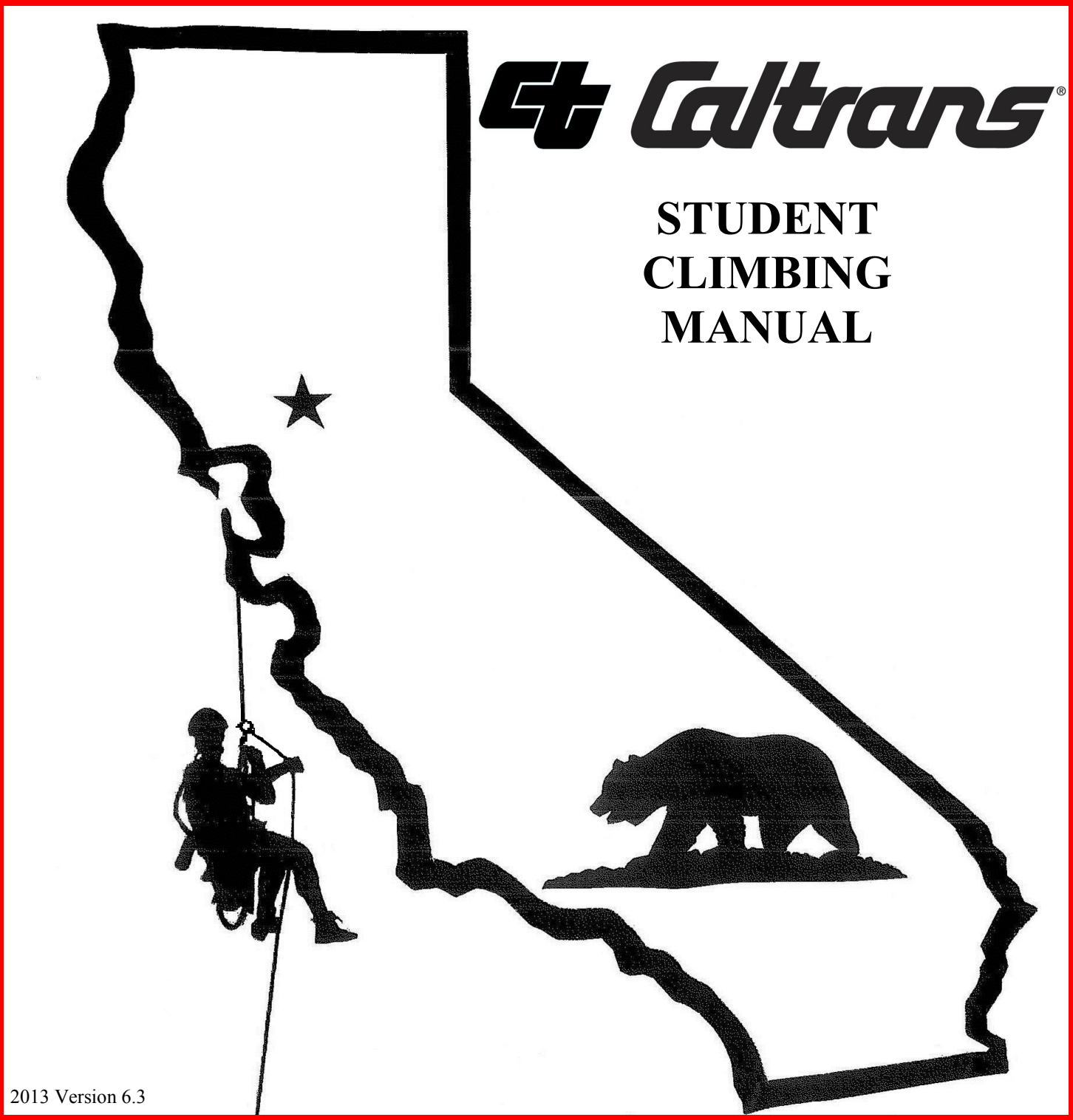
CALTRANS
BANK SCALING & ROCK CLIMBING



STUDENT CLIMBING MANUAL

2013 Version 6.3

IN MEMORY

OF OUR

FALLEN FRIENDS

IN

CLIMBING

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Table of Contents

Chapter 1

Introduction

This handbook is designed as a companion to the Caltrans Bank Scaling and Rock Climbing Training Course. Its purpose is to help climbers understand what is involved in bank scaling operations, as well as the gear and equipment necessary to do the work.

Throughout this handbook, reference is made to "climbers." A climber is any personnel assigned to perform rope work. Bank scalers, when required to work on rope, are climbers. Lookouts, when required to work on rope, are climbers. No matter what your classification is, if you are working on rope for Caltrans, you are considered a climber. All Caltrans climbers are volunteers.

Experienced climbers are a valued asset for the Department. Many agencies require that climbers have a minimum number of hours on rope, or years of experience, to work as a bank scaler. Keeping a personal climbing log helps to document your experience. As such, it is important to keep track of the number of hours you spend working on rope. In the Appendix of this manual, there is a Personal Climbing Log form to help keep track of your climbing hours.

Working on rope has its inherent dangers. It is important to always keep safety in mind as you work on rope. Safety starts with preparation. Just approaching a slope where there are unstable rocks means you have to be aware of your surroundings and the dangers they might pose. Considering this, a climber should be aware of the conditions and environment where they will be climbing. Also included in this manual is a Scaling Slope Assessment form. Each climber in a scaling operation needs to be familiar with the Assessment for the specific site they will be scaling. This will help to prepare you for your climb.

Classroom Topics

- **Introductions**
  - **Name**
  - **Department**
  - **Climbing experience**
- **Classroom**
  - **The safe approach to climbing and the different applications.**
  - **Code of Safe Operating Practices.**
  - **Cal-OSHA safety regulations.**
  - **Specifications for rockfall mitigation.**
  - **Personal Climbing Log**
  - **Climbing gear.**
  - **Rope safety.**
  - **Knots for rope, webbing, and accessory line.**
  - **Site evaluation.**
  - **Anchor systems and backups.**
  - **Wrap up.**
- **Field exercises.**
  - **Locations and access.**
  - **Anchor systems.**
  - **Buddy system.**
  - **Belay station.**
  - **Terminology.**
  - **Check off list.**
  - **Potential Hazards.**
  - **Emergencies.**
  - **Travelling to sites.**
  - **Different exercises.**

The Instructors

1	Darin Sullivan
1	Dennis Vizgaudis
HQ/01	Charlie Narwold
2	Salvador Torres, Jr.
2	Ryan Gomes
2	Eric Cummings
3	Mark Peters
3	Art Payne
HQ/04	Matt Gaffney
HQ/04	Ron Karpowicz
HQ/04	Wendy Conway
HQ/04	Tom Whitman
5	Steve Balaban
5	Zeke Dellamas
5	Billy Leu
5	Robert Nava
5	Jason Kline
HQ/05	John Duffy
HQ/05	Ryan Turner
HQ/05	Jeff Scardine
6	Mark Peton
7	Mark Johnson
9	James Patterson
9	Cody Collins
10	Eric Jakab
HQ/11	Brian Hinman
HQ/11	Richard Rusnak
HQ	Luis Sepulveda
HQ	Bill Webster

Scaling- Not Just a Random Act of Engineering

By definition scaling is the removal of marginally stable or unstable rocks from the face of a rock slope. It sounds simple enough. Rock Climbers call it trundling, kids call it playing, and the Swiss, as every Swiss school child learns, used it as a weapon to generate steinschlage or rockfall, to ward off invaders. Most recently the Allied forces in Afghanistan strategically targeted projectiles into loose rock outcrops to cause large rock falls onto selected targets. Caltrans geologists direct scaling operations to protect people and facilities from falling rocks. Maybe it's not so simple after all. Well, in fact, it isn't.

When is scaling appropriate? How is it done and by whom? Scaling is not "a random act of engineering" but is an organized, deliberate discipline founded on geologic and engineering principles and is a technique used throughout the world.

First and foremost is when to scale? Many older slopes throughout California are aging. In each instance, the aging process, often accelerated by winter storms and earthquakes, eventually weakens the surface of the slopes resulting in loose blocks of rock on the slope face. In time, just as with structures, the slope surfaces need maintenance. While a variety of maintenance options and repair designs are available to mitigate rockfalls, rock patrols and rock scaling are typically the first line of defense. With over 3000 miles of roadway in California having slopes with rockfall potential maintaining them is a challenging endeavor.

Every slope is different and is distinguished by its size, character, and properties. Assessing these characteristics falls into the responsibility of engineering geologists and maintenance personnel.

Engineering Geologists and Maintenance Evaluating a Slope

Maintenance forces know the slopes in their areas and understand each slopes behavior such as rockfall frequency, rockfall sizes, and when the rocks are falling. This information is invaluable to engineering geologists who study the rock properties, structure, and slope geometry as they relate to rockfall behavior. Together, rockfall characteristics are evaluated and the decision when to scale or not to scale is determined by answering the questions; is it to dangerous to scale? will the scaling operations cause more problems? or is it worth scaling?

Who does the scaling? In the 1860's during the great railroad project connecting Sacramento to Omaha, Chinese and Irish laborers moved loose rocks as the cuts were excavated and didn't look back. During the great dam projects of the early 1920's workers hung onto ropes with their bare hands or were slung in a crudely fashioned seat similar to a swing seat.

Caltrans Bank Scaling and Rock Climbing Training

1930's Climbing Techniques

Following World War II with the introduction of mountaineering techniques from Europe, climbers started looking towards much safer techniques for accessing the slopes. At first this technology, although sturdy, was heavy and limited movement on the slope. Today many improvements have been made for industrial climbing, recreational climbing and rescue climbing. But nothing in particular was developed for people working on rock cut slopes with loose rocks. It's no wonder because most people do not want to venture there.

Faced with this void Caltrans Engineering Geologists, in the mid 1980's, working with maintenance began developing a structured program for scaling slopes. Initially recreational climbing tools were used to access the slopes for reconnaissance, mapping, and design purposes. While on the slopes loose rocks were removed as part of the investigation and quickly it was realized that these climbing techniques enhanced mobility and safety on the slope and suited more comprehensive scaling operations.

Preparing for a Scaling Operation

Engineering geologists, in the early 1990's, workings closely with Caltrans rock and avalanche blasters began developing a class to train workers in scaling and teach the skills needed to access the slopes with ropes. First a maintenance code of safe operating practices was developed entitled "Bank Scaling and Rock Climbing." In conjunction with this an 8-hour class was developed and taught at the old META facility at Camp San Luis Obispo. Since those early classes many changes have occurred and today the class is 16-hours and taught at the Kingvale Maintenance Academy. A manual and supporting video have been developed and there are over 20 volunteer trained instructors.

Kingvale Maintenance Facility

Scaling teams and other trained personnel currently exist in all Districts. In addition to slope maintenance activities other disciplines are benefiting from this training including construction, surveys, geotechnical, hydraulics, storm water teams, and environmental.

Caltrans Bank Scaling and Rock Climbing Training

Rock Scaling

Caltrans scaling training program is the only one of its kind and Caltrans regularly receives inquires from across the US and abroad. Caltrans scaling teams have been featured in the National Geographic special "Landslides" and the Learning Channel Special "Disaster Detectives." It is truly a unique program enabling Caltrans to employ best management practices. Climb on!

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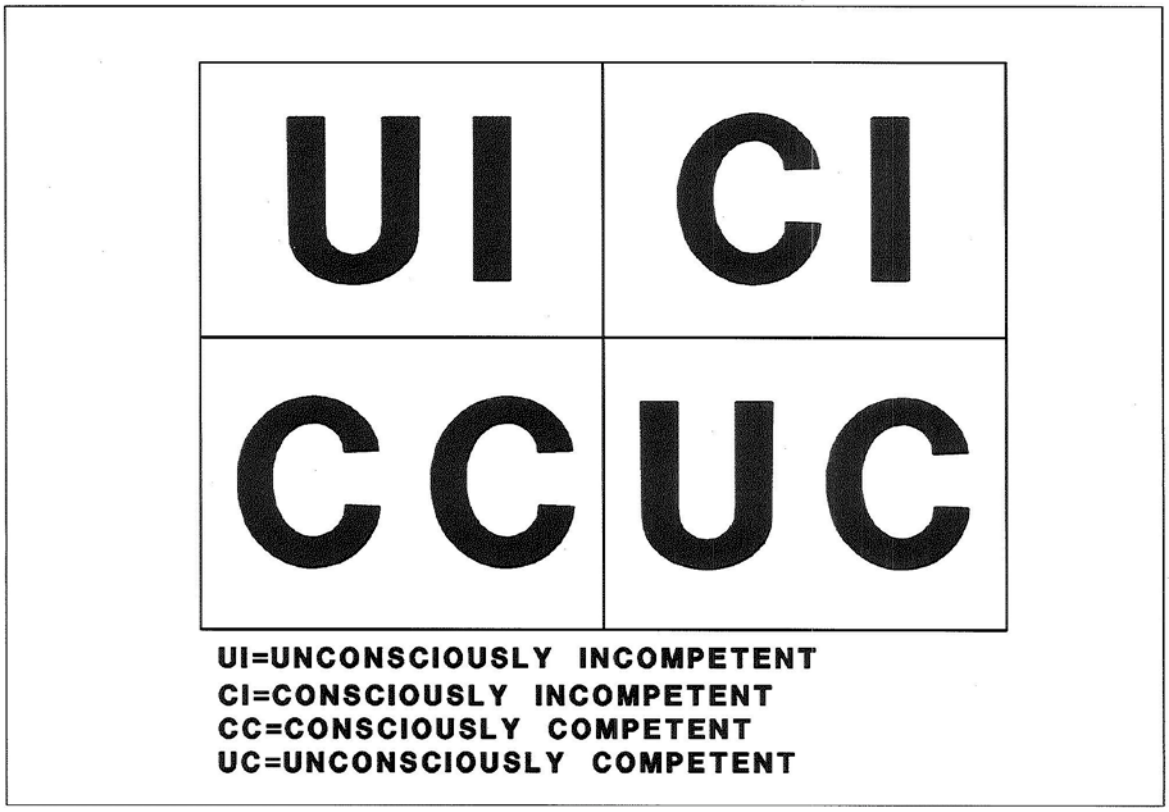
Chapter 2

Safety Procedures



BANK SCALING AND ROCK-CLIMBING PREPARATIONS

Before starting a scaling operation, take all precautions to protect the property, the traveling public and employees from injury or accidents.

1. Park where you can safely enter and exit the vehicle without creating a hazard for yourself or others.
2. Review the protection procedures and traffic control requirements for the work area.
3. Discuss specific site conditions and the SCALING ASSESSMENT FORM.
4. Discuss work procedures and assignments during pre-job briefing.
5. Discuss the General Safety Conditions outlined in the SCALING OPERATIONS - SITE RECON MEETING CHECKLIST.
6. Locate all utilities before starting operation.

A **qualified person** is a person who because of experience or instruction is familiar with the operation to be performed and the hazards involved.

A qualified Caltrans person directs the operation and has the authority to relieve any person for noncompliance of these orders.

Refer to the Caltrans Maintenance Manual, Volume 1, 2006, Chapter X - Scaling; and the Caltrans Safety Manual, Chapter 21 - Cut Slope Safety.

LOOKOUTS

Use lookouts to watch the face of the slope and to give warning when loose rock or other material starts to fall.

Place lookouts carefully to reduce their exposure to falling material, operating equipment and moving traffic. The number and placement of lookouts is at the discretion of the qualified person who is directing the operation.

- **Lookouts at the top of the slope shall attach a safety line and properly tie in.**
- **Lookouts review and change pre-planned escape routes as necessary.**
- **Lookouts have the authority to clear the area or stop work at any time.**
- **Rotate lookouts periodically to avoid lowered levels of alertness.**

Communication

Lookouts shall have adequate communications with climbers and equipment operators at all times.

If voice communications are used, an alternate alarm system shall be provided. (hand held air horn, etc.)

Should communications not work properly, the lookout shall stop the operations until the situation is corrected.

ROPE WORK

Personnel assigned to perform rope work shall be trained and outfitted with approved climbing gear in accordance with the safety commission, Union International des Association (U.I.A.A.). All safety belts, harnesses, lanyards, climbing ropes, lifelines, drop lines and carabiners shall meet or exceed ANSI A10.14-1975 standards.

- All rope work shall be performed on a voluntary basis.
- Review safe practice rules for equipment and pre-op equipment
- Use required personal protective equipment.
- All climbing gear shall be inspected daily, both prior and after use.
- Ropes used for bank scaling shall be a kernmantle static type approved rope for mountaineering.
- Ropes shall have 5400 pounds minimum tensile strength.
- A climber shall maintain two points of contact to the climbing rope during all climbing operations.
- All climbing ropes should have at a minimum a figure eight knot tied to in the end of the climbing rope.
- Rope ends shall be either braided or melted to prevent unraveling.
- Do not use climbing ropes for any purpose except climbing operations.
- Only approved mountaineering knots shall be used.
- Do not splice climbing ropes. Use only approved bends to connect ropes.
- Ropes made unsafe by damage or by any other reason shall be marked and not be used for climbing.
- Store ropes used for climbing away from cutting edges, sharp tools, corrosives, chemicals, or gas.
- Carabiner - All carabiners under impact loads shall withstand a minimum 5000-pound tensile test without fail. Refer to ANSI A10.14-1975.
- Carabiners shall never be oiled.
- Locking carabiners, or two opposite and opposed non-locking carabiners, shall be used at all connections between the climber and the anchor.

CLIMBING ON ROCKFALL PROTECTION SYSTEMS

(This page is under development)

CODE OF SAFE OPERATING PRACTICES

ROCK SCALING

Personnel assigned to scale slopes shall be trained and outfitted with approved climbing gear in accordance with the safety commission, Union International des Association (U.I.A.A.). All safety belts, harnesses, lanyards, climbing ropes, lifelines, drop lines and carabiners shall meet or exceed ANSI A10.14-1975 standards.

HAZARD REVIEW

OVERHEAD FALLING/SLIDING MATERIAL
ROCK AND DEBRIS ON THE ROADWAY
MOVING EQUIPMENT
MOVING TRAFFIC
WORKERS ON FOOT
SLIPPING AND TRIPPING HAZARDS
POOR VISIBILITY

SAFE OPERATING PROCEDURES

1. Pre-op equipment and review safe practice rules for applicable equipment.
2. Review work area protection procedures and any traffic control requirements.
3. Park in an area suitable for safe entering and exiting of vehicle and which does not cause a hazard to yourself and others.
4. While on foot make every effort to perform your work facing oncoming traffic.
5. Use required personal protective equipment.
6. Before starting any scaling operation, daily pre-job briefing, work procedures and assignments shall be discussed.
7. Location of all utilities shall be known before starting operations.
8. Before work is started a qualified person must evaluate what hazards are apparent and the scope of the work involved. This evaluation should include an examination of the area and adjacent areas for ground cracks and excessive water flows as well as loose boulders, trees and other debris on slopes.
   a. A qualified person is a person who by reason of experience or instruction is familiar with the operation to be performed and the hazards involved. Refer to Departmental Safety Manual, Section 5-20.
   b. A qualified Caltrans person will direct the operation, and have the authority to relieve any person for noncompliance of these orders.
9. Before starting any scaling operation all precautions shall be taken to protect property, traveling public and employees from injury or accidents.
10. Keep work area clear and be aware of surroundings. Danger areas shall be posted with signs and barriers.
11. Personnel assigned to scale slopes shall be trained and outfitted with approved climbing gear in accordance with the safety commission, (Union International des Association). All U.I.A.A. equipment shall meet or exceed ANSI A10.14-1975 standards for safety belts, harnesses, lanyards, lifelines and drop lines.
12. All climbing gear shall be inspected daily, both prior and after use.
13. Before climbing operations begin there shall be on site at least one trained aerial rescue climber on standby.

14. A lookout shall be used to continually watch the face of the slope and give warning when loose rock or other material starts to fall.

    a. Lookouts have the authority to clear the area or stop work at any time.

    b. The number and placement of lookouts is at the discretion of the qualified person who is directing the operation. Lookouts should be carefully placed to reduce their exposure to falling material, operating equipment and moving traffic.

    c. Lookouts shall have adequate communications with climbers and equipment operators at all times. When using voice communication devises with optional voice activated and push to talk modes, the lookout shall use the voice-actuated mode and equipment operators shall use the push to talk mode. If voice communications are used, an alternate alarm system shall be provided, e.g., hand held air horn, etc. Should communication not work properly, the lookout shall stop the operation until the situation is corrected.

    d. Lookouts shall have pre-planned escape routes which will be reviewed and changed as necessary.

    e. Lookouts should be changed periodically to avoid lowered levels of alertness.

    f. All lookouts at the top of the slope should have a safety line attached to themselves and be properly tied in.
15. Carabiners shall never be oiled. Keep carabiners out of dust and grit. All carabiners shall be equipped with self closing gate opening and should be equipped with a screw-locking device.
16. Double carabiners, opposite opposed, shall be used on all tie ends.
17. All climbing ropes shall meet or exceed ANSI A10.14-1975 standards (drop lines shall have 5400 pounds minimum tensile strength).
18. Ends of all ropes shall be either braided or melted to prevent unraveling. Ropes shall be a multi-strand synthetic type approved rope for mountaineering.
19. Only approved mountaineering knots shall be used. Figure of eight knots should be used on all tie ends and all knots shall be safeguarded be two overhand knots.
20. Climbing ropes shall not be used for any other purpose except climbing operations.
21. Climbing ropes shall not be spliced. Also, a figure of eight knot should be used on all tie ends and all knots shall be safeguarded by two overhand knots.
22. Ropes used for climbing shall be stored away from cutting edges, sharp tools. corrosives, chemicals, gas and oils.
23. Ropes used for climbing shall be coiled or suspended so that air can circulate through the coils during storage. Ropes made unsafe by damage or any other reason shall not be used for climbing.
24. Belay lines should be used during all climbing operations.
25. A warning shall be given by persons on the slope before rocks are released. "ROCKS" or "HEADS UP" are common terms for this purpose.

Note: Carabiners - All carabiners (D rings & snap hooks) under impact loads shall be of drop-forged steel with corrosion-resistant finish. They shall withstand 5000-pound (1.5 tonne) tensile test, with out fail. Snap hooks used for positioning only may be of steel rolled stock with a corrosion-resistant finish. Such hooks shall be capable of withstanding a tensile strength of 1500 pounds (0.6 tonne) with a maximum permanent deformation of 1/64th inch (0.3millimeters). Refer to ANSI A10.14-1975.

Reprinted from Division of Maintenance Code of Safe Operating Practices - Section II

Cal-OSHA – Climbing on Slopes

Title 8, Sub Chapter 4 , Article 24 is the governing safety order.
Subchapter 4. Construction Safety Orders
Article 24. Fall Protection
http://www.dir.ca.gov/Title8/sub4.html

§1671.1. Fall Protection Plan.

(a)This section applies to all construction operations when it can be shown that the use of conventional fall protection is impractical or creates a greater hazard.

(1)The fall protection plan shall be prepared by a qualified person and developed specifically for the site where the construction work is being performed and the plan must be maintained up to date. The plan shall document the identity of the qualified person.

NOTE: The employer need only develop a single site fall protection plan for sites where the construction operations are essentially identical.

(2)Any changes to the fall protection plan shall be approved by a qualified person. The identity of the qualified person shall be documented.

(3)A copy of the fall protection plan with all approved changes shall be maintained at the job site.

(4)The implementation of the fall protection plan shall be under the supervision of a competent person. The plan shall document the identity of the competent person.

(5)The fall protection plan shall document the reasons why the use of conventional fall protection systems (guardrails, personal fall arrest systems, or safety nets) are infeasible or why their use would create a greater hazard.

(6)The fall protection plan shall include a written discussion of other measures that will be taken to reduce or eliminate the fall hazard for workers who cannot be provided with protection provided by conventional fall protection systems. For example, the employer shall discuss the extent to which scaffolds, ladders, or vehicle mounted work platforms can be used to provide a safer working surface and thereby reduce the hazard of falling.

(7)The fall protection plan shall identify each location where conventional fall protection methods cannot be used. These locations shall then be classified as controlled access zones and the employer must comply with the criteria in Section 1671.2(a).

(8)Where no other alternative measure (i.e. scaffolds, ladders, vehicle mounted work platforms, etc.) has been implemented, the employer shall implement a safety monitoring system in conformance with Section 1671.2(b).

(9)The fall protection plan must include a statement which provides the name or other method of identification for each employee (i.e., job title) who is designated to work in controlled access zones. No other employees may enter controlled access zones.

STATE OF CALIFORNIA • DEPARTMENT OF TRANSPORTATION

SAFETY MEETING REPORT

PM-S-0110 (REV. 05/2009)

ACTION AND DISTRIBUTION:

- ☐ 1. First-line supervisor conducts meeting, completes, and sign form.
- ☐ 2. First-line supervisor retains and posts one copy.
- ☐ 3. First-line supervisor sends original to second-line supervisor for review.
- ☐ 4. Second-line supervisor reviews, signs original, and returns to first-line supervisor to file.
- ☐ 5. Additional routing to:

Note: See Chapter 2, Safety Meetings, in the Caltrans Safety Manual for details.

DATE	OFFICE / CREW / PROJECT NAME	COST CENTER / PROJECT NUMBER

PRINT NAME OF EMPLOYEES (Add additional sheets if required)

SAFETY TOPICS DISCUSSED

SAFETY SUGGESTIONS/COMMENTS

SUPERVISOR'S COMMENTS

FIRST-LINE SUPERVISOR SIGNATURE	DATE	SECOND-LINE SUPERVISOR SIGNATURE	DATE

SUGGESTED TOPICS FOR DISCUSSION

- ☐ Safe work habits
- ☐ Safe work conditions
- ☐ Codes of Safe Operating/Work Practice
- ☐ First aid treatment
- ☐ Maintenance, Chapter 8
- ☐ Traffic control/flagging
- ☐ Slip/trip/fall hazards
- ☐ Protective vehicles
- ☐ Respirator safety
- ☐ Confined spaces
- ☐ Hard hats
- ☐ Safety glasses
- ☐ Safety vest
- ☐ Body protection
- ☐ Foot protection

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SUMMARY

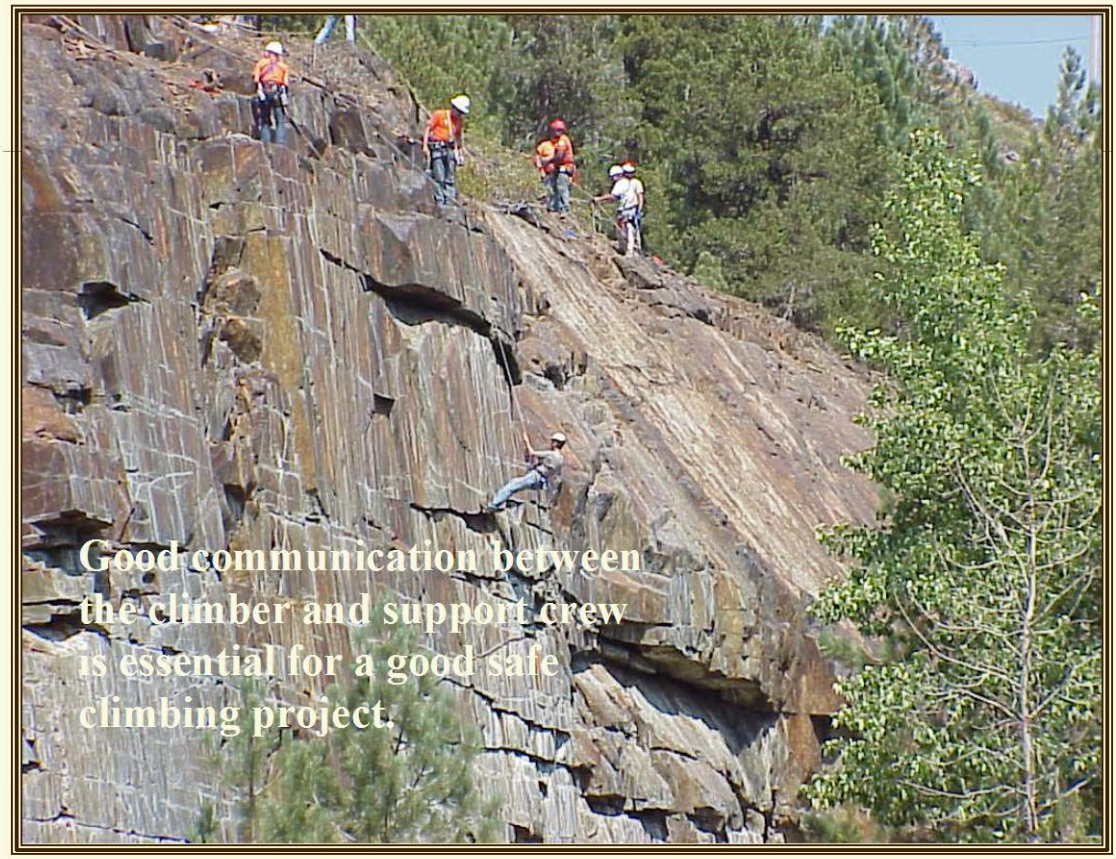
- **Preparation is key to safety**
- **Lookouts must be able to see the entire work area, and give warning when necessary**
- **Working on Rope requires specialized equipment and the training to use the equipment**
- **Follow Code of safe operating practices- Rock Scaling**
- **BE SAFE!**

REMEMBER!

ALWAYS USE TRAFFIC CONTROL WHEN WORKING ON SLOPES ABOVE THE HIGHWAY

Chapter 3

Site Evaluation



SITE EVALUATION PREPARATION

- **Approach the site with caution.**
- **Analyze the access and departure very carefully.**
- **Always have backup plan of exit.**
- **Never enter a situation that you are unsure of getting out of.**
- **Never descend into a depth that you are not prepared to climb up your rope to get out.**
- **Take note of hazards on the way down and keep an eye on them when they are above you.**
- **Always tell someone when you are going to climb.**

•Never climb alone.

ROPE CONTACT DURING SCALING

- 90 % of the time the slope conditions are such that the rope does not even touch the ground or contact is very limited and edge guards can be easily used to protect the rope.
- In more difficult conditions where there might be frequent rope contact with the ground or conditions are very loose and random rockfalls are possible, climbing on belay should be considered. This consists of the climber being on two ropes. The second rope is either a belay from a partner above the slope or the climber is rappelling with two ropes.
- Finally, some slopes are too unstable to scale and should be avoided.

ROPE CONTACT
DURING SCALING

1) AVOID
2) MITIGATE ┐├ **90%**
3) BELAYED
- **ASSISTED BELAY**
- **TWO ROPES**

4) DON'T SCALE OR CLIMB

SITE EVALUATION

An assessment of slope conditions must be performed before any scaling work begins. A qualified/ competent person shall complete a Slope Scaling Assessment form when first considering the location for scaling. A blank form is included in this chapter. The form will then be sent to a qualified person in the Geotechnical Branch.

The evaluation should include:

- Slope characteristics
- Conditions above the slope
- Roadway characteristics
- Previous rockfall and scaling activity
- Diagram of slope and areas to be scaled
- Photos
- The final Geotech classification

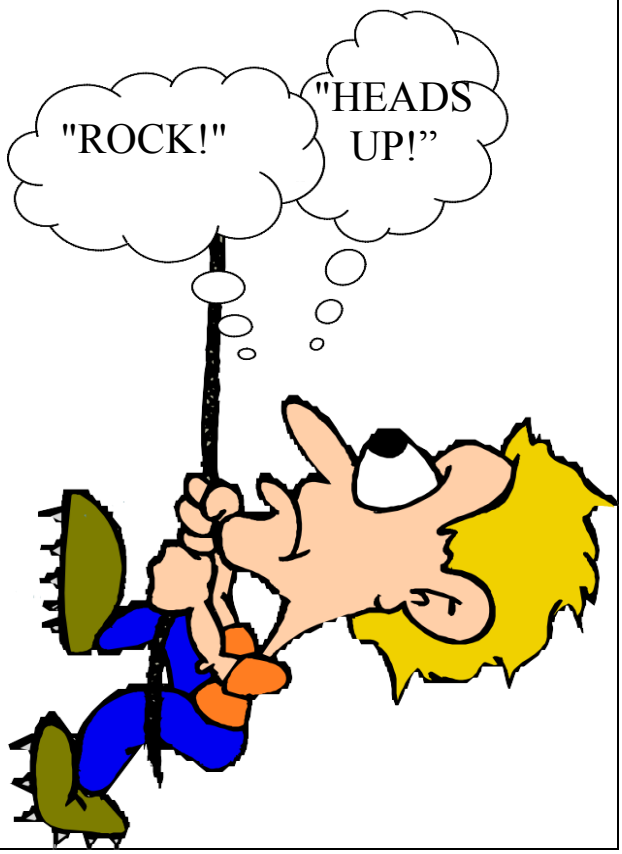
The result of the slope assessment will fall under one of five classifications. The classifications are summarized in the Scaling Classification System on the following page.

The slope conditions represented by a completed Slope Scaling Assessment form are valid for a maximum 90 days from the date of the assessment. Scaling operations must commence within the 90 day time period. Beyond 90 days, the slope shall be reassessed and a new Slope Assessment Form completed. Within the 90 days, should the slope conditions change due to an extraordinary event, such as freeze-thaw, storm activity, earthquakes, etc., the slope shall be reassessed and a new Slope Assessment Form completed.

A copy of the form shall be provided to each scaler, spotter, and ground control person at the site. Each scaler should keep a copy of the form for each scaling operation they have taken part in.

A qualified person must have successfully completed:

- The Beginner (Level 1) class
- The Refresher (Level 2) class
- The slope assessment training class
- And participated in a minimum of 6 hand rock scaling operations.



SCALING CLASSIFICATION SYSTEM

Class 1

- Beginner training required.
- Low slope lengths (<100') and shallow angles (<45 degrees).
- Anchor locations have easy access (slopes <20 degrees) and good abundant dependable anchors (large trees etc).
- Slope face is moderately eroded and light scaling is required.
- There are no key blocks, overhangs, chutes or presence of water.
- Light physical conditioning required.
- Basic anchor building skills required.
- Competent person to be on site watching the slope during scaling operations.

Class 2

- Beginner training required.
- Moderate slope lengths (<200') and slope angles between 45 and 70 degrees.
- Anchor locations have moderate access (<45 degrees) and good dependable anchors (large trees, rock out-crops, etc).
- Slope face is moderately to highly eroded and light to moderate scaling is required.
- There are no key blocks, overhangs, chutes or presence of water.
- Moderate physical conditioning required.
- Basic anchor building skills required.
- Competent person to be on site watching the slope during scaling operations.

Class 3

- Refresher training required.
- Moderate to high slope lengths (200' to 400') and slope angles between 45 and 70 degrees.
- Limited anchor locations (occasional trees, shrubs, rock out crops).
- Slope face is highly eroded and moderate to difficult scaling conditions.
- There are no key blocks; some overhangs, limited chutes or some water present.
- Good physical conditioning required.
- Good anchor building skills required.
- Competent Geotechnical person to be on site watching the slope during scaling operations.

Class 4

- Refresher training required.
- High slope lengths (>400') and slope angles (>70 degrees)
- Scarce to difficult anchor locations (occasional trees, shrubs, rock out crops).
- Slope face is extremely eroded and with difficult scaling conditions.
- There are no key blocks; numerous chutes and prominent overhangs.
- Excellent physical conditioning required.
- Excellent anchor building skills required.
- Competent Geotechnical person to be on site watching the slope during scaling operations.

Class 5

- No hand scaling on ropes unless a thorough geotechnical review is performed.

Slope Scaling Assessment

Version 4.1

Dist. _____Co. _____ Rte._____PM _____ Dir:____ ADT:_____
Slope Name: _____ Classification of Slope: _____
Preparer:_____ Reviewed By: _____ Date:_____(valid for 90 days max)

This form is to be prepared by a trained, qualified person and sent to Geotechnical Services for review by qualified personnel.

Previously Classified: no yes if yes, **Date:_____ Prev. Classification : _____**

PART 1 : GENERAL SITE INFORMATION

Slope Description

Cut Slope Natural Slope Recent/Old Slide (requires 2nd level review, contact Geotechnical unit in your area for additional review)

Slope Length (sketch in cross section in Part 2)

<100' <200' <400' >400' (significant exposure time)

Slope Angle (sketch in cross section in Part 2)

35° to 45° >45° to 70° >70° to 90° Overhanging

Slope Width (sketch in front view) W =_____(W/20 = # of Scalers) # of Scalers_____

Catchment Ditch Effectiveness (sketch in cross section in Part 2)

Good Catchment Moderate Catchment Limited Catchment No Catchment

Anchor Conditions above Slope (sketch in cross section)

Access	Easy	Difficult			
Angle	Flat	Moderate	Steep		
Vegetation	Trees	Shrubs	None		
Rock Outcrops	No	Yes	If yes, Many	Few	
Other Anchors (Ex. Fences, Utility Poles, Heavy Equip.)			No	Yes	Type_____
Mechanical Anchors Needed (Ex. Pickets, Fall-tech, Heavy Equip.)			No	Yes	Type _____

Exit Conditions

Dirt Road/Trail	**yes**	**no**	_____
Cross Country	**yes**	**no**	_____
Ropes required	**yes**	**no**	_____

Presence of Water (sketch in cross section and/or front view in Part 2) No Yes

If yes, Dry Wet Flowing

Chutes (sketch in front view) No Yes

If yes, Spacing: <20' 20' to 50' >50'

Shape/depth U shaped gentle sides U shaped steep sides V shaped steep sides

Overhangs (sketch in cross section and/or front view in Part 2) No Yes

If yes, <5' >5'

Slope Materials (sketch in cross section)

Soil Soil and Rock Rock

Rockfall Size S (<1' dia) M (1'–3' dia) L (3'-6' dia) XL (>6' dia)

Average _____ Maximum _____

Key Blocks (sketch in cross section and/or front view in Part 2) No Yes

Previously Scaled No Yes Don't Know

If yes, date_____ cubic yards scaled _____number of scalers _____number of spotters_____

Slope Scaling Assessment **Version 4.1**

Dist. _____Co. _____ Rte._____PM _____ Dir:_____ ADT:_____

Slope Name: _____ Classification of Slope: _____

Preparer:_____ Reviewed By: _____ Date:_____(valid for 90 days max)

PART 2 : SLOPE DIAGRAMS

Cross Section Sketch (use range finder)	**Front View Sketch**

Legend

CL = Highway Centerline

☺ = Location of Photo

↡ = Chute

↯ = Water

↴ = Overhang

Comments : _____

_____

_____

_____

_____

_____

_____

Slope Scaling Assessment **Version 4.1**

Dist. _____Co. _____ Rte._____PM _____ Dir:_____ ADT:_____

Slope Name: _____ Classification of Slope: _____

Preparer:_____ Reviewed By: _____ Date:_____(valid for 90 days max)

PART 3 : CLASSIFICATION SCORING SUMMARY				**Notes**
Old/New Slide	Pending Review	**Class 5**	○	_____
Slope Length	< 100 feet	Class 1	○	_____
	< 200 feet	Class 2	○	_____
	200 feet to 400 feet	Class 3	○	_____
	> 400 feet	Class 4	○	_____
Slope Angle	35° to 45°	Class 1	○	_____
	45° to 70	Class 2	○	_____
	> 70°	Class 3	○	_____
Anchor Conditions above the Slope				
Angle	Flat 0 to 20°	Class 1	○	_____
	Moderate 20° to 45°	Class 2	○	_____
	Steep >45° to 70°	Class 3	○	_____
	Vertical > 70°	Class 4	○	_____
Anchor Types	Trees	Class 1	○	_____
	Rock Outcrops	Class 2	○	_____
	Other	Class 3	○	_____
	Shrubs	Class 3	○	_____
	Mechanical	**Class 5**	○	_____
Slope Face Conditions				
Presence of Water	Dry	Class 1 and 2	○	_____
	Wet	Class 3 and 4	○	_____
	Flowing	**Class 5**	○	_____
Chutes Spacing	No chutes	Class 1	○	_____
	>50’	Class 2	○	_____
	20’ to 50’	Class 3 and 4	○	_____
	<20’	**Class 5**	○	_____
Overhangs	<5’	Class 1 to 4	○	_____
	>5’	**Class 5**	○	_____
Rock Size	S-M	Class 1 and 2	○	_____
	L	Class 3 and 4	○	_____
	XL	**Class 5**	○	_____
Key Blocks	No	Class 1 to 4	○	_____
	Yes	**Class 5**	○	_____

Overall Classification : _____

(Class 5 requires 2nd level review. Contact Geotechnical unit in your area for additional review)

Dist. _____Co. _____ Rte._____PM _____ Dir:____ ADT:_____
Slope Name: _____ Classification of Slope: _____
Preparer:_____ Reviewed By: _____ Date:_____(valid for 90 days max)

PART 4 : PHOTO PAGE

Scaling Crew Hand Scalers	Look outs	Competent person on site watching slope
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Chapter 4

Scaling

Caltrans Maintenance Manual

Rock Scaling Chapter

X.00 INTRODUCTION

Rock scaling is defined as the removal of marginally stable or unstable rocks from the face of a rock slope. Rock scaling is a maintenance management strategy that should be considered when the frequency or volume of rockfall requires additional resources beyond regular maintenance operations and other rockfall management strategies. For the purposes of this Chapter, only hand scaling methods are considered. Hand scaling is defined as scaling performed by workers suspended from ropes using hand-held pry bars or other hand tools to remove marginally stable or unstable rocks.

Scaling operations shall not be permitted unless a competent Lead Scaler, having completed the Caltrans Bank Scaling and Rock Climbing Class Refresher Training, is physically present on the site. Scaling operations shall be under the control of the competent Lead Scaler at all times. All Lead Scalers shall attend the Caltrans Bank Scaling and Rock Climbing Class Refresher Training every three years to maintain their proficiency.

> ***Note:*** Section 1540(a) of the Construction and General Industrial Safety Orders defines a *competent person* as : "One who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them."

Scaling operations shall be performed in accordance with the guidelines shown in the Caltrans Bank Scaling and Rock Climbing Manual and the Caltrans Rockfall Mitigation Manual.

Supervisors and Lead Scalers shall be furnished copies of the Caltrans Bank Scaling and Rock Climbing Manual, the Caltrans Rockfall Mitigation Manual, and the Construction and General Industrial Safety Orders of the Division of Industrial Relations (CAL/OSHA), referring to "Fall Protection." They shall periodically review the Caltrans Bank Scaling and Rock Climbing Manual, the Caltrans Rockfall Mitigation Manual, the Construction and General Industrial Safety Orders, and other pertinent resources to ensure that all applicable regulations are being followed.

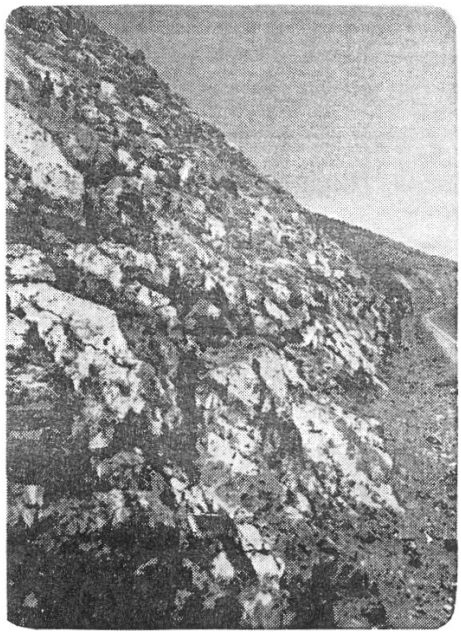
X.01 SLOPE SCALING ASSESSMENT FORM

Prior to commencement of any rock scaling operation, a Slope Scaling Assessment Form shall be prepared by a qualified/competent person. The form is designed to identify site factors as they relate to slope stability, site history, rockfall characteristics, and scaling operations. Scaling operations, if appropriate, may begin after review and approval of the form by qualified personnel from Geotechnical Services. The Slope Assessment Form shall represent the current conditions at the site and shall be revised as required if natural or other events change the conditions at the site. Scaling operations must occur within the time limits set forth in the Slope Assessment Form. A copy of the Slope Scaling Assessment Form shall be provided to each scaler, spotter, and ground control person at the site.

Caltrans Rockfall Mitigation Manual

Scaling or Trimming

Scaling is the removal of rocks and material (that are marginally stable) from the face of the slope. This is done by specially trained crews using pry bars and other tools to dislodge the rock, or it can sometimes be done by using a crane with a bucket to scrape the surface of the rock face. Trimming is the careful drilling and blasting away of overhanging rock.



Requires specially trained personnel and equipment

Scaling usually is not a permanent solution. Trimming of rock may be a permanent repair.

Scaling slopes by hand or with equipment is generally helpful for only two or three years. Maintenance forces are limited by California safety regulations; therefore, scaling on steep slopes must usually be performed by a contractor skilled in this line of work. The short time span that scaling is useful is due to the type of material and conditions that lend themselves to scaling. To successfully scale a slope, the rocks must be in a weak matrix that erodes and, thus, exposes new rock; or the rock is separated by numerous discontinuities to such extent that scaling can be useful; or there are individual loose rocks resting on ledges of bedrock. The latter example is commonly found on slopes that were overshot during construction or where freeze-thaw in an irregular face has caused rocks to move a short distance. Scaling of natural slopes, such as glacial deposits, above the road could encompass extensive work due to the large area that may be involved.

REMOVAL OF POTENTIALLY UNSTABLE BLOCKS BY SCALING

Scaling is a form of excavation used principally to remove loose or unstable rocks from a slope face. It is used on both natural and man-made slopes and is one of the most commonly used rock slope maintenance measures. Due to the ongoing weathering and relaxation of surficial blocks, scaling improvements are temporal and must be repeated periodically. It requires experienced personnel to be safe and effective. There are two basic approaches to scaling – hand scaling and mechanical scaling.

Hand scaling is done by workers suspended from ropes or working out of a crane or lift basket using hand-held pry bars. Slopes are always scaled from the top down for safety. The surface of the slope is evaluated and loose blocks that have the potential to fall are pried off the slope. This is an important distinction, since not all rocks that can be moved with a pry bar have the potential to fall. Hand scaling may be augmented using power-assisted mechanical equipment such as air pillows or splitters that are inserted into open cracks then expanded.

Scaling is performed in a controlled manner with traffic or other access beneath the scaling area prohibited, unless additional barriers or other forms of effective protection are in place. However, due to the erratic behavior of rockfalls, it is best to do scaling under temporary road closures with traffic queues allowed to clear when scaling is halted. Still, additional temporary protection may be required depending on down slope facilities, utilities and structures.

Figure 13-29. Routine hand scaling operation. (*Photograph courtesy of T. Badger*)

When scaling is performed using power equipment such as hydraulic hammers or backhoes, the method is termed mechanical scaling. Mechanical scaling may be a more efficient method of removing unstable blocks, but final checking and hand scaling of the finished slope is usually still required (Federal Highway Administration, 1993). Figure 13-30 shows mechanical scaling using a hydraulic hammer. Other common mechanical scaling methods include dragging a heavy object, such as a blasting mat or cat track, across the slope to abrade loose rocks.

Figure 13-30. Mechanical scaling using a hydraulic hammer (*Photograph courtesy of T. Badger*)

Scaling can also be performed using strategically placed explosives in cracks or drilled holes, or by using heavy construction equipment such as a trackhoe. It should be noted that without confinement, "crack blasting," the hand-loading of explosives into open cracks, can be relatively ineffective and dangerous; it may only produce loud explosions and fly rock.

In all cases, scaling operations should be observed and carefully controlled to prevent concentrated scaling that can lead to unsupported or over steepened slope areas. This is particularly true when using heavy equipment capable of excavating the slope.

Scaling may only be effective for a period of 2-10 years depending on site conditions; so it should not be considered a permanent mitigation measure. In some cases, due to localized slope disturbances, rockfall activity may slightly increase immediately following scaling. However, scaling is relatively inexpensive and overall is an effective rockfall mitigation technique. It is routinely used prior to constructing other mitigation efforts, such as rock bolts or draped mesh, or on newly excavated rock cuts to remove loose rocks that clearly pose a risk.

FHWA Rockfall Manual

7.2.1. Scaling

Scaling is an effective way to remove overhanging, protruding rocks or unstable rocks. Scaling methods are numerous and a site evaluation will determine the most cost- effective procedure for the program. Scaling at crests and on the faces of high steep slopes must be carried out by experienced personnel. The work will be performed from ropes or in a basket hanging from a boom with pry bars, hydraulic splitters or jacks, and small-scale explosives or chemical expanders, such as S-Mite or Bristar .

Mechanical scaling, such as dragging a cat track across the slope with the use of a boom crane, is generally a much quicker and safer method, but final hand scaling for remnant unstable rocks is still required. Mechanical methods such as the mechanical rock breaker, or the use of exploding shells from a howitzer, or high-pressure water monitoring, have been used to remove unstable material. The latter allows for remote scaling. It is more commonly used for snow avalanche control.

Periodic scaling should be performed as required on some slopes. Where numerous freeze-thaw cycles occur, scaling every 8 to 10 years is desirable. In dry warm climates, scaling cycles every 12 to 15 years may be adequate. Scaling must be performed thoroughly so it is not required every several years. While it is an interim mitigation method, it is also usually the least expensive mitigation procedure. In temperate climates, such as those found in the northwest, central and eastern U.S., scaling should begin in the spring after the frost leaves the rock. Rockfall frequency is usually greater during heavy precipitation, during high winds if trees are on the slope or crest, and during spring melt.

A scaling crew will normally comprise 2 to 4 members, depending on their support method. One equipment operator, who is usually the supervisor will clear the road and load the rock. There will be a truck on call. A crane and operator also may be used to lift a basket from which scaling is performed.

A common technique to protect the roadway during scaling is to cover the road with soil and build an earth berm to control the rolling rocks. Rockfall runout control at the highway must be provided. Procedures for this are described later. Traffic control at the highway must be developed. Scaling will usually have to coincide with periods of low traffic flow. Where traffic is extremely heavy, a detour may be required.

Draft nSSP

78-X MECHANICAL SCALING OR HAND ROCK SLOPE SCALING

78-X.01 GENERAL

78-X.01A Summary

1

Section 78-X includes specifications for removing loose rock and material from the slope face and providing rockfall runout control at the highway at locations shown.

2

78-X.01.B Submittals

78-X.01B(1) General

3

Submit evidence that rock scaling personnel involved in this project are trained in and have worked as a mechanical rock scaler. The foreman must have demonstrated experience as a rock slope scaling foreman. The rock scaler must have demonstrated experience on similar projects.

78-X.01B(2) Work Plan

4

The plan includes:

1. Proposed construction sequence and schedule
2. Type of equipment and tools to be used.
3. Number and distribution of foremen, equipment and operators scalers and lookouts.
4. Rock removal and disposal plan for the rock and debris generated from the rock scaling work, the rockfall runout control, including provisions to protect the highway and adjacent facilities.

78-X.02 MATERIALS

5

Not Used

78-X.03 CONSTRUCTION

6

Start rock scaling operations at the top of the work area as shown and proceed downward towards the highway removing all loose rock material as the work progresses.

7

The scaled face must be inspected and approved as completed. Dispose of rock and debris generated from the scaling operations.

78-X.04 PAYMENT

8

Not Used

expense, make all arrangements for the use of the haul routes.

ROCK SLOPE SCALING

Description

This work shall consist of the removal of loose blocks of rock on the slope, by use of hand scaling, hydraulic splitters or blasting (trimming) at locations shown in the Plans or as directed by the Engineer. The Contractor shall supply all materials, equipment and labor required to perform the work specified herein.

Submittals

Not less than 2 weeks prior to commencing the rock slope scaling, the Contractor shall provide to the Engineer:

1. Qualifications of the Contractor's personnel. The Contractor shall provide written evidence that the rock slope scaling foreman and rock slope scalers have performed satisfactory work in similar capacities elsewhere for a sufficient length of time to be fully qualified to perform their duties.

   The foreman shall not have less than 5 years of demonstrated experience as a rock slope scaling foreman. The rock slope scalers shall have at least 2 years of demonstrated experience on similar projects.

2. The Contractor shall submit a detailed work plan for each rock slope to be scaled. The plan shall detail:

   a. The proposed construction sequence and schedule.

   b. The types of equipment and tools to be utilized in the work.

   c. The number of rock slope scaling crews (crew is defined as one qualified working foreman, and two qualified scalers) to be employed on the project.

   d. Blasting plan for rock blocks requiring light blasting or trimming.

3. Work shall not begin until the appropriate submittals have been approved in writing by the Engineer.

Construction Requirements

Work shall proceed according to the work plan and schedule submitted by the Contractor prior to the commencement of the work.

Rock slope scaling shall be conducted on all rock slopes as directed by the Engineer and in accordance with the Contractor's work plan. Section A, of the contract Plans, has two areas of wire mesh slope protection that will remain intact. Loose rock hanging behind the remaining wire mesh must be removed during the rock slope scaling operation. This will require temporary detachment of the existing wire mesh to remove the loose rock.

The use of power equipment, such as backhoes, etc., shall be prohibited.

SR 20
MP 125.21 TO CABINET CREEK
ROCKFALL MITIGATION
92W020

60

The Contractor shall provide a qualified rock slope scaling crew that consists of a working foreman and two scalers. The crew size shall be maintained at all times. Any crew member who must leave for any reason shall be replaced immediately by a qualified replacement. If the scaling activities have the potential of endangering adjacent facilities the Contractor shall provide appropriate protective devices, as per the Contractor's work plan, prior to commencing the scaling work.

Rock slope scaling shall start at the top of the slope and work shall proceed downward toward the highway, removing all loose rock blocks as the work progresses. When blasting is required, the explosive force shall be sufficient to remove the rock block but not damage the surrounding rock. If drilling is required as part of the removal process (trimming), the drill holes shall be drilled parallel to the face (straight line) and have a spacing equal to ten times the drill hole diameter. The drill holes shall be loaded with a sufficient amount of explosives to break the rock between the drill holes but not damage the new face

Rock blocks or debris which hang up on the slopes during the scaling operations shall be removed upon completion of the first rock slope scaling pass. The new face shall be inspected by the Engineer to determine whether or not the rock slope scaling has been completed. If other rock blocks are identified that require removal, the Contractor shall continue to scale the slope until the scaling has been completed to the satisfaction of the Engineer.

All rock and debris produced during the rock slope scaling operation shall be removed and disposed of by the Contractor.

Measurement

Rock slope scaling will be measured on a crew hour (CRHR) basis. A crew is defined as a qualified working foreman and two qualified scalers.

Payment

The unit contract price per crew hour for "Rock Slope Scaling" shall be full pay for performing the work as specified.

DIVISION 2 SITE WORK
SCALING 02101-1

GENERAL

Description

Rock slope scaling shall be conducted on all rock slopes as directed by the Engineer (shown on Drawing 4) and in accordance with these specifications and the Contractor's work plan and shall include the removal of loose blocks of debris and vegetation from the slope by mechanical methods. Blasting or the use of ground surface power equipment, such as backhoes, etc. shall be prohibited except in Construction Zone 3 as shown on Drawing 4.

Crew Complement

The Contractor shall provide a minimum of one qualified rock slope scaling crew that consists of a working foreperson and two scalers. The crew size shall be maintained at all times. Any crew member who must leave for any reason shall be replaced immediately by a qualified replacement. If the scaling activities have the potential of endangering adjacent structures (e.g., guardrail, retaining wall, signs, etc.) the Contractor shall provide appropriate protective devices, as per the Contractor's work plan, prior to commencing the scaling work.

EXECUTION

Material Included

All slopes to be scaled are indicated on Drawing 4. Scaling of these slopes shall include the removal of all loose rock, whether in original position or not, all vegetation over 1/8 inch in diameter, and any existing wire mesh installed on the slope. Existing wire mesh and associated hardware shall become the property of the Contractor.

Methods

Rock shall be scaled manually using a suitable five foot standard steel mine scaling rod supplemented when necessary by pneumatic splitters. Vegetation shall be pruned or sawed off even with the rock face. In Construction Zone 3 only, alternative methods such as blasting or use of ground surface power equipment may be allowed at the discretion of the Forest Service. If blasting methods are to be used, this portion of the scaling work must proceed before any other scaling proceeds.

Caltrans Bank Scaling and Rock Climbing Training

GUIDELINES FOR DEVELOPING A SCALING PROGRAM

1. Identify Highway Slopes Prone to Rockfall
    - Request information from Maintenance Area Supervisors and Lead Workers
    - Identify chronic rockfall areas and prioritize sites
    - Collect basic site specific data such as :
        - Access for climbers
            - can climbers safely access the top of the slope?
            - is there an access road?
        - Anchor quality and quantity
            - what kind of natural anchors exist for climbers? (trees and rocks)
            - are there enough natural anchors in the right places?
            - if little or no natural anchors exist, install artificial anchorage. (pickets, Manta Rays)
        - Maximum slope height and total length of slope to be scaled
            - height determines the rope length required
            - length determines the number of scalers and the spacing interval
        - Typical rock size and expected quantity of material generated
            - rock size determines the type of scaling tools to use, are digging bars necessary?
            - quantity determines the type of load and haul operation to plan.
        - Frequency of rockfall
            - this determines the required frequency of scaling and possible permanent mitigation
        - Traffic control considerations
            - no scaling without traffic control. No exceptions.
            - both directions of the route must be closed intermittently during scaling ops.
            - if possible, both directions of the route are reopened simultaneously to expedite clearing of traffic.
            - should lane closure charts be requested? YES, always. Scaling can be very disruptive to public traffic.
            - is a detour available? If so consider full closure and detour traffic during scaling ops.
        - Public affairs issues
            - delay to the public should be expected, typically 30-45 minutes or more.
            - give PIO at least 1 week advance notice prior to scaling operations

2. Request Site Evaluations from qualified Geotechnical Personnel
    - Get concurrence on the applicability of scaling at each site. Prepare a Slope Scaling Assessment Form for each site.
    - Conduct a pre-scaling reconnaissance meeting with the Geotechnical representative at each proposed scaling site.
    - Establish a history of geotechnical study at the site.
    - Request follow-up scaling or mitigation studies if necessary.
        - does the site warrant a permanent rockfall mitigation project?

3. Maintain a Data Base of Scalers and a Current Climbing Gear List
    - Identify District scalers by name and Maintenance Station
    - Include personnel who have attended the training in Kingvale
    - Identify prospective climbers for future training and scaling operations
    - Identify a lead scaler for each site
        - The lead scaler must be a qualified person who is experienced and familiar with
        - the operation and the hazards involved
    - Maintain a current list of required climbing gear with vendors information and current prices
        - Each scaler must maintain a Personal Climbing Log
        - Each scaler must have the appropriate gear
        - Each scaler must have rope and scaling tools
        - Scaling tools include shovels, digging bars and ice axes.

4. Maintain a Data Base of Scaled Sites
    - Document the date, number of scalers and lead scaler
    - Together with Geotechnical personnel, determine the frequency of scaling required at each site.
    - Log the Slope Scaling Assessment Form for each site.
    - Document the type and quantity of rockfall mitigation recommended or employed, if any.

Caltrans Bank Scaling and Rock Climbing Training

Scaling Operations

SITE RECON MEETING CHECKLIST

TRAFFIC CONTROL CONSIDERATIONS

- ☐ CMS's should be used to alert motorists of delay in advance of operation. 30-45 min. delay is normal.
- ☐ Highway is closed in both directions and re-opened in both directions (if possible) to clear traffic faster.
- ☐ Typically scale 10-15 minutes, allow 10-15 minutes clean-up, then re-open lanes. Repeat as necessary.
- ☐ Radio Communication must be in place between the lead scaler(s) on the slope and ground control.
- ☐ Radio Communication must be in place between ground control and the flaggers.
- ☐ Determine if intermediate flaggers are required to prevent errant vehicles in the work area.
- ☐ Never scale or climb the slope without traffic control in place.

SCALING/CLIMBING CONSIDERATIONS

- ☐ Slope Assessment form is completed by competent/qualified personnel
- ☐ Determine the access route to the top of the slope.
- ☐ Identify site specific natural hazards such as snakes, ticks, poison oak etc.
- ☐ Assess anchoring conditions prior to the day of scaling.
- ☐ Artificial anchors can be installed if necessary. This may require a separate 1 day operation.
- ☐ All anchors must be double checked by the lead scaler(s) prior to first rappel.
- ☐ Installation of edge protection must be assessed.
- ☐ Spacing interval of scalers, typically 20-40 feet but is site specific.
- ☐ Competent person on site to observe slope during scaling operations.
- ☐ Use of "spotters" at the top, sides, or bottom of the slope to warn of incidental rockfall.
- ☐ All scalers must be Kingvale trained, competent and physically fit and a volunteer for this type of duty.
- ☐ All scalers should provide their own climbing gear, rope and scaling tool.
- ☐ The Rescue 8/Ascender combo rappel method must be used when scaling. No exceptions.
- ☐ All scalers descend at the same rate and stay at the same elevation on the slope.
- ☐ All scalers remain still during clean-up operations and periods of live traffic below.
- ☐ The best scaling tool is a long (80 cm) ice axe. Available at REI.
- ☐ Other scaling tools include short shovels and short digging bars.
- ☐ All scalers must use a climbing helmet with chin strap, not a hard hat.
- ☐ Standard PPE's such as boots, gloves, and safety glasses must be used.
- ☐ Other personal protective equipment such as dust masks, shin guards and gators are recommended.
- ☐ All scalers should bring water and snack food. A camel back is recommended.

GROUND CONTROL CONSIDERATIONS

- ☐ Identify haul site. Be prepared to remove large amounts of rock and dirt quickly.
- ☐ If possible, short haul to stockpile, then remove to final disposal site at a later date.
- ☐ Secure at least one loader, one dump truck and a plow truck to clear the roadway quickly.
- ☐ A power broom or sweeper is nice if available.

GENERAL SAFETY CONSIDERATIONS

- ☐ Identify the location of the nearest medical facility, have a map ready if in remote or unfamiliar area.
- ☐ Identify personnel on site who are trained in First Aid.
- ☐ Identify personnel on site who are trained in Aerial Rescue for an ambulatory victim.
- ☐ Identify a vehicle to be used to transport a victim in case of emergency.
- ☐ If an injury requires a victim be removed from the slope, call 911 and request a "High Angle Rescue."
- ☐ Prepare a Tailgate Safety Meeting Agenda and Sign in Sheet. Conduct a Safety Meeting before each

Summary

What is Rock Scaling?

- Scaling is the removal of loose rocks using hand tools and pry bars.
- Rock Climbers call it trundling.
- The Allied forces in Afghanistan used it as a weapon.
- Caltrans Maintenance and Geotechnical volunteers call it hard dusty rewarding work

When is scaling appropriate?

- Scaling is not "a random act of engineering" but is an organized, deliberate discipline founded on geologic and engineering principles and is a technique used throughout the world.

Why Scale?

- All slopes age.
- The aging process eventually weakens the surface resulting in loose blocks of rock.
- In time, just as with structures, the slope surfaces need maintenance.
- Rock patrols and rock scaling are typically the first line of defense.

When to Scale

- Every slope is different and is distinguished by
  - size
  - character
  - properties
- Assessing these characteristics falls to the responsibility of
  - maintenance personnel
  - engineering geologists
- Together rockfall characteristics are evaluated and the decision of when to scale or not to scale is made.

How is it done and by whom?

- Transcontinental Railroad Era Chinese and Irish laborers moved loose rocks
- During the great dam projects workers hung onto ropes with their bare hands
- Caltrans rock scalers using a blend of industrial and recreational climbing techniques

Scaling and Climbing as a Resource

- Emergency response.
- Site Inspection
- Scaling Operations
- Regular maintenance.
- Periodic Scaling of trouble slopes
- Slope investigations

Caltrans scaling training program is the only one of its kind

- Caltrans regularly receives inquires from across the US and abroad.
- Caltrans scaling teams have been featured in the National Geographic special “Landslides” and the Learning Channel Special “Disasters Detectives.”
- It is truly a unique program enabling Caltrans to employ best management practices for slope maintenance.

Chapter 5

Equipment

PERSONAL PROTECTIVE EQUIPMENT

CLIMBING HELMETS

A climbing helmet is required for all bank scaling and rock climbing activities. A Caltrans hardhat, with a chinstrap is better than nothing, but it is not an acceptable substitute for a climbing helmet.

The helmet is one of your most important pieces of equipment as it protects the grey matter between your ears. Head injuries are a major cause of death or serious injury to climbers. There isn't much more to say here other than good old Murphy's Law *can* take effect at any time and if it can happen…it will.

One thing you don't need to worry about when choosing a climbing helmet is its strength…get one approved by the U.I.A.A. Their labs simulate rock fall by dropping steel balls and pointed anvils several feet onto a helmet strapped onto a hardwood dummy. They also smash the front, back and sides of the helmet and try to rip off its chinstraps.

Other important considerations when selecting a helmet are ventilation, stability, weight (the mean is 15 ounces), and comfort. Everyone's noggin is different, so try on several helmets, with and without a hat, before buying. Make sure the helmet does not flop around if the straps loosen slightly. U.I.A.A. helmets must also meet ventilation and material standards.

The U.I.A.A. label doesn't say one helmet is stronger than another, nor does it rate helmets for certain purposes, such as ice climbing or rock climbing. It does say, when properly used, the helmet should protect your head from serious blows.

GLOVES

Refer to the Caltrans Safety Manual, Chapter 12.09 Hand and Arm Protection.

For the beginning climber, gloves may mask the heat that is generated during a rappel. For this reason, we do not allow beginning students to wear gloves during the first morning of rappelling. Feeling the heat on your bare hands gives you an idea of how much heat can be generated from friction on the rope.

More experienced climbers may wear gloves to protect their hands. Be sure that the gloves are a good fit. Loose fitting gloves can make it difficult to operate gear and can even snag during a rappel.

SAFETY GLASSES

Refer to the Caltrans Safety Manual, Chapter 12.06 - Eye and Face Protection

The State warehouse carries different styles of safety glasses. Safety glasses are necessary when working on slopes. Rocks can be dislodged by the rope above you. When belaying someone from below, the climber could accidentally kick rocks down towards you. It is important to be able to look up and spot any incoming objects in order to avoid them.

SHIN GUARDS

Shin guards are **highly recommended** during a scaling operation. If you've ever felt the pain of being kicked in the shin, you know its not a pleasant feeling. If you aren't wearing shin guards, or Kevlar gators, you are just inviting small rocks to come down and hit you. Anything from soccer shin guards to the hard plastic guards worn by hockey goalies will work.

HARNESS

Have you ever hung from a rope around your waist? If you have, you know that it is not a nice experience. A harness serves as a comfortable and reliable way to connect your body to a rope. The harness allows you to hang from a single point as it distributes the force of your weight across your legs and waist by means of thick webbing. Harnesses come in many styles and types. Selecting the proper harness for the type of work you will be doing is very important. Factors to consider when choosing a harness include, comfort, durability, reliability and cost. Remember during a scaling operation, you may be spending all day, for several days in a row, hanging in the harness. You will want a harness that fits well and remains comfortable for long periods of time.

There are several different styles of harnesses out there but whichever one you chose, when you are suspended from it you should stay in an upright position. An optional chest harness will help, with the trade -off of adding weight and bulk to the system.

> When sizing your harnesses, ensure that the webbing is double-backed through all load-carrying buckles with at least 3 inches of webbing extending beyond the buckle.

Pictured below are some of the harnesses currently being used by your colleagues at Caltrans.

Caring for your Harness:

- **Inspect your harness for wear spots after every use.**
- **When avoidable, do not lend your harness to others. Everyone uses equipment differently.**
- **The CT Climbers Harness Inspection form should be completed and stored with the harness.**

CT Climbing Harness Inspection Form

Inspector (Primary User): _____ Date: _____

Inspector (Co-worker/Supervisor): _____

Harness Manufacturer, Model & Serial Number: _____

Harness Checklist:

Examine each component for signs of damage. In non-metal stitched components, look for fraying, splits, stains, weathering, lack of suppleness, and other signs of wear. In metal and plastic components, look for cracks, grooving, warping, and other signs of wear.

Items to be checked:	Yes (OK)	No (Give descriptions)
Belay Loop		
Harness Belt		
Leg and Crotch Loops		
Primary Attachment Points		
Buckles		
Leg Loop Connectors		
Tool Attachment Points		
Label Markings		

Comments:

_____

_____

_____

_____

User Checklist:

Has user received training on proper use of harness? _____

Date of last training: _____

Does harness fit properly? _____

Signature: _____

RAPPEL AND BELAY DEVICES

The old days of body belays and rappelling are just that, old. Today's belay devices and rappel devices are really nothing more than a friction device. They introduce enough friction to allow a controlled decent on a rope. Like all tools used in scaling, a climber must be trained in the proper use of a rappel device. This is especially important since often times, **this device will be the primary connection between a climber and his rope.**

The standard rappel device for bank scaling operations is the Rescue 8 device. The Rescue 8, a variation of the Figure 8 rappel device, has "wings" or "ears" that can help prevent jams as the rope passes through it. It can be made of steel or aluminum. Steel is generally stronger, and will be rated to carry heavier loads. Aluminum devices have the benefits of being lighter and more efficient in dissipating heat.

To set up a Rescue 8 for rappel, the climber passes a bight of rope through the large opening, and brings the bight over the smaller end of the 8. The Rescue 8 is then connected to a primary connection point on the climber's harness using a locking carabiner. This "wrap" of the Rescue 8 creates the friction necessary for a controlled descent. Climbers may also bring the bight through the opening a second time for a "double wrap" that creates even more friction for greater control (See Chapter 9, Working On Rope).

There are many other rappel devices on the market. However, <u>Caltrans recommends using a Rescue 8 rappel device for scaling operations.</u>

A belay device, generally has two functions. The first is to allow rope to be fed through the device relatively freely, so that a climber on belay has the freedom to move around without restriction. The second function is to provide the belayer the means to quickly stop the descent of the climber in case of a fall. Because a belay device serves two functions, the belay must be tended vigilantly by the belayer; giving the climber enough slack rope to maneuver, but immediately ready to take up the slack and prevent a climber from falling.

Some descenders can also be used as belay devices; but make sure they have been approved for belaying. A Rescue 8 may be used as a belay device. Again, proper training to use the device correctly is important. **Be sure to use the small opening of the device when <u>belaying</u> with a Rescue 8 - the large opening of the device DOES NOT produce enough friction to stop a fall.**

The Caltrans primary method is to a belay using a Munter-mule hitch (See Chapter 7, Knots and Hitches) on a carabiner. The Munter-mule hitch wraps and pinches the rope to provide friction. The hitch can be tended to serve the same functions as a belay device. **One important feature of both rappel and belay devices, is that they must be able to be "locked off." When a device is locked off, rope is no longer allowed to pass through the device, preventing further descent of the climber.** The Munter hitch provides the friction for control; and the Mule knot can be used to lock off the belay. This is the method taught in this course.

Caring for your Rescue 8:

Friction and heat can cause damage to a Rescue 8. Be sure to inspect it for any cracks before and after use. Take care not to drop it. Dirt can increase the wear on the device, so care should be taken to keep dirt away from it. This applies to both the device and any rope passing though it (See Chapter 6, Rope). Grooving is a natural result from the friction it is exposed to. Keep in mind the strength of the device is directly proportional to the amount of metal remaining. In other words, if a groove has worn 1/4 of the way through the metal, the strength of the device is only 3/4 of its full strength. Retire the Rescue 8, if there is too much

DAISY CHAINS (PERSONAL ANCHORING SYSTEMS)

(This section is under development)

The Caltrans approved daisy chains are:

Knotted daisy chains

Hand -tied with 9/16th inch or 1 in webbing

Individually sewn loops.

Looped daisy chains

ASCENDERS

Ascenders are used to make upward progression on a rope. An ascender has a rope guide and a camming rope clamp. When the rope is in the rope guide and the cam is activated, the cam allows the ascender to slide in only one direction along the rope. With two ascenders on the same rope, a climber can ascend by alternating putting his weight on one ascender while sliding the other ascender upwards. Training and technique are important to efficiently traverse upwards on a rope.

Ascenders usually come in pairs; one for the right hand and one for the left. They are designed for one-handed operation. When holding the ascender in the correct hand, you should be able to open and close the cam with your thumb. There is also a safety lever that can keep the cam from opening fully, or lock the cam in the open position. Larger ascenders come with a molded hand grip for comfort and ease of use.

It is important that the ascenders you use are correct for the size rope you are climbing on. The CMI Large Ultrascender is designed for use on rope between 8.5mm and 16mm diameter.

A single ascender, when used correctly, may be used as a "self-belay." A climber **must** be properly trained to use an ascender for this purpose, as this is considered a "Life" connection.

CMI Large Ultrascender

One right and one left handed ascender, each with two 9/16" webbing slings

Caring for your Ascenders

Clean ASCENDERS with a mild detergent solution or disinfectant after use and dry, if necessary. *Cleaning and drying should be carried out immediately after every use in a marine environment.*

Store in a clean dry environment avoiding extremes of temperature, corrosive fumes or chemical substances. *If the ascender is exposed to chemicals, refer to chemical data sheets and/or the manufacturer.*

Do not use the ascender in extremely cold weather if there is a possibility of water or ice coming into contact with the ascender's moving parts. In these conditions, an alternative is to use prusik knots.

It is recommended that you examine the general condition and function of the ascender at least yearly.

It is difficult to estimate the lifespan of the ascender due to variations in use and care, but in normal usage, and with regular cleaning and lubrication, it should be more than five years.

JUMAR®

— with warranty

mountaineering — speleology
expeditions — rescuing

— Rope-ascender for climbing, descending, securing and load-hauling
— Reliable and safe
— Swiss EMPA resistance test nr. 116521
— Weight per ascender 9.2 oz
measurements 6.7 × 3.2 × 1. 4 in

A Blue handle for right hand
B Red handle for left hand
C Rope clamp of highly resistant chrome steel
D Safety lever
E Rope — diameters 6—14 mm

1 JUMAR ascending method: piton and rope knot easy to pass
2 Adapt foot sling to shoe once, afterwards just open and close
3 Fixed half open position: possible after the two notched angles of safety lever D have been cut off.
3. Fixed open position – single handed operation
4 Rope pull to stop backward movement
5 with pulley — suitable for pulley block

A few ascending methods:
1 JUMAR: hand—foot/hand—foot
6 Hand—seat/hand—foot
7 Chest/hand—foot (speleology)
8 Frog technique
9 Fixed rope (expeditions)

JUMAR
— easy to operate
— a favourite all over the world
— tested to 1.100 lbs

JUMAR
Limited Warranty

Resistance and operation of each JUMAR ascender are tested:

— Test load on suspended 11 mm braided rope = 4 900 N (≅500 kp ≅ 1 100 lbs)
— Breaking load* is approximately 7 000—8 000 N = 1600—1800 lbs
— Operation of rope clamp and safety lever are tested.

We guarantee that these tests are carried out and that we shall replace free of charge any part with a manufacturing or material defect.

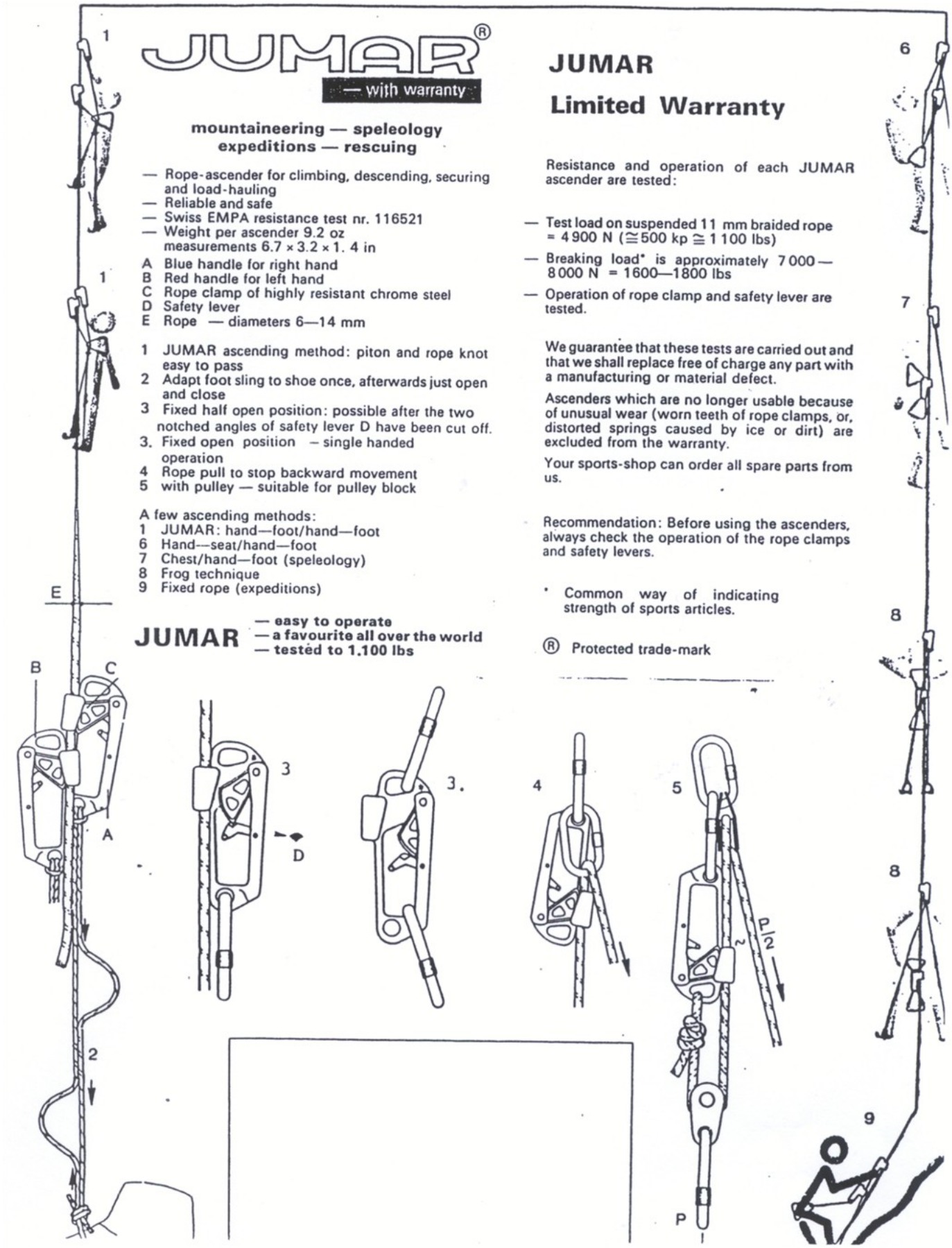
Ascenders which are no longer usable because of unusual wear (worn teeth of rope clamps, or, distorted springs caused by ice or dirt) are excluded from the warranty.

Your sports-shop can order all spare parts from us.

Recommendation: Before using the ascenders, always check the operation of the rope clamps and safety levers.

* Common way of indicating strength of sports articles.

® Protected trade-mark



CARABINERS

All carabiners under impact loads shall withstand a 5000-pound tensile test without fail. **Refer to ANSI A10.14-1975**

Carabiners are metal clips used to make an almost unlimited array of connections between rope, webbing, harnesses and other gear. Carabiners can be classified into two main categories, locking and non-locking.

As with other equipment, we recognize in carabiners a difference between sport climbing and rescue operations. In rescue, higher static loads are involved; personnel management and rope management becomes more complicated. Caltrans has developed a protocol for the most appropriate carabiners to be used in Caltrans slope climbing activities.

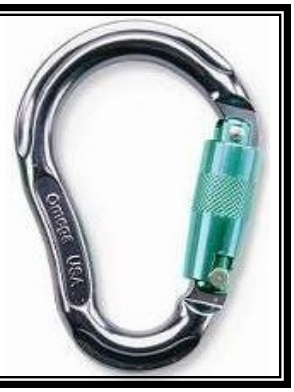
Application dictates the type of carabiner to be used. A locking carabiner is required for the connection between the harness and the descender device. A single locking carabiner or two opposite and opposed non-locking carabiners, at a minimum, are to be used for all life-supporting connections. Single non-locking carabiners may be used for directionals or other non-life-supporting connections.

For the greatest strength, the load applied to a carabiner should be along its major axis. A carabiner is one third as strong along its short or minor axis. The gate of the carabineer is not intended to take a load. The gate of a carabiner should remain closed at all times to ensure maximum strength. An open carabiner is about one third as strong as a closed one.

Please see the Chapter 2 Safety, Rope Work for more information concerning the safe use and care of carabiners. Avoid metal to metal connections whenever possible.

Swing Gate Self-Locking D

Large Locking D with gate that opens on an angle for easier accessibility. Opening a locking carabiner requires an action to unlock the gate; then a separate action to open the gate.



Standard Oval

The standard workhorse is a non-locking drop forged aluminum carabiner.

Screw-Lock Locking D

Large locking D with gate that requires a dedicated action to lock and unlock the gate.

CT Climbers should have at least 4 locking and 6 non-locking carabiners

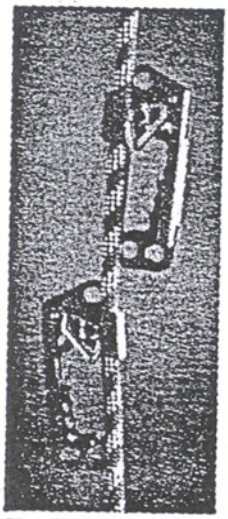
Caring for your Carabiners

Clean carabiners with a mild detergent solution or disinfectant after use and dry, if necessary. *Cleaning and drying should be carried out immediately after every use in a marine environment.*

Store in a clean dry environment avoiding extremes of temperature, corrosive fumes or chemical substances. *If the carabiner is exposed to chemicals, refer to chemical data sheets and/or the manufacturer.*

you can use either of the following rules: "fat end towards the anchor," or "the UP arrow points towards the load."

Handled Ascenders

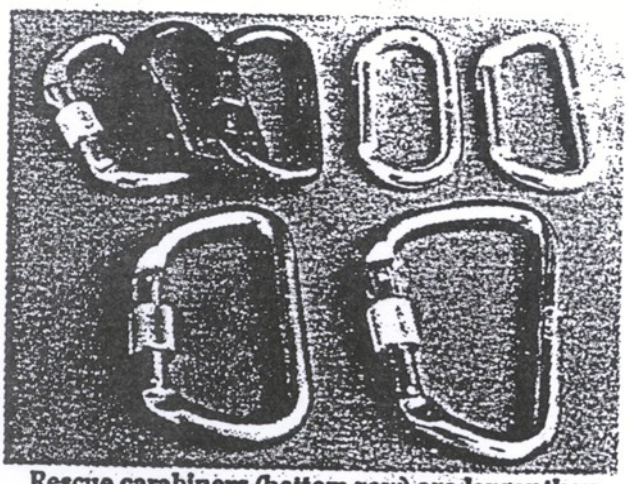


Typical Handled Ascenders

There are a variety of handled ascenders, but because of the way they grip the rope, for rescue purposes they are basically the same. These include Jumars, CMI Ultrascenders and the 5000 series, Petzl Expedition ascenders, and ones by Clog and Camp. Our generic name is a misnomer as most models are available in a version without a handle as well.

These ascenders have a trigger that releases the cam so that the rope can be inserted, allowing one-handed operation. The teeth on the cam help to grip the rope by digging into the sheath, as well as the cam jamming the rope against the shell. As a result, rope failure happens at a much lower loading than with the Gibbs. Some older models of Jumars have had frame failures at very low loads and should not be used. For information on different models of handled ascenders, see the manufacturer's literature. Their use for ascending ropes is well covered in the climbing and caving manuals.

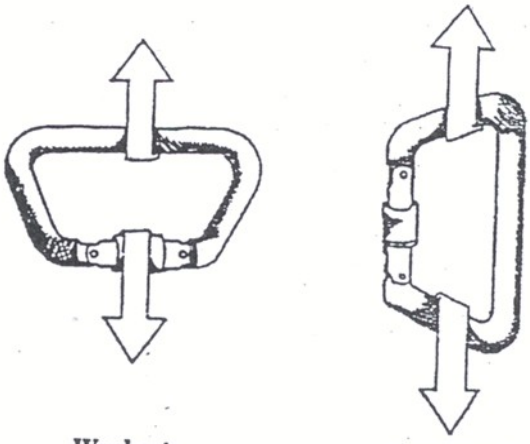
Carabiners



Rescue carabiners (bottom row) are larger than mountaineering carabiners (top row).

As with other equipment, we recognize in carabiners a difference between sport climbing and rescue operations. In rescue, higher static loads are involved, personnel management and rope management becomes more complicated. For these reasons, we have always recommended buying the best carabiners that you can find.

FUNCTION: Carabiners are designed to take the load on their long axis. Any loading different than this will reduce the strength of the carabiner. The gate of the carabiner is not intended to take a load



Weakest: Carabiner loaded on the short, or minor, axis.

Strongest: Carabiner loaded on the long, or major, axis.

Figure 7-1: Carabiner Loading

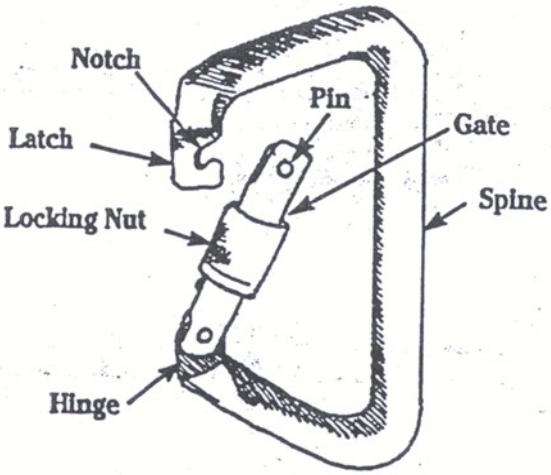


Figure 7-2: Parts of a Carabiner

By Bill Sumner
REI product development engineer

One of the most useful pieces of climbing hardware is the carabiner, a metal link used to hold things together. A typical carabiner is about 2 inches by 4 inches, weighs about 2.5 oz., and is made of an aluminum alloy such as 7075-T6 (see Figure 1).

High strength and easy-opening gates make carabiners useful for connecting ropes to anchors, carrying chocks and ice screws, rappelling, and securing equipment in rafts. On a simple trip you might need one or two. A difficult rock climb could require 50 to 75.

Carabiner basics

One of the most popular carabiner shapes is oval (Figure 2). **Oval carabiners** hold lots of gear, work well for carabiner brake rappels, and minimize carabiner shifts during aid climbing. Their symmetry and traditional design make them a popular choice for climbing applications.

D carabiners (Figure 2) get their name from their assymmetrical shape. Ds were developed to give a high strength-to-weight ratio, since the load is off-center, shifted towards the stronger, solid side. The gate, on the short side, is easy to locate. If minimum weight with maximum strength is important, Ds are your best choice.

Locking carabiners (Figure 3) have threaded or sliding sleeves to secure their gates. Applications include use with belay devices (such as Stitch plates), Munter hitches (a knot used for belaying that requires secure gate closure and a larger carabiner), and for specialized rescue applications.

Since carabiners are so versatile, there are dozens of special designs. For example, the tubing on Stokes' litters requires carabiners with extra-large gate openings. High-strength steel carabiners are also commonly used for rescue work. Corrosion is common in saltwater environments so marine carabiners are anodized for protection.

How strong does a carabiner need to be?

It depends on your application and how the carabiner is loaded. For climbing, carabiners with strengths ranging from 4,000 to 6,000 lbs. are common. This gives enough strength to hold long leader falls under most conditions. However, it is important to realize that a carabiner can be pulled in many directions and might have an open gate, which will significantly reduce the load it will hold.

For maximum load strength

The strongest direction to load a carabiner is along its major axis. This puts the load along the solid side and through the pins and notch of the gate. This is the way carabiners were designed to be pulled.

Pulls along the minor axis should be avoided, since the strengths in this direction are lower. For example, the REI Elite D tests to 5,060 lbs. along the major axis, but fails at 2,320 lbs. along the minor one. Likewise, the REI Elite Oval tests at 4,400 lbs. (major) and 1,795 lbs. (minor).

An open gate reduces the strength of a carabiner by an amount depending on its shape and size. For example, the REI Elite Oval tests at 4,400 lbs. along the major axis with the gate closed, but fails at 1,540 lbs. with the gate open. For the REI Elite D, the closed strength is 5,060 lbs. and open is 1,320 lbs. For maximum strength, it is important to make sure the gate is shut.

In critical applications, two carabiners may be used together, with gates on opposite sides to give double the strength and increased security against accidental gate opening. This eliminates the need for locking and steel carabiners in many situations.

Typical Carabiner

Figure 1

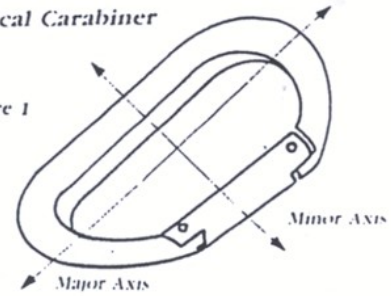
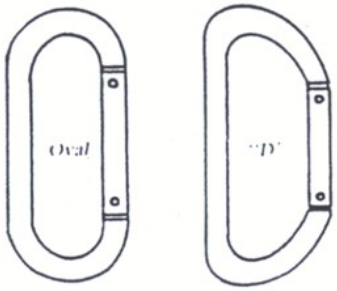


Figure 2



Choosing a carabiner

When choosing a carabiner, look for one that is strong enough for your intended use. Pick one that has a smooth gate action, has a gate and notch that are properly aligned, and has polished rivets that won't snag. Look for reliability in the manufacturer and retailer. Many carabiners are individually tested to half their rated strength to ensure the quality of manufacture.

Carabiners require some maintenance. File off burrs that develop. These catch ropes and runners, and may prevent gates from operating smoothly. Keep carabiners away from dirt and grit to keep the spring hole clean. If the gate does stick, remove burrs, clean with a solvent, and lubricate with dry graphite. Avoid oil, which holds dirt.

By reducing the size of carabiners, it is possible to reduce their weight. Latok is offering two Ds that are about an inch shorter than other carabiners but have major-axis strengths of about 3,810 lbs. and 4,800 lbs. Their weights are 0.93 oz. and 1.25 oz. respectively. If weight is more important than size (and some strength), these will make nice alternatives.

CAMP, an Italian climbing supplier, has patented a gate with the notch and pin reversed from the standard design. The CAMP gate is notched while the body has a pinned slot. This design reduces the snagging of wired chocks and webbing runners as they are removed from the carabiner. This also makes long-reach placements easier.

Recent Developments

Other recent developments include experimenting with a variety of different aluminum cross sections, and notching the body to improve grip. But these changes don't make much difference in strength-to-weight ratios. The major appeal of these carabiners is simply that they are different.

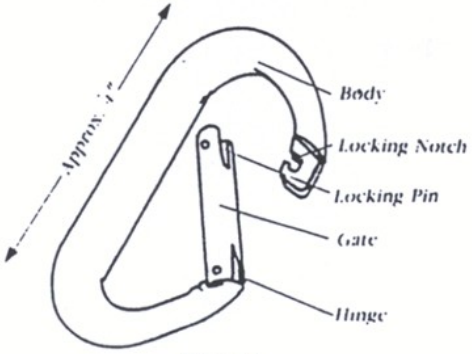


Figure 3

REI A1391, 7/86

NYLON WEBBING & 7mm ACCESSORY CORD

Nylon webbing is lightweight and has multiple uses. We like to use webbing for tying anchors since its wide surface area provides a good grip on the anchor point and provides high abrasion resistance.

For the same length, rope has more bulk than webbing. Some rescue squads use short lengths of rope to tie anchors. If a long extension is needed from the anchor to where you want to attach the system, use a rescue rope, rather than lengths of web or smaller lines tied together.

Accessory cord is also lightweight and has multiple uses. Accessory cord can also be used to tie anchors when abrasion is not a factor. For example, if artificial protection is used to build an anchor, the protection may be placed so the cord will not have to make contact with the ground.

- Each climber should have at least 50 feet of the 7mm cord available for various uses.
- Inspect all cord before using it.
- Each climber should have at least 100 feet of the 1" webbing and about 30 feet of the 9/16" webbing, available for various uses.
- Inspect all webbing before using it.
- Webbing may be marked with things like, year in service, or your initials.

Uses for webbing and cord include:

- Tied daisy chains
- Webbing Sling
- Connection between ascender and carabiner
- Anchor points (and Multipoint anchors)
- Emergency harness
- Basket hitch connection
- Girth hitch connections
- Cord Sling (Cordelette)
- Prusik (or other friction hitch) connection to climbing rope
- Accessory rope

There are hundreds of other possible uses for both webbing and cord, way too many to list here.

SUMMARY

Personal Protective Equipment.

- Helmets must have chinstrap to prevent helmet from falling off.
- Safety glasses when going down scaly slope or belaying someone from below.
- Warehouse carries different styles of safety glasses.
- Loose gloves can jam a rappel device.
- Shin guards are highly recommended during scaling operations.

Harness

- Check the fit of your harness
- Check the components of your harness: Buckles, leg loops, accessory loops, and waist support.
- Care for harness.
  - Inspect harness for wear spots after every use.
  - Do not lend others your harness. Everyone uses equipment differently.

Rappel and Belay devices

- A Rescue "8" is the recommended rappel device for scaling operations
- Some descenders can be used to belay climbers
- Must be able to lock off device
- A munter-mule hitch is the CT recommended method of belaying.

Daisy Chains (Personal anchoring systems)

- Use only CT approved daisy chains.

Ascenders

- One right and one left handed ascenders.

Carabineers – Locking and regular (non-locking).

- Should have at least 6 non-locking and 4 locking.

Nylon webbing

- Should have at least 100' of the 1" and about 50' of the 9/16", for various uses.
- Mark all webbing with year and initials.
- Inspect all webbing before using it.

7mm Cord

- Should have at least 50', for various uses.

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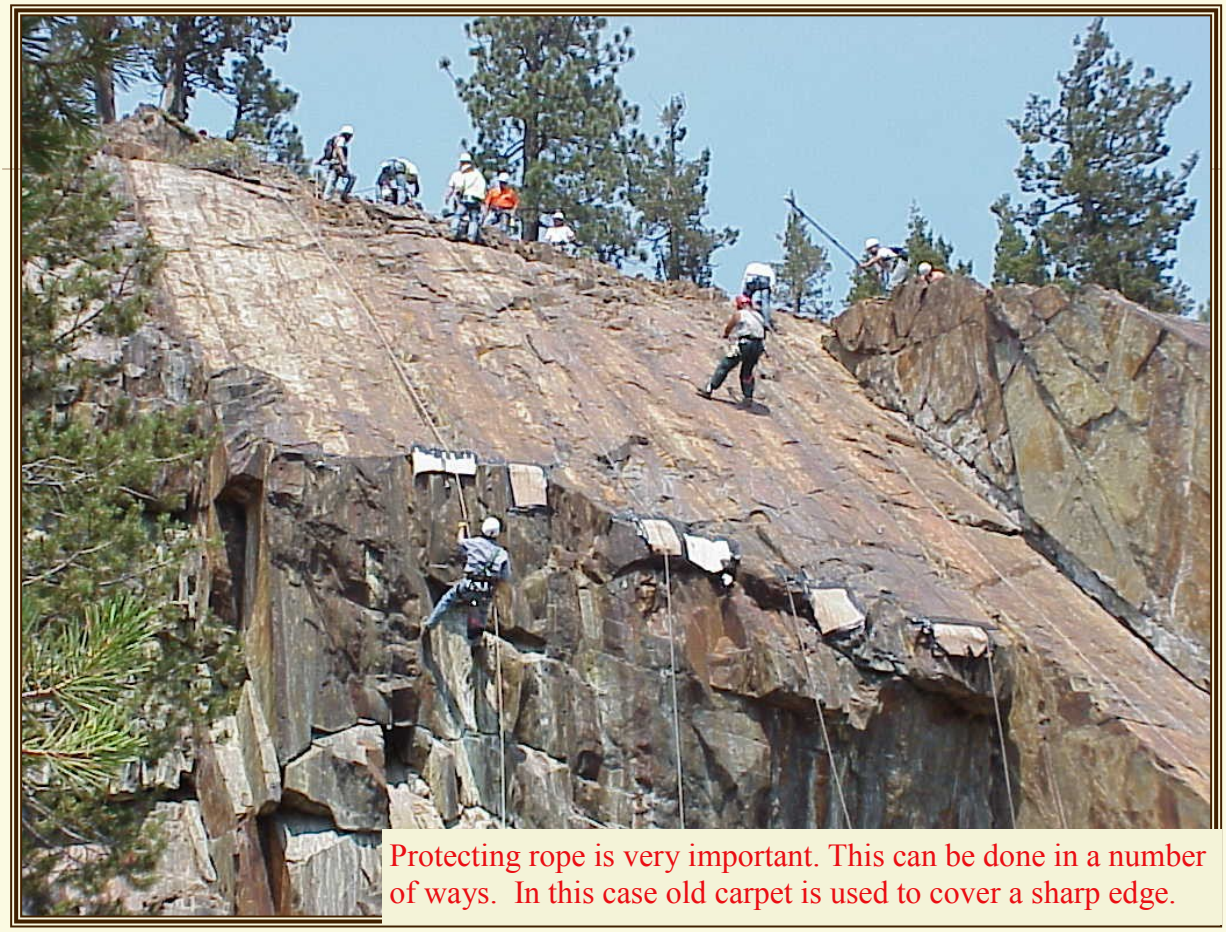
Chapter 6

Rope



Protecting rope is very important. This can be done in a number of ways. In this case old carpet is used to cover a sharp edge.

ROPE

A rope can be dead weight on the approach and an indispensable lifeline on the climb. It serves as a link in the communication between climber and belayer-its subtle tugs and jerks relaying the progress of a partner out of sight and hearing. A rope is cursed when it tangles, praised when it holds, and on occasion has the annoying habit of being just a few feet too short at the wrong time.

For bank scaling, we use Safety Blue Rope rated at 7000lb.

New England Safety Blue rope is a 1/2 inch (12.7mm) diameter static kernmantle rope. It gets its name from the blue inner core of the rope. The outer sheath covers the inner core, so if you can see the blue through the sheath, it's time to retire the rope. It is UIAA approved.

CONSTRUCTION

Lay and braided are two basic styles of rope construction. The type of material and the number of strands used to construct the rope generally determine the strength of the rope. Common natural fibers used to make rope include hemp, linen, cotton, jute and straw. Common synthetic fibers include nylon, polyesters and polyethylene.

Lay ropes

Lay (also called laid) rope refers to the construction method of rope used throughout history. It consist of three or more strands of fiber twisted together in one direction to "lay" the rope. This type of rope may be used for very mild slopes where you need just a little help walking up or down the slope.

Braided ropes

In braided ropes, multiple fibers are woven together in opposite directions to form the rope. This type of construction allows different properties to be built into rope. Using different synthetic materials can allow the rope to be stronger, more elastic, more water resistant, or more flexible.

Kernmantle ropes

In kernmantle ropes, the "mantle" is a woven sheath of nylon over the "kern," or core, of twisted strands. The mantle contributes about one-third of the rope's strength, but its main function is to absorb the abrasion that would be continually weakening the inner core, which provides most of the strength. It provides a smooth, uniform surface that reduces friction over rock and through carabineers. Kernmantle ropes are flexible, easy to handle, and hold knots well. While more expensive than lay ropes, they have many advantageous features for the technical climber. It is very important to inspect kernmantle ropes often, especially in a lifeline application, since damage to the kern may not be visible through the mantle. Sometimes a flat or soft spot under the sheath can be felt, which could indicate there is damage to the core..

Kernmantle vs. Lay ropes

- Lay ropes lack a protective sheath
- Kernmantle ropes can be constructed with different properties for different proposes
- Lay ropes tend to untwist when loaded, causing loads to spin
- **If the core of a kernmantle rope is damaged, it can be hard to detect!**

STATIC vs. DYNAMIC ROPE

Simply put, dynamic rope stretches while static rope does not. Technically, all ropes have a little bit of stretch when you put a load onto them, even static ropes. However, dynamic rope is specially constructed to have more elasticity. In the climbing community, you will hear a lot about how important it is to use dynamic rope. Dynamic ropes stretch when loaded, so they can soften the impact of a fall, reducing the shock on the body. This is important when the main function of the rope is for fall arrest.

Static rope is more applicable in rappelling and ascending operations. They are also the preferred rope for rescue operations. Static ropes reduce bouncing and allow for more control while descending. While ascending, nothing is more disheartening than making the effort to ascend a few feet, only to have the rope stretch back down to where you just were.

EDGE PROTECTION

In our class we take rope guarding very seriously. We use a combination of Velcro, canvas, plastic and metal roller caterpillar edge guards at various locations throughout our practice facility. Every climber should have access to some form of edge protection for use when they climb. Even an improvised form of edge protection is better than nothing. If nothing else is available, a canvas rope bag or even a spare shirt can be strategically placed to protect the rope from a sharp edge.

ROPE MAINTENANCE

Rope maintenance is very simple. If you are storing them, keep them in a dark, cool, dry place so that they don't get sun damaged and/or moldy. As a rule of thumb, you should not use a rope any more than five (5) years.

In rappelling, caving, and rescue applications it is important to take measures to protect the rope. Always take care to rig the rope safely and pad any places where it could be cut or abraded. Avoid dragging the rope from side to side under tension as the rock may abrade or saw through it. A rope under tension will abrade much more quickly than one that is not. Bouncing on your rope may also cause abrasion. It is also important to rappel slowly and in control. Fast bounding rappels are not only unsafe, but can generate enough heat through friction with the rappel device to melt or glaze the sheath of the rope. Once a rope is glazed; it loses a considerable amount of its flexibility and strength.

- **Avoid stepping on your rope as a matter of good housekeeping** even though recent testing has shown that dirt in the rope fabric does not weaken the rope.
- **Do not use climbing ropes for hauling** or for any purpose except climbing operations.
- **Do not splice climbing ropes.** Use a bend knot to connect to two ropes.

KEEP YOUR ROPE CLEAN

One of the biggest things you can do to extend the life of your rope is to keep it clean. To keep your rope clean, minimize its contact with the ground. Keep the rope in a rope bag when not in use. If you need to access the entire rope (to find the middle, to use both ends of the rope, …) pour the rope onto a tarp or a clean rock surface. Even the chemicals in concrete and asphalt, especially hot asphalt, are a concern. The chemicals and oils can leech into the rope and weaken it over time. Keeping your rope clean will give it longer life.

- Clean your rope when it becomes dusty, muddy, or dirty.
- Wash your rope in a washing machine using very mild detergent, such as Ivory.
- DO NOT dry your rope in the dryer. This will damage the rope but the damage will be undetectable.
- Hang your rope to air dry...out of direct sunlight.

You should retire the rope if it has:

- Been in use for more than five years
- Been used to haul a boat, or similar
- Taken any large falls
- The blue core visible through the sheath
- A soft or flat spot under the sheath

STORING YOUR ROPE

When not in use, the best way to store your climbing rope is to flake it into a rope bag. Flaking means starting at one end of the rope and letting the rest of the rope follow, without coiling or looping.

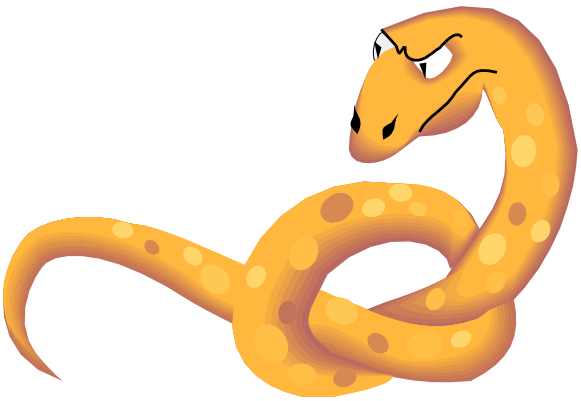
Start with tying a figure 8 stopper knot at one end of the rope, with about a foot of tail past the knot. Inside the bag, pass the tail through the eyelet at the bottom of the bag and tie another figure 8 stopper outside the bag. This will keep the tail from being pulled into the bag, and the rest of the rope from being pulled out the bottom of the bag. Also you cannot rappel off the end of your rope with this set up.

After tying the two knots, the rest of the rope can be "stuffed" into the bag, one bit at a time. It is important not to stuff coils or loops of rope as this may cause the rope to tangle and possibly knot itself. These tangles can only make it more difficult to smoothly feed the rope out later.

Another benefit of flaking the rope like this, is that every bit of the rope will pass through your hands as it is flaked. This allows you to look and feel for any damage to the rope.

Here are a few things to keep in mind when storing your rope:

- Keep your rope in a rope bag when not in use and keep it stored in a safe place. Ropes tend to "snake away."
- Properly flaking your rope into the bag ensures that it will be ready to go the next time you need it.
- Store ropes used for climbing away from cutting edges, sharp tools, corrosives, chemicals, or heat, sunlight, and humid conditions.
- Rope bags are made to hold lengths of 100', 200', and 300', etc. The proper length for a rope depends on its intended use. We generally use rope cut at 100' or 200'.



CLIMBING GEAR I

lifted. Front points should protrude out one-half to three-quarters of their length beyond the sole, and all points should be as close to the edge of the sole as possible.

CLIMBING ROPE

A rope can be dead weight on the approach and an indispensable lifeline on the climb. It serves as a link in the communication between climber and belayer: its subtle tugs and jerks relaying the progress of a partner out of sight and hearing. A rope is cursed when it tangles, praised when it holds, and on occasion has the annoying habit of being just a few feet too short at the wrong time.

Lay and kernmantle are the two basic choices of rope. Goldline and Skyline are American-made with a three strand lay construction. They are less expensive than kernmantle ropes, and very strong. The drawbacks of lay construction ropes are their lack of a protective sheath such as kernmantle ropes have, their stiffness, their high stretch under low loads, and their tendency to twist and kink on rappels.

KERMANTLE ROPES FOR THE TECHNICAL CLIMBER

Kernmantle ropes, while more expensive than lay ropes, have many advantageous features for the technical climber. The "mantle" is a woven sheath of nylon over the "kern," or core, of perlon strands. Perlon is the trade name for a type of nylon having characteristics desirable in climbing ropes. The mantle not only contributes about one-third of the rope's strength, it also absorbs the abrasion that would be continually weakening the inner core, and it provides a smooth, uniform surface that reduces friction over rock and through carabiners. Kernmantle ropes are flexible, handle easily and hold knots well.

The proper length for a rope depends on its intended use. For glacier travel and non-technical rock, a length of 120 feet is adequate. Ropes of 150 feet are standard for rock climbing; however, some parties prefer using 165-foot ropes.

Ropes with a 10.5mm to 11mm diameter are standard for every type of climbing except moderate snow climbing where 9mm ropes are adequate. Double rope technique with 9mm rope is very useful on long, winding routes to help eliminate rope drag and reduce the chance of cutting the rope over sharp rock.

ROPES UNDERGO IMPACT FORCE TESTS

Climbing rope breaks occur because the rope has been cut, overheated through misuse of a rappel device, or weakened by chemical contamination, ultraviolet rays or previous falls. If ropes are given the proper care, a more important consideration then becomes the impact force.

The impact force is the amount of energy transferred to a climber's body attached to the end of a rope during a fall. Impact force is one of the factors considered by the UIAA (Union Internationale des Associations d'Alpinisme), an international organization of alpine clubs that develops and maintains standards for ropes and other climbing equipment.

UIAA has devised a standard test for impact force involving a weight of 80 kilograms attached to one end of a 2.8 meter length of test rope. The other end of the rope is attached to a fixed anchor and passes through a carabiner 0.3 meters above this anchor. The weight is raised the remaining 2.5 meters and dropped, resulting in a free fall of 5 meters. This simulates a severe leader fall. The UIAA has determined that the impact force transferred to the weight at the end of the rope should not exceed 1200 kilograms on the first fall. The same length of rope must withstand five such impacts to meet minimum UIAA standards.

Each type of rope carried by REI has been tested by our quality control department. Kernmantle ropes meet or exceed UIAA standards. For a listing of the number of UIAA falls each rope can sustain, refer to the climbing rope section of the current REI catalog. All Goldline and Skyline sold through REI must meet our three-fall minimum standard.

While it is desirable to have a rope stretch under a severe load, thus lessening the impact force on a falling climber, it is inconvenient to have it stretch excessively under low static loads. Applying tension, rappelling, jamaring and sack hauling are all made more difficult by a rope that has the characteristics of a rubber band. The UIAA limit for low load stretch is six percent of the rope's length under a static load of 75 kilograms. All the ropes REI carries pass the six percent standard except Goldline and Skyline which, while they meet criteria for impact force and strength, exceed the limit for low load stretch.

PROTECTING A ROPE

The proper care of a climbing rope is vital to the climber's safety. Stepping on a rope at any time is considered extremely poor form and usually elicits a salty response from the rope's owner. When two or more climbers and their gear occupy the same tiny ledge, the proper climber will engage in a variety of contortions to avoid the rope underfoot.

Dirt can work its way into the fibers of a rope and cause internal abrasion. The dirty rope itself is an effective abrasive. Cases have been noted where a long, fast rappel with a dirty rope has resulted in a brake bar nearly worn through by the abrasion. To clean a rope, hand wash or wash in a tumble-type washer with a mild detergent in warm water, then drip dry. Do not machine dry. Washing a rope is not a weekly chore; it should be done only when the rope is obviously quite dirty.

Water can be a problem also. A rope can soak up a great deal of it, becoming heavy and hard to handle. So-called "Superdry" or "Everdry" ropes are made to repel water by treating the fibers with a water repellent before the rope is braided, ensuring lasting repellency that won't wear off after the first climb. Such treatment does not affect the handling characteristics of a rope to any discernible degree.

Ultraviolet rays cause a photochemical change in nylon that eventually weakens it. Short of climbing in the dark, not much can be done to protect a nylon rope from the effects of ultraviolet rays. The coloring of the sheath helps protect kernmantle ropes from UV deterioration. Damage caused by sunlight probably will not seriously weaken a climbing rope before other factors cause its retirement.

WHEN TO RETIRE A ROPE

When should a rope be retired? When there is any doubt about the rope's ability to hold a fall. There is a great deal of difference between the wear and tear on a rope used for snow climbing and fourth class rock, and one used for multi-day, big wall climbs where there is frequent jumaring, sack hauling, pendulums and a fall here and there. The user knows the history of a rope; he or she must decide.

After considerable research and testing by the Austrian Alpine Club and the British Mountaineering Council, the average service life of a rope has been determined to be 100 hours for a UIAA approved three-fall rope, 200 hours for a four-fall rope, and 400 hours for a six-fall rope.

CMC ROPE RESCUE MANUAL

ROPE AND WEBBING

CHAPTER 5

On a big wall in Yosemite Valley, outside the 40th floor of the Hilton or in a 600 foot pit under Georgia, your access and escape route is the rope. Whether you are rappelling, climbing, belaying or moving a stretcher, the rope makes the job possible while protecting rescuer and victim alike. Hanging high above the ground involved in the rescue is when you really appreciate your effort to get the best rope and gear possible.

TERMINOLOGY OF RESCUE ROPE

ROPE FIBERS: Nylon is the primary fiber used to manufacture rescue ropes. Its primary advantages are high strength, high resistance to abrasion, the ability to absorb shock loads and reasonable cost. Wellington Puritan and Pigeon Mountain Industries use Type 6,6 nylon. They say this is a premium grade cordage nylon and that its higher melting temperature) is what gives their ropes better abrasion resistance than ropes made with Type 6 nylon. Nylon ropes are sometimes called 'Perlon' ropes. Perlon is a European trade name for a Type 6 nylon used to make dynamic climbing ropes.

Polyester fibers have the strength and abrasion resistance advantages of nylon, but the low stretch feature of this fiber reduces its ability to handle a shock load. While nylon fibers absorb water with a strength reduction of up to 15 percent, polyester fibers do not. New England's KM III and some early Wellington Puritan Rhino Rescue Ropes featured a nylon core with a polyester sheath. The nylon core would handle the shock loads and the polyester sheath would provide the environmental protection.

Polypropylene and polyethylene fibers produce a rope that will float on water and are most often found in water rescue throwlines. Because of the fibers low strength and durability, rope manufacturers recommend that ropes made of these fibers should not be used for rappelling, hauling heavy loads or in rescue systems.

Figure 5-1: Three strand twisted or laid rope.

Figure 5-2: Static, kernmantle rope showing core (kern) and sheath (mantle).

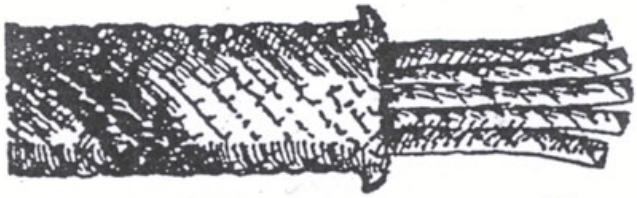


Figure 5-3: Dynamic, kernmantle rope used for rock climbing.

Figure 5-4: Double braid rope showing the braided sheath and braided core.

Manila is no longer considered acceptable as a fiber in life rescue ropes. Its strength is much less than nylon when new. Due to the aging of the natural fibers, the strength deteriorates rapidly even with the best care.

SUMMARY

- Climbing rope shall be UIAA approved. (Union Internationale Des Assocotions d'Alpineisine / International Organization of Alpine Clubs).
- Only use static line approved for bank scaling. Use Kernmantle rope.
- Dynamic ropes are mainly used for recreational climbing. These ropes have about a 10% elongation at the time of impact.
- Always inspect rope before a climb and after a climb.
- Never splice a climbing rope.
- Never use your climbing rope as a haul rope.
- A retired rope may be used for a haul rope, but should be easily identified as such.
- When a rope is retired it should be cut into smaller pieces so it will not be used for climbing.
- Do not allow someone to get a hold of a retired rope and use it for climbing.
- Avoid stepping on your rope. Stepping on a rope grinds in the dirt.
- Clean your rope when it becomes dusty, muddy, or dirty.
- You may wash the rope in a washing machine using a very mild detergent, such as ivory soap.
- Do not put your rope in the dryer to dry. This will damage the rope unnoticeably.
- Hang your rope to air dry, but not in direct sunlight.
- As a rule one should retire the rope after a severe impact fall. The sheath on the outside of the rope tends to hide the internal damage. The risk is too much to chance.
- Standard lengths of rope should be 100 or 200 feet. Recreational climbing rope may be different.
- Keep your rope in a rope bag when not in use. Store it in a safe place.
- Keep rope away from heat, chemicals, sunlight, and humid conditions.
- A rope tends to disappear when left exposed.
- Rope bags usually come sized for 100', 200', or 300' of rope.
- Do not lend your rope to anyone except those you trust to take good care of it.
- **Remember that your life depends on the integrity of the rope.**

Chapter 7

Knots and Hitches

KNOTS

Knots connect climbers to the rope and to the anchors. They enable us to make webbing and cordage into slings. They can secure ropes together, and provide a variety of functions in the climbing world, including, but not limited to; anchoring, lowering, belaying, self-rescue, and providing a place to hang our lunch.

We use "knot" as a general term; referring to all knots, hitches, and bends. The free end of the rope is the end you use to tie the knot, while the standing end refers to the rest of the rope.

- We use knots to form a loop or noose, fastens two ends of the same cord, or creates a "stopper" in the end of the rope.
- A bend joins two free ends together, and a hitch grips a shaft or another rope.
- A finished knot should be neatly "dressed" with no extraneous twists to facilitate easy visual inspections. Knots should also be cinched tightly for security.
- Rope, cordage and webbing are strongest when loaded in a straight line. When you bend the rope or web to create a knot, the strength of the rope is reduced.

FOUR MAJOR CONSIDERATIONS FOR KNOTS

The four major considerations for knots are:

1. Ease with which knot is tied.
2. Ease with which knot is identified.
3. Ease with which knot is untied.
4. Strength loss to line.

KNOT BREAKING STRENGTH

Remember that strength alone is not the only consideration. The Overhand loop is a strong knot, but may be impossible to untie after being loaded. The other loops are within a few percent, but much easier to untie.

Neatness counts when tying a knot. Making the rope run smoothly without any extra bends or twists is called dressing the knot. It makes the knot stronger, and easier to check.

KNOT SECURITY

A secure knot is one that does not come undone by tumbling or slipping. The figure 8 series of knots and the double fisherman tend to tighten no matter how they are loaded. Bowlines are not particularly secure, as they tend to loosen when the knot is loaded and unloaded or may tumble if pulled in the wrong direction.

The water knot can be secure but it must be set tight. Safety knots can be set on each side, but should not be relied upon entirely. Before climbing, always check the security of a previously tied water knot.

UNTYING KNOTS

To untie a knot, you need to create movement to generate slack somewhere in the knot that will allow more movement. Try pushing parallel ropes opposite directions, or bending a loop further. Sometimes twisting or rolling the knot between your hands will help.

People that work with rope a lot carry a fid or a marlinespike, each type a strong, slender tool that can be inserted into the knot to help loosen it.

In an emergency, if you cannot untie a knot, you should be equipped to safely cut the rope.

KNOT BREAKING STRENGTH

The tests used Federal Test Method 191A, 6016 since it is the method used by the manufacturer's to determine new rope strength. Four sets of five breaks were done to determine the strength of the rope and web without a knot. Five breaks were done for each knot and the average results reported. The knots were tied and Jerry Smith, California Mountain Company, Ltd. conducted the tests.

Control Rope	10,705	**Strength in Pounds**	**Percentage Lost**
Control Web	4,800		
BENDS			
Double Fisherman's Knot		8,440	21%
Figure 8 Bend (Flemish Bend)		8,640	19%
LOOPS			
Figure 8 Loop (with a bight)		8,560	20%
Figure 8 Loop (follow-through)		8,640	19%
Double Figure 8 Loop		8,820	18%
Inline Figure 8 Loop		8,000	25%
Bowline		7,180	33%
Overhand Loop (with a bight)		9,060	15%
Overhand Double Loop		7,900	26%
ROPE WITH A LOOP (a)			
Figure 8 Loop		6,960	35%
Inline Figure 8 Loop		6,280	41%
KNOTS IN WEBB			
Water Knot		3,060	36%
Overhand Loops		3,120	35%
Figure 8 Loop (with a bight)		3,360	30%
Figure 8 Loop (follow through)		3,560	26%
Water knot single loop		5,700	
Water knot double loop		12,920	
Water knot triple loop		22,860	

Caltrans Knots for Bank Scaling

We have grouped the knots according to what they do to help you picture which knots go where. You will notice that the knots group into a few families, which makes tying them easier to remember. We use the Figure 8 Family of knots in our climbing operations. Figure 8 knots meet all four considerations of the best rescue knot. In webbing, we use the Overhand family of knots.

Figure 8 Stopper

Father of the Figure 8 family. This knot allows retention of 80% of the rated strength of the line they tie into.

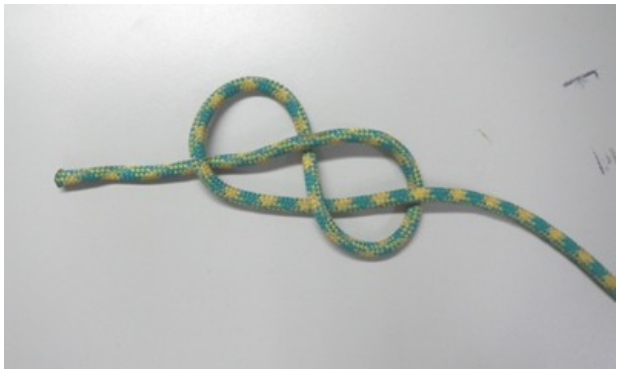


Figure 8 Bend (Flemish Bend)

Used to join two lines of approximately equal diameter together: If the two ends are the ends of the same piece of rope, this forms a loop.

Note:
The tail of the Figure 8 Bend or the Figure 8 Follow-through should be between one and two fists long.

Figure 8 Follow-through

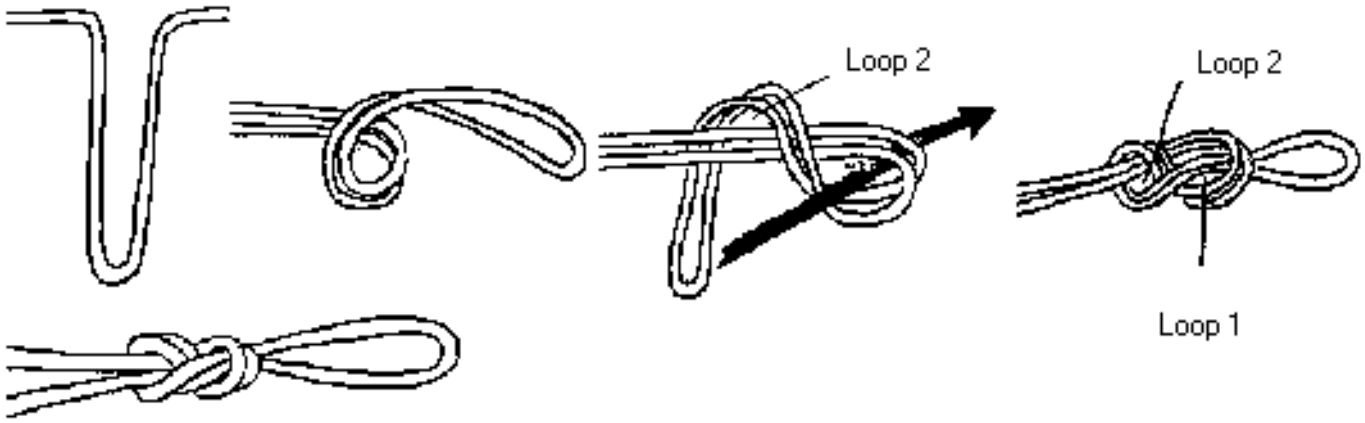
The Figure 8 follow-through is the knot we use to secure a line around a fixed anchor point. It is also used to tie in a climber on belay.

Figure 8 on a Bight

This is a common way to tie into the middle of a rope. Loading the rope from below weakens this knot.

Follow these steps to tie a Figure 8 on a bight:

1. **Form about a three-foot long bight at the point in the rope where you want to tie in.**
2. **Treat the rope as a single strand as you make a pretzel in the rope the same way you form the first half of a figure 8 follow-through knot.**
3. **Dress and set the knot.**

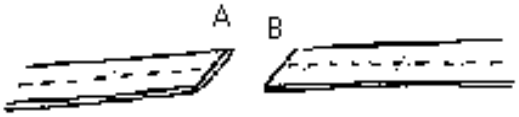


Water Knot

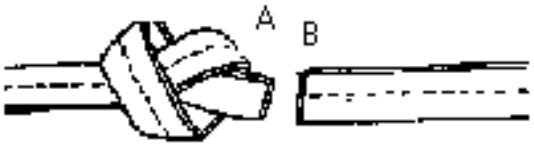
We use a Water Knot for joining nylon webbing only…this knot is not strong enough to use for rope. Make sure that you leave at least 3" of webbing extending from either side of the knot. These tails may be taped down with sticky tape.

To tie a Water knot:

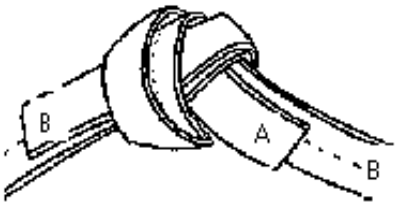
First, place two ends of webbing as shown.



Next, tie one of the ends in a loose overhand knot.



Then, take the free webbing end back through the overhand knot.

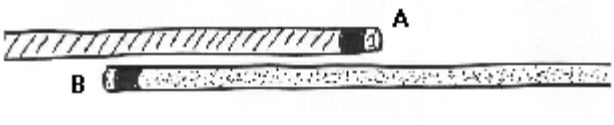


Double Fisherman's Knot

The double fisherman's knot is used for joining two ropes together, but it can be difficult to untie once loaded. Be sure that there is at least 4 inches of each rope extends from the knot after it is tied and tightened to allow for slippage.

To tie a Double Fisherman's knot:

Place the ends of rope to be joined together as shown.



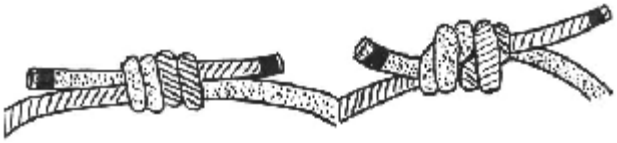
Wrap one end of the rope clockwise twice around the other rope and itself and work the rope so that the loops run back toward the main rope, wrapping them back on themselves.

Pull the rope running end of the rope through the rope you just created.

Repeat these steps with the other rope.

Pull the ends to set then pull the two sliding knots together and dress them.

The finished knot should look like this.



Girth Hitch

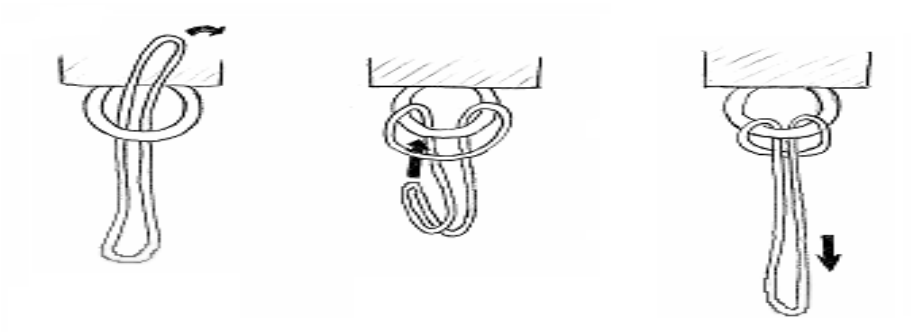
The girth hitch, also known as the cow hitch and the lark's head, can be used for many purposes. It can be used for joining two slings together. It is one of the simplest hitches to tie.

To tie a Girth Hitch:

Pull a bight of rope or webbing around the object.

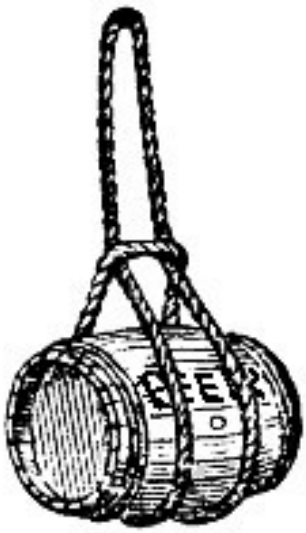
Bring the standing end of the rope or webbing through the same bight.

Pull on the standing end to secure the knot..



A girth hitch tied onto a ring.

A webbing girth hitch tied onto a cord sling.



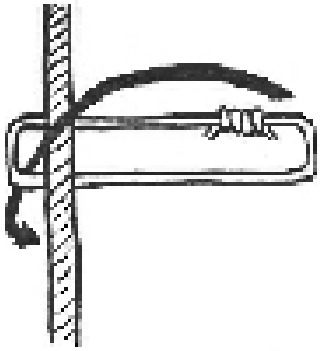
A girth hitch tied onto a keg of ...

Prusik Knot

We use the Prusik Knot to tie one rope onto another so that the knot holds when loaded, but still slides easily when loose.

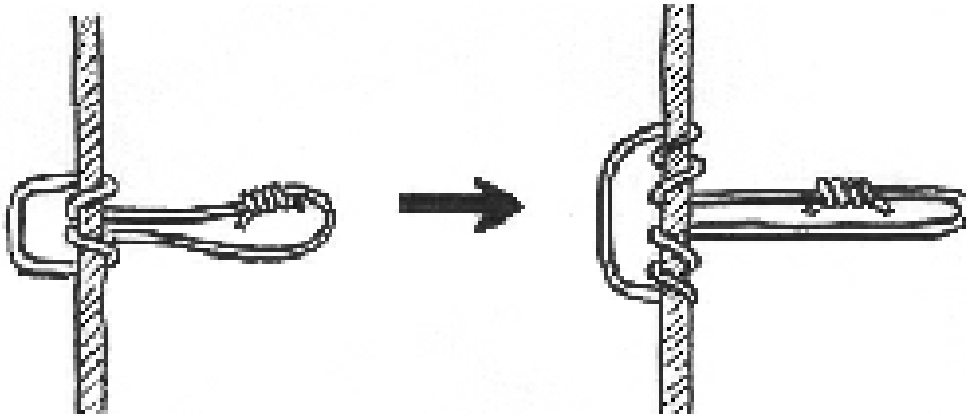
To tie a Prusik knot:

1. Tie a double fisherman's knot in a three to five foot loop of cord.



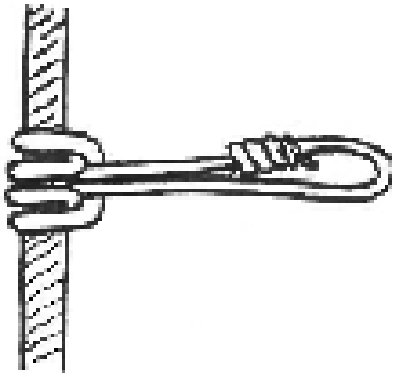
2. Place the loop either beside or underneath the main rope.

3. Pull the end of the rope with the double fisherman's knot up over the main rope and down through the prusik cord.

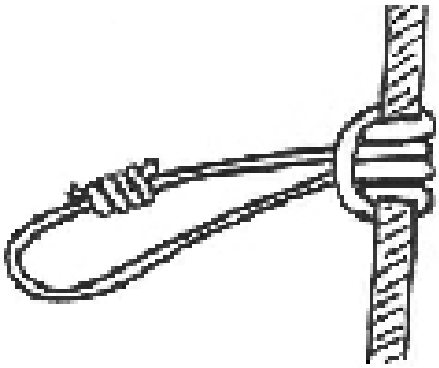


4. Repeat Step 3.

5. Pull on the long end of the rope to set the knot.



6. Dress the knot so it looks like the one below.

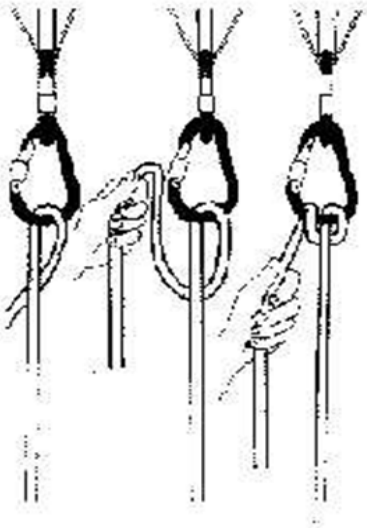


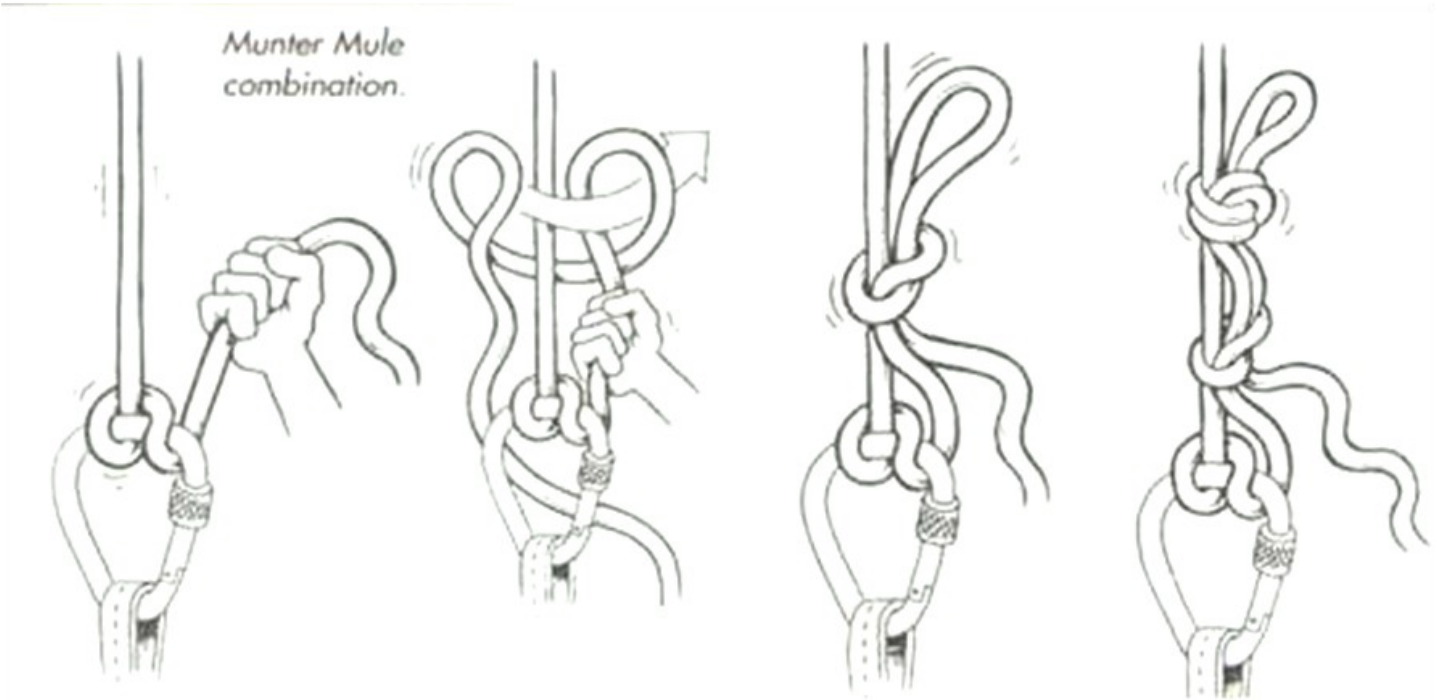
Munter hitch

The best friction knot, better friction then any belay device but has tendency to create kinks in the rope. Excellent method for belaying and lowering. The munter is reversible.

Twist a coil on the rope, then fold the lower strand over the upper strand, clip it into a carabiner. Can easily be transform into a clove hitch.

In rescue situation the Munter hitch combine with the blocking knot will keep the system releasable.



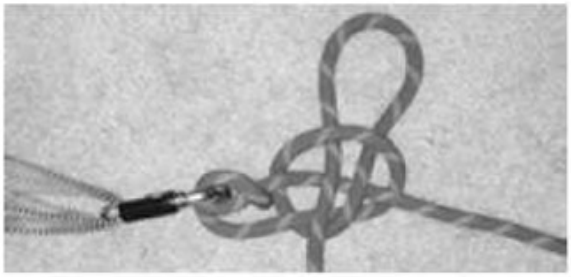


Tying Off a Munter Hitch on a Belay Line
A Sequential Article to Accompany Instruction
© 2002 Cyril Shokoples

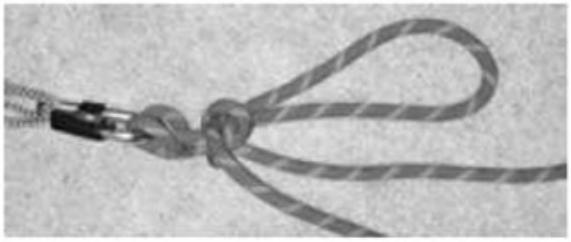
WARNING: Failure to use any or all of the devices or systems explained or illustrated in this article in an appropriate manner could result in property damage, injury or death. Expert instruction and constant practice are mandatory. This is not an instructional article. It is designed to accompany professional instruction and practice under supervision.

Step One: Hold the load on the Munter Hitch tightly during the entire process and DO NOT let go of the braking hand, even for an instant.

Step Two: Make a loop of rope exactly as shown.



Step Three: Pass a bight of rope through this loop as shown, creating an overhand slip knot.



Step Four: While ensuring that the load will not suddenly drop, tighten the overhand slip knot you have just made.

Step Five: With the bight of rope exiting your slip knot above, tie an overhand knot around the loaded line. At this point the Munter Hitch is tied off. Some people call this a "Tied – Off Munter Hitch" or "Blocked Munter Hitch" while in the US it is sometimes referred to as the "Munter Mule". You can know proceed to add additional backup knots or rig a system if required.

SUMMARY OF KNOTS

Figure 8 knot	The number one knot in climbing.
Figure 8 follow through	Used to tie into your harness and into anchors systems.
Figure 8 Bend	Used to connect the ends of two ropes together.
Figure 8 on a bight	Used to tie off to an anchor. Or hang your lunch from.
Water knot	Used for tying the ends of webbing together.
Double Fisherman's knot	Used for making up a cordelette.
Basket Hitch	Used for a quick anchor or directional.
Girth Hitch	Used to wrap and hold onto an object.
Munter-Mule combination	Used for lowering or belaying. A Mule ties off a munter.
Prusik	A rope on rope friction hitch.

Knots generally weaken the rope where they are located in the system. There have been many tests done to show this, but the actual strength loss numbers vary widely. The summary shown here indicates a range of relative strengths with some common knots tied in the system.

KNOT STRENGTH Summary

Knot	Relative Strength
No knot	100%
Figure Eight	70-75%
Double Fisherman	65-70%
Water Knot	60-70%
Overhand Knot	60-65%

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Chapter 8

Anchor Systems

Anchor Building

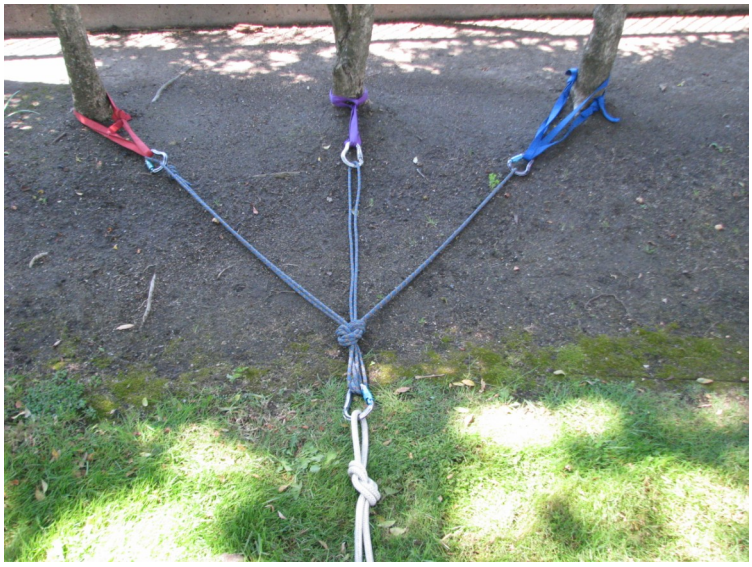
The goal of anchor building is to establish proper protection for the climber and a clear understanding of situation in which it will be used. It is important to know what we you are asking of the anchor and understand the limitations with the anchor design. The anchor must be sufficient to provide adequate strength for the anticipated climbing related activity and must take into consideration site variables and situations which could occur when it is being used.

In the beginning class, the focus is centered around establishing the basic concepts of single point anchorage utilizing adequately sized objects such as large trees, large rocks and vehicles. By the end of the beginning class, the student is expected to have a working understanding of utilizing webbing and static climbing rope to create a single point anchor sufficient to be safely utilized for a Caltrans climbing operation. This working understanding is accomplished by providing instructor lead demonstrations and multiple training exercises over the first two days of instruction.

In the refresher training course, anchor building techniques developed in the beginning class are reviewed and practiced. Additional demonstrations and instructor lead exercises are then provided to expand the student understanding of anchorage systems and application to varying site conditions. This additional training is intended to expand the students understanding of anchoring by introducing two point anchorage systems, multiple point anchorage systems and the concepts of anchor equalization. By the end of the refresher training, the student is expected to have the ability to develop a single point and multiple point anchorage system which could be safely utilized in a Caltrans climbing operation.

During each training session, the importance of proper site stewardship is discussed and practiced. For instance, it is important for the students to be able to indentify potential impacts to the climbing site. This includes understanding how ropes could cause long term damage to trees and shrubs, how visual impacts can be minimized by conscientious during site access, and minimizing long term impacts by developing thoughtful permanent anchorage systems

Single point anchorage systems

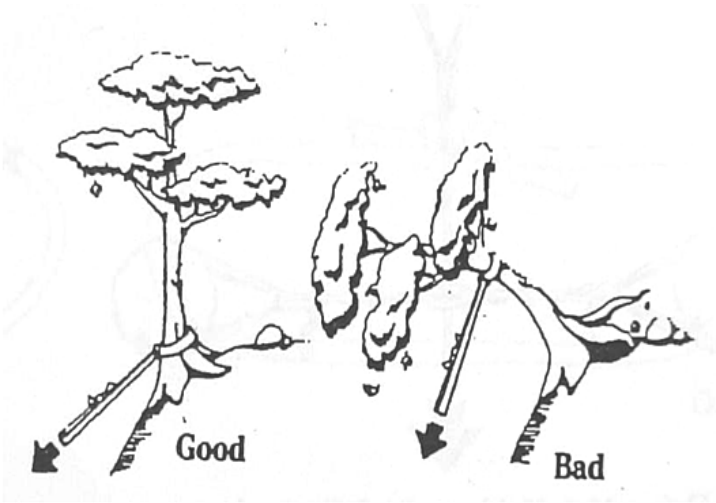


Multiple point anchorage systems

Anchor Systems

Recreational climbers have the luxury of climbing where they want to; usually well established routes with good, well known anchor points above. The climber can set her artificial protection at the anchor location, drop a rope and go on to climb safely, knowing she is tied into a solid anchor above. Caltrans bank scalers do not have that luxury. They often must access slopes where no recreational climber would even consider climbing. Think about it. The purpose of scaling is to remove loose rocks. A recreational climber likes rocks that they can grab onto and hang from. Caltrans scalers must often improvise an anchor out of the natural surroundings.

An anchor is the starting point of a system that will support the climber and anything he might need to carry. It is important to consider this when selecting the anchor. A large tree with a rope tied around it can be a solid anchor. Two of the more common anchors that we use in bank scaling are a Friction Wrap and a Figure-8 Follow Through, tied around a large tree or other solid object. Care must be taken when selecting a single-point anchor. A tree should be healthy with a good root system. Rocks should not be able to shift or roll. Observe if the rock is on the ground or in the ground.



Keeping the rope or webbing as close to the base of the anchor as possible maximizes the strength of the anchor. If there is a possibility of the web sliding up or off the anchor point, a Girth Hitch or a Clove Hitch will make the web grip the anchor point.

We like to use webbing for tying anchor points around rocks. It has high abrasion resistance and its wide surface area provides a good grip on the rock. . However, if a long extension is needed from the anchor to where you want to attach the system, use a rope, rather than lengths of webbing or smaller lines tied together.

Sometimes it is necessary to combine two smaller anchors to create a stronger anchor. When two anchor points are connected together at a single Master Point, an angle is created. If you do not use a long enough piece of web, the resulting interior angles will be large. As the angle increases, the force on the web (but not the anchor point) will increase. At high angles, the force can be as much as twice the weight of the load.

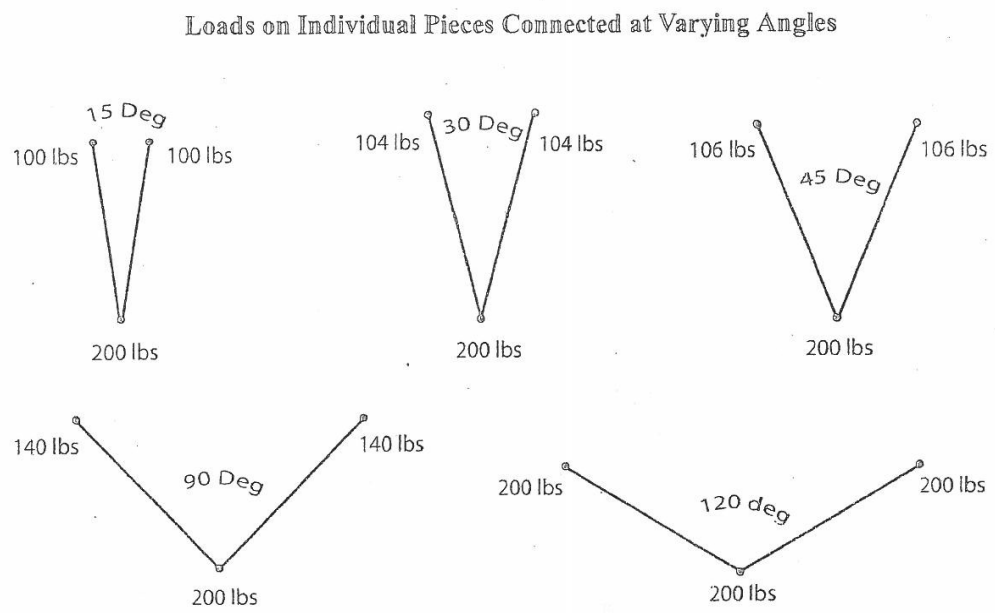
An anchor point may be strong when pulled one way, but much weaker when pulled in a different direction. Check the direction and make sure the anchor point will withstand the load.

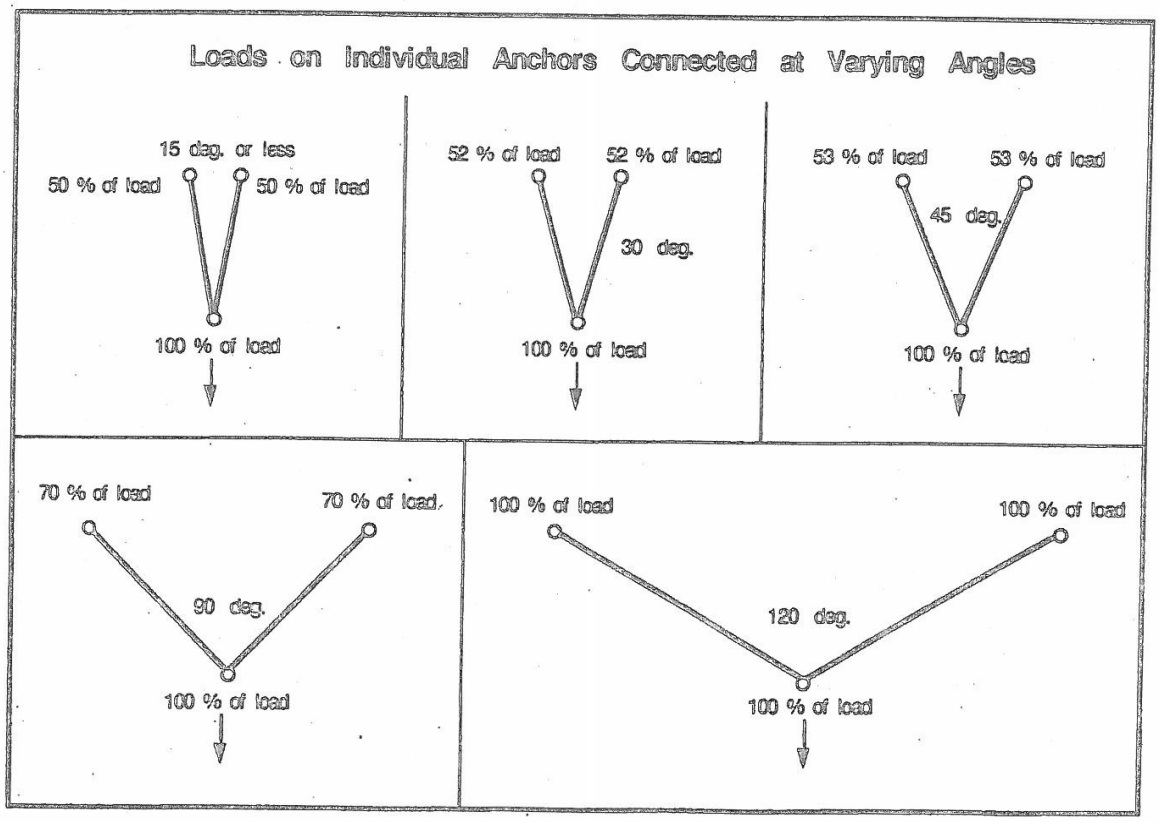
Here are a few things to think about when building an anchor:

- Choose an anchor system that is competent and easy to get to.
- Inspect the anchor tie and have someone else inspect it also.
- Tie your anchor knots neatly and tightly.
- Have a backup system built into your anchor point.
- Pre-load your anchor rope or webbing in the direction of pull.
- To connect a rope to a Master Point, use two opposite and opposing carabiners or locking carabiners.

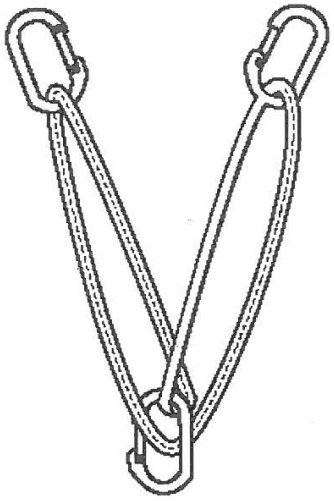
It is important to understand how different angles effect the loading of each element of the anchor system and directionals used. The larger the angle at the master point or the directional, the greater the load that each element will receive.

Angles and loads





Anchor Equalization

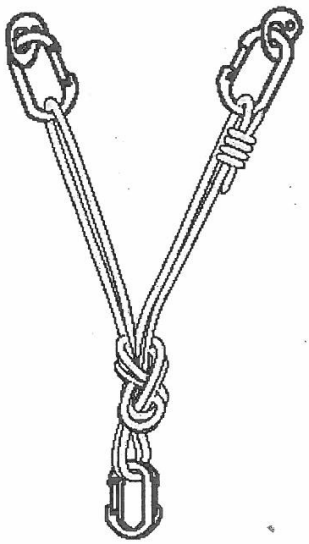


Pros
- equalized for changing directions of pull
- typically constructed with a normal length runner

Cons
- failure of one piece adds shock load to remaining pieces
- if sling fails, complete anchor failure occurs

Self Equalization

Pre - Equalization



Pros
- built in redundancy
- easy to use centralized clip in point
- no additional shock loading if one piece fails

Cons
- equalized for one direction of pull only
- ususally requires extra long sling

System to evaluate anchors—PESSBEE

P– Protection—Goal is perfect pieces

E– Equalization– Are the forces well distributed between anchors

S– Stability-Is the master point Stable

S-Strength-Is the anchor point strong enough

B-Belay-Can the belayer do a good job of managing the belay

E– Edges– Are the edges properly protected

E-Efficiency-Is the efficiently use available resources

I. Picket Holdfasts

A. Components

1. Pickets

a) Material used for the pickets-1" diameter, rolled steel, squared at one end, pointed at the other, 36" in length

b) Other suitable material for use as picket?

c) In a heavy rescue, often there is a need to utilize materials at the site as a resource

2. Material for forming a Spanish Windlass

a) Material used for the windlass-1/2" manila, three strand, laid rope, 15' in length

B. Construction specifics:

1. Picket

a) Driven 2/3 of their length into soil

b) Placed at a 15 degree angle on the non-load side

c) Distance between pickets should be approximately the length of the picket

d) Pickets placed in line, in the direction of the loading

2. Windlass

a) Tied with clove and half hitches

b) Start at bottom of rear picket and go to the top of the front picket

c) Multiple turns till approximately 12 - 24" tail remains

d) Finish off with appropriate hitch at either picket

e) Minimum of two full turns works best

f) Do not use the same piece of material to windlass all pickets

g) Tension is applied by twisting the wraps with another picket (or other suitable tool)

h) Tensioning results in the transfer of loading from one picket to another

i) Proper tensioning results in a integrated, load sharing anchor

j) Do not over tension; twist until the top of the forward picket moves and then back off and secure the tool used to form the twist

C. Loading

1. In average soil, the general guidelines for loading are:

a) Single picket = 700 lbs.

b) 1-1 = 1,400 lbs.

c) 1-1-1 1,800 lbs.

d) 3-2-1 4,000 lbs.

2. Numerous variables will affect the load capacity of the pickets

a) Type of soil

b) Moisture content of soil

c) Compactness of the soil

d) Materials used for pickets

e) Dimensions of material used for pickets

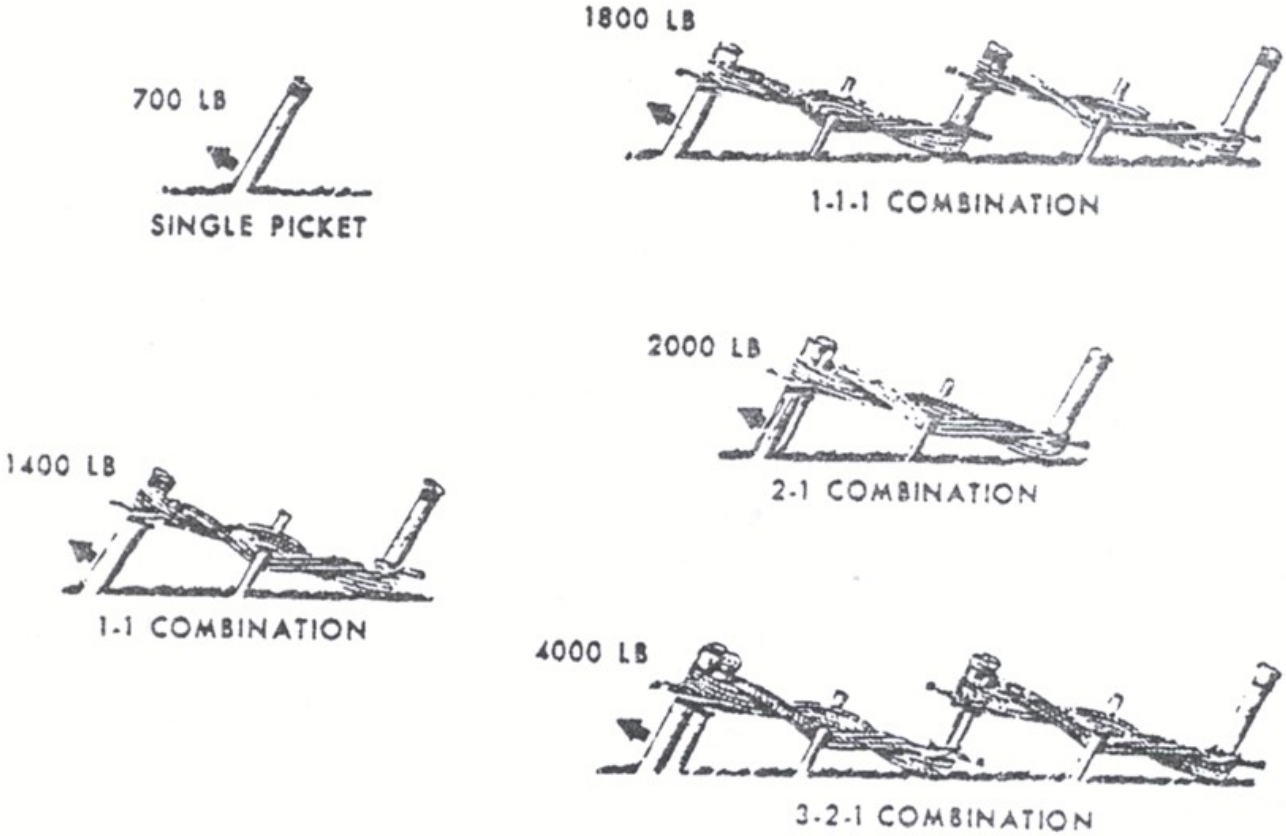
f) Loading: shock vs. gradual

g) Depth and angle of pickets

D. Application/Variations

1. Use of transoms with pickets

2. Multiple picket holdfasts rigged into a self-equalizing anchor



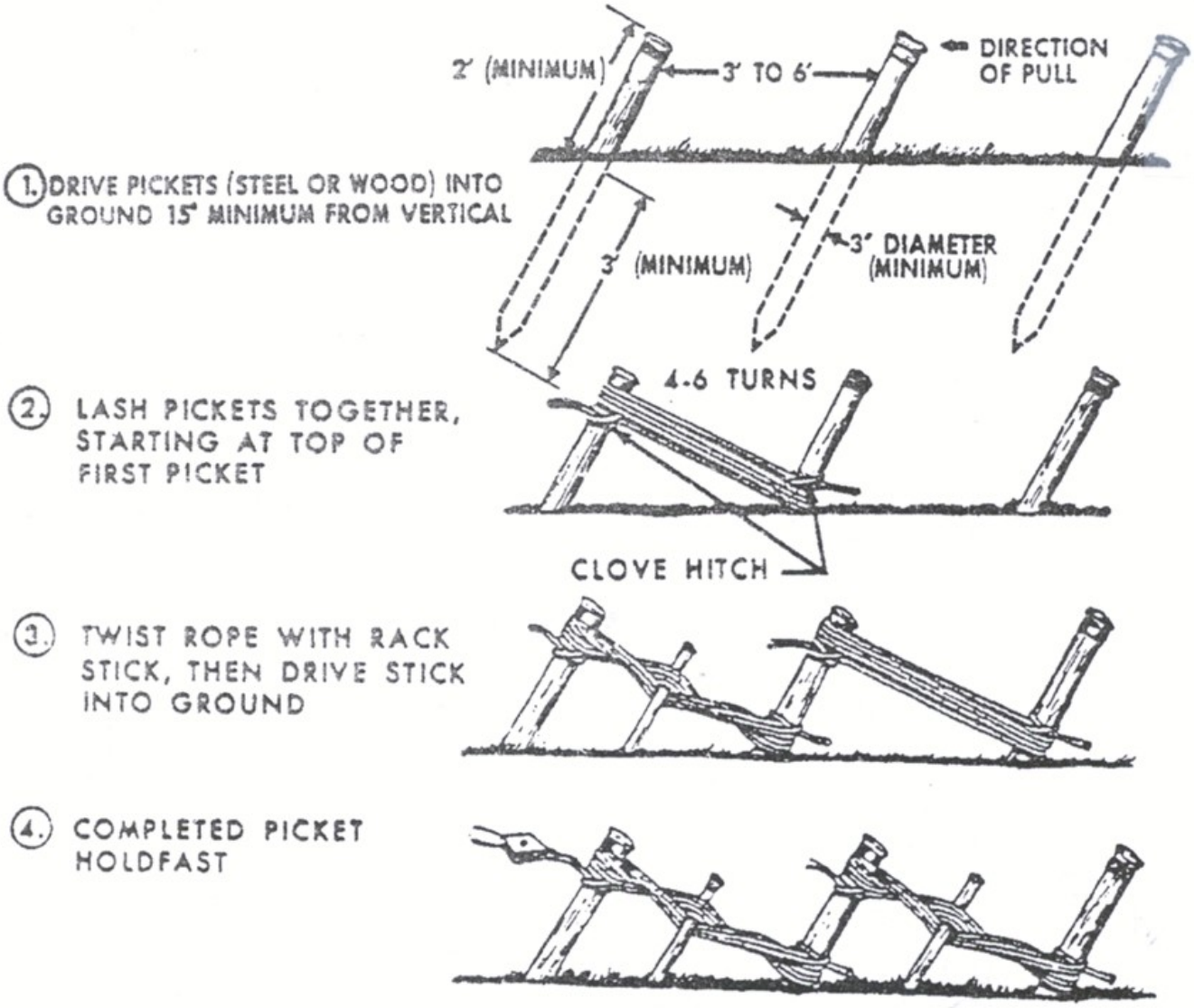
Picket holdfasts (loamy soil).

Holding Power of Picket Holdfast in Loamy Soil

Holdfast	Pounds
Single picket	700
1–1 picket holdfast	1,400
1–1–1 picket holdfast	1,800
2–1 picket holdfast	2,000
3–2–1 picket holdfast	4,000

Note. Wet earth factors:

Clay and gravel mixtures	0.9
River clay and sand	0.5



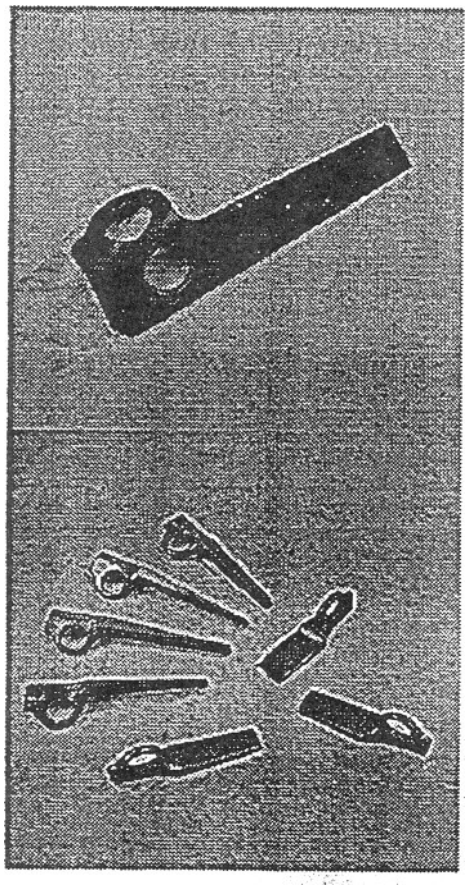
Preparing a picket holdfast.

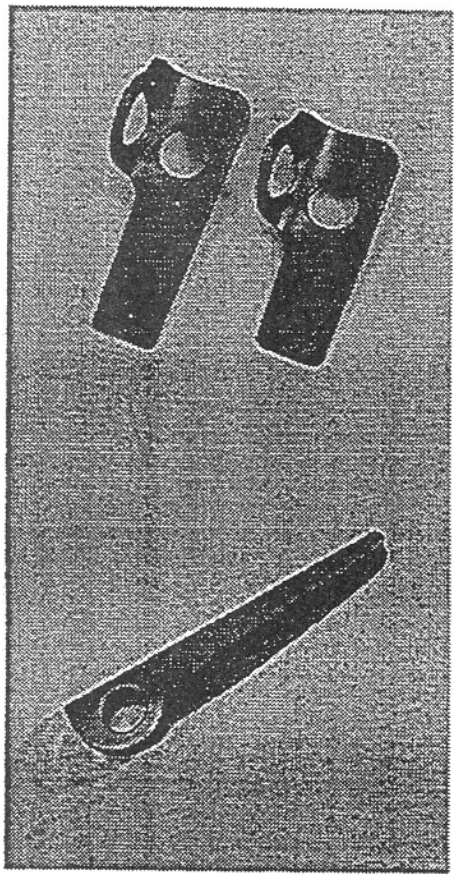
Lashed steel picket holdfast.

PITONS

Pitons are forms of passive protection that can be used for anchors or as directional's. Pitons are placed in cracks in rock by pounding them in with a hammer. Pitons come in a variety of shapes, sizes and lengths. The size and shape of the crack determines the correct size and shape of the piton that should be chosen. When properly placed, a ringing sound as opposed to a thud resonates with each hammer blow. A webbing loop should be placed through the holes in the pitons and the carabiner attached to the webbing. Remember to avoid metal to metal connections whenever possible. .

Thick Blade Various Sizes Cost $10.00

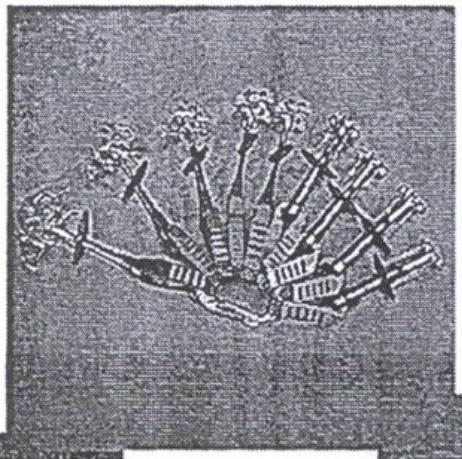


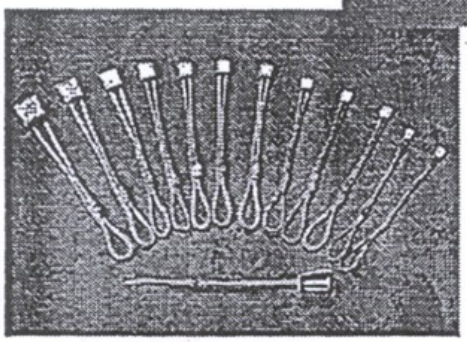


WIRE STOPPERS, NUTS & FRIENDS

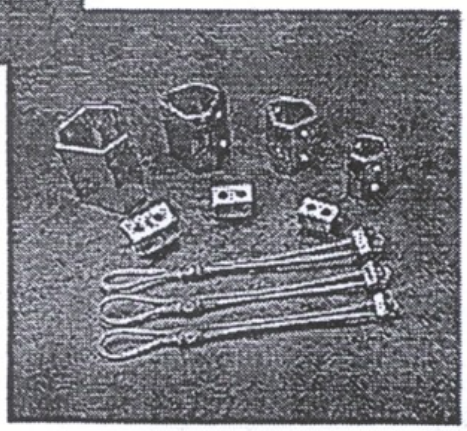
Like pitons, nuts and wire stoppers are forms of passive protection, whereas cam locks (also called friends) are active protection. Friends are mechanical devices that exert outward pressure on the inside walls of a crack locking themselves in place. Nuts and wire stoppers are placed in cracks and are held in place by the load applied to them. All of these devices can be used for anchors or directionals. Beware that when the direction of the load changes or during episodes of loading and unloading, nuts and wire stoppers can become loose and fall out. Remember to always use the "7-POINT RULE" when placing protection.

Friends
Various Sizes
Cost $55.00-$60.00 ea.





Wire Stoppers
Various Sizes
Cost $7.25 ea.



Nuts or Hexes
Various Sizes
Cost $10.75 ea.

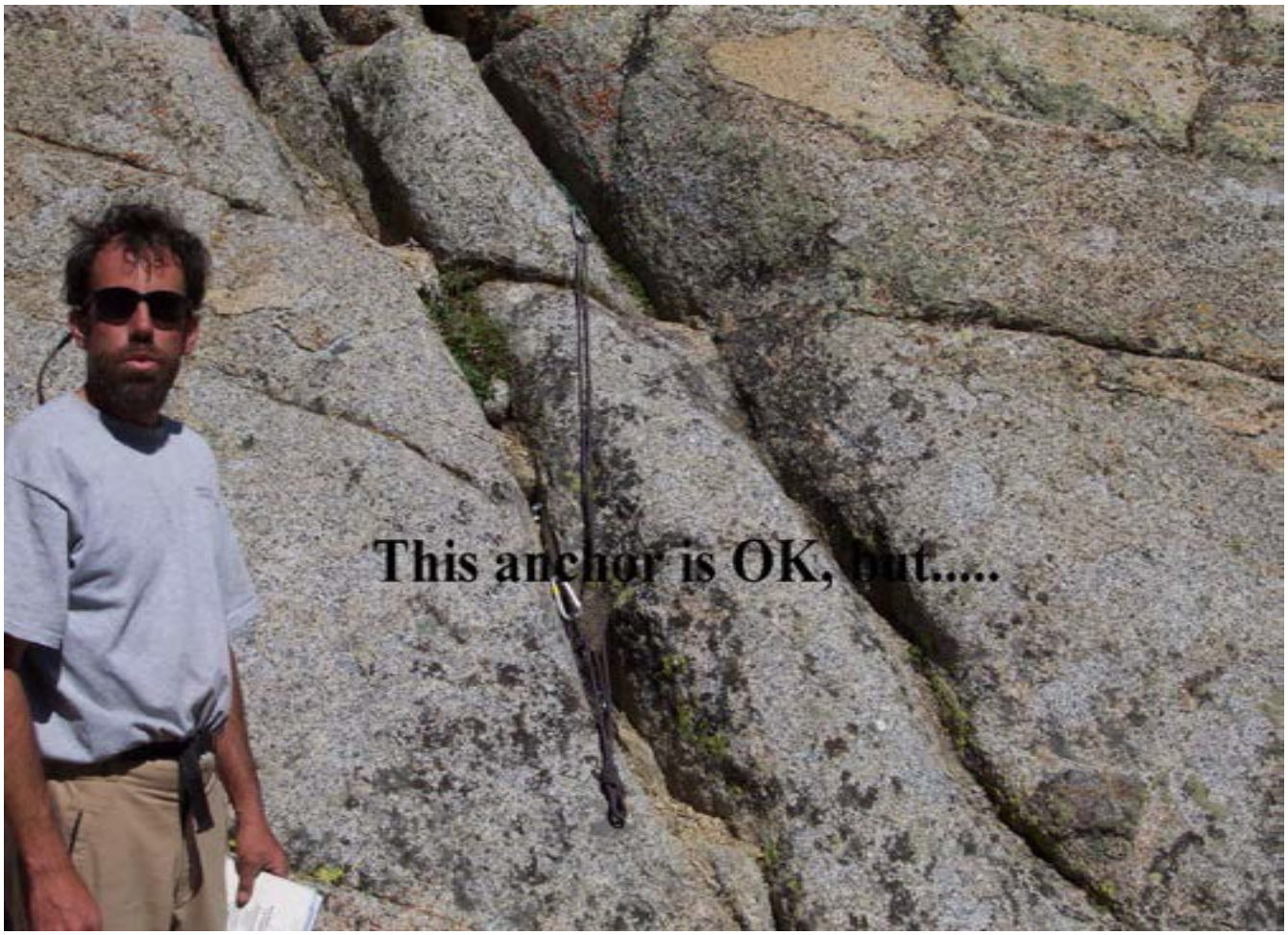
Sample Anchor Systems

Vehicle Anchor

Guardrail Anchor

SUMMARY ANCHOR SYSTEMS

- **Pick an anchor system that is competent and easy to get to**
- **Inspect the anchor tie and have someone else inspect it also**
- **Tie your anchor knots neatly and tightly**
- **Pre-load your anchor rope or webbing in the direction of pull. Is the anchor equalized?**
- **Use two opposite and opposing carabineers or locking carabineers at the master point**
- **Ensure that you have adequate edge protection**
- **Have you adequately protected the trees and minimized impact to the environment**



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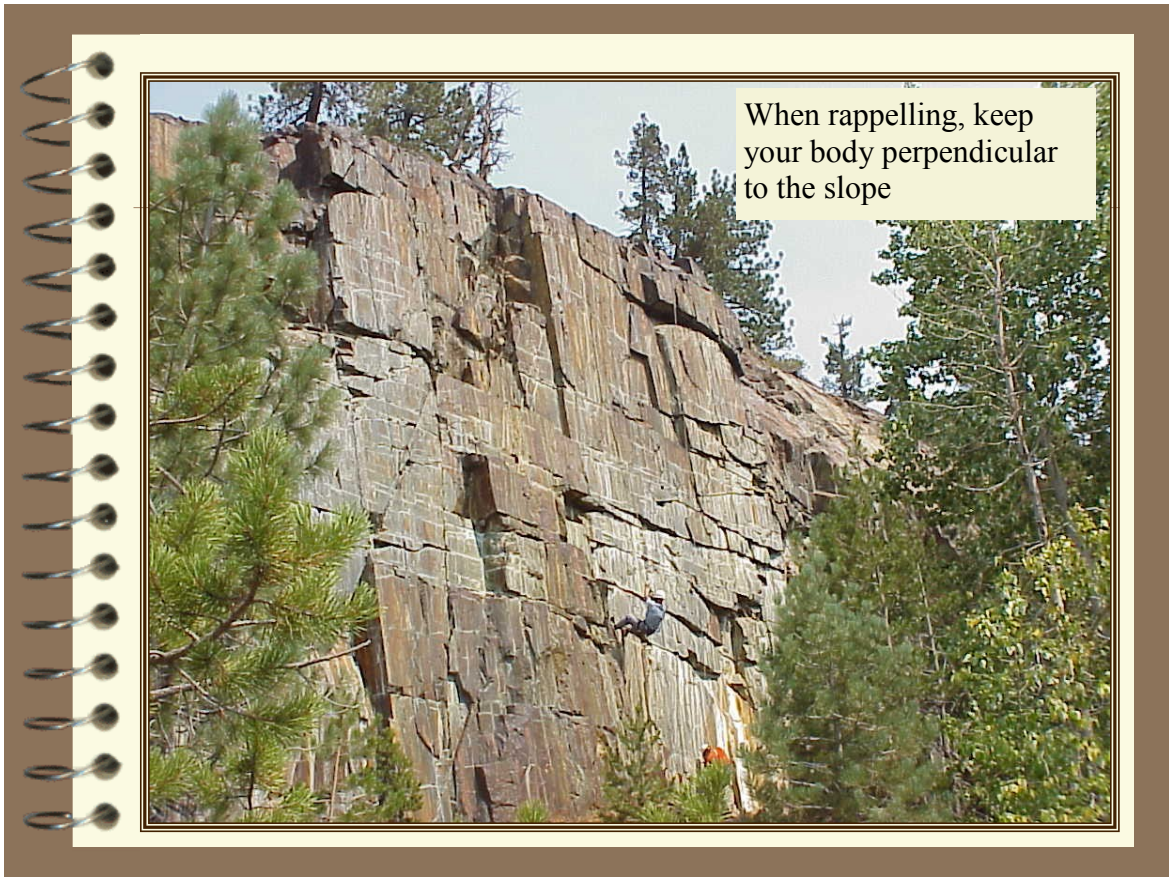
Chapter 9

Working on Rope



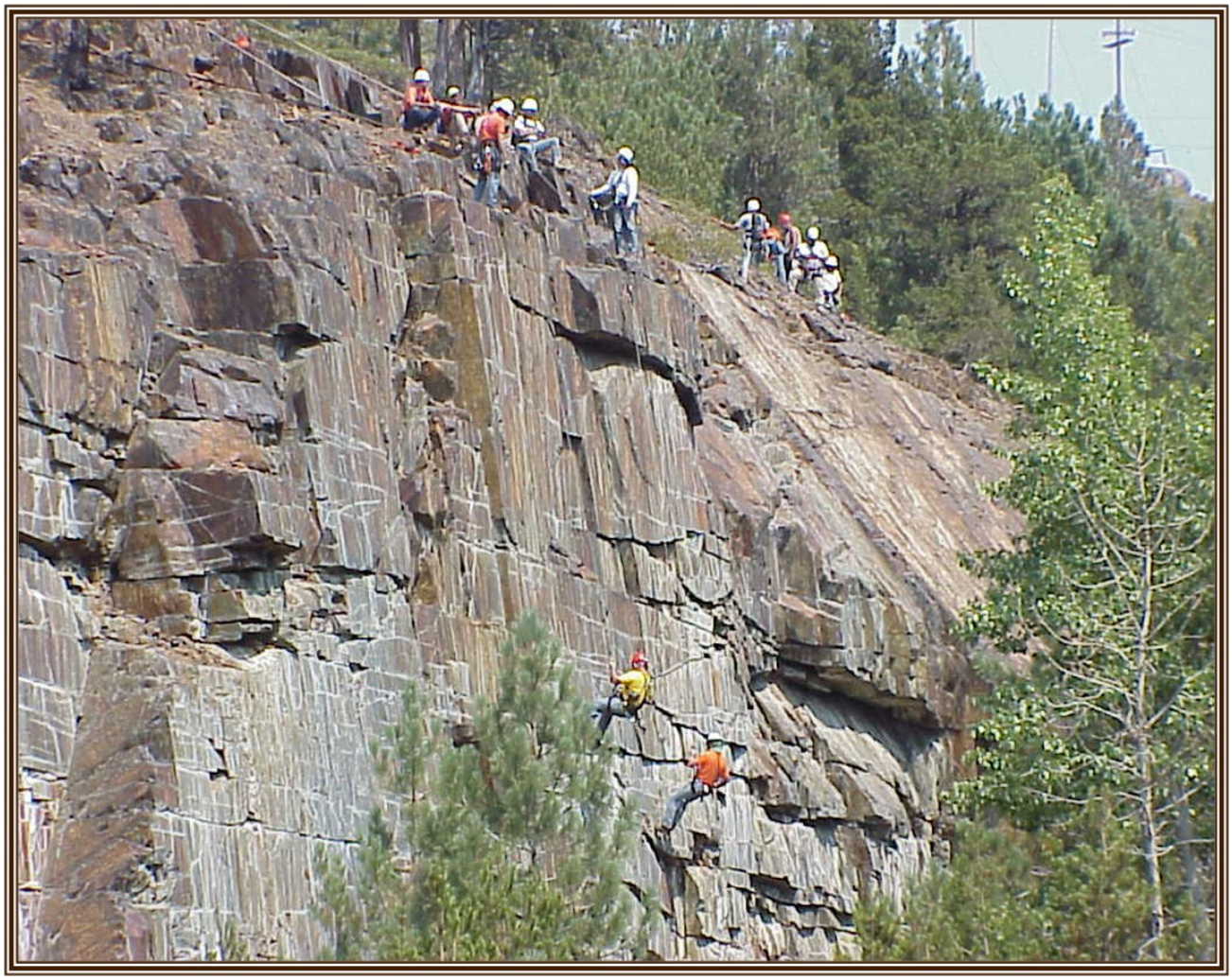
WORKING ON ROPE

Rope work for bank scaling includes:

- Rappelling
- Ascending
- Lowering
- Belaying.

In this manual, workers on rope are referred to as "climbers."

- All climbers should be tied in when within a minimum of 6 feet of the edge of the slope.
- When climbers are below them, belayers should have visual contact with the climbers and care should be taken to prevent rocks from falling onto the climbers below.
- The rope used for descending or ascending shall be securely anchored above, and have a figure-8 knot tied near the tail.



RAPPELLING

Most areas that require bank scaling are too steep to access safely without the help of a rope. With a rope anchored to a point above the slope, the climber can lower himself down a slope by rappelling. Rappelling, also known as abseiling, is a controlled decent using a rope. Proper rappelling technique is one of the main focuses of the entry-level Beginner class. The techniques taught involve using a Rescue 8 descender to introduce enough friction on the rope, so that the climber can control his descent with one hand. Once they have rappelled to a scaling location, climbers must be able to "lock off" the 8, so they can be free to work with both hands.

Rappelling is a technique used in both recreational and professional applications that require rope access. Recreational climbers might rappel down to the base of their climb; or cavers might rappel down to access an underground cavern. Another adventurer may rappel with a kayak on their back to the entry point of a white-water run. Industrially, rappelling might be used outside tall buildings to perform maintenance or wash windows; or by a rescuer to access an accident site. Military special forces may be trained to rappel from an airborne vehicle.

While all these applications fall under the broad category of rappelling, it is important to note that not all rappelling is the same. Someone trained to rappel down the side of a building to wash windows is not necessarily qualified to jump out of a helicopter. Similarly, someone trained only to use tree-climbing techniques would need additional training to learn the techniques used in bank scaling.

There are skills required in bank scaling that may not be included in other rope access disciplines. These skills include the ability to:

- Move side to side, perhaps to get a rock that is not directly below their anchor
- Move quickly out of the way of a falling rock dislodged from above
- Carry an entire days worth of tools and food up and down the slope
- Stay motionless on the slope, while live traffic runs below them

IMPORTANT!!

While rappelling, all persons shall maintain at least two points of contact with an anchored rope at all times, as noted below:

1. **The primary point of contact shall be a tended or locked off rappel device, such as a Rescue-8.**
2. **The second point of contact shall be an approved belay. If a self-belay is established, this may serve as the second point of contact and the belay omitted.**

RAPPEL SET UP

To rig a Rescue 8 for descending, a bight of rope is brought through the large opening of the device, then around the small end of the device, and finally pulled tightly against the device. The Rescue 8 is then attached to the climber's harness using a locking carabiner. The tail of the rope will be used to control the descent, so it should be on the side of the climbers strong hand. While scaling, the climber should keep the tail of the rope in its bag, attached to the climbers body; either clipped to the harness, or worn as a back pack. It is important not the have the tail hanging below the climber, since the climber will be knocking rocks below him.

Beginning climbers tend to hold the control line in front of them, near the Rescue 8. However, this is not only a weaker position for the climber's arm, it unfavorably allows the possibility that a glove, or even the hand, could ride into the device and jam it. Greater control can be gained by grasping the rope further away from the Rescue 8 and keeping the hand near or behind the hip.

A single "wrap" of the Rescue 8 can provide the friction necessary for a controlled descent of a single climber. However, there will be time when the climber will need to carry an extra-heavy load. There is a simple way to increase the amount of friction for even greater control. Bringing the bight through the opening a second time for a "double wrap" creates even more friction for greater control of heavier loads.

Single Wrap with Self-Belay

Double Wrap with Self-Belay

SELF-BELAY

A belay refers to a system that is used to arrest the fall of a climber. Typically a belay is a second rope that is independent of the climbing rope. The belay line is attached to the climber with a "hard" connection. The belay line is tended by a belayer. In case the climber were to lose control of his descent, the belayer could apply friction to the belay line, thereby arresting the climber's fall.

DESCENDER JAMS

What causes jams when rappelling?

- Gear, clothing, gloves and even fingers can be sucked into the descender.

- Fast rappels sometimes generate slack in the rope below the descender, usually after negotiating some sort of overhang. Such slack can cause the rope to slide up the sides of a figure eight descender and form a knot called a girth-hitch on the top of the descender. The girth-hitch knot secures under body weight and when stuck, no one-arm pull-up is going to get you out of this mess.

Nevertheless, sloppy rappelling form is the main cause for descender jams.

PREVENTION

Prevention goes a long way toward keeping you alive in rappelling.

- Using a Rescue eight reduces the chance of a girth-hitch lock-off.

- One way to keep a loop of rope from pulling over the sides of your figure eight descender is to pull the initial loop down through the large hole in the "eight" when it is rigged onto the rope. This keeps the vulnerable loop of rope on your side of the descender, away from the wall.

ASCENDING

During or after a scaling operation, it is sometimes necessary to ascend up the rope. Ascending a steep slope can be difficult, and it is important to use the advantages that your climbing gear provides. Ascenders have a cam which, when engaged, allows free movement on a rope in only one direction. If the ascender is pulled downward, the cam will close onto the rope, preventing downward movement.

Ascenders are used in pairs so that weight can be placed on one while the other one is moved up. On a slope, when you have reasonable footing, ascenders on the rope can provide stability. The climber can step forward/upward, moving one ascender up the rope as he steps. Upward progress is made as the climber alternates moving one ascender up, then the other. Training and practice are key to learning how to do this correctly and efficiently.

SWITCHING FROM RAPPEL TO ASCENT

The exit route from a scaling location may not always be the rappel to the bottom of the slope. When it is quicker or more convenient to return to the top of the slope, the climber must be able to safely switch from a rappel to an ascent. In class, we emphasize making this switch while maintaining a minimum of two points of contact to the climbing rope. While rappelling, the two points of contact are usually the tended rappel device and an ascender as a self belay. When setting a third point of contact, remember to tied off the rappel device to be able to work with both hands. The third point of contact could be as simple as setting a second ascender on the climbing rope. A third point of contact could also be a prusik hitch connecting the climbing rope to the climber's harness at a secure location.

PRUSIK

Friction knots offer a similar functionality to an ascender. Remember: friction creates heat and heat can damage ropes.

CHICKEN FOOTING

Chicken-footing is a technique used to ascend a rope in a near-vertical or free-hanging situation. Ascenders are made to hold in your hands, and even the strongest of people would find it nearly impossible to ascend a rope using only their arms. To effectively make an ascent, the climber needs to involve the strength of their legs. There are a couple of useful pieces of gear that can be applied here: the cord sling and the webbing sling. Using a carabiner, attach the cord sling to the lower ascender. The webbing sling can then be girth hitched to the cord sling. The combination of the two lengths of slings gives the climber a step for support to ascend.

IMPORTANT!!

When ascending, just like rappelling, the climber shall maintain at least two points of contact with the rope at all times

1. **This applies even while changing from a rappel set up to an ascent set up.**
2. **Each ascender counts as a single point of contact.**
3. **A prusik on the climbing rope may be a point of contact.**

ABOUT GIBBS ASCENDERS

GIBBS ASCENDERS WERE DESIGNED WITH SAFETY IN MIND.

Due to the design of the teeth GIBBS ASCENDERS cause a minimum of rope damage; yet they have an excellent record for holding on iced wet and muddy ropes

They have simple but durable construction

They are easy to assemble on the rope but will not come off unexpectedly

Each ascender is pull-tested to 1000 pounds just as they would be pulled in actual use

GIBBS ASCENDERS WERE DESIGNED TO BE VERSATILE

They can be used on any rope ½" in diameter or less

Their rounded teeth are preferred, especially on sheathed ropes

They can be rigged in various standard methods for mechanical prussiks and the Free Running Model can be operated with the feet or knees as well as with the hands

They can be used for self belay on a fixed rope since they slide up the rope naturally

GIBBS ASCENDERS are also excellent tools for pack hauling and rescue litter raising

The tremendous advantage gained by using the legs to do the work of climbing makes the GIBBS ASCENDER almost indispensible for long free drops At the 1971 NSS convention in State College, Pennsylvania Kirk MacGregor used the GIBBS ASCENDERS rigged to his knee and foot to climb 100 feet in 35 5 seconds — a new record

GIBBS ASCENDERS

FREE RUNNING MODEL

SPRING LOADED MODEL

GIBBS ASCENDERS IN ACTION

FOOT AND KNEE RIGGING

For long ascents this is the easiest method of climbing. Especially for free hanging climbs. One ascender is attached to a foot and the other to the opposing knee. This allows one to walk naturally up the rope and places the weight on both feet The third ascender attached to the seat harness allows the climber to sit down and rest An ascender at shoulder level will help the climber stand straight up and relieve the weight from his arms.

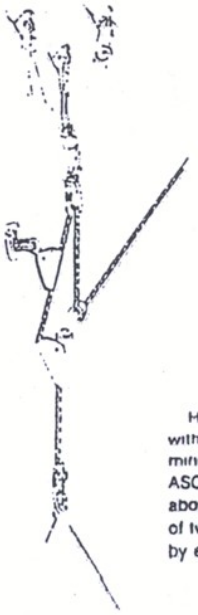
AID SLINGS

Fast and simple for following aid. Tie webbing from the lower ascender to your aid sling so that you cannot fall out of your aid slings. When following an overhang clip your aid sling to the piton then unclip the unweighted rope from the pin or remove one ascender and move it around the pin

GIBBS ASCENDERS IN ACTION

SAFETY ON FIXED ROPES

GIBBS ASCENDERS run easily along the rope as you walk They cause minimum rope damage and catch you if you fall They are not prone to jamming or icing up. They will not come off of the rope unexpectedly



PACK HAULING AND RESCUE LITTER RAISING

Heavy objects can be raised with complete control and a minimum of effort using GIBBS ASCENDERS The system shown above has mechanical advantage of two to one Lifting can be done by either arms or legs

BELAYING

A belay is a system set up to prevent a climber from falling, should he lose control during a climb. In a typical rappel situation with belay, a climber will rely primarily on their own climbing rope, and a second rope will serve as a belay line.

The belayer has two duties. The first is to feed or retract rope through the belay, so that a climber on belay has the freedom to move around without restriction. The second duty is to quickly stop the descent of the climber in case of a fall. To do both of these, the belay must always be in communication with the climber. In fact, there are some special terms that have been developed in the climbing community to quickly and effectively relay information between the climber and belayer.

BELAY LANGUAGE

- **"On Belay"** (Climber) - The climber is tied with an anchor knot (Figure 8 Follow Though) at the end of the belay line.
- **"Belay On"** (Belayer) - The belayer has secured the belay line with a munter-mule hitch, tending the slack in the line.
- **"Climbing"** (Climber) - The climber is ready to climb or rappel.
- **"Climb On"** (Belayer) - The belayer is ready to release slack in the belay line as the climber climbs or rappels.

LOWERING

Lowering is simple. Gravity. Oh, you mean a controlled lowering. Use belay techniques.

Caltrans Bank Scaling and Rock Climbing Training

(This page is being updated)

SUMMARY

All persons shall maintain at least two points of contact with the rope at all times while rappelling, unless otherwise noted below.

(This page is being updated)

Chapter 10

Haul Systems

Access from Bottom of Slope – Up-Haul System

In this situation, it is assumed that you must move the heavy equipment up the slope. Thus, you have suitable anchorage (truck, trees, etc) below the slope and the ability to create anchors above the area where you will be working.

The first step - climb up to the top of slope and build anchors on which you will rappel with climb and haul lines down to the bottom of slope. The haul lines will need to include a mechanical advantage system that can be carried down to the lower anchor point.

Access from Bottom of Slope – Up-Haul System

(continued)

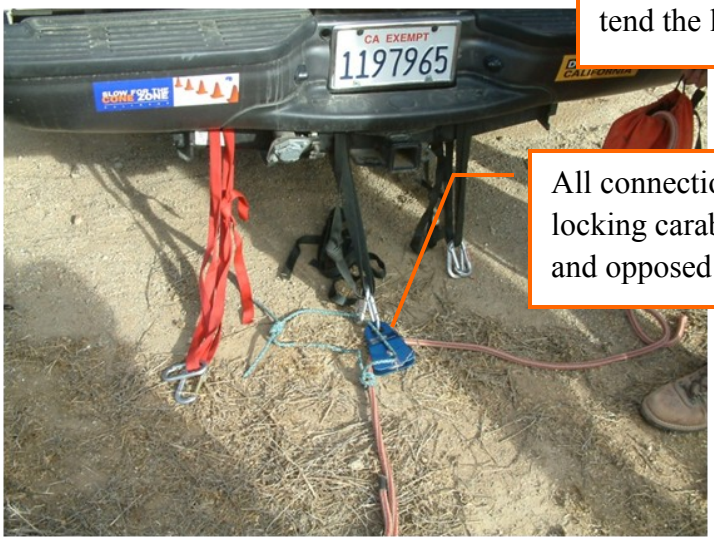
Once the climber line and haul rope have been carried to the bottom of slope, they need to be anchored to the truck or other anchor at the bottom of the slope.

This pulley is for a change of direction to allow better positioning. This situation requires a prusik backup

Access from Top of Slope – Climbers are tied in

In this situation, the access is again from the top of slope. The rigging is established to provide for one or more climbers to assist heavy equipment down the slope and then back up. This situation also requires an additional deckhand who will assist with lowering /raising the equipment and who will tend to the prusik.

Anchor setup is off the bumper of the vehicle. Make sure parking brake is set, keys are out of the ignition, and the webbing tie off avoids sharp bends and objects.



While the climbers are rappelling with the equipment, they can use the Rescue 8 ring with short prusik (3rd hand) as the 2nd point of contact if needed to assist with a heavy load. Use conventional rappel if assistance with load is not needed.

Access from Top of Slope – Climbers are tied in

(continued)

Convert to operation to raising by installing a short prusik to the load line. Deck hand to assist with "pulling" the equipment up the slope and providing support for the heavy load when climbers are repositioning themselves.

Convert Prusik by Shortening for raising

The equipment is lifted by the climbers and supported by the deckhand. Once lifted upslope, the climbers must alternate taking turns repositioning themselves and supporting the equipment

Climbers have converted to ascending position by attaching both ascenders to rope.

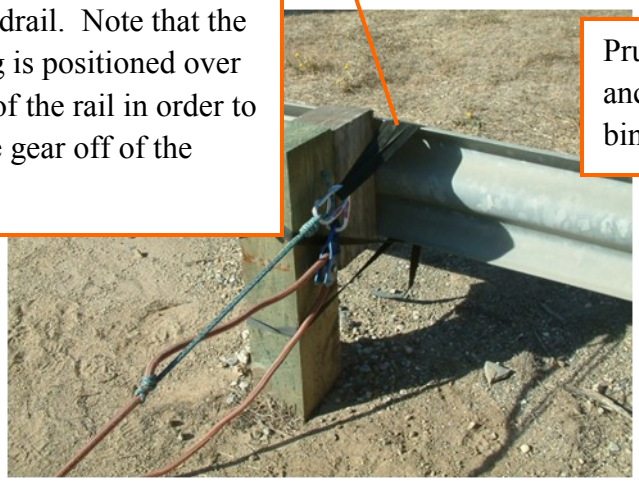
Access from Top of Slope on slope which can be walked down

In this situation, the access is from the top of slope. The rigging is established to provide support/backup for the equipment being hauled down the slope. This situation assumes that the operator can easily walk down the slope without the aid of a rope. This situation is intended to provide backup for the heavy equipment during transport and during operation.

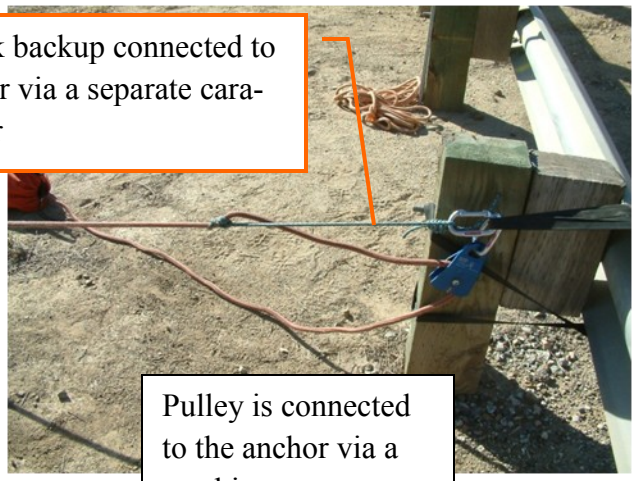
The climber is not tied in. The rigging is for the equipment being operated

The anchoring for this situation is accomplished by tying off on a guard rail element using webbing. The photo below illustrates a guard rail anchor configuration with a prusik backup. A pulley is used to limit friction in both lowering and raising. A carabineer can be used as a pulley if needed.

Webbing is used to tie off to the guardrail. Note that the webbing is positioned over the top of the rail in order to keep the gear off of the ground.



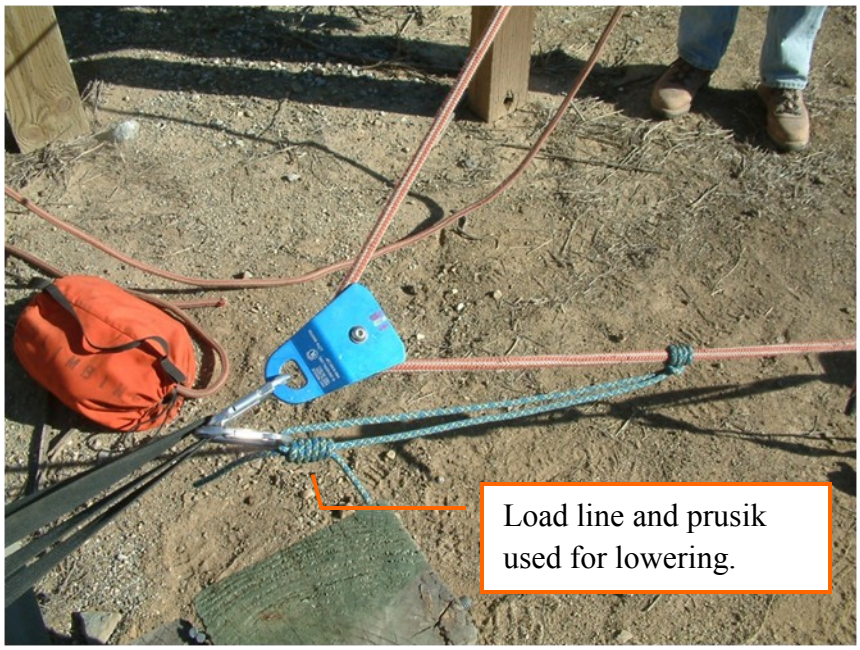
Prusik backup connected to anchor via a separate carabineer

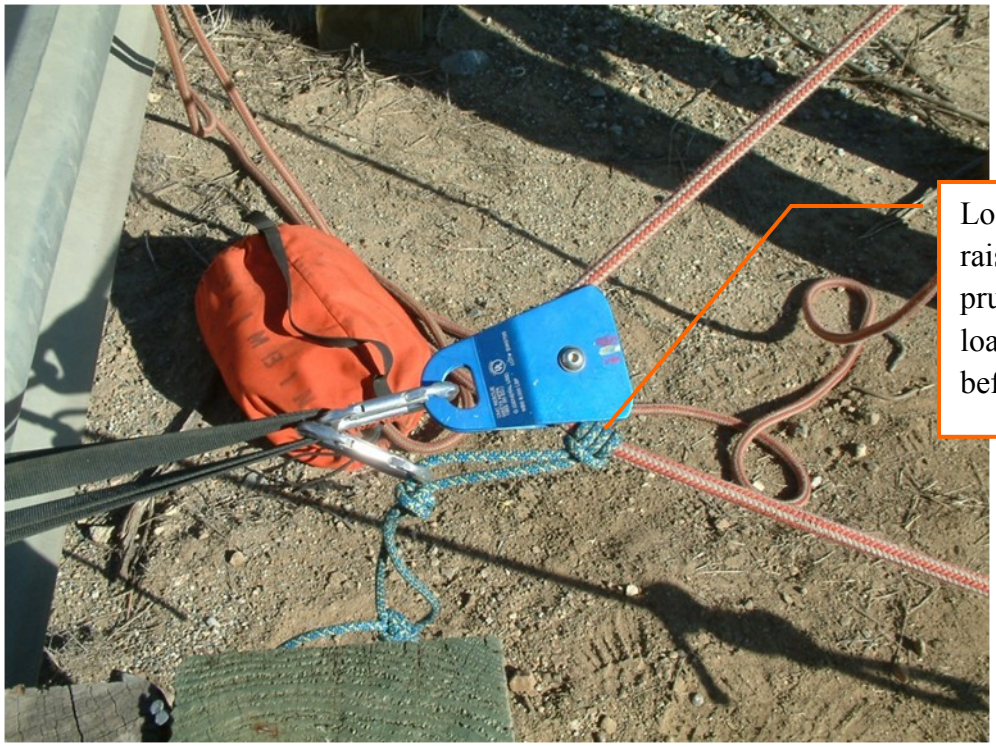


Pulley is connected to the anchor via a carabineer

Access from Top of Slope on slope which can be walked down

(Continued)





Mechanical Advantage Systems

Illustrated is a sample of a three to one (3:1) mechanical advantage:

Chapter 11

Aerial Rescue

Aerial Rescue

This method of aerial rescue is for use when the victim is ambulatory (able to walk). **If victim is unconscious or not ambulatory, call 911 and tell them this is a high-angle rescue.** Ideally the rescue crew consists of a rescuer and a deck hand. The deck hand is stationed at the top of the slope to assist. The rescuer rappels down from the top of slope to the victim and transfers the victim to the rescuer's rope. The rescuer then disconnects the victim from his or her rope with the assistance of the deck hand to provide slack, and rappels to the base of the slope cradling the victim during the descent.

Step 1: Rig for Rescue and Rappel

(This set up is for a right handed climber)

Extend the Rescue 8 by connecting it to the daisy chain with a locking carabineer approximately 3-4 feet from the belt. Ensure the Rescue 8 is within reach during rappel. Setup a double wrap rappel on the Rescue 8 to control the descent with the additional weight of the victim. Backup the rappel with a 3rd hand (cordelette and prusik hitch) as shown. Using a locking carabineer, connect the 3rd hand to a secure point on the harness. The cordelette may need to be shortened using an overhand knot. Some longer cordelettes may allow the prusik to run out of reach of the rescuer, and possibly up into the extended Rescue 8. The rescuer then rappels to and stops above the victim. The intent is to have the victim on the rescuer's left side. This frees the left hand to assist the victim during the final descent to the base of the slope while using the right hand to tend the 3rd hand and rappel with the Rescue 8. During rappel, the rescuer should be in communication with the victim. This allows the rescuer to offer some words of comfort and support to the victim, letting him know that a trained rescuer is on the way to help, while also getting a sense of the mental state of the victim. Another important piece of information that may be conveyed to the victim is to maintain two points of contact until the rescuer reaches him.

Aerial Rescue

(continued)

Step 2: Establish first point of contact

Using a locking carabineer, the rescuer connects the excess daisy chain from the victim's ascender to the lowest opening of the extended Rescue 8. If the excess daisy chain is too short, use a cordelette or sling to extend it. This will become the backup point of contact for the victim.

Step 3: Safety Knot

Rescuer ties an 8 on a bight on the rope below the 3rd hand. The rescuer then connects the bight to a secure location on her harness with a locking carabineer. This knot will function as the backup point of contact during the rescue.

Step 4: Chest Harness

The rescuer constructs a chest harness by tying two slings together with a girth hitch. The rescuer then connects the opposing ends of the chest harness together in front of the victim with a carabineer.

Aerial Rescue

(continued)

Step 5: Establish Second Point of Contact

Attach a locking carabineer to the victim's unused daisy chain at a length of approximately 1-foot above the victim's belt. This will position the victim half way between the extended Rescue 8 and the rescuer.

The rescuer then lowers herself to a level where the locking carabineer can be attached to the extended Rescue 8. This connection becomes the primary point of contact for the victim. The victim now has two points of contact.

Aerial Rescue

(continued)

Attach the chest harness carabineer to one of the victim's daisy chains in an attempt to keep the victim in a comfortable position. The chest harness is not a secure point of contact.

Aerial Rescue

(continued)

Step 6: Slack and Transfer Victim to Rescuer

Ensure all points of contact are properly connected. The rescuer then calls to the deck hand for "Slack." The deck hand releases the mule knot on the victim's rope and lowers the victim with the munter hitch.

This lowering transfers the victim's weight onto the rescuer's extended Rescue 8 with 2 secure points of contact. The rescuer can now pull the victim's rope down and disconnect the victim's ascender and Rescue 8.

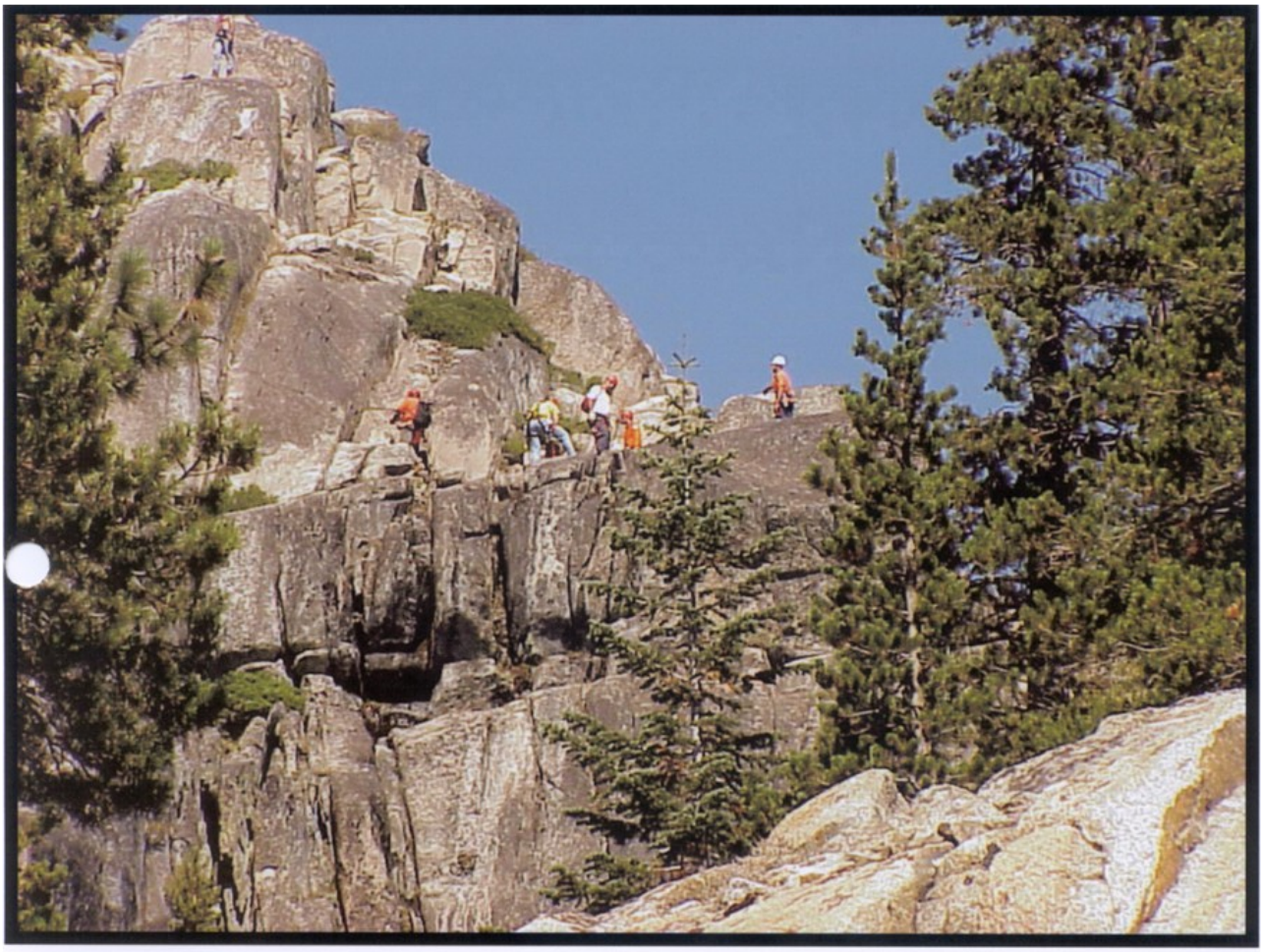
Step 7: Untie Safety Knot

Disconnect and untie the safety knot from the rescuer's rope.

Step 8: Rappel to the bottom of slope

The rescuer then rappels safely to the bottom of the slope, cradling the victim with the left hand to keep the victim in a safe position.

Glossary



CALTRANS
BANK SCALING AND ROCK-CLIMBING

A

Aid climbing - Moving up a rock using fixed or placed protecting as a means of progression (and not just for protection). AKA sixth class climbing.

Aider - Webbing ladder used for aid climbing. The word was probably coined by someone who couldn't spell the French word étrier.

Aid route - Route that can only be ascended using aid climbing techniques.

Alcove - A belay ledge that is surrounded by vertical rock on all sides.

A.M.S - Acute mountain sickness. (Ask your medical doctor.)

Anchor - Point where the rope is fixed to the rock.

Arete - A narrow (more or less - but often more less than more - horizontal) ridge.

Ascenders - Devices (e.g. Jumars) used to ascend a rope.

Avalanche - Lots of snow or ice sliding down a mountain.

B

Bail - To give up on a rock climb or a summit attempt because of bad weather coming in.

Barn door, to - To lose the foot and hand holds on one side of the body. Usually causes the climber to swing like a barn door.

Base camp - The lowest and largest fixed camp on a major ascent (or multiple ascents in the same area).

Beer - Liquid consumed in large quantities after climbing.

Belay, to - To secure a climber.

Belay Betty and Belay Bob - The girl or boyfriend of an addictive rock climber.

Belay station - A safe stance consisting of an anchor, a rope, and a belayer (AKA: "the belay")

Belayer - The person at the belay station securing the climber.

Belay "on" - When the belayer is ready to belay the climber up, he yells, "Belay on." (At least in the US. "Belay on" would only confuse the hell out of a British climber who prefers to hear "Climb when ready").

"Below" - Used in Britain to warn for impending impact with objects coming from above (e.g. falling rock). "Rock" in the US.

Bent gate carabiner - Carabiner with the gate bent to accept the rope more easily.

Beta - Insider information about a climb. Running or auto beta is someone telling you how to do the moves as you go (as in "can you please shut up with that running beta, I want to find out for myself").

Beta flash - Leading a climb with no falling or dogging, but with a piece of previous knowledge hints on how to do those crux moves. Even seeing someone do the climb already classifies as 'previous knowledge'.

Big wall - Rock climb that is so long and sustained that a normal ascent lasts several days.

Biner - Short for carabiner

Birdbeak - A tiny hooked piton manufactured by A5. It is similar to the old Chouinard "Crack'n up" except that it only has a single side and that it is intended to be hammered in if necessary.

Bivouac - Or short, bivi. An uncomfortable sleeping place in the middle of a route.

Black ice - Old ice that was exposed to extremely cold temperatures and snowfall. Usually found deep in shady colors, or on steep north faces. Very hard and dense ice that is difficult to climb.

Blast, to - To begin a big wall, after the line fixing is done. "We are gonna blast on Tuesday morning after we get the first three pitches fixed".

Blue ice - Very dense ice with a watery hue and few air bubbles.

Bomber - Used to indicate that something is exceptionally solid, e.g. an anchor, a hold. See also bombproof.

Bombproof - The illusion that an anchor is infallible

Bonehead - A (novice) climber with more braves than brains. Knows just enough about climbing to get himself and others badly hurt.

Bong - An almost extinct species of extra wide pitons. Now, large chocks are usually used instead.

Bootie - Gear (nuts, cams, etc.) that was left behind on a climb by the previous party.

Boulder, to - Climbing unroped on boulders or at the foot of climbs, to a height where it is still safe to jump off.

Bounce, to - To crater from an extreme height. Usually lethal.

Bowline - Sailing knot (not to be used for climbing, unless backed up with a second knot)

Brain bucket - AKA helmet. That all-important hard shelled thing that covers our (second?) most valuable asset.

Buttress - The part of the mountain or rock that stands in front of the main mountain face.

C

Cam - Generic reference to the family of spring loaded camming devices. Also referred to as springs

Carabiner - Metal connecting device. This most essential climbing device is also known as a "biner."

Chalk - Magic powder that makes the hands stick to even the smoothest rock.

Cheese grater, to - To slide down a slab while scraping the knees, hands, and face.

Chest harness - Bra-like looking harness (to be used with waist harness)

Chickenhead - Sometimes phallic shaped, protruding lumps that make excellent hand or footholds on granite, etc.

Chimed - Exhausted. "This climb has got me chimed."

Chimney - A wide crack that accommodates (most of) the body of the climber.

Chimney, to - A climbing technique used to conquer chimneys. Usually requires the use of the back and feet, arms, head and other body parts.

Chipped hold - A hold created with a hammer and chisel by a moron incapable of doing the climb as it is.

Chock - Generic reference to the family of passive wired protection devices, also called nuts, stoppers, wires, and rocks.

Chockstone - A stone wedged between a crack, a chimney, etc.

Chute - A very steep gully. The word chute is French for fall and refers to the rockfall that is very common in a chute.

Cirque - A deep and steep-walled basin on a mountain usually forms the blunt end of a valley.

Clean - Climbing without falling or dogging.

Cliff - A vertical piece of rock good for climbing (see also Crag).

Cliffhanger - Not just a film, but also the name for a small hooking device used to aid climb up small ledges and pockets.

"Climbing" - What the climber shouts after the belayer screams "Belay on."

Climbing gym - The second best thing to real rock.

Climbing shoes - Shoes made of sticky rubber that would have fit you comfortably when you were ten.

Clip, to - The reassuring action of putting the rope through a carabiner.

Clove hitch - A useful, easily adjustable climbing knot usually used to tie the rope into a ??

Cord - Thin static rope (5, 5.5 or 6 mm)

Crab - Short for carabiner.

Crack, in rock - A gap or fissure in the rock varying in width from nail to body width.

Crag - Name for a (small) climbing area.

Crampons - Very pointy footwear use to walk glaciers or climb ice.

Crank, to - To pull on a hold as hard as you can, and then some.

Crater, to - To fall and hit the ground, as in "I almost cratered".

Crest - The very top of a ridge.

Crevasse - A crack in the surface of a glacier.

Crimper - A very small hold that accepts only the finger tips.

Crux - The hard bit.

D

Daisy chain - A sling sewn (or tied) with numerous loops, used as an adjustable sling in aid climbing.

Deadpoint - A dynamic move where the next hold is grabbed at the very top of the motion (if you lunge upwards, that is just before you start falling again). By grabbing a hold in its 'deadpoint', you place the smallest possible loads on the holds.

Death wobbles - The eerie sensation of jittery legs. AKA to Elvis.

Deck - The usually unfriendly surface that welcomes you at the end of a grounder.

Demigod - Highest form of life in the climbing cosmos. Does not need rock to ascend to great heights.

Descender - Device used for rappelling.

Dihedral - The term for an inside corner (AKA "open book").

"Dirt me" - Slang for: 'Lower me'.

Dog (to dog a move) - Climbing, lowering, climbing again till a certain move is made (the usual mode of ascent...).

Double fisherman's knot - Solid knot used to tie two ropes or pieces of webbing together.

Double rope - Same as a half rope. Also the technique using two half ropes.

Downclimbing - Descending the difficult way.

Dry tool, to - To ascend a section of rock using ice tools - very common in mixed climbing.

Dude - Generic name for a climber.

Dynamic belay - A belay method in which some rope is allowed to slip during severe falls. A dynamic belay can severely reduce the impact force from a serious fall, but can also severely kill you if not done properly.

Dyno - Dynamic movement towards a distant hold.

E

Edge - A sharp edge on a rock face.

Edging - Foot technique where one uses the edge of the climbing shoe to stand on small footholds. The opposite of smearing.

Elvis, to - To have a twitching leg. Named for "Elvis, the King," who suffered this problem when singing before a crowd of screaming women.

Epic - The story of a well-planned climb that turned into a grueling adventure that ended well. As these stories are told over and over again - and they always are - the details get stretched to supernatural proportions for dramatic effect.

Étrier - (Pronounce with a French accent). Webbing ladder used for aid climbing. Also known as an 'aider'.

F

Face climbing - Not crack climbing.

Fall, to - A dynamic retreat from a climb (free-solo rappel). Note that it is never the fall that kills, it's the landing.

"Falling" - Yelled when a climber is (about to) fall.

Fall factor - The length of the fall divided by the amount of rope paid out.

FecoFile - A PVC tube used to store solid human waste on big walls. AKA: the Shit Tube.

Feet - Footholds.

Fifi hook - An open hook used to allow easy clipping during aid climbing. Usually found on aiders, daisy chains, etc.

Figure 8 - Metal rappelling/belaying device shaped like an 8.

Figure of eight - Very popular and solid tie-in knot.

Fingerlock - Masochistic technique to twist and wedge the fingers into a crack.

Firn - Old well consolidated snow, often leftover from the previous season. Closer to ice than snow in density, it may require the use of crampons.

Fisherman's knot - Simple knot to tie two ropes together. The double fisherman knot, however, is more popular.

Fixed pro - Bolts, rings, pitons, stuck nuts and cams and other pieces of un-removable pro that may be found on a climb. Use at your own risk.

Flail, to - To become very unsure and sketchy. When the flailing goes into frantic grabbing for holds, a fall is not far away.

Flake - A thin bit of rock that is detached from the main face.

Flapper - A piece of skin torn from your hand that creates a bloody wound. Usually happens if you hold on too hard when gravity is winning.

Flared - A crack or chimney with sides that are not parallel, but instead form two converging planes of rock.

Flash, to - To lead a climb with no falls or dogging and with no previous attempts on the climb. Two variations exist: the onsight flash (where the climber has never seen the climb before) and the beta flash (where the climber has studied the climb before or has seen someone do the climb). See there.

Following - Not leading a climb.

Free climbing - Moving up a rock using only hands, feet, and natural holds. Ropes and pro are only used for protection of the climber and not for progression.

Free solo - Free climbing while using no ropes for protection. You fall - you die.

Friend - Trade name for the original camming devices, now also available as Camalots, TCU's, Quads, Aliens, Big Dudes, etc.

G

Gas - The stuff your car and muscles run on. If you run out of gas...

Gate - The part of the carabiner that opens.

Gerry rail - A hold large enough for the most senior climbers.

Glacier - A slowly moving permanent mass of ice.

Gnarly - Difficult, sharp, hard. Usually in reference to a hold or a move.

God-save-me - The type of hold one lunges for hoping it will be the perfect bucket.

Goomba - Novice climber who thinks he knows it all. Unlike boneheads, Goombas don't know enough to get hurt.

"Got me?" - A wake up call for the belayer, used to warn them you are about to put some weight on the rope.

Grade - A number that denotes the seriousness of a route: Not to be confused with the rating of climb, which describes the technical difficulty.

Gravical - The adrenaline high felt with a lot of air between you and ground level. 'This is gravical, dude'.

Grease, to - Not being able to hold on to a particularly slick hold, due to the presence of sweat, lactic acid or sand. Not uncommon in overused crags

Grodle - Climbing English for awesome or cool.

Grounder - A fall where the kinetic energy is not absorbed by the rope and pro, but rather by mother earth herself. Can hurt badly.

Grigri - Nifty but somewhat controversial belaying device made by Petzl.

Gripped - Paralyzed with fear and utterly confused.

Gully - A wide, shallow ravine on a mountainside.

Gumbie - Also spelled Gumby. An inexperienced or new rock climber.

H

HACE - High Altitude Cerebral Edema. Liquid in the brain as a result of high altitude exposure. Few people live to tell what it is like.

Half rope - A rope of 9 or 8.5 mm that has to be used together with a second rope when leading a climb.

Handjam - Slightly masochistic technique where the hand is wedged into a crack.

Handle - Big banana-shaped hold often found in indoor gyms. Great for waving hello to admiring bystanders. It may sound bizarre, but I've never seen one of those outdoors...

Hangdog, to - See Dog.

H.A.P.E - High Altitude Pulmonary Edema. Liquid in the lungs as a result of high altitude exposure. Pretty serious condition that can quickly lead to HACE if a descent to lower altitudes is not made immediately. See also HACE.

Hardman / hardwoman - A climber with seemingly superhero strength who has survived epics of grandiose proportions.

Harness - Piece of clothing that identifies you as a climber. The coolness factor can be significantly enhanced by hanging things from the harness that go “clink”.

Haul bag - Large and robust bag used to haul food, water, climbing gear, sleeping bag, television, satelite dish, and other essential equipment that is required, up a big wall. Also know as "the pig".

Headwall - Where the face of a mountain steepens dramatically.

"Help" - The vocal alternative to 6 signals a minute. In far away countries, try S.O.S. -- it doesn't mean anything but is understood by most**.**

Helmet - Solid plastic device that can sometimes protect the head from falling stones or impact (AKA: brainbucket).

Hex - Short for Hexentrix. A type of nut with an excentric hexadiagonal shape. Works for wedging (as a nut) but also for camming.

Hold - Anything that can be held on to.

Horn - Spike of rock that can be for a great hold or not so great protection. The same as a chickenhead.

Hurtin unit - That member of the climbing team that is suffering from severe exposure to alcoholic beverages the night before.

I

Ice axe - Device used for ice climbing, glacier crossing, or scaring away burglars.

Ice screw - A protection device for ice climbing: Looks like a large bolt that can be screwed into hard ice.

J

Jam, to - Wedging body parts into a crack.

Jingus - Gnarly, sharp, hard, or radical. Often used as an expletive.

Jug - Very large hold (short for jug handle) (AKA: "bucket").

Jugs - Big wall lingo for Jumars, or any other type of ascenders.

Jug, to - To jumar up a line (big wall lingo).

Jumar - A type of rope ascending device.

Jumar, to - To ascend a rope using ascenders.

K

Kernmantle rope - Modern climbing rope consisting of bundles of continuous nylon filaments (Kern) surrounded by a braided protective sheath (Mantle).

Kilonewton - An abbreviation usually found on carabiners and other climbing gear. For those of you who are not engineers, one kilonewton is about 100 kg or about 220 lbs. (And for those of you who are, don't bother lecturing me).

Knotted cord - Piece of cord with a knot tied into the end that is used for protection (pretty much like a nut). The traditional method of protecting climbs.

L

Layback/Lieback - Somewhat clumsy looking climbing technique where hands and feet work in opposition.

Leader - The person who leads a climb.

Lead, to - To ascend a climb from the bottom up, placing protection (or clipping protection) as you go.

Ledge - Flat bit on a rock (can be miniature or gigantic).

Limestone - Type of rock found in abundance in southern France (usually white and full of pockets and holds).

Locking biner - Carabiner that can be locked.

Lock-off - To hold on to the rock with one bent arm while using the other arm to reach up for the next hold or to place or clip protection. Lock-offs on small holds will get you pumped in a hurry.

Lowering - To descend something or somebody.

M

Manky - Term used to describe a fixed bolt that looks like it was placed before the last ice age. Use these bolts at your own discretion. (Also a Scottish term for dirty)

Mantle - A difficult balancing move useful for getting onto ledges.

Mixed climbing - Climbing with a combination of different methods of ascent. e.g mixed free and aid climbing, mixed rock and ice climbing, etc.

Moat - The gap between snow and ice on a rock wall. Has posed problems ever since the middle ages.

Mountain rescue - The people who put their life on the line when you screw up badly.

Munge - The dirt and vegetation that can sometimes be found in cracks.

Multi pitch climb - Climb that consists of more than a single pitch.

N

Nailing - An ancient term used to describe direct-aid climbing with pitons.

Needle - Rock with a characteristic pointed shape. Also known as pinnacle, aiguille, gendarme, etc.

Névé - Consolidated granular snow formed by repeated freeze-and-thaw cycles. Also used to indicate permanent snowfields.

Nut - Metal wedge used for protection in cracks.

Nut key - The piece of metal that Americans call a nut tool.

Nut tool - Piece of metal that can be used to remove stuck nuts or cams.

O

"Off Belay" - Yelled when the climber no longer requires a belay (e.g. because she/he has reached a stance). Once the belayer hears "off belay", he/she removes the rope from the belay device and yells "belay off".

"On Belay ???" - Query to verify if the belayer is ready to secure the climber.

On-sight flash - Leading a climb with no falls and no dogging and without any prior attempts, watching someone do it or beta on how to do the moves.

Open book - Same as a dihedral or inside corner. Two panes of rock join in an acute or obtuse corner that faces left or right.

Outside corner - Also known as pillar or arete.

Over-cam, to - Compressing a cam to its absolute minimum size during placement, effectively eliminating the possibility of extraction.

Overhand knot - A simple (but solid) knot in a double rope.

Overhand loop - The simplest type of knot possible.

Overhang - Rock (or ice) that is "more than vertical".

Over-kilned - A boiler plate or flaky rock

P

Pass - The lowest passage between two mountains.

Party ledge - A somewhat larger ledge used to rest (and party !) during a particularly hard or long climb. Sometimes used to refer to the belay station on a multipitch climb.

pendulum - A swing on the rope, either intentional to gain a distant anchor on big wall climbs or unintentional when falling during a traverse with not enough pro in place.

Pig - The haul bag using for big wall climbing.

Pillar - Outside corner

Pimp, to - To do a short semi-dynamic stab. It's not quite a dynamic move, but it's also not quite static. It's the happy median.

Pink point - To red-point a climb where the pro and runners have been pre-placed.

Pitch - A section of climb between two belays and no longer than the length of one rope (this used to mean 45m, nowadays pitches can also be 50 or even 60m long -- check your topo).

Piton - Metal spike hammered into a crack (has come in disuse for all but some special applications)

Pocket - A hold formed by a (small) depression in the rock.

Portaledge - A hanging tent with built in bed used on big walls (and big trees).

Pro, Protection - Anchors placed during the climb to protect the leader.

Prusik - The sliding knot or the method to ascend a rope (named after its inventor, Dr. Karl Prusik).

Pumped - The feeling of overworked muscles. Most climbers are familiar with the forearm pump: too much finger work causes the forearms to swell and the strength to disappear. With a serious forearm pump, even holding a glass of beer can become a serious challenge.

Pumpy - Describes a climb that will leave you pumped.

Q

Quickdraw, quick - Short sling with carabiners on either side.

R

Rack - The climbing gear carried during an ascent.

Rack, to - To sort the rack before engaging on the next climb or pitch.

Rad - Not trad. Slang for sport climbing.

Rally, to - To climb exceptionally well; especially on difficult climbs.

Ramp - An ascending ledge

Rappel, to - Also: to rap. Descending by sliding down a rope. Known in Britain (and Germany) as abseiling.

Rappeler - Individual who enjoys sliding down ropes instead of climbing up rocks. The second-lowest form of life on earth (second only to the touron)

Rating - A number denoting the technical difficulty of the climb. See here for more on ratings and grades.

R.D.S. - Rapid Deceleration Syndrome. Military term for the very sudden illness that happens at the end of a long fall.

Redpoint - To lead a climb without falling or dogging after a number of attempts. This is different from onsight, where the climb is lead without falling or dogging on its first attempt.

Resin - An alternative to chalk. Resin (or "pine tree resin" to use its full name) is made from the yucky stuff that sticks to your hands when you touch a pine tree. Because resin is mostly colorless, it is preferred to chalk in some areas. But caution: Don't let the color fool you. Resin can do permanent damage to the rock and in fact is not allowed anywhere in the US for that reason.

Resident protection - Fixed pro.

Rib - A slender buttress. Something between a buttress and an outside corner.

Ridge - The high divide extending out from a peak.

Ring - A large (2 inch diameter) ring that is cemented in the rock as a bolt. Rings are very common in Germany and France and are excellent for rappelling and hanging belays.

"Rock" - Scream let out to warn people down below that a piece of rock has been overcome by gravity. The loudness, number of repetitions, and/or panic in voice with which this word is uttered is often an indication of the seriousness of the rock.

Roof - Seriously overhanging part in a climb (more or less horizontal).

Rope - Long and round nylon fabrication. Climbing ropes are generally between 10 and 11 mm in diameter (with the exception of "half ropes" which are between 8.5 and 9mm in diameter).

"Rope" - Should be yelled when a rope is about to be thrown to the base of the crag (though most of the time it seems like "rope" is shouted about 1-2 seconds after the rope is thrown).

Route - A certain path up a rock or mountain.

Runner - A loop of tape or webbing either sewn or tied. In the UK, a 'runner' is a running belay.

Runner - A runner threaded or looped around chockstones, flakes, horns or chickenheads for protection.

Runout - Distance between two elements of pro. A route is "runout" when the distance between those two elements of pro becomes uncomfortably long.

S

Schwag - Terrible rock conditions.

Scrambling - Easy climbing, usually unroped.

Screamer - A very, very long fall.

Screamer - Special piece of equipment meant to reduce the impact of a screamer (the fall) on the belay system.

Scree - Loose rocks and stones that cover the slope below a cliff. With every step, scree slides under your feet.

Screwgate - The type of carabiner that can be locked with a screw. See also twistlock. In the US this is usually called a 'locking biner'.

Scrube - A hammer-in, screw-out type of ice screw.

Second - The climber who follows the leader. See also following.

Send, to - To climb a route with ease. "I'm gonna send this route, dude!"

Serac - A block or tower of ice on a steep glacier or in an ice fall. Since seracs are created by the force of gravity working on the glacier or ice fall, they can come down at any moment.

Sewing-machine leg or arm - A leg (or arm) under tension that suddenly starts jerking up and down like a sewing machine. Stretch the muscle, take a deep breath, and don't think of falling... (see also: to Elvis or the death wobbles).

Sewn-up - When so much gear is on a trad route that it looks like it has been sewn shut.

Sharp end - The end of the rope to which the leader is attached.

SH ! or Oh F*** ! -** Often heard during a fall... (Well-educated climbers in the UK sometimes say "sugar"- but only if they're not in too much trouble).

Short roping - Technique where both climbers are tied close together into the middle of the rope. The rest of the rope is then carried over the shoulders in a coil. Frequently used for simul-climbing. The term (and technique?) is used frequently in the Canadian Rockies.

Short roping - Belaying technique where the belayer keeps the leader under tension in an attempt reduce the length of a fall.

Side pull - A handhold that needs to be held with a horizontal (sideways) pull.

Sit start - To start a bouldering problem from a sitting position. See also 'Yabo Start'.

Sierra wave - A lenticular cloud found mostly in the Sierras, but known to be forebode of bad weather in the Mont Blanc area.

Sketch pad - A cushion used for bouldering.

Skyhook - A particular type of hook used for aid climbing

Slab - Flat and seemingly featureless, not quite vertical piece of rock.

"Slack" - Yelled when the climber needs more rope (e.g. to clip into protection).

Sling - What the Americans call a runner.

Slingshot - A toprope setup where the belayer belays on the ground (where the climber starts climbing) and the rope is pre-clipped through the anchor at the top of the climb. In the UK, top-roping or bottom-roping (depends where the belayer stands).

Sloper - Pathetic downward slanting hold. (Usually look like buckets from below.)

Smearing - Foot technique where a big part of the climbing shoe is used to generate as much friction as possible. The opposite of edging.

Softman / softwoman - A former hardman/woman who can accomplish climbs of epic proportion in comfortable style. Always has the warmest jacket, the biggest sleeping pad, the best food, and the finest of consumables. A title to aspire for.

Soloing - Climbing alone, though not necessarily without the protection of a rope (unless you're in the UK, where a solo is always a free solo).

Spray, to - To brag or gloat.

Stem, to - Bridging with the feet between two holds.

"Stick it" - American slang meaning "hold on" or "go for it".

Stoked - Fired up, ready to play, very excited, really wanting to finish a particular climb.

Stylin' - Looking good, climbing well, having the most colorful clothing.

Stylin' - Living like a softman or softwoman.

Summit - The top of a mountain or rock.

Summit, to - To reach the summit.

T

"Take" - American monosyllable for "Up Rope". Also used by top-ropers and sports-climbers to indicate that they have reached the top and want to be lowered.

Talus - Large blocks of rock. A coarse variation of scree.

Tape knot - Or threaded overhand knot.

Tarn - A small lake.

10 essentials - That part of your climbing gear you don't want to leave at home.

"Tension!" - Yelled out to the belayer to make sure he really takes in the slack. Usually "tension" is used by a climber that is ready to pop off. The progression of severity usually goes "up rope", "tight rope", "tension!".

"That's me" - Part of the climbing dialogue. Courtesy call to the belayer to indicate that the slack in the rope is all taken up and that further pulling is pointless.

Third classing - Climbing without a rope on easy ground (see also class)

Threaded overhand - Solid but not failproof knot also known as water knot or tape knot, or ring bends when used on webbing.

Thrutchy - Requiring a whole lot of strength (and enthusiasm in a way). Used in Australia - where all the climbing is upside down.

Tick marks - Little smears of chalk used to locate holds when bouldering.

"Tight rope" - Or just "Tight". Urgent request to the belayer to take the slack out of the system. Somewhat stronger than "up rope."

Toe - The bottom of a buttress.

Topo - A short drawing of the route. Good topos will allow you to spot the line right away, show the placement of bolts and belay stances, indicate where the crux is and what rating it has.

Top-rope - Free climbing a route that has the safety rope attached to the top of the climb (usually one walks to the top to set up the top-rope belay).

Touron - A cross between a tourist and a moron. Typically asks stupid questions like "How did you get the rope up there?"

Trad - Traditional climbing characterized by the placing of protection (cams, nuts, etc.) in cracks and pockets. Trad also includes multi-pitch routes often with long runouts.

Trad fall - A fall during a trad climb sometimes accompanied by the popping sound of protection succumbing to the temptations of gravity. See also 'crater' and 'screamer'.

Traverse - Horizontal climb.

Trucker - Synonym for 'Bomber'.

Tunnel - A tunnel through or hourglass shape in the rock that allows a runner or cord to be fed through for protection.

Twistlock - A locking carabiner where the gate is locked with a spring-loaded clip.

U

Undercling - A hold that would be a perfect bucket if gravity were upside down. As it is, underclings are usually awkward holds that require lieback type moves.

"Up Rope" - Yelled by the leader or the follower when she/he wants a tighter belay.

V

Verglas - Thin water ice on rock.

Vôgen - Great, super. "Everything's vôgen."

W

Warthog - A roughened spike hammered into certain kinds of ice or frozen turf for protection. Very popular on mixed climbs in the UK

"Watch me" - Call to indicate the climber is about to do something stupid -- like fall.

Water ice - Ice formed directly from frozen water. Water ice is clear and brittle and contains few air bubbles. Sometimes water is even flowing around the ice. Can be found in the colors of the High Sierra in autumn (and in many other places).

Water knot - See tape knot.

Way - Extremely. “I was way scared on that run-out”.

Webbing (tubular) - Flat and strong strip of nylon that is hollow in the inside.

Webbing (loop of) - A runner made of webbing.

Whipper - A very long fall.

White ice - Ice with lots of air bubbles that form from melted-and-frozen snow. Good climbing stuff.

Wombing - Doing a no-hands-rest.

Woodie - A homemade climbing wall.

X

Y

Yabo - As in 'yabo start'. A 'sit start'. Named after John Yablonski a stud southern California climber, who was nicknamed Yabo.

Yard, to - To pull on a piece of protection. Strictly speaking, aid climbing.

YDS - Yosemite Decimal System.

Z

Zipper - A fall where the protection pulls out one after the other as the leader succumbs to gravity. Often ends with a grounder (or a cardiac arrest).

Z-Pulley System - Complicated rope setup that allows you to hoist heavy weights with relatively little force. Excellent for rescuing or hauling bags.

Reference: New Jersey Rock-Climbing Club web site

Appendices

Caltrans Bank Scaling and Rock Climbing Training

									S NUMBER :
YEAR :				PERSONAL CLIMBING LOG					NAME :
					* Slope	Climbing Hours			
Date	County -	Rte -	PM	Location Name	Classification	Scaling	Training	Other	Work Description
						Scaling	Training	Other	
				Year Totals					
				Total Climbing Hours					

* Slope Classification for scaling locations only. Include a copy of the Slope Scaling Assessment form for each scaling operation.

Caltrans Bank Scaling and Rock Climbing Training

S NUMBER : _____

NAME : _____

CLIMBING LOG
SUMMARY SHEET

Year	Total Climbing Hours	Scaling Hours	Training Hours	Other Climbing Hours
2003				
2004				
2005				
2006				
2007				
2008				
2009				
2010				
2011				
2012				
2013				
TOTALS				

Caltrans Bank Scaling and Rock Climbing Training

2013 CT CLIMBING GEAR LIST

Eastside sports in Bishop, Ca. has agreed to serve as a one stop shop for our Caltrans Climbers. As such, you can call them and ask for the current Caltrans Climber package. The phone number is 760-873-7520. They are on the approved vendor list as #VC0000012031 Wilson Eastside Sports in Bishop Ca.

If you prefer to use another vendor, we have successfully used the outfits shown below to purchase the items listed. The pricing and item numbers change periodically so if you choose to order from one of these vendors, make sure you are getting what we have recommended.

The following is the current recommended gear list. You can purchase the entire package or individual items as needed.

Yates Gear Inc.
1-530-222-4606, yatesgear.com

Item	Item#	Qty	Price	Extension
Tactical Shield Harness (military style buckle)	208	1	159.00	159.00

REI Commercial Sales
1 (800) 258-4567, REI.com

Item	Item#	Qty	Price	Extension
7 mm Accessory Cord	716226	50 ft	.45/ft	22.50
9/16" Webbing (Slings and Daisy Chains)	610111	50 ft	.28/ft	14.00
1" Webbing	737298	100 ft	.36/ft	36.00
Auto Locking Pear Shape Carabiner (large)	698146	6	18.25 ea	109.50
Non Locking Carabiner	662847	6	6.50 ea	39.00
Petzl Ecrin Roc Helmet	471157	1	99.99 ea	99.99

Bishop Company
562-698-9818

Item	Item#	Qty	Price	Extension
½" New England Rope (Safety Blue Line)	Spool (600ft)	1	359.00	359.00

CMI
1-800-247-5901, CMI-Gear.com

Item	Item#	Qty	Price	Extension
CMI Ultrascenders Large	ULT01B	1 pair	164.60	142.40
CMI Rescue 8	Rescue R1000	1	45.95	45.95

CMC Rescue
1-800-235-5741, cmcrescue.com

Item	Item#	Qty	Price	Extension
Rope Bag 100ft -orange	430101	2	31.00	62.00
Rope Bag 200ft -orange	430201	2	54.00	108.00

TOTAL (APPROX) = $ 1197.34

STRENGTH OF MATERIALS

ROPE
1/2" (12mm) Safety blue 7,000lbf=30-31kN
7mm (cord) 2,500lbf=10-11kN

WEBBING
1" tube 4,000lbf=16-17kN
9\16" tube 2,300lbf=9-10kN

SLINGS
Cordelette (7mm) (double fisherman's bend) 1,975lbf=7-8kN
Webbing 1"tube (water knot) 2,560lbf=10-11kN; 9\16"tube (water knot) 1,472lbf=5-6kN

HARNESS\BELT
Yates "Shield" 3,600lbf=16kN

CARABINERS
OMEGA oval non-locker: spine 4,950lbf=22kN; open 1,350lbf=6kN; side 1,800lbf=8kN
OMEGA quick lock: spine 5,395lbf=24kN; open 2,020lbf=9kN; side 2,250lbf=10kN

ASCENDER
CMI "Ultrascender" 4,600lbf=19-20kN (At a 42" free fall ascender tears sheath)

RESCUE 8 RING
CMI Rescue 8 10,000lbf=43-44kN

CLOVE HITCH
Testing by the Department of Defense indicated that it was possible for the knot to slip at 700 to 1200 lbs of load and for the sheath destruction and core damage to occur at 1200 to 1400 lbs. When tied incorrectly, with the load strand farthest away from the spine of the carabineer, it was found that the knot tried to align itself with the spine at 250 lbs and carabineer failure occurred before rope breakage - at approximately 38 % of the carabineers rated strength.

CLASS CHECKLISTS

BANK SCALING AND ROCK CLIMBING

BEGINNER

- FIGURE-8 *stopper knot*
- 8-ON-A-BIGHT *anchor & tie off fray*
- FIGURE-8 BEND *connect ropes*
- FIGURE-8 FOLLOW-THROUGH *anchor*
- WATER KNOT *sling & ascenders*
- FISHERMAN'S BEND *cordelette*
- GIRTH HITCH *anchor & sling*
- BASKET HITCH *anchor*
- PRUSIK HITCH *point of contact, third hand, & double rope rappel*
- MUNTER-MULE *belay & lowering*

ANCHORS
- FRICTION ANCHOR
- FIGURE-8 FOLLOW THROUGH

BATMAN SLOPE
- RAPPEL & ASCEND
- RAPPEL w/ THRUST RESCUE
- RAPPEL w/ SELF RESCUE
- BELAY w/ MUNTER
- FLAKE ROPE

BUNNY SLOPE
- RAPPEL-ON-BELAY
- RAPPEL-ON-BELAY & ASCEND
- RAPPEL-ON-BELAY & SELF-RESCUE
- RAPPEL-OFF-BELAY
- SWITCH ROPES

SIDEWALKS
Students must ascend each sidewalk one time.

BIG WALL
- RAPPEL-ON-BELAY
- RAPPEL-OFF-BELAY
- RAPPEL-OFF-BELAY & SELF-RESCUE

OVERHANG
- RAPPEL-OFF-BELAY
- RAPPEL-OFF-BELAY & SELF-RESCUE

CHAIN: Tie a *FRICTION* or *FIGURE-8 FOLLOW-THROUGH* anchor. Connect a practice rope w/ a *FIGURE-8 BEND*. Tie an *8-ON-A-BIGHT* in the standing end. Attach a locking carabiner. Tie a *MUNTER-MULE*. Attach the *CORDELETTE*, which includes the *DOUBLE FISHERMAN'S BEND*, w/ a *PRUSIK HITCH*. Attach the *SLING*, which includes the *WATER KNOT*, to the cordelette w/ a *GIRTH HITCH*. Tie a *FIGURE-8 STOPPER KNOT* to the end of the last rope.

EQUIPMENT
- HARNESS (x 1)
- DAISY CHAINS (x 2) *follow belay loop path*
- LOCKING CARABINEERS (x 4)
- NON-LOCKING CARABINEERS (x 6)
- ASCENDERS (x 2)
- RESCUE-8 (x 1) *connect to belay loop, follow the belay loop path w/ a locking carabineer, extended on a daisy chain*
- HELMET (x 1)
- SLING (x 1) & CORDELETTE (x 1)

TERMINOLOGY
- WORKING END: The part of the rope you hold in your hand.
- STANDING END: Rope hanging from, or on the opposite side of, the knot from the working end.
- BIGHT: When a rope is doubled back on itself with the strands parallel and close together.
- LOOP: A twisted bight where the strands cross each other.
- TAIL: The short end left over, dangling from one side of a knot near the end of the rope.
- KNOT: Two parts of the same rope purposefully twisted or intertwined.
- BEND: Two ropes or the ends of the same rope joined together.
- HITCH: Fastening a rope to a fixed object (tree, carabineer, or rope).
- FLAKE: To coil or uncoil the rope one layer at a time into a stack.

BANK SCALING AND ROCK CLIMBING

REFRESHER

DAY 1
Review BEGINNER SKILLS. Introduce the EQAUALETTE *(2-point, 3-point, Magic-X)*. ROPE-RODEO

DAY 2
Set up two anchors with Munter Mules on Batman Slope. Teach the Aerial Rescue. Rotate as Victim, Rescuer, & Deck Hand at least two times.

AERIAL RESCUE

1. RESCUER SET-UP. The Rescuer connects to a climbing rope using a Third Hand and an Extended Rescue-8. Rescuer rappels to and stops above the Victim.
2. SAFETY LINE. Connect the Victim's excess daisy chain hanging from the ascender connected to the climbing rope to the Extended Rescue-8 using a locking carabineer. If the excess daisy chain is not long enough, girth hitch a sling or cordelette to the excess daisy chain or locking carabineer.
3. CHEST HARNESS. Construct a chest harness by connecting two slings together with a girth hitch. Insert one arm of the Victim into one loop, wrap the chest harness around the back of the Victim, and insert the other arm into the other loop. Connect the opposing ends of the chest harness together in front of the Victim with a carabineer.
4. SHORT DAISY CHAIN. Disconnect the Victim's unused daisy chain from the ascender. Connect the daisy chain to the chest harness as close as possible to the Victim's belt. Connect a locking carabineer to the daisy chain above the chest harness connection point. The proximity of the locking carabineer to the belt will dictate the distance between the Victim and Rescuer when descending. Holding this locking carabineer open, the Rescuer will rappel until they can connect it to the Rescuer's Rescue-8 or the Safety Line locking carabineer. *REMAIN SEPARATED. Do not connect the short daisy chain to the Rescuer's daisy chain or locking carabineer.*
5. SLACK & REMOVE. Ensure all points are properly connected. The Rescuer call for, "SLACK." The Deck Hand partially unties the Mule and informs the Rescuer that they will, "FEEL A POP". The Deck Hand unties the remainder of the Mule. The Victim's weight is transferred to the Rescuer's climbing rope. While the Deck Hand controls the Munter, the Rescuer pulls the Victim's rope toward them and disconnects the Victim's Rescue-8 and ascender from the slacked climbing rope.
6. RAPPEL. Cradling the Victim, the Rescuer will rappel until the Victim can be laid softly onto the ground.

Each group rotates as Victim, Rescuer, & Deck Hand at least one time at the Big Wall and one time at the Overhang.

Caltrans

BANK SCALING AND ROCK CLIMBING

EQUIPMENT CHECK

HARNESS (x 1) • Appropriate type (no bikini harness), size, and fit (two finger rule). • Ensure waist and leg loops are buckled and snug with no twists. • Inspect condition of, material, stitching, buckles, gear loops, and belay loop (tug test).	HELMET (x 1) • Appropriate type, use climbing helmets only, no hard hats. • Ensure proper fit, chin strap is buckled and snug with no twists. • Ensure a name tag is on front of helmet.
DAISY CHAINS (x 2) (PERSONAL ANCHORING SYSTEMS) • Appropriate type (use tied webbing or individual stitched loops). • Attached with a girth hitch that follows the belay loop path.	LOCKING CARABINERS (x 4) & NON-LOCKING CARABINERS (x 6) • Inspect each carabineer for damage and proper function. • Inspect for cracks, large nicks, sticking gates, and/or seized screw locks.
ASCENDERS (x 2) • Appropriate type (preferred CMI Ultrascenders). • 2 webbing loops (redundancy) with water knots (never too much tail). • Loops attached to locking carabiners connected to daisy chains. • Inspect condition of teeth and moving parts (cleanliness and no sticking) • Adjust the lengths of the daisy chains. 	RESCUE-8 (x 1) (RAPPEL OR BELAY DEVICE)  • Appropriate type with ears and sufficient number of holes to accommodate connecting carabineers (preferred CMI Rescue 8 Ring). • Inspect condition (cracks, excessive wear and rope burns). • Connect to either the belay loop, to a locking carabiner that follow the belay loop path, or extended on a daisy chain (always use locking carabiner). • Tap for soundness (ping not thud).
SLING (x 1) & CORDELETTE (x 1) • Inspect condition of webbing and chord (cleanliness, frays, and cuts) • Sling tied with water knot (never too much tail) • Cordelette tied with fishermen's bends.	ROPE • Inspect condition of rope during flaking. • Cleanliness, frays, and cuts. • Abraded or stretched sheath. • Hard or soft core. • Discoloration (chemical or UV light exposure)
CARE & STORAGE • Avoid exposure to UV light, excessive/unnecessary abrasion, & chemicals (solvents). • Wash soft equipment (rope, harness, daisy chains, sling, and cordelette) in washing machine or by hand and line dry in shade. • Discourage loaning gear (knowledge of equipment history and to maintain possession)	Personal Protective Equipment (PPE) • Leather gloves (no synthetic materials). • Safety Glasses • Boots/Long Pants/ • Shin Guards (Optional)

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Application of mountaineering techniques to rock cut slope analysis and rockfall mitigation

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ABSTRACT: Rockfall has been reported along nearly 3000 miles of California highways. As transportation corridors become more restrictive, stabilization of existing rock cuts become critical. Typically, these sites are in areas where access is limited to examination from road level. Application of mountaineering techniques to aid the engineering geologist in conducting a close-up examination of rock slopes is discussed. Guided by radio with an experienced ground crew using oblique aerial photos from road level, the Engineering Geologist on ropes can collect critical data on the slope. Planar features controlling stability can be examined and measured directly. Changes in discontinuity spacing, presence of water, or attitude can be measured directly. Critical control points on the slope can be accurately located by a survey crew at road level shooting a target held by the mountaineering crew. The application of rock mechanics to cut slope design and rockfall mitigation through safe, controlled climbing techniques is emphasized.

1. INTRODUCTION

In California there are thousands of miles of highway that are cut through rock. As highway usage increases, these highway corridors are constantly undergoing improvements. Current trends in land usage frequently limit transportation corridors. As these corridors become more confined, stable new slopes and stabilizing old problem slopes becomes increasingly critical.

In the past, cut slopes were constructed without analysis of the rock characteristics which resulted in problem areas. Today high rock cut slopes are being designed based on rock characteristics using rock mechanic techniques. The parameters used in these designs are typically obtained from investigations conducted at road level and the surrounding slopes. Rock design has, therefore, been limited by the Engineering Geologists lack of access to the actual rock cut slope face.

Mountaineering techniques involving climbing ropes allows the Engineering Geologist (EG) to move freely on the slope and conduct a hands-on investigation of rock faces. This paper outlines mountaineering procedures used by the California Department of Transportation (Caltrans) to investigate rock cut slopes and presents case histories where mountaineering techniques were used in rock cut investigations.

2. MOUNTAINEERING

Mountaineering often conjures images of treacherous climbs up Half Dome, expensive equipment, superior physical condition, and years of training. Climbs of that magnitude do require such preparation. Climbing rock cut slopes, however, is much less intense and can be performed by anyone in good physical condition.

Understanding the techniques and equipment is important. Instruction regarding both the use of the equipment and techniques is essential for safe climbing. Instruction is available from outdoor organizations such as the Sierra Club and climbing groups. Classes can be designed for all levels of skill and experience. The classes are inexpensive and provide students with the opportunity to see if they are suited to this activity.

2.1 Equipment

Mountaineering equipment costs are low, especially compared to potentially high costs incurred by improper rock design. Quality equipment can be purchased for a few hundred dollars from specialty sporting goods stores.

The following is a general list of mountaineering equipment used by Caltrans EGs for rock slope investigations:

- Mountaineering rope; A synthetic fiber, 7/16' in diameter, that is lightweight, strong, and manageable.
- Seat harness; Provides safety and comfort while the climber hangs from the rope.
- Nylon webbing; Made into loops called runners, the purpose of which is to connect the climber to points of security such as rock knobs and/or anchors placed by the climber.
- Carabineers; Metal devices similar to large safety pins, used to connect various elements of the climbing gear, such as rope and piton.
- Anchors; Common types are pitons, chockstones and wired stoppers. These are pieces of metal of various shapes placed or driven into cracks in the rock for protection.
- Rescue-8 ring; A metal device shaped like an 8, which provides friction for control during the belay.
- Ascenders; Mechanical devices used for climbing, descending, securing, and load hauling.
- Etriers; A short rope ladder used in pairs in conjunction with ascenders for ascending steep and difficult rock faces.

This equipment is available from a variety of manufacturers. Our current inventory is sufficient to meet the needs of rock cut slope investigation. While most of the equipment will last for many years with proper care, ropes and webbing become frayed and weakened and, therefore, require periodic inspection and replacement.

2.2 Ground support

A major factor in the success of this type of investigation is the support crew. Most crews consist of two EGs, one assistant, and when necessary, traffic control crews. At least two people on the job should have training in mountaineering (preferably the two EGs on the job). This is a safety consideration. The alternate climber can help in the event of an accident and can relieve the other climber when he is tired. If possible, a team of EGs should be estab- lished that works together consistently, thereby promoting efficiency and safety. In Caltrans, Engineering Geology Section, three EGs have been trained together and work together. In most cases, two of the three are available for projects requiring rope work.

Before the investigation begins, oblique photographs of the entire site should be obtained. Most sites are photographed from the surrounding slopes; in cases where terrain and/or access presents a problem, photographs are taken from a helicopter. Eight by 10-inch photos are the most ideal size to work with. Larger prints were found to be cumbersome. The photos are used to aid the EGs in locating target spots, to direct the climbing EG to key locations, and for mapping, which is done directly on the photos during the investigation.

Communication between the entire crew is essential. We have found that manual or voice- activated radios provide the easiest and safest form of communication. Both are satisfactory; however, the voice-activated radio is the most convenient. When a rock is intentionally or accidentally dislodged by the climbing EG, hand signaling and shouting cannot compare to the advantages of immediate radio contact with everyone in the support crew. Radio communication also makes it easier for the support EG to direct the climbing EG and to relay data.

When available, a survey party is on-site to accurately record specific locations and slope geometry as designated by the EG.

2.3 Technique

When all the preliminary preparations are completed, the climbing can proceed. The mountaineering rope is secured at a stable location at the top of the cut and the geologic investigation is conducted as the EG rappels down the slope. Data are collected and transmitted via radio to the support EG at road level. The support EG uses the photos and his road-level perspective to direct the climbing EG as he works on the slope. Target areas can be identified, examined, mapped, and recorded. As the investigation progresses, additional data, identified by the climbing EG not noticeable from road level, are relayed to the support EG who records and maps the data on the photos.

On the slope, the EG's mobility is essentially unrestricted. The rescue-8 ring and one ascender are used during the rappel. A second ascender allows an easy ascent if necessary. Difficult

ascents, such as vertical cuts and overhangs, are relatively easily performed by attaching etriers (rope ladders) to the ascenders.

Stopping to work is easily achieved by one quick movement with the ascender. At this time, both hands are free to measure the attitudes of controlling planar features or do other work. Moving at an angle to the right or left is facilitated by placing anchored protection into the rock. This anchorage prevents the rope from sliding across the rock, and dislodging rocks above the climbing EG, and it prevents the climbing EG from swinging across the rock face if he should slip.

After one section of the slope has been adequately examined, the rope is moved to a new station, and the investigation proceeds.

These mountaineering techniques permit the EG to move with relative ease up, down, and across the entire rock slope. In this fashion, a detailed geologic investigation can be conducted on the slope above the roadway in a relatively short amount of time. The results of this type of investigation using mountaineering techniques have been successful and well received. Such detailed investigations have yielded information necessary for recommendations regarding the most appropriate and economical design for improving rock cut slopes.

3. CASE HISTORIES

The following case histories illustrate the advantages of working on the slope and compare the results to those obtained from road level.

3.1 Panorama Point

The site is located within the eastern portion of the San Bernardino mountains. The rock type at the site is Quartz Monzonite, late Cretaceous in age. This rock unit is referred to as the "Cactus Granite". The cut slope is approximately 1/2:1, 200 feet in width, and 125 feet high. Caltrans maintenance workers noticed that rockfall had increased in recent months from a few rocks per month to a few rocks per week. Several rocks as large as 11 feet by 2.4 feet fell within two weeks of each other. In the vicinity of these occurrences, several cracks appeared to be widening behind rock adjacent to the roadway.

A detailed investigation was conducted in October 1986. The investigation included mapping the extent of the cracking, measuring strikes and dips of the discontinuities, and locating water seepages. In addition to this, a number of precariously placed rocks were pushed off the slope and their rock trajectories observed.

Results from the mountaineering investigation

Detailed mapping done on the slope face revealed a pattern of small wedge failures occurring above the overhanging rock. It was discovered that the failures were associated with a particular discontinuity. Fractures observed at road level were found to extend upslope and were critical to the design. It was also determined that controlled blasting in a limited area would mitigate the unstable section. In addition, certain areas were to be reinforced with rock bolts. This design would not affect the nearby homes.

3.2 Kern Canyon

The project is located at the base of the Kern River Canyon. The canyon is approximately 1700 feet deep at this site. The upper slopes of the canyon are I 1/4: I while the inner gorge of the canyon can be 1:1 or steeper.

Bedrock at this site is gray fractured qabbro-diorite, Jurassic in age. The rock is locally intruded by numerous white pegmatite dikes.

The existing cut slope is approximately 200 feet in length, 90 feet high, and ragged. The slope angle is nearly vertical.

Local Caltrans highway engineers plan to make a safety improvement at this location by improving the radius of curvature. They requested that a cut slope investigation be done to determine the steepest stable cuts that can be constructed.

A detailed investigation was conducted in December 1987. This investigation consisted of measuring discontinuity attitudes, mapping, classifying the discontinuities, and locating water seepages.

Results from the road level investigation

Data collected from road level indicated that a 1/2: I slope would be stable. For this design, approximately 11,000 cubic yards of material would be excavated. A second option was to construct a 1/4: 1 slope, reinforced with rock bolts. This design would reduce excavation volumes by 50 percent. The rock bolt design consists of 100 sixteen-foot rock bolts spaced eight feet apart.

Results from the mountaineering investigation

This part of the investigation also concluded that a 112: I slope or a reinforced 1/4: 1 slope would be stable. However, specific data collected on the slope revealed that the discontinuity spacing was regular enough to map three distinct discontinuity groups and that each group warranted its own bolt design. The first group, having closely spaced discontinuities, required 33 twelve foot bolts spaced 6 feet apart. The second group, with moderately spaced discontinuities, required 16 twenty-foot bolts 12 feet apart. The third group was so large that

no reinforcement was required. The resulting overall design reduced the amount of reinforcement necessary for stability by 40 percent, resulting in significant savings.

3.3 McDonalds Bluff

The site is located along the upper slopes of the Trinity River Canyon. The canyon is approximately 1200 feet deep at this site. Natural slopes of the canyon are
1 1/4:1 or flatter but become steeper below the roadway.
Bedrock is highly fractured meta-sedimentary rock, pre-Cretaceous in age. The rock 1s intruded locally by diabase dikes.

The cut is approximately 980 feet long and 480 feet high. The existing cut stands on an overall 1 1/9:1 slope but is quite variable with some sections being near vertical.

An investigation was requested by local Caltrans maintenance personnel because of the frequency of rockfall. In addition to rockfall, the site also experiences occasional debris slides and rockslides large enough to close the roadway. An investigation was conducted in August 1988.

Results from the road level investigation

Very little specific data could be collected from road level that pertained to the instabilities. Visibility was limited from road level and adjacent slopes. Stereographic analysis of data collected at road level indicated that a 1 112:1 slope would be stable. However, this analysis was based on the premise that the discontinuity orientations were similar 500 feet upslope.
In highly fractured rock this assumption requires confirmation. If such a slope were constructed, it would generate approximately 700,000 cubic yards of material. Other mitigation measures considered were construction of a viaduct, redirecting the road away from the cut, installation of a rock shed over the roadway, or installation of a catchment wall at grade.

Results from the mountaineering investigation

On the slope, instabilities unseen from road level were mapped and identified. At this time, discontinuity orientations were measured for stereographic analysis, and slope profiles were measured for rock trajectory analysis. Other information collected at this time included locating sources of potential rockslides and debris avalanches. The investigation also yielded information useful in evaluating the feasibility of localized mitigation measures such as rock nets, draped wire mesh, scaling, and trimming.

This investigation yielded information that ruled out localized mitigation measures such as rock nets, draped wire mesh, scaling, and trimming. The mountaineering work developed information on rock sizes and trajectories that will help in the design of the more comprehensive measures.

4. CONCLUSION

The accuracy and precision of data determine the accuracy of the design. Mountaineering techniques used in rock slope investigations provide data otherwise not available for rock cut design. As exemplified in the case histories, information collected on the slope can provide data that improves design or provides additional information that supports recommendations made from road level observations. In either case, the use of mountaineering techniques for rock slope analysis improves the quality of the data the Engineering Geologist needs to analyze rock cut slopes.

Circa 1987
Tim Beck and John Duffy

S FAMILY ACTIVITIES

ACTIVITY	DESCRIPTION	PRODUCTION UNIT		ASSET
S10000	SAND/ROCK PATROL	VEMI	Vehicle Miles	RW
S20000	STORM PATROL	VEMI	Vehicle Miles	RW
S21000	FLOOD CONTROL	EAOC	Each Occurrence	RW
S30110	MINOR SLIDE/SLIP REMOVE/REPAIR	EAOC	Each Occurrence	RW
S31010	REPAIR/REPLACE ROCK FALL PROTECTION	EAOC	Each Occurrence	RW
S31040	ROCK SCALING	ACRE	Acre	RW
S32050	BENCH CLEANING	EAOC	Each Occurrence	RW
S33000	BLASTING	EAOC	Each Occurrence	RW
S40010	MAJOR SLIDE/SLIP REMOVE/REPAIR	CUYD	Cubic Yard	RW

TASK ACTIVITIES

TASK*	TASK DESCRIPTION
INSPCT	INSPECTION ACTIVITY
INVCPL	INVESTIGATE COMPLAINTS
OJT	ON THE JOB TRAINING
USAWRK	UNDERGROUND SERVICE ALERT WORK
SUPR	SUPERVISION

***Note:** A Task Code for charging Inspections, Complaint Investigations, On the Job Training, Underground Service Alert Work, Supervision, etc can be entered using the "Task" field on the Work Order Labor Cost Tab. (Task Definition instructions can be found in Appendix 2 of this manual.)

A Work Order should be associated with a "job", and the post mile limits should be reflective of the actual work area. This can be very important for budgetary, environmental, and legal issues.

One Work Order should not be used to record multiple work locations with a broad (all-inclusive) post mile range. Each work location should be given its own Work Order number.

Questions regarding this should be directed to your District IMMS Coordinator.

S31040 – ROCK SCALING

Purpose

Removal of loose and potentially unstable rocks and boulders from slopes if the slope has been recently damaged by storms or other catastrophic events.

Traffic control should be charged to support on the Additional tab of the Work Order when charging to this Activity, and should not be considered "M" Family work.

Special Requirements:
Note: Refer to Appendix 1 for a complete listing and description of available Maintenance Types and Priority codes.

Do not use this Activity when working for others.
Refer to Y Family, work for others.

Maintenance Type:
Supervisor Discretion

Priority Code:
Supervisor Discretion

E-FIS Project: 0000000304
E-FIS Sub Object: 036
E-FIS Reporting Code: N/A

Production Unit: ACRE
Production Unit Calculation: Acre (Measured parallel to slope).
One acre equals 43,560 square foot.

REFERENCES

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2. California Department of Transportation, 2006, Rock Scaling, Chapter X, Caltrans Maintenance Manual Volume 1, Division of Maintenance, Sacramento, California, (Currently being developed) due September 2013, http://www.dot.ca.gov/hq/maint/manual/maintman.htm

3. California Department of Transportation, 2012, S31040-Rock Scaling ,S Family Activities, Chapter 12, Part 2, Caltrans Maintenance Manual Volume 2, Division of Maintenance, Sacramento, California, http://onramp.dot.ca.gov/hq/maint/imms/EFIS_Revisions/Coded_Final_Draft_S_Family_v1.02.pdf

4. California Department of Transportation, 2012, Code of Safe Operating Practices, http://onramp.dot.ca.gov/hq/maint/mset/CSOP2012.pdf

5. FHWA, 1993, Rockfall Hazards Mitigation Methods, Publication No. FHWA-SA-93-085, Chapter 7.2.1, Scaling.