELAYED CROSSINGS

13-26. Certain conditions may require using a rope system to aid in crossing or even keep Soldiers from being exposed to water. When the depth begins to approach knee to waist level and the current is strong enough to potentially knock a Soldier off balance, then using a handline (one rope bridge with belay line) could be appropriate. This is the safest form of crossing simply because Soldiers have direct influence from either riverbank.

13-27. Crossing on a handline will still require everyone to enter the water. In a case where water and air temperature significantly increase the risk of hypothermia, artificial height or other considerations may need to be implemented. Joining two or more ropes will only be possible for a handline. The maximum distance a one-rope bridge is capable of spanning is about one-half to two-thirds the length of the rope in use.

13-28. An advantage of using a belayed crossing is the safety aspect. If individual control is lost, personnel can be pulled to the unloading bank by those belaying. Disadvantages of this technique are the time required for preparation, the number of available anchors, and the time dedicated to recovering the crossing site.

### ESTABLISHING THE FAR ANCHOR

13-29. Whether a handline or rope bridge (see chapter 16) is to be installed, someone must cross the stream with one end of the rope and anchor it on the far side. The most capable and strongest swimmer in the party should perform this duty. Swimmers should be belayed across for their own safety. The belay position should be placed as far above the crossing as possible. If the current is too strong for individuals, they will pendulum back to the near bank. Rescuers should be poised on the near bank at points where individuals will pendulum back, should they fail to reach the far bank. The initial crossing site should be free of obstacles that would snag the rope and prevent the pendulum from going back to the bank for an easy recovery.

13-30. Individuals may attach the belay rope to their seat harness or a swami belt with a carabiner. They should never tie directly into the rope when being belayed for a stream crossing. If swimmers are swept away and become tangled, they must be able to release themselves quickly from the rope and swim to shore as best they can. Individuals may also choose to tie a fixed loop into the end of the belay rope and hang on to it, where they can immediately release it in an emergency.

13-31. Anytime a crossing site must be used where swimmers may encounter problems getting to the far bank, they should wear a life vest or other personal flotation device (PFD). If swimmers must release the rope at any time, they will have to rely on their own water survival skills and swimming ability to get to shore. A PFD greatly increases personal safety. A PFD may also be used by the last individuals across, as they will release the rope from the anchor and be belayed across as the first individual.

## INSTALLATION OF A HANDLINE

13-32. If it is possible to use a rope high enough above the water to enable Soldiers to perform a dry crossing, then a rope bridge should be installed as such. If this is impossible, and the rope must be installed to assist in a wet crossing, then it should be installed as a handline. (See figure 13-4.)

13-33. The far anchor should be downstream from the near anchor so that the rope will run at an angle downstream from the near anchor, about 30° to 45°, rather than straight across the stream. Here again, it is easier to move with the current as opposed to directly across or against it.

13-34. The rope may be anchored immediately on the far bank, pulled tight, and anchored on the near bank. If a tighter rope is required, the handline may be installed with a transport tightening system. (See chapter 16.)

13-35. A second climbing rope is used as a belay. (See figure 13-5, page 330.) One end of the belay rope will be on the near bank and the other end on the far bank. It should be sent across with the strong swimmer. An appropriate knot is tied into the middle of the belay rope to form two fixed loops. Each loop is approximately 6-inches long. One loop is connected to the handline with a carabiner and individuals crossing connect one loop to themselves. The loops are short enough so individuals are always within arm's reach of the handline should they slip and let go. Individuals are belayed from both the near and far banks. If a mishap should occur, the individual can be retrieved from either shore, whichever appears easiest. The belay on the opposite shore can be released, allowing the individual to pendulum to the bank. It is important not to anchor or tie the belay rope to the belayer so that it may be released quickly if necessary.

## MOVEMENT

13-36. Crossing will always be performed on the downstream side of the handline, shuffling the feet with the downstream foot in the lead. Under most circumstances, the handline should be crossed by one person at a time. This keeps rope stretch and load on the anchors to a minimum. Hands should remain on the handline, on either side of the belay line tie-in point. Individuals should look upstream for obstacles, and pick up a good athletic stance, keeping their body slightly perpendicular to the current. Take small steps while keeping the feet close to the ground to avoid any unwanted influence forced onto the body by rushing water. Either rucksacks can be carried on the back the same way as for individual crossings, or they can be attached to the handline and pulled along behind the individual. If a large amount of equipment must be moved across the stream, especially heavier weapons, such as mortars, recoilless rifles, and so on, then a site should be selected to install a rope bridge. (See chapter 16.)

13-37. Disadvantages to the belayed crossing include the large amount of time dedicated to site preparation, individual crossings, positioning of security teams, and lack of natural anchors on the riverbanks. Additionally, only one person is belayed at a single time, with personnel on each bank dedicated to the belay, leaving fewer personnel for security at any given time.

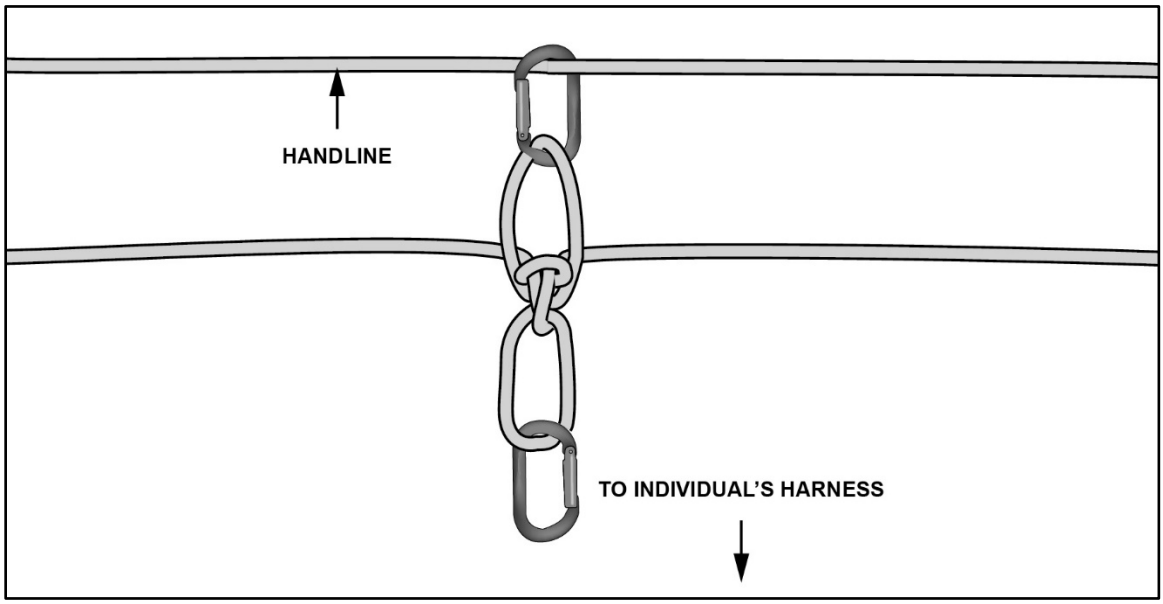



**Figure 13-4. Belay with handline**

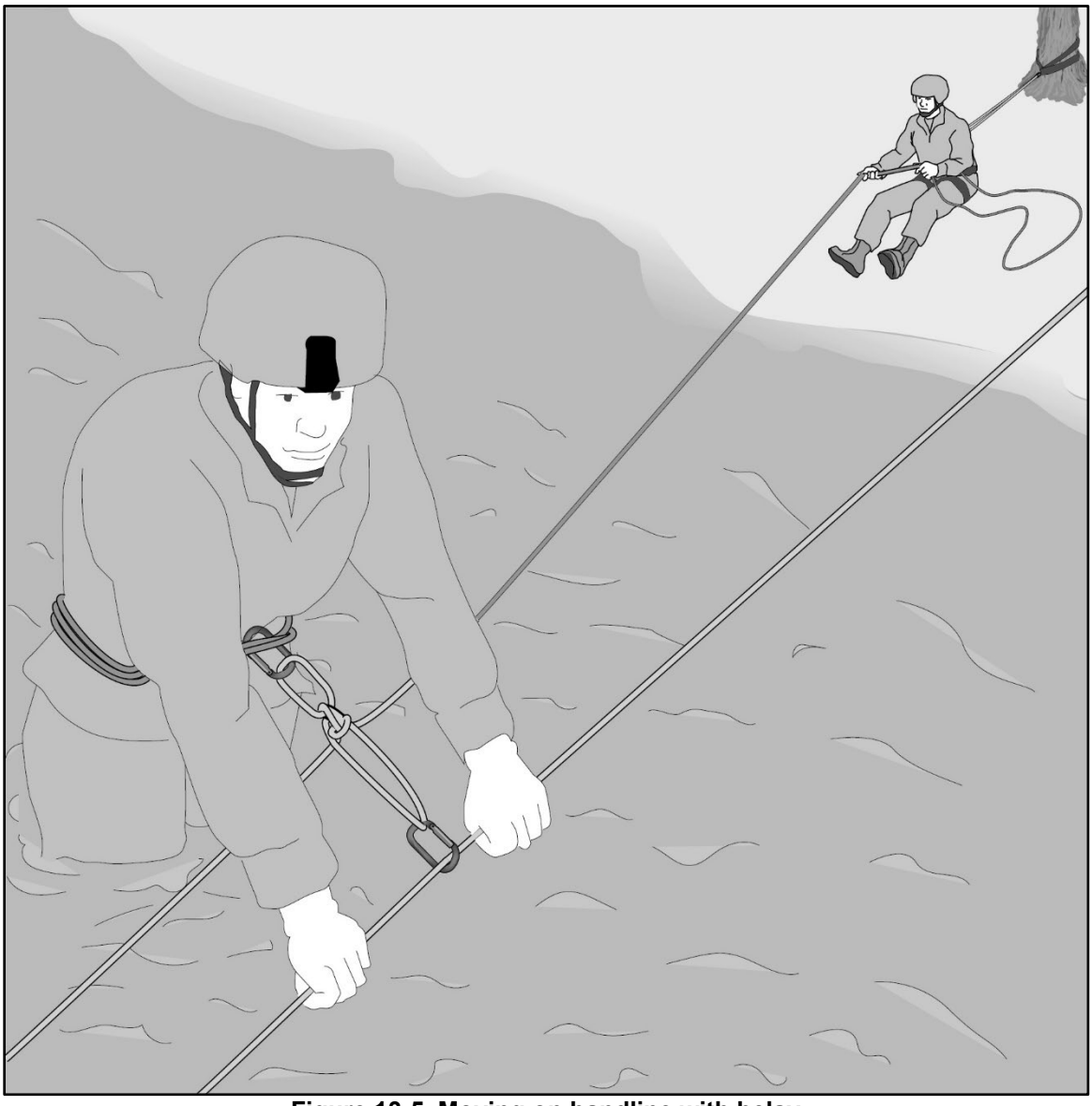


**Figure 13-5. Moving on handline with belay**

# SWIMMING

13-38. Soldiers may find themselves alone and have no choice but to swim across, or they may find themselves suddenly plunged into a swift river or rapids. Soldiers should consider the following actions if Soldiers are in a situation that forces them to swim during a crossing:

- Immediately strip away gear or clothing that restricts free movement and increases their signature.
- Instead of fighting the current, work with the flow of water to get to a dry location downstream. It is often easier to negotiate hazards and see where Soldiers are going if they face downstream and fan the hands alongside the body to add buoyancy. They should use their hands to also fend off submerged rocks and position their feet as a shock absorber to shove off unseen or hidden obstacles.
- Keep the head above water to identify obstacles or debris that Soldiers may impact. Take the opportunity to breathe between breaks if waves begin to rise over Soldiers' heads.
- Avoid backwater eddies, bubbly water, water churning upwards, and converging currents. All these hazards have the potential to create unpredictable buoyancy and possibly undertow.

- If the shore is too difficult to reach, seek out the closest and safest spot, such as a sandbar, to get out of the water as quickly as possible. Hypothermia will set in quickly in colder waters.

## SECTION III – ADDITIONAL CONSIDERATIONS AND HAZARDS

13-39. River and stream crossings present one of the most hazardous situations faced by military mountaineers. Substantial experience is necessary to properly evaluate and mitigate swift water hazards.

# SAFETY GUIDELINES FOR RIVER AND STREAM CROSSINGS

13-40. The following safety procedures are minimum guidelines that should be followed when conducting a river or stream crossing:

- All weak swimmers should be identified before a crossing so that stronger swimmers may assist in crossing.
- Not every river or stream can be crossed safely. If it is possible, cross at a different time or place, use a different technique, or choose another route.
- The technique used is directly dependent upon water depth, speed of the current, stream bottom configuration, width of the stream, and individual experience.
- The safest methods of crossing in the water are always with the use of a handline or rope bridge.
- If the installation of a handline or rope bridge becomes too difficult at a given crossing site, then that site should be considered too hazardous and another site selected.
- A lookout should be posted 50 to 100 meters upstream to watch for any obstacles that may be carried downstream and interfere with the crossing.
- When conducting individual crossings (those without a handline or rope bridge), spotters or security should be posted downstream with poles or ropes prepared to throw, for assistance or rescue. Medical personnel should be prepared for cases of hypothermia.
- When the unit knows a rope installation is required for crossing, at least two life vests or other PFDs should be on hand. These PFDs provide additional safety for the strong swimmer who must establish the far anchor and the last individual across who retrieves the system.

# WATER SURFACE CLUES

13-41. Observing and analyzing the top of the water can give military mountaineers an indication of what to expect beneath the surface. Water is not often clear enough to see all the hazards that could make the crossing difficult or have adverse effects on personnel attempting to cross. The following are common clues that can provide ideas of what lies beneath the surface.

- Riffles or ripples—if they are lined up, there are likely one or several rocks that form a line. In shallower water, it could mean a stable, rocky riverbed.
- Holes, souse holes, or keepers—depressions that can form from water moving around an obstacle. The rise and drop on the surface can be visibly seen. Avoid stepping here as these rises and drops could suction Soldiers' feet and debris can fall.
- Convergences and their depth—can increase the force the water has on someone attempting to cross.
- Eddy or back eddy—swirling of water and the reverse current created when water flows over or around an object or terrain. The consistency of a current is very unpredictable.

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## Chapter 14

# Glacier Travel and Crevasse Rescue

Ten percent of the Earth's land mass is covered by glaciers. Glaciers are rivers of ice flowing under the influence of gravity, constantly restructuring the mountains around them. They often provide the best route in otherwise impassable terrain but can contain crevasses and other hazards that can cause injury, death, or compromise a unit's mission. Soldiers operating in glaciated terrain must understand these hazards, be well versed in the fundamentals of glacier travel, and be proficient with crevasse rescue techniques.

## SECTION I – GLACIER FUNDAMENTALS

14-1. Glaciers can be large enough to cover an entire continent. They may move only inches or hundreds of feet a year. Movement is caused by gravity, slippage over the bedrock, or by the internal flow in the ice. It is important for route planning and risk management to understand glacial features and understand how they form and move. Dismounted movement across glaciers is hazardous; however, glaciers often provide the easiest passage through more technical terrain on surrounding slopes and faces.

## GLACIERS

14-2. Glaciers form over time by the weight of accumulating snow compressing older layers of snow into ice. As snow accumulates, gravity takes over and the ice begins to move downhill. The weight of millions of pounds of ice makes a small film of water that acts as a lubricant, enabling it to slide.

14-3. The upper part of the glacier where the annual snow accumulation exceeds the melt is called the accumulation zone. Further down the glacier, the area where melt exceeds accumulation is an area called the ablation zone. The imaginary line between the two zones is known as the firn line.

### CLASSIFICATION

14-4. There are two classifications of glaciers: alpine glaciers and ice caps. Alpine glaciers form in high mountain bowls. Ice caps can cover thousands of square miles, such as those that cover Greenland and Antarctica.

### TYPES OF ALPINE GLACIERS

14-5. The following are four types of glaciers:

- Valley glacier—resides and flows in a valley.
- Cirque glacier—forms and resides in a bowl. These do not advance beyond the bowl.
- Hanging glacier—these are a result of valley or cirque glaciers flowing and deteriorating. As the movement continues, portions separate and are sometimes left hanging on mountains, ridgelines, or cliffs.
- Piedmont glacier—formed by one or more valley glaciers, spreads out into a large area.

# GLACIER OBSTACLES

14-6. Units intending to use glaciers for travel routes must be familiar with their hazards and characteristics to ensure safe and efficient movement on them. Failure to identify and prepare for obstacles, which can come in the form of vertical terrain, can slow or prevent movement. Failure to identify and prepare for hazards can result in significant injury or loss of life.

14-7. Glaciers contain many different features that can impede travel. (See figure 14-1.) They are—

- Bergschrund—the bergschrund is a giant crevasse found at the upper limit of glacier movement. It is formed where the moving glacier breaks away from the ice cap or snowfield above. The bergschrund can be high and overhanging and can create an obstacle to movement when moving from the valley floor onto the mountainsides.
- Crevasses—crevasses are cracks in the glacier caused by irregularities in the bedrock under the glacier as it moves and flows. Crevasses often form where the angle of the slope increases greatly, causing tension to split open the snow and ice. They also commonly form wherever the glacier makes a turn. They can be transverse, longitudinal, or lateral, depending on their orientation to the direction of the glacier's movement. Crevasses can be 200-feet deep but are normally 40- to 100-feet deep. Crevasses often hinder travel across glaciers. Snow often conceals crevasses, causing possible major falling hazards to Soldiers. Bypassing them can increase travel time and distance. Snow bridges that form over them can give way without warning. During the summer, the ice is less covered with snow and most crevasses are exposed. They can still be hazardous at night or in reduced visibility.
- Moat—the moat is a gap formed where the snow and ice are melted by the warmer rock along the edge of a glacier. The edge of a moat is often undercut. Depending on its size, the moat may be an obstacle to moving on or off the glacier.
- Icefalls—icefalls result from the flow of the glacier down a steep ridge. The ridge forces the ice up into a jumbled mass as the glacier flows over the rock. These present formidable obstacles and should be avoided.
- Serac—seracs are ice walls and towers that form in icefalls or on the lower edge of hanging glaciers. They are unstable and can fall unexpectedly. Travel below seracs or hanging glaciers should be avoided when possible.
- Nunatak—a nunatak is an island of bedrock that protrudes up through the glacier, creating an obstacle to glacial movement. It creates pressure in the ice that can form crevasses, seracs, and icefalls.
- Water hazards—streams that run on the surface and then disappear into a hole are called moulins. Moulins form when meltwater from the glacier finds a crevasse and moves to the ground below the ice. A fall into a moulin can carry a Soldier into the glacier and result in almost certain drowning. The glacial streams above this point must also be treated with respect. They are cold, can be deep, and the slick walls of their channels make them difficult to escape. In the summer, glacial thaw water can form troughs. This water can freeze at night, forming glacial swamps.
- Steep slopes—glaciers often include steep slopes that can create falling hazards, especially in firm snow conditions.
- Moraines—moraines are piles of rock and other debris that have either fallen onto the glacier or been pried loose by it as it moves along. There are four basic types:
  - Lateral moraine—this is the rock debris along the valley wall.
  - Medial moraine—formed when two glaciers come together, and the lateral moraines are forced out into the middle of the glacier.
  - Terminal moraine—the rock debris at the toe of the glacier, which is being dredged up and pushed down the valley. A glacial stream often flows out from under the terminal moraine.
  - Ground moraine—the rocks and debris under the glacier that can be exposed if the glacier stops and then begins to move again.
  - Generally, the outside of a moraine wall is stable, but the side facing the glacier can be steep and loose and should be avoided. A moraine may be the only path, but it can be awkward and tiring due to the unstable rocks.

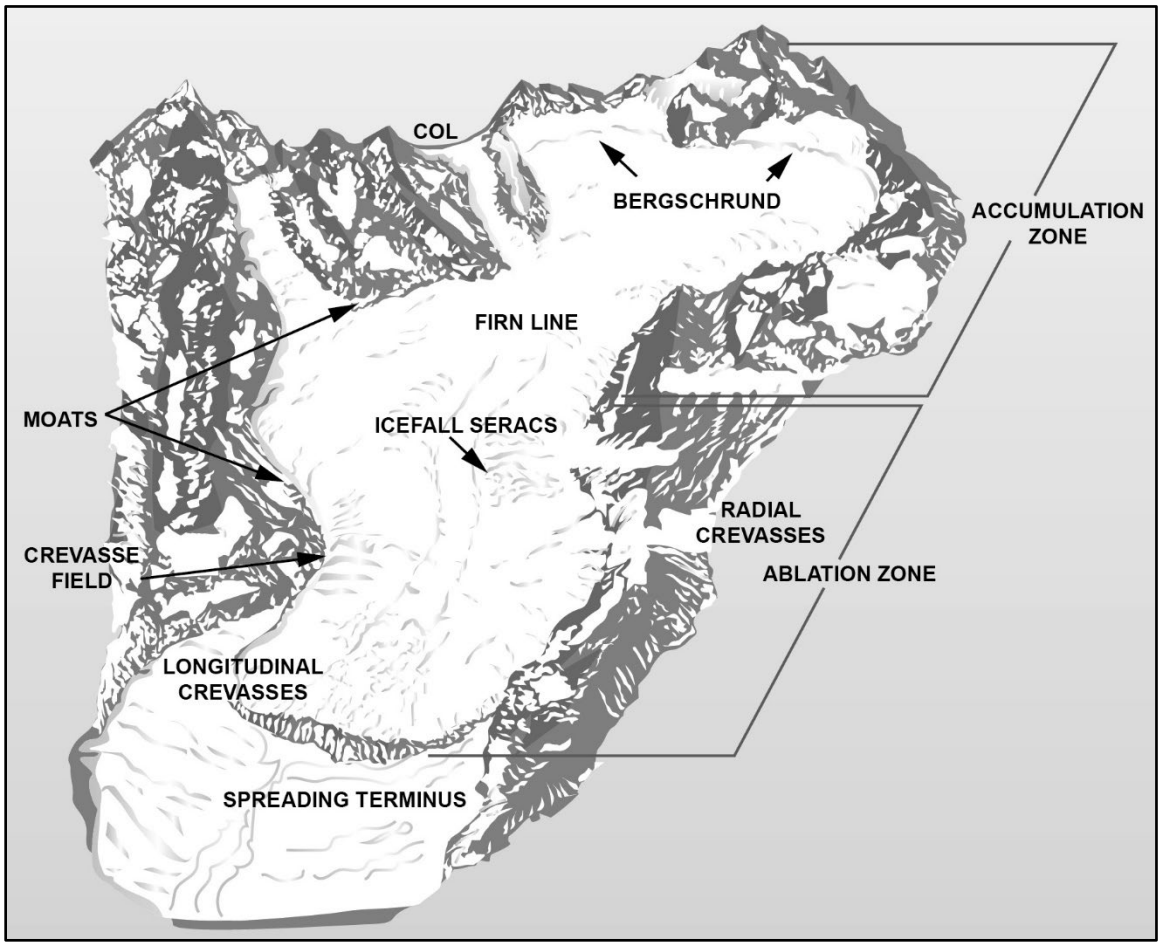



**Figure 14-1. Glacier features**

## SECTION II – FUNDAMENTALS OF GLACIAL TRAVEL

14-8. Glaciers are often good avenues of approach to the interior of a mountain range. Travel can be slow, and dangerous but easier than traveling on steep, loose, or exposed ridgelines. Glaciers are typically large open danger areas and should be treated as such during tactical operations. Units traveling on glaciers are subject to observation from all the surrounding high ground. A capable detachment may be required to provide an overwatch for the force traveling below.

# EQUIPMENT

14-9. A variety of specialized mountain equipment may be necessary for Soldiers traveling on glaciers. The following items are not a comprehensive list.

### ROPES

14-10. The use of ropes allows Soldiers to move in small rope teams and have some protection from crevasse falls. The type, length, and diameter of ropes selected for this purpose may vary depending upon how steep and heavily crevassed the glacier is. It is also determined by the number of Soldiers per rope team, and whether there are mutually supporting teams. Smaller diameter, lighter weight ropes are generally preferred.

### HARNESSES

14-11. Harnesses enable the individual connection to the rope team.

### ICE AXE AND CRAMPONS

14-12. Ice axes and crampons may be necessary for movement over snow or ice on a glacier but also provide the ability for a Soldier on a rope team to self-arrest to control, stop, and hold the fall of another climber. Ice axes may also be used for snow anchor construction for crevasse rescue.

### SKIS AND SNOWSHOES

14-13. In deep snow conditions, skis or snowshoes make movement more efficient. They also distribute weight over a greater area when crossing crevasses, which can reduce the likelihood of breaking through a hidden snow bridge. Snowshoes may be more practical than skis for roped glacier travel unless all members of a rope team are skilled skiers.

### PRUSIKS, SLINGS, AND CORDELETTES

14-14. Short prusik loops, slings, and cordelettes can be used for ascending a rope after a crevasse fall. They are used for belaying rope team members and creating anchors, load transfers, and hauling systems in crevasse rescue. Slings can be used to improvise a chest harness, if necessary, and can be useful to rig the rucksack for removal in the event of a fall. Each Soldier should carry a cordelette, a sling, and a short prusik.

### SNOW ANCHORS

14-15. Snow or ice anchors, such as pickets and ice screws, are often carried for use in crevasse rescue. In some snow conditions, ice axes, skis, and other items may be used to create an anchor.

### WANDS

14-16. Wands are sticks used as markers and can be utilized in many ways. They can be used to mark the location of known crevasses on frequently used routes or used in pairs forming an X to indicate danger. They can be used while setting up bivouac sites to mark the boundaries of safe areas. They are sometimes useful for whiteout navigation in heavily crevassed terrain. Wands can be made using 4-foot bamboo garden stakes with tape or flagging.

### OTHER GLACIAL GEAR

14-17. The following items are typically carried and necessary for connecting to rope, connecting to prusiks, securing rucksacks or sleds, and facilitating crevasse rescue.

- 2 to 3 locking carabiners.
- 2 or more nonlocking carabiners.
- Belay or rappel device.
- Rescue pulley (optional).

## USE OF THE ROPE

14-18. A central question when considering travel over glaciers is whether to use a rope for fall protection. The hazard of hidden crevasses on a glacier varies considerably. In some circumstances, it may be preferable to travel unroped on crevassed glaciers; however, this is not typical. Deciding whether to rope together as a team depends upon the season, mode of travel, snow conditions, and the conditions of the glacier itself.

14-19. Traveling unroped is faster. It makes communication and dissemination of information easier; it can be done with untrained Soldiers. It eliminates the transition times required for tying in and preparing for roped travel. It also allows for movement in tactical formations and a better security posture.

14-20. During the summer season, with clear skies and good visibility, crevasse risk on a glacier below the ablation zone is often negligible because crevasses can easily be seen as avoided due to lack of snow cover. In early season, or in low visibility, this same glacier could be quite dangerous. The decision of whether to rope up should not be taken lightly and should be made by only experienced mountaineers. Below is an example of various risk levels and guidance:

- Zero risk—bare glacier ice, free of snow and with few crevasses. There is no concern for hidden crevasses because all crevasses are visible. In periods of limited visibility, rope up. In good visibility,

travel unroped. If there is a danger of a sliding fall that could lead to a crevasse fall, use the belayed climbing techniques covered in chapter 10.

- Low risk—hard, dense snow conditions in summer, or early morning frozen conditions after a cold night. Concern for hidden crevasses is low and snow bridges are strong. In limited visibility, rope up. In good visibility, travel unroped with caution and be alert for changing conditions. Have harnesses on and equipment available to make the transition to roped travel easier.
- Moderate risk—soft summer snow conditions. Breaking through a snow bridge or into a hidden crevasse is possible. Rope up.
- High risk—soft or weak snow on a glacier with many crevasses. Crevasses are hidden and snow bridges are weak. Breaking through snow bridges and falling into hidden crevasses is likely. Avoid travel, if possible. If travel is required, rope up and use cautious route finding.

## DETERMINING FALL HAZARD VERSUS CREVASSE HAZARD

14-21. In glaciated terrain, there can be both a risk of falling on steep ground as well as a risk of falling into crevasses. These risks are not managed in the same way. Crevasse hazard is best managed with good route finding and by keeping 8 to 10 meters of rope between Soldiers. Rope teams can usually stop crevasse falls because these occur on low-angled terrain without falling hazard. On flat terrain or soft snow, the arresting Soldiers are not typically at risk of sliding into the crevasse and are often able to stop the fall by slumping in the snow, rather than a full team self-arrest.

14-22. Falls on steep firm snow or an icy slope have almost no chance of being stopped by a rope team. Steep fall hazard is better managed by belaying Soldiers individually as described in chapter 10 or simul-climbing with protection placed for the team. It can be tempting to travel on steep slopes using crevasse fall protection techniques, but this is an illusion of safety. A fall can pull the entire rope team from the slope, often with fatal consequences.

14-23. Since these risks can change often from crevasse hazard to falling hazard and vice versa, changing strategies is important. The following paragraphs discuss using the rope for crevasse fall protection only.

## DETERMINING ROPE TEAM SIZE

14-24. When using the rope, team size can be a difficult decision, and several factors must be considered. Smaller rope teams are faster and can move more efficiently than larger teams. Larger teams can easily arrest a fall and have more immediate resources to haul someone out of a crevasse. Training levels and overall unit size are also factors in determining team size. The following list describes advantages and disadvantages of various rope teams:

- Two-person teams—travel is faster and more efficient. However, in the event of crevasse fall, one Soldier must hold the fall. When not traveling with other rope teams nearby, that Soldier must also construct an anchor while holding the fallen Soldier, transfer the weight, and then conduct a rescue. For this reason, only use two-person teams when both team members are highly experienced. Requires approximately 60 meters of rope.
- Three-person teams—generally preferred for most glacier travel. Maintains a relatively low team size, while having two Soldiers to hold a fall and potentially haul the Soldier out. It is possible to have one untrained or minimally trained Soldier on this team when placed in the middle. End climbers must both have good route finding and crevasse detections skills and must be proficient with all crevasse rescue strategies. Requires 45 to 50 meters of rope.
- Four-person teams—travel is slower and less efficient, but the large team is more likely to hold a fall. May be preferred versus multiple two-person teams when there is more than one untrained or inexperienced Soldier. Requires 30 to 40 meters of rope.
- Teams of five or more—travel is slow and cumbersome. Obstacles slow the group even more with each additional Soldier. The entire team must slow down or wait as each member negotiates it. Rope management and communication between members become more difficult. Teams of five or more are not recommended but may be necessary in situations where there are many Soldiers without sufficient experience. Multiple ropes or sections of ropes may be necessary to ensure adequate spacing between Soldiers on rope teams of more than five.
- Mutually supporting teams—mutually supporting teams, such as two teams of three, (rather than one team of six), or a team of two and a team of three, (rather than one team of five), should be used

when experience levels make it possible. Multiple teams allow one team to simply hold the fall and supporting teams to use their own rope and resources to conduct a crevasse rescue. This strategy can also decrease the amount of excess rescue rope that individual teams must carry.

## DETERMINING SPACING BETWEEN SOLDIERS

14-25. It is best to have no more rope between Soldiers than necessary. Longer rope distance slows progress and makes it more difficult to communicate and coordinate movements. Smaller teams need slightly more spacing than larger teams. This distance needs to span crevasses so that only one Soldier is at risk at a time when crossing. Some general guidelines are given but spacing may need to be increased for exceptionally large crevasses.

- Two-person teams—10 to 12 meters.
- Three-person teams—8 to 10 meters.
- Four-person teams—7 to 9 meters.

### Two-Person Teams

14-26. In the event of a crevasse fall, each member of a two-person rope team must have enough spare rope available to reach fallen Soldiers and back to haul them out. (See figure 14-2.) This usually involves 60 meters or more of rope to have adequate spacing between Soldiers. With Soldiers spaced approximately 12-meters apart, they would each have 24 meters of spare rope to be used for rescue. A figure eight on a bight can be tied at 6 meters on each side of the rope's middle mark. These can be used as attachment points for team members and are each clipped into the harness with a locking carabiner and a nonlocking carabiner opposite and opposed. The remaining rope can be coiled and worn over the shoulder or placed into the rucksack. Soldiers must also tie several stopper knots on the rope connecting them. These additional knots aid in arresting a fall by catching in the lip of the crevasse and can often greatly reduce tension on the arresting climber, making it easier to construct an anchor. These are mandatory for two-person teams and can be either alpine butterfly knots or overhands on a bight. Since each knot takes up about 1 meter of rope, this length must be factored in as well.

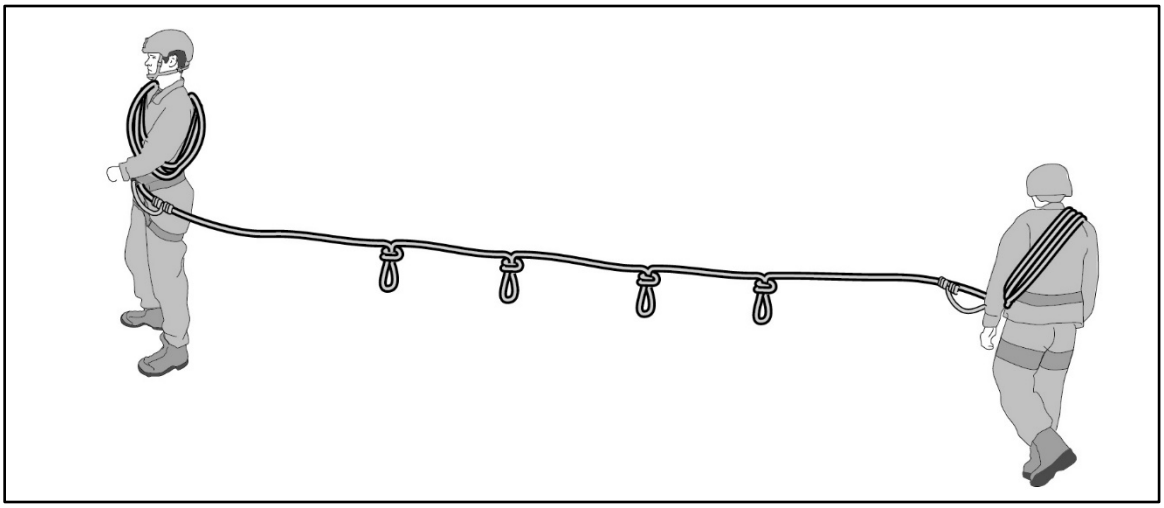


**Figure 14-2. Two-person rope team**

### Three-Person Teams

14-27. For three-person teams, the rope is broken up into quarters. (See figure 14-3.) Each end Soldier carries enough extra rope to reach the middle Soldier. So, with 10 meters of spacing between people, each end Soldier will be carrying an additional 10 meters or more of rope each. Stopper knots are unnecessary in three-person teams because there is generally sufficient holding power. A figure eight on a bight is tied and attached to the middle person's harness with a locking carabiner and nonlocking carabiner opposite and opposed. Each

end Soldier measures approximately 10 meters out from the middle and attaches the same way with a figure eight on a bight. Remaining rope can be coiled and worn over the shoulder or stuffed in the rucksack.

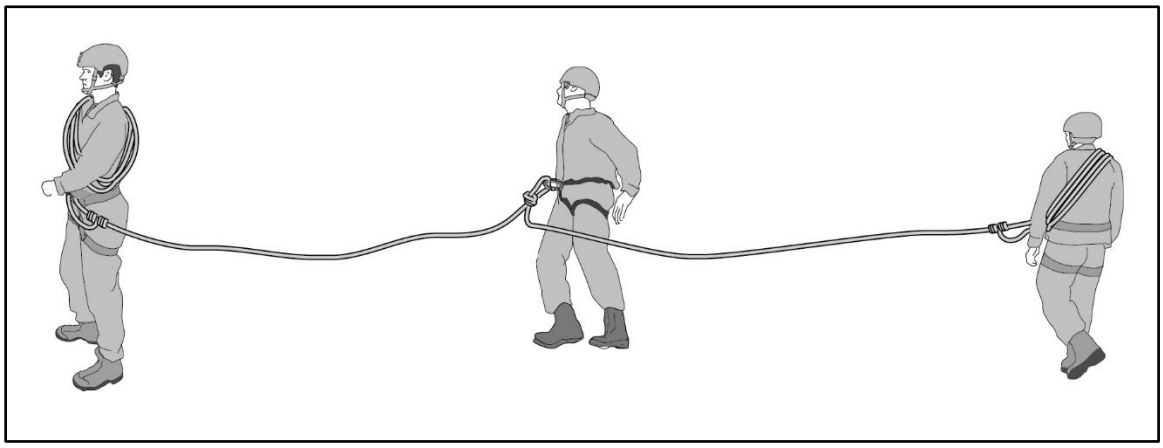


**Figure 14-3. Three-person rope team**

### Four-Person Teams

14-28. Four-person teams can simply divide the rope into thirds and use the entire length. The end Soldiers tie into the ends of the rope and the middle Soldiers clip in as described for two- and three-person teams. If a longer rope is used and shorter spacing between Soldiers is desired, end climbers can coil and stow rope as described above.

## OTHER PREPARATIONS

14-29. Mountaineers often pre-place one or more prusiks on the rope. (See figure 14-4, page 340.) These can be used as part of a system to ascend a rope for self-rescue in a crevasse fall or for load transfer when rescuing another Soldier. Having at least one is useful for keeping slack out of the rope when grouping in one location to communicate or conduct other tasks. The prusik can be attached to the harness with a separate locking carabiner or the same locking carabiner used for the attachment to the rope.

14-30. A 120-cm sling (48 inches), or two 60-cm slings (24 inches) attached together, can be improvised quickly to construct a chest harness. To do this, pass the loop through both arms and behind the back, forming an X in the back, then connect the two bights in the front with a carabiner. This is only to be used after a crevasse fall to remain upright and make self-rescue easier. Chest harnesses are worn when a crevasse fall is likely.

14-31. Mountaineers can prepare the rucksack with a sling and carabiner so that in the event of a crevasse fall the Soldier can remove the rucksack immediately and clip to the rope to dangle below.

14-32. Snow anchors, wands, or other equipment should be distributed among the team.



**Figure 14-4. Preparation chest harness, rucksack removal sling for use with prusik ascent**

## ROPE MANAGEMENT

14-33. The rope should be kept extended on a glacier. It should not have unnecessary slack or be taut. Excess slack will cause a Soldier to fall deeper into a crevasse, placing more force on other members of the team and increasing the difficulty of arresting the fall. The falling climber is more likely to hit something or become stuck or wedged.

14-34. A rope with the correct amount of tension lies on the snow with a gentle curve, out of the way of the feet. It can be helpful to hold the rope to the front when traveling downhill and to the rear when traveling uphill. Pace should be adjusted to maintain correct tension in the rope by feel, especially during stops and starts. The Soldier in the lead should set a pace that others can easily follow.

14-35. During sharp turns, the rope tends to go slack as the lead Soldier makes a change in the direction of travel, but then it becomes taut as the next Soldier approaches the turn. During turns, team members should adjust pace and keep appropriate tension. New tracks may need to be made outside the leader's footprints to do this.

14-36. As a rope team reaches a rest area or bivouac location, the rope must remain extended until the area has been probed for crevasses. Once it has been deemed safe, the lead member may belay team members into the area by pulling rope through the prusik, with ice axe in hand, ready to self-arrest. Soldiers in the rear may also belay themselves into the location in the same manner. When leaving the location, the same process happens in reverse. (See figure 14-5.)

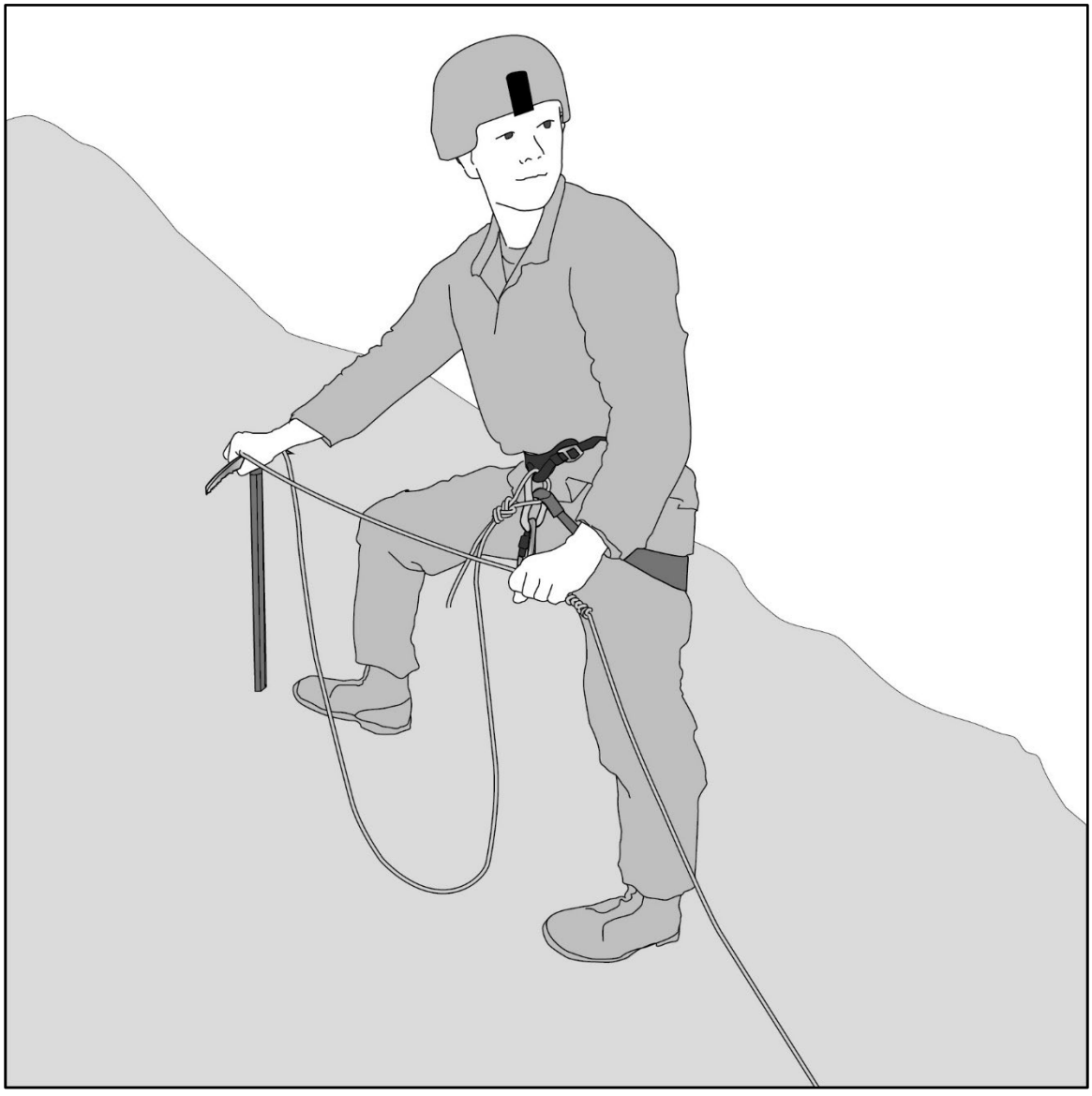


**Figure 14-5. Using prusik to belay other Soldiers**

# ROUTE FINDING AND CREVASSE DETECTIONS

14-37. Crevasse falls are extremely dangerous, even when traveling roped up with experienced Soldiers. Even when all Soldiers manage the rope well and the fall is stopped immediately, severe injuries can result. Ice axes, crampons, and collapsing snow bridges can cause injuries. Detection and avoidance are the primary skills needed to eliminate the need for crevasse rescue. On heavily crevassed glaciers, it is advisable to use an advanced party to scout and mark the safest route in advance of the main body. This can save hours of wandering, slow progress, and running into dead ends. Once relatively safe routes are established, it can reduce the skill and experience level required of the main body.

## INFORMATION GATHERING

14-38. Big picture views of the terrain can be very helpful. A maze of crevasses can be analyzed more easily from above than from within. It is a good idea to take digital photos whenever high ground provides a vantage point. Because glaciers move so slowly, crevasse patterns remain constant from year to year, making even old photographs useful for study. Intelligence products or online mapping resources (see appendix B) that contain satellite imagery can provide overhead views. These may contain imagery taken during the summer or late season and show the general trends and locations of dense crevasses that may be only partially filled in or have suspect snow bridges when traveling during winter and early season.

## TIMING

14-39. On snow covered and heavily crevassed glaciers, snow bridges are firmer at night or early in the morning. If stable, they can often provide more direct lines of travel. Warmer daytime temperatures can soften these snow bridges, increasing the likelihood of crevasse fall. This may require finding a longer alternative route.

14-40. Be cautious after snowstorms. Fresh snow can fill in and blend in what might otherwise be detectable crevasses.

14-41. Seasonal timing is equally important. Although unit leaders may not have much say in the time of year they are required to travel on glaciers, a basic understanding of how seasonal changes affect surface conditions is important. Below are descriptions of typical conditions in the midlatitudes:

- Autumn—in late season conditions, most crevasses are clearly visible and snow bridges have melted out to their maximum extent. Travel is generally safest, as there is little risk of unexpected crevasse fall, but route finding can be difficult and require long detours and lengthy movement times around crevasse fields. In steeper terrain, firm conditions can make falling hazard a higher concern.
- Winter—early winter is especially hazardous. Unconsolidated snow hides crevasses but often does not effectively bridge them. Crevasses are more difficult to detect, and unexpected falls are more likely. In late winter, deeper snow conditions may provide more effective snow bridges. Increased snow loads may cause bridges to sag, making detection easier. Skis or snowshoes are often required.
- Spring—snowfall has reached its maximum depth, making glacier travel safest. Snow bridges are at their strongest and the snowpack strengthens from warmer weather. Skis or snowshoes are often required, but lines of travel are typically much more direct.
- Summer—early morning travel on firm snow surfaces makes travel easier, but snow bridges are beginning to weaken. As crevasses open, finding direct routes becomes challenging again. Seracs and icefalls also become more hazardous.

14-42. In some geographical regions further from the poles, these trends can be nearly opposite with surface conditions revolving strictly around dry and rainy seasons.

## ZONES OF TENSION AND COMPRESSION

14-43. Crevasses are formed by tension. Tension is created as glacier ice stretches over rolls in the terrain and where it stretches due to different rates of flow within the glacier. These crevasses form perpendicular to the direction of the stretch. Recognizing where this tension is likely to occur can help with predicting their likely locations when snow fills in or conceals them. Crevasses are more likely at the top of a roll, where the terrain gets steeper and drops away below it. They are also common near the edges of valley glaciers, where additional drag and friction occurs against the valley walls, and the center of the glacier is moving faster. These "marginal" crevasses point toward the center of the glacier at an angle. For this same reason, the centers of glaciers generally have fewer crevasses and are preferred travel routes.

14-44. Compression zones occur where the underlying bedrock flattens out and where glacial ice slows down or piles up. Here, crevasses become narrow and eventually disappear. Glacial ice can also pile up in bowls and flat benches in the terrain and where glaciers flow together. These areas of compression can be relatively crevasse-free. Observing these zones and working to link them together are keys to good route finding.

## SURFACE CLUES

14-45. Clues to locating crevasses below the surface of the snow can be subtle and difficult to recognize, but it is important for determining an appropriate crossing technique. It can also be just as important to recognize similar clues that do not indicate crevasses and to not waste time and effort on long detours.

- Sagging—snow covering larger crevasses gradually deforms and sags under its own weight. Early in the process, this may be barely noticeable, but later the outlines of the crevasse become more defined. Sometimes a slight change in sheen or texture can be observed. Other times, a slight change in color, from dust or windblown snow settling in a subtle depression, can be visible. These should be approached with caution. Snow is, however, an inherently uneven surface, so not every dip, groove, or color change represents a crevasse. In low visibility or flat light, these can be impossible to recognize.
- Nearby crevasses—since crevasses are often found in groups and tend to form parallel to one another, look for other crevasses, patterns, or depressions nearby that have similar orientation.
- Parallel cracks—in the case of larger crevasses, parallel thin cracks can sometimes form at the edges of a giant snow bridge. Although these can have the appearance of two narrow crevasses, they can be the boundaries of a single, giant snow bridge.

## PROBING

14-46. Snow probing in areas that look suspicious can be done using an ice axe. It can identify crevasses, determine its true lip, and investigate the extent, length, and width of a crevasse. To probe, the shaft of the axe is thrust into the snow a couple feet ahead of where one moves, looking for a noticeable reduction in resistance. If there is a sudden drop in resistance, there is likely a crevasse, but it can also be a soft snow layer. Probing requires experience to accurately interpret. The short length of an ice axe makes this difficult. Avalanche probes and ski poles with the basket removed are better choices, if available. Probing is also required for determining safe bivouac locations.

## CROSSING TECHNIQUES

14-47. There are a variety of options and techniques for crossing crevasses, and leaders must understand and be capable of incorporating any combination of them to adapt to the terrain. Rope teams should travel perpendicular to the direction of crevasses to reduce the risk of exposing more than one Soldier at a time. (See figure 14-6, page 344.)

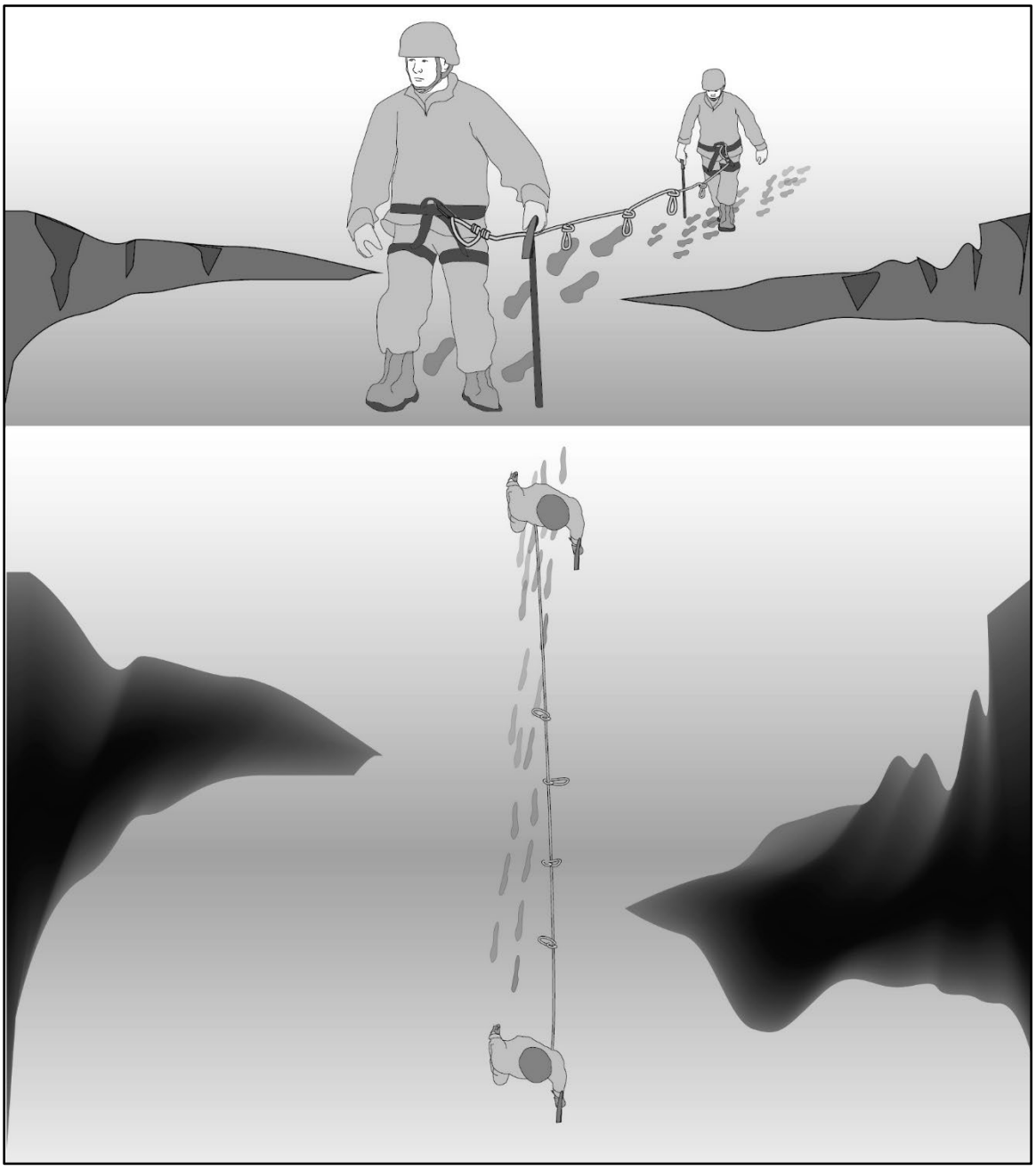


**Figure 14-6. Crossing perpendicular to crevasses**

## End Running

14-48. There is no guarantee as to the dependability of snow bridges. Sometimes it is preferable to cross at one end of a crevasse where its width narrows, rather than take a chance with a snow bridge. (See figure 14.7.) With large crevasses, this could lead to traveling a quarter of a mile or more to gain 30 feet of forward progress. In winter or spring, seasonal snow may still cover the narrow ends of a crevasse. What looks like the end of the crevasse might not be its actual end. This assessment can require some judgement. Make a wide swing, probe carefully, and cross at a right angle to the crevasse.

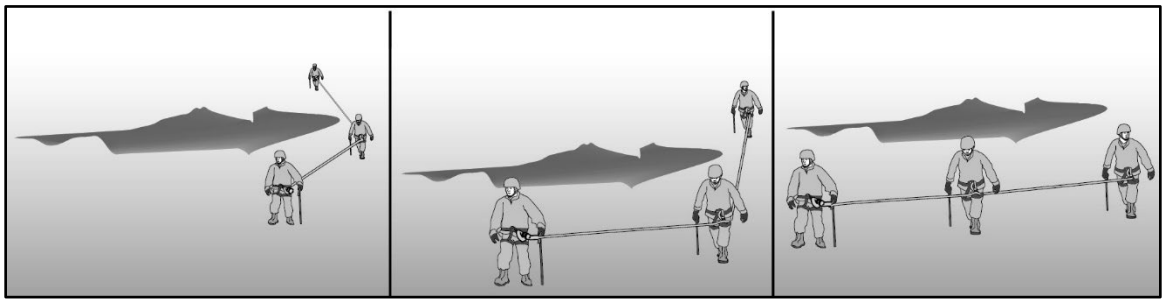


**Figure 14-7. End running crevasses**

## Using a Snow Bridge

14-49. When end running is not practical, use snow bridges to cross. (See figure 14-8.) Always attempt to get a look at the crevasse from the side before committing to it, and probe when approaching the lip. The remaining Soldier in the team provides a moving belay by controlling the slack and remaining ready to self-arrest. Once the leader is across, the rest of the team must follow exactly in the leader's footsteps. At this point, the leader controls slack and remains prepared for self-arrest. Prusiks can be used here to manage slack in the rope during this process as well. If there is doubt as to one's ability to stop a fall, a fixed belay must be constructed with a snow or ice anchor.

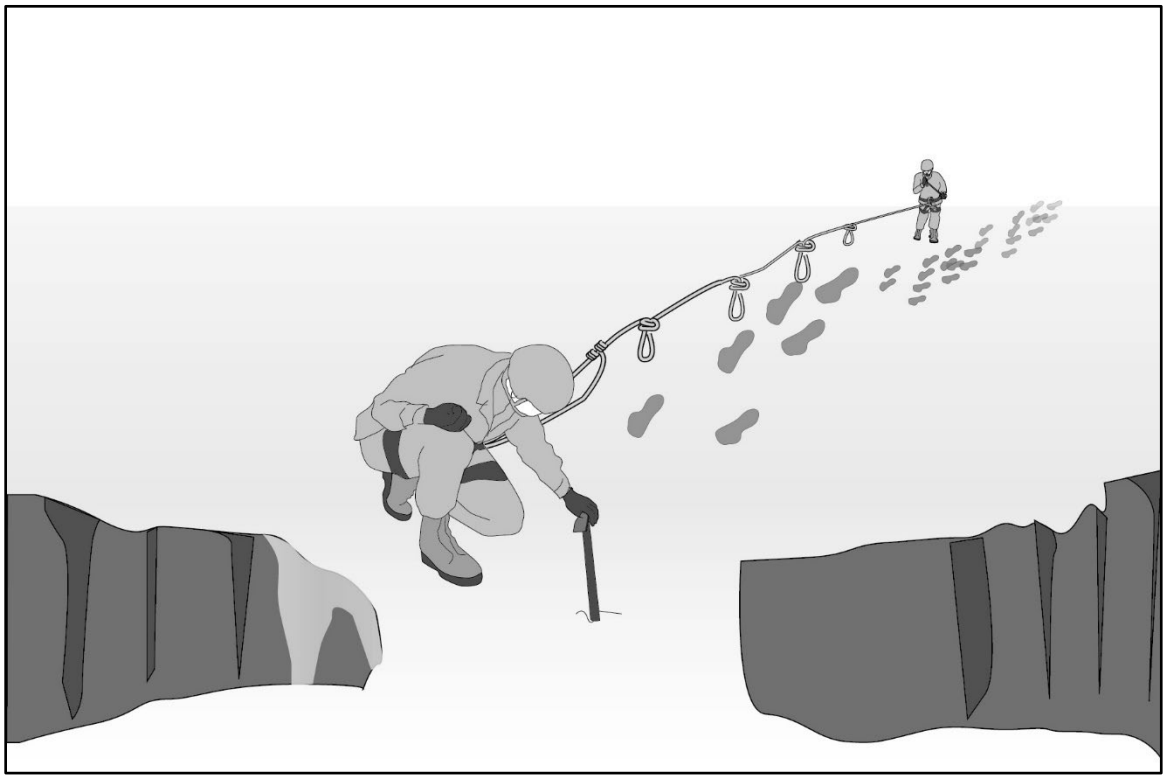


**Figure 14-8. Using a snow bridge**

### Jumping

14-50. Only conduct jumping when the gap is short. Running leaps requiring big push offs from suspect crevasse lips and falls can result in serious injury. Jumping should not be attempted unless there are no other options. Enough slack must be provided for the jumper to clear the crevasse without question. Be wary of catching a crampon and use common sense.

### Climbing into the Crevasse

14-51. Occasionally, it may be practical to climb down into a shallow crevasse and climb back out the other side. Standard belay techniques (see chapter 10) should be used. Be especially aware of bottoms that appear solid but are not.

### Echelon Formation

14-52. When it is impractical to travel perpendicular to existing crevasses and Soldiers must travel parallel, the echelon formation can be used. (See figure 14-9.) This keeps team members still to the rear but offset slightly to the side. This provides an alternative to following the leader's tracks in a single-file line. This should only be used on heavily crevassed sections where all crevasses are visible and there is very little risk of falling into a hidden one.

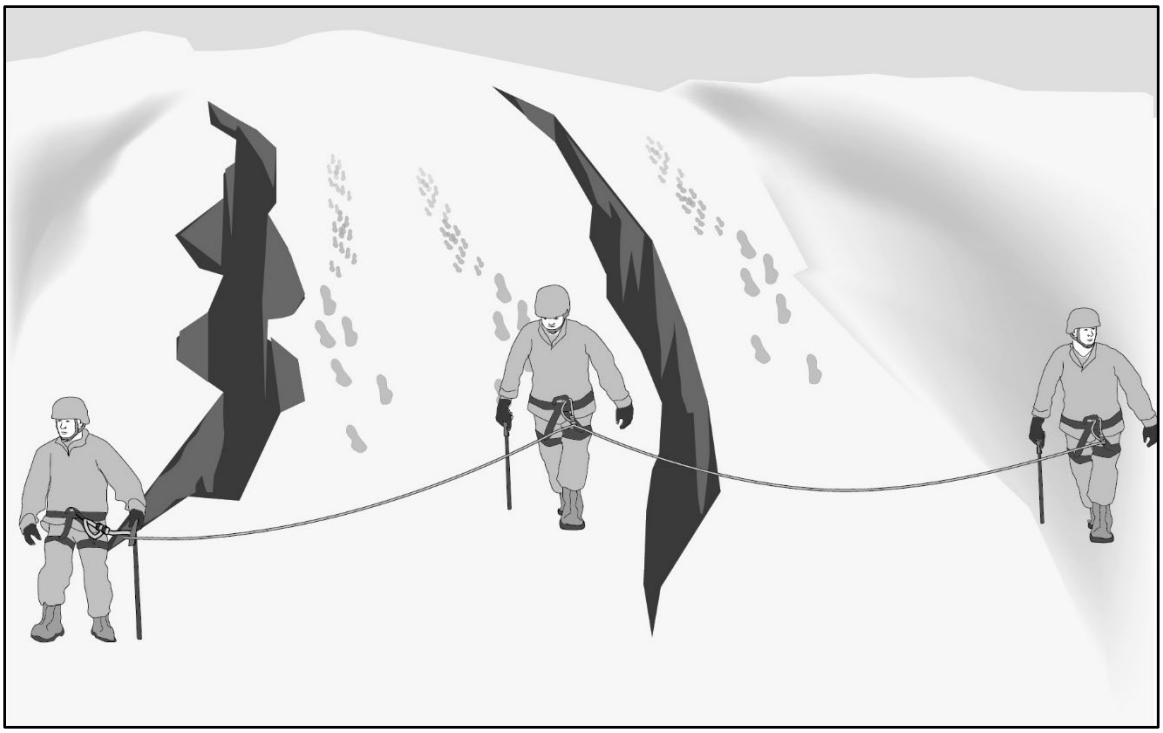


**Figure 14-9. Echelon formation**

## SECTION III – CREVASSE RESCUE TECHNIQUES

14-53. Solid crevasse rescue skills are essential for elements traveling in glaciated terrain. While this may be impractical in circumstances involving large numbers of personnel, the ability to react appropriately to crevasse fall cannot be overlooked.

# CREVASSE FALL CONSIDERATIONS

14-54. Mutually supporting rope teams should have a minimum of one Soldier per team who is trained in crevasse rescue. This will ensure that rescue capability can always be provided, even when the more experienced member of another rope team is the one to fall in. Two trained Soldiers are necessary in rope teams traveling independently, away from supporting teams.

14-55. Crevasse falls are rarely dramatic and sudden falls that rip team members off their feet and result in someone dangling down inside an abyss. In fact, most crevasse falls involve breaking through a snow bridge but falling no further than waste deep, and with minimal force exerted on team members. Despite this, Soldiers must be trained to deal with more severe falls and be able to adapt and adjust to a variety of circumstances. Options for crevasse rescue involve an abundance of variables. They depend largely upon the breakdown of rope teams, the number of Soldiers per rope, conditions of the glacier, and specific equipment carried. A comprehensive and detailed description of crevasse rescue techniques is well beyond the scope of this publication. Instead, the steps and decision process typically used for a three-person rope team are described below.

# STEPS TO TAKE FOR CREVASSE FALL

14-56. The following steps should be considered in the event of a crevasse fall with a three-person rope team.

## STOP THE FALL

14-57. Stop the fall immediately. Some falls may be barely noticeable, while others may require dropping into the self-arrest position in the opposite direction. Stopping falls on firm surfaces can be more difficult than soft ones. Once the fall is arrested, both rescuers should kick crampon points into the snow to establish a strong, stable position to prevent the victim from slipping any further. Communication can often be made with the victim at this point. In circumstances where Soldiers have only fallen a few feet or are stuck in the snow bridge, they may be able to climb out unassisted. If a Soldier is not able to quickly self-recover, then the following steps must be taken. (See figure 14-10, page 348.)

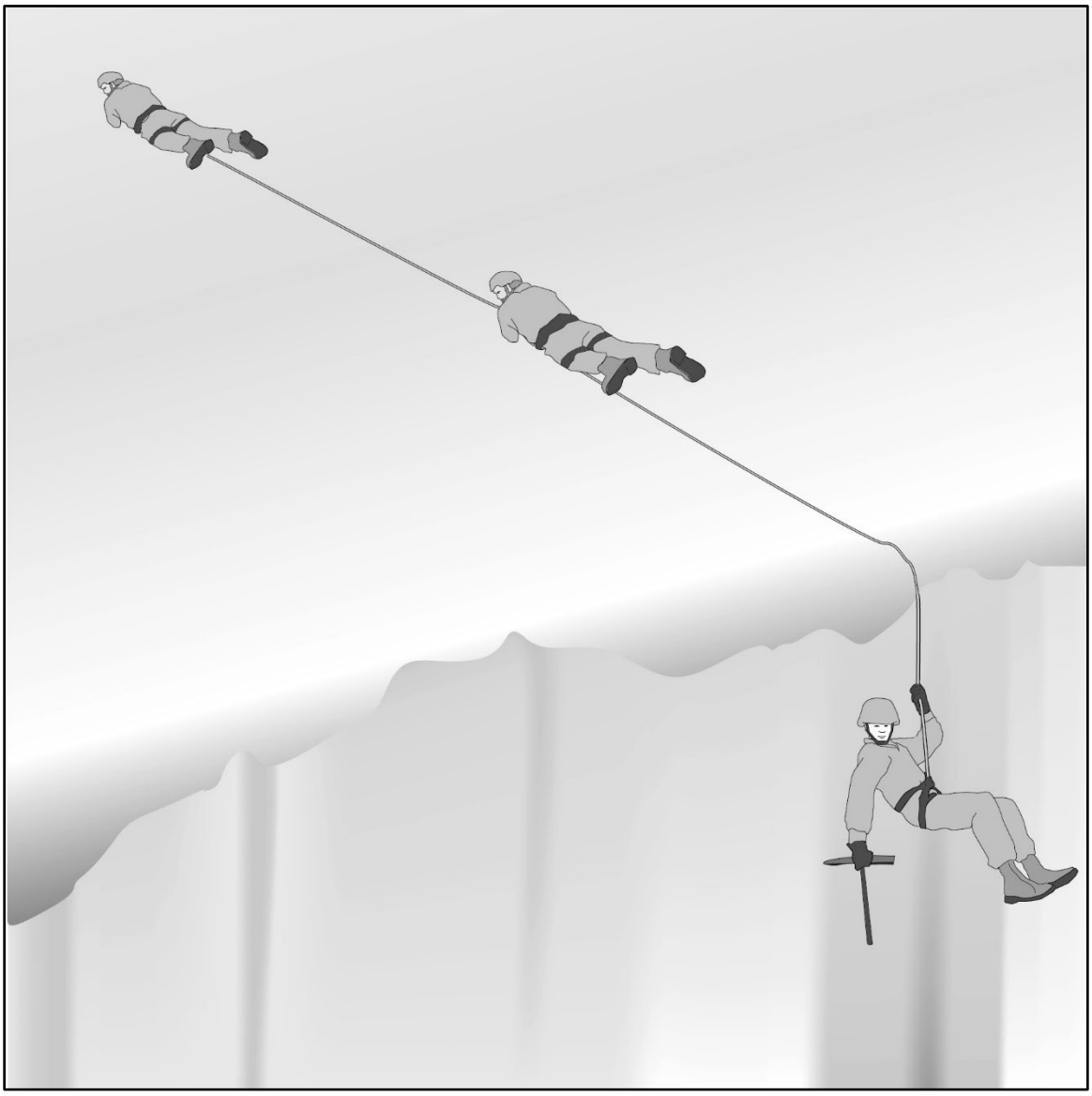


**Figure 14-10. Stopping a crevasse fall**

## CONSTRUCT AN ANCHOR AND TRANSFER THE LOAD

14-58. When another rope team is available, then they can construct an anchor and help the team transfer the load of the fallen Soldier onto it. (See figure 14-11.) Otherwise, the Soldier on the opposite end is usually the one to complete this step. End Soldiers slowly get out of the self-arrest, making sure that middle Soldiers can still hold the weight. End Soldiers establish an anchor (see chapter 9 for snow and ice anchors) below the middle climber and towards the crevasse. They attach a prusik to the loaded rope and clip it to the anchor with a locking carabiner. If there is limited distance between the middle climber and the crevasse lip, the anchor can be constructed above the middle climber. In this case, the slack rope itself, between the middle and end climber can be used to attach directly to the anchor.

14-59. Next, the end Soldiers get back into the self-arrest position to back up middle Soldiers as they transfer the weight of fallen Soldiers onto this prusik. Once pressure is relieved from middle Soldiers, it is common for them to continue backing up this anchor while the end climber improves it or constructs additional components. This anchor must be unquestionably strong, as it may be used to haul the Soldier out. The prusik should also be backed up with a suitable knot clipped to the anchor.

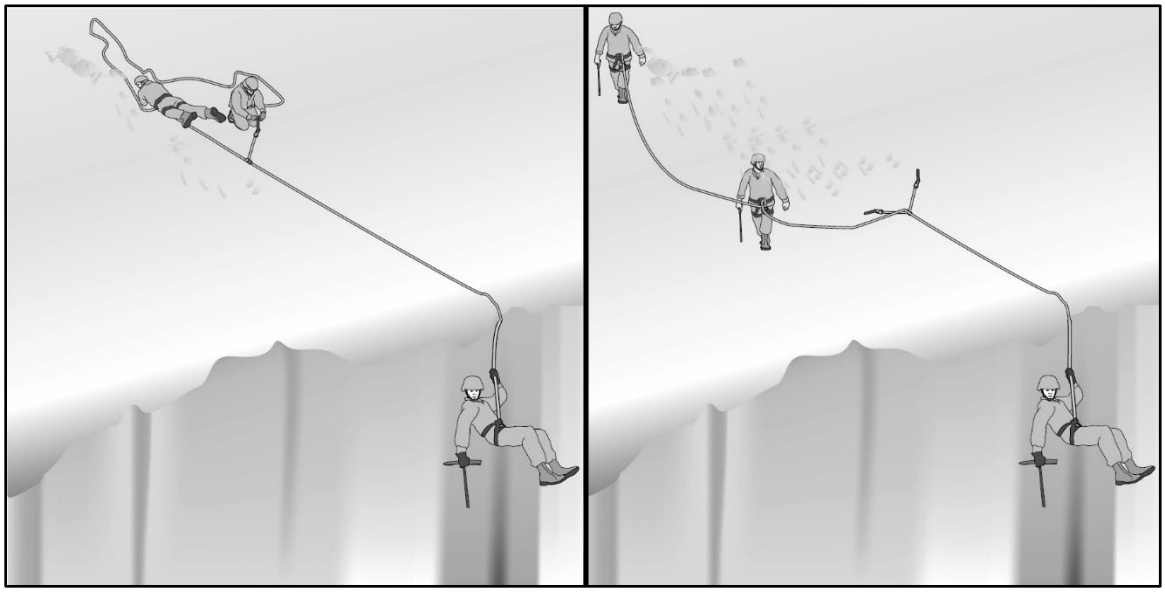


**Figure 14-11. Construct the anchor and transfer the load**

## COMMUNICATE WITH THE FALLEN CLIMBER AND MAKE A PLAN

14-60. To make a clear assessment and develop a plan, it is best to approach the edge of the crevasse where the fallen Soldier can be seen and heard. This can be done by one of the team members using a safety prusik attached to the unweighted portion of the rope. Exercise caution approaching the edge. Determination of what to do next will depend on how far down the climbers are, whether they sustained injuries, extent of any injuries, and characteristics of the terrain in and around the crevasse. The loaded rope can often become entrenched into the lip of the crevasse, complicating rescue options. This may be a good time to pad underneath the rope to prevent this from becoming worse with an ice axe shaft, foam pad, or rucksack slid underneath the rope as close to the edge as can be reached. This can take some work, and items used for padding should be anchored so that it cannot fall into the crevasse. Various options for rescue are described below.

### Self-Rescue

14-61. Self-rescue can be achieved by the fallen climber ascending the rope itself using a prusik ascent (see paragraphs 11-39 through 11-49, pages 282 through 284) or other techniques discussed in chapter 11 and is also shown in figure 14-10, page 348. When possible, this is often the easiest and fastest option. The prusik ascent prevents the fallen Soldier from becoming cold waiting for rescuers. Getting the weight of the rucksack off the body and onto the rope is also particularly helpful for staying upright. Assistance from team members may be required to surmount the crevasse lip. The method does not work if the fallen Soldier sustained significant injuries.

### Belay

14-62. Belays may be a fast, easy option when crampons and ice axes can be used to climb out of the hole, especially if or when the rope is too entrenched in the crevasse lip to prusik out. The remaining free end of the rope can be passed down to the fallen climber to tie into the harness with, while a team member above creates a belay at the anchor. Again, if the fallen Soldier is injured, this method may not be possible.

### Haul

14-63. If none of the above options are viable, a more complex solution of hauling the fallen climber out will be needed.

## HAULING

14-64. Hauling techniques used for MA described in chapter 12 may be used for hauling; however, there are circumstances specific to working with crevasses that must be considered.

### Direct Haul

14-65. This refers to hauling systems constructed on the fallen climber's weighted strand of rope. A common example is the 3:1 hauling system. (See figure 12-4, page 307.) This is constructed by untying the backup knot behind the prusik and using this remaining rope to construct the system. A disadvantage to the direct haul is that it does not work if the rope is entrenched in the crevasse lip. This method is also impractical if there are knots tied in the weighted rope to help hold the crevasse fall. (See figure 14-12.)

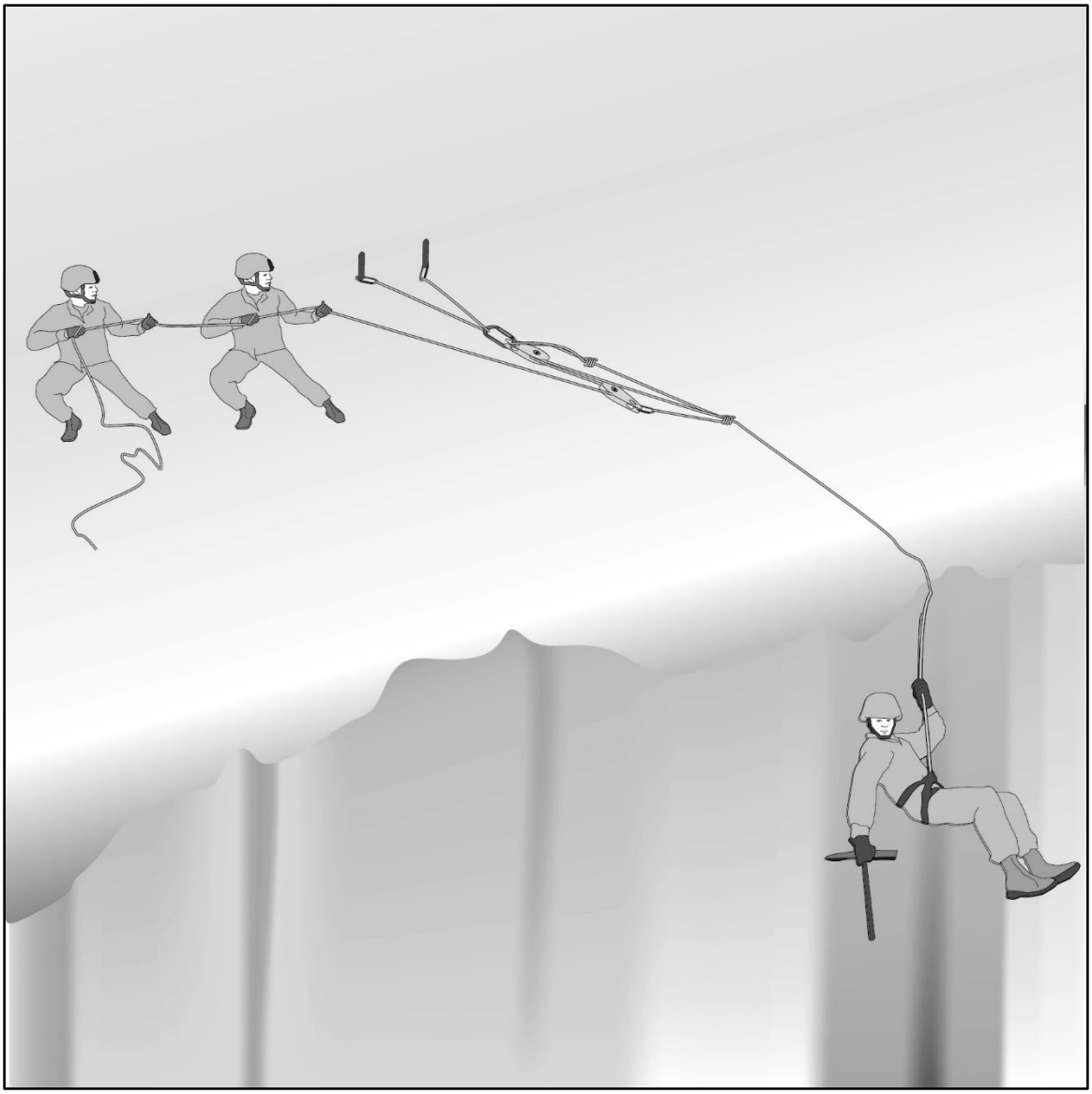


**Figure 14-12. Direct haul using a 3:1 hauling system**

## Drop Loop

14-66. Drop loops refer to hauling systems that use a bight of rope sent down and attach to the fallen climber's harness, independent of the climber's weighted strand. (See figure 14-13.) An example is the 2:1 hauling system. (See figure 12-3, page 307.) This is often the preferred method because the crevasse lip can be padded prior to hauling and because the victim can often assist by pulling on the strand opposite the haul strand. Drop-loop hauls do require victims to clip the bight of rope into the harness, so in the case of an unconscious victim, this step may need to be done by first rappelling to them then re-ascending. Drop-loop systems can be performed using the remainder of the rope or by a separate rope team utilizing a different rope altogether. Progress must still be captured during the haul for safety. This may be done by pulling rope through the prusik on the original tensioned rope.

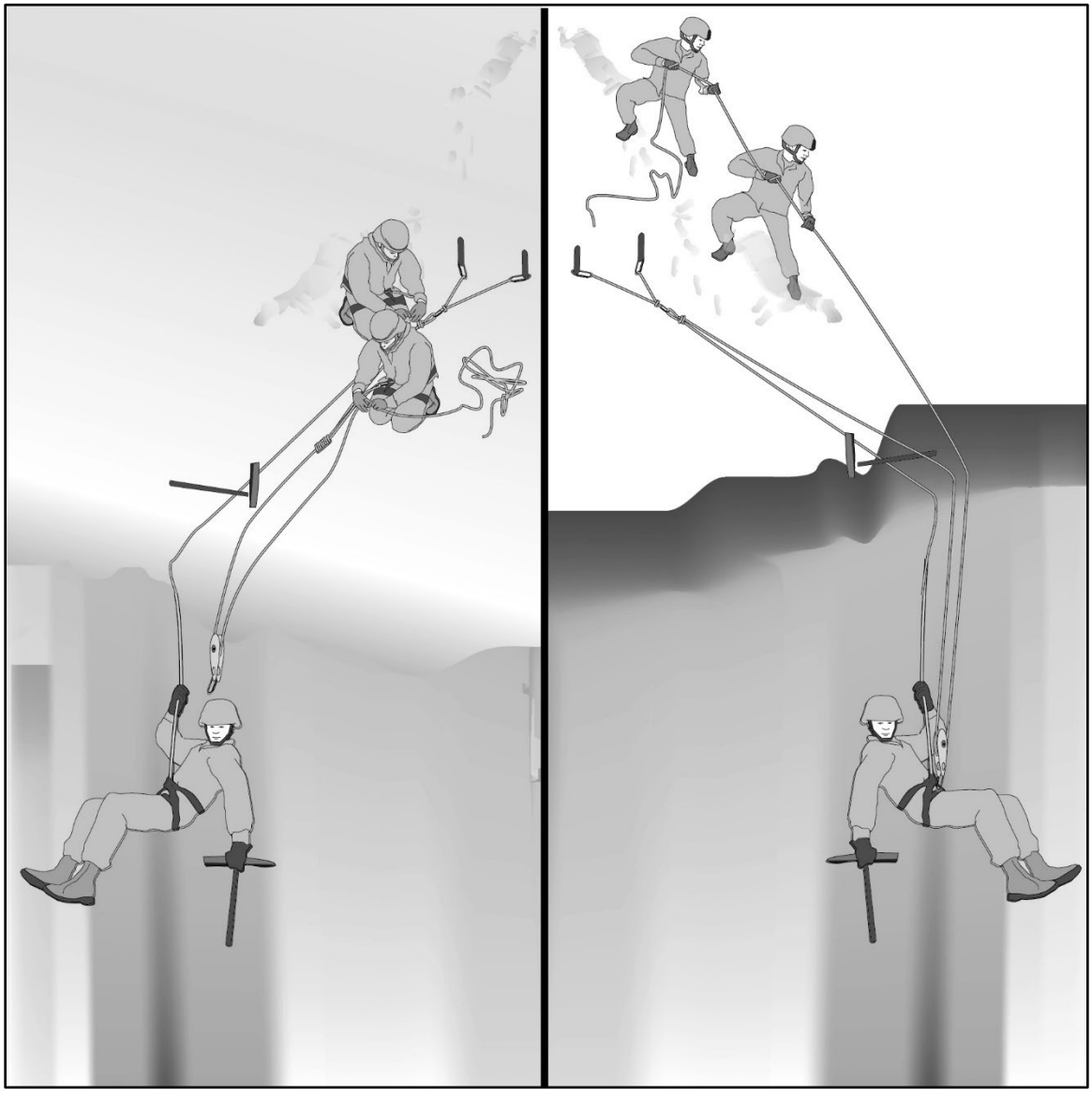


**Figure 14-13. Drop-loop rescue system (2:1)**

## SECTION IV – TRAINING

14-67. Even when mutually supporting rope teams are used, good route finding, and crevasse detection skills are critical. Every rope team must have at least one Soldier with solid crevasse rescue skills. Commanders cannot just hope for seasonally low-risk conditions, nor can they rely solely on advanced parties or recon teams to consistently find routes that are passable without the need for ropes. A lack of expertise can leave units with a large capability gap.

14-68. Training and experience in glacier travel are most productive when conducted on glaciers. Most glaciated terrain in the lower 48 states is in the Pacific Northwest. The high cost of travel and time commitments to access them make training plans difficult for units to execute. Most of those glaciers involve acquiring climbing permits. It can take the better part of a training day for the approach on foot to these higher elevations; any training would typically involve a bivouac. This makes it inconvenient even for units located at Joint Base Lewis-McChord, Washington. Ambitious commanders, however, might utilize these or other glaciated terrain in Alaska, Europe, or elsewhere, to create training events that combine glacier experience with other aspects of mountain warfare.

14-69. In the absence of glaciated terrain, units can still conduct simulated training exercises focusing on the basic strategies for roping up and preparing individual and team equipment. Crevasse rescue skills can be rehearsed using short sections of steep terrain. This should be conducted in locations without serious falling hazard, and back-up ropes or belays should be considered while techniques are being learned. Having a few unit members with advanced level training will improve the quality and outcomes of this training.

## Chapter 15

# Mountain Rescue and Evacuation

A unit's capability to conduct mountain rescue and evacuation is a critical part of mountain operations. Swift and efficient rescue can mean the difference between success and failure of a mission or even the survival of a casualty. In mountainous terrain, even relatively minor injuries may require evacuation. The type of injury, distance to be moved, terrain, training level of the team, and litter capabilities determine the evacuation technique chosen. Air evacuation is preferred. However, the weather, tactical situation, or operational ceiling of the aircraft may make this impossible. Therefore, it is imperative that all personnel are trained in mountain evacuation techniques and are self-sufficient. Casualties should be triaged before evacuation. The most experienced medical personnel available perform triage (physician, physician's assistant, or medic).

## SECTION I – RESCUE OPERATIONS

15-1. Every commander should have a MEDEVAC plan before undertaking an operation. This plan should have dedicated assets (primary, alternate, contingency, and emergency) in place so as not to rely on a single evacuation platform or method. Rotary-wing aircraft may be available to remove casualties from cliffs or inaccessible sites and to quickly transport casualties to a medical treatment facility. However, high altitudes and gusting winds reduce the ability of fixed-wing or rotary-wing aircraft to assist in operations. Therefore, relying solely on aircraft or specialized equipment is a poor substitute for careful planning.

15-2. The two types of rescue operations encountered by units operating in mountainous environments are deliberate and improvised.

### DELIBERATE

15-3. Deliberate rescue is when the mission objective itself is a rescue operation, thus allowing time for focused planning and the use of specialized rescue specific equipment.

### IMPROVISED

15-4. Improvised rescue situations are encountered when a casualty is sustained during normal operations and conducting a rescue was not the intended objective. Even improvised rescue operations should be practiced and rehearsed to minimize the negative effects on mission capability. All operations should have a CASEVAC plan developed before an emergency arises (plan for the worst and hope for the best). Ensure that the MEDEVAC plan is well thought out and comprehensive. These plans must be understood by all who may be involved in a potential rescue.

### PLANNING

15-5. The rescue tasks must be identified by obtaining the following information:

- Number of casualties by precedence (urgent, priority, routine, convenience).
- Number of casualties by type (litter or ambulatory) and the nature of their injuries.
- Terrain features and with respect to the location of the casualties.
- Tactical situation.
- Any assets available to aid in security, rescue, treatment, and evacuation.
- If treatment can be provided at the scene or if the casualty requires movement to a safer location.
- Additional personnel or equipment required for the rescue operation.
- Any circumstances that may require specialized skills.
- Weather conditions.
- Difficulty of the terrain.
- Time available.

15-6. Route selection when planning mountain CASEVAC often depends upon technical capabilities. In some cases, trained personnel and equipment available for low- or high-angle rescue may allow for safer, less physically demanding operations. A lack of these resources and capabilities may require traveling longer distances around steeper terrain, greatly increasing the burden on rescuers.

# CONSIDERATIONS

15-7. Time considerations can cause a leader to compromise planning stages or treatment (beyond first aid). Make a realistic estimate of time available as quickly as possible to determine the action time remaining. The key elements are the casualty's condition and ability to endure the environment. Time available is a balance between these conditions and the resources and personnel available.

15-8. There are many additional considerations for the rescue team during deliberate rescue:

- Typically, team members must distribute and carry all equipment, including hot food and drinks, stoves, sleeping bags, bivouac equipment, warm clothes, ropes, and stretchers.
- Evacuation routes often require extensive preparation and can involve establishing anchor points, belays, fixed ropes, lowers, and raises.
- Altitude and visibility can greatly affect the team as well as the casualty. Maximum use of secure, reliable trails or roads is essential.
- Protection from the elements, such as blankets, tarps, warming layers and rain gear, can be vital. Even a mild rain can complicate an otherwise simple rescue. In higher altitudes, extreme cold or strong winds can greatly increase the rescue's time and complexity.

# GENERAL STEPS

15-9. Regardless of whether a rescue is deliberate or improvised, the following steps must be taken upon arrival at the rescue site to accomplish a safe and efficient rescue operation:

- Assume command—one person and one person only is in charge.
- Scene safety—prevent further injuries to the casualty and to others. Explore all options for casualty access prior to committing to one. Use reasonable care in reaching the casualty. Rescuers must not become casualties.
- Immediately ensure the casualty has an open airway, control serious bleeding, and protect the casualty from further harm and from environmental hazards. If the casualty is unconscious, continually monitor for a pulse.
- Do not move the casualty until determining the extent of injuries unless necessary to prevent further injury or if the casualty is in a dangerous or exposed location.
- Do nothing more until the situation has been thoroughly considered. Resist the urge for action. Speed is less important than correct actions and decision making. The decisions made on scene drive the rest of the rescue (for example, casualty rigging, packaging, route selection, anchors, and rope systems).
- Decide whether to evacuate with available resources or to send or call for help. Speed in getting to the next level of care must be balanced against the probability of further injury. This is especially crucial if working with inexperienced personnel, insufficient equipment, or terrain or weather hazards.
- When the evacuation route is long and arduous, a series of litter relay points or stations should be established, if possible. These help to manage the welfare of both the casualty and the rescue team. These stations should be staffed with the medical personnel and equipment necessary to provide proper treatment.
- Helicopters or heated vehicles, if available, should be used for evacuation. While the use of aircraft or vehicles is preferred and can expedite a rescue operation, evacuation of a seriously wounded Soldier should never be delayed awaiting aircraft, vehicle, or a change in weather.

# SPECIALIZED TRAINING

15-10. Rescue team members must receive basic instruction in military mountaineering and first aid, prior to any training and rehearsals for mountain rescue and evacuation. Individual mobility skills, knowledge of knots and basic rope systems, and the ability to sustain and protect themselves from the environment are

essential. Once formal evacuation training has been received, proficiency can be maintained by periodic integration with other concurrent training exercises. Scenarios that require simple casualty movement techniques, with and without litters, as well as low-angle slope evacuations (see section II) can easily be created. Scenarios are added when time becomes available during or following other training exercises. These opportunities allow commanders to quickly evaluate a unit's preparedness to carry out basic rescues if needed, refresh level 1 skills, and help to reinforce unit teamwork and problem solving. Basic military mountaineers, at a minimum, should oversee this training. Medical personnel should be present. Rescues in complex 4th- and 5th-class terrain, whether real or simulated, require advanced-level training and skills, and they must be led by level 2 and level 3 mountaineers.

## PROLONGED FIELD CARE

15-11. The mountain environment is defined by austere and remote conditions. This environment, combined with the difficulty of patient movement, creates situations that can extend patient management over many hours or days. *Prolonged field care* is the continued delivery of medical care prior to patient movement beyond the holding capability of that role of care (JP 4-02).

15-12. Medical personnel with standard training may be required to perform beyond their skillset. Specific training should be conducted to prepare medical and nonmedical personnel for prolonged field care situations. Tactical combat casualty care uses protocols aimed primarily at preventing mortality in the first few hours of treatment, prior to arrival at surgical resuscitative care. However, patients in the mountains lacking fast and immediate evacuation are often at risk for complications, such as sepsis, multi-organ system failure, respiratory compromise, and other serious conditions. Prolonged field care begins with the sound principles of tactical combat casualty care, but when care is extended over hours or days, treatment must continuously be re-evaluated. Diligence is necessary to minimize the effect of potentially harmful interventions and to prevent, recognize, and treat conditions that may develop over time.

15-13. Critical patients ultimately require care in a hospital with surgery, blood products, an intensive care unit, and advanced imaging. A combination of rescue skills training and prolonged field care skills are necessary to make this possible.

# SECTION II – CASUALTY MOVEMENT TECHNIQUES

15-14. Casualties in the mountains can be moved and transported in a variety of ways, from simple manual field carries to high-angle evacuations using litters and complex rope systems. The type of injury, distance to be moved, time available, and resources will determine the best technique for a given situation.

## MOVING CASUALTIES WITHOUT LITTERS

15-15. There are varieties of circumstances where casualties may move, be moved, or be carried without the use of litters. This could be a result of sustaining relatively minor injuries, not having a litter available, or not having the available personnel for litter transport. Alternatively, these could involve moving a casualty in technical terrain that is not suited for transport in a litter. If casualties are able, they can walk, with one or more rescuers walking alongside, to provide physical support. A rescuer close behind can help in difficult terrain. Have team members ahead to select the easiest route and remove loose branches and other obstacles. Ski poles may be helpful if they are available. In situations where the casualty cannot walk, simple techniques described in the Soldier's Manual of Common Tasks (fireman's carry, two-hand, four-hand, saddleback, piggyback, pistol belt, and poncho litter) may be useful. However, rugged mountainous terrain often demands other techniques. The most basic one-man carries include the webbing or rope carry, the rope coil carry, and the rucksack carry.

### NYLON WEBBING OR ROPE CARRY

15-16. A 4.5-meter piece of webbing or rope can be used to improvise a buddy carry system. (See figure 15-1, page 356.) Place the middle of the webbing around the casualty's back and under the shoulders, crossing in front of the chest. Place the ends over the carrier's shoulders (from back to front). Bring the ends alongside the carrier's ribs, through the casualty's crotch, and around the outside of the casualty's thighs. The carrier then ties the ends of the webbing together around the waste with a square knot.

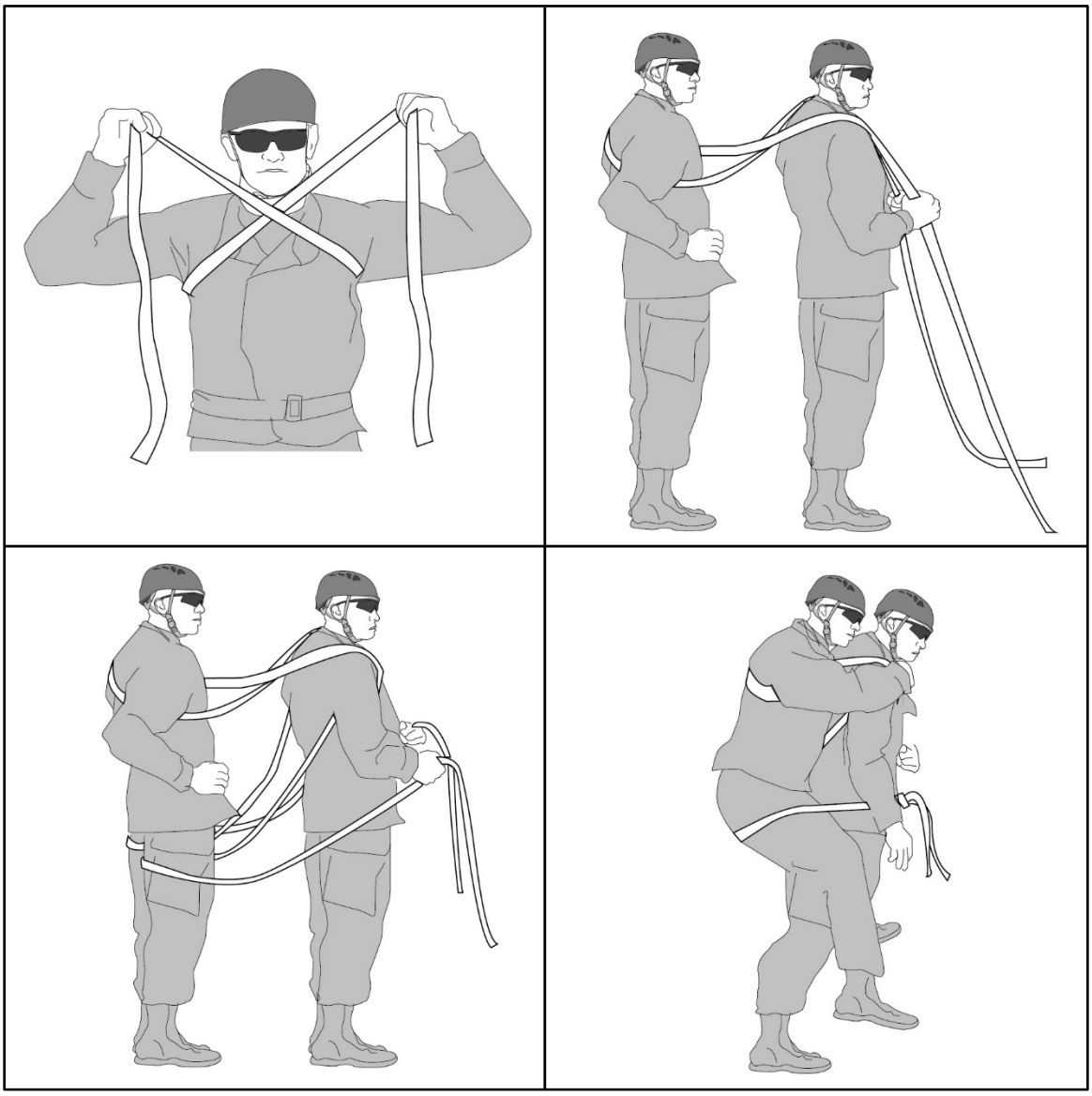


**Figure 15-1. Webbing or rope carry**

## ROPE COIL CARRY

15-17. A dynamic or static rope can also be used as an improvised buddy carry system. (See figure 15-2.) Coil the length of rope using the mountain coil technique, sizing the loops to fit from the casualty's armpits to crotch, and then separate the coil in half to form a pair of loops. Place the casualty's legs through the loops and slip the upper part of the loops over the carrier's shoulders. A short piece of webbing can be used to tie these loops together.



**Figure 15-2. Rope coil carry**

## RUCKSACK CARRY

15-18. The rucksack carry is another method of back carry. Make slits in the sides of a large rucksack so the casualty can step into it as though it were a pair of shorts. Then the carrier wears the backpack as usual. This requires the contents of the carrier's pack to be carried by another Soldier.

## TANDEM RAPPEL

15-19. Rappelling with a casualty is not often the first choice in rescue. It is typically preferable to lower a casualty with a rescuer during descents because it allows the rescuer to focus on controlling the casualty rather than having to control both the casualty and a rappel. However, in the case of a sturdy, conscious patient with nonlife-threatening injuries, it is possible to rappel together with a rescuer. To do this, a rappel extension can be created using a 48-inch sling or cordelette as shown below to allow both the casualty and rescuer to rappel from the same device but slightly offset from one another. (See figure 15-3, page 358.) The rescuer must add an autoblock back up behind the device.

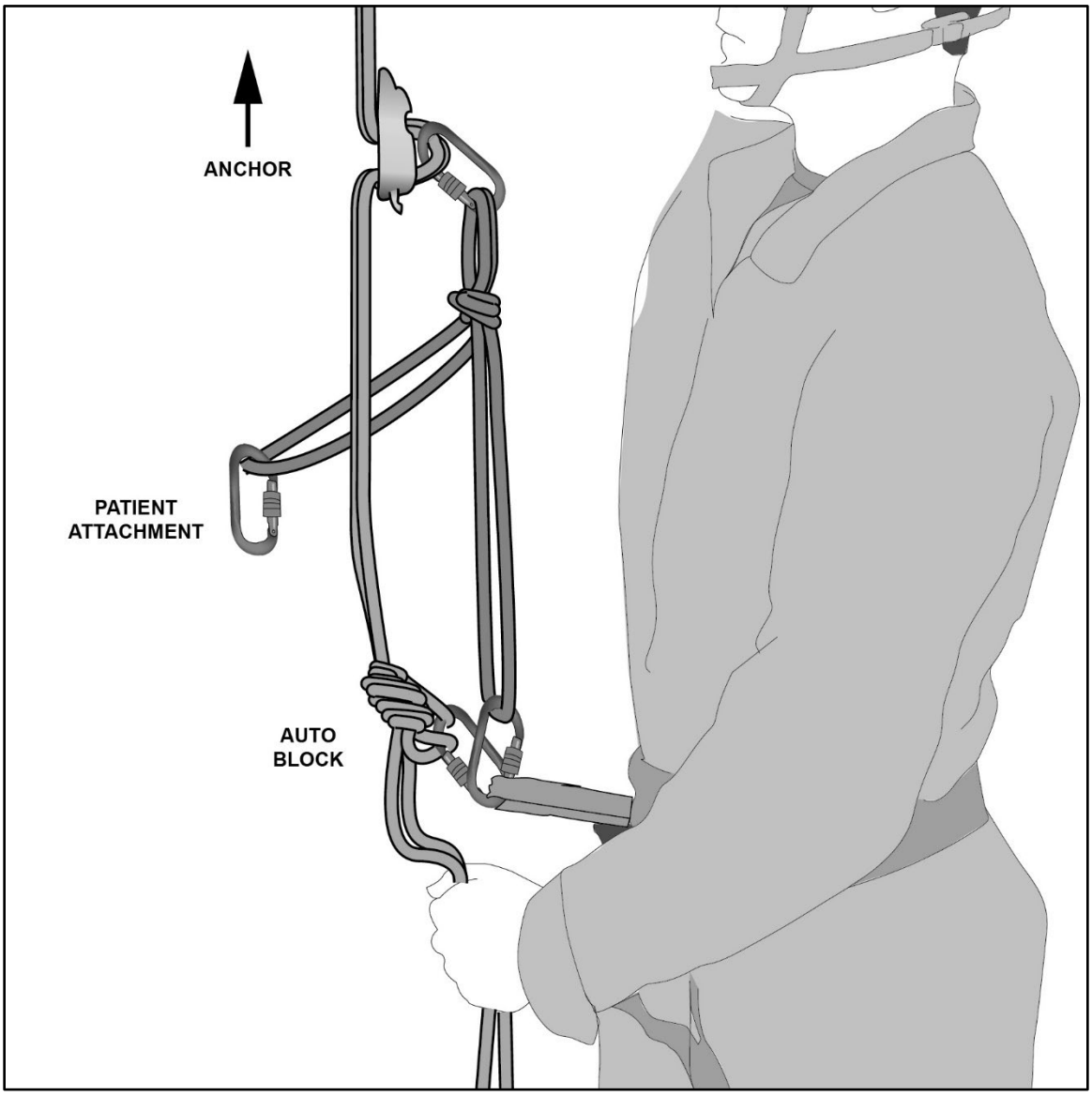



**Figure 15-3. Tandem rappel rigging**

### ROPED MOVEMENTS

15-20. Casualties can also be placed in a seat or improvised harness and lowered or hauled through steep terrain using the techniques described in chapter 12. This may be done with ambulatory patients or may be necessary in situations where an injured Soldier must be moved from a cliff to an alternate location where packaging in a litter is more easily accomplished. This may require considerable assistance from rescuers or other Soldiers. It should only be attempted when necessary and after any immediate life-threatening injuries have been treated. Remember the more complex the technical rope systems become, the more time consuming they tend to be, increasing exposure and vulnerability to enemy attack.

## MOVING CASUALTIES IN LITTERS

15-21. Usually, casualties with significant injuries in the mountains need to be evacuated with the use of a litter. Several types of litters are available for transporting casualties in rough terrain.

## MANUFACTURED LITTERS

15-22. The following litters are readily available to mountaineering units:

- The poleless, nonrigid litter is lightweight and readily available but is the least favored litter. It does little to protect the patient's injuries and is not appropriate for attachment to any rope system.
- The standard collapsible litter is readily available in all units and may be rigged for movement over rough mountainous terrain. However, it is not suitable for carry as a contingency litter due to its bulk and weight.
- A rigid, metal-framed, basket-style litter that is rated for hoist operations is very well-suited for moving casualties through mountainous environments. These litters provide excellent patient protection and spinal immobilization, and when rigged properly, can readily attach to a variety of technical rope systems. The drawbacks to this type of litter are that it is heavy and is not designed to slide over surfaces. A single-wheel attachment is available, which vastly increases the efficiency of movement over moderate terrain but comes at the cost of an even greater weight to be carried.
- The patient rescue and recovery collapsible litter system is a lightweight, semirigid, rollout plastic litter that can also be rigged to meet rating requirements for hoist operations. The most commonly issued and used version in mountaineering is the rescue litter, which provides excellent patient support and protection. This is the preferred litter for mountain operations due to its versatility and relatively low weight. However, it is not a spinal immobilization device. A backboard must be used with this system for patients who have injuries to the shoulder area. This system will accommodate long and short backboards, scoop stretchers, and most other immobilization equipment.

## IMPROVISED LITTERS

15-23. Litters can be improvised in the field using several techniques, but all of them require construction materials and time, generally offer less patient protection, and are more prone to breakage.

15-24. Litters can be made by securing poles inside blankets, tarps, ponchos, jackets, shirts, sacks, or bags. Poles can be improvised from strong branches, tent supports, skis, and other similar items.

15-25. If poles cannot be found, a large item, such as a blanket, can be rolled from both sides toward the center. Then the rolls can be used to obtain a firm grip to carry the casualty. If a poncho is used, the hood must be up and under the victim, not dragging on the ground.

## PATIENT PACKAGING

15-26. Casualties must be packaged and secured to litters before movement in rough terrain. Proper packaging should achieve stabilization, immobilization, protection from hypothermia, and preparation for transport. Physically strapping a person into a litter is relatively easy but making it comfortable and effective can be a challenge. The needs of litter bound casualties are great and should not be overlooked or underestimated. The decisions made during initial packaging will affect the physical and mental outcomes for the casualty in the end.

15-27. The rescuer's goals are as follows:

- Package the casualty to avoid causing additional injury.
- Ensure the casualty's comfort and warmth with focus on preventing hypothermia.
- Immobilize the casualty's entire body in such a way as to allow continued assessment during transport.
- Package the casualty neatly so that the litter can be moved easily and safely.
- Ensure that casualties are safe during transport by securing them within the litter and belaying the litter as necessary.

15-28. Rescuers follow the same basic principles of the cold-weather clothing system to create a hypothermia wrap (hypo-wrap). The fundamental goal is to reduce heat loss. The outermost layer should be a VB to protect the casualty and the insulating layers from the environment. Use a ground pad to protect against conductive heat loss using a closed cell or inflatable foam pad. A closed-cell foam sleep pad is preferable because it will not rupture, and it can be cut into pieces for additional medical treatments (such as splints and neck braces). Begin layering with available insulating materials. The casualty's equipment should be used first before sacrificing clothing or sleep systems from non-injured Soldiers. Rescuers put the casualty into the wrap and place additional layers of insulation on top of the casualty.

15-29. Consider protecting the insulating layers from casualties themselves if there is a possibility they could become incontinent. A trash bag or waterproof bag with leg holes cut in it can be filled with socks or T-shirts to form a diaper. Wrap the casualty as completely as possible, leaving only necessary areas exposed. When available, hot water bottles should be added and placed by the casualty's axillary areas (armpits, groin) and the neck to provide active rewarming.

## MOVEMENT TECHNIQUES

15-30. ATP 4-02.13 covers general principles of handling and moving with litters—principles that apply in all terrain. However, in rugged mountainous terrain, teams must often move considerably slower. Extensive personnel may be required to ensure adequate rest and safety. Advanced teams may be useful for route selection and clearing.

15-31. For longer movements, it can be useful to add slings or cordelettes to the litter rim or handles for each litter bearer. These slings can be passed over the shoulders to the opposite hand, allowing each bearer to push down with the hand opposite the litter. This can help to reduce strain on the arm and hand carrying the litter, as well as providing some height adjustment.

15-32. In severely uneven terrain, such as talus or boulder fields, the pass-through technique can make movement safer for both the casualty and rescuers, provided extra personnel are available. To conduct the pass-through technique, simply have extra litter bearers take up static positions in the terrain ahead of the litter and as close to one another as possible. The litter is then passed forward into the hands of the extra litter bearers. As soon as litter bearers in the rear become obsolete, they move around and take up a new position further ahead in the direction of travel. They then wait until the litter reaches them and repeat the technique. This allows rescuers to remain still as the litter is transported, taking advantage of secure footing and stable positions. In this way, the litter is less likely to be dropped and litter bearers are less likely to sustain an injury attempting to move and carry the heavy load at the same time.

15-33. If a litter can be dragged, attaching ropes may make doing so easier and more controllable. Ropes can be attached to the front of the litter for dragging purposes as well as to the rear of the litter for use with a brakeman to slow the speed of the litter on gentle descents. This technique can speed up evacuation in conditions that allow for it, such as snow-covered terrain. (See figure 15-4.)

15-34. On flat or low-angle snow-covered terrain, two ropes can be attached to the corners of the litter with girth hitches to allow up to four Soldiers to pull, brake, and steer the litter. This enables moving up, down, and traversing slopes with better control to prevent the litter from tipping over.

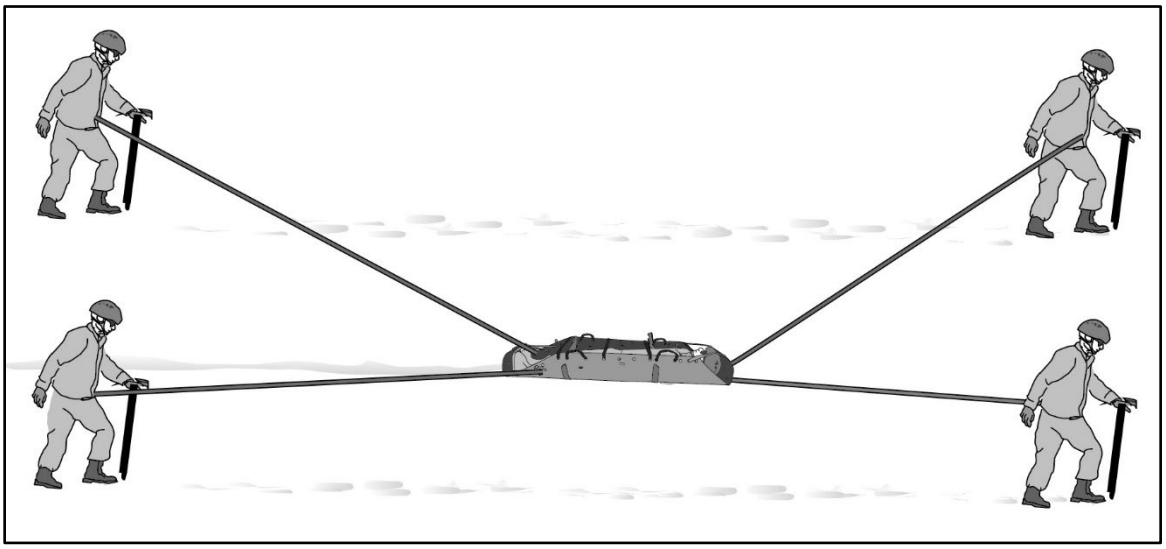


**Figure 15-4. Rope litter drag**

# LOW-ANGLE RESCUE

15-35. Low-angle rescue can generally be categorized by roped litter evacuations on low to moderately steep slopes where much of the weight of the casualty and rescuer is still supported by the ground. In this terrain, the litter slides along the slope, either up or down, depending on the direction of travel. The rope pathway should be cleared prior to casualty movement. All precautions must be taken to keep the litter within the fall line of gravity to eliminate pendulum swings. In all situations, the rescue team should strive to solve the terrain problem safely with the least technical solution.

## ROPE ATTACHMENT

15-36. Rescue litters are generally oriented vertically during low-angle slope evacuations. (See figure 15-5.) The rescue rope is attached to a vertical attachment point at the head of the litter with a locking carabiner or carabiners. The rope is connected at the head of the litter for comfort and for ensuring that blood does not pool at the casualty's head during transport.

15-37. Many techniques can be used to create a vertical attachment point at the head of the litter. (See figure 15-6, page 362.) Techniques may be improvised, based on the type of litter and available equipment. Ensure that this fixed loop attachment point connects multiple components of the litter for redundancy. In the case of the patient rescue and recovery system, use the short length of rope that comes with the system and follow the manufacturer's instructions for creating this.

15-38. The end of the rescue rope can then be attached to this point with a figure eight on a bight and connected with a locking carabiner. Ropes used for rescues should be static (low stretch) and should have a minimum breaking strength of 30 kilonewtons (kNs).

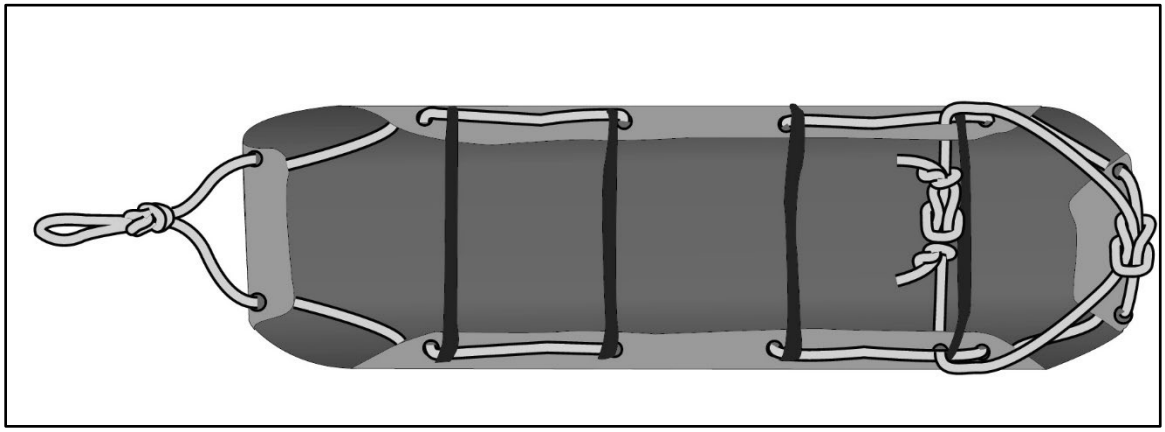


**Figure 15-5. Litter rigged for vertical orientation**

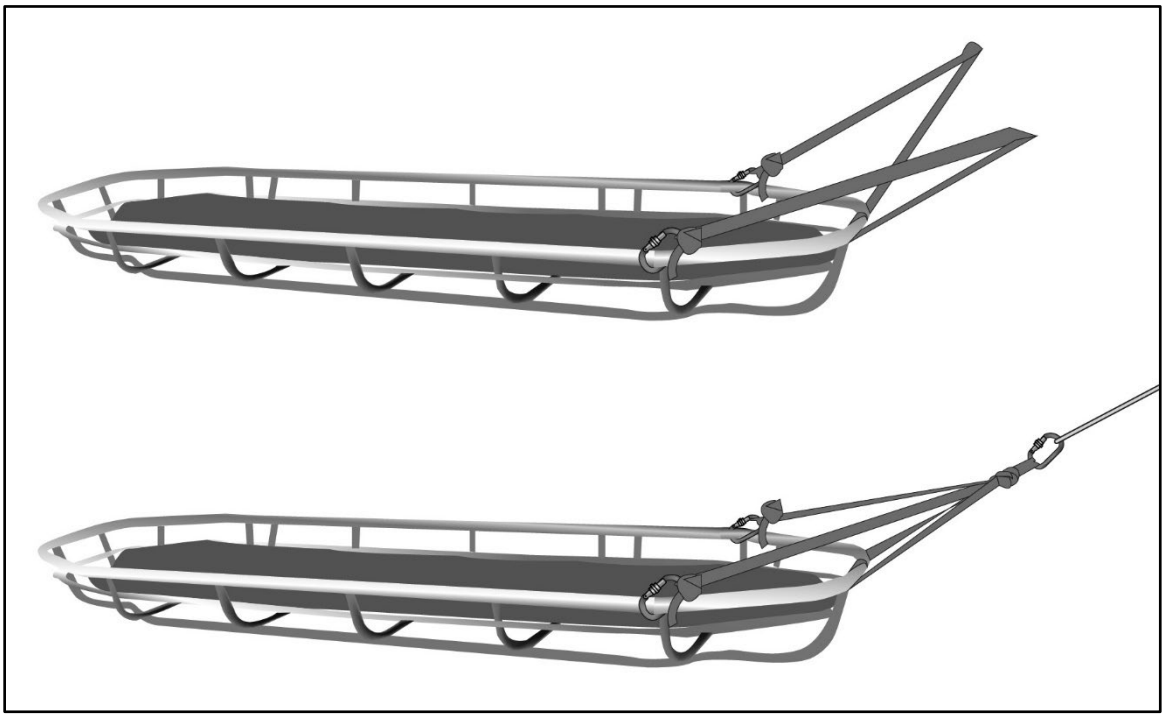


**Figure 15-6. Basket litter rigged for vertical orientation**

## BELAYS

15-39. In some situations, the rescue rope can be used to simply provide a tight belay for the casualty while litter teams carry a litter up or down slopes. Many of the various belay techniques described in chapter 10 are appropriate for this; however, the terrain must be gentle enough that there is no falling hazard to members of the litter team.

## ATTENDANTS

15-40. In steeper terrain where lowering or raising the litter from above is necessary, there is often a falling hazard for the litter team. If rescuers cannot safely walk beside the litter, it is typically advisable to use a single rescuer attached to the system as an attendant. This attendant's primary responsibility is to ensure the litter and casualty do not roll over, become hung up on terrain obstacles, or create slack in the system.

15-41. One technique is to attach the rescue rope to the litter head using a bowline with a tail that is long enough to reach the bottom of the litter when stretched out. The long tail is then be used by a litter attendant as an attachment point to the system in situations where it is necessary. (See figure 15-7.) This can also be achieved using a figure eight on a bight with enough rope behind the knot to extend this distance.

15-42. The attendant can attach directly into the end of this rope with another figure eight on a bight attached to a locking carabiner in the harness or by tying directly in with a rerouted figure eight. An autoblock or prusik can also be attached to this strand of rope to allow the attendant to adjust position in relation to the litter and hang completely from the system. Occasionally but less often, two attendants may be required to manage the litter.

15-43. These methods use some of the rope that is available for the rescue. In cases where the length of available rope is limited, it may be prudent to improvise the attendant's attachment using other materials, such as a cordelette.

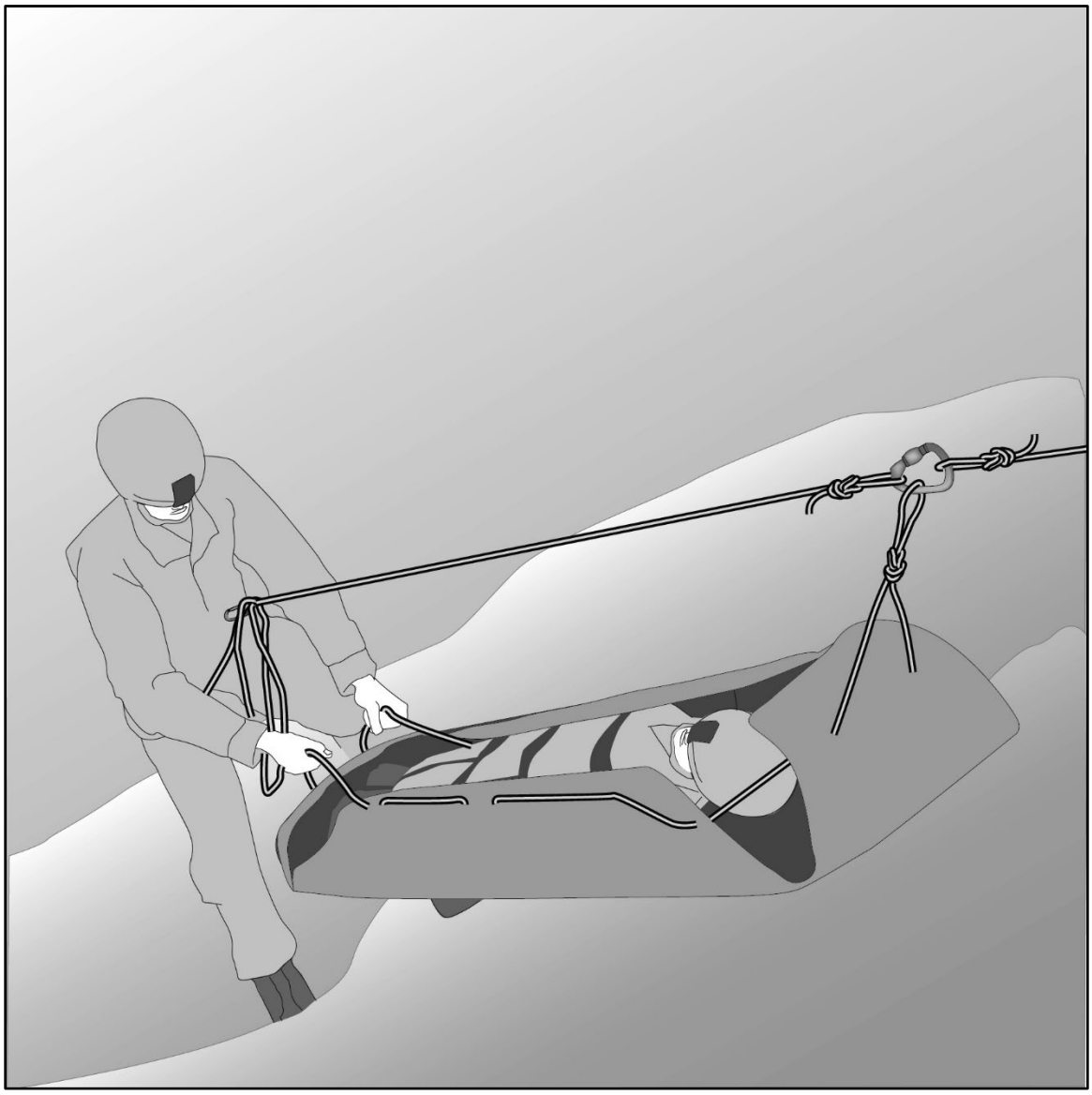


**Figure 15-7. Litter rigged for lowering with long-tailed bowline and attendant attached**

## LOWERING

15-44. The litter and attendant can be lowered using various lowering techniques described in chapter 12. Select or construct extremely solid anchors, tie off the end of the rope to close the system, and apply appropriate hands-free backups. The rope pathway should be cleared prior to casualty movement, and all precautions must be taken to keep the litter within the fall line of gravity to eliminate pendulum swings. A Soldier secured safely near the edge can often be helpful to relay commands and help control the speed of the lower. Avoid rope pathways with sharp rock edges or loose terrain with rockfall potential.

15-45. If it is necessary to lower the litter and attendant multiple rope lengths, multiple anchor stations and lowering teams may be required to achieve this. Complex situations such as this require excellent leadership, terrain assessment, and communication.

### RAISING

15-46. The litter and attendant can be raised through steep terrain using the various hauling techniques described in chapter 12. This could be done by a hauling team from above using main force or by creating MA using one of the systems previously described. If using main force, a prusik or other friction hitch should be attached to the rope and anchored as a progress capture. An additional member on the haul team must be dedicated to managing the prusik during this method. If using MA, the hauling team must pull slow and steady and should be extremely aware of the loss of feel for the load. In either case, the rope pathway should be cleared prior to casualty movement, and all precautions must be taken to keep the litter within the fall line of gravity to eliminate pendulum swings. A Soldier secured safely near the edge can often be helpful to relay commands and help control the speed of the haul. Avoid hauling in terrain with sharp rock edges or loose terrain with rockfall potential.

## HIGH-ANGLE RESCUE

15-47. High-angle rescue generally refers to roped evacuations down steep cliffs and 5th-class terrain. High-angle rescue requires formal training, experience, excellent judgement, and good technical problem-solving skills. It often requires a substantial amount of time. Only level 2 and 3 military mountaineers should only conduct high-angle rescue, when necessary. There are often many variables involved in high-angle rescue, and thus, there is no prescriptive set way to deal with the many challenges that can be encountered. Because a combination of skills and techniques may ultimately be required, including climbing techniques, belays, rappels, hauling and lowering methods, or even the use of high lines, a comprehensive focus is well beyond the scope of this training circular. Rather, this section will focus on some of the fundamental principles and commonly used tools and techniques.

### LITTER RIGGING

15-48. Whether a rescue litter or a rigid metal basket is used for a high-angle evacuation, the rigging is similar. The litter can be rigged for horizontal orientation, like a helicopter hoist configuration, or it can be rigged for a vertical orientation the same as described for lower-angle evacuations. In many cases, it is ideal to package the casualty in a manufactured or improvised harness. This allows the harness to connect to the rope system independently of the attachment to the litter itself. This can also be achieved with webbing using a variety of techniques.

#### Horizontal Orientation

15-49. Horizontal orientation of the litter is often used in cases where the nature of the injury makes vertical orientation unsuitable, such as spinal, pelvic, and lower leg injuries. (See figure 15-8.) Severely hypothermic and cardiac patients should also be kept as horizontal as possible during transport. The rescue litter comes with two hoist straps that can be used for this. In the case of a similar metal basket litter, cordage or webbing can be rigged to connect the four corners to a single midline attachment point. (See figure 15-9.) Ensure the head end of the litter is slightly higher than the foot end, about 6 inches when unloaded. Use locking carabiners and ensure that all carabiners used in the rigging are oriented correctly. It is easy to create a dangerous situation by cross-loading carabiners.

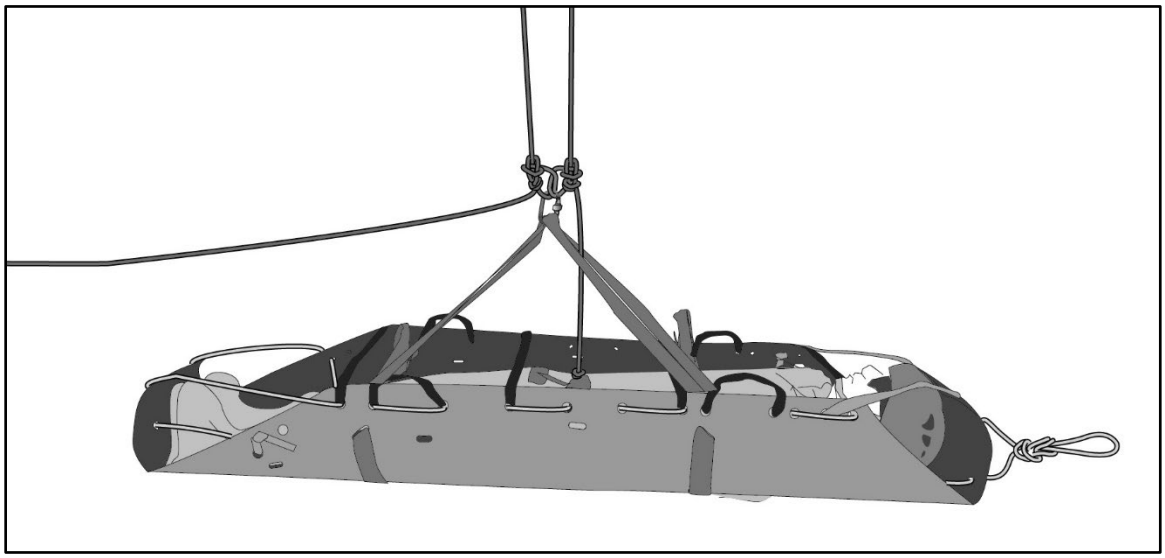


**Figure 15-8. Litter rigged horizontal orientation with hoist straps**

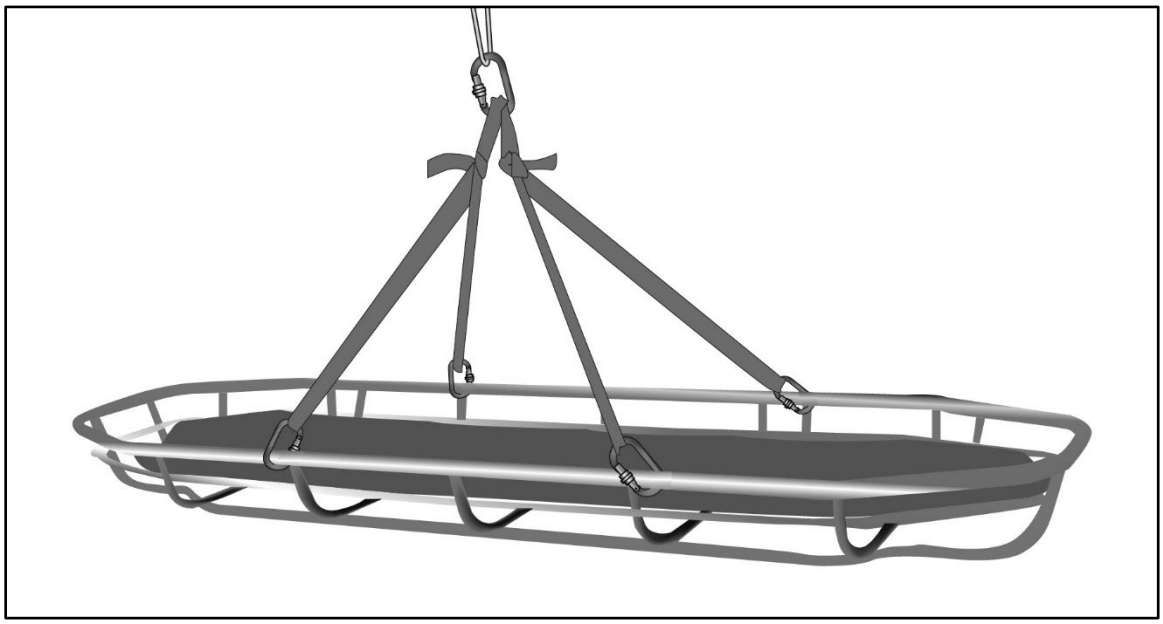


**Figure 15-9. Basket litter rigged for horizontal orientation**

## Vertical Orientation

15-50. Vertical litter orientation is often preferred as it can make for a simpler and more fluid edge transition. It is also lower profile, protects the patient better from rockfall and other hazards, and does not require a change in rope attachment point when transitioning to or from low-angle terrain. However, this method can be unsuitable for casualties with spinal, pelvic, and some lower leg injuries and requires securing the patient in such a way to minimize movement in the litter once evacuation begins.

## ROPE SELECTION

15-51. Rope rescue systems should meet the industry standard 10:1 static system safety factor (SSSF). Calculate the SSSF by first determining the force created by the rescue load. Each person attached to the system is estimated to create 1 kN. Therefore, one casualty and one rescuer are estimated to be a 2-kN load. For a 2-kN load, all components of the rescue system must be rated to 20-kN breaking strength to meet the 10:1 SSSF requirement. In this case, ropes would require a minimum breaking strength of around 30 kN to account for an estimated 1/3 strength loss when knots are tied into the rope. Most static kernmantle ropes 11 mm in diameter meet this 30 kN threshold. However, for mountain rescue operations, it is much more practical to use lighter weight ropes that can more easily be carried, allow for faster response times, and function better with other components of the mountaineering kits. These may have MBSs that are a little less than 30 kN, but the advantages often outweigh the risks of encroaching on the very robust 10:1 SSSF. More important than the strength of a thinner diameter rope, users must be cognizant of edge abrasion issues. These ropes should be static (low stretch) and should have a minimum diameter of 9.5 mm and a minimum breaking strength of 26 kN.

15-52. Rescues can be carried out using single or tandem rope systems.

### Single Rope

15-53. Single rope technique, much like that described for use with low-angle rescue, is typically simpler to construct and operate, and generally requires less equipment overall. However, it does not include redundancy for system or rope failure. Equipment breakage or human error can have catastrophic results. Consider using this technique only when there is no prominent edge transition, no sharp rock edges on the pitch, and time and resources are limited.

### Tandem Rope

15-54. Tandem rope technique is more complex and time consuming, and gear intensive to construct. However, it has the added benefit of built-in redundancy against system or rope failure or human errors in rigging and operation. Consider tandem rope systems when there are prominent or difficult edge transitions due to the potential for high-peak forces in the event of failure, sharp rock edges, or when there is limited team experience regarding the rigging of anchors and lowering or belay systems.

15-55. Tandem rope technique uses two separate ropes referred to as the main line and the belay line. Each rope system requires a separate anchor. The main line is used to haul or lower the litter, and the belay line is there in case of main line failure.

15-56. The two ropes are connected to the litter attachment point with interlocking long tailed bowlines. (See figure 15-10.) The tail or free end of each bowline is used as a secondary attachment point for the patient and the litter attendant.

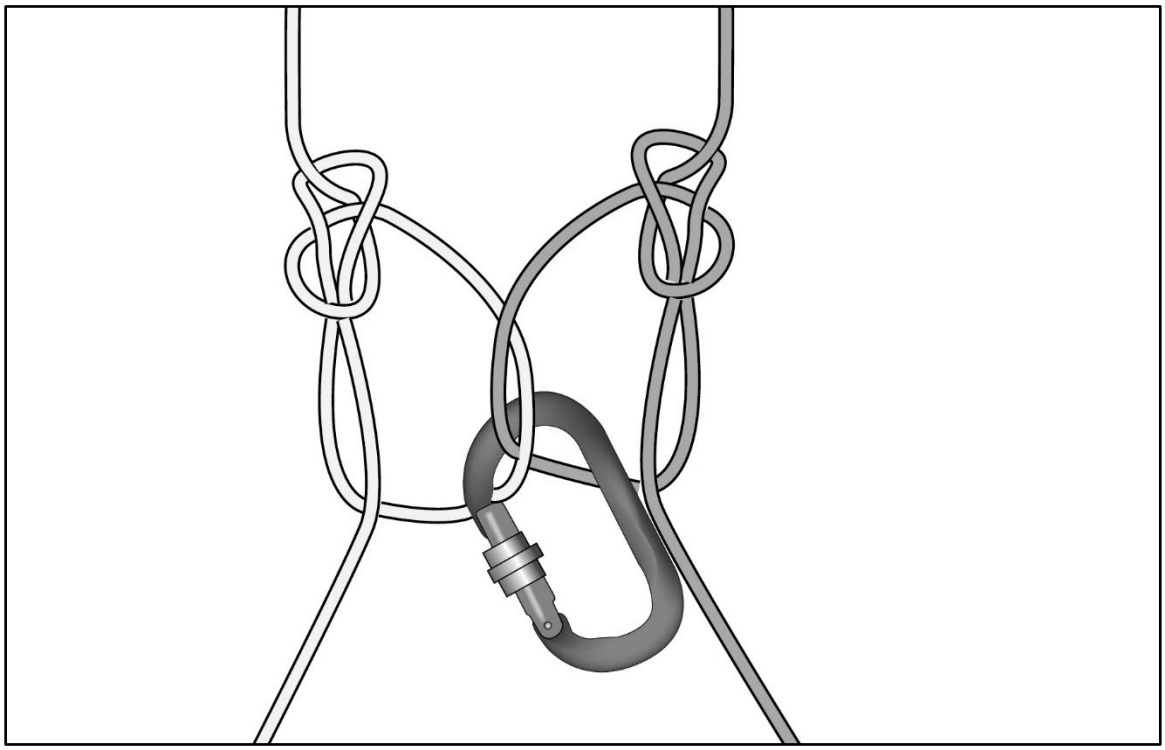


**Figure 15-10. Interlocking long tail bowlines**

15-57. The main line is often routed through a high directional or A-frame near the top edge of the cliff to reduce friction at the edge, and to make the transition over the edge easier. (See figure 15-11, page 368.)

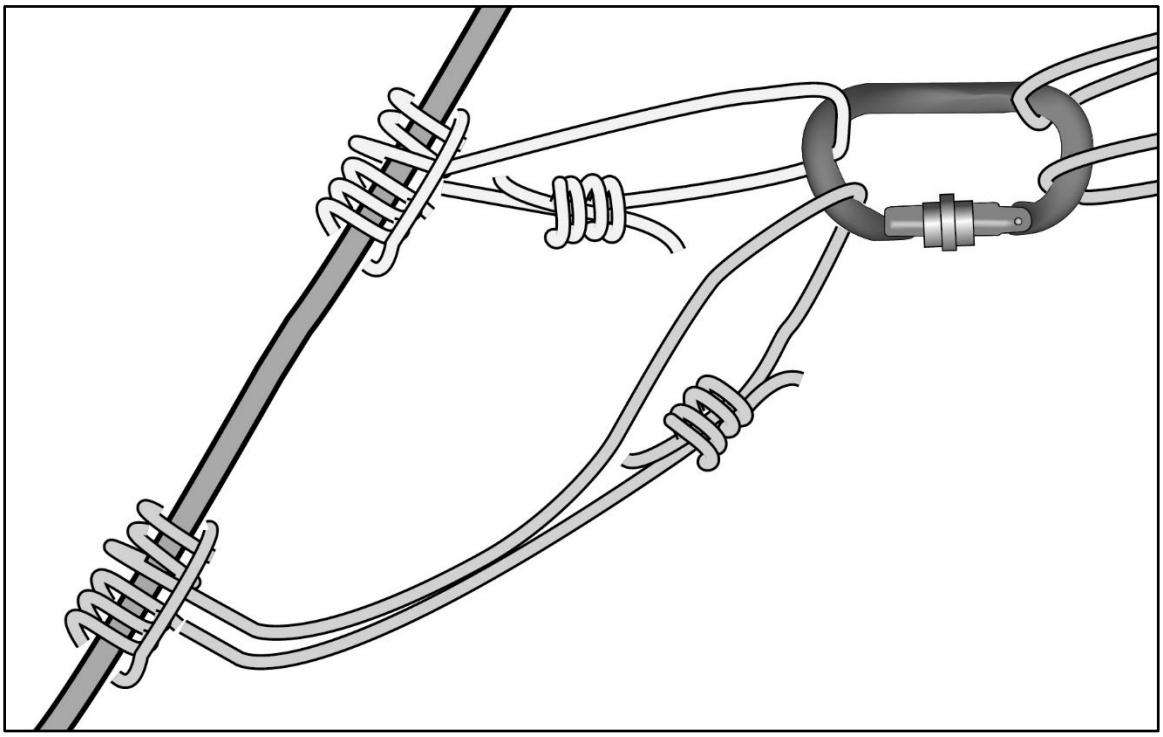


**Figure 15-11. Tandem prusik belay**

## LOWERING

15-58. Sites suitable for lowering should have solid anchor points, good loading and unloading platforms, and good clearance for the casualty along the route. Terrain with sharp rock edges or loose terrain with rockfall potential should be avoided when lowering is necessary. The litter and attendant can be lowered using various lowering techniques described in chapter 12, but techniques that generally provide greater friction are preferred. The end of the rope should be tied off to close the system.

## RAISING

15-59. Sites suitable for hauling should have solid anchor points, good loading and unloading platforms, and good clearance for the casualty along the route. Terrain with sharp rock edges or loose terrain with rockfall potential should be avoided when hauling is necessary. The litter and attendant may be hauled using techniques described in chapter 12. Systems with higher ratios may be necessary, as well as redirection and piggyback techniques.

## BELAY LINE

15-60. While a properly constructed main line and solid anchor system should not fail, there is potential for a severe shock to the system if the attendant slips going over the edge. If such a slip occurs, the shock load will be significant due to the short amount of rope available to absorb the force, and the static nature of all the system components. The separate belay line is also here for this purpose. If a high directional is used, the belay line should not be routed through it. This would cause a greater fall distance before the belay line could catch the load in the event of failure or breakage of the high directional.

15-61. While there are manufactured devices available that meet the criteria for a technical rescue belay, the simplest and most field expedient method is called the tandem prusik belay. Two prusiks, preferably made from 7- or 8-mm nylon static utility cord are tied approximately 2-inches apart on the belay line. The length of the prusik closer to the anchor should be a few inches shorter than the other prusik. These prusiks are then attached to the belay anchor with a locking carabiner. To use the belay, keep an uphill hand on the two prusiks

together and the downhill hand on the downhill side of the rope. Feed rope through the prusiks with a "hitchhikers grip" (thumbs out) and keep a bow of rope approximately 8 to 12 inches of slack between the hands. There should be only a few inches of slack between the downhill hand and the litter. In the event of a blown edge transition or of main line failure, the prusiks will be ripped out of the belayer's hands and catch the load. Tandem prusiks and belay line are also helpful when transitioning from a lower to a raise or when passing a knot through the lowering system.

## POSITIONS AND RESPONSIBILITIES

15-62. A high-angle rescue requires a skilled team to be conducted. The following positions are a bare minimum and mandatory for a safe evacuation.

### Team Leader

15-63. The team leader has overall responsibility for the operation. The team leader considers all available options and selects the most appropriate technique for the situation. The team leader makes judgments based on the nature or urgency of the injury, the tactical situation, the nature of the terrain, and the personnel and resources available. The team leader briefs the plan, provides the necessary guidance to the team members, and oversees the operation until complete. The team leader should not handle the main line or the belay, but in short workforce situations, should be found near the edge to assist in communication. The team leader establishes and supervises a formal rigging inspection process, as well as the command and control protocol for all technical operations.

### Belayer

15-64. The belayer manages the belay ensuring the prusiks do not lock out. Typically, the belayer is responsible for construction and rigging of the belay.

### Main line

15-65. The main line will consist of either a one- or two-person lowering team or a haul team for raises. In the case of teams, only one person should be the spokesperson to keep communications clear. Typically, the main line team is responsible for anchor construction and hauling system rigging.

### Edge Safety

15-66. The edge safety keeps the edge area clean of debris, places edge protection if necessary, and assists the load over the edge during the transition. The edge safety also relays commands between the attendant and the personnel above. During difficult edge transitions, two edge safeties may be used.

### Attendant

15-67. This litter attendant manages the handling of the patient and litter during the technical portion of the rescue. Often the primary focus of the attendant is making sure that the litter is protected and keeping slack out of the system. These often require pulling the litter out away from the terrain for smooth lowers or raises. This is considerably taxing and may require having an adjustable length attachment to the rope system. The litter attendant should have both primary and secondary attachment points for redundancy. The litter attendant determines and adjusts the rate of litter movement up or down as necessary.

### Inspections

15-68. Units should develop their own deliberate inspection protocols for rescue rope system rigging. At a minimum, rigging for each system component (for example, main, belay, litter) should be inspected systematically as a deliberate step by advanced mountaineers who did not participate in building it.

### Control

15-69. In some cases, to free up the team leader, a separate control person is used for actual commands. This allows the team leader to maintain a broader perspective and continue to think about the next phase or stage

of the operation. The control gives commands to lower or raise the load, especially during the critical edge transition phase.

## COMMAND AND CONTROL

15-70. Precise commands and singular control are necessary for safe operations. All commands should originate either with the team leader, control, or, in some cases, the edge safety. A variety of commands can be used but must be short, simple, and clear. Always include the name of the position in the command, such as SLACK ON MAIN or TENSION ON BELAY. Before any lowering or raising operations take place, a roll call is necessary to ensure all personnel are ready. The roll call should start with personnel near or at the edge and work backwards to the main. Once all personnel are ready and checked and the litter and attendant are in position, begin the operation by calling UP ON MAIN or DOWN ON MAIN. Once the litter is moving, the speed can be adjusted, as necessary. To halt all movement, call STOP. All teams continue to act as if the load is on belay until the command OFF BELAY is given.

15-71. Radios are usually necessary to maintain contact with the attendant on the litter. Once the attendant is over the edge, in high winds, yelling is not reliable and produces a sound signature that can travel unpredictable distances in mountainous terrain.

## Chapter 16

# Rope Bridges

Operations in mountainous terrain often encounter obstacles, such as fast flowing water, ravines, or rock fields. Well-trained mountaineers can exploit this terrain with the use of rope bridges and high lines. These allow units to take the terrain out of the equation by using a rope suspended in the air to cross the obstacle. High lines are a type of rope bridge. The two terms are often used synonymously, and the techniques are relatively interchangeable; however, for the purposes of this training circular, we will refer to rope bridges when used for assisting personnel for river crossings and the term "high lines" to denote rope installations used to span longer or higher gaps in terrain.

## SECTION I – TECHNIQUES

16-1. A rope bridge is a rope tensioned between two anchors and suspended off the ground to assist units with crossing rivers. These are sometimes necessary in situations with swift and dangerous currents or very cold water, where keeping the majority of Soldiers dry is important.

16-2. Rope bridges can pose distinct disadvantages. Though linear in nature, rope bridge crossings in a tactical environment should be considered VDAs. This is because units establishing and using them are fixed and potentially split by the river obstacle for prolonged periods. This can put them at a significant tactical disadvantage. (See ATP 3-21.50 for more VDA-crossing considerations.)

## CONSTRUCTION

16-3. The rope bridge is constructed using a static rope. The rope is anchored on the far side of the obstacle in the same manner as described for using handlines in paragraphs 13-26 through 13-29, page 327. It is then tensioned and anchored on the near side of the obstacle. A rope bridge may be built many ways depending upon the tactical situation and area to be crossed. However, all rope bridges share common safety principles for construction and use. Rope bridges must be tensioned as low as practical on the anchor while still facilitating suspending loads and off-loading them. The creation of artificial height (covered later) can be used for rope bridges. The type and location of the tensioning system depend on terrain and situation.

### METHODS OF TENSIONING

16-4. There are multiple ways to apply tension to a rope. The method selected depends on the length of the bridge, equipment available, personnel available, and time. Regardless of the method used, the principle remains the same; apply just enough tension to facilitate ease of crossing through the terrain.

**WARNING**

**Ropes must not be overtensioned. An overtensioned rope is in its weakest state, and the system can apply exponential forces during use. Critical failures can occur with overtensioned ropes.**

## HAND TIGHT

16-5. The simplest and least equipment-intensive method is hand tightening the rope. Once Soldiers anchor one side of the rope, they pull the rope as tight as they can. Next, they tie off the rope using one of three methods: mule knot secured with an overhand knot (see figure 16-1), round turn around anchor and two half hitches on a bight, or a high strength tie off (tensionless hitch). (See figure 16-4, page 374.)

***Note.*** Figure 16-2, and figures 16-3 and 16-4, page 374, illustrate the transport tightening system.

16-6. The benefit of hand tensioning the rope is that it is the fastest way to get the rope tight. The limitation is that if the rope bridge span is long, it may not be possible to apply adequate tension to the rope using this method. Adequate tension may require more personnel than units have available.

## TRANSPORT TIGHTENING SYSTEM

16-7. The transport tightening system can be used to tighten a rope bridge when additional tension is necessary. One Soldier on the near side ties a knot that is easily untied after being placed under tension (for example, an alpine butterfly or figure-eight slip knot with a half hitch to stabilize the adjustable bight [see figure 16-1]) approximately 1 to 2 meters from the near side anchor. They place a locking carabiner into the loop of the knot. At that time, Soldiers route the remainder of the rope around the near side anchor point and clip the rope into the carabiner.

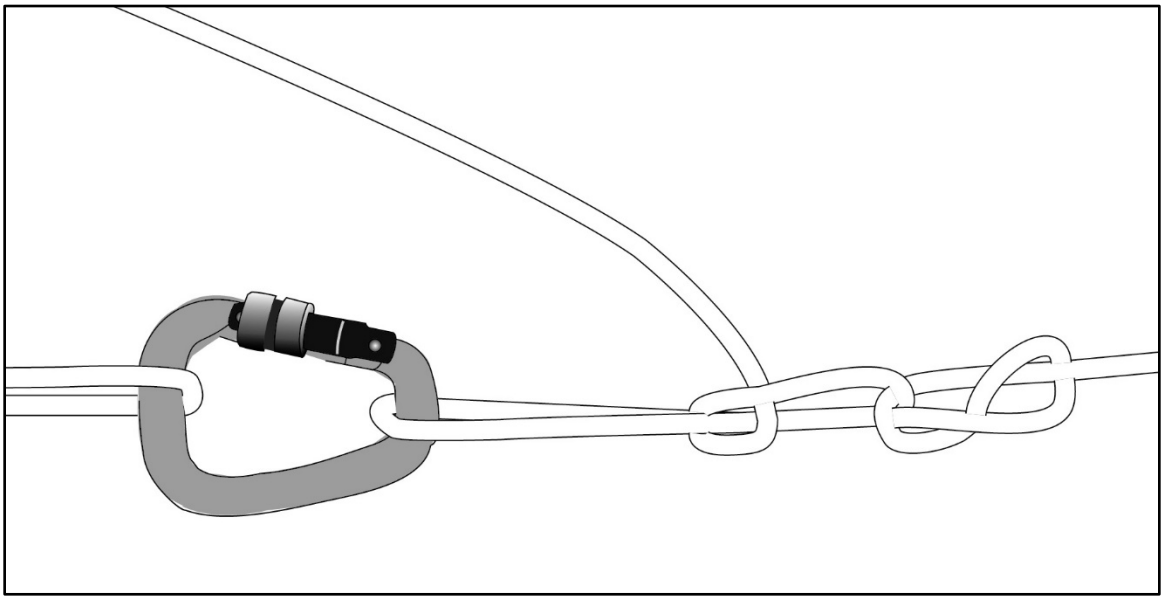


**Figure 16-1. Transport tightening system**

16-8. The pull team on the near side pulls the slack out of the installation rope. The knot should be close enough to the near side anchor to allow personnel to easily load the installation.

16-9. The rope then can be secured using one of the same three methods described above.

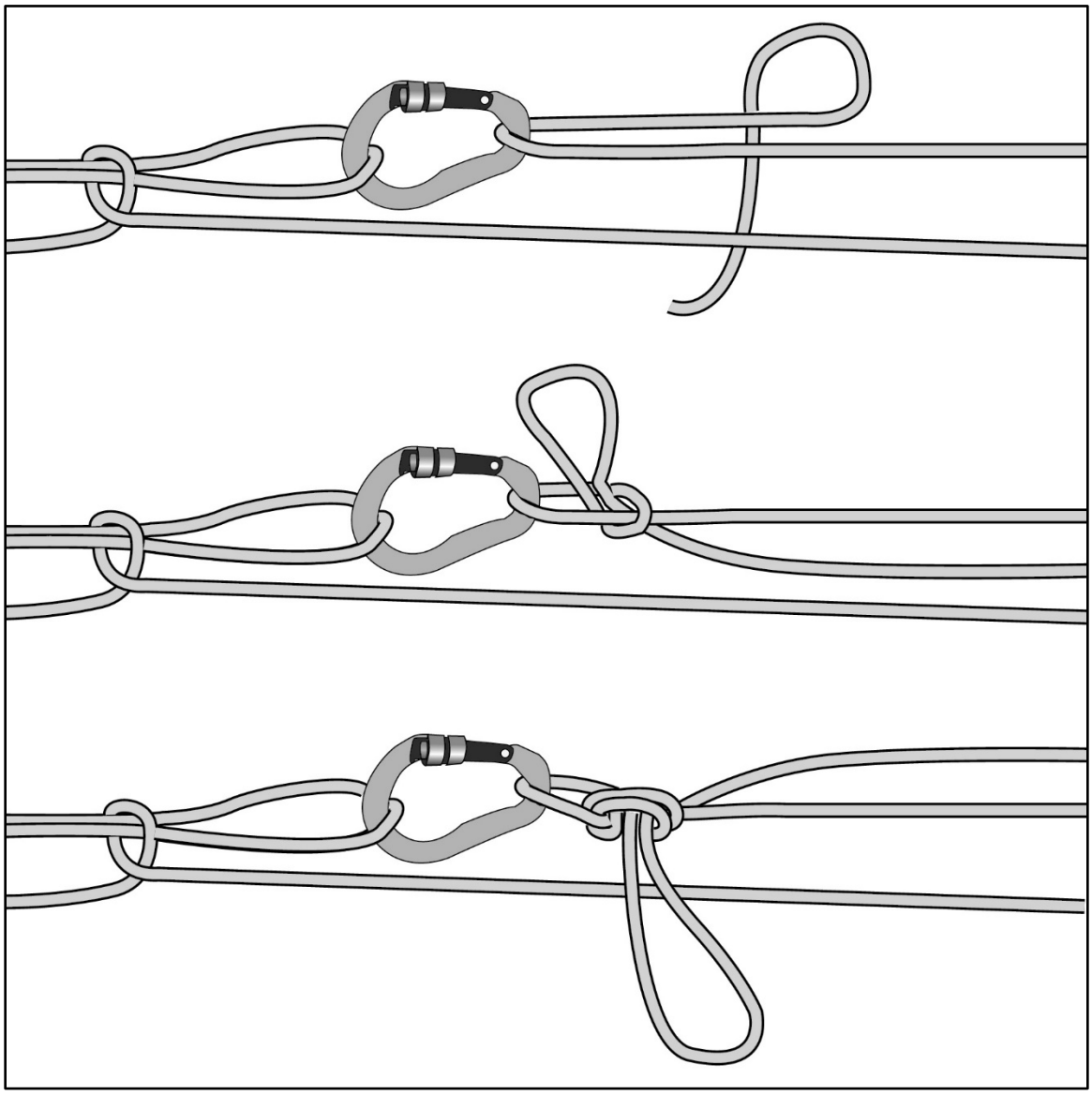


**Figure 16-2. Mule knot secured with an overhand knot**

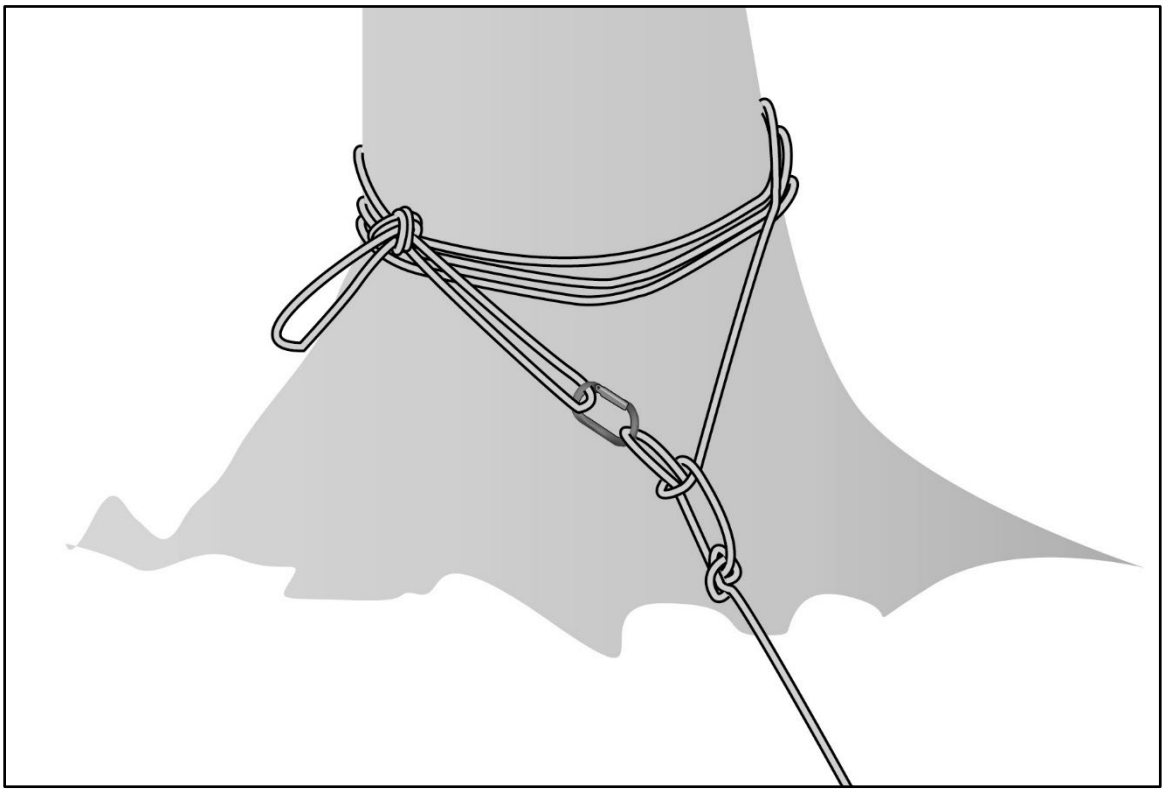


**Figure 16-3. Round turn around anchor and two half hitches on a bight**

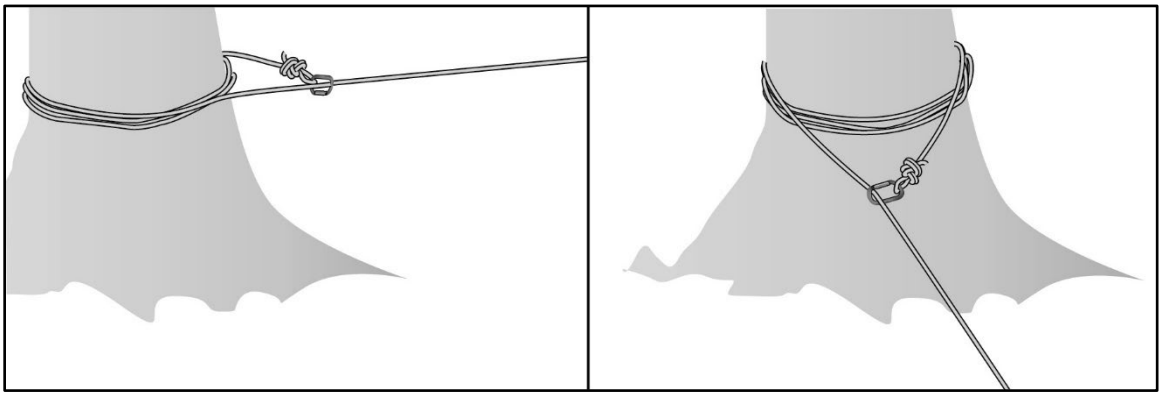


**Figure 16-4. High strength tie off (tensionless hitch)**

16-10. The benefit of using the transport tightening system is that the MA allows more tension to be applied to the rope with limited personnel and minimal equipment. The limitations are the increased system platform size required, reduced MA due to friction generated by rope redirects, and time of construction.

## SIMPLE 3:1 TIGHTENING SYSTEM

16-11. The simple 3:1 tightening system is another method for gaining MA (see chapter 12).

16-12. The benefits of the simple 3:1 system are increased efficiency in tensioning, the capability to tension on a smaller platform, and the ability to re-tension due to rope stretch. The drawbacks are increased complexity, time, equipment, and the possibility of overtensioning the rope. The limitations are that the system requires more equipment, is more complex to construct, is easier to overtension and the increased time required to construct.

**WARNING**

**No more than four personnel should be used to tighten the rope when a simple 3:1 or a transport tightening system is used to apply tension. Using more personnel can overtighten the rope and bring the rope critically close to failure.**

# REDUNDANCY

16-13. A rope bridge constructed with a single rope has the risk of critical failure due to cutting and lacks redundancy. A redundancy (in rigging) is the condition in which a rope system will not fail as the result of any single component of the system failing. If the risk or critical nature of the load requires an additional level of redundancy, a second rope bridge may be constructed parallel to the first one. Examples of critical loads are a casualty, Soldiers crossing a rope bridge that is high off the ground, and a dry river crossing where a separate belay rope is not used. If two ropes are used, they should be as close as possible so that a single carabiner can be clipped to both lines. An individual would attach to both ropes when crossing, thus having a backup in case of failure. Redundancy is not always necessary or practical but is typically used in training as a risk management tool.

# METHODS OF CROSSING

16-14. All wet crossing techniques using handlines are covered in chapter 13. Methods of dry crossings using rope bridges is determined by several factors:

- The load being transported on the rope bridge (such as personnel, equipment, and litter).
- The risk of the terrain (such as fast-moving water and catastrophic falls).
- The angle of the rope bridge (such as level, ascending, and descending).
- Equipment available (such as extra ropes, harnesses, and rigging equipment).

16-15. Leaders must evaluate the situation and determine the most efficient means of crossing. For example, the method chosen for moving a light element with no sustainment gear across a 10-foot stream is different from the method chosen for moving crew-served weapons across a 50-foot-wide, fast-moving river.

16-16. If Soldiers can transport themselves across, they can choose either the commando crawl or the Tyrolean traverse.

## COMMANDO CRAWL

16-17. Soldiers lie on top of the rope with a foot hooked on the rope and a knee bent, o positioned nearly in line with the buttocks; the other leg hangs straight to maintain balance. They progress by pulling with their arms. To recover if they fall over, Soldiers hook one leg and the opposite arm over the rope, and then push down with the other hand to regain position.

## TYROLEAN TRAVERSE

16-18. Soldiers don a harness or tie a field expedient harness and attach a locking carabiner into it, with the nose of the carabiner facing up and away from their body. They then face the rope and clip into the rope bridge. Soldiers rotate under the rope and pull with their hands and arms to make progress. The Tyrolean traverse is the preferred method. If crossing with rucksacks, a carabiner is inserted into the frame and attached to the rope bridge. Soldiers then place one or both legs through the shoulder carrying straps and pull the rucksack across.

## TAGLINES

16-19. Heavy equipment will require the use of a tagline. A tagline is used to pull objects from the near side to the far side. An additional rope is brought across the rope bridge and anchored to the far side. The other end is anchored on the near side. All the slack is pulled to the near side, and a figure eight on a bight knot is tied at the loading platform. A carabiner is inserted into the loop and clipped onto the rope bridge.

16-20. If the rope bridge is longer than half a rope length, two separate ropes are required to create a tagline. One end of the far-side tagline is brought across the obstacle and anchored to the far side. The other end is secured to a carabiner. One end of the near side tagline is secured at the near side, and the other end is secured into the same carabiner as the far-side tagline. That carabiner is then placed onto the rope bridge.

16-21. If the rope bridge is descending (the far-side anchor is significantly lower than the near side), a belay may need to be added to the tagline system. The tagline attached to the near side will be converted into a belay (see chapter 10) to allow for a controlled movement across and down the rope bridge.

## EQUIPMENT RIGGING

16-22. Any special equipment, such as crew-served weapons, ammunition, or supplies, must be rigged for movement across the rope bridge. A unit SOP may dictate the rigging of these items, but many expedient methods exist. The rigging should use various items that would be readily available to a deployed unit. Some of these items include tubular nylon webbing, cordage (various sizes), and carabiners.

16-23. Equipment that can be bundled together, such as rucksacks, should be Bundles can be created with a cordelette. If there are insufficient personnel on the far side to lift the bundle for unloading, a releasable Munter mule can be utilized at the point of attachment to the tagline.

16-24. Litters can be transported across a rope bridge if there is a secure means of attaching the litter to the rope, such as the rescue litter with its horizontal lift straps. The carabiner of the tagline will remain on the rope bridge. On each side of this carabiner, using the hauling line tie a middle-of-the-rope clove hitch around the carabiners of both horizontal lift straps of the litter. Remove the slack between the carabiners. Then place the carabiners in each of the lift straps onto the rope bridge. (See figure 16-5.) The same technique used for the rucksacks is used to pull the litter across.



**Figure 16-5. Litter rigging**

# ARTIFICIAL HEIGHT

16-25. Artificial height is often useful or even necessary to raise the height of rope bridges. (See figure 16-6, page 378.) This may be needed when desiring dry river crossings or to better facilitate the loading and unloading of personnel or equipment. Artificial height may be needed on one or both sides of a rope bridge.

16-26. Occasionally, bridge sites may be selected where a tree with a high sturdy limb may be slung with rope or cord. On rock faces, artificial anchors may be constructed in convenient locations. Otherwise, A-frames may need to be constructed.

16-27. A-frames are structures constructed with poles to create artificial height for use with rope bridges. Two sturdy poles are needed. The exact size of the poles depends on the type of load and location of the installation. The average size A-frame pole should be at least 3 inches in diameter and 9 to 12 feet long. Three to five 13-foot cordelettes are needed depending on the size of the poles used for the A-frame.

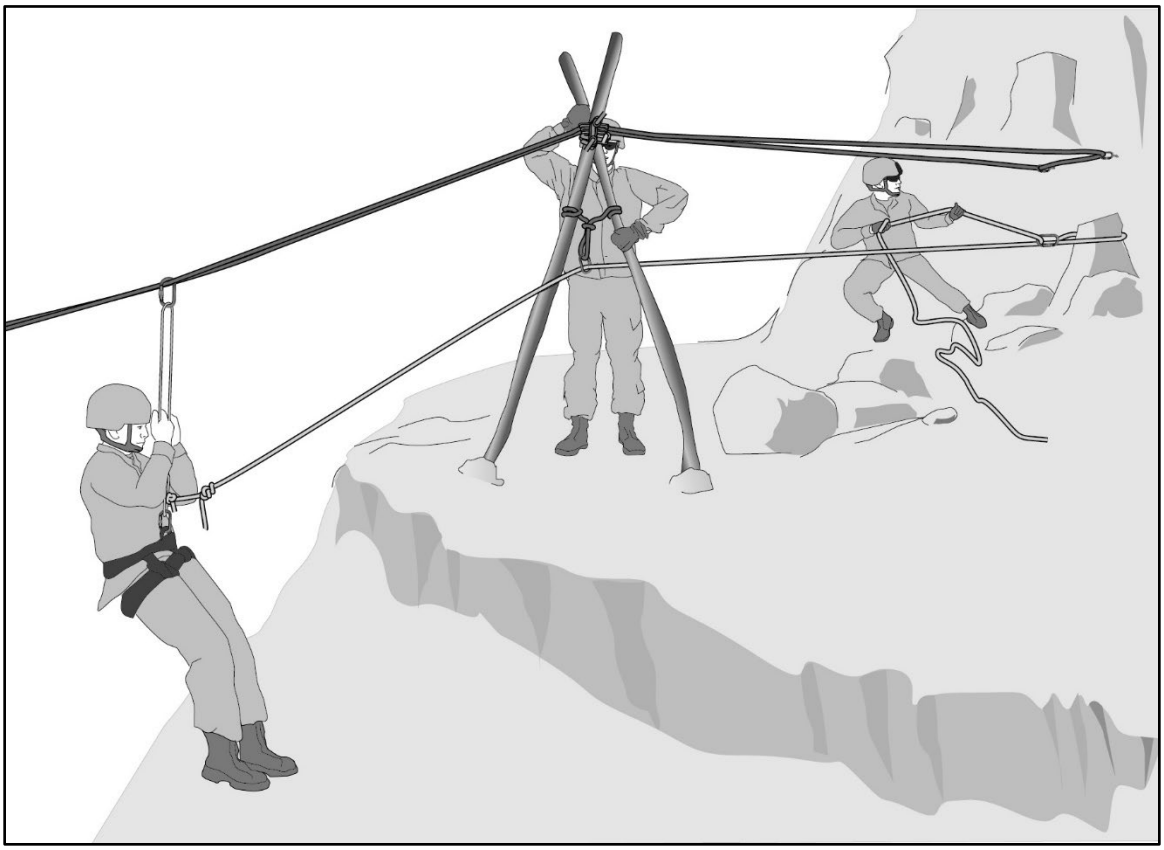


**Figure 16-6. Artificial height (A-frame) used with high line**

## A-FRAME CONSTRUCTION

16-28. There are many acceptable techniques and variations for the construction of A-frames. The general process is described as follows: (See figure 16-7.)

- Place two suitable poles with the butt ends flush and mark the desired apex on both poles.
- With a section of rope or cordelette, tie a clove hitch around one of the poles a few inches above the apex marking, leaving about 12 inches of tail to the outside of the poles. (See figure 16-7[A].)
- With the poles side by side, wrap the remaining length of rope horizontally around both poles six to eight times, wrapping downward from the clove hitch. (See figure 16-7[B].) It may be necessary to join another section of rope to the first with an appropriate joining knot. Position this knot on the outside of one of the poles so as not to interfere with the vertical wraps. (See figure 16-7[C].)
- On the last horizontal wrap, continue around the pole that does not contain the clove hitch, pass the rope between the poles below the wraps, and make four to six tight vertical wraps around the horizontal wraps. (See figure 16-7[D].) Make the wraps as tight as possible. The vertical wraps must be as flat as possible next to each other. Insert a carabiner into the last two vertical wraps. (See figure 16-7[E].)
- On the last vertical wrap, pass the rope between the poles above the horizontal wraps. Tie it off with a square knot in the section of rope coming from the clove hitch. Secure with overhand knots tied in the tails. (See figure 16-7[F].)

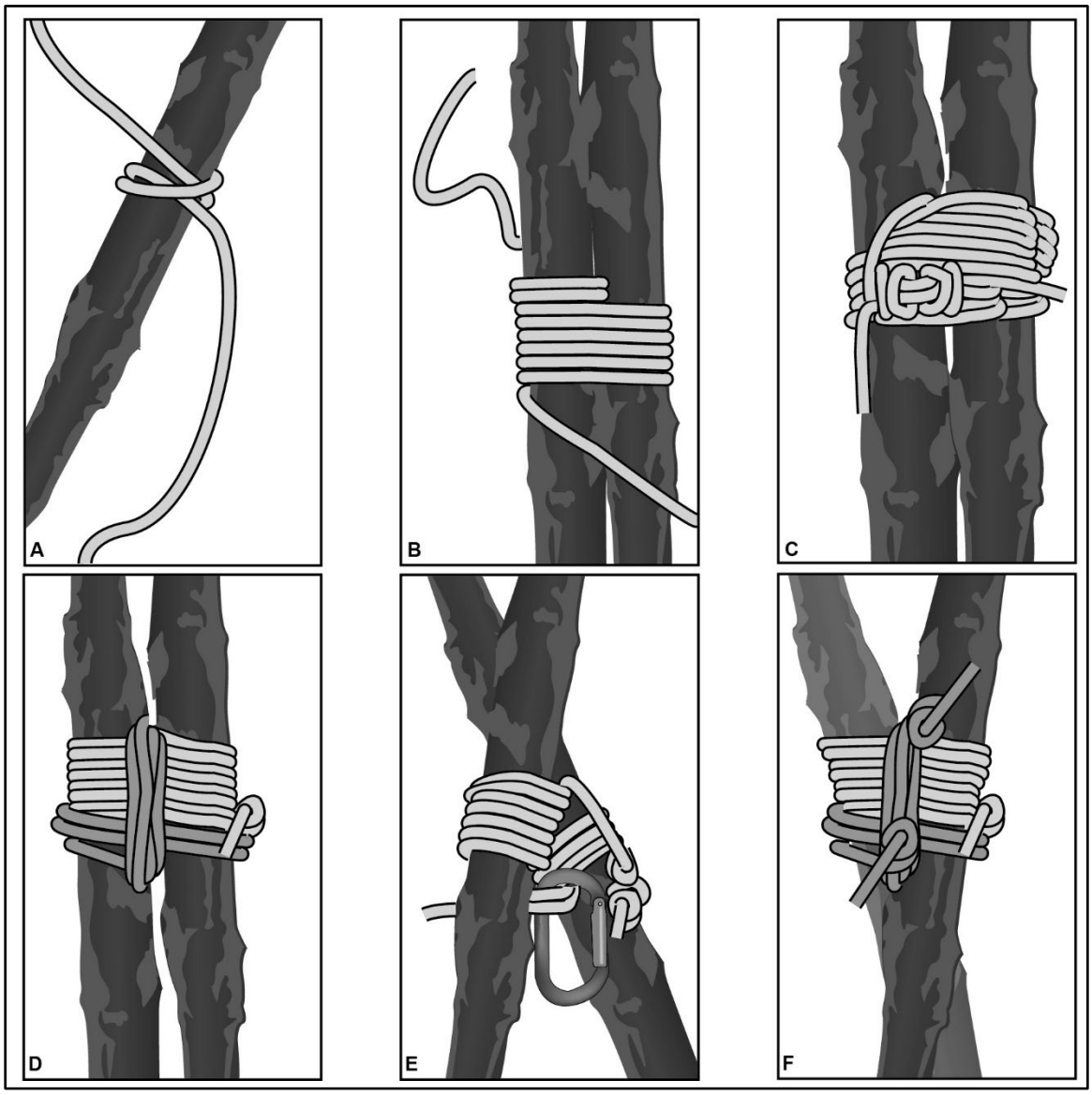



**Figure 16-7. A-frame horizontal and vertical wraps**

16-29. Use a spreader rope to prevent the A-frame from collapsing from pressure applied at the apex. (See figure 16-8, page 380.) Secure the legs of the A-frame together with a cordelette to fix the maximum spread. If the ground is soft, dig the legs in about 6 inches. If the ground is a hard surface, anchor the bases of the poles at a 45°-angle to secondary anchor points. The spreader rope should be no more than 6 inches above ground level.

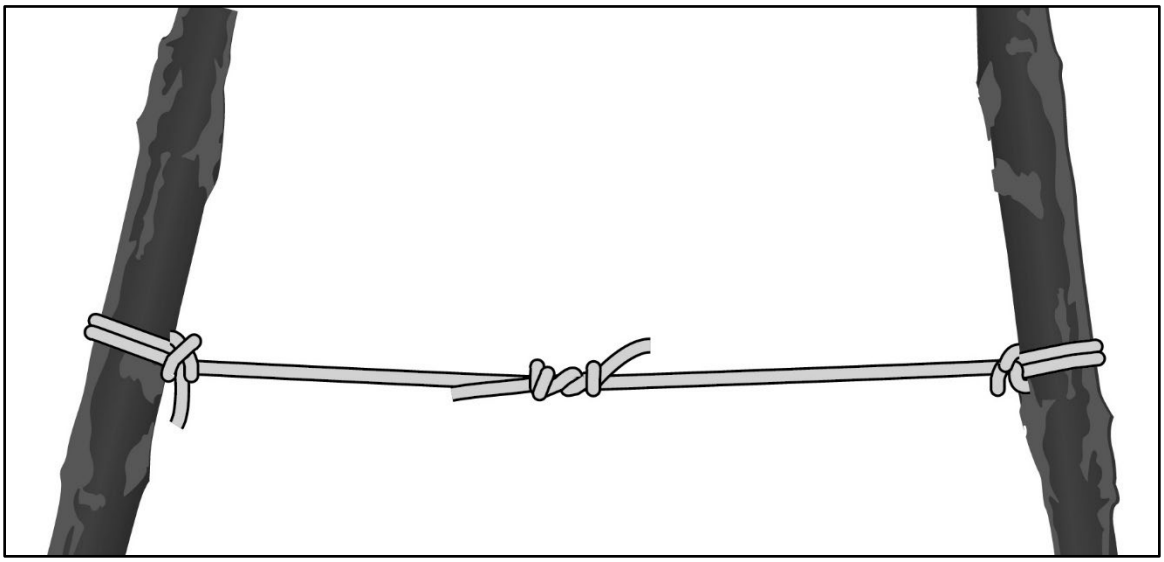


**Figure 16-8. A-frame spreader**

## ANCHORING THE A-FRAME TO THE INSTALLATION ROPE

16-30. If used, an A-frame must be anchored to the installation rope. Tie a clove hitch at the center of a cordelette. Place it over one of the poles above the apex and move down to the apex so that the locking bar of the clove hitch is to the inside of the A-frame. Secure each end of the cordelette to one of the tightened static lines with two prusik knots—one forward and one to the rear of the A-frame on the same static line rope. (See figure 16-9.)

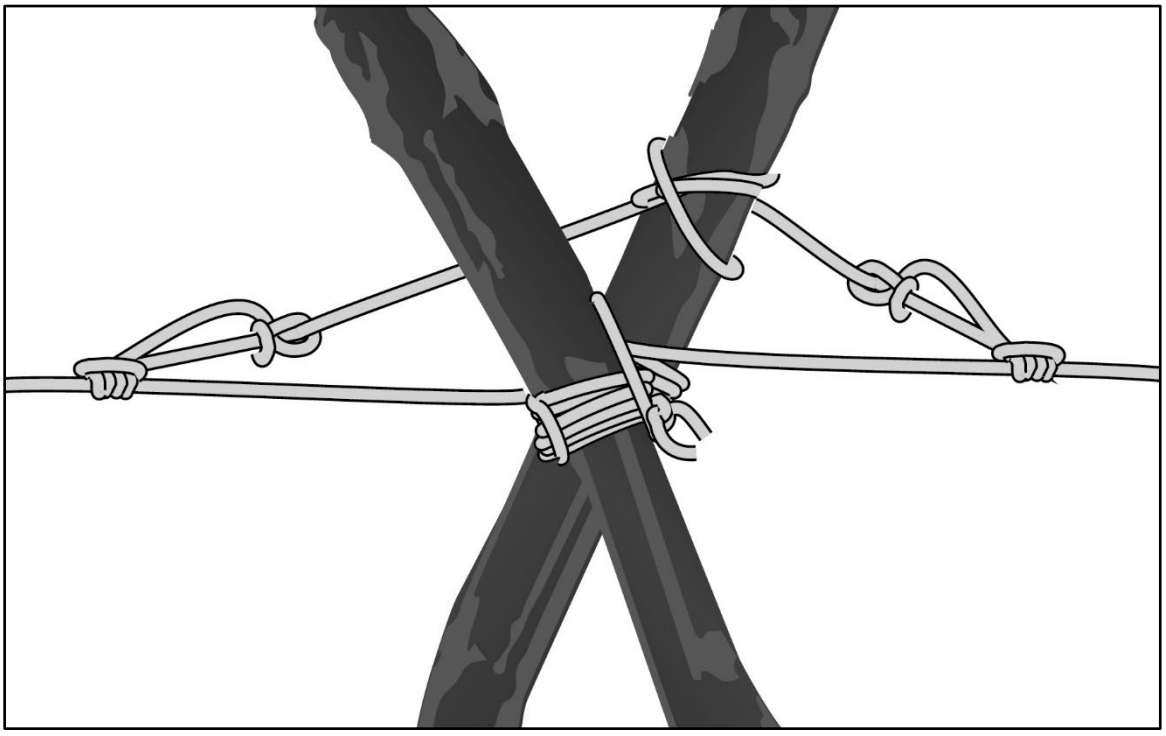


**Figure 16-9. Anchoring the A-frame to the installation rope**

16-31. Position the A-frame so that the angles created by the A-frame bisecting the installation rope are approximately equal on both sides. This creates downward pressure holding the A-frame in position, not forcing it in a lateral direction. It must also be placed in a straight line between the upper and lower anchor points.

# RETRIEVAL

16-32. If the element is crossing the obstacle as part of a longer movement, and there are no follow-on troops, the system must be installed to be retrievable:

- Nearside personnel untie the high-line system maintaining the near side ends of both the installation rope and belay or tagline rope.
- Far-side personnel pull all slack across the obstacle.
- Nearside personnel secure the end of the installation line to the anchor.
- Tie a fixed loop in the near side end of the installation rope.
- Secure the fixed loop to the installation rope around the nearside anchor with a locked carabiner.
- Far-side personnel pull the installation rope tight with several personnel, and then wrap it around an anchor tree with a minimum of two full wraps. Those personnel maintain control of the end of the rope keeping it tight with the tree by hand or can close out the rope by means of two half hitches like the close out on the transport tightening system. Another method is for far-side personnel to build a new tightening system on their side to tighten the rope.
- Nearside personnel attach the tagline to installation line figure eight on a bight using a locked carabiner and a fixed loop. The tagline remains slack.
- Nearside personnel attach themselves to the installation line in the same way as the main body and cross the high line.
- Once all personnel are on the far side, the installation rope is unwrapped from the far-side anchor and allowed to go slack. If a new tightening system was used, it is broken down.
- The tagline is then pulled across the obstacle dragging the installation line with it until both ropes are on the far side. Ensure all knots are removed from both ropes before pulling.

# HIGH LINES

16-33. A high line is a type of suspended rope bridge used to transport equipment or casualties high above difficult terrain that might otherwise be impassable. These can be used for personnel movement as well, although this is less common. The high line is used over large rivers, ravines, chasms, or diagonally from the top of a cliff to the ground below. The system may be established on different planes, varying from horizontal to near vertical. High lines keep the load suspended above the terrain as it travels directly between the near- and far-side anchors.

16-34. High lines come with a high level of risk due to the height of the load above the ground. High lines used for personnel movement require careful calculation to ensure system failure will not occur, resulting in catastrophic fall injury. They should only be constructed by advanced or master military mountaineers who have been formally trained in high-line construction for this purpose.

## SITE SELECTION

16-35. The crossing site must have appropriate anchors at the near side and the far side and suitable loading and off-loading platforms. If the anchors do not provide enough height to allow clearance, additional height, such as an A-frame, may be used.

## INSTALLATION

16-36. The same options and tightening techniques used for rope bridges can also be used for high lines; however, due to the higher consequences of rope or equipment failure, a second rope as described earlier must always be used for redundancy. Construction of high lines can be time-consuming and equipment intensive. Installation teams are likely to require additional skills and techniques to get the far end of the installation ropes to the far side of the obstacle.

16-37. Artificial height is used the same way as described for rope bridges.

### EQUIPMENT RIGGING, BELAYS, AND TAGLINES

16-38. Slings and cordelettes can be used to attach loads to the installation ropes and can be modified as necessary. (See figure 16-10.) Two examples are using two ends of a piece of webbing with a water knot or using a sewn sling. Place a locking carabiner on the high line and place the webbing or sling into it. Bring the bight at the bottom end of the sling up (double it) and clip it into the locking carabiner. A second locking carabiner can now be placed into the two bights. Attach the load by running the long loop of the carrying sling through the load and attaching the bottom loop to the traverse rope carabiner.

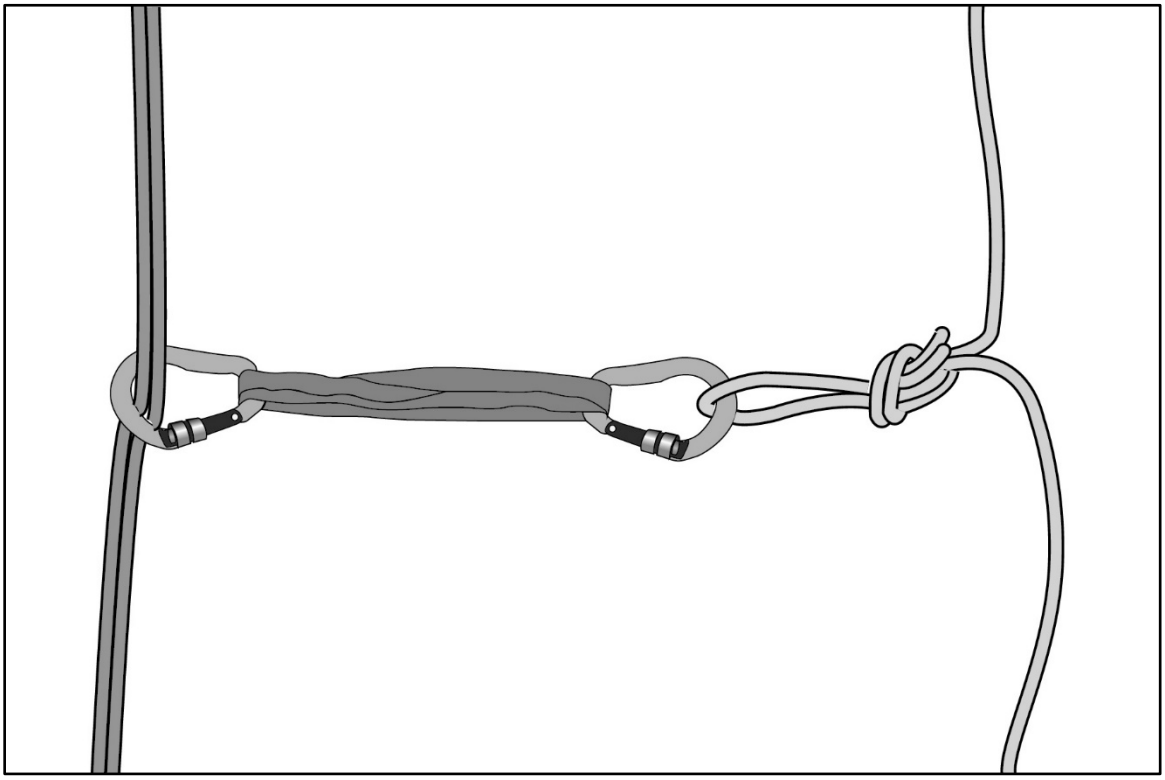


**Figure 16-10. Carrying sling**

16-39. Attach a lowering rope to the second locking carabiner in the carrying sling when speed of the load must be controlled. (See figure 16-10.) Standard lowering techniques discussed in chapter 12 can be used. This rope can be attached to the A-frame using an additional carabiner attached to the carabiner that is in the apex. If Soldiers are crossing, they should hold onto the carrying sling and keep their hands off the installation rope.

16-40. Taglines can also be used as described for rope bridges and are nearly always necessary when the high line does not contain a relatively constant downgrade.

### RETRIEVAL

16-41. The high line can be retrieved in a manner like the one rope bridge. However, as it is often used to move equipment and casualties, it can be dismantled after it is no longer needed without being retrievable.

## SECTION II – GUIDING LINES

16-42. A guiding line (see figure 16-11) is an effective means of transporting a litter over uneven, broken terrain (talus) commonly found at the base of cliffs. A guiding line is established and tightened in the same manner as a descending high line using MA but is not tied off once tensioned. The tensioning team retains control of the haul strand and adjusts tension in the installation line as the litter is lowered down it. The litter's

descent is controlled by a separate team operating the lowering system using a second rope. (See chapter 12 for hauling and lowering systems.) These two teams work together to ensure the litter travels just high enough above the broken terrain to keep movement smooth. Additionally, attendants may move on foot through the terrain to help guide the litter around obstacles.

16-43. The main benefit gained from using a guiding line over a high line is the reduction in risk. Because the guiding line is only tensioned enough to lift the litter in the air, the rope is at a very low risk of being over tensioned and the litter is never high above the ground. Using a high line in the same piece of terrain would usually involve suspending the litter high above the ground on a highly tensioned rope. Additionally, movement down a guiding line is much easier on the casualty than being hand carried through large talus.

16-44. While guiding lines can be a lower risk solution, they can be more complex and are usually more time-consuming. Leaders must ensure that their element is formally trained on guiding lines and has the equipment necessary to accomplish the task safely.

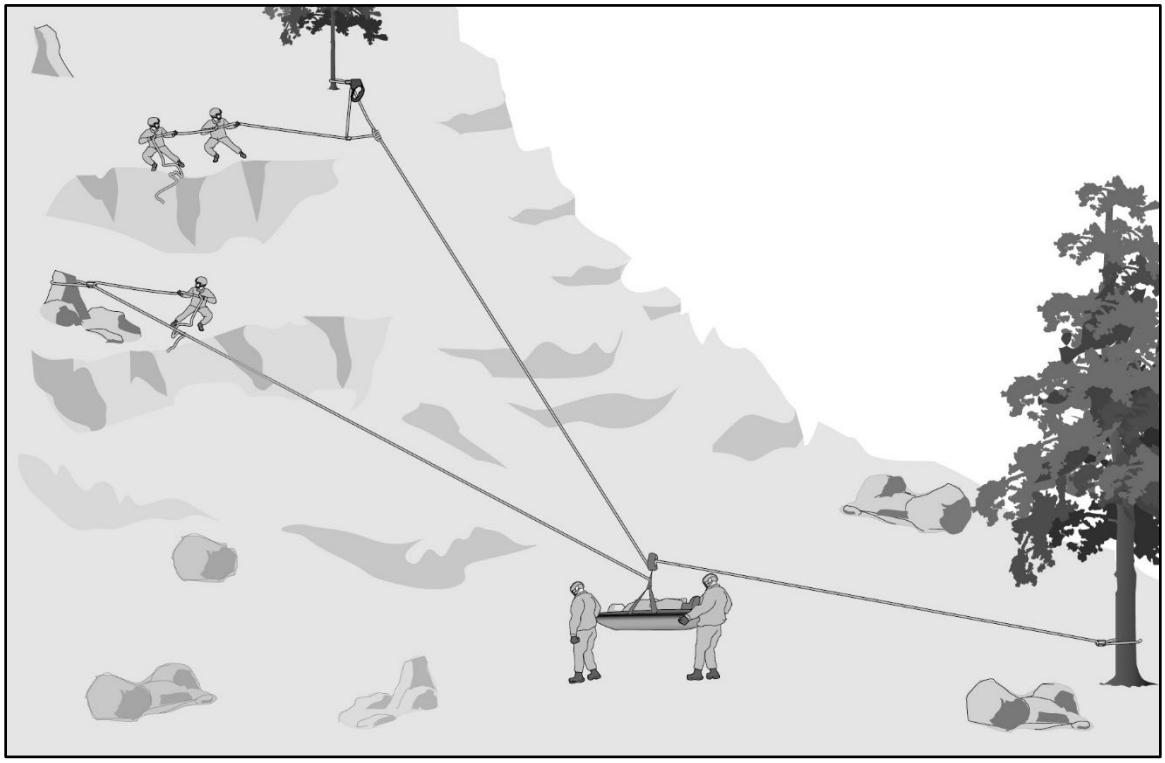


**Figure 16-11. Guiding lines**

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## Appendix A

# Climbing Route Classification

The most important tools for risk management in the mountains are route selection and evaluation. Accurately evaluating and selecting routes in high consequence terrain requires a well-developed understanding of technical route classification systems and experience climbing the terrain they describe. Route classifications allow military mountaineers to identify appropriate routes for their Soldiers' skill levels and the technical rope systems required to move on them safely. Misunderstanding or miscommunicating route difficulty can place the life of the mountaineer or the lives of the Soldiers they lead in danger. The U.S. military does not have its own technical route classification systems. Therefore, military mountaineers must use those developed for civilian mountaineering. The classifications discussed in this chapter breakdown and describe the difficulty associated with routes in various types of terrain. Understanding them provides military mountaineers with the base from which to build route identification and selection experience.

## ROCK CLIMBING CLASSIFICATIONS

A-1. There are several systems for classifying different aspects of rock-climbing difficulty. Different types of climbing require different classifications. Also, skill is not the only factor involved in classifying difficulty. The amount of time and effort necessary to complete a climbing route is often more important than what the hardest move on it is. Depending on the type of route being planned, one or all these route difficulty systems should be considered.

### YOSEMITE DECIMAL SYSTEM

A-2. In North America, the YDS is used to rate the difficulty of rock-climbing routes. It categorizes terrain according to the techniques and physical difficulties encountered when rock climbing. The YDS classes are—

- Class 1—hiking.
- Class 2—off-trail scramble with the occasional use of hands.
- Class 3—moderate scrambling, with short steps of easy climbing. Ropes may be used for beginners, but a guide can often manage the terrain with good coaching and modeling.
- Class 4—simple climbing, with exposure. A rope is often used. A fall could be fatal.
- Class 5—rock climbing. Usually requires climbers to rope up, belay, and place protection to protect the leader from a long fall.

A-3. Class 5 is further subdivided to rate the difficulty of the climbing. The YDS only rates the hardest move on a pitch and does not account for strenuousness, difficulty of placing protection, or quality of the protection:

- Class 5.0 to 5.4—easy. This is the simplest form of free climbing. Hands are necessary to support balance. Easy for experienced climbers.
- Class 5.5 to 5.6—intermediate. Often no more physically difficult than easier climbing but requires trusting friction and smaller holds. The climber can experience vertical position or overhangs where there are positive holds that require moderate levels of energy expenditure.
- Class 5.7 to 5.8—moderate. Considerable climbing experience is necessary. Longer stretches of climbing requiring several points of intermediate protection. Climbing often requires specific techniques, such as jamming, liebacks, or mantles.
- Class 5.9 to 5.10—hard. Requires well above average ability and excellent condition. Exposed positions, often combined with small belay points. Passages of the difficult sections can often be accomplished under good conditions. Often combined with aid climbing.
- Class 5.11 to 5.15—very difficult. Requires more climbing ability, experience, and energy expenditure. Only talented and dedicated climbers reach this level.

A-4. The original YDS was designed as a closed scale ending at 5.9. When climbing standards surpassed the original scale, 5.10 was added, and broken down further into a, b, c, and d categories (for example, 5.10d). Each increase in letter grade is comparably to an increase in grade in the original system.

A-5. A plus sign (+) or minus sign (-) are sometimes added, denoting that a pitch is more strenuous at the grade.

A-6. The YDS only rates the difficulty of the climbing and does not denote the quality and quantity of protection and consequence of a fall; therefore, guidebooks often use a second protection rating.

- G—good protection options in quality rock that are closely spaced.
- PG—good protection, but runout sections on easier parts of pitches may exist.
- PG-13—route requires climbing sections where protection cannot be placed. A lead climber should be confident climbing at the grade. Protection is adequate, and if it is placed correctly, it should protect the leader.
- R—protection is inadequate and there is potential for a long fall, which may cause serious injuries. A lead climber should be extremely confident at the grade.
- X—little to no protection on the pitch. Ground fall, serious injury, or death possible from a fall.

## AID CLIMBING RATINGS

A-7. Aid climbing is done using gear and protection to create upward progress on the rock, instead of hands and feet. It is rated not by the physical difficulty of the climbing but the quality and spacing of the placements for gear:

- A0—French-free. No aiders are required. This technique involves using a piece of gear to make progress, such as clipping a sling into a bolt or piece of protection, and then pulling up on it or stepping up in the sling. Usually this is only needed to get past one or two moves that are more difficult on free climbs.
- A1—Easy aid. The placement of protection is straightforward and reliable. Every placement can hold a fall. This technique requires aiders (etriers) and is fast and simple.
- A2—Moderate aid. Placements are good but may be difficult to place. Usually, A2 involves one or two moves that are difficult with good protection placement below and above the difficult moves, with no serious fall danger.
- A3—Hard aid. Each pitch may require several hours to lead. There will only be a few pieces of gear in the pitch capable of holding a fall, with potential falls of 15 to 20 meters. These falls, however, are usually clean and might not cause serious bodily harm.
- A4—Serious aid. Most placements will hold only body weight. There may only be a few solid pieces in a pitch. Falls can be 25 to 30 meters, with bad landings and risk of serious injury.
- A5—Extreme aid. All placements can hold only body weight. Usually, no protection placed on the entire route can be trusted to stop a fall.

## CLIMBING COMMITMENT GRADE

A-8. Commitment grades (National Climbing Classification System) inform the climber of the approximate time a climber trained to the level of the climb will take to complete the route:

- I—several hours.
- II—half of a day for the technical portion of the route.
- III—most of the day for the technical climbing, any difficulty.
- IV—long, full day of climbing. Hardest pitch rated 5.7 YDS or harder.
- V—requires at least a day and a half to complete the technical portion of the route, with the hardest pitch rated at 5.8 or harder. Requires a planned bivouac on the route for most teams.
- VI—longer than 2 days. Big wall-style climbing, often with extensive aid climbing, hauling of equipment, and supplies for many days on the wall.

## INTERNATIONAL RATINGS

A-9. Climbing difficulties are rated by different systems in other parts of the world. There are countless systems in use, and even within these systems, there are regional variations in the ratings. All ratings are highly subjective. When traveling and climbing, local guidebooks include charts that compare rating systems.

# ICE CLIMBING CLASSIFICATIONS

A-10. Ice formations change from year to year and throughout the season, causing their difficulty rating to fluctuate. However, they generally form in the same areas and with the same steepness as the underlying features that they build on. Ice climbing ratings have technical and commitment ratings. The numerical ratings are often prefaced with waterfall ice, alpine ice, or mixed rock and ice.

A-11. Technical difficulty ratings are as follows:

- 1—a frozen lake or streambed.
- 2—a pitch with short sections of ice up to 80°; lots of opportunity for protection and good anchors.
- 3—sustained ice up to 80°; the ice is usually good, with places to rest, but it requires skill at placing protection and setting anchors.
- 4—a sustained pitch that is vertical or slightly less than vertical; may have special features, such as chandeliers and run-outs between protection.
- 5—a long, strenuous pitch, possibly 50 meters of 85° to 90° ice, with few, if any, rests between anchors. The pitch may be shorter but on featureless ice. Good skills at placing protection are required.
- 6—a full 50-meter pitch of dead vertical ice, possibly of poor quality; requires efficiency of movement and ability to place protection while in awkward stances.
- 7—a full-rope length of thin vertical or overhanging ice of dubious adhesion. An extremely tough pitch, physically and mentally, requiring agility and creativity.
- 8—simply the hardest ice climbing ever done; extremely bold and gymnastic.

A-12. Commitment ratings are as follows:

- I—a short, easy climb near the road, with no avalanche hazard and a straightforward descent.
- II—a route of one or two pitches within a short distance of rescue assistance, with little objective hazard.
- III—a multipitch route at low elevation or a one-pitch climb with an approach that takes about an hour. The route requires anywhere from a few hours to a long day to complete. The descent may require building rappel anchors, and the route might be prone to avalanche.
- IV—a multipitch route at higher elevations; may require several hours of approach on skis or foot. This route is subject to objective hazards, possibly with a hazardous descent.
- V—a long climb in a remote setting, requiring all day to complete the climb itself. Requires many rappels off anchors for the descent. This route has sustained exposure to avalanches or other objective hazards.
- VI—a long ice climb in an alpine setting, with sustained technical climbing. Only elite climbers will complete it in a day. A difficult and involved approach and descent, with objective hazards ever-present, all in a remote area.

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# Appendix B
# Route Planning Tools

## SECTION I – ONLINE RESOURCES

B-1. There are many online resources available to assist with route planning in the mountains. It is important to note that these resources are not secure. Therefore, they should never be used for operational planning. They are an excellent resource for conducting mountaineering training off military installations.

B-2. Online resources are an excellent tool to use while gaining experience training in mountainous environments to further develop as a military mountaineer. These resources will help develop solid information-gathering habits. This collection must go beyond standard map reconnaissance. It allows Soldiers to gather important information that would not otherwise be discovered from a map sheet.

B-3. These resources when combined with solid map reconnaissance are vital to aid in safe navigation and information gathering. This will enable Soldiers to create the most accurate picture of the terrain and environment in which they are about to step foot in. They are also essential in mitigating the risk associated in the pursuit of the highly demanding training required to become a proficient military mountaineer.

B-4. See TC 3-25.26 for more information on general route planning strategies.

### NAVIGATIONAL RESOURCES

B-5. Numerous free web-based mapping resources combine detailed maps and excellent route planning tools in a user-friendly format. Many allow users to create printable maps that also show the route, distance, and change in elevation. These programs have slope-shading functions, which help to easily identify steeper sections of terrain. This is particularly useful when identifying avalanche hazards. Soldiers should seek out digital mapping resources to aid in their planning, hazard assessment, and route creation.

### CLIMBING ROUTE INFORMATION

B-6. From a unit training perspective, the two resources listed in paragraphs B-7 and B-8 can aid leaders in the planning process by identifying specific areas that meet realistic training objectives. These resources provide leaders with information that helps prevent potentially dangerous situations or exposing Soldiers to training that is more aggressive than they can conduct safely.

B-7. Mountain Project is the most popular free online climbing guidebook. The website has detailed information about rock-climbing routes all over the world. The mobile, app-based program allows mountaineers to view information on the go. It is a comprehensive collection of information, but it is user submitted. Using a current guidebook for a specific climbing area can still be the most reliable resource.

B-8. Summit Post is an online-based mountaineering resource for information about hiking or climbing larger nontechnical and technical peaks. The nonprofit website has user-submitted trip reports and updated trail and route conditions. It is a great resource for planning expedition-style climbs for high-altitude mountaineering objectives. The website features a vast selection of mountains from around the world.

## SECTION II – OTHER RESOURCES

B-9. Guidebooks, local climbing organizations, governmental and private land management organizations, and national alpine associations are all great additional resources for route planning and information gathering.

B-10. There are many other additional resources available; it would be difficult to name them all. It is best to research the specific area in which Soldiers intend to travel and gather as much relevant and current information as possible. It is also important to use any resources available to research seasonal weather patterns, prevailing winds, and areas of potential flooding.

## GUIDEBOOKS

B-11. A guidebook is a publication containing detailed climbing routes and approach route information. Current local guidebooks are still the most comprehensive and useful tool for gathering information on a specific climbing route or mountain. They contain detailed instructions for getting to these remote areas including the approach to the climb or trailhead. They contain invaluable route information and are readily available for most established mountaineering training areas.

## LOCAL CLIMBING ORGANIZATIONS

B-12. When information is not readily available in guidebooks (such as when training overseas), it may be beneficial to contact a local climbing organization in the area. These organizations exist all over the world even in the most remote and unlikely locations. The local community can provide some of the most accurate and current information that may not be available anywhere else.

## U.S. GOVERNMENT LAND MANAGEMENT AGENCIES

B-13. The U.S. government manages millions of acres of public lands that are excellent training venues for military mountaineering training. Generally, most training areas are managed by the Bureau of Land Management, National Park Service, or U.S. Forest Service. Other outstanding areas fall under the management of a state government, such as the Adirondack Park in New York. Training on public lands can be a complicated process that varies from organization to organization. Units planning to train on public lands must contact the land management organization early in the planning process to determine requirements and restrictions. Often, some agencies require up to 9 months of lead time.

## NONGOVERNMENTAL LAND MANAGEMENT ORGANIZATIONS

B-14. Some outstanding training areas such as the Shawangunk Mountain range in New York and New Jersey are under the management of private, nongovernmental land management, or conservation organizations. As with federal and state land management agencies, training planners should research regulations and restrictions on group and military use of the training area and contact the managing organization early in the planning process to ensure success in the training event.

# SECTION III – TIME-DISTANCE ESTIMATION

B-15. The time-distance method covered in chapter 7, table 7-2, page 148 is useful but very general. The Munter method described below affords planners more options to enhance their time-to-distance estimate.

## THE MUNTER METHOD

B-16. The Munter method is an accurate method of calculating route times during planning. It is the most accepted time-distance formula used by mountain professionals and guides. The Munter method combines map distance (kilometers) and elevation change (meters) into a unit of time (hours), then it is divided by an estimated movement rate (kilometers per hour) using various terrain conditions. This method allows the user the ability to break the movement up into different legs and account for different modes of travel. This method is simple to calculate and allows the planner increased flexibility to account for the various paces, changes in elevation, increased loads, and environmental conditions that exist in mountainous terrain.

B-17. When planning, create a route table like the one in the examples below. (See figure B-1 and figure B-3, page 392.) The Munter method form below is meant to be a baseline tool for route planners. It begins with basic data about the weather, situation, hazards, load, and group assessment to set the framework for decision making. These pieces of data paint a picture of the situation and enable the planner to properly account for terrain difficulties, rest breaks, and other additional time requirements. A sample calculation is provided as well as a baseline table to begin determining route legs. As planners become more experienced in the terrain, the table can be customized to their unit abilities.

| Point | Grid | Elevation | Elevation + or - | Azimuth | Distance | Units | Divider | Leg Time | Timeline |
|---|---|---|---|---|---|---|---|---|---|
| X | ZZ 6365 2687 | 300 m | N/A | N/A | N/A | N/A | N/A | N/A | 0600 |
| Y | ZZ 6479 3018 | 800 m | 500 m | 19 | 3.5 km | N/A | N/A | N/A | N/A |
| Z | ZZ 6866 3120 | 200 m | 600 m | 76 | 4 km | N/A | N/A | N/A | N/A |

**LEGEND**

| | | | |
|---|---|---|---|
| **km** | **kilometer** | **N/A** | **not applicable** |
| **m** | **meter** | | |

SAMPLE

**Figure B-1. Munter route table, example (with basic navigation information)**

B-18. Gather the information needed in the table and use the calculation below to find the time it takes to move from point to point. (See figure B-2.)

B-19. For this example, consider the terrain open and unrestrictive along the route. For the following example, assume open unrestricted terrain and a movement goal centered on physical training.

| *FORMULA* | *UNITS* | *MODIFIERS* | |
|---|---|---|---|
| *# of units x 60 min* | 1 unit for every 1 km of travel | Descending: | Ascending: |
| Modifier | 1 unit for every 100 meters change (gain or loss) | Walking 6 | Walking 4 |
| | *Multiply total units by 60 (min)* | Skiing 10 | Skiing 4 |
| | | Bushwhacking 2 | Bushwhacking 2 |
| **Legend:** #–number; km–kilometer; min–minute | | | |

**Figure B-2. Munter calculation formula and modifier guide**

B-20. For each route leg, add one unit for every kilometer of distance. A half kilometer would be 0.5 units. Then find the change in elevation between points and add 1 unit for every 100 meters change (gain or loss) in elevation during the leg. Add the number of units together for the specific leg.

B-21. Next, multiply this number by 60 (minutes).

B-22. Identify if it is an ascent or decent of the terrain. Then select the appropriate modifier to describe the type of movement through the terrain.

B-23. If moving at a patrolling pace, use the bushwacking modifier. Walking should be considered movement on a trail or in open unrestrictive terrain.

B-24. Scree or boulder fields should be considered bushwhacking. Movement in deep snow without flotation from skis or snowshoes should be considered bushwhacking.

B-25. With the modifier identified, the formula can now be calculated. The result is time in minutes to move that leg.

B-26. Complete the route table to estimate the total movement time. Keep in mind this method does not account for any halts in movement, recon, or other operational tasks associated with a patrol. (See figure B-3, page 392.)

| Point | Grid | Elevation | Elevation + or - | Azimuth | Distance | Units | Divider | Leg Time | Timeline |
|---|---|---|---|---|---|---|---|---|---|
| X | ZZ 6365 2687 | 300 m | N/A | N/A | N/A | N/A | N/A | N/A | 0600 HRS |
| Y | ZZ 6479 3018 | 800 m | + 500 m | 19 | 3.5 km | 8.5 | 4 | 127.5 mins | 0808 HRS |
| Z | ZZ 6866 3120 | 200 m | - 600 m | 76 | 4 km | 10 | 6 | 100 mins | 0948 HRS |

**LEGEND**

| | | | |
|---|---|---|---|
| HRS | hours | mins | minutes |
| km | kilometer | N/A | not applicable |
| m | meter | | |

SAMPLE

**Figure B-3. Munter route table, example (completed)**

B-27. Calculate travel time from point X to point Y:

- Determine units—there is a 500-meters elevation gain (5 units) and a travel distance of 3.5 (3.5 units). Therefore, the total units for this leg are 8.5. Record in appropriate box in chart.
- Determine raw travel time—8.5 units are then multiplied by 60 minutes, yielding 510 minutes.
- Determine adjusted travel time—this movement involves significant ascent, and the method of travel is walking. Therefore, a modifier of 4 is used.

***Note***. This example assumes the movement is in unrestrictive terrain.

- The raw travel time (510 minutes) is then divided by the modifier (4) to yield an actual projected leg time of 127.5 minutes (or 2 hours and 8 minutes). Record in appropriate box in chart.
- Determine approximate point arrival time—add the actual projected leg time (2 hours and 8 minutes) to the start time for the leg. Record in appropriate box in chart.

B-28. Calculate travel time from point Y to point Z:

- Determine units—there are 600 meters of elevation loss (6 units) and a travel distance of 4 kilometers (4 units). Therefore, the total units for this leg are 10. Record in appropriate box in chart.
- Determine raw travel time—10 units are then multiplied by 60 minutes, yielding 600 minutes.
- Determine adjusted travel time—this movement involves a significant descent; the method of travel is walking. Therefore, a modifier of 6 is used.

***Note***. This example assumes the movement is in unrestrictive terrain.

- The raw travel time (600 minutes) is then divided by the modifier (6) to yield an actual projected leg time of 100 minutes (or 1 hour and 40 minutes). Record in appropriate box in chart.
- Determine approximate point arrival time—add the actual projected leg time (1 hour and 40 minutes) to the start time for the leg. Record in appropriate box in chart.

# NORTHERN WARFARE TRAINING CENTER METHOD

B-29. This technique was developed specifically for military mountaineers:

- 4 kilometers per hour flat terrain. 2 to 3 for elevation.
- 1 hour per 300 meters (1,000 feet) elevation gain.
- 1 hour per 400 to 600 meters (1,600 feet) elevation loss.
- + 10 minutes per kilometer for every 20 pounds over 50 pounds.

## Appendix C

# Technical Equipment

## SECTION I – SAFETY STANDARDS

C-1. The UIAA Safety Commission develops and maintains safety standards for mountaineering equipment. They are an independent safety commission recognized by 60 manufacturers and certify over 1,800 mountaineering products sold worldwide. Manufacturers must meet the standards set forth by the UIAA to be certified.

## SECTION II – ARMY MOUNTAINEERING KITS AND THEIR NATIONAL STOCK NUMBER LISTS

C-2. There are currently three specialized mountaineering kits available in the Army inventory. They are the HAMK, ACTK, and SIMK. Individual components and quantities in these kits continue to change, as they are developed to fit the needs of the Army.

## HIGH-ANGLE MOUNTAINEERING KIT

C-3. The HAMK is the Army's general-purpose mountaineering kit. It is designed to outfit a platoon with the equipment necessary to negotiate up to 3rd-class terrain with some level 1 trained Soldiers acting as trainers and leaders. This kit can enable a platoon to negotiate 4th-class terrain if used in conjunction with the ACTK and level 2 trained Soldiers establishing rope systems and acting as trainers and leaders. Table C-1 lists HAMK components, and tables C-2 and C-3, page 394, contain product and national stock number information for HAMKs.

**Table C-1. High-angle mountaineering kit components**

| *Item* | *Quantity* |
|---|---|
| Mountaineering harness | 40 |
| Locking carabiner | 80 |
| Nonlocking carabiner | 80 |
| Belay device | 40 |
| Sewn webbing (24-inch) | 80 |
| 7-mm cord, 200-meter spool | 1 |
| 10-mm static rope, 200-meter spool | 1 |
| Rope washer | 1 |
| Rope cutter | 1 |
| Visual users guide (pamphlet) | 40 |
| **Legend**: mm–millimeter | |

**Table C-2. High-angle mountaineering kit product information**

| *NSN* | *Product Name* | *Product Description* |
|---|---|---|
| 8465-00-NSH-0148 | Army Mountain Kit (AMK)–High-Angle Mountaineering Kit (HAMK) Module | AMK–HAMK 1 of 3 modules |
| **Legend**: NSN–national stock number | | |

**Table C-3. High-angle mountaineering kit national stock number list**

| *Kit NSN* | *Kit Name* | *Item NSN* | *Item Name* | *Type* | *Size or Class* |
|---|---|---|---|---|---|
| 8465-00-NSH-0198 | HAMK-Single Pack | 8465-01-578-8910 | Harness, Mountaineering | I* | – |
| | | 8465-01-578-8898 | Carabiner | H | -1 |
| | | 8465-01-578-8906 | Carabiner | X* | – |
| | | 8465-01-578-7850 | Belay Device, Mountaineering | – | – |
| | | 8305-01-578-8909 | Webbing, Mountaineering | I* | I |
| | | | Visual User's Guide, HAMK | – | – |
| 8465-00-NSH-0205 | Belay Device, Mountaineering Replacement Kit | 8465-01-578-7850 | Belay Device, Mountaineering | – | – |
| 8465-00-NSH-0206 | Carabine Type H(1) Replacement Kit | 8465-01-578-8898 | Carabiner | H(1) | – |
| 8465-00-NSH-0207 | Carabiner Type X Replacement Kit | 8465-01-578-8906 | Carabiner | X* | – |
| 8465-00-NSH-0208 | Harness, Mountaineering Replacement Kit | 8465-01-578-8910 | Harness, Mountaineering | I* | – |
| 8305-00-NSH-0002 | Webbing, Mountaineering Replacement Kit | 8305-01-578-8909 | Webbing, Mountaineering | I* | III |
| 4020-00-NSH-0013 | Rope Replacement Kit (HAMK) | 4020-01-577-8714 | Rope, Kernmantle | IV* | I |
| | | 4020-01-577-8686 | Rope, Kernmantle | IV* | I |
| 4940-00-NSH-0000 | Rope Maintenance Kit | 4940-01-582-8347 | Rope, Cutter, Electric | – | – |
| | | 4940-01-582-5658 | Washer, Rope | – | – |
| 7610-00-NSH-0007 | Visual User's Guide, HAMK (Set of 10) | | Visual User's Guide, HAMK | – | – |
| ***Note***. Asterisks beside type numbers (for example, I, X) correspond to supply codes and differ from size or class numbers. The legend explains the type (supply) codes. | | | | | |
| **Legend**: HAMK–high-angle mountaineering kit; I–subsistence, rations; IV–construction materials, lumber, sandbands; NSN–national stock number; X–nonmilitary items, landscaping | | | | | |

# ASSAULT CLIMBER TEAM KIT

C-4. The ACTK is used by level 2-trained Soldiers who are capable of lead climbing. It can be used in all classes of terrain. It is designed to support a three-Soldier assault climber team. Table C-4 lists ACTK components, and tables C-5 and C-6, contain product and national stock number information for ACTKs.

**Table C-4. Assault climbing team kit components**

| *Item* | *Quantity* |
|---|---|
| Mountaineering harness | 3 |
| Locking carabiner | 9 |
| Nonlocking carabiner | 30 |
| Belay device | 3 |
| Sewn webbing (24-inch) | 20 |
| 7-mm cord, 200-meter spool | 1 |
| 9-mm dynamic rope, 60-meter pre-cut | 2 |
| Rope washer | 1 |
| Rope cutter | 1 |
| Set, spring-loaded camming devices | 1 |
| Nut tool | 3 |
| Trigger repair kit for cams | 6 |
| Assault climber bags | 3 |
| Set, chock anchors | 1 |
| Mechanical ascender | 3 |
| **Legend**: mm–millimeter | |

**Table C-5. Assault climbing team kit product information**

| *NSN* | *Product Name* | *Product Description* |
|---|---|---|
| 8465-00-NSH-0149 | Army Mountain Kit (AMK)–Assault Climber Team Kit (ACTK) Module | AMK–ACTK 1 of 3 modules |
| **Legend**: NSN–national stock number | | |

**Table C-6. Assault climbing team kit national stock number list**

| *Kit NSN* | *Kit Name* | *Item NSN* | *Item Name* | *Type* | *Size or Class* |
|---|---|---|---|---|---|
| 8465-00-NSH-0201 | Anchor, Rock, Chock, Replacement Kit | 8465-01-578-6458 | Anchor, Rock, Chock | I* | 1 |
| | | 8465-01-578-6642 | Anchor, Rock, Chock | I* | 2 |
| | | 8465-01-578-6671 | Anchor, Rock, Chock | I* | 3 |
| | | 8465-01-578-6823 | Anchor, Rock, Chock | I* | 4 |
| | | 8465-01-578-6849 | Anchor, Rock, Chock | I* | 5 |
| | | 8465-01-578-6852 | Anchor, Rock, Chock | I* | 6 |

**Table C-6. Assault climbing team kit national stock number list (continued)**

| *Kit NSN* | *Kit Name* | *Item NSN* | *Item Name* | *Type* | *Size or Class* |
|---|---|---|---|---|---|
| 8465-00-NSH-0201 | Anchor, Rock, Chock, Replacement Kit | 8465-01-578-6859 | Anchor, Rock, Chock | I* | 7 |
| | | 8465-01-578-7082 | Anchor, Rock, Chock | I* | 8 |
| | | 8465-01-578-7089 | Anchor, Rock, Chock | I* | 9 |
| | | 8465-01-578-7162 | Anchor, Rock, Chock | I* | 10 |
| | | 8465-01-578-7310 | Anchor, Rock, Chock | I* | 11 |
| | | 8465-01-578-7347 | Anchor, Rock, Chock | I* | 12 |
| | | 8465-01-578-7490 | Anchor, Rock, Chock | I* | 13 |
| 8465-00-NSH-0202 | Anchor, Rock, Camming Device, Type I Replacement Kit | – | Anchor, Rock, Camming Device | I* | 3 |
| | | | Anchor, Rock, Camming Device | I* | 4 |
| | | | Anchor, Rock, Camming Device | I* | 5 |
| | | | Anchor, Rock, Camming Device | I* | 6 |
| | | | Anchor, Rock, Camming Device | I* | 7 |
| 8465-00-NSH-0203 | Anchor, Rock, Camming Device, Type II Replacement Kit | – | Anchor, Rock, Camming Device | II* | 00 |
| | | | Anchor, Rock, Camming Device | II* | 0 |
| | | | Anchor, Rock, Camming Device | II* | 1 |
| | | | Anchor, Rock, Camming Device | II* | 2 |
| 8465-00-NSH-0204 | Ascender, Mechanical– Single Pack | 8465-01-579-3239 | Ascender, Mechanical (Left) | I* | – |
| | | 8465-01-579-3245 | Ascender, Mechanical (Right) | II* | – |
| 8465-00-NSH-0215 | Bag, Assault Climber Kit (Set of 3) | 8465-01-578-8828 | Bag, Assault Climber | – | – |
| 8465-00-NSH-0216 | Belay Device, Mountaineering Kit (Set of 3) | 8465-01-578-7850 | Belay Device, Mountaineering | – | – |
| 8465-00-NSH-0217 | Harness, Mountaineering Kit (Set of 3) | 8465-01-578-8910 | Harness, Mountaineering | I* | – |

**Table C-6. Assault climbing team kit national stock number list (continued)**

| *Kit NSN* | *Kit Name* | *Item NSN* | *Item Name* | *Type* | *Size or Class* |
|---|---|---|---|---|---|
| 4020-00-NSH-0008 | Pick, Chock Kit (Set of 3) | 4240-01-582-5611 | Pick, Chock | – | – |
| 4020-00-NSH-0011 | Rope Replacement Kit (ACTK) | 4020-01-577-8686 | Rope, Kernmantle | I* | III |
| | | 4020-01-577-8748 | Rope, Kernmantle | III* | I |
| 7610-00-NSH-0005 | Visual User's Guide, ACTK (Set of 10) | 7610-00-NSH-0003 | Visual User's Guide, ACTK | – | – |
| ***Note.*** Asterisks beside type numbers (for example, I, II) correspond to supply codes and differ from size or class numbers. The legend explains the type (supply) codes. | | | | | |
| **Legend**: ACTK–assault climbing team kit; I–subsistence, rations; II–expendables or durable items; III–petroleum, oils, and lubricants; NSN–national stock number | | | | | |

# SNOW AND ICE MOBILITY KIT

C-5. The SIMK is designed to outfit a platoon with safety and mobility equipment for operations in snow- and ice-covered mountainous terrain. This kit should be used in conjunction with the HAMK and ACTK, if planning to conduct operations above 2nd-class terrain. Table C-7 lists HAMK components, and tables C-8 and C-9, page 398, contain product and national stock number information for HAMKs.

**Table C-7. Snow and ice mobility kit components**

| *Item* | *Quantity* |
|---|---|
| Avalanche Transceiver | 43 |
| Snow Picket Anchor | 8 |
| Avalanche Probe | 20 |
| Snowshoes | 43 |
| Avalanche Shovel | 20 |
| Crampon | 43 |
| Mountaineering Axe | 40 |
| Ice Tool | 3 |
| Ice Screw 16 mm | 10 |
| Ice Screw 19 mm | 10 |
| **Legend**: mm—millimeter | |

**Table C-8. Snow and ice mobility kit product information**

| *NSN* | *Product Name* | *Product Description* |
|---|---|---|
| 8465-00-NSH-0146 | Army Mountain Kit (AMK)–Snow and Ice Mobility Kit (SIMK) Module | AMK–SIMK 1 of 3 modules |
| **Legend**: NSN–national stock number | | |

**Table C-9. Snow and ice mobility kit national stock number list**

| *Kit NSN* | *Kit Name* | *Item NSN* | *Item Name* | *Type* | *Size or Class* |
|---|---|---|---|---|---|
| 8465-00-NSH-0200 | SIMK Mobility Kit – Single Pack | 8465-01-578-7741 | Axe, Ice | I* | III |
| | | 8465-01-578-8908 | Crampon | I* | – |
| | | 8465-01-558-9958 | Snowshow, Assault, Military | – | – |
| | | 8465-01-NSH-0147 | Crampon, Center Strap Extender | – | – |
| | | 7610-00-NSH-0004 | Visual User's Guide, SIMK | – | – |
| 8465-00-NSH-0209 | Anchor, Ice, Screw 16-cm Replacement Kit | 8465-01-578-6433 | Anchor, Ice, Screw | I* | 1 |
| 8465-00-NSH-0210 | Anchor, Ice, Screw 19-cm Replacement Kit | 8465-01-578-6447 | Anchor, Ice, Screw | – | III |
| 8465-00-NSH-0211 | Anchor, Snow Replacement Kit | 8465-01-578-8717 | Anchor, Snow | I* | I |
| 8465-00-NSH-0218 | Anchor, Snow Kit (Set of 4) | 8465-01-578-8717 | Anchor, Snow | I* | I |
| 8465-00-NSH-0220 | Crampon Kit (Set of 2) | 8465-01-578-8908 | Crampon | I* | – |
| 8465-00-NSH-0221 | Crampon, Center Strap Extender Kit (Set of 2) | 8465-00-NSH-0147 | Crampon, Center Strap Extender | – | – |
| 4240-00-NSH-0017 | Shovel, Avalanche with Probe Kit | 4240-01-582-8261 | Shovel, Avalanche | – | – |
| | | 4240-01-582-8278 | Probe | – | – |
| 8465-00-NSH-0222 | Snowshow, Assault, Military Kit (Set of 2) | 8465-01-558-9958 | Snowshow, Assault, Military | – | – |
| 8465-00-NSH-0223 | Transreceiver, Avalanche Kit (Set of 2) | 8465-01-572-3962 | Transreceiver, Avalanche | – | – |
| 7610-00-NSH-0006 | Visual User's Guide, SIMK (Set of 10) | 7610-00-NSH-0004 | Visual User's Guide, SIMK | – | – |
| ***Note***. Asterisks beside type numbers (for example, I, II) correspond to supply codes and differ from size or class numbers. The legend explains the type (supply) codes. | | | | | |
| **Legend**: cm–centimeter; I–subsistence, rations; NSN–national stock number; SIMK–snow and ice mobility kit | | | | | |

# Glossary

The glossary lists acronyms and terms with Army or joint definitions. Where Army and joint definitions differ, (Army) precedes the definition. Terms for which TC 3-97.61 is the proponent are marked with an asterisk (*). The proponent publication for other terms is listed in parentheses after the definition. The majority of terms are defined IAW current common usage across the mountaineering community.

## SECTION I – ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| **°** | degree |
| **ABD** | assisted braking device |
| **ACTK** | assault climbing team kit |
| **AMS** | acute mountain sickness |
| **AR** | Army regulation |
| **ATP** | Army techniques publication |
| **BHK** | big honking knot |
| **C** | Celsius |
| **cam** | camming device |
| **CASEVAC** | casualty evacuation |
| **CE** | European Conformity or Conformité Européene |
| **cm** | centimeter |
| **CPR** | cardio-pulmonary resuscitation |
| **CTA** | Common Table of Allowances |
| **DA** | Department of the Army |
| **DROP** | determine level of mobility, reduce redundant or nonessential equipment, organize resupply, police Soldiers |
| **F** | Fahrenheit |
| **FM** | field manual |
| **GPS** | Global Positioning System |
| **HACE** | high-altitude cerebral edema |
| **HAMK** | high-angle mountaineering kit |
| **HAPE** | high-altitude pulmonary edema |
| **kN** | kilonewton |
| **IAW** | in accordance with |
| **LOC** | line of communication |
| **MA** | mechanical advantage |
| **MEDEVAC** | medical evacuation |
| **METT-TC (I)** | mission, enemy, terrain and weather, troops and support available, time available, civil considerations, and informational considerations |
| **mm** | millimeter |

| | |
|---|---|
| **MMB** | Master Mountaineer Board |
| **MOLLE** | modular lightweight load-carrying equipment |
| **mph** | miles per hour |
| **NCOIC** | noncommissioned officer in charge |
| **OAKOC** | observation and fields of fire, avenues of approach, key terrain, obstacles, and cover and concealment [military aspects of terrain] |
| **OIC** | officer in charge |
| **PFD** | personal flotation device |
| **SIMK** | snow and ice mobility kit |
| **simul-climbing** | simultaneous climbing |
| **SOP** | standard operating procedure |
| **SOSES** | shape, orientation, size, elevation, slope |
| **SSSF** | static system safety factor |
| **TB MED** | technical bulletin (medical) |
| **TC** | training circular |
| **TTP** | tactics, techniques, and procedures |
| **UIAA** | Union des International Alpine Association |
| **U.S.** | United States |
| **USARIEM TN** | U.S. Army Research Institute of Environmental Medicine technical note |
| **UV** | ultraviolet |
| **VB** | vapor barrier |
| **VDA** | vertical danger area |
| **YDS** | Yosemite Decimal System |

## SECTION II – TERMS

***advanced military mountaineer**

A Soldier who has graduated from the Basic Military Mountaineer Course and at least one of the Advanced Military Mountaineer courses. An advanced military mountaineer has been trained in advanced mountaineering techniques and is also known as a level 2 mountaineer.

***aid climbing**

Climbing technique in which standing on or pulling oneself up via devices attached to fixed or placed protection is used to make upward progress.

***assault climber**

A role assigned to a Soldier or team during tactical operations who is responsible for the location and establishment of technical routes in class 3 or higher terrain; ideally, a level 2 mountaineer.

***basic military mountaineer**

A Soldier who graduated from the Basic Military Mountaineer Course. Basic military mountaineers have been trained in basic mountaineering techniques, such as fundamental mobility skills necessary to move safely and efficiently in mountainous terrain, and are also known as level 1 military mountaineers.

***belay**

A system of using a rope as a backup in steep terrain to arrest a Soldier’s fall should one occur.

***bolt**

A type of rock protection or anchoring component comprised of an expansion bolt or glue-in shaft attached to a hanger to which a carabiner can be attached.

***brake strand**

The strand of a rope system that controls the rate at which a load is lowered or a rappeller descends.

**carabiner**

A D-shaped or oval-shaped metal link, with one spring-hinged side, that is used in mountaineering as a connector between soft materials and to capture a freely running rope.

***cold-weather injury**

Any preventable injury resulting from exposure to cold environmental conditions.

***coil**

A secure configuration of rope that allows for easy transport without tangling.

**couloir**

Narrow snow- or ice-filled gully.

**dynamic rope**

Kernmantle rope designed to stretch and absorb force, primarily used to protect climbers from fall injuries.

**fall protection**

Any anchor clipped to a running rope used in belay systems that limits the distance a roped climber falls, should a fall occur.

**friction hitch**

A type of hitch tied with webbing or cordage around a rope that can be moved easily while no force is applied to it but cinches and becomes fixed when tensioned.

**guidebook**

A publication containing detailed climbing routes and approach route information.

**gully**

A channel caused by erosion, especially by water running down a slope; it is generally narrower and steeper than a draw.

**hands-free backup**

A rigging technique, involving friction hitches or mechanical devices that prevent a load from falling should control of a brake strand be lost.

**hauling system**

A technical rope system used to move a load up steep or vertical terrain comprised of rigging that generates increased mechanical advantage and captures progress.

**high-strength tie off**

A single-point anchoring method that retains maximum installation rope strength and releasability, using multiple-round turns around the anchor object to create friction, and securing the end back to itself ensuring no force is applied to any component knots or carabiners.

**installation rope**

The primary load-bearing rope or strand in a rope system.

**kernmantle rope**

A rope constructed with a load-bearing core of twisted synthetic fibers and a protective outer sheath of interwoven synthetic fibers.

**knot**

The fixed portion of a rope that has been manipulated around itself, another object, or both during the process of being tied for some purpose. Sometimes referred to as a "hard knot" since its condition will remain intact until actively untied.

***lead climbing**

Climbing a route while attached to the end of a rope to place devices in rock, ice, or snow for fall protection with a belayer located below.

***lead climber**

The first climber to negotiate a route, for whom a top belay is not possible, and who assumes the most risk of injury in a fall.

***load management**

The act or strategy of planning and packing loads to reduce negative impacts on Soldier physical performance.

***lowering system**

A technical rope system used to move a load down steep or vertical terrain in a controlled fashion using friction hitches or mechanical devices.

***master military mountaineer**

A Soldier extensively trained and experienced with mountaineering techniques who the commander appoints to serve as a subject matter expert. Master military mountaineers are graduates of the Basic Military Mountaineer Course and Advanced Military Mountaineer Course. They possess all the skills of the advanced military mountaineer and have extensive practical experience in a variety of mountain environments in both winter and summer conditions.

***mechanical advantage**

Reduction in the force required to move a load, which comes at the cost of time and distance. Specific rope rigging techniques in mountaineering generate mechanical advantage.

**multipoint anchor**

More than one fixed object joined with technical rigging to form an anchor system capable of suspending the weight or arresting the fall of an attached load.

**natural anchor**

A natural fixed object (such as a tree, rock formation, or ice formation) to which a rope system can be secured, and is of sufficient size, weight, and security to suspend the weight of or arrest the fall of an attached load.

**pitch**

A section of a climb that comprises the distance between two belay stations, which can be up to a standard rope length (60 meters).

**prolonged field care**

The continued delivery of medical care prior to patient movement beyond the holding capability of that role of care. (JP 4-02)

**redundancy (in rigging)**

The condition in which a rope system will not fail as the result of any single component of the system failing.

**safety knot**

A backup knot tied to prevent a primary knot from slipping loose.

**scrambling**

The act of moving over difficult or broken terrain, characterized by using mostly walking techniques but requires some use of the hands for balance or other specific climbing techniques.

**self-equalizing anchor**

A multipoint anchor comprised of adjustable strands from each anchor component to a shared attachment point that allows for maximum load sharing even when direction of pull changes during use.

***simul-climbing**

A belay technique involving two Soldiers climbing simultaneously while attached to the ends of a rope which runs through the fall protection.

**snowpack**

The entire mass of snow covering a given area of terrain.

**static rope**

Kernmantle rope designed for minimal stretch under load, primarily used for hauling, lowering, and anchor systems construction.

***technical route**

A route through steep or broken mountainous terrain that presents significant risk of fall injury and requires special movement techniques or ropes to ensure adequate safety for Soldiers moving through it.

***vertical danger area**

Steep terrain that significantly restricts a unit's ability to maneuver, thereby putting the unit at significant tactical disadvantage should enemy contact be made while moving through the VDA.

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# Index

Entries are by paragraph number.


**3**

3:1 tensioning system. 16-12

**A**

ablation zone. 14-3
accumulation zone. 14-3
adjustment halt, 89
advanced military mountaineer. 2-11, 6-11, 6-37, 6-47, 6-139
aerial resupply. 4-87
aerobic capacity. 4-5
A-frame. 16-29
aid climbing. 10-19
altimeters. 7-11, 7-30
anabatic winds. 1-63
anaerobic capacity. 4-6
anchors
  ice. 9-71
  multipoint, 201
  multi-point. 9-72
  pre-equalized. 9-16
  rock. 9-24
  self-equalizing. 9-15
  single-point, 197
  snow. 9-101
  top rope. 10-55
  tree. 9-18
artificial rock protection. 9-27
ascending techniques (rope), 283, 11-38, 11-137
atmospheric pressure. 1-55
avalanche
  equipment. 5-46
  problems. 5-30
  search and rescue, 77, 5-40

**B**

backpacks. 6-17
  MOLLE. 6-46
back-stacking. 8-143
balance. 6-3, 6-53
base layers. 4-34
basic military mountaineer. 2-8
belay
  alpine. 10-118
  climber, second. 10-99
  crevasse rescue. 14-62
  device. 10-63, 10-102
  guide mode. 10-103, 10-124
  lead climber. 10-84
  rescue, 372, 15-39, 15-60
  stream crossing. 13-26
  tandem prusik. 15-61
  terrain. 10-121
  top rope. 10-64
bivouac. 4-90
bollard. 9-104
bolts. 9-40
  definition. 9-39
boulders. 1-20
butterfly coil. 8-136

**C**

camming devices. 9-55
carabiner. 8-13
CASEVAC. 15-4, 15-6
chimney climbing technique. 6-77
class terrains. 1-46
couloir. 1-8
crevasse rescue, 350, 14-12

**D**

dynamic rope. 8-7

**E**

EARNEST-H. 9-17

**F**

fair weather cumulus. 1-76
fall protection. 2-24
field expedient harness. 8-124

**G**

glacier features. 14-7
gully. 1-8

**H**

hands-free backup. 11-115
hauling system. 12-1
hauling systems
  1 1 simple. 12-10
  2 1 simple. 12-10
  3 1 simple. 12-10
  5 1 complex, 313
  5 1 simple. 12-10
  6 1 compound. 12-11
  7 1 complex. 12-12
  9 1 compound. 12-11
hauling systems, simple, 2 1. 14-66
high-strength tie off. 9-21

**I**

installation rope. 8-91

**K**

kernmantle rope. 8-3, 8-5
knot
  definition. 8-30
knots
  alpine butterfly. 8-60
  autoblock. 8-95
  bends. 8-32
  big honking (BHK). 8-121
  bowline. 8-78
  bowline on a bight. 8-84
  clove hitch. 8-104
  directional figure-eight knot. 8-57
  double fisherman's. 8-72
  figure eight on a bight. 8-48
  figure-eight bend. 8-63
  figure-eight slip. 8-45
  flat overhand. 8-69
  garda hitch aka ratchet, alpine clutch. 8-118
  girth hitch. 8-87
  hitches. 8-33
    friction. 8-34
      Bachmann. 8-101
      klemheist. 8-98
  inline figure eight. 8-44
  loop, 159
  mule. 8-115
  Munter hitch. 8-109
  overhand safety. 8-43
  prusik. 8-90
  rerouted figure-eight. 8-51
  safety knot
    definition. 8-27

Entries are by paragraph number.


square knot. 8-75
super Munter hitch. 8-112
triple bowline. 8-81
two-loop figure eight. 8-54

**M**

mixed climbing. 6-161

**N**

natural anchor. 9-26

**P**

pitch. 10-16

**R**

redundancy (in rigging). 16-13
rope climbing team. 2-8
rope drag. 10-91
rope rescue systems. 15-51

**S**

scrambling. 6-33
simul-climbing. 7-63
smearing. 6-60
snow
bridges. 14-49
types of. 1-24
snowpack
definition, 7
static rope. 8-5

**W**

water contaminants. 4-76
water purification. 4-81

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**26 November 2025**

By Order of the Secretary of the Army:

**RANDY A. GEORGE**
*General, United States Army*
*Chief of Staff*

Official:



**MATTHEW L. SANNITO**
*Administrative Assistant*
*to the Secretary of the Army*
2532801

**DISTRIBUTION:**
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PIN:102540-000