RESCUE SYSTEMS 1

APPENDIX A

STUDENT TASK BOOK

STUDENT TASK BOOK

The Rescue Systems 1 Student Task Book lists every requirement that will be evaluated. Each student's performance will be observed and recorded by the instructor. The grades will then be evaluated and the instructor will determine if the student successfully met the performance standards for this course and should be issued a course completion certificate.

RESPONSIBILITIES

(A) State Fire Training is responsible for:

(1) Ensuring the Rescue Systems 1 training site meets all site requirements.

(2) Ensuring the course instructor(s) are registered for the level and subject of instruction to be taught.

(3) Issuing certificates for successful course completion.

(B) The student is responsible for:

(1) Reviewing and understanding instructions in the student manual.

(2) Satisfactorily completing all course requirements.

(3) Ensuring their Rescue Systems 1 Student Task Book is accurately recorded and maintained.

(4) Filing and keeping their Rescue Systems 1 Student Task Book with their other personal or career records.

(C) The Primary Instructor(s) is responsible for:

(1) Being qualified and proficient

(2) Explaining to the students the purpose of and process for completing the Rescue Systems 1 Student Task Book.

(3) Explaining to the students their responsibilities.

(4) Accurately evaluating and recording on the Rescue Systems 1 Student Task Book all course requirements completed by the students.

INSTRUCTION FOR COMPLETING THE TASK BOOK

The Rescue Systems 1 Student Task Book allows the instructor to record a student's performance for both technical and manipulative jobs. These evaluations are made

by observing the student's participation in the classroom and their manipulative performance at each skill station.

Task Book Headings

Student: Enter your name.

Class Dates: Enter the beginning and ending date of the class.

Module: Lists the module name and the technical and manipulative performance requirements by lesson plan number and topic.

Time Frame: Lists the estimated time frame for teaching the job.

SM Page #: Lists the corresponding page number from the student manual.

Grade Code: Area to record the student's performance.

Instructor #: The evaluating instructors enter their State Fire Training registration number.

Instructor Initials: The evaluating instructors enter their initials.

Date: The evaluating instructor enters the date the instructor trainee was evaluated.

Grade Codes

"A" The student successfully completed the performance standard.

"B" The student did not complete certain portions of the performance standard and additional guidance is required.

"C" The individual is severely deficient in the performance standard and must remediate this job.

"D" The student missed more than _____ hours of instruction.

STUDENT: **CLASS DATE:**

ORIENTATION MODULE		Time Frame	SM Chapter	Grade Code	Evaluating Ins. # and Initials	Date
Introduction To Rescue Systems		**2:00 to 4:00**				
1-1	Course Objectives & Overview	0:30	Chapter 1			
1-2	Urban Search & Rescue Planning	0:30	Chapter 2			
1-3	Rescue Scene Organization & Management	0:15	Chapter 3			
1-4	The Urban Search & Rescue Operational System (Optional)	1:00	Chapter 4			
1-5	Overview Of US&R Standards, Mandates, & Regulations (Optional)	0:15	Chapter 5			
1-6	Rescuer Safety In US&R Operations	0:45	Chapter 6			
1-7	US&R Search Terminology, Procedures, & Resources (Optional)	0:30	Chapter 7			
1-8	US&R Medical Care & Safety For Victims (Optional)	0:15	Chapter 8			
Rescue Rope & Related Equipment		**1:00**				
2-1	Rescue Rope & Related Equipment	1:00	Chapter 9			
Knots		**1:30**				
2-2	Introduction To Rescue Knots	0:10	Chapter 10			
2-3	How To Tie A Figure Eight Stopper	0:10				
2-4	How To Tie A Figure Eight On A Bight	0:10				
2-5	How To Tie A Figure Eight Follow Through	0:10				
2-6	How To Tie A Figure Eight Bend	0:10				
2-7	How To Tie An In-Line Figure Eight	0:10				
2-8	How To Tie An Overhand Bend	0:10				
2-9	How To Tie A Double Overhand Bend	0:10				
2-10	How To Attach A 3-Wrap Prusik Hitch To A Rescue Rope	0:10				
Rescuer & Victim Packaging		**2:20**				
2-12	How To Tie Two Half Hitches	0:10	Chapter 10			
2-13	How To Tie A Round Turn & Two Half Hitches	0:10				
2-28	How To Tie & Attach The Rescue Chest Harness	0:15	Chapter 12			
2-29	How To Don & Attach A CMC ProSeries Rescue Harness	0:15				
2-31	Introduction To The Rescue Litter	0:30	Chapter 13			
2-32	How To Secure A Victim To A Rescue Litter	0:30				
2-33	How To Rig A Rescue Litter For Low Angle Rescue, 3-Person Method	0:15				
2-34	How To Rig A Rescue Litter For Low Angle Rescue, 4-Person Method	0:15				
Rack Pulley Mariner's Hitch		**1:10**				
2-37	Introduction To The RPM	0:10	Chapter 14			
2-38	How To Attach & Operate A Brake Bar Rack As Part Of A RPM	0:15				

STUDENT: **CLASS DATE:**

ORIENTATION MODULE		Time Frame	SM Chapter	Grade Code	Evaluating Ins. # and Initials	Date
2-39	How To Attach & Operate A Figure Eight Descender As Part Of A RPM	0:15				
2-40	How To Construct & Operate A Mariner's Hitch As Part Of A RPM	0:20				
2-41	How To Attach A Prusik Loop To A RPM For Use As A Ratchet Device In A Haul System	0:10				
	TOTAL HOURS:	**6:00 to 8:00**				

COMMENTS:

STUDENT:			CLASS DATES:			
ROPE/LOW ANGLE MODULE		**Time Frame**	**SM Chapter**	**Grade Code**	**Evaluating Ins. # and Initials**	**Date**
Introduction to Anchor Systems		**2:30**				
2-14	Daily Overview & Safety Briefing	0:10	---			
2-15	Introduction To Anchor Systems	0:30	Chapter 11			
2-16	How To Tie A Tensionless Anchor	0:10				
2-17	How To Tie A Single Loop Anchor Sling	0:10				
2-18	How To Tie A Multi-Loop Anchor Sling (also in Ladder Module)	0:10				
2-19	How To Tie A Three Bight Anchor Sling	0:10				
2-20	How To Tie A Lark's Foot Anchor Sling	0:10				
2-21	How To Construct A Back-Tied Anchor System	0:10				
2-22	How To Construct A Two-Point Self-Adjusting Anchor System	0:20				
2-23	How To Construct A Three-Point Self-Adjusting Anchor System	0:20				
2-24	How To Construct A Two-Point Load Sharing Anchor System	0:10				
Introduction To Rappelling		**0:30**				
2-44	Introduction To Rappelling	0:30	Chapter 16			
Introduction To The Belay System		**0:15**				
2-42	Introduction To The Belay System (also in Ladder Module)	0:15	Chapter 15			
Rappelling		**1:15**				
2-43	How To Construct & Operate A Belay System (also in Ladder Module)	0:15	Chapter 15			
2-45	How To Rappel Using A Figure Eight Descender - High & Low Anchor Point	0:30	Chapter 16			
2-46	How To Rappel Using A Brake Bar Rack - High & Low Anchor Point	0:30				
Lowering & Raising Systems		**1:45**				
2-47	Introduction To Rope Rescue Lowering & Raising Systems	0:15	Chapter 17			
2-48	Mechanical Advantage Systems Utilizing The 3:1 Piggy Back, 2:1 Ladder Rig, & 3:1 Z-Rig, Including Directional Changes	0:15				
2-49	How To Construct & Operate A Lowering System To Lower An Ambulatory Person	0:30				
2-50	How To Change A Lowering System To A Raising System (Z-Rig) With & Without A Change Of Direction	0:15				
2-51	How To Construct & Operate A Z-Rig Raising System To Raise An Ambulatory Person	0:30				
Low Angle Rescue		**2:45**				
2-52	Introduction To Low Angle Rescue Systems	0:30	Chapter 18			
2-53	How To Attach An Ambulatory Victim To A Low Angle Rescue System	0:15				

STUDENT: **CLASS DATES:**

ROPE/LOW ANGLE MODULE		Time Frame	SM Chapter	Grade Code	Evaluating Ins. # and Initials	Date
2-54	How To Construct & Operate A Lowering System To Lower An Ambulatory Person For Low Angle Rescue	0:30				
2-55	How To Construct & Operate A Z-Rig Raising System To Raise A Rescuer & An Ambulatory Victim For Low Angle Rescue	0:30				
2-56	How To Construct & Operate A Z-Rig Raising System With A Change Of Direction To Raise Three Rescuers & A Nonambulatory Victim For Low Angle Rescue	0:30				
2-57	How To Construct & Operate A 3:1 Piggy Back Raising System With A Change Of Direction To Raise Four Rescuers & A Nonambulatory Victim For Low Angle Rescue	0:30				
	Total Hours:	**8:20 to 9:00**				

COMMENTS:

STUDENT: **CLASS DATES:**

HEAVY OBJECTS/BREAKING & BREACHING MODULE		Time Frame	SM Chapter	Grade Code	Evaluating Ins. # and Initials	Date
Heavy Objects		**5:15**				
3-1	Introduction To Heavy Objects Operations	0:20	Chapter 19			
3-2	Levers, Cribbing, Wedges, & Rollers	0:20				
3-3	How To Construct Crib Beds	0:20				
3-4	How To Raise & Lower A Heavy Object Using Pry Bars	1:00				
3-5	How To Use Rollers & Pry Bars To Move A Heavy Object	0:30				
E 3-1	Raise, Stabilize, Move, & Lower A Single Heavy Object	0:30	---			
E 3-2	Raise, Stabilize, Move, & Lower Multiple Heavy Objects	1:15	---			
E 3-3	Raise, Stabilize, Move, & Lower Multiple Heavy Objects While Safely Managing & Extricating A Victim	1:00	---			
Breaking & Breaching		**2:30**				
4-1	Introduction To Breaking & Breaching	0:30	Chapter 20			
4-2	How To Breach Plywood & Wood Frame Construction Materials	0:30	---			
4-3	How To Breach Drywall, Stucco Lath & Wood Frame Construction Materials	0:45	---			
4-4	How To Breach Light Weight Concrete Construction Materials	0:45	---			
	TOTAL HOURS:	**7:45**				

COMMENTS:

STUDENT: **CLASS DATES:**

LADDER MODULE		Time Frame	SM Chapter	Grade Code	Evaluating Ins. # and Initials	Date
Ladder Rescue		**0:10**				
5-1	Daily Overview & Safety Briefing	0:10	---			
ANCHORS		**2:00**				
2-11	How To Tie A Clove Hitch	0:10	Chapter 2			
2-18	How To Tie A Multi-Loop Anchor Sling (also in Rope/Low Angle Module)	0:10				
2-25	Introduction To Picket Holdfast Anchors	0:10				
2-26	How To Construct A 1-1 Picket Holdfast Anchor	0:30				
2-27	How To Construct A 1-1-1 Picket Holdfast Anchor	0:30				
5-2	Introduction To Lashing	0:10	Chapter 21			
5-3	How To Form A Round Lash	0:10				
5-4	How To Form A Square Lash	0:10				
Belay System		**0:30**				
2-42	Introduction To The Belay System (also in Rope/Low Angle Module)	0:15	Chapter 15			
2-43	How To Construct & Operate A Belay System (also in Rope/Low Angle Module)	0:15				
Ladder Rig		**0:15**				
5-21	How To Construct & Operate A 2:1 Ladder Rig With Pulleys	0:15	Chapter 21			
Ladder Gin		**1:15**				
5-8	Introduction To The Ladder Gin	0:15	Chapter 21			
5-9	How To Construct & Operate A Ladder Gin - Open Field	0:30				
5-10	How To Construct & Operate A Ladder Gin Against A Vehicle	0:30				
Ladder "A" Frame		**1:35**				
5-11	Introduction To The Ladder "A" Frame	0:15	Chapter 21			
2-35	How To Rig A Rescue Litter For Raising & Lowering In A Vertical Position	0:15	Chapter 17			
5-12	How To Construct & Operate A Ladder "A" Frame	0:50	Chapter 21			
2-30	How To Tie & Attach A Hasty Harness	0:15	Chapter 12			
Ladder Rescue Systems		**3:50**				
5-13	Introduction To Ladder Rescue Systems	1:00	Chapter 21			
5-14	How To Construct & Operate A Moving Ladder Slide	0:15				
5-15	How To Construct & Operate A Ladder Slide	0:15				
5-16	How To Construct & Operate An Exterior Leaning Ladder	0:15				
5-5	Introduction To Ladder Slings	0:10				
5-6	How To Construct & Attach Slings To A Ladder	0:15				

STUDENT: **CLASS DATES:**

LADDER MODULE		Time Frame	SM Chapter	Grade Code	Evaluating Ins. # and Initials	Date
2-36	How To Rig A Rescue Litter For Raising Or Lowering In A Horizontal Position	0:15	Chapter 17			
5-20	How To Construct & Operate An Interior Leaning Ladder Using The Ladder As Friction	0:15	Chapter 21			
5-19	How To Construct & Operate An Interior Leaning Ladder Using Carabiners As Friction	0:15				
5-7	How To Sling A Spar & Operate As A Lowering System	0:10				
5-17	How To Construct & Operate A Cantilever Ladder Rescue System Using A Ladder Rig	0:30				
5-18	How To Construct & Operate A Cantilever Ladder Rescue System Using A Ladder As Friction	0:15				
5-22	How To Construct & Operate A 2:1 Ladder Rig Without Pulleys	0:15				
	Total Hours:	**9:15 to 9:45**				

COMMENTS:

STUDENT: **CLASS DATES:**

SHORING MODULE		Time Frame	SM Chapter	Grade Code	Evaluating Ins. # and Initials	Date
Emergency Shoring						
6-1	Introduction To Structure Shoring Systems	0:45	Chapter 22			
6-2	Introduction To Basic Tools & Equipment For Emergency Shoring Operations	0:15	Chapter 23			
6-3	Introduction To Spot Shores Utilizing Timber, Post Screw Jacks, & Ellis Clamps	0:15	Chapter 24			
6-4	How To Construct A Timber Spot Shore	0:10				
6-5	How To Construct A Post Screw Jack Spot Shore	0:10	Chapter 25			
6-6	How To Construct An Ellis Clamp Spot Shore	0:10	Chapter 26			
6-7	Introduction To The Vertical Shore	0:15	Chapter 27			
6-8	How To Construct A Vertical Shore	0:30				
6-9	Introduction To The Horizontal Shore	0:15	Chapter 28			
6-10	How To Construct A Horizontal Shore	0:15				
6-11	Introduction To The Window & Door Shore	0:15	Chapter 29			
6-12	How To Construct A Window & Door Shore	0:15				
6-13	Introduction To A Sloped Surface Shore With Cribbing	0:15	Chapter 30			
6-14	How To Construct A Sloped Surface Shore With Cribbing	0:15				
6-15	Introduction To The Solid Sole Plate Raker Shore System	0:15	Chapter 31			
6-16	Introduction To The Flying Raker Shore System	0:15				
6-17	How To Construct A Solid Sole Plate Raker Shore System	0:45				
6-18	How To Construct A Flying Raker Shore System	0:45				
6-19	Introduction To The Cutting Station	0:15	Chapter 32			
6-20	How To Cut Wedges & Gusset Plates	0:15				
6-21	Introduction To Measuring Tools Used To Determine Raker Length & Angle	0:30				
6-22	How To Cut A 45° Angle Raker	0:30				
6-23	How To Cut A 60° Angle Raker	0:30				
	TOTAL HOURS:	**8:00**				

COMMENTS:

CHAPTER 1 - COURSE OBJECTIVES AND OVERVIEW

COURSE HISTORY

The Rescue Systems 1 course was originally developed in 1980 and entitled "Heavy Rescue" as a revision to the United States Department of Defense Manual, Heavy Duty Rescue, No. IG 14-3, 1963. In 1987, the course was updated and retitled "Rescue Systems 1, Fundamentals of Heavy Rescue" published by the California State Fire Marshal, State Fire Training. Funding grants for both of these projects were provided by the Federal Emergency Management Agency (FEMA) and administered by the California Office of Emergency Services (OES).

The Rescue Systems 1 course has been used as a model rescue course throughout the nation and abroad. It is often identified in nationally recognized organizations as a required course or a course containing equivalent curriculum such as the National Fire Academy, FEMA, and the National Fire Protection Association (NFPA).

In 1999, the course was updated again and reconfigured so that it could be taught in either a modular or continuous schedule format. Funding for the 1999 update was provided by the CDF/State Fire Training.

COURSE OBJECTIVES

The Rescue Systems 1 Course is designed to:

1. Provide training in the subject elements required for the California Urban Search & Rescue (US&R) Basic and Light Operation levels.
2. Provide information for the recognition of unique hazards associated with the collapse or failure of light frame construction.
3. Provide a working knowledge of the resources and procedures for performing search operations inside and beneath debris of light frame construction.
4. Provide training in the procedures for performing victim access operations inside and beneath debris of light frame construction.
5. Provide training in the procedures for performing victim extrication operations inside and beneath debris of light frame construction.

COURSE OVERVIEW

1. The Rescue Systems 1 course can be taught in either a "modular" or "continuous" schedule format and course dates will be dependent on which schedule format is used.
2. Students will be grouped by squad, team, company, or other configuration.

3. Each class will begin on time and student attendance is mandatory. A lunch break will be dependent on which schedule format is used.
4. Notify your instructor immediately of any injury sustained during the course and of any previous injury or limitation that would affect your participation in a training evolution.
5. Each instructor will determine the amount of personal protective equipment (PPE) to be worn by each student at each class work site. Each student should have the following minimum PPE in his or her possession at all times:
   - Bump cap or fire helmet
   - Eye protection
   - Safety boots, recommended steel toe and shank
   - Leather gloves
   - Long sleeve shirt or brush fire coat
   - Long pants or brush fire pants
6. A task book will guide the instructor and the student through the tasks required for completion of this course.

CHAPTER 2 - URBAN SEARCH AND RESCUE PLANNING

ESTABLISH LEGAL AUTHORITY AND RESPONSIBILITY

Planning is probably the single most important function for a proper and effective response to structural collapse incidents. Planning needs to be done by every organization that could be involved in responding to these types of incidents.

One of the most common problems at a major rescue incident is the time wasted trying to decide who is in charge and who is responsible. If those questions are not answered ahead of time, confusion and duplication of effort will result.

During the planning process, the legal authority should be identified. Local codes, ordinances, and policies will dictate what organization or agency has the legal authority for search and rescue. The fire department may have the legal authority only in urban environments and law enforcement may have the legal authority in wilderness environments or for search and rescue incidents resulting from a natural disaster or both. State laws identify when state resources can be called to help and Federal laws dictate when federal resources can be activated.

Once legal authority has been determined, the identification of who is responsible for specific actions at an incident site must be established.

The fire service is responsible for fire suppression. No other agency can perform that function, so it becomes the fire service's primary responsibility. If a community relies entirely on the fire service to perform search and rescue from collapsed structures and there is a major fire at the same time, then the rescue of victims from that collapsed structure may have to wait. That may not be acceptable.

Traditionally the fire service is also responsible for initial emergency medical services, hazardous material incident response, and many forms of rescue.

Law enforcement is responsible for security, site control, crime scene investigation and, in some cases, search and rescue. Structural collapse incidents where people are killed or injured need to be handled as potential crime scenes. Some law enforcement agencies may believe that structural collapse rescue training is only for the fire service. A quick review of the 1989 Loma Prieta, CA earthquake, 1994 Northridge, CA earthquake and 1995 Oklahoma City, OK bombing will find almost every law enforcement agency in the affected area was heavily involved in rescue situations.

Other agencies and organizations have vital roles to play in structural collapse incidents, and those roles need to be identified before an incident occurs.

DEVELOP A VULNERABILITY AND HAZARD ASSESSMENT

A vulnerability and hazard assessment will allow you to find out how susceptible your community is to certain types of events that could cause a disaster. What could happen in the future?

- Windstorm
- Earthquake
- Flood
- Tsunami
- Landslide
- Snow Avalanche
- Explosion
- Hurricane
- Tornado

Determine community vulnerability by researching what has happened in the past. If it has happened once, it may happen again. Take the opportunity to learn from historical events that have occurred within your community and neighboring communities. Identify the problems that existed or potential problems that could exist when these events occur and develop a plan of action to deal with them.

Survey your community for potential hazards near dams with a large population in the down stream impact zone, old and unreinforced masonry structures, power generating stations, chemical plants, and low lying areas susceptible to flood, landslide, and snow avalanche.

Historical and current information pertaining to community vulnerability and hazards can be found in your local Building Department, geological organizations, and local and state emergency management agencies.

IDENTIFY RESOURCES

By identifying the hazards and potential problems, you can identify available resources to solve the problem. If the resource does not exist within your community, you obtain it or you can identify resources from outside your community and arrange to use them through local mutual-aid agreements.

Local jurisdictions must use available resources first. When local resources are overwhelmed, additional resource requests are routed through mutual-aid agreements, then to the county, to the state and eventually to the federal government.

Local authorities maintain command and control of local incidents even when state and federal resources are requested.

Resource lists should be included within the plan. The lists should identify:

- The resource
- The resource capability
- How to contact the resource
- The resource response time
- Any other pertinent information

Local Resources

Local resources may include:

1. Fire service and law enforcement.
2. Local emergency medical service providers.
3. Community Emergency Response Teams (CERT) or Disaster Assistance Response Teams (DART) from businesses, schools, and industry.
4. Volunteer search and rescue teams traditionally used in wilderness situations.
5. Public works departments and utility companies with heavy equipment and tools for breaching roadway surfaces and lifting heavy objects.
6. Heavy equipment and construction trade unions and companies.
7. Sewer companies, which may have remote cameras for surveying sewer lines that could be used in searching void spaces.

State Resources

State mutual-aid agreements allow fire and law enforcement agencies to cross-jurisdictional borders to assist affected areas.

The governor of a state can declare a State of Emergency and activate state resources such as the National Guard to assist local jurisdictions.

Federal Resources

A Presidential declaration of a disaster is required to implement the Federal Response Plan (FRP) through the Stafford Act. The FRP is managed by the Federal Emergency Management Agency (FEMA). Federal resources are organized into 12 Emergency Support Functions (ESF). Urban Search and Rescue (US&R) is ESF-9. The Department of Defense (DOD) military resources are accessed through the FRP.

RESPONSE COORDINATION

The first local emergency service provider on scene is responsible for on site incident management and coordination. They must immediately establish command, provide initial orders to arriving resources, and request additional resources as needed. The person in charge may change throughout the incident as higher-ranking supervisors arrive. A Unified Command structure may be necessary due to the involvement of multiple agencies and jurisdictions having statutory or political responsibility or authority. Large incidents may require the activation of an Emergency Operations Center (EOC) to coordinate and support multiple resources

Emergency Operations Center

The Emergency Operations Center (EOC) may be identified by a different name, but whatever the name, it is the place where incident information is collected and executive policy decisions are made that result in resource coordination, support, and emergency response. At the EOC, the overall disaster priorities are established and resources are allocated. It provides a single point for collection, evaluation, display, and dissemination of information. It facilitates verification of information, which helps to control rumors.

The EOC gathers and processes a wide variety of incident information such as:

- Location of problems and number of victims
- Available resources and assistance needs
- Road and infrastructure status
- Evacuation center and shelter locations
- Anticipate and plan for future needs
- Documents for recovery assistance and future planning

The EOC is also used to consolidate and disseminate incident information to:

- Responding and assisting resources
- Politicians and the civilian population
- Media
- Agencies requesting assistance
- State agencies and Federal authorities

The EOC can be a large, complex command center with the latest in communications and technology, or it can be the place with the only working telephone. In either case, it is a vital link in the successful coordination of a major rescue incident.

In a large multiple-site incident, each individual incident site will have its own Incident Commander (IC) and Command Post (CP). Each IC will send status reports and resource requests to their Department Operating Center (DOC) or directly to the EOC if a DOC has not been established. The

DOC will forward status reports and resource requests to the EOC for overall incident resource coordination and support.

Each political jurisdiction should have an identified EOC and backup location, as well as identified and trained EOC supervisors and staff.

Local EOC

The local EOC gathers information on the severity of damage and their capabilities, then relays this information to the County EOC. The local EOC requests additional resources through the County EOC when overwhelmed by the incident.

County EOC

The County EOC gathers information on the severity of damage and capabilities from local EOCs within their jurisdiction and relays this information to the State EOC. The County EOC coordinates the allocation and use of resources from unaffected communities within their jurisdiction. The County EOC requests additional resources through the State EOC when overwhelmed by the incident.

State EOC

The State EOC gathers information on the severity of damage and capabilities from the County EOCs and relays this information to the FEMA Regional Operations Center. The State EOC coordinates the allocation and use of State resources, the resources from unaffected Counties and requests additional resources through the FEMA Regional Operations Center when overwhelmed by the incident.

FEMA Regional Operations Center (ROC)

The United States is divided into ten federal response regions. Each region gathers information on the severity of damage and capabilities from the State EOCs within their jurisdiction and relays this information to the Emergency Information and Coordination Center (EICC) is Washington, D.C. The FEMA ROC coordinates the allocation and use of resources within their jurisdiction and requests additional resources through the EICC when overwhelmed by the incident.

TRAINING

Training should be provided to those local resources that will initially respond such as the fire department, law enforcement, and emergency medical services. Local support resources that will respond when requested such as volunteer search and rescue teams, public works departments, utility companies, and the American Red Cross should also receive training. Those facilities or groups with large numbers of people such as local government departments, schools, hospitals, commercial businesses, and the community should be trained to reduce the impact on limited local emergency resources during a disaster or other significant incident.

Training subjects should include, but not be limited to:

- Planning and hazard assessment
- Scene organization and management
- Safety and self-sufficiency
- Basic first aid and cardio pulmonary resuscitation (CPR)
- Basic search procedures and lifting techniques
- Basic utility control and fire extinguisher use
- Specialized training for the local resources that will attempt to mitigate the more hazardous structural collapse situations.

BUDGETARY NEEDS

Budgetary needs will be identified during the Urban Search & Rescue Planning process. Those items may include, but will not be limited to:

- Tools and equipment to function at an identified operational level at the scene of a structural collapse
- Information packets, training supplies and props
- Disaster supplies and communication equipment
- EOC training and facility equipment needs
- Mitigation measures to address identified vulnerabilities and hazards
- Funding for equipment maintenance
- Funding for continuing education

FOUR PHASES OF STRUCTURAL COLLAPSE RESCUE

Phase I: Size-up, Scene Management, and "Surface" Victim Rescue

Phase I starts with the occurrence of the event and can last a few minutes or several hours, depending on the magnitude of the event. Several things must occur at the same time during Phase I to ensure a smooth and orderly response.

The first and most important function is to find out how big the problem is by conducting a size-up of the incident. This is done by sending out reconnaissance (recon) teams to assess the overall damage. Size-up can be as simple as an organized walk around an involved structure or complicated involving recon of the entire community. Quite often, the size-up function is not performed because the tendency in a disaster situation is to stop and help the first victims or fix the first problems encountered. By doing this, larger groups of victims and problems that are more serious may go unreported for many minutes or even hours. Emergency service providers should not stop at the first victims or problems encountered unless the situation can be quickly resolved so that the size-up process will continue.

A good size-up will tell those in command if they can handle the situation with available resources or if they are going to have to call in additional resources and mutual aid. It will tell them what kinds of additional resources are going to be needed, and the hazards that need to be dealt with.

While size-up is occurring, it is essential to establish an Incident Command System (ICS). Once the IC is in place and information is flowing about the nature of the problem additional resources can be requested as needed. A staging area for the requested resources and a location for the treatment of injured victims should be established. Activate and staff the local EOC if needed. An Incident Action Plan (IAP) and a back up plan should be formulated by the IC or the EOC command staff at incidents involving a large portion of the community.

Simultaneously, along with size-up and scene management, "surface" victim rescue occurs. Surface victims are often defined as victims who are injured, but not trapped. Surface victims are usually injured in falls or are struck by falling objects, are located outside and inside noncollapsed buildings and account for approximately 50% of the victims at a structural collapse incident. Most surface victims are rescued by spontaneous rescue teams consisting of family, friends, coworkers, or passersby before the arrival of organized rescue personnel. They are usually removed easily from further danger, provided basic first aid, or transported to advanced medical care if needed.

Some organizations prefer to split Phase I into two phases. However, because size-up and scene management activities usually occur at the same time or before the rapid rescue of surface victims they are grouped together here as a Phase I. Concentrating on surface victim rescue in Phase I of an incident will do the most good for the most people, in the shortest amount of time with limited resources.

Phase II: Search All Accessible Areas and Void Spaces

Phase II takes place after organized rescue teams arrive and after an ICS is established. Rescue teams use the information gathered during the size-up and reconnaissance to start searching the most likely spots where victims could be trapped inside noncollapsed and collapsed buildings. The most likely areas to search first should be based on verbal reports from survivors or witnesses, building use, and time of day.

Methods of locating people who are lightly trapped inside a collapsed building might include a physical search, voice "call out" hailing system, trained Urban Search & Rescue dog teams, and specialized listening and looking devices.

Approximately 30% of the victims at a structural collapse incident are "lightly" trapped in accessible areas inside noncollapsed buildings. Victims are usually trapped by building contents like file cabinets, bookshelves, refrigerator, machinery, and small pieces of debris rather than by the structure itself.

Approximately 15% of the victims at a structural collapse incident are trapped inside accessible void spaces created by the collapsed structure. Victims may also be trapped by building contents inside accessible void spaces created by the collapsed structure. A highly trained and equipped rescue team of up to ten people can take an average of four hours to extricate a victim trapped in an accessible void space.

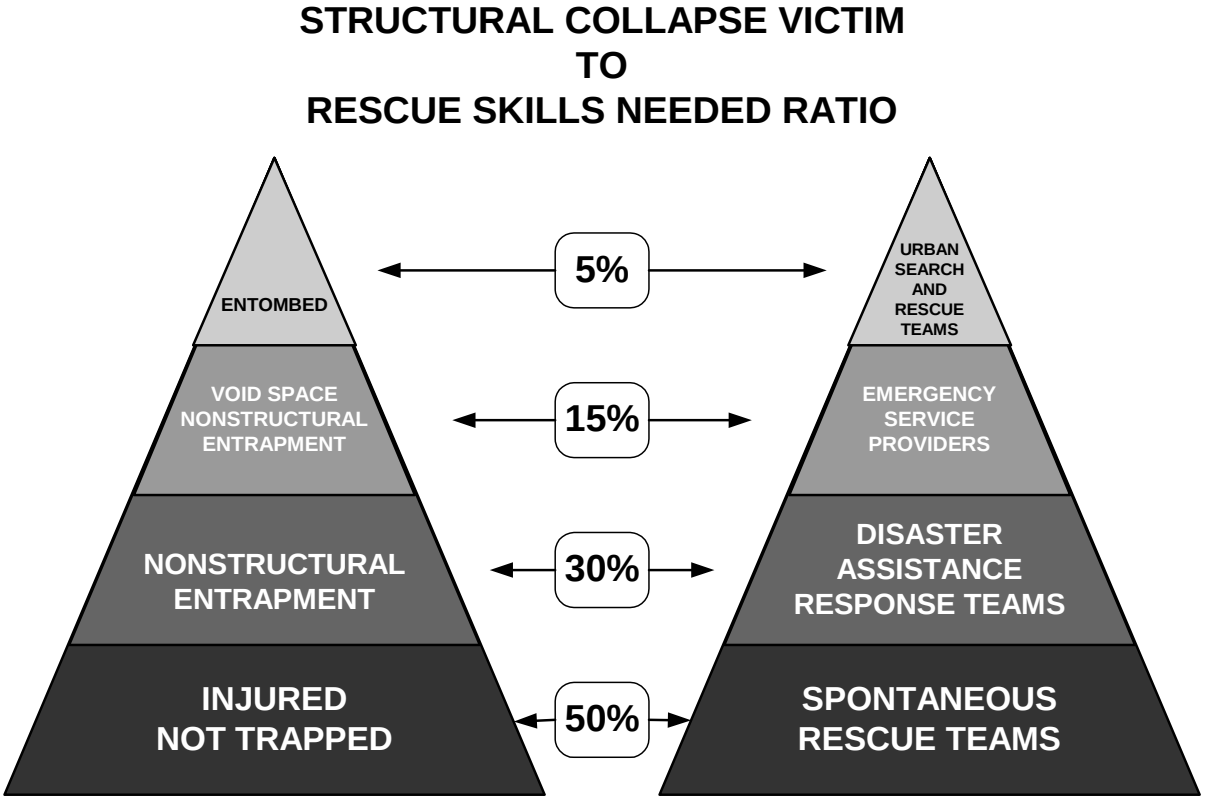


Figure 2.1

Phase III: Selected Debris Removal

Phase I and II will produce the majority of victims that can be rescued in a timely manner. Approximately 5% of the victims at a structural collapse incident are entombed or trapped by primary structural components such as walls, floors, columns, support beams, and roofs. A highly trained and equipped rescue team of up to ten people can take an average of ten hours to extricate a victim entombed or trapped by primary structural components.

Selected debris removal is a very hazardous situation. The cost to benefit ratio (danger to rescuers vs. live victim rescue) must be evaluated. The following operational procedures should be considered:

1. Remove all rescue personnel from the structure and mitigate all possible hazards.

2. Develop a systematic plan for removing the selected portions of debris based on advise from an on site structural engineer and the highest probability of finding live victims.
3. Constant coordination and communications with all heavy equipment and rescue team members must be maintained at all times
4. If possible, remove the debris from the top towards the bottom.
5. Mark newly created debris piles to prevent future rescue teams from searching the rubble just moved.
6. Limit the number of rescue team members inside and near the structure to a minimum.
7. Develop a contingency plan for live or deceased victims found.

Phase IV: General Debris Removal

Phase IV occurs when the possibility of finding any live victims is highly unlikely due to the victim count, duration of the incident or other factors such as weather extremes or cause of the collapse. The structure and debris are systematically removed with heavy equipment without regard or preference to any particular location. Develop a contingency plan for the remote possibility of a live victim being found. Rubble removed from the structure must be inspected for bodies and body parts. Any bodies or body parts found must be handled in a predetermined manner coordinated with local law enforcement and/or coroner officials.

CHAPTER 3 - RESCUE SCENE ORGANIZATION AND MANAGEMENT

THE INCIDENT COMMAND SYSTEM (ICS)

Organized Approach to Managing Any Incident

The Incident Command System (ICS) allows an organized approach to managing any emergency incident. It is adaptable to any incident, large or small. It is also adaptable to any type of incident such as a fire, emergency medical situation, flood, hurricane, earthquake, or structural collapse.

The ICS is universally applicable and acceptable. It allows for a logical expansion of command, personnel, and other resources as an incident escalates. It is adaptable to multi-agency and multi-discipline response to incidents. By featuring common terminology, personnel from many disciplines and agencies can operate in one system.

Use of the ICS for an urban search and rescue incident helps assure uniformity and control of the response. It allows the incident to expand from a local response to a regional, state, or federal response with minimal loss of continuity. It increases the likelihood of the available resources being allocated properly, based on actual need. It also allows incoming resources to understand and fit into the local command structure.

The system expands in a logical manner by filling supervisory and functional positions only when needed. It limits the number of personnel responsible to each supervisor with an effective span of control usually limited to five persons per supervisor. Supervisors have overall functional responsibility for their assignment which allows reasonable control of personnel and rescue efforts and improves overall safety in the highly unstable rescue environment.

Major Functions Within ICS

The ICS is divided into five major functions: command, operations, planning, logistics, and finance/administration.

The command function is accomplished by the Incident Commander (IC). This position is filled during every incident, whether it is a single unit response or a multi agency, multi-discipline response. ICS assures that the system can be expanded as the need arises. The IC is responsible for the overall management of the incident and determines the overall strategic goals for the incident with input from other members of the organization. Large disasters often employ a unified command emergency management structure. A unified command may have several persons with equal functional or jurisdictional responsibilities managing the incident and making jointly agreed upon decisions. One person remains in charge as the IC in a unified command structure.

The Operations Section is responsible for managing all operations directly related to accomplishing the tactical objectives identified in the Incident Action Plan (IAP). Search and rescue teams will work in this section. The Operations Section is managed by the Operations Section Chief.

The Operations Section may be further divided to lessen the span of control. The next method of reducing the span would involve dividing into a "branch." The branch is a major functional or geographic segment of the Operations Section. A branch is managed by a Branch Director

Groups are resources assembled at an incident to perform a special function in a Branch, if activated. As an example, a Rescue Branch may be further divided into groups that include the Search Group and the Rescue Group. A group is managed by a Group Supervisor.

Divisions are smaller geographic areas of a Branch, if activated. A large incident may be divided into Division A at one rescue site and Division B at a second, more remote rescue site. A division is managed by a Division Supervisor.

Again, these additional components are only established to maintain a manageable span of control. All personnel must understand their position within the in-place ICS and operate through the chain of command.

The Planning Section is responsible for collecting, evaluating, and using all of the information pertaining to the incident and developing the IAP for each operational period. The Planning Section helps to determine the effectiveness of current actions and recommends alternate strategies. Planning also documents the actions taken during an incident and provides technical expertise as required. The Planning Section is managed by the Planning Section Chief.

The Logistics Section is responsible for providing all facilities, services, and materials in support of the incident. This includes such areas as food, shelter, supply, and communications. The Logistics Section is managed by the Logistics Section Chief.

The Finance/Administration Section is responsible for all financial and cost analysis aspects of the incident. This function oversees the documentation of time and costs associated with personnel, supplies, and equipment as well as the documentation of private resources used throughout the incident. The Finance/Administration Section is managed by the Finance/Administration Section Chief.

ICS ORGANIZATIONAL CHART

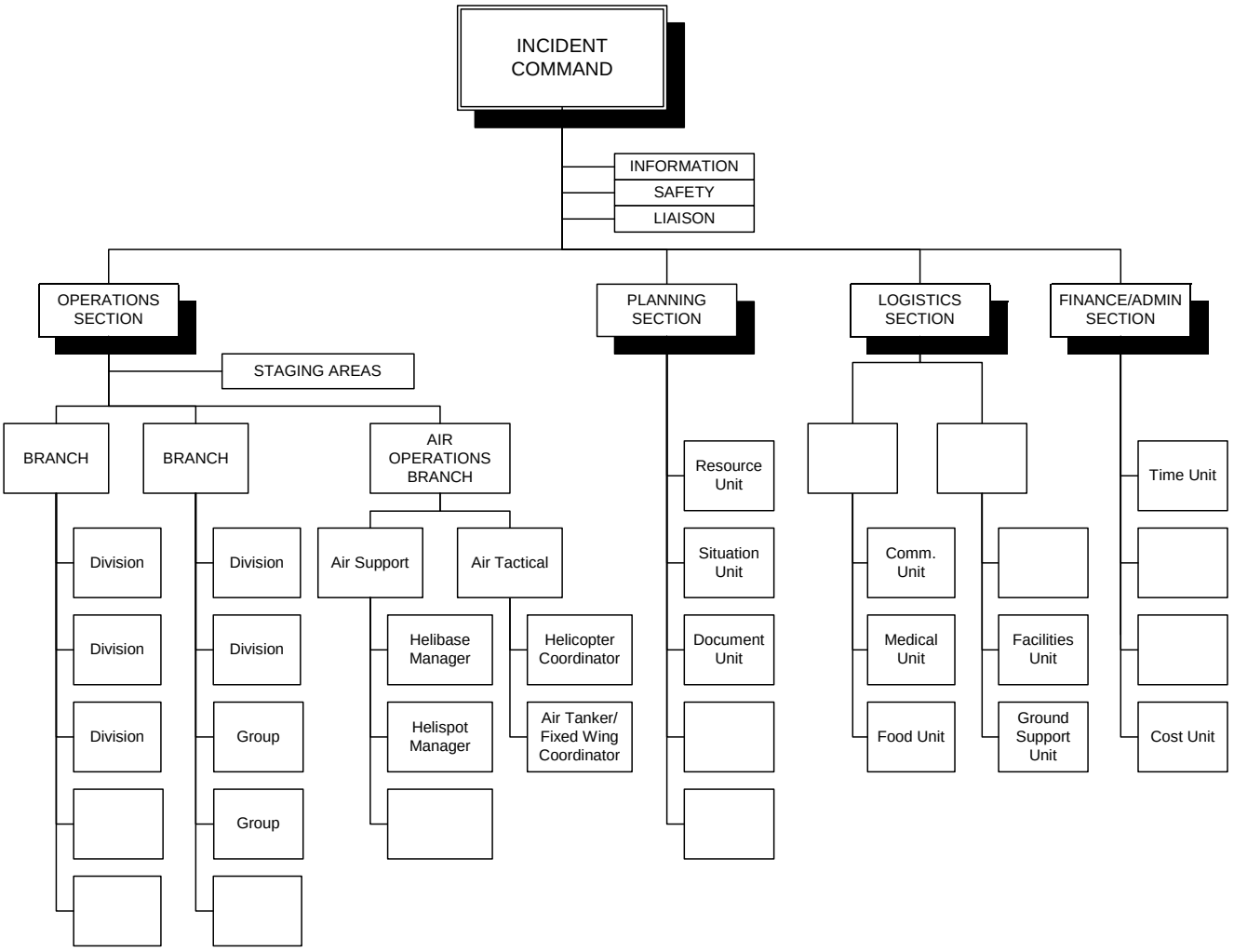


Figure 3.1

THE STANDARDIZED EMERGENCY MANAGEMENT SYSTEM (SEMS)

Because of the 1991 East Bay Hills Fire in Oakland, CA, Senate Bill 1841 was introduced by Senator Petris. The California legislature passed the bill into law in 1993. The intent of the law is to improve the coordination of state and local emergency response in California. The law is found in Section 8607 of the Government Code and requires local governments to use SEMS by December 1, 1996 when responding to emergencies in order to be eligible for state funding of response-related costs.

SEMS is applicable to the following five response levels:

- Field (On scene at incidents)
- Local government
- Operational Area
- Region
- State

SEMS incorporates the use of the ICS and is extremely valuable for multi-agency or inter-agency coordination to facilitate decisions for overall emergency response activities, including the sharing of critical resources and the prioritization of incidents.

COMMUNICATIONS

Communication, both on and off the scene, is an important part of organization. Communication allows resources to be utilized at the correct location and allows status and progress to be monitored throughout the incident.

On Scene Communications

On scene communications are communications at the actual work site. The rules are the same for all communications during any incident. Communications from personnel on scene are channeled through the chain of command to the on scene IC for proper action. If the proper action requires off scene communication, this is communicated by the on scene IC. This allows information to be passed in an organized manner to the proper level of authority.

Off Scene Communications

Off scene communication includes communication to the overall IC off scene during a multi-site operations. It includes communication to the communication center for additional resources or for information updates.

Effective Communications

Effective communications must be two-way, traveling both up and down the chain of command. Two-way communication allows feedback to be provided as well as the status of the situation to be updated throughout the incident. Two-way communication allows concerns to be identified and addressed at each level of the organization/operation. It also allows for the specific identification and documentation of problems, the need for additional resources to be readily identified and acted upon, and helps assure that safety issues are identified and documented by all concerned.

Reasons for Communications

Communications must take place for status updates, identification of hazards and safety issues, to direct and coordinate resources, and to request additional resources.

Communication Methods

Communication methods include the vehicle or portable radio, hard wire telephone, cellular phone, fax, and pager. The use of a "runner" to pass information can be effective, depending on distance and terrain. A megaphone or loudspeaker and signaling devices, such as an air horn, whistle, or hand signals, also may be effective.

A computer with a modem may be used to send and receive information. This is especially effective if a system is in place to send/receive information before the incident.

All methods of communication have limitations. Radios have a limited number of available frequencies. These frequencies are often not compatible and could interfere with other operations. Some frequencies do not operate well in concrete structures. The 450 MHZ range seems to work best in these structures. A radio communication plan to identify who is using what frequency must be developed.

The telephone system may be out of service, or there may be overloaded due to a lack of available lines. The hard wire telephone limits movement. A cellular system can also be "down" with no available or "full" cellular receiver/transmission sites.

Runners may not communicate the message accurately and are subjected to hazards traveling across the rescue site. Using a runner is only possible when there are available personnel. A signal system is effective if the involved personnel know what the signals mean.

Compatibility of Communications

Some guidelines must be followed when operating in a multi-agency, multi-jurisdictional situation. Use clear text; state what you need in plain English. Transmit the message in plain English without the use of slang or "10" codes. The message must be kept short without extraneous detail, understandable, and spoken clearly at a reasonable pace.

Personnel should always use their assigned radio designations. Remember that your designation during a multi-agency, multi-disciplinary, and multi-jurisdictional response may not be your usual designation. The designation to be used will be assigned/confirmed by the IC or your immediate supervisor.

SCENE CONTROL

Gain Control of the Site

Rescuers must gain perimeter control of the site as soon as possible. If you do not have control of the perimeter, you do not have control of the scene. This can be a very difficult task. The emotions of civilians trying to perform rescues are high. In many cases, people are trying to rescue family or friends and are reluctant to discontinue their efforts. It is very important for safety that the first-arriving rescuers control civilian rescuers at the site as soon as possible. The potential for a secondary collapse is great and, although they mean well, civilians may hamper the overall effort of the organized rescue personnel.

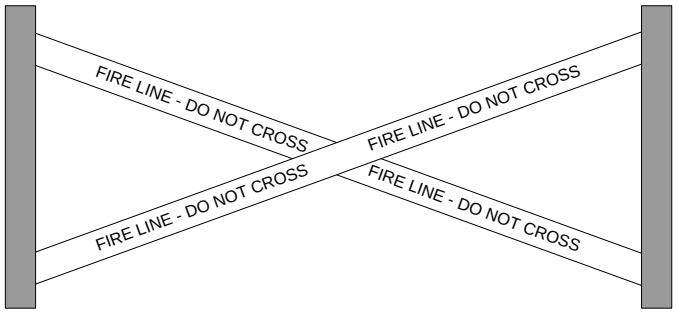
Spontaneous rescuers or convergent volunteers present before the arrival of trained rescue personnel can be a significant resource, if organized and under the direction of the IC. Use caution not to use these resources when making assignments in hazardous or unsafe areas. It will be very difficult to remove spontaneous rescuers or convergent volunteers without providing them with another assignment due to their emotional attachment to the victims they may be attempting to rescue. Manage all interactions with spontaneous rescuers or convergent volunteers with sensitivity.

In order to assist with control of the site and in order to identify the area of concern, a physical barrier should be established around the entire site. This could be a large area depending on the physical layout and impact of the incident.

When using barrier tape, a single piece placed straight across the access indicates a controlled access area (crowd control more than a specific hazard) and crossing the tape indicates a specific hazard area and do not enter. Other possible methods to control the scene are fencing, either temporary chain link or plastic construction mesh, pylons, and barricades. In most cases, police agencies or public works departments can assist in acquiring the necessary materials.

RESCUE WORK SITE SET UP

COLLAPSE/HAZARD ZONE
To control all access to the immediate area of the collapse that could be impacted by secondary collapse and falling debris. Only rescue personnel directly involved in search and extrication operations are allowed in this zone.



OPERATIONAL WORK AREA
To control the access to the rescue work site except for assigned emergency personnel supporting the operation.

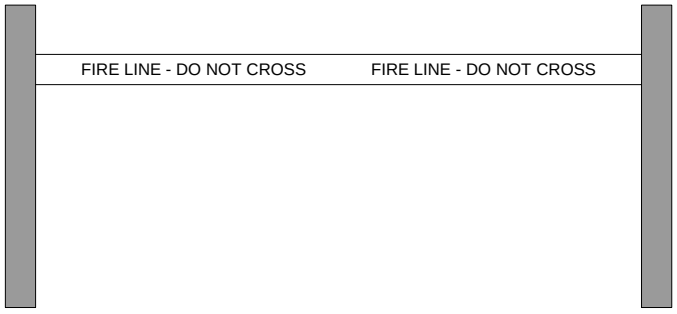


Figure 3.2

Other useful resources in controlling the site are the police and the military. These agencies are established and have standard procedures for controlling specific areas. These resources and their actions must be coordinated with the IC.

Control Access

Access must be controlled through entrance/exit points to allow for personnel accountability and control.

Establish Best Access Route to the Incident

The IC must communicate the best access to the site for incoming resources. This allows an organized approach to the scene, taking into consideration access conditions and anticipated need/utilization of resources.

Establish the Incident Command Post (ICP)

The location of the Incident Command Post (ICP) or (CP) is an important part of the initial incident setup. The CP must be located away from the hazard area. The IC should not have to deal with potential hazards and should not be placed in a hazardous position. The location of the CP must be communicated to resources and the communication center.

The CP should provide shelter from weather, and privacy as needed. Access to the CP should be limited to allow control of the area and to decrease the potential for large numbers of personnel to gather there. Security should be provided as needed. The CP should be located away from noisy operations and should not be crowded with unnecessary personnel or resources.

Establish a Staging Area

The IC should establish and identify a staging area for incoming resources. This site should be away from the immediate scene, but provide reasonable access to it. The staging area should be large enough to handle the anticipated volume of first-to-arrive, immediate-need resources. Resources assigned to staging should keep in communication with the IC or Operations Section Chief at the incident site and be ready to respond to an assignment within three minutes. The chosen site should minimize disruptions of other activities, including the normal flow of traffic, if possible.

The IC should establish and identify the location of a base for planned need resources that will arrive later. A base is usually established when the mitigation of the incident will probably take longer than one 12-hour operational period. Considerations in the selection of a long-term staging area or base should include sanitary facilities, food and drink, and shelter.

Control the Site to Decrease Freelancing

Controlling the access/egress assures that the use of resources, which includes personnel, is documented. Controlled access improves safety by limiting the number of personnel within the danger area. It also assures accountability, as each person or resource is checked in and out through staging and to the IC, Operations Section Chief, Branch Director, or Division/Group Supervisor.

INITIAL ACTIONS AT THE SCENE OF A STRUCTURAL COLLAPSE

1. Complete all aspects for Phase I of structural collapse rescue
   - Size-up, scene management and "surface" victim rescue
2. Identify and request additional resources
   - Local and mutual aid resources
   - Specialized resources such as structural engineers, US&R search dogs, US&R technical specialists
   - Specialized equipment such as cranes, front loaders, and dump trucks
3. Control site perimeter and spontaneous rescuers or convergent volunteers
4. Secure all utilities
5. Deploy fire protection hose line, if necessary for the type of structure and present conditions
6. Request support resources such as the American Red Cross, Salvation Army, utility companies, etc.
7. Establish priorities, develop and implement plans with organized resources to accomplish the remaining phases of structural collapse rescue
8. Phase II
   - Search all accessible areas and void spaces
9. Phase III
   - Selected debris removal
10. Phase IV
    - General debris removal

CHAPTER 4 - THE URBAN SEARCH AND RESCUE OPERATIONAL SYSTEM DESCRIPTION

ICS-US&R 120-1 DECEMBER 30, 1994

Introduction

The Urban Search and Rescue (US&R) organizational module is designed to provide supervision and control of essential functions at incidents where technical rescue expertise and equipment are required for safe and effective rescue operations. US&R incidents can be caused by a variety of events such as earthquakes, floods, and hurricanes that cause widespread damage to a variety of structures and entrap hundreds of people. Other examples of US&R incidents can range from mass transportation accidents with multiple victims to single site events such as trench cave-in and confined space rescue operations involving only a few victims. US&R operations are unique in that specialized training and equipment are required to mitigate the incident in the safest and most efficient manner possible.

Initial Urban Search & Rescue operations will be directed by the first arriving company officer who will assume command as the Incident Commander (IC). Subsequent changes in the incident command structure will be based on the resource and management needs of the incident following established ICS procedures.

Additional resources may include US&R Companies and US&R Crews specifically trained and equipped for urban search and rescue operations. The US&R Company is capable of conducting search and rescue operations at incidents where technical expertise and equipment are required. US&R Crews are trained urban search and rescue personnel dispatched to the incident without rescue equipment. US&R Companies and Crews can be assigned as a single increment, grouped to form US&R Strike Teams, or added to other resources to form a Task Force. US&R single increments, Strike Teams and Task Forces are managed the same as other incident resources.

Due to the unique hazards and complexity of urban search and rescue incidents, the IC may need to request a wide variety and amount of multi-disciplinary resources. (See Appendix E, Additional Urban Search & Rescue Resources).

US&R Companies and Crews have been categorized or "typed." Typing is based on an identified operational capability. Four levels of US&R operational capability have been identified to assist the IC in requesting appropriate resources for the incident. These levels are based on four general construction categories and related incidents the rescuer may encounter, and identifies minimum training and equipment required for safe and effective rescue operations in these situations. Levels of US&R operational capability and general construction categories are identified in the Glossary of Terms, Appendix A, and Appendix B.

Urban search and rescue incidents may occur that will require rescue operations that exceed a resource's identified capability. When the magnitude or type of incident is not commensurate with a capability level, the IC will have the flexibility to conduct rescue operations in a safe and appropriate manner using existing resources within the scope of their training and equipment until adequate resources can be obtained or the incident is terminated.

UNIFIED COMMAND

A Unified Command structure may need to be utilized at US&R incidents due to the involvement of multiple agencies and jurisdictions having statutory or political responsibility or authority. A Unified Command, located at a single Command Post, is the best method for ensuring effective information flow, coordination, and safety and to ensure maximum utilization of resources that can reduce fiscal impact.

Example

An urban search and rescue incident involving a multi-agency and multi-jurisdictional response would be an earthquake causing the collapse and damage to several structures over a large but confined area crossing jurisdictional boundaries. The event has trapped multiple victims in densely populated areas of the city that contracts its law enforcement capability from the adjacent county. In this city, the fire department will have responsibility for fire suppression, initial medical treatment, and search and rescue. Law enforcement will be responsible for scene security, traffic control, and evacuation. Additional resources from a variety of agencies and organizations will be required to mitigate the incident. A unified command structure will ensure effective coordination and utilization of each responding resource.

ICS MODULAR DEVELOPMENT

The flexibility and modular expansion capabilities of the Incident Command System provides an almost infinite number of ways US&R resources can be arranged and managed. A series of modular development examples are included to illustrate one possible method of expanding the incident organization based on the example scenario described above.

The ICS Modular Development examples shown are not meant to be restrictive, nor imply these are the only ways to build an ICS organizational structure to manage urban search and rescue resource at an incident. To the contrary, the ICS Modular Development examples are provided only to show conceptually how one can arrange and manage resources at an urban search and rescue incident that builds from an initial response to a multi-branch organization.

ICS Modular Development Examples

Initial Response Organization

The first Fire Department Company Officer to arrive will assume command of the incident as the Incident Commander. Initial response resources are managed by the IC who will assume all Command and General Staff functions and responsibilities.

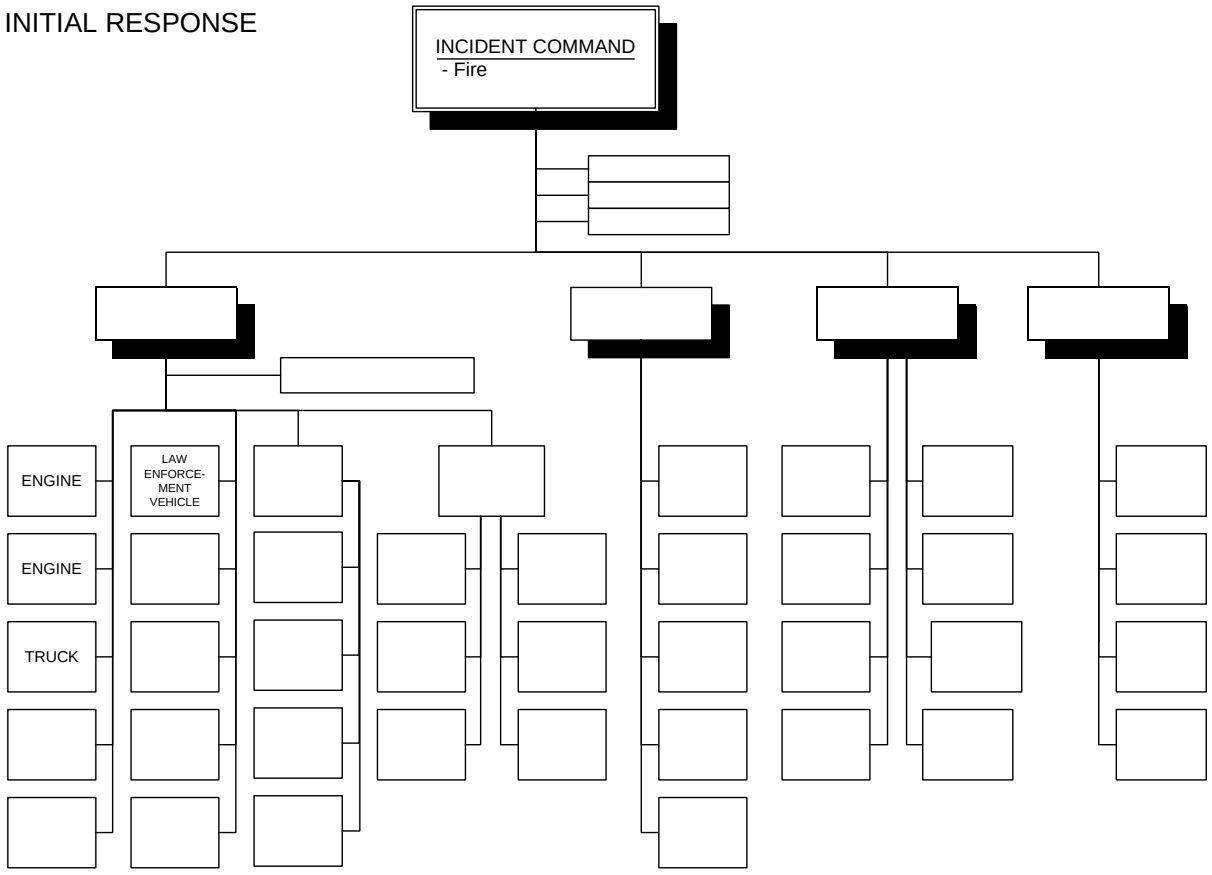


Figure 4.1

Reinforced Response Organization

In addition to the initial response, more Law Enforcement, local Engine and Truck Companies, and Mutual Aid resources have arrived. The IC has established a Safety Officer to assure personnel safety and a Public Information Officer to manage the large media presence. A Staging Area is established to check-in arriving resources. The incident is geographically divided into Divisions "A" and "B" to better manage resources. The original Engine and Truck Companies are grouped together to form Task

Force #1. The second Local Engine and Truck Companies to arrive are grouped together to form Task Force #2. Public Works is removing debris from the street to improve access and egress routes. Examples of possible assigned functions are enclosed in brackets below each resource.

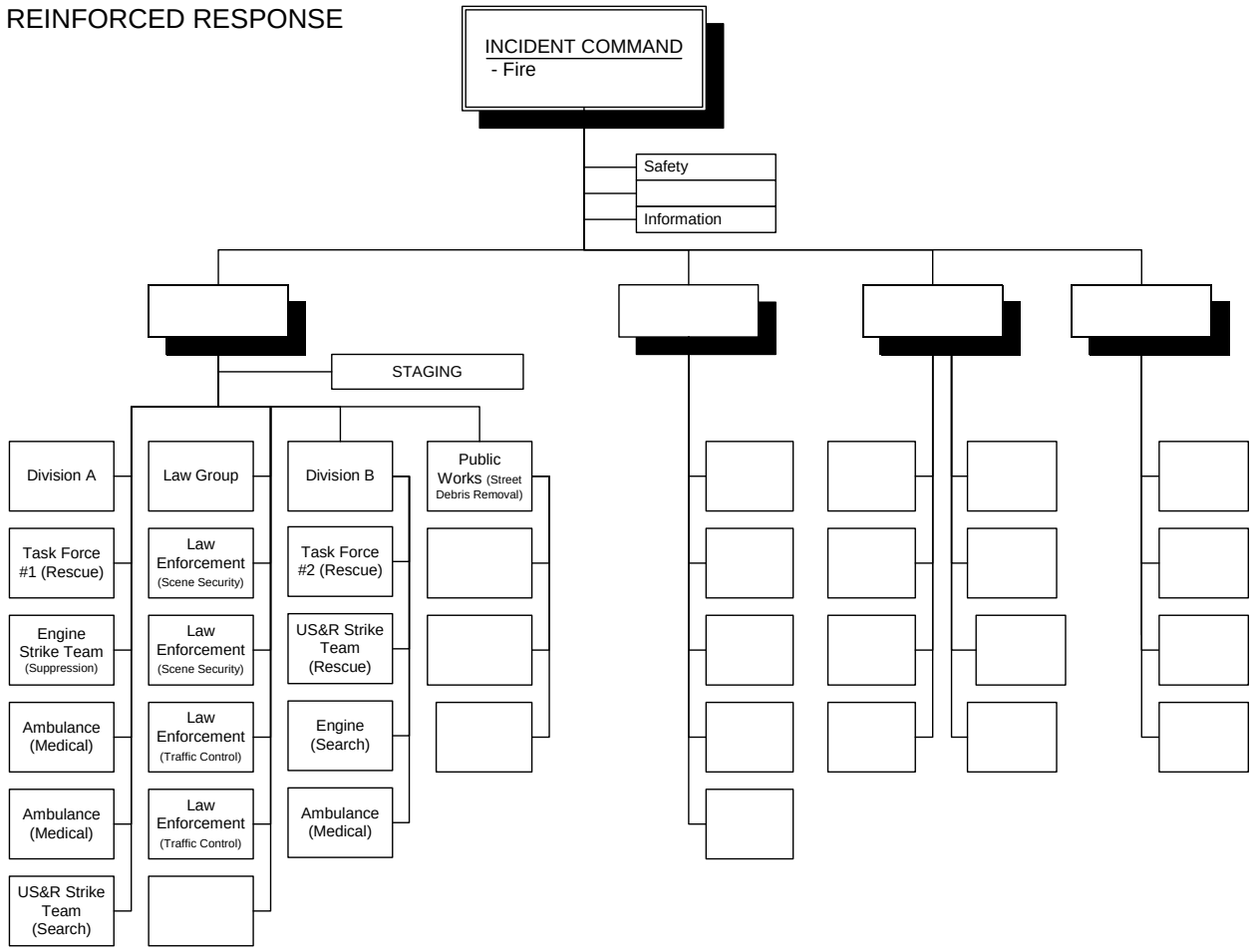


Figure 4.2

Multi-Group/Division Response Organization

The IC forms a Unified Command with the senior ranking Law Enforcement official on scene, adds a Liaison Officer to the Command Staff to coordinate assisting agencies participation, and assigns an Operations and Planning Section Chief. Several operational Units have been formed to better coordinate the large amount of resources at the incident. A Law Group and Medical Group have been formed. A Structural Engineer Technical Specialist is assisting Division "B" resources with structural

damage assessment. A Hand Crew Strike Team is conducting debris removal. One State/National US&R Task Force has arrived and is assigned to Division "A." One US&R Technical Specialist who understands the unique complexities and resource requirements at US&R incidents has been assigned to the Planning Section.

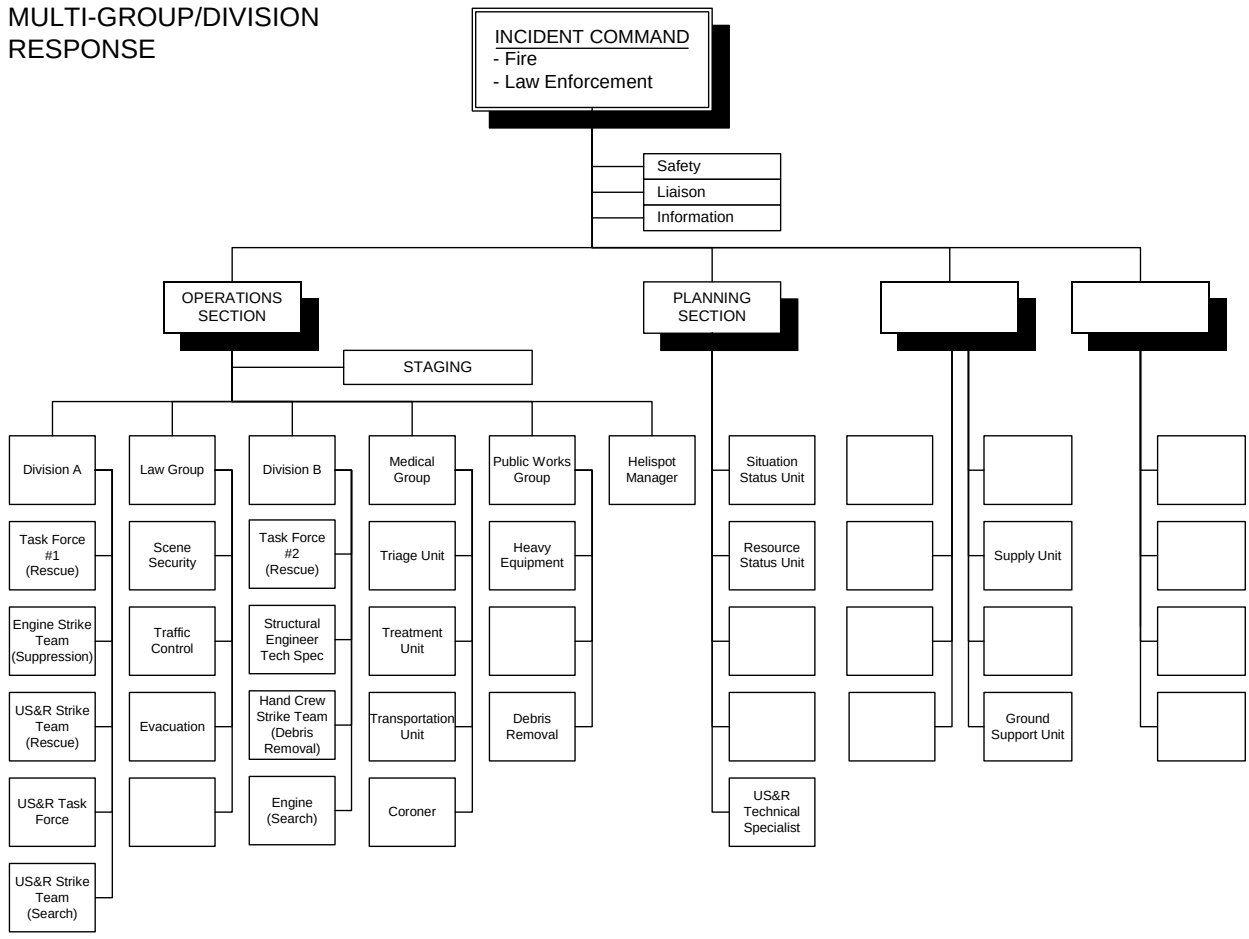


Figure 4.3

Multi-Branch Response Organization

The Incident Commander has assigned a Logistics and Financial/Admin Section Chief. The Operations Section has established five branches with similar functions to better coordinate and manage resources. The Planning, Logistics, and Finance/Admin Section have several Units operational to support the large amount of resources at the incident.

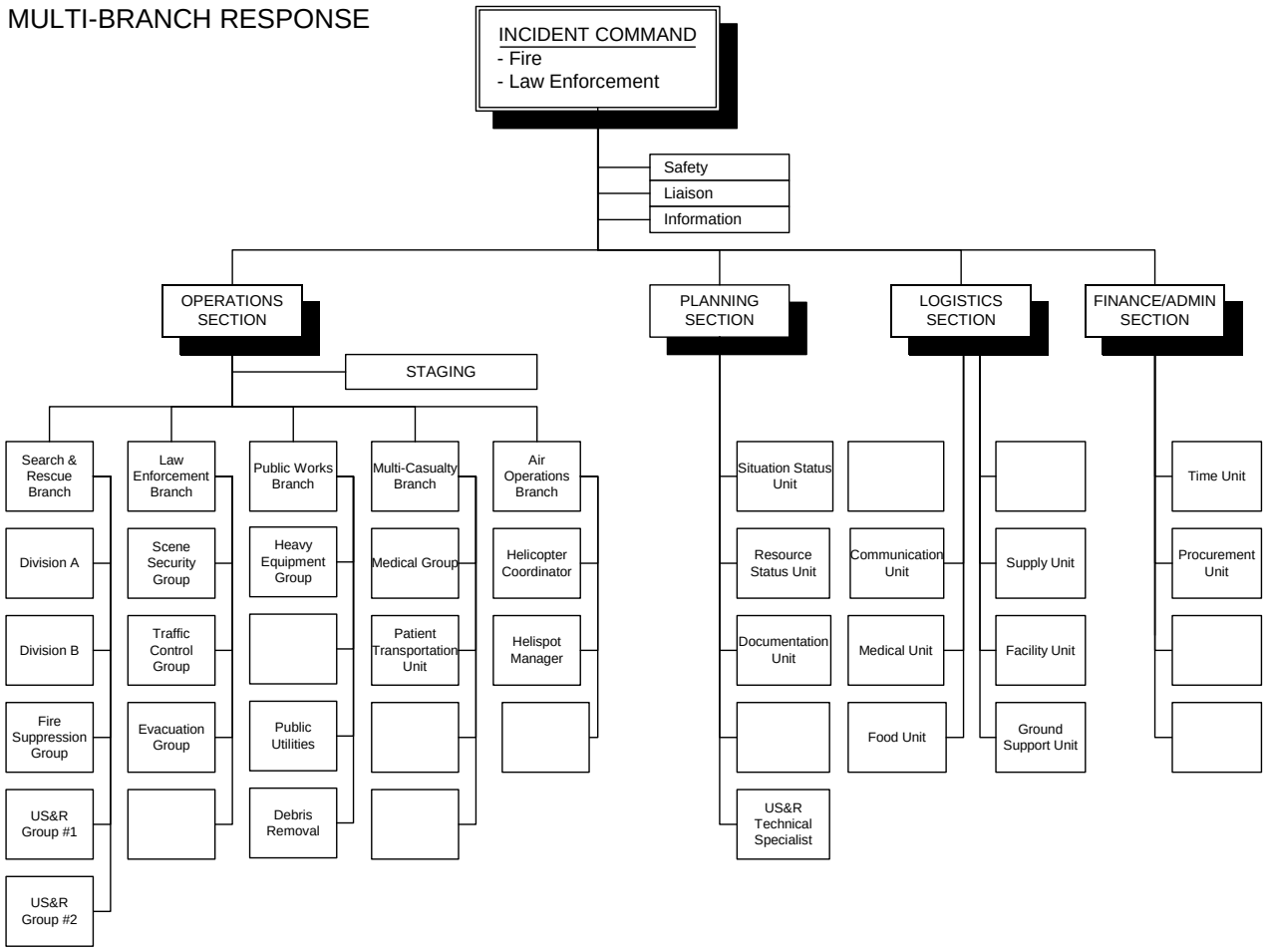


Figure 4.4

GLOSSARY OF TERMS

Basic Operational Level: The Basic level represents the minimum capability to conduct safe and effective search and rescue operations at structure collapse incidents. Personnel at this level shall be competent at surface rescue that involves minimal removal of debris and building contents to extricate easily accessible victims from noncollapsed structures.

Basic Rope Rescue: Rescue operations of a noncomplex nature employing the use of ropes and accessory equipment.

Confined Space Rescue: Rescue operations in an enclosed area, with limited access/egress, not designed for human occupancy and has the potential for physical, chemical, or atmospheric injury.

Heavy Floor Construction: Structures of this type are built utilizing cast-in-place concrete construction consisting of flat slab panel, waffle, or two-way concrete slab assemblies. Pretensioned or post-tensioned reinforcing steel rebar or cable systems are common components for structural integrity. The vertical structural supports include integrated concrete columns, concrete enclosed or steel frame, which carry the load of all floor and roof assemblies. This type includes heavy timber construction that may use steel rods for reinforcing. Examples of this type of construction include offices, schools, apartments, hospitals, parking structures, and multi-purpose facilities. Common heights vary from single story to high-rise structures.

Heavy Operational Level: The Heavy level represents the minimum capability to conduct safe and effective search and rescue operations at structure collapse incidents involving the collapse or failure of reinforced concrete or steel frame construction and confined space rescue operations.

Heavy Wall Construction: Materials used for construction are generally heavy and utilize an interdependent structural or monolithic system. These types of materials and their assemblies tend to make the structural system inherently rigid. This construction type is usually built without a skeletal structural frame. It utilizes a heavy wall support and assembly system to provide support for the floors and roof assemblies. Occupancies utilizing tilt-up concrete construction are typically one to three stories in height and consist of multiple monolithic concrete wall panel assemblies. They also use an interdependent girder, column, and beam system for providing lateral wall support of floor and roof assemblies. Occupancies typically include commercial, mercantile, and industrial. Other examples of this type of construction type include reinforced and unreinforced masonry (URM) buildings typically of low-rise construction, one to six stories in height, of any type of occupancy.

Light Frame Construction: Materials used for construction are generally lightweight and provide a high degree of structural flexibility to applied forces such as earthquakes, hurricanes, tornadoes, etc. These structures are typically constructed with a skeletal structural frame system of wood or light gage steel components, which provide support to the floor or roof assemblies. Examples of this construction type are wood frame structures used for residential, multiple low-rise occupancies, and light commercial occupancies up to four stories in height. Light gage steel frame buildings include commercial business and light manufacturing occupancies and facilities.

Light Operational Level: The Light level represents the minimum capability to conduct safe and effective search and rescue operations at structure collapse incidents involving the collapse or failure of light frame construction and basic rope rescue operations.

Medium Operational Level: The Medium level represents the minimum capability to conduct safe and effective search and rescue operations at structure collapse incidents involving the collapse

or failure of reinforced and unreinforced masonry, concrete tilt-up, and heavy timber construction.

Precast Construction: Structures of this type are built utilizing modular precast concrete components that include floors, walls, columns, and other sub-components that are field connected upon placement on site. Individual concrete components utilize imbedded steel reinforcing rods and welded wire mesh for structural integrity and may have either steel beam, or column or concrete framing systems utilized for the overall structural assembly and building enclosure. These structures rely on single or multi-point connections for floor and wall enclosure assembly and are a safety and operational concern during collapse operations. Examples of this type of construction include commercial, mercantile, office, and multi-use or multi-function structures including parking structures and large occupancy facilities.

Search Marking System: A standardized marking system employed during and after the search of a structure for potential victims.

State/National Urban Search & Rescue (US&R) Task Force: A 62-person team specifically trained and equipped for large or complex urban search and rescue operations. The multi-disciplinary organization provides five functional elements, which include command, search, rescue, medical, and technical. The US&R Task Force is designed to be used as a "single resource" and not disassembled to make use of individual task force elements.

Structural/Hazards Marking System: A standardized marking system to identify structures in a specific area and any hazards found within or near the structure.

Urban Search & Rescue (US&R) Company: Any ground vehicle(s) providing a specified level of US&R operational capability, rescue equipment, and personnel.

Urban Search & Rescue (US&R) Crew: A predetermined number of individuals that are supervised, organized, and trained principally for a specified level of US&R operational capability. They respond with no equipment and are used to relieve or increase the number of US&R personnel at the incident.

APPENDIX A

Four General Types of Building Construction

The construction types and occupancy usage of various structures may require the utilization of a variety of different techniques and materials. The four general construction categories the rescuer will most likely encounter in collapse situations are light frame, heavy wall, heavy floor, and precast concrete construction. These four general classifications of construction usually comprise the majority of structures affected by collapse and failure.

Light Frame Construction

Materials used for construction are generally lightweight and provide a high degree of structural flexibility to applied forces such as earthquakes, hurricanes, tornadoes, etc. These structures are typically constructed with a skeletal structural frame system of wood or light gage steel components, which provide support to the floor or roof assemblies. Examples of this construction type are wood frame structures used for residential, multiple low-rise occupancies, and light commercial occupancies up to four stories in height. Light gage steel frame buildings include commercial business and light manufacturing occupancies and facilities.

Heavy Wall Construction

Materials used for construction are generally heavy and utilize an interdependent structural or monolithic system. These types of materials and their assemblies tend to make the structural system inherently rigid. This construction type is usually built without a skeletal structural frame. It utilizes a heavy wall support and assembly system to provide support for the floors and roof assemblies. Occupancies utilizing tilt-up concrete construction are typically one to three stories in height and consist of multiple monolithic concrete wall panel assemblies. They also use an interdependent girder, column, and beam system for providing lateral wall support of floor and roof assemblies. Occupancies typically include commercial, mercantile, and industrial. Other examples of this type of construction type include reinforced and unreinforced masonry buildings typically of low-rise construction, one to six stories in height, of any type of occupancy.

Heavy Floor Construction

Structures of this type are built utilizing cast-in-place concrete construction consisting of flat slab panel, waffle, or two-way concrete slab assemblies. Pretensioned or post-tensioned reinforcing steel rebar or cable systems are common components for structural integrity. The vertical structural supports include integrated concrete columns, concrete enclosed or steel frame, which carry the load of all floor and roof assemblies. This type includes heavy timber construction that may use steel rods for reinforcing. Examples of this type of construction include offices, schools, apartments, hospitals, parking structures, and multi-purpose facilities. Common heights vary from single story to high-rise structures.

Precast Construction

Structures of this type are built utilizing modular precast concrete components that include floors, walls, columns, and other subcomponents that are field connected upon placement on site. Individual concrete components utilize imbedded steel reinforcing rods and welded wire mesh for structural integrity and may have either steel beam, or column or concrete framing systems utilized for the overall structural assembly and building enclosure. These structures rely on single or multi-point connections for floor and wall enclosure assembly and are a safety and operational concern during

collapse operations. Examples of this type of construction include commercial, mercantile, office and multi-use of multi-function structures including parking structures and large occupancy facilities.

APPENDIX B

Four Levels of US&R Operational Capability

Basic Operational Level

The Basic level represents the minimum capability to conduct safe and effective search and rescue operations at structure collapse incidents. Personnel at this level shall be competent at surface rescue that involves minimal removal of debris and building contents to extricate easily accessible victims from noncollapsed structures.

Light Operational Level

The Light level represents the minimum capability to conduct safe and effective search and rescue operations at structure collapse incidents involving the collapse or failure of light frame construction and basic rope rescue operations.

Medium Operational Level

The Medium level represents the minimum capability to conduct safe and effective search and rescue operations at structure collapse incidents involving the collapse or failure of reinforced and unreinforced masonry, concrete tilt-up, and heavy timber construction.

Heavy Operational Level

The Heavy level represents the minimum capability to conduct safe and effective search and rescue operations at structure collapse incidents involving the collapse or failure of reinforced concrete or steel frame construction and confined space rescue operations.

APPENDIX C

Four Levels of US&R Operational Capability Minimum Training

Basic Operational Level

The Basic Operational level represents the minimum capability to operate safely and effectively at a structural collapse incident. Personnel at this level shall be competent at surface rescue and rescue involving minimal removal of debris and building contents to extricate easily assessable victims from noncollapsed structures. Rescue operations would include removal of victims from under furniture, appliances, and the surface of a debris pile. Training at the basic level should at a minimum include the following:

A. Size-up of existing and potential conditions and the identification of the resources necessary to conduct safe and effective urban search and rescue operations.

B. The process for implementing the Incident Command System.

C. The procedures for the acquisition, coordination, and utilization of resources.

D. The procedures for implementing site control and scene management.

E. The identification, utilization, and proper care of personal protective equipment required for operations at structural collapse incidents.

F. The identification of construction types, characteristics, and expected behavior of each type in a collapse incident.

G. The identification of four types of collapse patterns and potential victim locations.

H. The recognition of the potential for secondary collapse.

I. Recognition of the general hazards associated with a structural collapse and the actions necessary for the safe mitigation of those hazards.

J. The procedures for implementation of a structural identification marking system and a structural hazard marking system. (Appendix F)

K. Procedures for conducting searches at structural collapse incidents using appropriate methods for the type of collapse.

L. The procedures for implementation of a search marking system. (Appendix G)

M. Procedures for the extrication of victims from structural collapse incidents.

N. Procedures for providing initial medical care to victims.

Light Operational Level

Personnel shall meet all Basic level training requirements. In addition, personnel shall be trained in hazard recognition, equipment use and techniques required to operate safely and effectively at structural collapse incidents involving the collapse or failure of light frame construction and basic rope rescue as specified below:

A. Personnel shall be trained to recognize the unique hazards associated with the collapse or failure of light frame construction. Training should include but not be limited to the following:

   1. Recognition of the building materials and structural components associated with light frame construction.

   2. Recognition of unstable collapse and failure zones of light frame ordinary construction.

   3. Recognition of collapse patterns and probable victim locations associated with light frame construction.

B. Personnel shall have a working knowledge of the resources and procedures for performing search operations intended to locate victims who are not readily visible and who are trapped inside and beneath debris of light frame construction. Training should include but not be limited to the following:

   1. Types of search resources: Urban search and rescue dogs, optical instruments (search cameras), seismic/acoustic instruments (listening devices).
   2. Capabilities of search resources.
   3. Acquisition of search resources.

C. Personnel shall be trained in the procedures for performing access operations intended to reach victims trapped inside and beneath debris associated with light frame construction. Training should include but not be limited to the following:

   1. Lifting techniques to safely and efficiently lift structural components of walls, floors, or roofs.
   2. Shoring techniques to safely and efficiently construct temporary structures needed to stabilize and support structural components to prevent movement of walls, floors, or roofs.
   3. Breaching techniques to safely and efficiently create openings in structural components of walls, floors, or roofs.
   4. Operating appropriate tools and equipment to safely and efficiently accomplish the above tasks.

D. Personnel shall be trained in the procedures for performing extrication operations involving packaging, treating, and removing victims trapped inside and beneath debris associated with light frame construction. Training should include but not be limited to the following:

   1. Packaging victims within confined areas.
   2. Removing victims from elevated or below grade areas.
   3. Providing initial medical treatment to victims at a minimum to be BLS (Basic Life Support) level.
   4. Operating appropriate tools and equipment to safely and efficiently accomplish the above tasks.

Medium Operational Level

Personnel shall meet all Light level training requirements. In addition, personnel shall be trained in hazard recognition, equipment use and techniques required to operate safely and effectively at structural collapse incidents involving the collapse or failure of reinforced and unreinforced masonry (URM), concrete tilt-up, and heavy timber construction.

Heavy Operational Level

Personnel shall meet all Medium level training requirements. In addition, personnel shall be trained in hazard recognition, equipment use and techniques required to operate safely and effectively at structural collapse incidents involving the collapse or failure of reinforced concrete or steel frame construction and confined space rescue.

APPENDIX D

Four Levels of US&R Operational Capability Minimum Equipment Lists

These lists identify the minimum amount of tools and equipment needed to provide a safe and acceptable level of service for each of the four levels of US&R operational capability. The amount, size, and type of equipment listed can be increased to provide a higher degree of safety and service in each level of US&R operational capability.

US&R Basic Level – Minimum Equipment List

1 Axe (flat head)
1 Axe (pick head)
1 Backboard with two (2) straps
2 Blankets (disposable)
1 Bolt cutter (30")
1 Building marking kit (see Tool Information Sheet)
3 Carbide hacksaw blade packages
2 Claw wrecking bars (3')
2 Cold chisels (1"x 7⅞")
1 Cribbing and wedge kit (see Tool Information Sheet)
2 Crosscut handsaws (26")
1 First aid kit (see Tool Information Sheet)
2 Hacksaws (heavy duty)
4 Pinch point pry bars (60")
1 Scoop shovel "D" handle
2 Sledge hammers (8-10 lb.)
2 Sledge hammers (3-4 lb.)
1 Trauma kit (see Tool Information Sheet)

US&R Light Level – Minimum Equipment List

6 Camming devices (see Tool Information Sheet)
12 Carabiners (locking "D", 11 mm)
2 Carpenter belts

US&R Light Level – Minimum Equipment List

1 Chain saw (see Tool Information Sheet)
2 Commercial harness (Class II or better)
2 Duct tape (rolls)
2 Edge protections (see Tool Information Sheet)
2 Framing hammer (24 oz.)
2 Friction devices (see Tool Information Sheet)
2 Hydraulic jacks (minimum 5 ton)
1 Litter and complete prerig (see Tool Information Sheet)
1 Nails (see Tool Information Sheet)
2 Pick off straps (see tool information sheet)
3 Pulleys (2" or 4" rescue)
1 Shovel, long handle round point
1 Shovel, long handle square point
2 Ropes (150' x ½" kernmantle, static, NFPA approved)
6 Steel pickets (1"x4")
2 Sledge hammers (short, 3-4 lb.)
3 Tape measures (25')
2 Tri or speed squares
1 US&R Basic equipment inventory
1 Webbing kit (see Tool Information Sheet)

US&R Medium Level – Minimum Equipment List

1 Air bag sets (3 bag, 50 ton with 3 spare air bottles)
1 Air monitors (3 range)
1 Anchor kit (see Tool Information Sheet)
1 Bolt cutters (heavy duty, 42")
12 Carabiners (locking "D", 11 mm)
1 Chain set (see Tool Information Sheet)
1 Circular saw (12" with 2½" gal fuel)
2 Circular saw blades (12" carbide tip)
2 Circular saw blades (12" diamond, continuous rim)
12 Circular saw blades (12" metal cutting)
1 Come along (2/4 ton)
2 Commercial harnesses (Class II or better)
1 Cribbing and wedge kit (see Tool Information Sheet)
1 Demolition hammer, large (see Tool Information Sheet)
1 Demolition hammer, small (see Tool Information Sheet)
1 Electrical detection device (see Tool Information Sheet)
8 Ellis clamps
1 Ellis jacks

US&R Medium Level – Minimum Equipment List

1 Etrier set
6 Extension cords (50')
4 Floodlights (500 watt)
2 Friction devices (see Tool Information Sheet)
1 Generator (5 kw)
4 Haul buckets (metal or canvas)
2 Hi-lift jacks with extension tubes
1 Junction box (4 outlet with GFI)
8 Lumber (4'x4'x8')
6 Pipe (6'x1½", Schedule 40)
1 Pipe cutter (multi-wheel, 1½")
1 Pressurized water spray can
3 Pulleys (2" or 4" rescue)
2 Ropes (20'x½" static kernmantle, NFPA approved)
2 Ropes (300'x½" static kernmantle, NFPA approved)
1 Rotary hammer (1½")
1 Rotary hammer bit kit (see Tool Information Sheet)
1 Saw, electric (10¼")
1 Sawsall
18 Sawsall blades (metal)
12 Sawsall blades (wood)
6 Screw jacks, pairs (1½")
2 Shovels, short, folding
2 Skill saw blades (10¼" carbide tip)
12 Skill saw blades (10¼" metal cutting)
1 Tool kit (see Tool Information Sheet)
1 US&R basic equipment inventory
1 US&R light equipment inventory
1 Ventilation fan (see Tool Information Sheet)
1 Webbing kit (see Tool Information Sheet)
1 Wye electrical adapter

US&R Heavy Level – Minimum Equipment List

1 Air bag (upgrade high pressure to a total of 245 tons)
1 Air bag regulator, control valve with 2 additional hose
1 Air monitor (3 range)
2 Belts (carpenter)
1 Box ram set nails with washers (2½")
1 Box ram set nails with washers (3½")

US&R Heavy Level – Minimum Equipment List

2	Building marking kits (see Tool Information Sheet)
24	Canisters, respirators (replacements)
1	Chain saw (12" electric with spare carbide tip chain. If ***not*** already present from light inventory.
1	Circular saw (16" with 2½ gal fuel)
2	Circular saw blades (16" carbide tip)
2	Circular saw blades (16" diamond tip, continuous rim)
1	Come along (2/4 ton)
1	Cribbing and wedge kit (see Tool Information Sheet)
1	Cutting torch (see Tool Information Sheet)
1	Drill (½", variable speed)
1	Drill bit set (carbide tip, ¼" - ⅝")
1	Drill bit set (steel, ⅛" - ⅝")
1	Duct tape (case)
32	Ellis clamps
1	Ellis jack
6	Extension cords (50')
1	Extrication stretcher for confined areas
4	Floodlights (500 watt)
1	Generator (5 kw)
2	Gloves (high voltage)
1	Hammer, large demolition (see Tool Information Sheet)
1	Hammer, small demolition (see Tool Information Sheet)
2	Hammers (24 oz framing)
2	Harnesses, full body (Class III or better)
1	Hydraulic rescue tool (see Tool Information Sheet)
1	Junction box (4 outlet w/GFI)
1	Level (4')
1	Level (6")
1	Mechanical axe (high voltage)
1	Mechanical grabber (high voltage)
1	Nail gun (ram set powder actuated with 150 red charges)
1	Nail gun, pneumatic (framing type, 6p-16p)
1	Nails (see Tool Information Sheet)
1	Nails, nail gun (case, 16p)
1	Nails, nail gun (case, 8p)
1	Paint (orange spray, line marking, downward application type)
12	Pipe (6' x 1½", Schedule 40)
8	Post screw jacks
1	Rebar cutter (1" capacity)
6	Respirators (canister type)
1	Rotary hammer (1½")

US&R Heavy Level – Minimum Equipment List

1 Rotary hammer bit kit (see Tool Information Sheet)
3 SABA (supplied air breathing apparatus) umbilical system with escape bottles and 250' hose each
1 Sawsall
18 Sawsall blades (metal)
12 Sawsall blades (wood)
6 SCBA (with PAL and 1 spare bottle each)
12 Screw jacks, pairs (1½")
2 Shovel, folding, short
12 Steel pickets (1"x4')
1 Stone wheel, green (to sharpen carbide tips on tools)
1 Technical search device (see Tool Information Sheet)
2 Tri or speed squares
1 Tripod (human rated, 7'-9' with hauling system)
1 US&R Basic equipment inventory
1 US&R Light equipment inventory
1 US&R Medium equipment inventory
1 Ventilation fan (see Tool Information Sheet)
1 Water spray can (pressurized)
1 Wye electrical adapter

US&R TOOL INFORMATION SHEET

Anchor Kit	1 box ⅜" x 5" Hilti Kwick bolt concrete anchors 25 ea ⅜" SMC stainless steel anchor plates 25 ea ⅜" Drop forged H/D eye nuts Anchors and plates are for rope system anchor points
Building Marking Kit	2 ea orange spray paint, line marking (downward application type) 4 ea lumber chalk 2 ea lumber crayon (red) 2 ea lumber crayon (yellow) 4 ea lumber pencil
Camming Device	Prusik loop (7 mm or 8 mm) or Gibbs ascender or combination of each
Chain Saw	Gasoline or electric w/carbide tip chain and one spare chain and bar oil Gasoline: 2½ gallons of spare fuel and oil mixture Electric: Need electric power source and 100' of extension cord

US&R TOOL INFORMATION SHEET

Chain Set	1 ea 1' w/a grab hook on each end 1 ea 5' w/a grab hook and a slip hook 1 ea 10' w/a grab hook and a slip hook 1 ea 20' w/a grab hook and a slip hook All chain is ⅜", Grade 7 or better
Cribbing & Wedge Kit	24 ea 4" x 4" x 18" 24 ea 2" x 4" x 18" 12 pr 4" x 4" x 18" wedges 12 pr 2" x 4" x 12" wedges Containers to store and carry
Cutting Torch	One or more plasma cutter, exothermic torch w/50 rods, heavy duty oxy/acetylene torch w/spare O_2 cylinder or other similar device
Demolition Hammer, Large	Electric, pneumatic, or gasoline 60 lbs. Minimum 2 ea bull point bits 2 ea chisel point bits
Demolition Hammer, Small	Electric, pneumatic, or gasoline 30-45 lbs. Minimum 2 ea bull point bits 2 ea chisel point bits
Edge Protection	Commercial edge rollers, canvas tarps, split fire hose or any combination of each
Electrical Detection Device	Hot stick electrical alert device, volt/Ohm meter, or other device to alert crew members of electrical current
First Aid Kit	Basic first aid supplies for minor injuries to 6 victims or crewmembers. Example of items to carry include: band aids, eye wash, 4" x 4" gauze pads, gauze dressings, triangular bandages, elastic bandages, etc.
Friction Device	Figure 8 w/ears or brake bar rack or one of each
Hydraulic Rescue Tool	Gasoline, electric, or manual device w/10,000 lbs. minimum force. Able to cut, spread and pull. Gasoline: 2½ gal. spare fuel and oil.
Litter and Complete Pre-rig	Litter capable and rated for horizontal and vertical lift and hoist. Pre-rig can be commercial or pre-assembled to include adjustment and attachment capability.

US&R TOOL INFORMATION SHEET

Nails	25 lbs. 16p vinyl coated (green sinkers) 25 lbs. 8p vinyl coated (green sinkers) 25 lbs. 16p duplex Note: High humidity areas may require cadmium coated nails to prevent rust during long term storage
Pick Off Strap	Webbing strap with one "D" ring at one end and one "V" ring adjuster on webbing strap. (Webbing: 1¾" wide with 10,000 lbs. rating, minimum 42" long) (Hardware strength 5,000 lbs. rating)
Rotary Hammer Bit Kit	1 ea carbide tip bits, ⅜", ½", ¾", 1", 1½", 2" 2 ea bull point bits Appropriate adapters for bits and depth range capability
Technical Search Device	One or more of the following: Optical instruments (search cameras), Seismic/Acoustic instruments (listening devices)
Tool Kit	1 ea 12" crescent wrench 1 ea 8" crescent wrench 1 ea slip joint pliers 1 ea channel lock pliers 1 ea wire side cutters 1 ea ½" socket set w/ratchet and 6" extension 1 ea ½" breaker bar 1 ea ball peen hammer 1 set standard head screwdrivers 1 set Phillips head screwdrivers Any other tools required for maintenance and repair of equipment in cache
Trauma Kit	Basic supplies to treat trauma injuries to 6 victims or crewmembers. ALS type equipment (i.e., IV solutions, drugs, etc.) is not listed but may be carried if authorized. Examples of items to carry include large trauma dressings, splints, airways, bag valve respirator w/large and small masks, etc.
Ventilation Fan	Electric or gasoline powered w/extension tube to direct air flow
Webbing Kit	6 ea 1" x 5' 6 ea 1" x 12' 6 ea 1" x 15' 6 ea 1" x 20' All webbing is spiral weave nylon, 4000 lb. minimum tensile strength. Each webbing length must be a different color.

RESCUE SYSTEMS 1 TOOL SUPPLEMENT

This Rescue Systems 1 course is intended to meet the California Governor's Office of Emergency Services Urban Search and Rescue Light Operational Level. The Light Tool Cache lists a majority of the tools required; in certain instances, specific tools and techniques are used in this course to further enhance the rescuer's ability and efficiency. The following tools will need to be added to meet the Rescue Systems 1 curriculum in its entirety.

- 6 short 8mm prusik loops (57" cord)
- 7 long 8mm prusik loops (70" cord)
- 9 prusik minding pulleys (2")
- 5 anchor plates
- 1 tin snip
- 1 wire cutter
- 1 utility knife
- 52 pieces of 24" cribbing
- 4 Ellis clamps
- 1 Ellis jack
- 2 Ellis post screw jacks
- 1 pipe screw jack
- 2 steel framing squares

APPENDIX E

Additional US&R Resources

US&R Technical Specialist(s)

The Urban Search & Rescue Technical Specialist may assist ICS management with technical expertise in search, rescue, and effective use of existing and responding resources. US&R Technical Specialists may be assigned to any part of the organization. They are ordered through normal Mutual Aid request procedures.

US&R Dogs

These dogs and handlers are trained to search and find victims in collapsed or failed structures. They are ordered through normal Mutual Aid request procedures.

Structural Engineers

In most cases, responding resources will have access to local structural engineers through their local building department. Additional structural engineers may be ordered through normal Mutual Aid request procedures.

Heavy Equipment

Heavy equipment such as cranes, front loaders, and dump trucks are often needed in large quantities at structure collapse incidents. They are normally available through local public works departments and private contractors. If additional heavy equipment resources are needed, they are ordered through normal Mutual Aid request procedures.

State/National US&R Task Force

The Federal Government, through the FEMA, has established several State/National Urban Search & Rescue Task Forces throughout the nation. All US&R Task Force activities are coordinated through the State Office of Emergency Services (OES) who serves as the primary point of contact for FEMA. A US&R Task Force is also a state resource that can be acquired without a request for Federal assistance. All requests for a US&R Task Force must go through normal Mutual Aid request procedures. US&R Task Forces are able to deploy within six hours of notification.

Each US&R Task Force is comprised of 62 persons specifically trained and equipped for large or complex urban search and rescue operations. The multi-disciplinary organization provides five functional elements that include command, search, rescue, medical and technical. The US&R Task Force is very self-sufficient for the first 72 hours and has a full equipment cache to support its operation. Transportation and logistical support is provided by either State or Federal resources.

The US&R Task Force can provide round-the-clock urban search and rescue operations (two 12-hour shifts). The US&R Task Force Search element will include physical, canine, and electronic. The Rescue element can conduct rescue operations in all types of structures. The Medical element is primarily responsible for the care and treatment of task force members and entrapped victims during extrication. The Technical element provides personnel competent in structural integrity assessments, hazardous materials, heavy equipment and rigging, communications, and logistics.

The US&R Task Force is commanded by a Task Force Leader and is organizationally at the same level as any Strike Team/Task Force. The Task Force Leader is assisted by a US&R Task Force Safety Officer and Plans Officer. The US&R Task Force is unique in that unlike other task forces it is designed to be used as a "single resource." It should not be disassembled to make use of individual task force elements.

APPENDIX F

Structure/Hazards Marking System

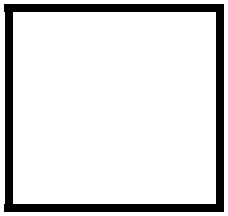
The identity and location of individual structures is crucial at incidents involving several structures or large areas of damage. The use of existing street names and addresses should always be considered first. If due to damage this is not possible, use the existing hundred block and place all even numbers on one side of the street and all odd numbers on the other side. Mark the new numbers on the front of the structure with orange spray paint. If due to damage the name of the street is not identifiable start with the letter "A" using the phonetic alphabet "Alpha", "Bravo", Charlie, etc.

Structure hazards identified during initial size-up activities and throughout the incident should be noted. This structure/hazards mark should be made on the outside of all normal entry points. Orange spray paint seems to be the most easily seen color on most backgrounds and line marking or downward spray cans apply the best paint marks. Lumber chalk or lumber crayons should be used to mark additional information inside the search mark itself because they are easier to write with that spray paint.

A large (approximately 2') square box should be outlined at any entrance accessible for entry into any compromised structure. Use orange paint for this marking. Specific markings will be clearly made adjacent to the box to indicate the condition of the structure and any hazards found at the time of this assessment. Normally the square box marking would be made immediately adjacent to the entry point identified as safe. An arrow will be placed next to the box indicating the direction of the safe entrance if the structure/hazards marking must be made somewhat remote from the safe entrance.

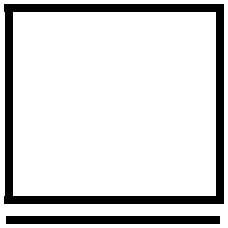
Structure/Hazards Markings

Make a large (2' x 2') square box with orange spray paint on the outside of the main entrance to the structure. Put the date, time, hazardous material conditions, and team or company identifier outside the box on the right hand side. This information should be made with lumber crayon/ chalk.



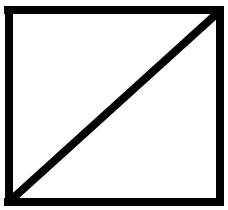
9/12/93
1310 hours
HM – nat. gas
SMA – E-1

Structure is accessible and safe for search and rescue operations. Damage is minor with little danger of further collapse.



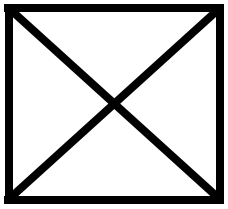
9/12/93
1310 hours
HM – none
SMA – E-1

Structure is significantly damaged. Some areas are relatively safe, but other areas may need shoring, bracing, or removal of falling and collapse hazards.



9/12/93
1310 hours
HM – nat. gas
SMA – E-1

Structure is not safe for search or rescue operations. May be subject to sudden additional collapse. Remote search ops may proceed at significant risk. If rescue ops are undertaken, safe haven areas and rapid evacuation routes should be created.



9/12/93
1310 hours
HM – nat. gas
SMA – E-1

Arrow located next to a marking box indicates the direction to a safe entrance into the structure, should the marking box need to be made remote from the indicated entrance.

APPENDIX G

Search Marking System

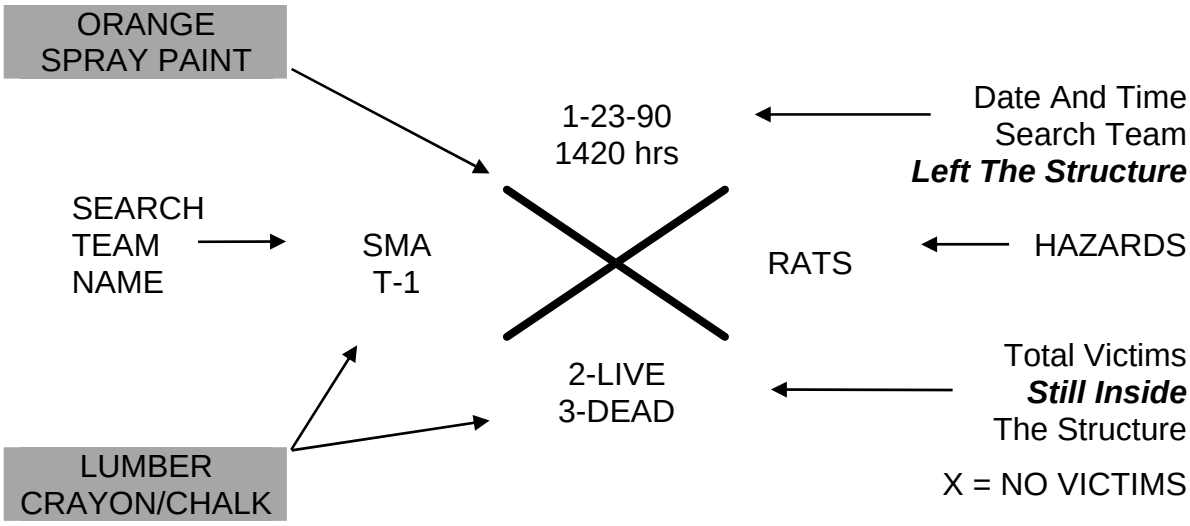
Search markings must be easy to make, easy to read and easy to understand. To be easily seen the search mark must be large and of a contrasting color to the background surface. Orange spray paint seems to be the most easily seen color on most backgrounds and line marking or downward spray cans apply the best paint marks. Lumber chalk or lumber crayons should be used to mark additional information inside the search mark itself because they are easier to write with than spray paint.

A large distinct marking will be made outside the main entrance of each building or structure searched. This "Main Entrance" search marking will be completed in two steps. First, a large (approximately 2') single slash shall be made near the main entrance at the start of the search. After the search of the entire structure has been completed, a second large slash shall be drawn in the opposite direction forming an "X." Specific information will be placed in all four quadrants of the Main Entrance "X" summarizing the entire search of the structure. The left quadrant is for the Rescue Team Identifier. The top quadrant is for the date and time the search was completed. The right quadrant is for any significant hazards located in the structure. The bottom quadrant is for the number of "LIVE" or "DEAD" victims still inside the structure. Use a small "X" in the bottom quadrant if no victims are inside the structure.

During the searching function, while inside the structure a large single slash shall be made upon entry of each room or area. After the search of the room or area has been completed, a second large slash shall be drawn in the opposite direction forming an "X." The only information placed in any of the "X" quadrants while inside the structure shall be that pertaining to any significant hazards or the number of "LIVE" or "DEAD" victims.

Search Markings

Main Entrance Search Marking



URBAN SEARCH & RESCUE RESOURCES

Always use the prefix US&R for Urban Search and Rescue (US&R) resources. Order Single Resource or Strike Team by Type (Capability – **HEAVY, MEDIUM, LIGHT, or BASIC**)

	Type 1 (Heavy)	Type 2 (Medium)	Type 3 (Light)	Type 4 (Basic)
Type (Capability)	Reinforced Concrete Steel Structures Confined Space Rescue	Reinforced/Unreinforced Masonry (URM) Tilt Up Construction Heavy Timber	Light Frame Construction Basic Rope Rescue	Surface Rescue Non-Structural Entrapment in Non-Collapsed Structures

RESOURCE	***RADIO***	***COMPONENT***	***TYPES***			
			1	2	3	4
US&R Company	USAR Company (phonetic)	Equipment Personnel Transportation	Heavy Inventory 6 *	Medium Inventory 4 *	Light Inventory 3 *	Basic Inventory 3 *
US&R Crew**	USAR Crew (phonetic)	Personnel Trained to Appropriate Level Supervision Transportation	6	6	6	6
State/National US&R Task Force	Pre-Assigned Two Letter State Task Force Designator And # Identifier (CA – TF5)	Equipment Personnel Transportation	US&R Task Forces are comprised of 62 persons specifically trained and equipped for large or complex urban search and rescue operations. The multi-disciplinary organization provides five functional elements that include command, search, rescue, medical, and technical.			

* Requests should include vehicle capabilities when necessary (i.e., four wheel drive, off-road truck, engine, etc.)

** The agency/department sending an US&R Crew will identify the Supervisor.

STRIKE TEAM TYPES AND MINIMUM STANDARDS

	STRIKE TEAM TYPES	*NUMBER/ TYPE*	*MINIMUM TASK CAPABILITIES*	*STRIKE TEAM LEADER*	*PER SINGLE RESOURCE*	*TOTAL PERSONNEL*
Kind US&R COMPANY	AR	2 - Type 1 (Heavy)	Vehicle(s) Equipped for Reinforced Concrete, Steel Structures, Confined Space Rescue	1	6	13
	BR	2 - Type 2 (Medium)	Vehicle(s) Equipped for Reinforced and Unreinforced Masonry, Tilt-Up Construction, Heavy Timber	1	4	9
	CR	5 - Type 3 (Light)	Vehicle(s) Equipped for Light Frame Construction and Basic Rope Rescue	1	3	16
	DR	5 - Type 4 (Basic)	Vehicle(s) Equipped for Surface Rescue and Non-Structural Entrapment in Noncollapsed Structure	1	3	16
Kind US&R CREW	GR	3 - Type 1 (Heavy)	Trained for Reinforced Concrete, Steel Structures, Confined Space Rescue	1	6	19
	HR	3 - Type 2 (Medium)	Trained for Reinforced and Unreinforced Masonry, Tilt-Up Construction, Heavy Timber	1	6	19
	IR	3 - Type 3 (Light)	Trained for Light Frame Construction and Basic Rope Rescue	1	6	19
	JR	3 - Type 4 (Basic)	Trained for Surface Rescue and Nonstructural Entrapment in Noncollapsed Structures	1	6	19

CHAPTER 5 - OVERVIEW OF US&R STANDARDS and REGULATIONS

In order to safely perform life saving rescue operations, individuals should be aware of and familiar with all related standards, mandates, and regulations. These standards, mandates, and regulations establish the foundation of acceptable practices and safety at US&R related incidents.

FIREFIGHTING RESOURCES ORGANIZED FOR POTENTIAL EMERGENCIES (FIRESCOPE)

FIRESCOPE ICS-US&R 120-1

FIRESCOPE ICS-US&R 120-1 identifies the Incident Command System (ICS) structure and the four (4) levels of US&R operational capability, training, and equipment requirements for US&R resources.

- Basic
- Light
- Medium
- Heavy

Firescope ICS 420-1

Fire Service Field Operations Guide (FOG)

In addition to containing ICS organizational examples for other types of incidents such as General Fire Ground, Hazardous Materials, Multi-Casualty, and High Rise, the guide also provides a summary of ICS-US&R-120-1 in Chapter 15 in the pink pages.

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

National Fire Protection Association (NFPA) standards cannot be considered as mandated unless legally adopted by an agency. They can and should be considered as a common practice and benchmark within the industry.

NFPA 1006 - Standard for Rescue Technician Professional Qualifications

Establishes the minimum job performance requirements necessary for the fire service and other emergency response personnel who perform technical rescue operations.

- Rope rescue
- Surface water rescue
- Vehicle and machinery rescue
- Confined space

- Structural collapse
- Trench rescue

NFPA 1500 – Fire Department Occupational Safety and Health Program

Contains minimum requirements for a fire service related occupational safety and health program. Applicable to public, governmental, military, private, and industrial fire department organizations providing rescue, fire suppression, emergency medical services, hazardous materials and mitigation, special operations, and other emergency services

NFPA 1670 – Standard on Operations and Training for Technical Rescue Incidents

NFPA 1670 identifies and establishes levels of functional capability for safely and effectively conducting operations at a technical rescue incident to the awareness, operations, and technical levels.

Applicable to organizations that provide response to technical rescue incidents:

- Structural collapse
- Water rescue (dive, ice, surf, swift water)
- Rope rescue
- Confined space
- Vehicle and machinery
- Wilderness
- Trench and excavation

NFPA 1983 – Standard on Fire Service Life Safety Rope and System Components

NFPA 1983 specifies minimum performance criteria, design criteria, and test methods for new life safety rope and new system components.

- Personal escape rope
- Life safety harness
- Belts
- Auxiliary equipment used for rescue and training by the fire service or similar emergency service organizations

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI) STANDARDS OF PRACTICE

- ANSI Z87.1 - Standard for eye and facial protection
- ANSI Z89.1 - Standard for protective head wear

OCCUPATIONAL STANDARDS AND HEALTH ADMINISTRATION (OSHA)

Both California and the federal government have OSHA related branches with associated field offices. OSHA should be considered a safety practices monitoring and enforcement agency.

OSHA has both fined and assigned punitive damages in cases where violations have occurred.

- OSHA 29 CFR 1910.10 Blood Borne Pathogen
- OSHA 29 CFR 1910.120 Hazardous Materials Technical Standards
- OSHA 29 CFR 1910.130 Eye and Face Protection
- OSHA 29 CFR 1910.134 Standard for Firefighting Related to Two In and Two Out
- OSHA 29 CFR 1910.134 Standard on Respiratory Protection
- OSHA 29 CFR 1910.135 Standard on Head Protection
- OSHA 29 CFR 1910.136 Standard on Foot Protection
- OSHA 29 CFR 1910.138 Standard on Hand Protection
- OSHA 29 CFR 1910.146 Permit Required Confined Space
- OSHA 29 CFR 1910.147 The Control of Hazardous Energy (Lockout/Tagout)
- OSHA 29 CFR 1910.5 Fall Protection, Escape and Rescue Standards
- OSHA 29 CFR 1910.95 Noise Exposure Standard
- OSHA 29 CFR 1926.652 Excavations

CALIFORNIA CODE OF REGULATIONS (CCR)

CCR affects all California governmental agencies as of December 1, 1996. Requires Standardized Emergency Management System (SEMS) training and use in order to be eligible for state funding of emergency response–related costs.

Code Section 8607

- Standardized Emergency Management System (SEMS)

CHAPTER 6 - RESCUER SAFETY IN US&R OPERATIONS

INTRODUCTION

Structural collapse operations cover a wide range of incident scenarios. These incidents can be as relatively minor as a deck or porch collapse resulting in easily accessible victims, or as heavily taxing as a multistory concrete building collapse that entombs hundreds of victims. Regardless of the collapse scenario encountered, first responders must be familiar with a variety of safety hazards and associated issues. Effective rescue operations at a structural collapse will only be possible if rescuers are fully aware of the hazards involved and the methods necessary to mitigate those hazards.

In order for rescuers to perform at an optimum level of safety, they must be familiar with:

- Categories of hazards; building construction types and characteristics
- Types of collapse voids and likely areas of survivability
- Safety equipment
- Safety procedures
- Safety considerations

Understanding and properly applying these factors is essential if rescuers are to perform rescue operations safely in a structural collapse.

STRUCTURAL COLLAPSE GENERAL HAZARDS

Structural Instability

The aftermath of a building collapse will cause a variety of structural instability hazards for rescuers. These may include weakened walls, floors, columns, or beams that are incapable of supporting the remains of the structure. Secondary collapse of structural elements will be a major concern to rescuers working in areas supported by these weakened building parts.

Freestanding walls and damaged or loose chimneys can easily fall because of a lack of support, wind load, or earthquake aftershocks. In earthquake-prone areas, collapses resulting from quakes will be highly vulnerable to further collapse because of aftershocks.

Normal settlement and shifting debris, vibrations, and aftershocks can cause secondary collapse and previously accessible voids to become inaccessible, or eliminate the void spaces altogether. Secondary collapse may cause currently undamaged attached or exposed structures in close proximity to fail.

Very often, structural stability is difficult to evaluate and requires the services of a structural engineer. Responders are encouraged to contact structural engineers in their response areas to determine their availability if needed.

Overhead Hazards

Rescuers performing operations at a collapse site must evaluate the scene for overhead hazards that have the potential to fall and strike rescuers. Overhead hazards may include loose debris and building components suspended overhead, sections of concrete hanging from attached reinforcing bars, or dislodged bricks precariously perched on a broken wall assembly. Unsecured building contents such as file cabinets, bathtubs, refrigerators, and other furnishings can also create overhead hazards should they fall out of the structure.

Damaged electrical wires hanging low or heavily tensioned and ready to fail may pose an electrocution danger, choking, and entanglement hazard.

Scaffolding and stacked building supplies, such as piles of drywall perched on an upper floor of a building under construction, are overhead hazards common to construction site collapses. Rescuers must take the necessary time to evaluate their surroundings and to identify these potential hazards before committing resources to a dangerous area.

Rescue operations that are being performed also can create overhead hazards from crews working above each other and the sudden failure of rigging chains or slings that are damaged or overloaded during a crane lifting operation. This may cause massive building components to be dropped on rescuers working in close proximity to where the lift is being performed. It is for this reason that all rescuers must be informed when heavy equipment will be used for performing rescue operations. All rescuers also must clear the area when a load is being lifted overhead.

Surface Hazards

The environment within which rescuers must operate at a building collapse will be full of sharp debris that can cause injury. This debris will differ depending on the building's construction and contents. Generally, rescuers will be faced with broken glass, nails, wood splinters, jagged metal, and rough masonry. Difficult footing will be common due to spilled fluids and pools of water and sewage. Ground fissures, depressions and uneven or unsecured walking surfaces around the collapse site will add to difficult footing which can potentially result in injuries to responding personnel.

Water and other liquids on the ground will obscure the view of the walking surface and reduce friction, potential electrocution if contacting an energized power source and drowning if the water is deep enough to cover the rescuer's face. Liquids will also cause hypothermia problems for rescuers and victims, add additional weight to structural elements and debris and softens the ground supporting structural elements and debris.

Rescuers must be aware of the potential for downed or exposed live electrical wires. All wires and conduits must be considered live until confirmed otherwise.

Heavy equipment vibrations can cause debris to shift and secondary collapse. Engine noise can drown out communication and other sounds which could warn rescuers of changing conditions, operators with an obstructed view while backing or turning could run into damaged structures and over rescuers, and a secondary collapse can be caused by lifting, pulling or removing structural components with powerful heavy equipment unable to feel the structure shifting.

Additional potential surface hazards include open manholes resulting from flooding, or ground-level openings created by the force of the collapse. Fallen trees and utility poles blocking roadways may cause access problems for responding apparatus and personnel.

Below-Grade Hazards

These hazards will occur in areas such as basements, underground parking garages, or low lying void spaces. The potential exists in these areas for the accumulation of atmospheric hazards due to ruptured natural gas lines or spilled chemicals. Contaminated atmospheres can be flammable, toxic, or oxygen deficient. Flooding from broken water or sewer lines also may cause difficulties for rescuers by obscuring the view of the walking surface and reducing friction, electrocution if contacting an energized power source, drowning if the water is deep enough to cover the rescuer's face and contamination from raw sewage and other chemicals mixing with liquids.

Utility Hazards

The most common utility types include natural gas, propane, electrical, steam, water, and sewage. When these utilities are disrupted because of a collapse, they will cause serious safety hazards for rescuers. These will include electrocution and fire hazards from broken electrical wiring, and explosion hazards from broken natural gas and/or heating fuel lines. Disrupted steam lines can cause burns to rescuers exposed to them. Sewage from broken sewer lines can release toxic gases such as hydrogen sulfide or methane, and can expose rescuers to bacteria.

Hazardous Materials

The California Health and Safety Code defines hazardous materials as "any material that because of its quantity, concentration, or physical or chemical characteristics, poses a significant present or potential hazard to human health or safety, or to the environment if released." Common examples are flammables such as gasoline, corrosives such as hydrochloric acid and toxics such as pesticides.

The type of building affected and its normal contents will help to identify potential hazardous materials that may be released during a collapse. Rescuers must be cognizant of this potential at residential dwellings as well commercial establishments.

Residential hazardous materials can be found in kitchens, laundry rooms, garages, and sheds and may include ammonia, bleach, oven and drain cleaners, spot removers, gasoline, paint thinners, pool chemicals, pesticides, herbicides, and other garden supply chemicals.

Commercial establishments that are common to most cities and towns and their associated hazardous materials include:

- Supermarkets, hardware and sporting good stores: paint and paint thinners, caustic paint removers and oven cleaners, pesticides, herbicides, and aerosol cans, liquid and powder chlorine, muriatic acid flammable gases, gunpowder and ammunition.
- Schools: gases, flammable liquids, cleaning supplies, poisons, and biological hazards in chemistry and biology classrooms.
- Hospitals and laboratories: flammable and toxic gases, flammable liquids, poisons, cryogenic liquids, radioactive, and biological hazards.

Other Hazards

Rescuers may face additional incident hazards that do not fall into any previously listed categories. Some of these hazards are related to the cause of the collapse, and others are actually created by rescuer actions. Fire, smoke, or explosions force responders to wear a higher level of personal protective gear than normal collapse operations. The collapse may have resulted from the fire or explosions, or the fire and smoke may be the result of the collapse. Secondary explosions may be caused by a secondary explosive device intended to harm the rescuers.

It is important for rescue workers to realize that a collapsed structure will be much more susceptible to fire after the collapse and much harder to extinguish. This is due to the disruption of any built-in suppression systems, disrupted utilities, and the larger surface-to-mass ratio of the splintered flammable building materials and deep difficult to access debris piles.

Vibrations from various sources are a safety concern to rescuers, because these can cause a secondary collapse of unstable building parts. Vibration sources can include:

- Rail traffic, such as trains and subways
- Vehicular traffic on nearby roadways
- Air traffic or helicopters over the collapse site
- Heavy construction equipment
- Responding fire and rescue apparatus

Particulate matter such as smoke, concrete dust and asbestos must be recognized and appropriate personal protective equipment (PPE) must be worn to prevent this material from entering a rescuer's respiratory system. Exposure to particulate matter can cause immediate and long-term problems if not appropriately mitigated.

Rescuers will be faced with several hazards created by their own actions such as operating internal combustion engines and power tools within confined areas and contaminating the atmosphere. Rescuers may have difficulty operating heavy tools in small and cramped spaces in awkward positions causing potential muscle strain.

Loud noises will be created by rescuers using power tools inside confined areas and while operating around heavy construction machinery. This can cause damage to rescuer hearing, ineffective communications, and the inability to hear structural element movement and a victim's calls for help.

Uncoordinated rescue operations and unorganized rescue teams can add weight and cause unnecessary movement above other rescuers.

FOUR GENERAL TYPES OF BUILDING CONSTRUCTION HAZARDS

Light-Frame Construction

Light-frame construction refers to residential homes and apartments of up to four stories, and principally constructed of wood. The principal weakness of light-frame buildings is the lateral strength of the walls and the connections. Due to this weakness, collapses may occur when lower-level walls are too weak to resist lateral forces applied on the building. Heavy loads on these weak walls can result in complete collapse. Part or all of the building can fall, projecting away from the building's original foundation. This may result in upper stories collapsing due to the first story failure. These types of structures are highly susceptible to fire due to disrupted utilities and high surface-to-mass ratio of splintered wood and other light-frame materials.

Rescuers operating at a light-frame building collapse should check for stability problems by looking for badly cracked walls, leaning walls, an offset of the structure from the foundation, or a leaning first story in multi-floor dwellings. In addition, cracked and leaning masonry chimneys and separated porches, split-level floors, and roofs should be evaluated. Other hazards include broken utility connections, loose heavy roof tiles, HVAC, or solar equipment.

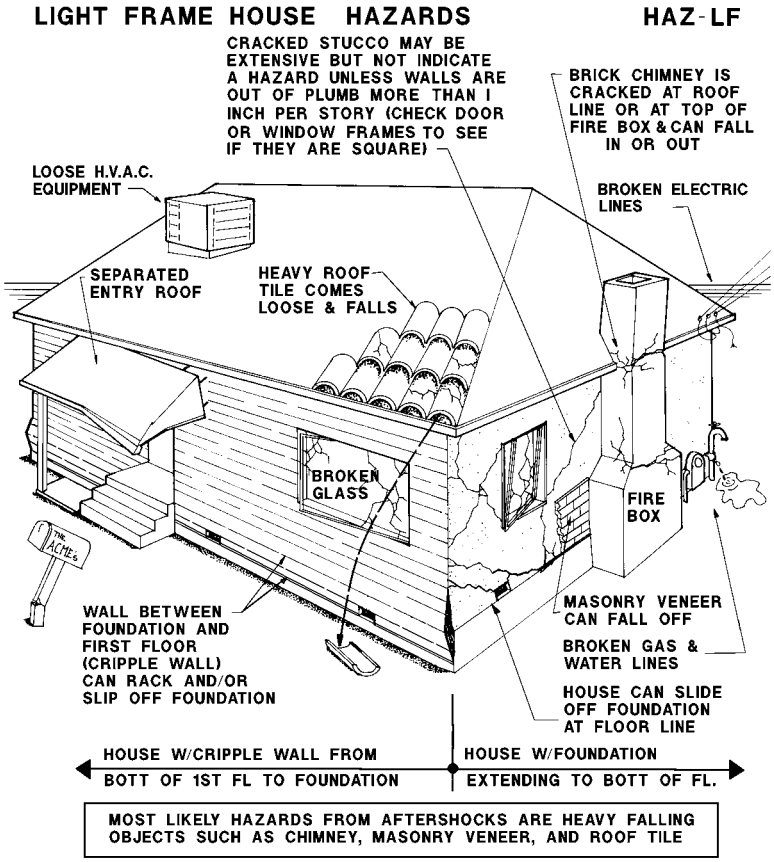


Figure 6.1
Light-Frame Construction

Heavy Wall Construction

These buildings are one to six stories in height, and may be residential, commercial, industrial, or institutional. They have heavy and thick walls and wooden or lightweight concrete floors. Their principal weakness is in the lateral strength of the walls and the connections between the walls and floor or roof assemblies. Collapses are usually partial and are due to the heavy, weakened walls falling away from the floors. Falling hazards are very common at these buildings due to the amount of small, loose masonry components resulting from the collapse. When operating in an unreinforced masonry (URM) building make sure to check for loose and broken parapet walls and ornamental masonry, broken connections between walls and floors, cracked wall corners, and unsupported and partly collapsed floors. Other hazards include broken utility connections, loose signs, HVAC, or solar equipment.

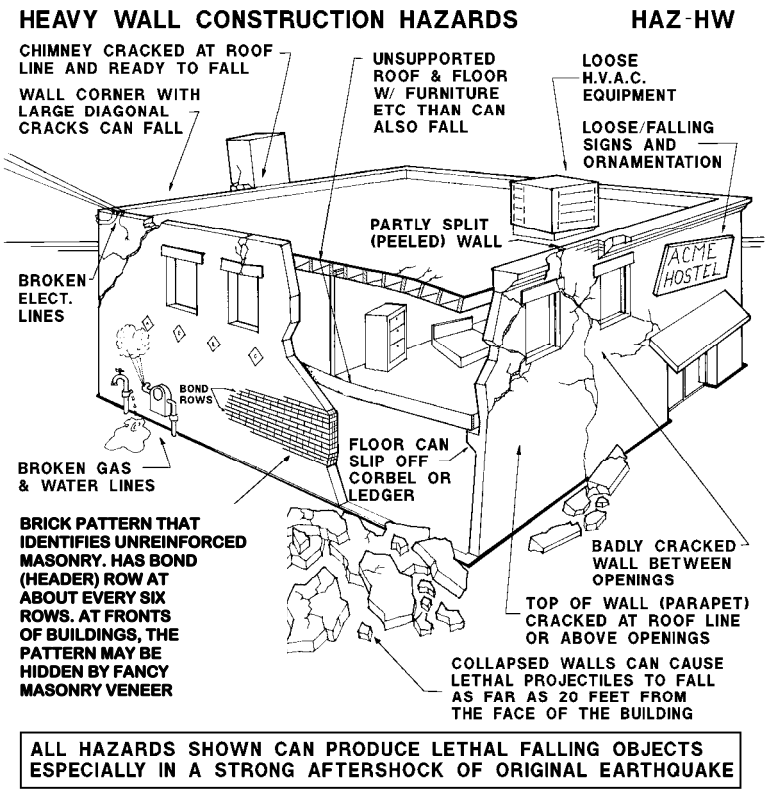


Figure 6.2
Heavy Wall Construction

Buildings with tilt-up/reinforced masonry walls generally are industrial and commercial buildings, one to five stories tall. Their principal weakness is in the connection between the wall and the floors or roof. Typical failures result in the wall falling away from the floor or roof edge. This can result in the top of the wall falling as far away from the building as its height. When operating at these structures, rescuers must perform an effective evaluation that should include checking the connections between the wall and floors, and the wall and the roof. Also, check the connection between beams and columns, and look for badly cracked walls or columns.

Heavy Floor Construction

Structures in this category can be residential, commercial, or industrial. They have concrete frames and may be up to twelve stories tall. This category includes concrete highway bridges. The principal weakness of these structures is the poor column reinforcement and inadequate connections between floor slabs and columns. Collapse from the failure of these parts can be partial or complete.

These structures often fall down on themselves, or they may fall laterally if the columns are strong enough. Other hazards include broken utility connections, loose signs, HVAC, or solar equipment.

Rescuers should evaluate the stability of the structure by checking the following areas: 1) the confinement of the concrete within the reinforcement of the columns; 2) cracking of columns at each floor line; 3) diagonal shear cracking in major beams adjacent to supporting columns; and 4) cracks in shear walls.

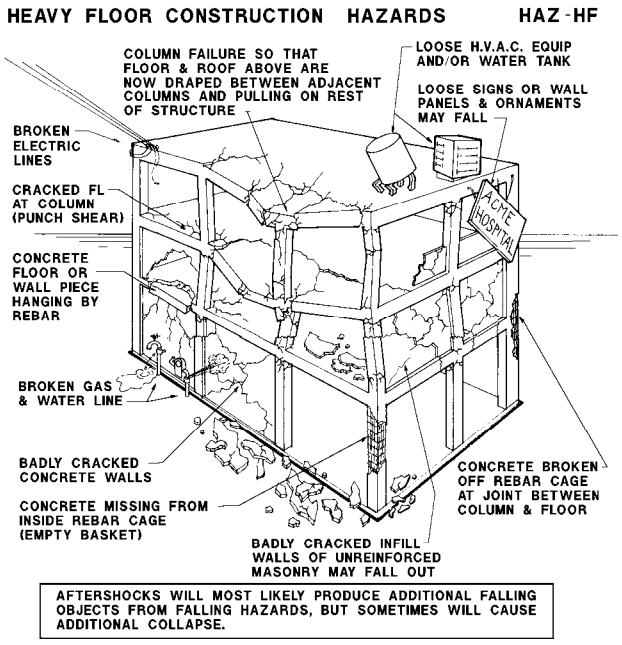


Figure 6.3
Heavy Floor Construction

Precast Construction

Precast structures may be commercial or residential and include precast parking facilities. These structures generally are one to twelve stories in height. Principal failure is due to the weakness of the connectors used to connect building parts such as floors, walls, and roof. The weak connectors fail during earthquakes or other failure-causing events. These failures will often create many falling hazards as precast sections break loose and become unstable. Rescuers operating at a precast building collapse should check beam-to-column connections for broken welds and cracked corbels. Column cracking at top and bottom joints, as well as wall panel connections and shear wall connections at floor areas, must be checked to determine the stability of the structure. Other hazards include broken utility connections, loose signs, HVAC, or solar equipment.

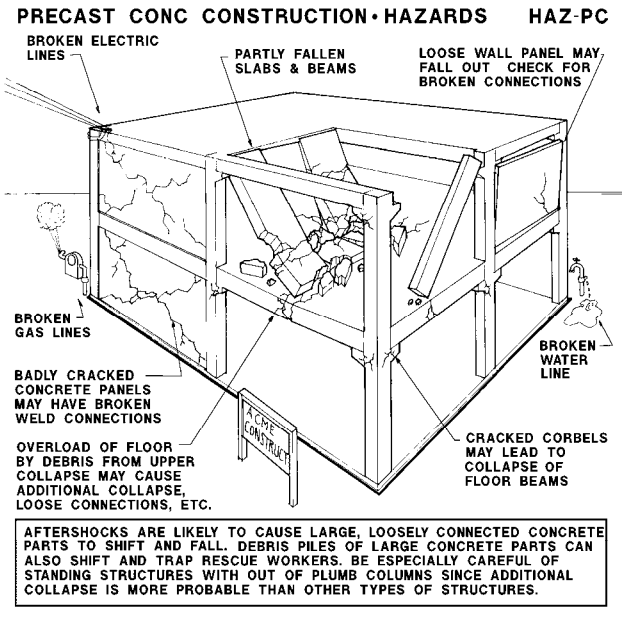


Figure 6.4
Precast Construction

FOUR TYPES OF COLLAPSE PATTERNS

Most collapses result in the original shape of the building being significantly changed. The rescuer can find any one or a combination of four types of collapse patterns because of these changes. The four types of collapse patterns are generally associated with heavy wall construction but may be present in all type of construction.

Lean-To Collapse Pattern

The lean-to collapse pattern is often formed when a wall failure causes a floor or roof section to fall completely on one side, while the other end remains supported. This collapse usually results in a triangular-shaped void that is considered a survivable void space. A survivable void is an area where the likelihood for survival of victims is high.

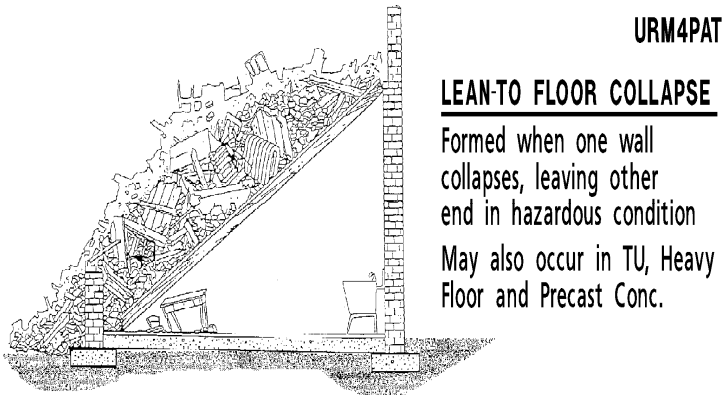


Figure 6.5
Lean-To Collapse

Remember that the remaining supported end of the fallen section may be precariously attached and could require additional support. Shoring may also be required on the outside of the wall supporting the floor or roof if rescuers must perform void exploration and extrication. Rescuers may find victims inside the void space under the floor or roof and under of the debris pile.

V-Shape Collapse Pattern

The V-Shape collapse pattern will be created when a floor assembly collapses in the middle due to failure of center supports or overload of the floor. The result is two identifiable voids that are created on each side of the broken floor assembly. Victims can be found in these two survivable void areas as well as under the debris pile. Shoring may be required on the outside of both walls supporting the floor sections.

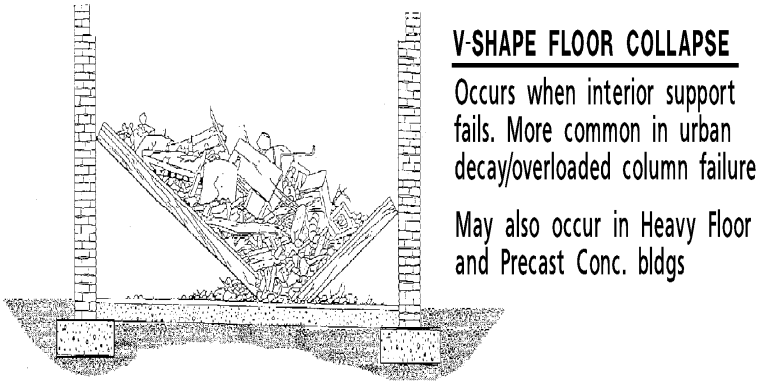


Figure 6.6
V-Shape Collapse

Pancake Collapse Pattern

The pancake collapse pattern is formed when single or multiple floors and/or roof collapse resulting in a layering effect. The resulting voids are limited in space and are difficult to access, especially in concrete structures. Victims are often found in the small spaces created where the floors are separated by supporting building contents such as furniture, appliances, or equipment.

Broken structural components that have fallen between the floor slabs during the collapse also may act to support the floor and create a void area. Rescue access is made by horizontal access through existing or created openings. Breaking and breaching through floor slabs from above or below may be necessary to gain access into the void areas.

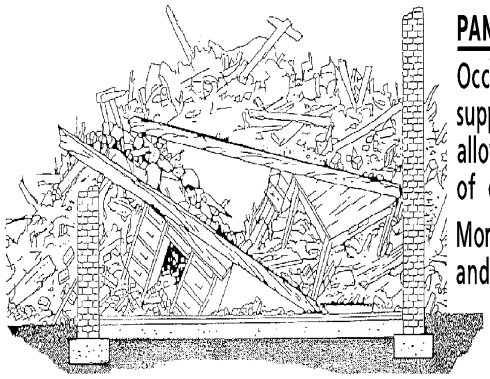


Figure 6.7
Pancake Floor Collapse

Cantilever Collapse Pattern

The cantilever collapse pattern is formed when a wall collapse results in one end of the floor(s) and/or roof to hang unsupported and suspended above the other floor(s) on the side where the wall failed. The opposite end of the floor assembly remains attached to the wall at its original connection point.

This type of collapse pattern is extremely unstable and dangerous. Extensive shoring is required to make the area safe before any search and rescue operation. Rescuers must use good judgment and extreme caution when operating in this area. Victims may be found in the void spaces under the hanging floor(s) and/or roof.

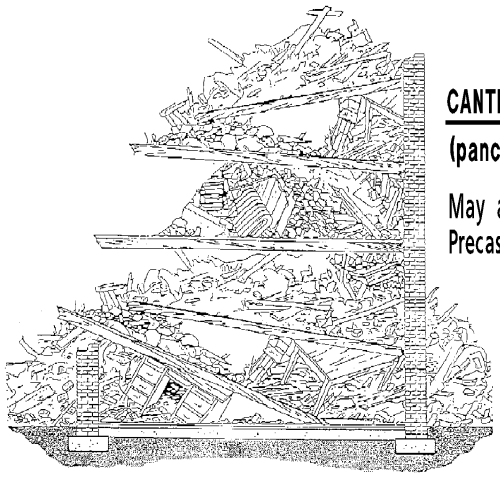


Figure 6.8
Cantilever Floor Collapse

PERSONAL PROTECTIVE EQUIPMENT (PPE)

The first response to a structural collapse will bring a wide variety of willing rescuers to the scene, including law enforcement officers, fire fighters, emergency medical personnel, hospital employees, public works employees, private sector contractors and/or untrained civilian volunteers. These responders may arrive with varying degrees of personal protective equipment ranging from very inadequate to highly efficient. For rescue work in an area strewn with broken glass, protruding nails, and jagged metal, normal street clothing or light work uniforms are not adequate.

Personal protective equipment is required to protect against abrasion from sharp objects, puncture wounds of the feet and hands, head injuries from falling objects and accidental impact, eye injuries

from flying objects, twisted ankles, burns from fire, lung injuries from dust, and hearing damage from loud noises. Personnel performing rescue operations must use the following personal protective equipment to limit injuries:

- **Breathing Apparatus**. Required for protection from hazardous vapors, smoke, and oxygen deficient atmospheres less than 19.5%. Self-contained breathing apparatus have a limited air supply and should not be taken off to access small spaces. Supplied air line systems provide longer duration of use and entry into smaller areas.
- **Communication Equipment**. A portable two-way radio and a personal alarm device.
- **Dust Mask**. Common paper type dust masks do not effectively filter out small particles or asbestos. Canister respirators with proper filters are more effective.
- **Eye Protection**. Safety goggles and glasses. Regular prescription glasses, sunglasses, or fold-down shields on helmets are not adequate.
- **Flame Resistant Clothing**. Brush fire clothing, coveralls, or heavy work clothing with long sleeves. Structural fire fighter clothing is often too confining, hot and will quickly tire the rescue worker.
- **Flashlight or Headlamp**. Rescuers should have at least two light sources at all times, in case one fails.
- **Hearing Protection**. To protect the wearer from loud noises generated by power tools and heavy construction equipment.
- **Helmet or Hard-Hat**. Structural fire fighter helmets are usually too confining and heavy for structural collapse rescue work.
- **Knee Pads**. To protect the knees of rescuers while crawling.
- **Leather Gloves**. To protect the hands from abrasions, cuts, and punctures.
- **Safety Boots**. Recommend steel toe and shank.

SAFETY CONSIDERATIONS

The IC, the Safety Officer and Assistant Safety Officers, supervisors and all rescue workers must consider safety as an integral part of the overall action plan. Safety considerations must be adhered to throughout the incident.

Lookouts, Communications, Escape Routes, and Safe Zones (LCES)

The acronym LCES, stands for Lookouts, Communications, Escape Routes and Safe Zones and are the areas that must be addressed in all operations and safety plan to insure the safety and accountability of all response personnel.

Lookouts

The lookout function is normally assigned to the Safety Officer but is everyone's responsibility.

Safety Officer Duties and Responsibilities

The assignment of a Safety Officer is one element of providing and maintaining a safe operational work environment. At least one Safety Officer should be assigned to each work unit or rescue team. They should position themselves in a safe area where they can oversee the work site to look for hazardous conditions or inappropriate worker actions. Safety Officers should not engage in the actual rescue work, as this will limit their ability to concentrate on overall unit safety.

The overall incident Safety Officer and his/her assistants should use a safety checklist as a reference guide to make sure that all safety issues are reviewed, analyzed, and properly addressed. They must also monitor the entry times and work duration of rescuers who enter the building or void space. This assures accountability of personnel.

Rescuers will have a natural tendency to want to continue to work without a break. Safety Officers must ensure that all workers adhere to a rotation period to lessen the potential for injury from overwork.

Safety Officer Checklist

STRUCTURAL COLLAPSE RESCUE OPERATIONS

CONCERNS	ASSESSED	CONTROLLED
Structural Instability		
Fire/Haz Mat		
Utilities		

Atmospheric Conditions:

O_2		
Toxic		
Explosive		

Reassess Atmosphere:	Time/Status	Time/Status	Time/Status
O_2			
Toxic			
Explosive			

PERSONNEL CONTROL / ACCOUNTABILITY

Assess Entry Team Readiness: Check off

- Proper level of protection _____
- Personal lighting _____
- Communications adequate _____

Assess Backup Team Readiness: Check off

- Proper level of protection _____
- Personal lighting _____
- Communications adequate _____

Evacuation Signal Reviewed and Understood Check off

ENTRY / EXIT TIMES	ENTER	EXIT
Team:		
Team:		
Team:		
Team:		

REHABILITATION / MEDICAL ASSESSMENT

	ASSIGNED	STATUS
Team:		
Team:		
Team:		
Team:		

SAFETY SUPPORT

	ASSESSED	STATUS
Lighting		
Structural Stability Monitors		
Areas Cordoned Off		
Protective Gear Needed		
Additional Shoring Needed		
Ventilation		
Other		

Buddy System

Working in and around collapsed structures is hazardous, and the potential is high for injury to rescuers. Rescuers should consistently work within a buddy system, in teams of at least two persons, working and staying together at all times while on the incident scene. When working in a danger area, void space, or inside the structure, workers must remain together and communicate; if one person is required to leave then all must leave. This is required to enhance the safety of rescuers and to maintain accountability of rescue personnel.

Communications

Effective communications at a structural collapse scene are an absolute necessity. Rescuers must clearly and consistently report their status and maintain contact with their supervisors, and the incident commander. This is especially important for personnel operating in hazard areas. A formal radio communications plan must be developed so that all personnel on the rescue site know who is assigned to which radio frequencies. Each rescue team member should have a portable radio for optimum communications effectiveness. Communications must be maintained through voice, touch, or sight. Inside rescue team members must maintain contact with their buddies. Team leaders must be made aware of progress, welfare, and needs on a timely basis throughout the operation. It also is important that predetermined hand signals are known, recognized, and practiced by all team members.

In situations where rescues require the interaction of multiple rescue teams, search teams, and other rescuers such as public works personnel, make sure information is communicated to these people when your actions will affect their operations.

Emergency Signals

Because of the high potential for secondary collapse, dangerous conditions, and the need to communicate other important information, an emergency signaling system should be adopted and in use by all personnel at the incident site. Emergency signals must be a loud identifiable and prearranged signal sounded when hazardous conditions or information requires immediate attention. Emergency signals can be made using devices such as a whistle, air horn, vehicle horn, or bell. Each structure or large area of operations may need to have its own distinct emergency signal device when multiple rescue operations are taking place in the same area to reduce confusion.

The emergency signals in use by the FEMA US&R Response System and several other states and departments are:

- Evacuate the area: three short blasts, (one second each)
- Cease operations/All quiet: one long blast, (three seconds)
- Resume operations: one long and one short blast

If rescuers become trapped, they should immediately attempt to communicate with other team members, team leaders, supervisor, the incident commander, or anyone outside the structure.

Communication methods can include portable radios equipped with an emergency trigger, personal alarm devices, and shouting for assistance. Tapping a solid object onto a solid part of the structure can sometimes be heard farther away than shouting for assistance or personal alarm device. A suggested entrapped signal is the same that the hailing search method uses which is a continuous five taps – pause – five taps – pause.

Escape Routes

Rescuers must pre-establish a path to an area of safe refuge. The safest method of exiting an area may not be the most direct route that may be in the path of collapse or falling hazards. Remaining in place may be an option if the area is safe or can be made safe with shoring or removal of hazards. Escape route access and direction may change throughout the duration of the rescue operation. The escape plan should be constantly updated to reflect changing situations and the new plan must be communicated to and acknowledged by all affected personnel.

Safe Zones

Safe zones, also referred to as "safe havens" are pre-established areas of safe refuge, safe from known or potential hazards. These areas can be designated outside the "hot zone" or agreed upon safe areas within the "hot zone." If the safe zone is within the "hot zone" rescuers may have to construct a shoring system or remove hazards to make the area safe enough to remain in place.

Part of the safety plan must provide for a personnel accountability check or "head count" to be conducted in a safe zone after an evacuation signal is sounded. The results of the personnel accountability check must be immediately provided to the supervisor who forwards this information through the chain of command to the IC.

Personnel Accountability System

A personnel accountability system must be in place to keep track of all team members at all times through their supervisor. If adequate staffing allows, assign a Personnel Accountability Officer to conduct or supervise this important function. Periodic personnel accountability checks should be conducted during the duration of the incident and immediately after an evacuation.

Rescue Team Hydration

Dehydration of rescue team members can occur quickly during heavy work periods. Each rescue team member should consume at least 8 to 12 ounces of water or electrolyte supplement every 30 minutes during heavy work periods. Coffee, tea, and caffeinated liquids can increase the dehydration process.

Rescue Team Rotation

Rotate teams on a regular basis. During heavy work periods, some teams need to rotate every 15 to 30 minutes. Rescuers have a tendency to want to work longer periods without a break. Monitor and track entry times and work duration periods. If the rescue situation allows, rotate crews in an overlapping arrangement. This means that not all rescuers who are actively involved in doing the hands-on work should be relieved at the same time.

Remove and replace only part of the crew at one time to allow the new workers to become accustomed to the plan of action and the rescue tactics being applied. This overlap of personnel may allow for the smoother transition of operation and a more effective rescue.

Personal Hygiene

All personnel on the rescue site should wash their hands and face with soap and potable water before eating. Lavatory facilities and hand washing stations must be provided for long duration rescue operations. Only eat food and drink liquids that have been properly prepared and stored by trained personnel such as the American Red Cross or Salvation Army. Eating and drinking items brought to the scene by well wishing civilians may cause illness and can render a rescue team member or an entire rescue team useless.

Stress Factors Awareness

Rescue operations at a collapsed building will be very taxing on everyone involved. Safety Officers, supervisors and all team members must be aware of the potential for critical or extended incident stress and how it will affect rescue workers. All team members must also be aware that prolonged rescue operations, fatigue, the sight of multiple deaths and injuries, and the frustration of wanting to do more can create potentially debilitating stress levels in rescue workers. All team members need to monitor themselves and other team members for critical or extended incident stress signs and symptoms which may include a significant change in a persons usual personality, withdrawing from the group, unable to sleep, nightmares, loss of appetite, use of drugs, or excessive amounts of alcohol.

In order to limit the effects of critical or extended incident stress and personal injury to responders, crews should be rotated on a regular basis to a rehabilitation area. This is especially important if operations will last for many hours or several days.

It is important to provide rescuers in the rehabilitation area with:

- Shelter from the weather
- An opportunity for rest and sleep during prolonged incidents
- Food, drink, and lavatory facilities
- Spare safety gear, such as gloves, dust masks, and eye protection

CHAPTER 7 - US&R SEARCH

In order for any rescue be a successful, the victim(s) must be located. The rescue is dependent upon the completion of a thorough and successful search operation. Basic search techniques allow the rescuer to determine the location of victims and identify means of access to those victims in order to remove them to a safe area. A search operation must be well organized and use the tools available to the on scene personnel. These tools may be as basic as an organized physical search performed by on scene personnel or a more technical search using specially trained dogs or sophisticated electronic devices.

Additionally, the findings of the search effort must be clearly communicated. Methods to communicate this information include basic verbal communication through the chain of command as well as an organized and consistent marking system that should be placed on the actual structure during multi-site operations.

GATHER INFORMATION TO LOCATE VICTIMS

The information gathering process to locate victims begins before the event occurs. Knowledge of the specific structure and the type of occupancy helps to determine the number and locations of victims. Size-up and recon begin organized information gathering specific to the event.

Relevant information must be gathered to help in organizing the search process. The type of occupancy (hospital, school, factory) provides valuable information regarding the expected number of occupants. Construction materials and the building layout will affect the way the building will behave following a significant event. This information can be further quantified by the time of day and the day of the week. A school would not be expected to be fully occupied if the incident occurred after normal school hours on the weekend.

Before and during the search, rescuers should identify the type of collapse patterns that have occurred. This will assist in locating probable victim survival areas within the structure. Keep in mind the characteristics of the four types of collapse patterns as they relate to the potential void spaces created and proper stabilization techniques. Hazards to victims and rescuers should be identified, removed, or mitigated before and during the entire search and rescue operation.

Search personnel also should consider other potential victim locations within the structure. These include areas least likely to collapse, such as stairwells, hallways, and elevator shafts. Underground parking garages and basements are also safe areas where victims may survive but not be able to escape.

A good source for relevant information available before the incident is the Pre-Incident Site Plan. Additional information is also acquired during size-up and recon. Verbal reports from survivors, co-workers, eyewitnesses, and relatives can provide knowledge about the victim's last known location. Contractors and building engineers who were involved in building construction or maintenance may provide valuable information regarding potential victim locations, building layout, and access. These

personnel may also have building plans that could be invaluable during recon as well as the search process.

TYPES OF SEARCH

The Hasty Search (Primary Search) and the Extensive/Grid Search (Secondary Search) are the two search types. The Hasty Search provides rapid detection of potential victims, assists in the size-up of the rescue problem and helps to determine priorities. The Extensive/Grid Search involves a thorough systematic search, redundant checks, and verification with alternate search resources and confirms exact location of victims(s).

SEARCH CATEGORIES

The three main search categories are Physical Search, US&R Canine Search, and Technical Search. Both the US&R Canine Search and Technical Search require specific resources and a significant commitment to training. Each search category has advantages and disadvantages. Usually no single resource or tactic is sufficiently effective on its own. The most effective search strategy should blend all available resources into a logical sequence.

Physical Search

Physical search involves the deployment of personnel to systematically conduct a physical search of all the accessible areas and void spaces. The physical search process is usually accomplished with readily available resources capable of quickly covering large areas and does not require search specialists or unique electronic equipment. Volunteers can be quickly trained to support the effort. Visual sighting provides conclusive verification of the exact location, position, and condition of found victims and positive findings do not require secondary verification.

Generally, only surface and readily accessible victims will be located and this tactic is most effective during daylight hours. Other limitations of the physical search are that it requires rescuers to work in close proximity to potential danger areas and that rescuers cannot access all voids in the building.

This organized approach to victim location ideally should involve personnel with backgrounds in several areas. First, safety personnel familiar with potential structural collapse hazards should be included. If available, a structural engineer, preferably familiar with collapse situations, and personnel familiar with the specific structure to be searched should be part of the search team.

Hailing System

The hailing system (Figure 7.1) is a technique often used in conjunction with physical search, canine search, and technical search tactics. Search personnel are placed in calling and listening positions as close as possible around the site to be searched. Spacing between search personnel is approximately 25'-50' apart in safe locations. The team leader signals for silence and all work in the area to stop. In a clockwise rotation, each searcher calls out loudly or with a megaphone stating, "If you can hear me call out for help or tap five times on part of the structure." At the same time of the call out, searchers may also tap five times on part of the structure or debris pile in an effort to elicit a response. All search personnel are to listen and attempt to get a "fix" on any sound heard. All search personnel are to point in the direction of any sound heard. If more than one searcher hears the sound, the direction they are pointing will triangulate on the location where the sound is emanating. Any sound heard should be verified with at least one additional fix from another angle or location.

1. Place searchers in calling and listening positions around the search area. (25'-50' apart)
2. Team leader calls for silence and all work in the area to stop.
3. Team leader directs potential victims to call for help and tap on part of the structure 5 times.
4. All searchers listen and try to get a "fix" on any sound they may hear.
5. Any sound heard should be verified with at least one additional "fix" from another person at a different angle.

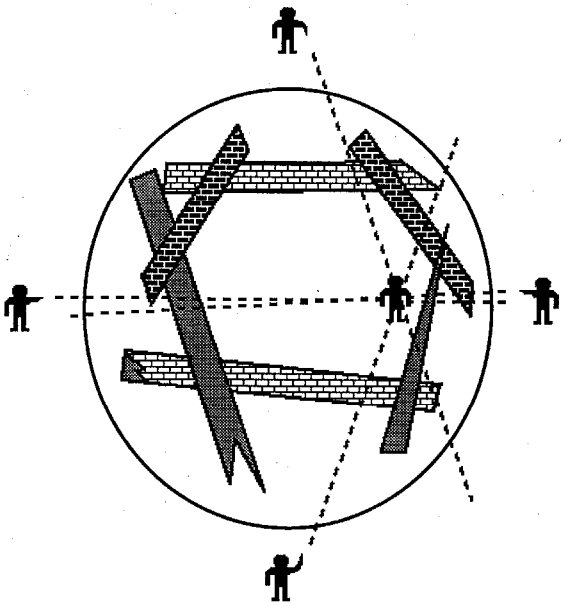


Figure 7.1
Hailing System Search Method

The hailing system technique can be accomplished with readily available resources capable of quickly covering large areas and does not require search specialists or unique electronic equipment. Volunteers can be quickly trained to support the effort that may triangulate a victim location day or night from relatively safe positions. The effectiveness of the Hailing system diminishes over time as victims' condition deteriorates. Victims must be capable of making recognizable sounds where ambient site noise is intrusive. Additional search tactics may be required to pinpoint the exact location of the victim and the results of this tactic are not conclusive that all victims have been located.

The procedure for conducting a physical search should begin with organizing the search personnel. A team leader must be identified and communication established with the Incident Commander (IC). Search personnel should be reminded to use the "buddy system" with a minimum of two persons per search team. If available use an existing site plan or draw the structure layout to keep track of where you have been, where you need to go and any hazards or victims located during the search. Search the area around the structure first. Walk around the site to

identify and remove any surface victims found. At the same time, document and inform the IC of the location of any heavily entrapped victims, who cannot be readily accessed or rescued.

During the walk around and after entering the structure, use the hailing system when appropriate. Enter the structure only if it is safe to do so. Structural stability and hazard concerns should be addressed before entry. Initiate the search marking system before entering the structure.

Search all of the accessible interior rooms and areas inside the structure in an organized manner. Areas should not be skipped unless for safety reasons, and any area skipped should be documented on the site plan. To search smaller individual rooms or areas, use the "Go Right – Stay Right" search method. A minimum of two search team members enter the structure, keeping in visual or physical contact with the wall on their right while searching in and under all possible entrapment or hiding places of each room or area. Using the same door to enter and exit each room or area ensures that they will not miss any room or area. By turning around and reversing the process the search team members will always be able to find their way out of the structure.

1. Search team in a straight line remains in visual contact.
2. Search team waits for individual room search team members.

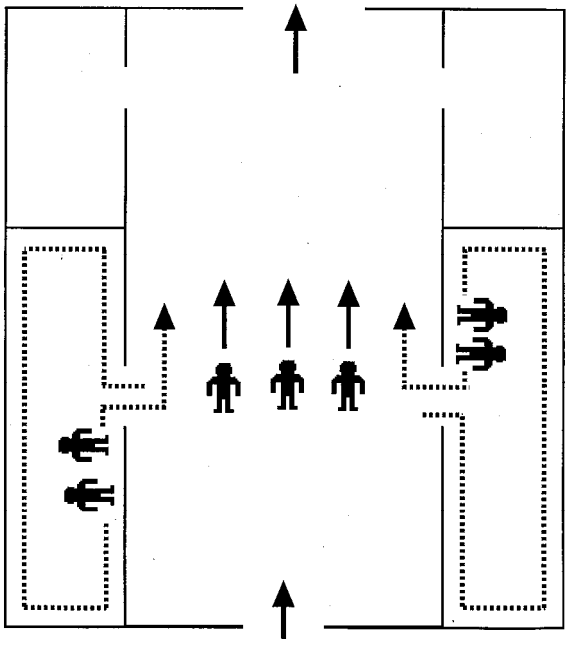


Figure 7.2
Line Search Method

The "Line Search" method (Figure 7.2) should be used to search large rooms or areas. Search team members spread out in a straight line and slowly walk the entire width and length of the room or area being searched. The main body of the search team waits for other team members searching inside individual rooms or areas with the "Go Right - Stay Right" search method (Figure 7.3) and takes more time to complete.

During the search operation, use the victim location marking system to identify any potential victim locations or confirmed victims that are not readily visible.

Search debris piles, using caution when moving materials. Unorganized movement of rubble may cause the debris pile to shift or additional failure of the structure. Mark debris piles that have been searched or have been moved from one location to another to prevent unnecessary searching or debris movement by other personnel.

All victims contacted must be encouraged not to give up; if possible, contact should be maintained until they are rescued. Explain the situation to the victim, and at the same time, evaluate the victim's position, entrapment, and medical condition. This information may assist in determining the best extrication approach. Also, question the victim about other known occupants of the structure. If safe to do so, leave two search team members with an entrapped victim to monitor the victim's condition, provide encouragement and direct rescuers to the exact location. Continue to search if assigned to the search function. The entire structure must be completely searched in order to locate all possible victims and identify potential hazards. Stopping the search function to perform a time consuming rescue as soon as a victim is located can prevent the discovery of more easily accessible victims or the identification of significant hazards. The site should be continually searched until all potential victims are located or accounted for.

Previously unidentified victims may be found after walls and floors are breached or debris removed.

Report all findings to the IC. Information should include the location of the search team when complete with an area, location of any victim with a description of victim condition, entrapment and hazards, and any access information for the rescuers.

1. Buddy System: Minimum of 2 persons per search team
2. Enter and leave the structure using the same door.

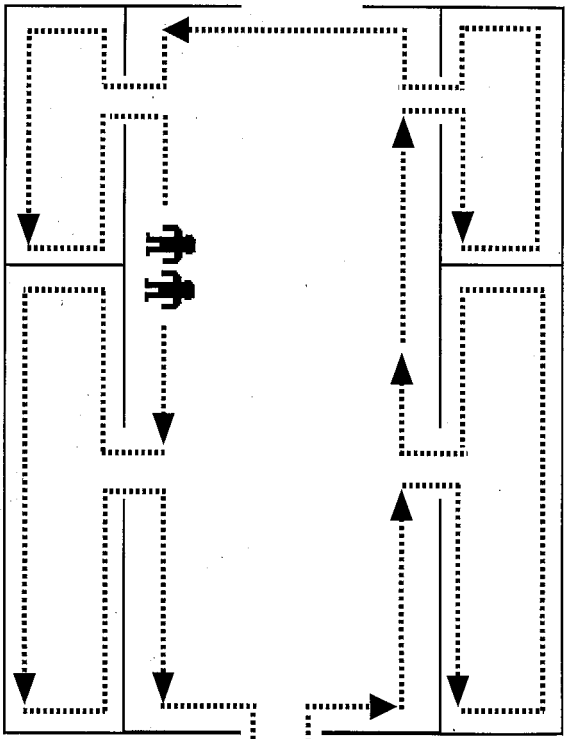


Figure 7.3
Go Right - Stay Right Search Method

US&R Canine Search

A US&R canine search is accomplished with a trained and certified US&R canine and handler team. A second US&R canine/handler team is often used to verify a potential victim location. Extreme caution should be used if attempting to use dogs and handlers with other types of training. Canines trained in police service, drug detection, and wilderness search lack specific experience and training for this type of work. Possible harm to the victims and the canine/handler team may occur without extensive experience and training working in and around structural debris and rubble.

The US&R canine search can cover large areas in a relatively short period of time. This tactic can be used for both hasty and extensive/grid search operations. Many US&R canines can differentiate between live or dead victims buried deep within a collapsed structure or debris pile.

They can work "off lead" from the handler in unsafe areas, traverse debris, and gain access to voids. Trained and certified US&R canine and handler teams are a limited resource with more being trained and certified each year. Team performance may vary according to individual handler or canine capabilities, health and temperament. Continuous refresher training is required to maintain an acceptable level of performance. The duration of the operation will be affected by weather and the physical condition of the canine. Aromatic contaminants such as marking paints, gasoline-powered tools, and other searchers will compromise the effectiveness of the canine search. The optimum working conditions are cool to mild temperatures, moderate to high humidity, and a light steady breeze. Most canines will require frequent work/rest breaks, usually alternating in 20-30 minute time blocks. Additional search tactics may be required to pinpoint the exact location of a victim.

Technical Search

There are primarily three types of technical search resources. They include electronic listening devices, visual search devices and other electronic search devices. Each technical search device requires trained operators and specialized equipment costing from a few hundred to several thousand dollars.

Electronic listening devices can detect sounds made by conscious victims buried deep within a collapsed structure or debris pile. They are able to cover large areas and may triangulate on a victim location with a range of 5'-25' acoustic (voice) and 50'-150' seismic (vibrations). The effective range of these devices is greatly affected by the type and congruency of debris. Most of the devices have two-way sound capability to communicate with the victim and some have paper readouts for comparative analysis and documentation. Some have computer interface for filtering ambient noise and matching sounds. Electronic listening devices may be used to verify other search tactics. Less sophisticated acoustic devices may be found with public works agencies used for leak detection.

The usefulness of electronic listening devices diminishes over time as the victim's condition deteriorates and how well ambient site noise and vibrations can be controlled. These devices are best used at well-controlled sites or at night and early morning when ambient noise is reduced. Some of these devices require a skilled technician and up to four assistants. Duration of the operation is limited by battery constraints. This type of device should be used in conjunction with the Hailing system and may require additional search tactics to pinpoint the exact location of the victim. The results of this search tactic are not conclusive that all victims have been located.

The two primary categories of visual search devices are "video" where images are transmitted to a TV screen and "optical" where the image is viewed directly through fiber-optic bundles or mirrors to a monocular eyepiece. Both categories provide conclusive verification of the exact location, and general position and condition of the victim. Some devices can be used through openings as small as ¼" and can extend as far as 10'. Some devices have two-way communication, provide their own light source, and are flexible enough to be positioned into tight awkward areas. These devices require a skilled operator and the duration of operation is limited by battery constraints. Field of view, depth of view and light intensity may be limiting factors. The search area is limited to safe accessibility and reach of the device and the results do not indicate a complete search of the site. Less sophisticated visual

devices can usually be acquired from below-grade contractors, utility companies, and public works agencies.

Other electronic search devices include:

- Thermal sensing devices that are capable of locating thermal differences or "hot spots" in darkness or smoke. These devices cannot "see through walls," light debris, and in many cases multiple layers of clothing or heavy dust to locate victims.
- Infrared and ultraviolet sensing devices are capable of seeing light radiation either just below or just above the visible light spectrum producing a monochrome picture. These devices are often used to conduct covert surveillance but have not proven to be very effective in US&R situations
- Electromagnetic (EM) wave detection (radar) is capable of detecting both heartbeat and respirations through as much as 10' of concrete and steel debris. Some of these devices are expected to become smaller and less expensive in the future and may become a viable resource.

Completion of the initial search provides information to allow an organized and logical approach to safe victim rescue. Information gathered and documented during the search reported to the IC should include search team status, victim location, structural condition, and hazards. Continuation of the search function with as many available resources and techniques until all the victims are located or accounted for must be part of the ongoing incident process.

SEARCH MARKING SYSTEM

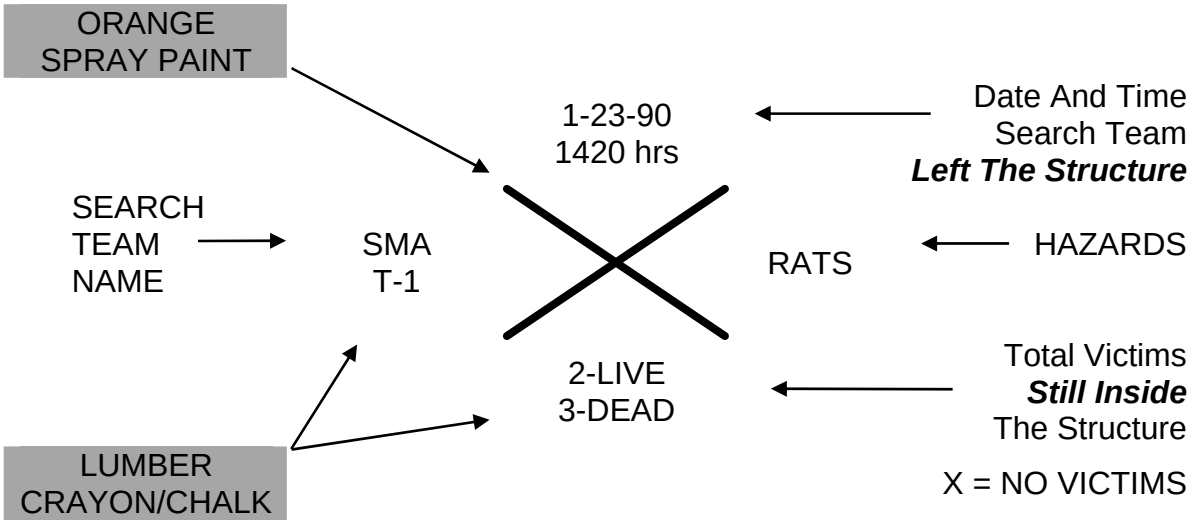
Search markings must be easy to make, easy to read, and easy to understand. To be easily seen the search mark must be large and of a contrasting color to the background surface. Orange spray paint seems to be the most easily seen color on most backgrounds and line marking or downward spray cans apply the best paint marks. Lumber chalk or lumber crayons should be used to mark additional information inside the search mark itself because they are easier to write with than spray paint.

A large distinct marking will be made outside the main entrance of each building or structure searched. This "Main Entrance" search marking will be completed in two steps. First, a large (approximately 2') single slash shall be made near the main entrance at the start of the search. After the search of the entire structure has been completed, a second large slash shall be drawn in the opposite direction forming an "X." Specific information will be placed in all four quadrants of the Main Entrance "X" summarizing the entire search of the structure. The left quadrant is for the Rescue Team Identifier. The top quadrant is for the date and time the search was completed. The right quadrant is for any significant hazards located in the structure. The bottom quadrant is for the number of "LIVE" or "DEAD" victims still inside the structure. Use a small "X" in the bottom quadrant if no victims are inside the structure.

During the searching function while inside the structure, a large single slash shall be made upon entry of each room or area. After the search of the room or area has been completed, a second large slash shall be drawn in the opposite direction forming an "X." The only information placed in any of the "X" quadrants while inside the structure shall be that pertaining to any significant hazards or the number of "LIVE" or "DEAD" victims.

Search Markings

Main Entrance Search Marking



VICTIM LOCATION MARKING SYSTEM

During the search function, it may be necessary to identify the location of a known or potential victim. The amount and type of debris in the area may completely cover or obstruct the location of the known or potential victim. The victim location marking symbols are made by the search team or other individuals conducting search and rescuer operations whenever a known or potential victim is located and not immediately removed. The victim location marking symbols should be made with orange spray paint with a line marking or "downward" application spray can.

A large (approximately 2') "V" is painted near the location of the known or potential victim. An arrow may need to be painted next to the "V" pointing towards the victim when the victim's location is not immediately near where the "V" is painted.

Mark the name of the search team or crew identifier in the top part of the "V" with paint or a lumber marker type device. This identifier may be useful to obtain additional information from the team who originally located the victim.

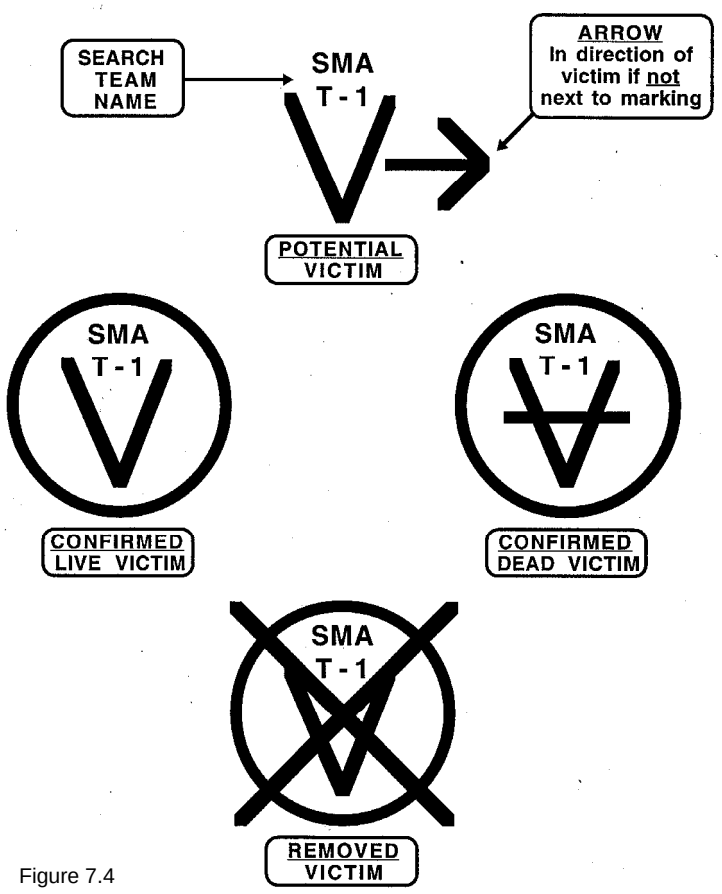
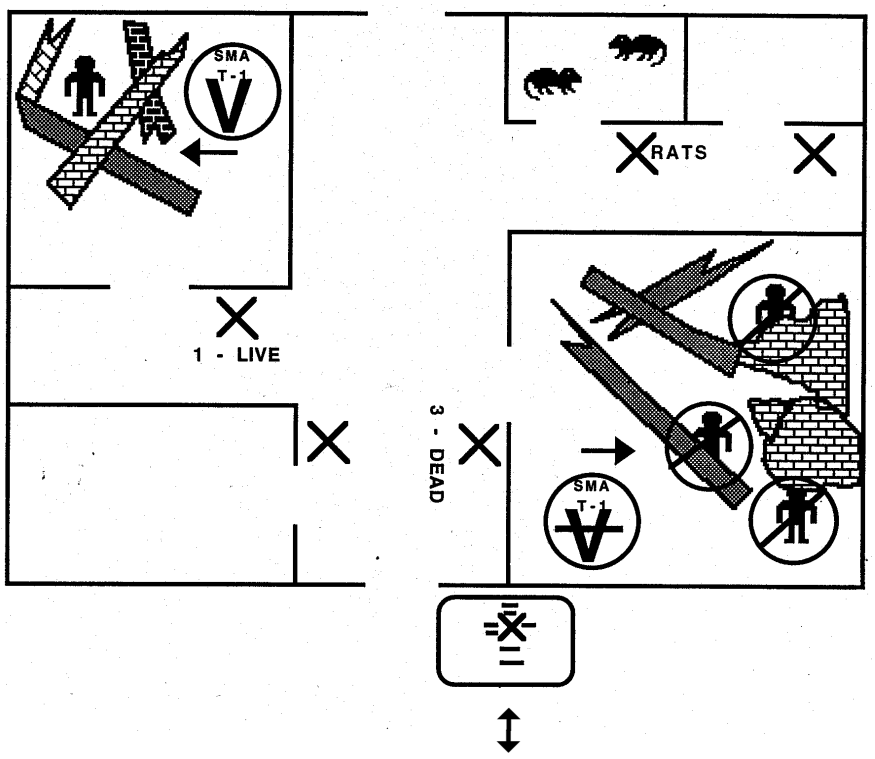


Figure 7.4

Paint a circle around the "V" when the location of a victim has been **confirmed** either visually, vocally, or hearing specific sounds that could indicate a high probability of a victim. This may be done when the victim is initially located or may need to be done later after some debris removal or use of specialized search equipment. A US&R canine alert will initially receive the "V" **without** a circle to indicate a **potential** victim. A circle would be painted around the "V" when the location of a victim has been **confirmed** either visually, vocally, or audibly hearing specific sounds which could indicate a high probability of a victim.

Paint a horizontal line through the middle of the "V" when a **confirmed** victim is determined to be deceased. Paint an "X" through the **confirmed** victim symbol after all victims have been removed from the specific location identified by the marking.

The victim location marking symbols and number of victims, if known, must be placed on the developing site map during the search of the structure or area.



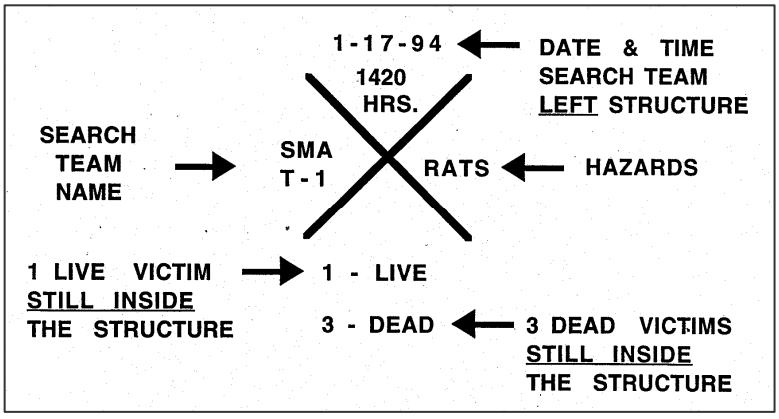


Figure 7.5

CHAPTER 8 - US&R MEDICAL CARE AND SAFETY FOR VICTIMS

BASIC MEDICAL CONSIDERATIONS

A structural collapse incident can cause multiple victims to be injured in a variety of ways and locations. Utilizing some basic medical care and safety procedures during the rescue operations will greatly assist in providing the most victims with the best possible chance for recovery.

It is imperative that rescuers not lose sight of their primary objectives in responding to structural collapse incidents. Rescuers must be able to stabilize or maintain the existing situation and access, stabilize, and remove victims without further harm.

Before beginning rescue operations, the IC should establish a location to place injured victims. This location is often known as a casualty collection point (CCP) or treatment area. If rescue operations begin before establishing a CCP, victims from the incident are often gathered and placed at different and multiple locations that makes triage, treatment, and transport more difficult. Use established triage procedures to sort multiple victims to do the most good for the most people with the limited resources available.

Determine Likelihood of Victim Survival

Another consideration of the IC is the potential for survival of the victims, based on the type of collapse situation and on the length of time the victim has been trapped. Research done after several earthquakes with entrapped victims has illustrated that survival is proportional to the length of time a victim is entrapped. The greatest chance of survival occurs within the first 24 hours, and 80% of those who can be saved will usually be rescued within that time period.

Typical survival rates of trapped victims:

- 30 minutes 91% survive
- 1 day 81% survive
- 2 days 36.7% survive
- 3 days 33.7% survive
- 4 days 19% survive
- 5 days 7.4% survive

INJURIES ASSOCIATED WITH STRUCTURAL COLLAPSE

A collapsed structure places significant forces on a victim's body and the contents of a structure have tremendous potential to cause injury in a collapse.

Types of Injury

The time of day of the structure collapse can be a possible indication of the type of injury rescuers may encounter. A higher instance of head, neck, and back trauma can be expected during the day and early evening when people are normally found in standing and seating positions. A higher instance of broken bone, soft tissue, and crushing injuries can be expected during the late evening and early morning hours when people are normally laying in bed or trying to escape with less than adequate clothing or protection.

Other Medical Concerns

Hypothermia, or decreased body temperature, is a concern in cold temperatures when the patient may have been exposed to the environment for extended periods of time. Wet clothing, lack of normal heating and insulation systems, building components that absorb heat, inability of the patient to move, and existing weather conditions all increase the possibility of hypothermia. Rescuers must protect the patient from the environment during the rescue effort.

Hypovolemia, or a loss of blood volume, can occur as a result of impacts and injuries to the body as a structure collapses. Shock as a result of hypovolemia is a life-threatening problem. Rescuers must stop the bleeding and provide oxygen and intravenous fluid replacement if possible.

Inhalation injuries result from many sources during a structural collapse. Large quantities of dust are a significant irritation to the respiratory system and may even suffocate the patient. Rescuers should be prepared to protect both themselves and patients from dust.

Other respiratory problems can result from hazardous atmospheres created by the escape of normally contained products. Examples include natural gas and onsite hazardous materials. It is important to protect both the patient and the rescuer from these hazardous environments throughout the rescue effort.

Dehydration, or inadequate fluid intake, becomes a concern based on the environment and the length of time the patient is trapped. Drinking fluids is the best way to improve hydration but in many cases this in not possible. In these situations, the best solution to the hydration problem may be an intravenous line (IV) started by advanced life support personnel before removal of the patient from the structure.

Nutrition also becomes a concern, especially as the length of time of the incident increases. This should be addressed by advanced life support personnel trained to deal with this type of situation.

Compartment syndrome can occur when a patient's limb has been trapped for over four hours. The limb swells until the skin is stretched to its maximum. These patients will need advanced life support care and aggressive surgery to relieve the pressure to save the limb and possible amputation to save the victims life.

Crush syndrome occurs as a result of crushing pressure on certain parts of the body, typically the lower extremities. Blood flow to and from the injured area is absent for over four hours. Then the injured tissue dies and gives off toxins. A sudden release of pressure allows the toxins to flow into the bloodstream, where they could have an effect on other organs in the body and possibly cause death. Crush syndrome has been called the "grateful dead" syndrome because the patient is appreciative and talking to the rescuers while trapped and during the extrication, but once freed the toxins are released and the patient dies.

Most importantly, rescuers must be able to recognize crush syndrome as a possibility and provide treatment prior to patient extrication.

Contact/Consult Medical Resources

If available, advanced life support personnel familiar with crush syndrome should provide treatment for the patient. High-flow oxygen by non-rebreather mask, large volumes of intravenous fluids, cardiac monitoring, and certain medications are appropriate for treatment before releasing the weight load off the victim.

The longer a patient is trapped, the greater the long-term effect; the greater the entrapment time, the lower the chance for long-term survival. Compartment and crush syndromes become concerns after four hours and a certainty after six hours.

Personnel on scene must contact and consult with available medical resources. Structural collapse incidents are long in duration (typically greater than eight hours). Patients' conditions may be unstable, and rescuers may not be able to move them because they are trapped. Compartment and crush syndromes require specific advanced life support medical treatments. This treatment must be administered or supervised by trained personnel familiar with structural collapse injuries. Moving a patient may require very careful handling to minimize the possibility of further injury.

Potential Treatment by Rescuers

- High-flow oxygen by non-rebreather mask
- Cervical spinal immobilization
- Monitor cardiac activity
- Administer certain advanced life support medications
- Immobilize and package the victim for removal
- Maintain body temperature
- Protecting the victim from the environment. Consider helmet, eye protection and dust mask or oxygen mask for victim.
- Protect the patient from rescue activities. Sparks, breaking and breaching debris, and accidentally dropped tools and equipment.

Victim Movement over Debris Piles

If possible, rescuers should not walk over uneven, unstable, or slippery surfaces while carrying victims. Rescuers should secure footing, form a human chain, and pass the victims from rescuer to rescuer. Placing a victim on a backboard or other stable stretcher type device will provide a secure platform with good handholds for the rescuers.

BASIC INFECTIOUS DISEASE SAFETY

If a victim does not have a disease prior to injury or death, they do not become infectious because of the injury or death. Rescuers should take basic infectious disease safety precautions, which includes wearing the same PPE to protect themselves from other types of structural collapse hazards. PPE for cuts, abrasions, eye, and respiratory protection. Additional PPE is needed for potential contact with body fluids. Rubber latex gloves put under the leather work gloves will prevent damage to the rubber gloves during work activities. If significant contact with body fluids is expected due to the rescue operation, the rescuer should wear a moisture barrier over their work clothes such as a Tyvec disposable coveralls and shoe covers often used at hazardous material incidents.

General Infectious Disease Safety Rules

- If it is warm and wet and not yours, get if off you as soon as possible.
- If contact with body fluids, wash with soap or mild disinfectant as soon as possible.
- Wash your hands and face before eating anything.
- Remove and wash clothing with soap and water as soon as possible if contact with body fluids.
- Immunizations against hepatitis and tetanus should be kept current.
- If contact with a significant amount of body fluid has occurred, rescuers should consider decontaminating boots, gloves, and outerwear with soap and water or a mild disinfectant.

CHAPTER 9 - RESCUE ROPE AND RELATED EQUIPMENT

This unit is not a rope rescue course in the true sense. The techniques and skills taught are the basics needed to perform rescues using rope and rescue equipment to safeguard the rescuer and victim. The material covered in this unit is only one element needed to learn these skills. Instruction from a skilled and experienced trainer is necessary as well. Before you consider yourself a skilled rescuer, you need to practice these skills in the proper manner and maintain proficiency through a regular training program until the skills become instinctive.

> The rope rescue equipment described in this manual is generic in nature. Before rope rescue equipment purchase or use, each equipment manufacturer should be consulted to ensure compatibility of size, construction, characteristics, and intended use with other equipment manufacturer's products.

INTRODUCTION

The technical rescue environment is hazardous. Rescue personnel must think about safety at all times and pay close attention to detail. A proper rescue system requires not only quality equipment and up-to-date techniques, but also skilled and intelligent rescue personnel who are capable of making good decisions. Such good judgment comes from quality training and experience.

Technical rope rescue is a vast and constantly changing field. It is so complex that no one individual can have all of the answers. There is no one correct way to perform rope rescue because there are many methods available to accomplish the same task. Some are better than others are. Rescue personnel need to keep an open mind, listen, watch, and learn from others working in this field. Choose the techniques, systems, and equipment that best fit your needs and your environment.

This unit of Rescue Systems 1 should not be a self-instructional guide. It should be used only with the guidance of a qualified instructor.

BASIC ROPE RESCUE EQUIPMENT

Rope rescue equipment is divided into two general categories, software, and hardware. Software includes rope, webbing, prusik loops, pick-off strap, and commercial harnesses. Hardware includes carabiners, pulleys, anchor plates, ascending, and descending devices.

Rescue Software

Rescue Rope

Rescue rope is used for a variety of purposes in technical rescue. It is the primary tool for raising and lowering rescuers, equipment, and victims. It is used to protect rescuers and victims as they move and work in elevated positions where a fall could cause injury or death. It is used to create pulley systems.

Rescue Rope Construction

There are many types of rope on the market today, but only a few specially manufactured ropes meet the stringent requirements for rescue or life safety rope.

Synthetic ropes have replaced natural fiber ropes in the past several years. Natural fiber ropes such as manila, hemp, and sisal come from plant fiber. The fiber is woven together, and since the entire rope is made of many short fibers, the strength is uncertain and inconsistent. Natural fiber ropes do not have sufficient strength in manageable sizes to safely hold live loads. Any rescue team still using natural fiber ropes today is risking legal liability from catastrophic rope failure.

Synthetic rope is lighter, stronger, and more resistant to decay and rot than natural fiber rope. Nylon synthetic rope is the preferred material for rescue rope. There are several different kinds of nylon ropes manufactured for rescue use. Some ropes have a high stretch factor and are designed for mountain climbing. These ropes, called **high stretch (dynamic) ropes**, stretch at least 10% at 450 lbf. (pounds force) (2kN), and may stretch as much as 60% of their length before breaking. This is to absorb the shock of a falling load and reduce the impact on the falling climber and on his/her anchors and equipment. High stretch (dynamic) rope is used when long falls may be anticipated; it is not practical for rescue work. High stretch rope acts like a rubber band when loaded, which is a definite hazard and disadvantage when trying to raise or lower a heavy load.

Low stretch (static) ropes are the preferred types of rope for rescue work. They stretch very little when loaded, less than 5% at 450 lbf. (2kN) with a minimum elongation of not less than 15% @ 75% of breaking strength, and a maximum elongation of not more than 45% @ 75% of breaking strength (NFPA 1983, 1995 edition). They should not be used where the stretch of a high stretch (dynamic) rope may be needed to absorb the shock of a long fall.

Low stretch (static) rescue rope is constructed using a kernmantle design. Kernmantle is a German word meaning core and sheath. The kern, or core, is made up of continuous parallel fibers running the length of the rope. This is known as block creel construction. The core carries the majority of the load, or about 75%-90% of the rope's strength, and is protected by the mantle or sheath. The sheath is a tight weave of nylon that carries the remainder of the load. By its design, low stretch (static) rope has

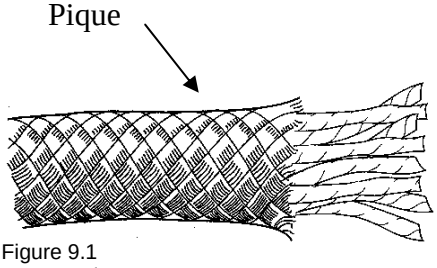


Figure 9.1
Kernmantle Rope
Courtesy of CMC Rescue, Inc.

a thicker sheath that protects it from abrasion damage. The sheath also protects the core from abrasion, dirt, and the effects of sunlight, which can weaken nylon with prolonged exposure.

Most rescue rope used in the fire service today is ½" (12.7mm) diameter, low stretch kernmantle rope. Some rescue teams have gone to 5/8" (15.8mm) diameter rope for the greater breaking strength. The problem with this is that the larger rope costs more, weighs more, and is harder to handle. Most rescue hardware in use today is not compatible with ropes larger than ½" (12.7mm). There really is no need to use a rope larger than ½" (12.7mm); by today's manufacturing standards ½" (12.7mm) rescue rope meets or exceeds the minimum safe working and breaking strengths. NFPA 1983 is the standard for life safety rope.

Minimum breaking strength for rope used in one-person systems shall not be less than 4,500 lbf. (20kN). Minimum breaking strength for rope used in two-person systems shall not be less than 9,000 lbf. (40kN). There will be a 15:1 safety margin. This means a single rope system can be used and still meet the safety standard. All Rescue Systems 1 systems require two ½" (12.7mm) NFPA-certified ropes.

An extreme rescue load is given as 600 lbf. (~3kN), about the weight of two fully equipped rescuers. A 9,000 lbf. breaking strength rope with a 600 lbf. (~3kN) load provides a 15:1 safety margin.

NFPA 1500 (1997) 5-9.3 states: life safety rope may be reused if inspected before and after each use, and no impact load, damage, or exposure to any chemical material known to deteriorate rope has occurred.

Refer to the full NFPA 1983 (1995 ed.) and NFPA 1500 (1997 ed.) 5-8 on fire service life safety rope, harnesses, and hardware for the specific requirements.

Inspection

Visually inspect the rope for:

- Unusual wear
- Cuts
- Exposed core material
- Excess wear and abrasion of the sheath material
- Discoloration that could be from chemical contamination
- Burn marks from excessive friction and heat buildup

Feel the rope as it is being stuffed into the rope bag for:

- Soft spots
- Kinks
- Unusual bulges
- Inconsistent texture and flexibility
- Unequal diameter or thickness
- Excess contamination from dirt and debris

Any of these could indicate damage to the core of the rope, and may require taking a rope out of service. If in doubt, take the rope out of service.

Cleaning

- Keep ropes clean of mud and dirt, which can act as a sharp abrasive if allowed to work its way into the core of the rope
- Wash rope in a standard front-loading washing machine or in an open tub by hand
- Wash in cold water
- Do not use strong detergents, as they may cause damage to the rope
- To avoid mildew and mold, make sure the rope is completely air dried before storing in a rope bag
- Do not dry rope in direct sunlight

Storage

One of the most convenient methods of storing and carrying rope is in rope bags. It is easier and quicker to stuff a rope into a bag than it is to coil it. Rope bags protect the rope from damage, make deployment quick and easy. Bagged rope can be carried to remote rescue sites more easily than coiled ropes.

Nylon rope can be damaged by many substances and materials, and by poor storage habits. Prolonged exposure to sunlight will degrade nylon rope. Moisture will cause mold and mildew to grow which may weaken a rope; rope should be stored in a dry area. Acids, chemicals, and strong detergents will damage nylon.

Storing a rope with knots left in it will eventually cause that portion of the rope to weaken. Storing rope on concrete can cause damage from the caustics found in some concrete mixes. If stored on a

vehicle, rope should be kept away from fuel, oil, and exhaust fumes, as these will cause rope to degrade in strength.

Damage

When working around any software, take caution to avoid serious damage. There are many ways to damage a rope while in use. Objects falling and striking rope can cut or crush the fibers, but the number one cause of rope failure is abrasion and cutting as the rope runs over sharp edges. This can be avoided by using edge protection wherever possible.

There are many forms of edge or abrasion protection that can be used, including turnout coats, packs, and heavy clothing. Fire hose sections split down the middle, carpet, and salvage covers are all potentially good abrasion protection. There are also commercial devices that can be purchased such as edge rollers. Stepping on a rope forces dirt and debris into the rope's core, which accelerates wear from abrasion.

Nylon has a low melting point, and is easily damaged by excessive heat. The minimum melting temperature of low stretch nylon rope is 400° F. When two pieces of nylon come in contact, with one stationary and the other in motion, the heat buildup caused by the friction will cut right through the stationary piece of nylon. There are many situations in technical rescue where this could occur, and care must be taken to avoid this problem at all times. Fast rappels will also cause severe overheating of metal components, which can damage the rope. Properly controlled rappels will prevent this hazard.

Strength

Bending rope fiber reduces the strength of a rope. Any knot will reduce the strength of a rope. Whenever a rope is placed under a load with a sharp bend in it, there is a strength loss. The bigger the diameter of the bend, the less strength loss. Tests have shown that there is not a significant loss of strength until nylon rope is bent to less than four times the diameter of the rope. For a ½" (12.7mm) rope, the minimum bend should be 2" to maintain the maximum strength.

Marking

Rescue rope should be marked or tagged, so that the history of each individual rope can be maintained. Each rope should have an identifying mark or number on both of its end. A middle mark is sometimes helpful and saves time when setting up some rescue systems.

Rope marking should be done with material that has been approved by the rope manufacturer to avoid potential damage to nylon strands (no petroleum based markers).

Rope Log

A rope log for recording the usage of each rope must be maintained. Information to be recorded includes:

- Purchase date
- Manufacturer
- Size
- Length
- Whether it is high stretch (dynamic) or low stretch (static)
- Whether it is lifeline or utility grade rope (how the rope was used)
- Any unusual loading
- Whether a fall was caught
- Whether any object fell onto the rope
- What materials (sand, glass, etc.) the rope was in contact with
- Washings

Every time a rope is used, the usage should be recorded in the rope log. Information about how it was used will help to decide when to retire a rope from service. When to retire a training rope will be determined by reviewing the rope log, inspecting the rope for damage, and by using common sense and good judgment.

Ropes should be retired:

- If there is excessive sheath wear
- When more than half of the outer sheath yarns are broken in one pique
- After severe shock force from a fall, or when stressed with a load beyond that it was designed to hold
- If contaminated by chemicals
- When worn out from use or age
- When an inspection exposes an obvious fault or damage
- When usage cannot be accounted for

Sample Rope Log

SERIAL NUMBER	ID MARKING	LENGTH	DIAMETER
DATE OF MANUFACTURE	ISSUE DATE	DATE IN SERVICE	
FIBER	COLOR	CONSTRUCTION	MANUFACTURER LOT #

INSPECT THE ROPE FOR DAMAGE OR EXCESSIVE WEAR EACH TIME IT IS DEPLOYED AND AGAIN AFTER EACH USE. IMMEDIATELY RETIRE ALL SUSPECT ROPES

DATE USED	INCIDENT LOCATION	TYPE OF USE	ROPE EXPOSURE	DATE INSPECTED	INSPECTOR INITIALS	ROPE CONDITION AND COMMENTS

PURCHASED FROM: _____ PURCHASE DATE: _____

REMARKS: _____

_____

Rescue rope and software should be purchased only from a reputable dealer or manufacturer of rescue equipment. Quality lifeline rope normally is not available from marine or hardware stores.

Prusik Cord

Prusik cord is narrow rope, 8mm in diameter for this course. It is the same low stretch, nylon Kernmantle construction as rescue rope. Prusik cord is used primarily to make Prusik loops.

Prusik Loops

Prusik loops were originally designed to allow a climber to ascend a vertical rope. The prusiks allowed climbers to perform self-rescue if they fell into a crevasse. Prusiks have been adapted to rescue work and perform three important functions in rescue systems as hauling prusiks, braking prusiks, and ratchet prusiks.

In a raising system, the **hauling prusik** grabs the rope and pulls it into motion as part of a mechanical advantage system. The **ratchet prusik** holds the rope while the mechanical advantage system is reset. In a belay system, the **tandem braking prusiks** grab the belay line to prevent it from moving if there were a mainline failure thus providing safety for the rescuer/victim.

When working with ½" (12.7mm) rescue rope the prusiks should be 8mm in diameter. Prusik cord must be compatible with the particular rescue rope that is being used. Some ropes have a special coating that reduces friction and thus reduces the effectiveness of prusik hitches that are attached to them. Special care must be taken in selecting compatible rescue rope components. Soft, pliable rope is preferred for prusik material. The cord used for prusik loops should be pinch tested to determine if it is pliable enough to adequately grab onto the rescue rope. This is done by bending the cord into a bight with two fingers. If the distance between the cords on either side of the bight is greater than the diameter of the cord, the cord is too stiff and the prusik hitch will not grab the rope. Conversely, if the accessory cord is too supple and the bight has almost no gap at the bend, the cord will grab too quickly and absorb very little shock. The goal here, especially with a braking prusik, is to allow the prusik to slip before setting on the rope thereby absorbing some of the shock as the prusik arrests the moving rope.

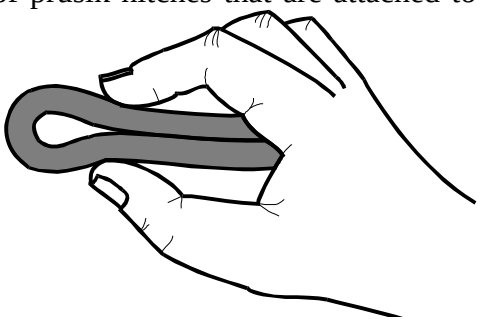


Figure 9.2
Prusik Cord Pinch Test

The 8mm prusik cord used for prusiks on ½" (12.7mm) rope are cut to 70" (1.79m) in length to create long prusiks and 57" (1.46m) in length to create short prusiks (these lengths are compatible with 2" prusik minding pulleys). Several of each size is needed in most rescue systems. Each length of 8mm cord is tied into a continuous loop using a double overhand bend. Once tied, prusiks should remain tied. A single prusik attached to the ½" (12.7mm) mainline with a three-wrap prusik hitch is used for a hauling and ratchet prusik. A set of tandem prusiks, one long and one short, attached to the ½" (12.7mm) belay line with three-wrap prusik hitches, is used for a braking prusik.

Tests by several different groups from different areas have shown the tandem prusik belay system to be the most effective means of protecting a rescue load. It was the only system tested that was consistently able to stop and hold rescue loads dropped from nominal heights without serious damage to the belay line. The tandem prusik belay is easy to set up, versatile, secure, and reliable. It also requires training and practice on the part of the rescuer to operate properly.

There are other mechanical devices on the market that can perform the same function as the prusik. However, these devices were designed to ascend vertical ropes only, not to catch a falling load. In slow pull tests, these devices have caused serious damage or severed the rope at about ⅓ of the strength of the rope. Prusiks start to slip at about ⅓ of the rope's strength and then seize, warning of an overloaded system.

Some rescuers are concerned about supporting a load with 8mm rope, thinking that it is a weak link in the system. In fact, 8mm prusiks are stronger than the main line with a knot in it, attached, and bent around a carabiner. In all the testing done, Prusiks have never failed at the bend of a carabiner.

Care and Maintenance

Same as for rope.

Webbing

Webbing is used extensively in rescue work to build anchor systems, create harnesses, package and secure victims; and to lash rescue components together.

Because of its very small diameter, webbing is a better material to use when snapping into carabiners because it is more efficient in maintaining its strength. 4,000 pound webbing loses very little of its strength when bent around a carabiner.

Webbing is relatively inexpensive and can be cut into short lengths for many uses. It is lightweight and easy to tie.

Construction of Webbing

Nylon tubular webbing should be used in rescue applications. There are different methods of manufacture. Until the year 2000, the preferred method of construction was spiral weave/shuttle loom. Although this type of construction is still safe to use, it is being replaced with needle loom construction which is flat webbing that is folded and stitched together on one side.

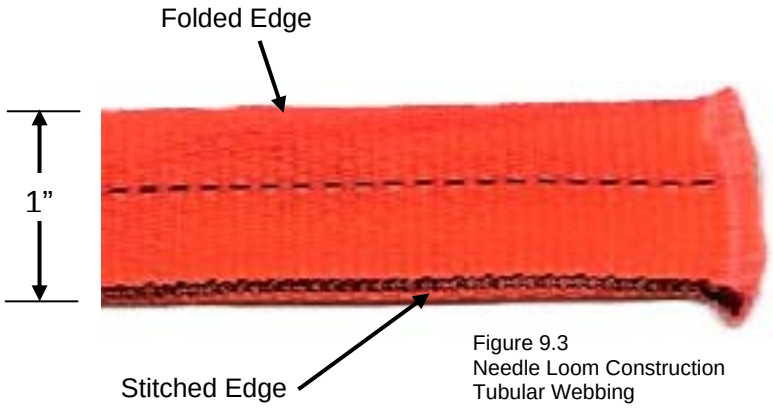


Figure 9.3
Needle Loom Construction
Tubular Webbing

Webbing comes in several sizes. The 1" size is most widely used and has a 4,000 pound breaking strength. 2" webbing has a breaking strength of 7,000 pounds.

Webbing is available in a variety of colors. A system of color-coding webbing to determine length greatly aids in setting up rescue systems. If you know, for example, that all pieces of orange webbing are 20' in length, it is easy to select the proper piece of webbing to construct a specific anchor sling or to lash a victim into a litter.

This Rescue Systems 1 course uses the following color-coding for all webbing:

- Green 5'
- Yellow 12'
- Blue 15'
- Orange 20'

These colors are standard with most manufacturers and can be purchased from various rescue suppliers. These lengths have proven to be the most useful for rescue applications.

Care and Maintenance

Same as for rope.

Pick-Off Strap

The pick-off strap is a section of 1¾" webbing used to connect the rescuer and victim together during a rescue to "pick-off" a victim who is stranded on the side of a building, rock face or other slope. This strap is about 48" in length and has a "D" ring sewn on to one end. In the middle, a sliding buckle allows the rescuer to adjust the distance between himself and the victim. The other end is folded over and sewn to ensure that the buckle does not come of during adjustment.

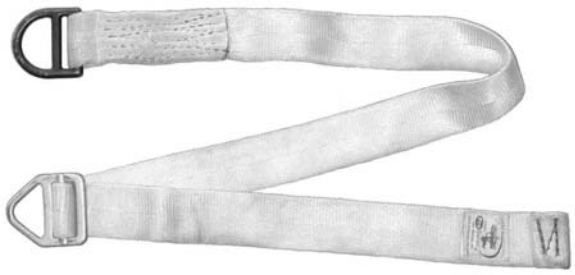


Figure 9.4
Pick-Off Strap

Care and Maintenance

Same as rope for the webbing portion plus inspect "D" ring and buckle.

Rescue Harnesses

Many commercial harnesses on the market are made specifically for rescue work. NFPA Class II commercial rescue harnesses are required for this course. Requirements for rescue harnesses will be found in NFPA 1983.

When selecting a commercial harness there are several things to consider, including the primary purpose for which it will be used. A **full body harness** provides better support and security, but is somewhat restrictive. A **seat harness** alone may be adequate in most situations. When combined with a chest harness it gives the rescuer options unavailable with a full body harness. A **chest harness** should not be used by itself in rescue situations, but always in conjunction with a seat harness.

Figure 9.5
NFPA Class II Harness

Adjustable harnesses are preferable for rescue team equipment caches. They can be worn by various persons or adjusted over layers of clothing, depending on the weather.

Harnesses designed for recreational climbing may be used, but they come with various attachment loops, which may catch on debris in collapsed structures. **Not all climbing harnesses meet NFPA standards.**

Some rescue harnesses should not be used for recreational climbing, where long leader falls could occur. Make sure you follow manufacturer's instructions and purchase a harness appropriate for its intended use.

Care and Maintenance

Same as for pick-off strap.

Rescue Hardware

Carabiners

Carabiners, sometimes called snap links or crabs, are metal connectors that link the different components of a rescue system together.

There are four basic parts of a carabiner:

- Spine
- Lock
- Gate
- Hinge

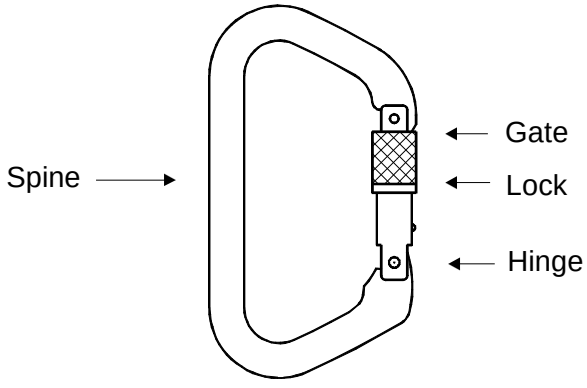


Figure 9.6
Carabiner

Carabiners for rescue work should be the locking type to prevent unwanted gate openings and come in a variety of shapes and sizes.

Carabiner Construction

Carabiners are made of aluminum or steel. Rescue teams that must carry their equipment long distances, such as mountain rescue teams, tend to use the lighter weight aluminum variety. Those rescue teams that are not as concerned about portability tend to use the stronger but heavier steel variety.

Carabiners' strengths vary depending on the manufacturer. Aluminum carabiners have a breaking strength of from 6,000-8,450 pounds. Steel carabiners run between 9,000 and 13,000 pounds breaking strength.

Aluminum Carabiners

- Are lighter
- Do not rust
- Are usually less expensive
- Wear out faster
- Are not as strong
- May be damaged by dropping and shock loading

Steel Carabiners

- Are stronger
- Are less susceptible to abrasion and wear
- Are heavier
- Are more expensive
- May rust
- Require more maintenance
- May also be damaged by dropping and shock load

Refer to the NFPA 1983 standard for minimum breaking strengths.

Carabiners come in different sizes but the standard locking "D" will fit most rescue applications. Large locking "D" carabiners are available and will fit over most rescue litter rails.

Carabiners for mountaineering are designed to be lightweight, so they are smaller and in some cases are made of hollow aluminum. These are not strong enough for most rescue applications, and should be avoided. Rescue carabiners will be made of solid aluminum or steel and will be large enough in diameter to hold a large amount of material inside the carabiner.

Standard locking rescue carabiners that meet the NFPA 1983 standard are strong enough to stand-alone. Some rescue systems advocate doubling up carabiners and turning them so the gates are opposite and opposed. This is to prevent accidental opening of a gate during a rescue and the loss of the connection. With locking carabiners, this is unnecessary and, in fact, has led to side loading of carabiners and damage to carabiner gates and locking mechanisms.

Locking carabiners are at full strength when the gate is closed and locked. A locking carabiner should not be unlocked and opened when under load. There are some circumstances when a locking carabiner has come unlocked on its own while in a system. This can happen if the locking mechanism is rolled across a face of a cliff or a building. It can be overcome by making sure the gate is turned away from the face.

Another way gates have come open is from vibration, which can cause the lock to unscrew. This can be overcome by turning the gate down so gravity is working against the gate to keep it closed.

Care and Maintenance

Carabiners must be kept clean of dirt and oil. Wipe them down with a clean rag and keep them off the ground to prevent dirt from being forced into the gate and locking mechanisms. Use a ground cloth, coat, or other object to lay out hardware when setting up systems. This will not only keep everything clean, but will help to prevent loss of equipment as well.

Sharp burrs and nicks in carabiners and other hardware are damaging to software. If they are small, they can be gently filed or sanded off.

Carabiners with gates that stick or will not close should be discarded if they cannot be fixed by blowing out the lock and hinge with compressed air. Do not use oil or grease to lubricate, because it collects dirt and dust and acts as an abrasive compound and wear out the mechanism or jam it.

Things to Avoid

Carabiners are designed to be loaded end to end. They should never be side loaded.

Opening a loaded carabiner can cause serious damage to the carabiner or even complete system failure. A common mistake is locking a carabiner while it is loaded. When the weight is taken off the system, the locking mechanism should not come undone. Therefore, carabiner locks should be tightened before loading only.

Carabiners within a system should be of the same style and from the same manufacturer.

Rescue Pulleys

In technical rope rescue, rescue pulleys are used to:

- Change direction of force on a running rope
- Reduce rope friction
- Create mechanical advantage for hauling systems

There are many types of pulleys on the market for use in rescue systems. The lightweight type, used by climbers to haul loads and perform self-rescue, is not strong enough for rescue work.

Figure 9.6
Rescue Pulleys - 2" and 4"

Rescue pulleys are made of all metal for maximum strength. The *sheave* or the area that the rope runs on should be metal, and should be the proper width for the diameter of rope being used. Not only should it be wide enough, but also its diameter should be four times the diameter of the rope for minimum loss of rope strength as the rope bends around the sheave.

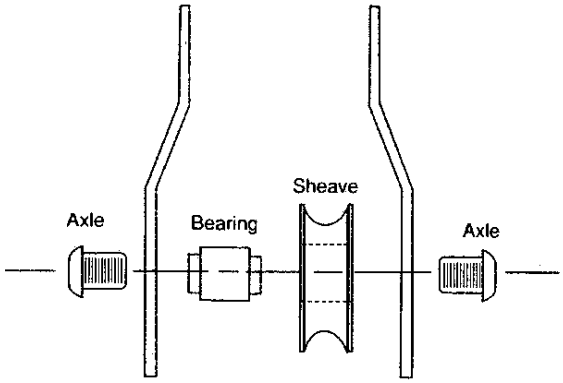


Figure 9.7
Parts of a Pulley

The **side plates** must be moveable so they can be placed on the rope anywhere in the system. The *axle* should be firmly attached with rounded bolt heads to prevent damage to other rescue system components.

The **bearing** should be the sealed ball-bearing type so it turns freely and will not be contaminated with dirt and debris.

There are special pulleys manufactured to meet technical rope rescue requirements. **Prusik minding pulleys** are designed to work with Prusiks to make a self-tending brake system for belay lines and ratchets for mechanical advantage pulley systems.

Knot passing pulleys are designed to allow a knot to pass through. This is important when two lines need to be tied together in order to reach a victim. This pulley allows the knot to pass through the mechanical advantage system, which would not be possible with standard pulleys.

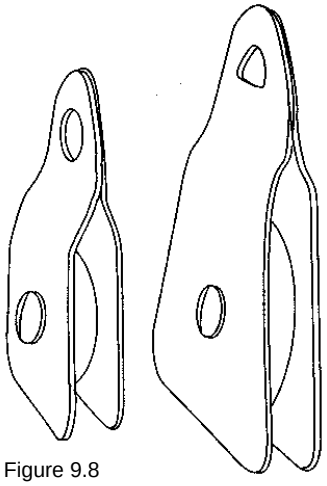


Figure 9.8
Prusik Minding Pulley

Double sheave pulleys are valuable for setting up parallel systems and for increasing mechanical advantage.

Refer to the NFPA 1983 standard for minimum breaking strengths.

Care and Maintenance

Pulleys need to be kept clean and free of any sharp edges, nicks, or burrs. These can be lightly filed or sanded off. Ensure that the bolts holding the pulley together are tight, and that the sheave and side plates rotate freely. The attachment point should be checked for wear and elongation. This can indicate excessive loading, and the pulley should be discarded if any such defects are found. Do not lubricate the bushings or bearings with grease or oil; it will attract dirt and other debris that will create excessive wear.

Figure Eight Descenders

Figure 9.9
Figure Eight Plate

Figure eight descenders were designed as descending or rappelling devices. They work by creating friction when the rope is wrapped around them. The original figure eight plate looked like a numeral eight, but with unequal rings. The larger ring is the location where the rope passes through to create friction, and the smaller ring is for attaching to a harness or anchor. Rescue-eight descenders have an added feature called ears. These were added to prevent the rescue rope from accidentally forming a girth hitch and causing a jam that is difficult to fix. Rescue-eight descenders with ears are larger than conventional figure eight descenders used for recreational climbing. Rescue-eight descenders are easier to lock off and accept larger ropes. They are stronger and, because they are larger, they dissipate heat more quickly.

There are several problems associated with the use of figure eight descenders:

- They twist any rope that goes through them
- They are one-person devices with limited ability to hold heavier loads
- Once attached to a system, friction cannot be increased to any great degree

For many years, figure eight descenders were used for breaking devices on lines belaying rescue (two person) loads. Drop tests have shown that figure eight descenders are inadequate for stopping a rescue load with as little as a one meter drop. Figure eight descenders should only be used for **one-person rappels** of limited distance, and for **lowering one-person loads**.

Refer to the NFPA 1983 standard for minimum breaking strengths.

Care and Maintenance

As with all other hardware, sharp edges and burrs will destroy software very quickly and should be filed off. Dirty rope will wear hardware more quickly than clean rope. Wear greater than 15% the original thickness is excessive, and the figure eight descender should be discarded.

Brake Bar Rack

Brake bar racks are friction devices, designed for use on the mainline, in lowering systems or for rappelling. Friction is created by reeving the rope over and under the bars; the more bars used, the greater the friction. Adjusting the distance between the reeved bars along the rack, with maximum friction obtained by pushing the bars close together can also control friction. Four bars should be used when a single person load is on the line. The rope should also pass under the last bar used when rappelling to simplify tying off the rack, in mid-rappel, without losing friction.

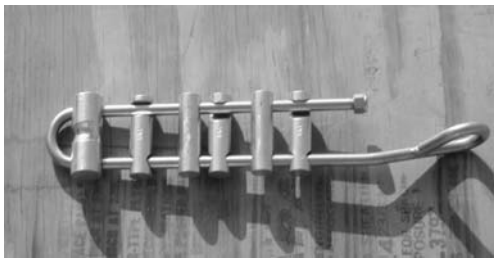


Figure 9.10
Brake Bar Rack

Parts of the brake bar rack include:

- A steel rack, with an eyelet and retaining nut
- Aluminum or steel bars, six bars minimum
- One 1" top bar with a training groove
- One ¾" bar with a straight slot
- Four ¾" bars with angled slots

When reeving a brake bar rack the rope should first contact the large (1") bar passing over the training groove. The rope should then pass under the next bar (with the straight slot) forcing the bar against the rack. The rope then passes over and under the rest of the bars. The training groove in the large bar and the straight slot in the second bar are provided to ensure that the rack is reeved properly.

Care and Maintenance

A small file or emery cloth can be used to round any burrs or sharp edges, and the Brake Bar Rack should be inspected for worn bars, cracks, secure nut, or bent rack. It should be removed from service if the rack is deformed or cracked, or when a bar is worn to less than ⅓ of its original diameter.

Mechanical Ascender

The mechanical ascender is a common ascender used in the fire service. All ascenders are designed for use in ascending a fixed rope. They may be used in rope rescue pulley systems as a ratchet cam or hauling cam. The potential force of the rope rescue system must not exceed the manufacturer's rated strength of the device.

Refer to the NFPA 1983 standard for minimum breaking strengths.

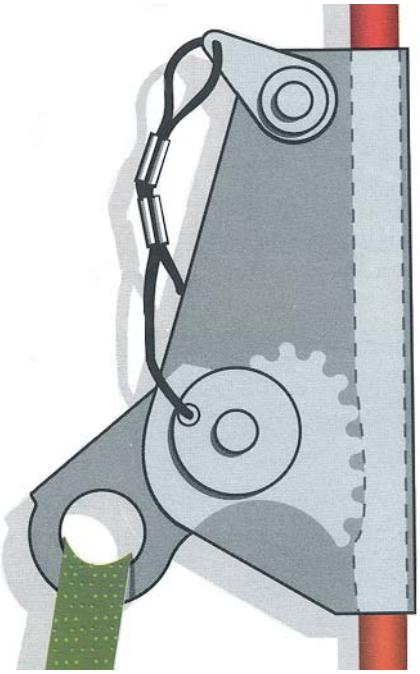


Figure 9.11
Ascender

Components of the ascender may include:

- Shell
- Cam (may be free running or spring loaded)
- Pin

Care and Maintenance

A small file or emery cloth can be used to round any burrs or sharp edges. The ascender should be inspected for worn cam teeth, egg shaped or cracked pinholes, and worn cord or chain holding pin and cam to sleeve. It should be removed from service if the sleeve or cam are cracked, when the sleeve is deformed, if the pinhole is worn enough to allow the pin to slip out or if it has been dropped from waist height.

Cautions

Ensure that the pin is through both sides of the sleeve and locked before use. Do not use as a brake cam. Some tests have shown that when an ascender is used as a braking cam and is subjected to a significant shock load, the rope it is connected to has occasionally parted.

Edge Protection

Edge protection is used to protect rope and webbing from abrasion and sharp edges. There are several types of edge protection on the market such as edge rollers, roof rollers, and edge guards.

Edge Roller

Edge rollers are constructed of an aluminum frame and rollers. The frames may be connected together in series to provide protection on multiple sides.

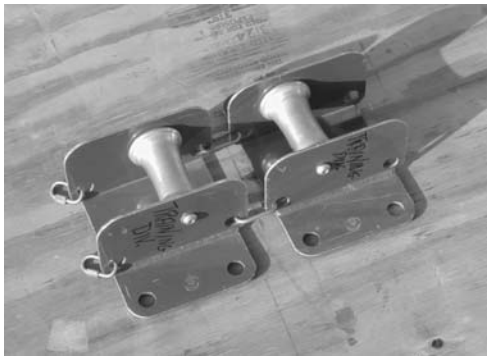


Figure 9.12
Edge Rollers

Care and Maintenance

A small file or emery cloth can be used to round any burrs or sharp edges. The edge roller should be inspected for wear on the rope contact points, tightness of any nuts and/or bolts, and moving parts should move smoothly. It should be removed from service if the rollers are stuck or damaged, or if the frame is damaged.

Edge Guard

Edge guards may be constructed of canvas, rigid plastic, or fire hose.

Figure 9.10
Edge Guard

Care and Maintenance

They must be kept clean by wiping or rinsing with water and they should be inspected for excessive wear.

Anchor Plates

Anchor plates are used to gather equipment. They are stamped from sheet aluminum (not cast) or stainless steel. The strength is per manufacturer. Refer to the NFPA 1983 standard for minimum breaking strengths.

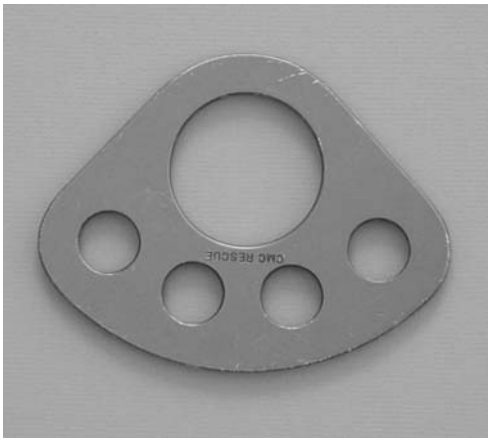


Figure 9.11
Anchor Plate

Care and Maintenance

Clean with a damp cloth. Do not drop. Inspect for cracks, deformation, and burrs. Remove from service if cracked, deformed, or dropped from a significant height (waist high). Burrs can be removed with emery cloth of file.

CHAPTER 10 - INTRODUCTION TO RESCUE KNOTS

Rescue knots are a key link in all rope rescue systems. Rescue personnel must continually practice and develop knot-tying skills until they can tie knots properly in the dark, when cold, or tired. An improperly tied knot or the incorrect knot could result in system failure. A rescue team should rely on a small number of knots that perform a variety of functions. Knots should be standardized so everyone on the team can readily identify and safety check a system.

QUALITIES OF A GOOD RESCUE KNOT

There are many knots but only a few are necessary to perform rope rescue. To be a good knot for rescue, knots should meet certain criteria.

- Easy to tie
- Easy to identify to determine if they are tied correctly
- Will not work loose on their own
- Minimally reduce rope strength
- Relatively easy to untie after loading

Knots should be untied before storing. Knots left tied will decrease a rope's strength over time.

KNOT TERMINOLOGY

There are many different names for knots and there is confusion as to what is and is not a knot. In an effort to standardize terminology, this unit will attempt to use the current names for each knot, but will list other names by which they are known.

- The **running end** of a rope is the part that is to be used for work such as hoisting, pulling, or belaying.
- The **working end** of a rope (also known as the loose end or bitter end) is the part used in forming a knot.
- The **standing part** of a rope is between the working end and the running end.
- A **knot** is a rope or webbing that is intertwined.
- A **bend** is two rope or webbing ends connected together.

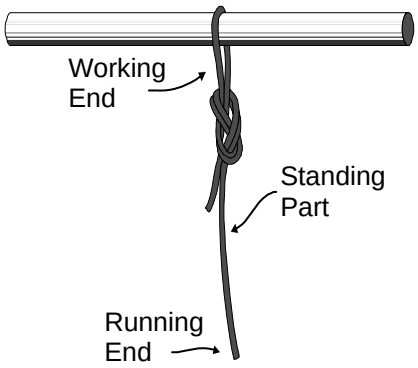


Figure 10.1
Parts of a Rope

- A **hitch** is a rope or webbing around an object (if the object is removed the hitch will fall apart).
- A **bight** is formed by simply bending the rope back on itself while keeping the sides parallel.
- A **loop** is made by crossing one side of a bight over the standing part so that the rope crosses itself.
- A **round turn** is made by continuing to cross one side of a loop all the way around to form a circle with the ends of the rope parallel as in a bight.

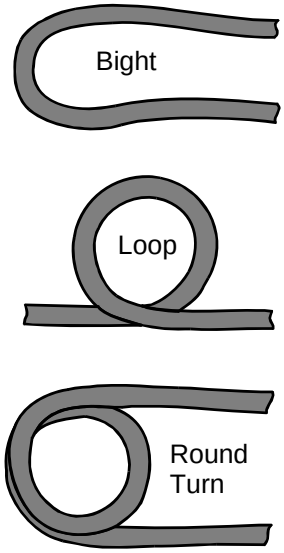


Figure 10.2
Bight, Loop, Round Turn

FAMILY OF EIGHT KNOTS

The family of eight knots meets most of the criteria for a good rescue knot. These knots are popular in the rescue community because they are:

- Secure when tied correctly and unlikely to come apart with flexing and bending
- Easy to identify and to see if they are tied correctly
- Easy to learn

As with any knot, the family of eight knots need to be dressed and set, which means all the strands should run parallel and lie flat against each strand. This makes the knot stronger and easier to check for safety. "A knot that looks bad probably is bad."

Figure Eight Stopper

The figure eight stopper, also known as the figure eight knot, is used as the foundation knot for other knots in the family of eight's. It is called a stopper because it is used in the end of a rappel line to prevent someone from rappelling off the end of the line. It is also used to keep rope ends from accidentally running through hardware in a system. Figure 10.3 shows the foundation for the family of eight knots, the figure eight stopper knot. It should look like a number eight when held up by either end.

Figure 10.3
Figure Eight Stopper

Figure 10.4
Figure Eight on a Bight (1)

Figure 10.5
Figure Eight on a Bight (2)

Figure Eight on a Bight

A figure eight on a bight is tied in the same manner as the stopper, but is tied with a bight in the rope to form a loop of rope at one end. This is a secure loop for attaching the rope to anchors, equipment, or rescuers. A tail at least 6" in length must be left at the end of the rope.

Figure 10.6
Figure Eight Follow Through (1)

Figure 10.7
Figure Eight Follow Through (2)

Figure Eight Follow-Through

This knot is used in place of the figure eight on a bight when it is not possible to slip the loop over the intended object or clip it in with a carabiner. The figure eight follow through allows tying directly into or around an object. A figure eight stopper is tied and then the working end of the rope is passed around the object and follows the path made in forming the stopper back through the knot. The key to this knot is to leave enough length on the working end of the rope to pass around the object and complete the knot, leaving a 6" tail. The result is the same as the figure eight on a bight.

Figure 10.8
Figure Eight Bend (1)

Figure 10.9
Figure Eight Bend (2)

Figure Eight Bend

The figure eight bend is used to join the ends of one rope or the ends of two ropes of the same diameter together. A figure eight stopper knot is tied in the working end of the rope and left loose. The other end of the same rope or the working end of the other rope is passed through the figure eight stopper following the path used to form the stopper. Six-inch tails are left on the ends of the rope coming out of the knot.

In-Line Figure Eight

The in-line figure eight is a directional knot that can be tied in the middle of a rope for attaching loads or for creating a truckers' hitch, which is useful for tensioning guy lines when building ladder gins and "A" frames.

Figure 10.10
In-Line Figure Eight (1)

Figure 10.11
In-Line Figure Eight (2)

Figure 10.12
In-Line Figure Eight (3)

Overhand Bend

The overhand bend (also known as a water knot, ring bend, or tape knot) is used for tying the ends of webbing together or to form a continuous loop of webbing. This bend must be tied leaving at least 2" tails. After any twists are removed, all four legs are set by pulling on each one to remove any slack.

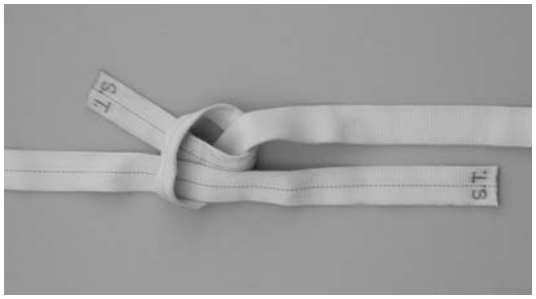


Figure 10.13
Overhand Bend (1)

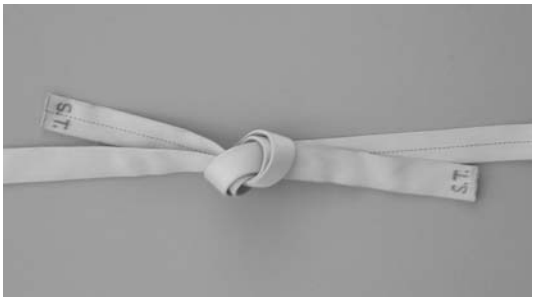


Figure 10.14
Overhand Bend (2)

Double Overhand Bend

The double overhand bend is used to tie two equal diameter rope ends together. It is the preferred knot for tying prusik loops. It must be tied leaving at least 2" tails in the prusik cord and 6" tails in the rope. The double overhand bend is also known as a grapevine knot or a double fisherman's knot.

Figure 10.15
Double Overhand Bend (1)

Figure 10.16
Double Overhand Bend (2)

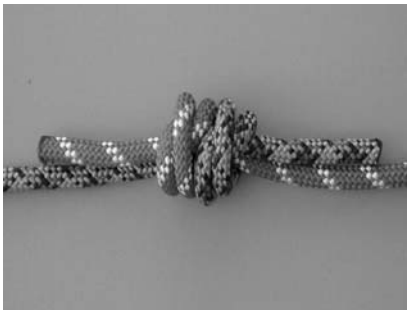


Figure 10.17
Double Overhand Bend (3)

Three-Wrap Prusik Hitch

This is the method of attaching prusik loops to rope for hauling prusiks, ratchet prusiks, and braking prusiks. A two-wrap prusik hitch is often used in mountaineering but does not have sufficient holding power for rescue applications.

Figure 10.18
Three-Wrap Prusik Hitch (1)

Figure 10.19
Three-Wrap Prusik Hitch (2)

Figure 10.20
Three-Wrap Prusik Hitch (3)

Clove Hitch

The clove hitch is used to secure the working end of a rope or webbing around an object. Slack is removed from the standing part of the rope by pulling on the working end to cinch up the knot.

Figure 10.21
Clove Hitch (1)

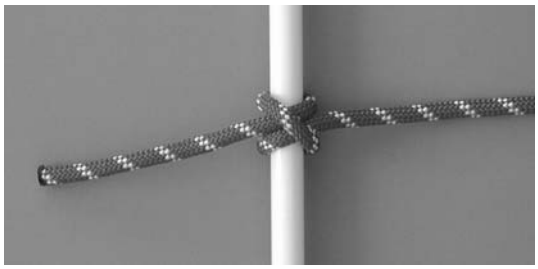


Figure 10.22
Clove Hitch (2)

Figure 10.23
Two Half Hitches

Two Half Hitches

Two half hitches are used to secure the working end of a rope or webbing. They usually follow a knot or round turn around an object. Two half hitches can be formed using the end of the rope or a bight may be formed in the rope to simulate the end.

Round Turn and Two Half Hitches

The round turn and two half hitches is used to secure the end of a length of webbing to an anchor point such as a ladder rung or the frame on a rescue litter.

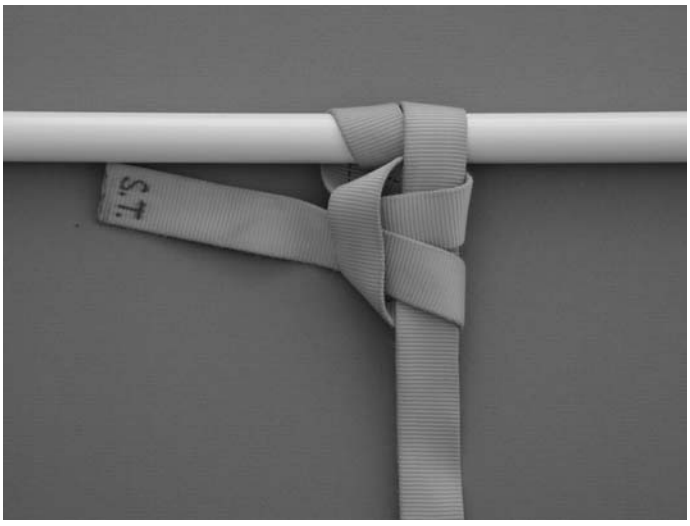


Figure 10.24
Round Turn & Two Half Hitches

CHAPTER 11 - ANCHOR SYSTEMS

An anchor (also called an anchor point) is a stationary object capable of supporting the load attached to it. An anchor system is the rope, slings, and hardware used to attach a load to the anchor, and includes the anchor. Selecting an anchor is not a skill that can be taught in class or from a book. It takes experience in the field, training, and practice before you can reliably select safe anchors and set up safe anchor systems.

TYPES OF ANCHORS

An anchor can be either natural or fabricated. Natural anchors, such as large living trees, large rocks, and root systems, are common in the wilderness environment. When an anchor's stability is questionable then multiple anchors may be needed to create a solid anchor system.

When natural anchors do not exist, as is often the case in the urban environment, fabricated anchors need to be created with vehicles, or established on or in buildings. They can be built with pickets, or can be made by drilling holes and inserting expansion bolts and other devices.

Vehicles make good anchors as long as these strict rules are followed:

- The vehicle must have solid points to connect to (frames and axles are the most reliable)
- The engine must be turned off, and the key removed from the ignition
- The brake must be set, and the wheels chocked
- Everyone must clearly understand that the vehicle cannot be moved during the rescue

Buildings have many potential solid anchors, but care must be taken. Rust, corrosion, or weathered and deteriorating mortar and brickwork may weaken anchor points that look solid. Try to select structural components of the building, such as:

- Structural beams and columns
- Well-established anchors for large machinery and equipment
- Solid large-mass portions of the structure

Spanning window and door openings with furniture, timber, or other strong material can create anchors.

When buildings are structurally unstable as the result of collapse, it may be necessary to establish ground anchors with pickets. Pickets will be discussed in detail later in this unit.

CONSIDERATIONS WHEN SELECTING ANCHORS

When selecting anchors several factors must be considered:

- What is the purpose of the system that is going to be attached to the anchor?
- What direction will the pull come from?
  - A ***nondirectional anchor*** is one that will withstand a pull from any direction
  - A ***directional anchor*** is one that will withstand a pull in only one direction
- Where is the anchor in relation to the load and the activity?

METHODS OF ATTACHING WEBBING SLINGS TO AN ANCHOR

Girth Hitch

A "girth hitch" or "Lark's foot" is the least acceptable method of attachment, and shall ***not*** be used for main line connection to anchors. A potentially dangerous over stressing of the webbing where it crosses itself and bends back can damage the webbing.

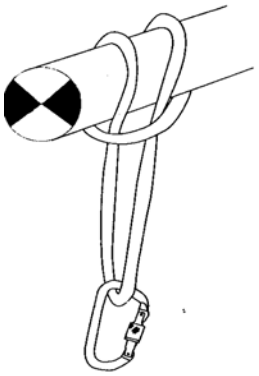


Figure 11.1
Girth Hitch

The girth hitch should only be utilized in a vertical/horizontal fall arrest, one-person system, (also known as lead climbing) as part of the belay protection.

Single Loop Anchor

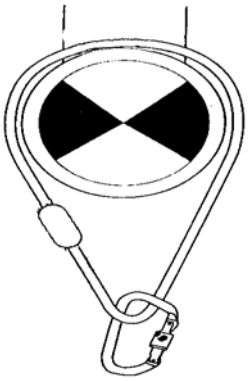


Figure 11.2
Single Loop Anchor

Single loop is acceptable for single person loads in special applications, such as ladder slings so long as the material selected is long enough to allow for a shallow angle between the legs.

Three-Bight

A three-bight is the second best choice of connection if a pretied or presewn sling is used. To avoid serious side loading of carabiners the critical angle at the point of attachment must be kept well under the 90-degree maximum. (These "critical angles" will be discussed later.) Some side loading will occur regardless of the angle.

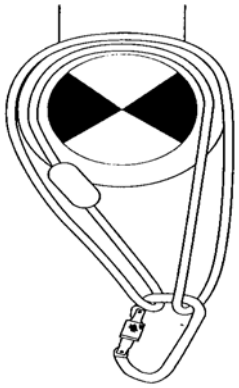


Figure 11.3
Three-Bight

Multi-Loop Anchor (Wrap Three, Pull Two)

Multi-loop is the preferred way to attach webbing to any anchor because additional strength is gained with the additional strands of webbing. In the "Wrap Three, Pull Two" multi-loop, a length of webbing is wrapped around the anchor three times and tied with an overhand bend. By grabbing two strands and pulling them tight, one strand cinches down on the anchor to prevent slipping up or down. The overhand bend should be located against a 3" or longer anchor on the load side to reduce the force on the knot. This will allow the knot to be untied more easily after loading.

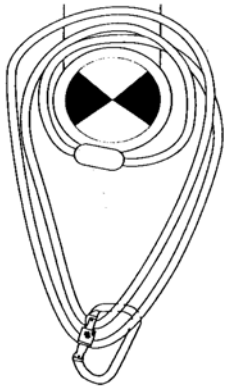


Figure 11.4
Multi-Loop Anchor

The length of webbing selected needs to be long enough to form an angle no greater than 90° between the two legs to prevent over stressing each individual leg.

Tensionless Anchor

The tensionless anchor is a quick and easy anchor that requires a minimum amount of equipment. It is also the strongest method of anchoring a rescue line. The tensionless anchor is designed to wrap around a round or oval shaped anchor. The anchor must be at least four times the diameter of the rope to maintain full strength of the rope. The running end of the rope is wrapped at least four times around an anchor point, such as a tree, in a neat series of wraps. As with all anchor systems, the tensionless anchor should be applied as low on the anchor point as possible. A figure eight on a bight is tied in the running end, and a carabiner is snapped into it. The carabiner is then snapped onto the standing part of the rope.

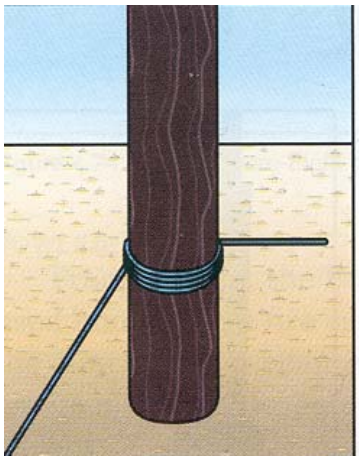


Figure 11.5
First Step in a Tensionless Anchor

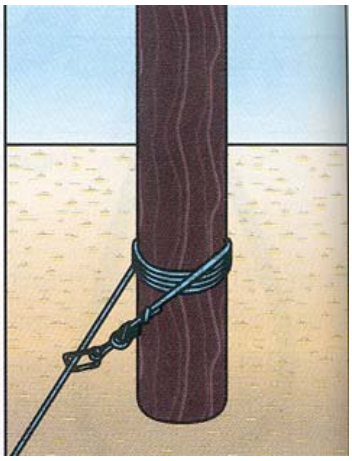


Figure 11.6
The Completed Anchor System

Courtesy of IFSTA Fire Service Rescue Sixth Edition p.110

MULTI-POINT ANCHOR SYSTEMS

Two and Three Point Load-Sharing Anchors

A system that employs load sharing between multiple anchor points is only desirable in certain situations. As long as each anchor leg is stressed equally, the anchors are sharing some of the load. Any shift in the direction of the load, however, shifts the entire load onto one anchor. If the reason for using multiple anchors is because one is inadequate, then **failure** of the anchor system may result if the load shifts to that anchor point.

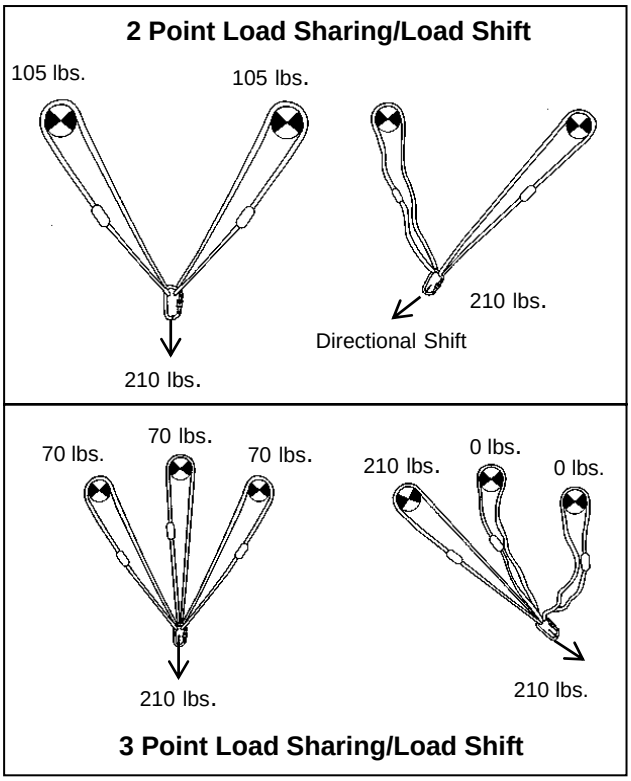


Figure 11.7
Load Sharing Anchors

Self-Adjusting Anchor Systems

The self-adjusting anchor system, also known as self-equalizing anchor system, centers the system between two or more anchor points. It allows the load to be distributed to each anchor point by permitting the point of attachment to shift within the anchor as the system is loaded. **Caution**; once the full load is on the system, the friction is too great to allow further equal distribution during a load shift. The inability for the system to provide equal distribution on the anchor points could cause an anchor to fail. If one of the anchor points fails, the shift to the remaining anchor points will cause a drop in the system toward the load. If the anchor legs are long, this drop can create a shock load on the remaining anchor points that may result in their failure. Keeping the adjusting anchor sling legs short (12" maximum) reduces this problem. When the anchor points are not close together, tag lines are used to extend them to a collection point where the self-adjusting anchor is attached. This allows the adjusting legs of the system to remain short.

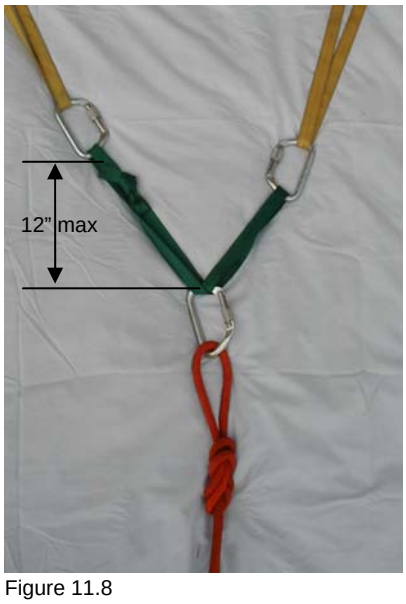


Figure 11.8
Two Point Self-Adjusting Anchor

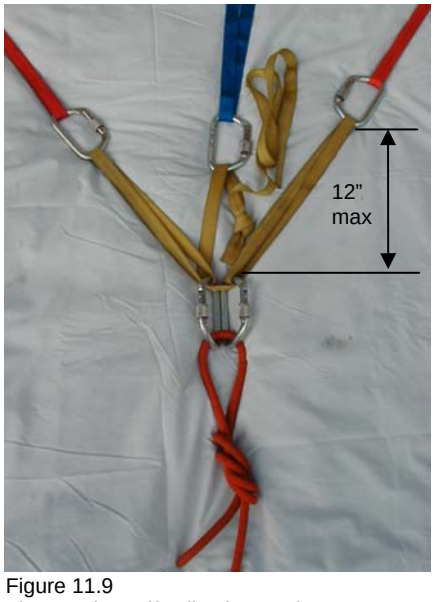


Figure 11.9
Three Point Self-Adjusting Anchor

Back Tied Anchor System

Pretensioned back tying is another method of creating a secure anchor system from a single questionable anchor (similar concept to picket systems).

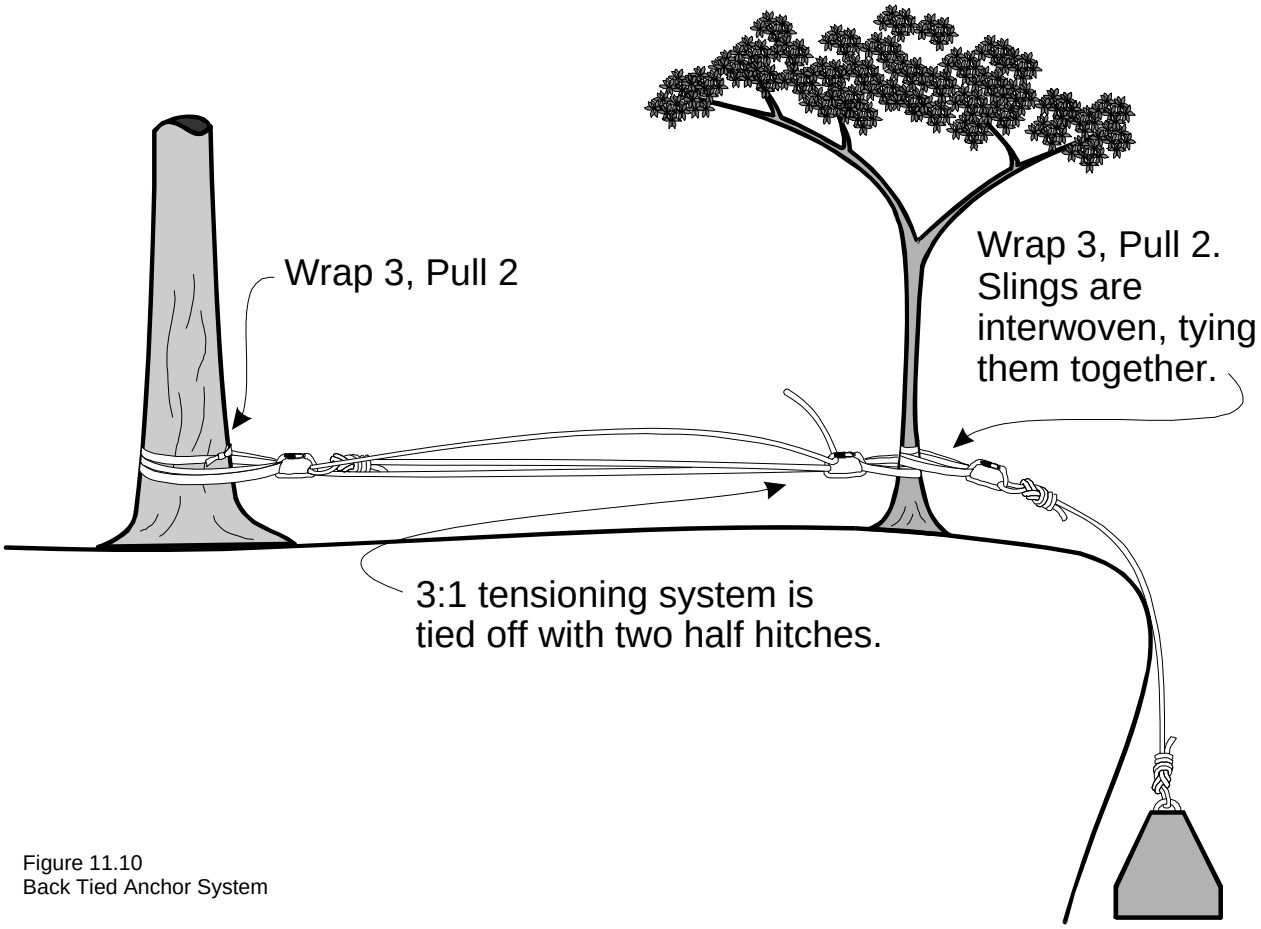


Figure 11.10
Back Tied Anchor System

Back tied anchors are the preferred method of creating a secure, multi-point, and directional anchor system. By using this method, a weak anchor point located close to the rescue site can be made solid. The only limitations are the length of the material being used to back tie. Use webbing or rescue rope to connect the anchor to the back tied anchor with a simple 3:1 mechanical advantage system. (Use carabiners without pulleys to save equipment.) Intertwine the back tied system with the forward anchor webbing to create an integral system. Tension the 3:1 system and pull the center portion of the back tied system while under tension to remove remaining slack. Tie off with a couple of half hitches or use a prusik to hold the 3:1 system. Check the back tie(s) "awhile later" for additional stretch, known as creep. This is accomplished by retightening the 3:1s and retying them.

The back tied anchor should be located directly behind the first anchor, in line with the load, but if that is not possible use two back ties in order to balance out the direction of pull on the forward anchor.

CRITICAL ANGLE

A concern when rigging any anchor system is to avoid creating too wide an angle between the legs of the system. Try to select anchors that are relatively close together, and use lengths of webbing and rope that are long enough to avoid creating wide angles.

The angle between anchor points, known as "field angle" **should never exceed 90°**. Angles greater than this **critical 90°** begin to exert forces on the anchors that will be greater than the load itself. Anchors and material used to build anchors can easily be over stressed and fail under these forces. A 90° angle distributes 92.5% of the load to each anchor. A 120° angle distributes 100% of the load to each anchor. This defeats the entire purpose of constructing multiple point anchors.

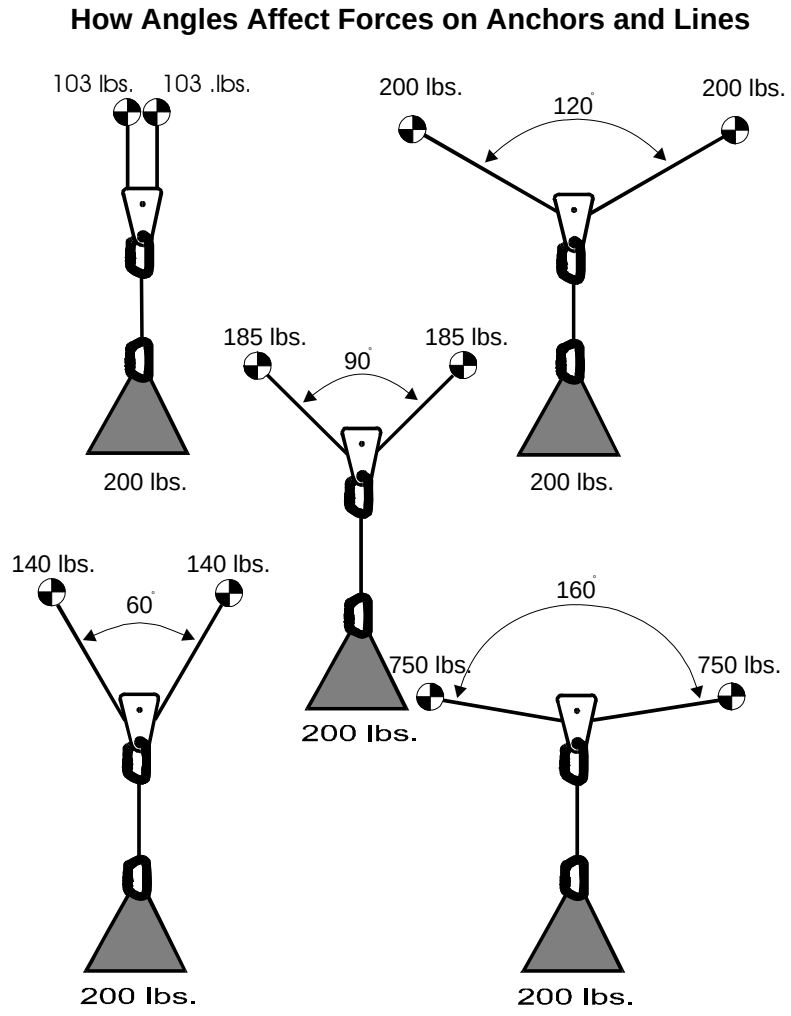


Figure 11.11
Critical Angle

PICKET ANCHOR SYSTEMS

When other anchors are not available, anchors can be constructed using pickets. Picket systems take time to set up and are limited by the stability of the soil they are being driven into. The ideal material to use for pickets is 1" diameter rolled steel that is 4' long, pointed at one end, and squared off at the other. It is difficult to find adequate material to use for pickets, so it is recommended that rescue teams carry a supply of at least six pickets with them.

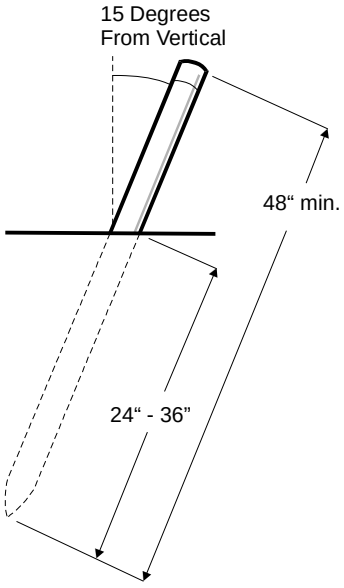


Figure 11.12
Single Picket

Picket Construction

A picket should be driven 2'-3' into the soil (2' in stable soil, up to 3' in unstable soil) at a 15° angle from vertical away from the intended load. Driving additional pickets behind it, 3' apart, in line with the intended load and tying them together with lashing material will reinforce a single picket. Connect the pickets together with a 20' length of 1" nylon webbing or ½" (12.7 mm) utility rope between each picket. The lashing between pickets is called a Spanish Windlass. It is connected to the base of the rear picket with a clove hitch or round turn and two half hitches. Starting at the base of the rear picket, wrap the lashing material to the top of the forward picket with three to six wraps, and tie off with another clove hitch or round turn and two half hitches. Use a picket, wooden stick, or other piece of debris inserted between the wraps to twist the windlass in order to tension the lashing between pickets. Tension only until the forward picket starts to move, then back off one half turn and secure the device used to twist the windlass by driving one end into the ground. Proper tensioning results in the load being shared by each picket. The load should be connected to the base of the forward picket.

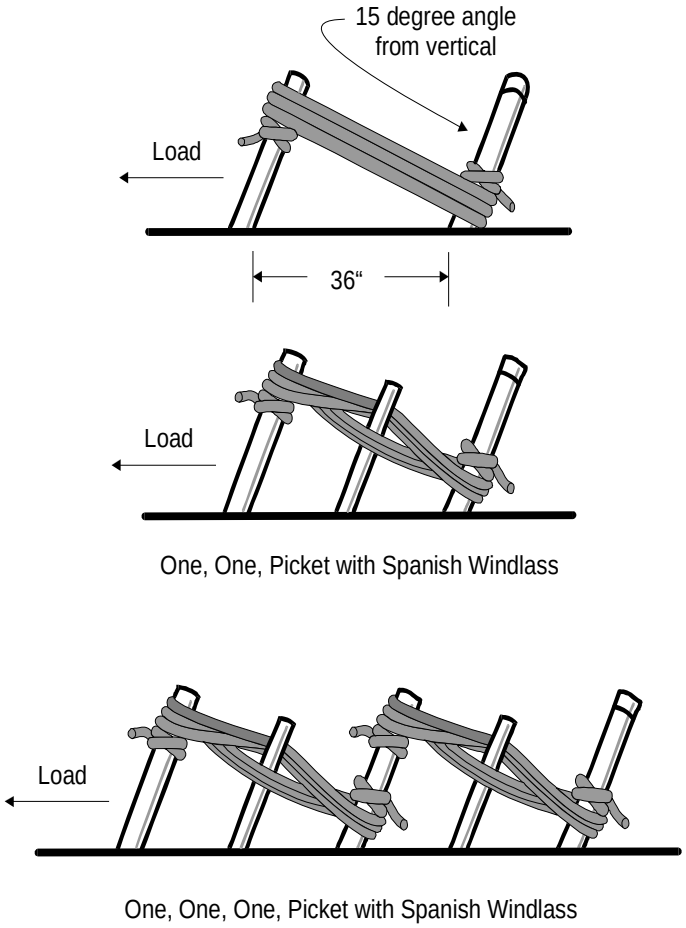


Figure 11.13
Picket Systems

Picket Capacities

The load capacity of a picket is determined using loamy soil of average compactness. Many variables affect the load capacity of pickets. The type of soil is most important.

- Clay and gravel mixtures have only about 90% of the holding power of ordinary soils.
- The holding power of river clay and sand is only about 50% of ordinary soils
- The soil's moisture content and compactness affect the holding power
- The material used for pickets, the dimensions, and how they are placed affect the holding power
- Pickets hold longer under a gradual pull than if they are exposed to a sudden shock force

A single picket can hold up to 700 lbf. A 1-1-1 combination picket or three pickets in line and lashed together will hold about 1,800 lbf. A 3-2-1 combination can hold as much as 4,000 lbf. The latter is built by driving three pickets and securing them together as a bundle. This becomes the primary anchor point. Two pickets are driven together and tied into a bundle behind the three. One picket is driven behind those, and all are lashed together with a Spanish Windlass system.

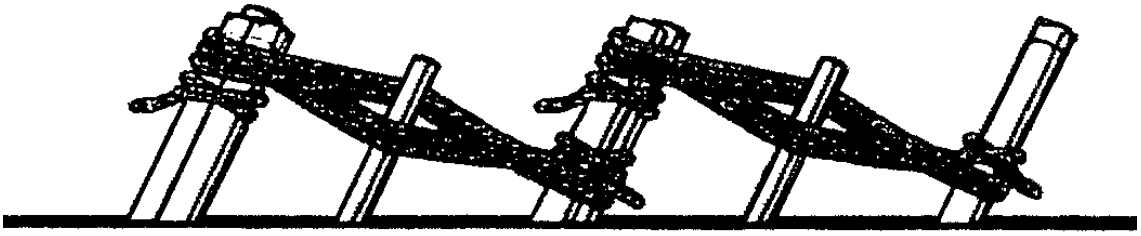


Figure 11.14
Three, Two, One, Picket with Spanish Windlass

CHAPTER 12 - RESCUE HARNESSES

To perform as a professional rescuer a commercial rescue harness is necessary. The NFPA Class II Commercial Rescue Harness is required for this course. The Class II rescue harness provides the rescuer/victim with adequate support while being suspended from a rope rescue system for extended periods. Some seat harnesses formed from 1" webbing have been known to cause injury to rescuers when suspended for extended periods. Of the many commercial harnesses on the market, each must be worn according to the manufacturer's specifications.

CHEST HARNESS

The chest harness is made from a 12' or 15' length of webbing, depending on the size of the rescuer or victim that is wearing the harness. The chest harness is necessary for all rescuers and victims that are raised or lowered on a rope rescue system. The chest harness is not designed to be used alone it is to be used with a seat harness. The harness will keep the rescuer/victim from inverting while being suspended from a rope rescue system. The harness will also distribute the force over a greater portion of the body during a fall when the belay catches the load. In a low angle rescue situation the chest harness is not necessary since the rescuers do not leave the ground.

Figure 12.1
Chest Harness

HASTY HARNESS

The hasty harness is a pelvic harness that is made from a 12' or 15' length of webbing. The hasty harness is only to be used as a quick method of attaching a victim or rescuer to a rope rescue system for a rapid rescue. It should not be used as a primary method of packaging a rescuer/victim because of its limited means of security.

Figure 12.2
Hasty Harness

CHAPTER 13 - THE RESCUE LITTER

The rescue litter, or Stokes basket as it is often referred to, has been the standard for victim removal over rough terrain for many years. It is designed for lifting and lowering the victim with a rigging system or for being hand carried. This device is not used by itself for spinal immobilization. It may be used, however, with other devices to achieve spinal immobilization. Due to its size, it is not easily used in a confined space or limited access area. This device is bulky and will require at least two rescuers to carry it to the victim unless it is transported by a rigging system.

There are a variety of rescue litters designed for rescue work. The steel frame rescue litters are the most commonly used in the rescue field. Steel frame rescue litters can be found in different configurations. There are rectangular litters for accommodating large back boards, break-apart litters for ease of storage or carrying in the wilderness, split leg litters which limit the use of standard back boards, and plastisol-coated litters which have a rubberized coating for nonsparking and nonconducting requirements.

Plastic rescue litters are typically not considered the best choice for rope rescue operations due to lack of structural durability. There are two basic types of plastic rescue litters. One type has a metal frame, which provides structural support designed for rope rescue operations. The other type has a metal top rail only. While suitable for water or snow rescues, plastic rescue litters generally are not suitable for rope rescue operations. Regardless of the rescue litters being used, their components need to be inspected prior to use.

COMPONENTS

Steel Frame Rescue Litter

- Main frame
- Ribs
- Skids
- Inserts
  - Chicken wire
  - Nylon mesh

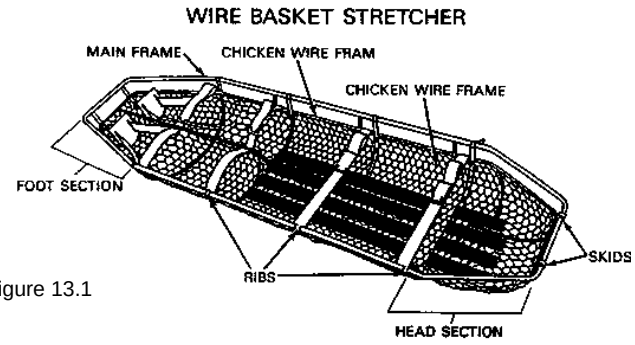


Figure 13.1

Plastic Rescue Litter

- Main frame
- Plastic shell

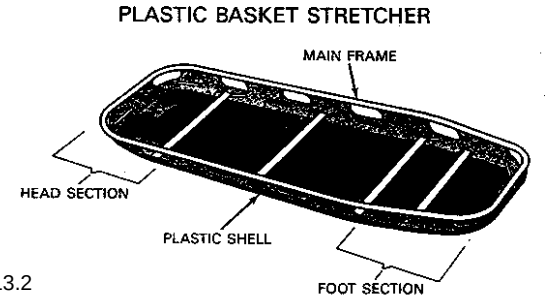


Figure 13.2

CARE AND MAINTENANCE

Rescue litters should be inspected for bends, cracks, or breaks in the main frame, broken welds, broken or cracked plastic shell, and damage to inserts. Normal cleaning can be accomplished by using soap and water. Decontamination shall be done as per department procedures. Rescue litters should remain out of direct sunlight when not in use.

VICTIM LASHING

The victim lashing in a rescue litter consists of a pelvic lash and a chest lash, which is referred to as the interior lash. The interior lash keeps the victim from sliding out of the rescue litter at the head or foot ends. The exterior lash keeps the victim from coming out of the top of the rescue litter. All three lashes can be made with 20' lengths of webbing. Depending on the size of the victim different lengths of webbing may be necessary. In order to lessen abrasion to the lashing from other surfaces, *do not wrap the main frame*.

Chest Lash

1. Before beginning the chest lash, the webbing used for the pelvic lash should be placed in the litter.
2. Lay a 20' piece of webbing across the litter with the middle at the point where the victim's crotch will be.
1. Form an 18" in the middle of a 20' piece of webbing and lay it in the litter so that the top of the loop is where the top of the victim's head will be.
2. Pass the loop over the victim's head to nipple line.
3. Wrap the webbing ends under each arm and pass through loop at chest.
4. Remove slack ensuring crossed webbing at victim's shoulder blades does not ride up on neck.
5. Tie an overhand knot in the webbing around the loop at the point it passes over the nipples on each side.
6. Tie a round turn and two half hitches at the ends of the webbing around a rib below the victim's waist where the rib meets the main frame. (Figure 13.3)

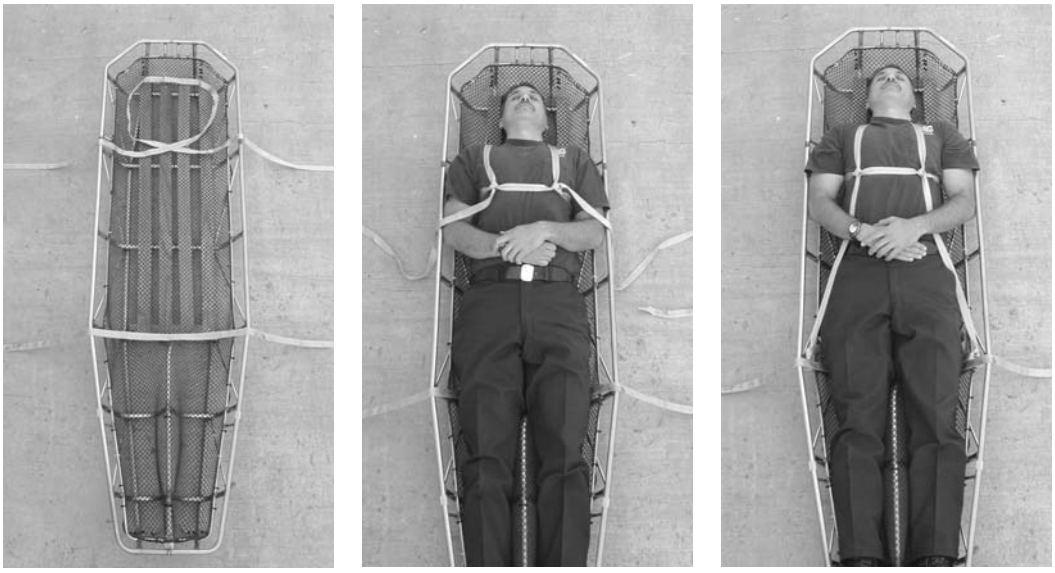


Figure 13.3
Litter, Chest Lash

Pelvic Lash

1. Pull midpoint of webbing between legs up to victim's waist creating a 6" triangle.
2. Pass ends of webbing around thighs and through triangle pulling up towards shoulders to remove slack.
3. Tie an overhand knot in the webbing on each side at the point it passes through the triangle.
4. Tie a round turn and two half hitches at the ends of the webbing around a rib near the victim's shoulders where the rib meets the main frame.

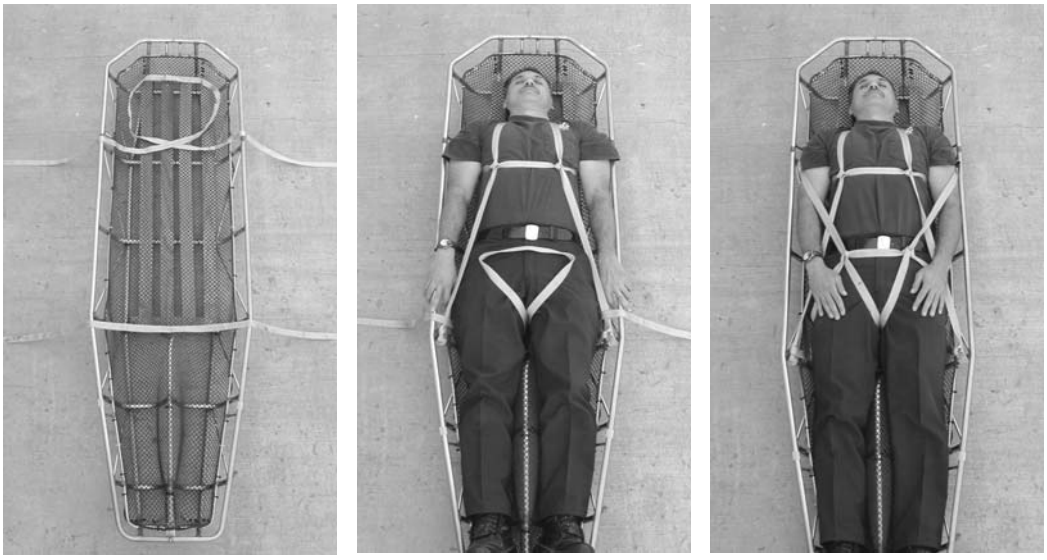


Figure 13.4
Litter. Pelvic Lash

Exterior Lash

1. Place a 20' piece of webbing across the victim's legs with the mid point at or below the knees.
2. Pass the ends of the webbing around the rib at or below the victim's knees on both sides where the rib meets the main frame.

   DO NOT WRAP THE MAIN FRAME!
3. Cross the webbing and pass the ends of the webbing around the next rib moving towards the head.
4. Repeat this operation until webbing passes around the ribs near the victim's shoulders.
5. Tie a round turn and two half hitches at one end of the webbing around the rib to secure the end.
6. Remove slack by pulling webbing from secured end toward free end.
7. Tie a round turn and two half hitches with the free end around the rib to secure the webbing.

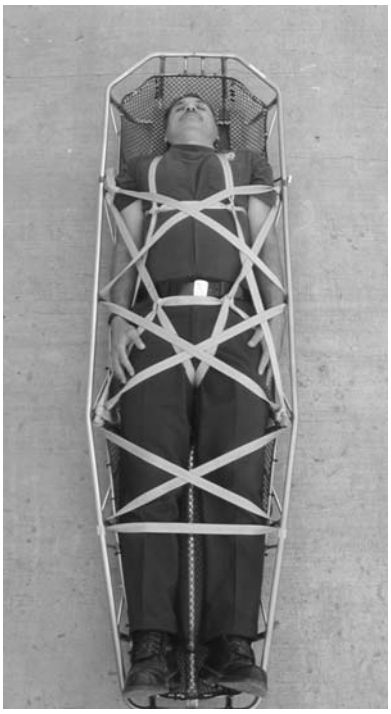


Figure 13.5
Litter, Exterior Lash

RESCUE LITTER RIGGING

The rescue litter can be rigged for horizontal lift, vertical lift, and low angle carry. To rig the rescue litter a commercial stretcher harness, rope pre-rig, or improvised pre-rig is required to connect the rescue litter to the rope rescue system. In this class, we will be using the rope pre-rig.

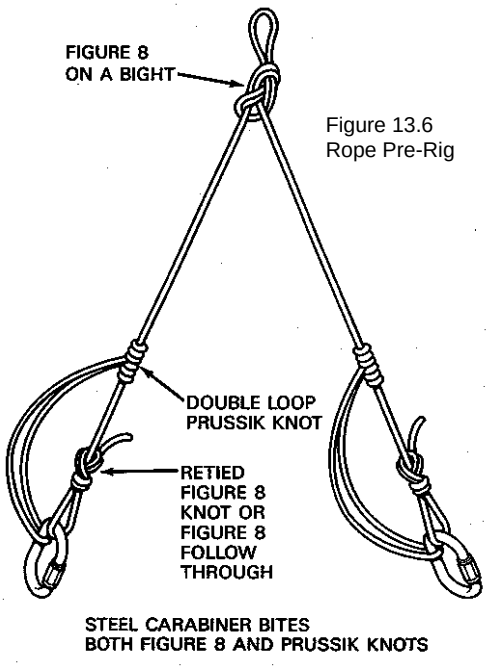


Figure 13.6
Rope Pre-Rig

Pre-Rig Construction

Rope Pre-Rig (Two Are Required To Rig A Rescue Litter)

1. Tie a figure eight on a bight in the middle of a 16' rescue rope.
2. Tie a figure eight on a bight at the end of each leg of the pre-rig.
3. Attach a prusik loop above each figure eight on a bight with a three-wrap hitch.
4. Attach a carabiner to the bight and the prusik loop on each leg of the pre-rig.

Improvised Pre-Rig with Webbing (Two Are Required To Rig A Rescue Litter)

1. Tie a figure eight on a bight in the middle of a 20' length of webbing.
2. Tie an overhand on a bight 1' down from the center knot on each tail.
3. Pull the webbing ends through the same attachment points on the litter as those used for the rope pre-rig.
4. Pass the ends of the webbing through the overhand on a bight and adjust length so that the victim's head is slightly higher than the feet.
5. Tie off the ends of the webbing with two half hitches.

Low Angle

The low angle rescue litter rigging can be rigged for a three or a four-person carry. The number of litter tenders may depend on the victim's weight or available personnel.

Three Litter Tenders

1. Rig a litter for vertical raising at the head of the litter. A 5' length of webbing is the preferred length for this sling.
2. Attach the figure eight on a bight knots in the end of the main and belay lines to an anchor plate or multi-directional ring with a steel carabiner.

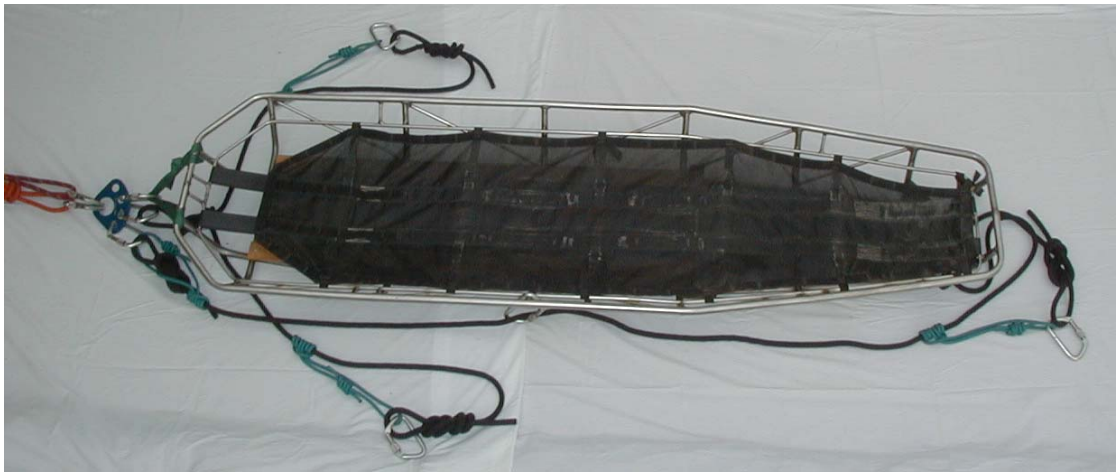


Figure 13.7
Litter Rigging, Low Angle, 3 Person

3. Attach the sling at the head of the rescue litter to the anchor plate with a steel carabiner.
4. Attach the center figure eight on a bight from one half of a pre-rig to the anchor plate. The ends of this half pre-rig are where the front two litter tenders will be attached to the system with carabiners

to their pelvic harnesses. One rescuer will be positioned on either side of the litter. The prusiks attached to these tails will allow the tenders to better position themselves along the side of the litter.

5. Untie the middle figure eight on a bight in the other half of the pre-rig. This length of rope will secure the third rescuer at the foot of the rescue litter. Attach the figure eight on a bight and prusik loop at one end of this pre-rig to the anchor plate with a carabiner. Use a carabiner to clip the rope into the main frame of the litter at the victim's elbow. This will keep the rope from passing over the victim's body when it is attached to the rescuer at the foot of the litter. The rescuer at the foot of the litter uses the prusik at the end of the pre-rig attached to his pelvic harness to adjust his position.

Four Litter Tenders

1. Rig a litter for vertical raising at the head of the litter. A 5' length of webbing is the preferred length for this sling.
2. Attach the figure eight on a bight knots in the end of the main and belay lines to an anchor plate or multi-directional ring with a steel carabiner.
3. Attach the sling at the head of the rescue litter to the anchor plate with a steel carabiner.
4. Untie the middle figure eight on a bight on each half of the pre-rig.
5. Attach the figure eight on a bight from the end of one half of a pre-rig to the right side of the anchor plate. The prusik hitch from this end and the figure eight on a bight at the opposite end of this half pre-rig are where the right front and rear litter tenders will be attached to the system with

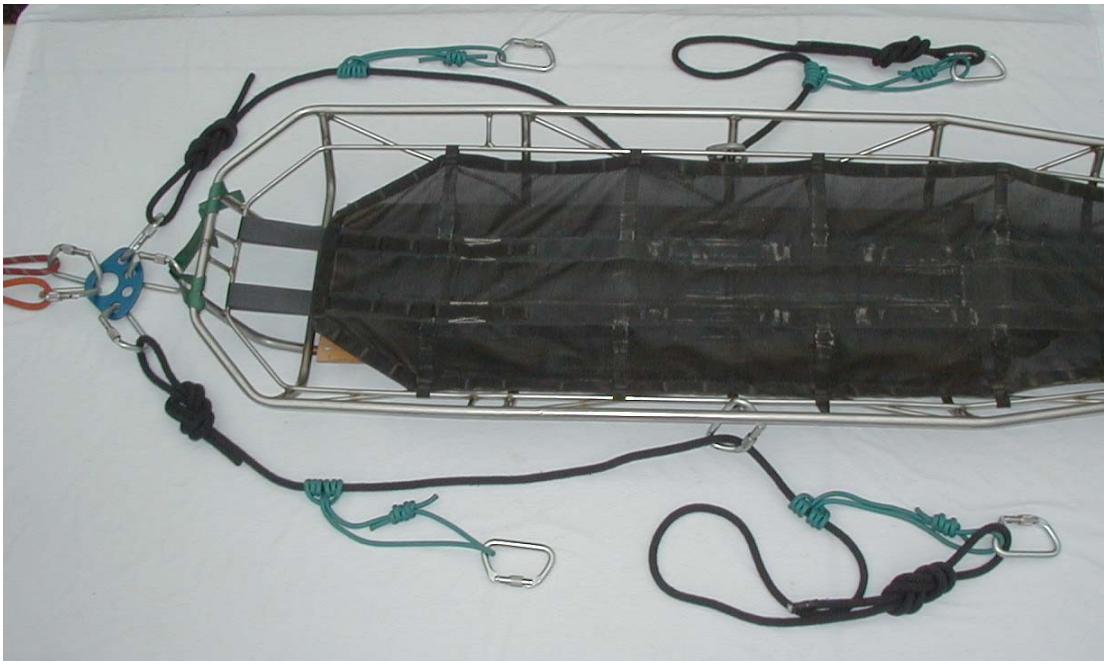


Figure 13.8
Litter Rigging, Low Angle, 4 Person

carabiners to their pelvic harnesses. The front litter tender will be positioned near the victim's shoulder. The rear person will be positioned near the victim's thighs. The prusiks attached to these tails will allow the tenders to better position themselves along the side of the litter. Use a carabiner to clip the rope into the main frame of the litter at the victim's elbow. This will keep the rope from passing over the victim's body when it is attached to the rescuer at the foot of the litter.

6. Attach the figure eight on a bight from the end of one half of a pre-rig to the left side of the anchor plate. The prusik hitch from this end and the figure eight on a bight and prusik at the opposite end of this half pre-rig are where the left front and rear litter tenders will be attached to the system with carabiners to their pelvic harnesses. The front litter tender will be positioned near the victim's shoulder. The rear person will be positioned near the victim's thighs. The prusiks attached to these tails will allow the tenders to better position themselves along the side of the litter. Use a carabiner to clip the rope into the main frame of the litter at the victim's elbow. This will keep the rope from passing over the victim's body when it is attached to the rescuer at the foot of the litter.

Figure 13.9
Litter Rigging, Vertical Raise

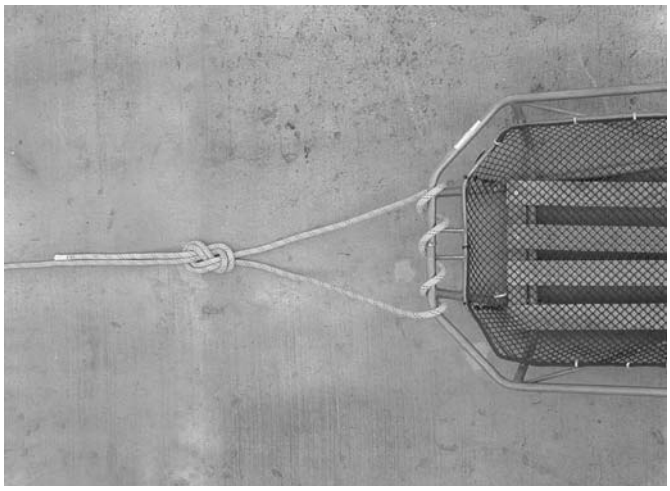
Vertical Attachment

Webbing Sling Method

1. Wrap a 5' length of webbing around the main frame at the head of the rescue litter. Beginning outside one of the skids and ending outside the opposite skid. Avoid weld in the middle.
2. Secure with an overhand bend.
3. Pull the webbing from the center of the main frame (at the weld point) until it reaches the end of the sling.
4. Rotate sling until knot is off to one side
5. Attach to rope with a carabiner clipped into figure eight on a bight.

Direct Attachment to Rope Method

1. Tie a figure eight stopper knot about 3' from the end of the rope.
2. Wrap the end of the rope around the main frame at the head of the rescue litter. Beginning outside one of the skids and ending outside the opposite skid. Avoid weld in the middle.
3. Secure with a figure eight follow through with the end of the rope using the stopper knot.



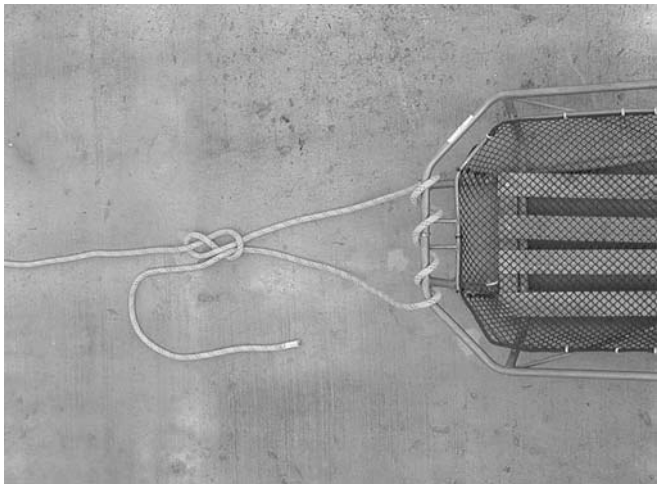


Figure 13.10
Litter Rigging, Vertical Raise, Improvised

Horizontal Attachment

1. A rope pre-rig is attached to the rescue litter with steel carabiners.
2. Carabiners clip around the main frame, between small rib (stops) provided to prevent carabiners from sliding up and down on the main frame. The carabiner gates go toward the inside of the basket.
3. The pre-rig is adjusted to keep the victim's head slightly higher than the feet or as patient care dictates.

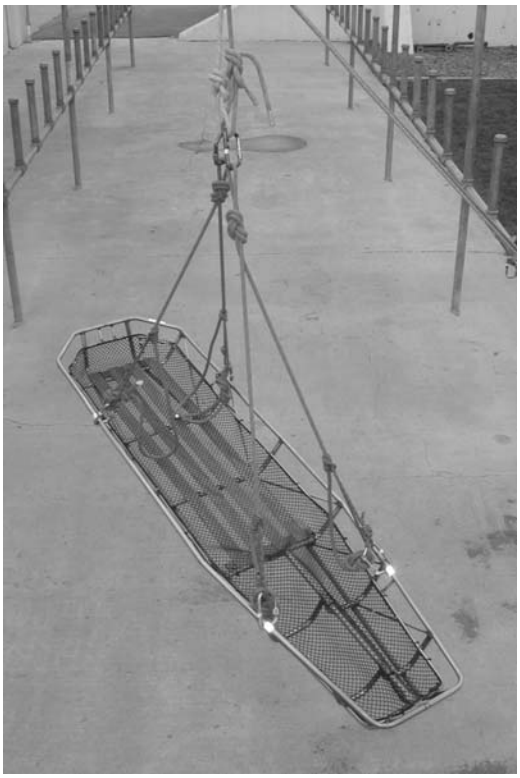


Figure 13.11
Litter Rigging, Horizontal Raise

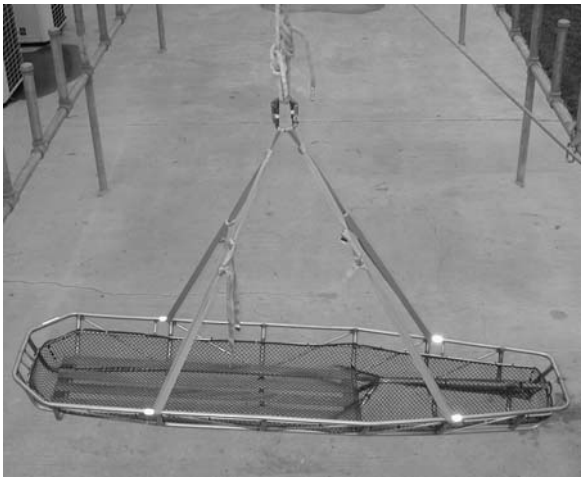


Figure 13.12
Litter Rigging, Horizontal Raise, Improvised

CHAPTER 14 - THE RPM SYSTEM

The RPM is an acronym for Rack, Pulley, and Mariner's hitch. These are some of the components incorporated into a rope rescue system used to manage the main line at the anchor point on simple rope rescue lowering and raising systems. This system helps rescuers organize the main components into a package so that they can set up a lowering system then change over to a raising system or from a raising system to a lowering system. The system consists of an anchor plate, a brake bar rack or figure eight descender, mariner's hitch, prusik minding pulley, rescue pulley, short prusik loop, long prusik loop, and three carabiners.

The anchor plate is attached to the anchor sling with a carabiner through the large diameter hole. The remaining components are attached to the small diameter holes on the opposite end of the anchor plate. The brake bar rack or figure eight descender is attached with a carabiner to the hole on the left side when you are facing the anchor. The rescue pulley is attached with a carabiner to one of the middle holes. This pulley is utilized as the mechanical advantage pulley for the Z-rig. The long prusik loop is attached to the same carabiner as the rescue pulley and is utilized as a hauling prusik for the Z-rig. The Gibbs ascender may be used as a substitute for the long prusik loop and referred to as a hauling cam. The Mariner's hitch is attached to the hole on the right side with the carabiner on the end of the Mariner's hitch that has two carabiners. The prusik minding pulley and the short prusik loop are attached to the carabiner on the opposite end of the Mariner's hitch. The prusik minding pulley is the change of direction pulley for the Z-rig. The short prusik loop is utilized as a ratchet prusik on the Z-rig.

Figure 14.1
RPM System

LOWERING SYSTEMS

The lowering system lowers rescuers and/or victims from a higher level to a lower level in order to accomplish removal. Lowering rescuers to make victim contact provides the rescuer with much more control than rappelling by leaving the rescuer's hands free to maneuver or control the victim. The system requires a main line with a friction device to control the descent and a belay system to provide safety for the rescuers or victims.

RAISING SYSTEMS

The raising system is used to raise rescuers and/or victims from a lower level to a higher level in order to accomplish removal. The raising system incorporates a mechanical advantage system on the main line, a Z-rig, to enable the hauling team to raise the rescuer/victim. A belay system is also required with the raising system to provide safety for the rescuers or victims. When the raising system is incorporated into the RPM system the change over from raising to lowering and lowering to raising can be accomplished with a great deal of efficiency.

ROPE RESCUE SYSTEM SAFETY CHECK

Each rope rescue system must be safety checked prior to operation. A safety check includes:

1. All anchor components
2. All belay systems components
3. All main line components
4. Rescuer/victim packaging

The safety check includes the following operations:

- A visual scan looking for properly tied knots and bends
- Looking for carabiners that are properly aligned and locked
- Looking for loose clothing, hair, or equipment that could get caught in a system
- Touching each knot as you look at it, and turning it over to inspect it
- Physically touching a carabiner and squeezing to make sure it is locked
- Checking every knot and carabiner in an entire system prior to loading the system

The safety check ensures that all parts of the system are properly assembled, tied, and secured. A member of the crew who has not constructed the component being checked performs the safety check.

HOW TO CONSTRUCT AND OPERATE A MARINER'S HITCH AS PART OF A RPM

LOAD RELEASING DEVICES

Mariner's Hitch (Load Releasing Hitch)

The Mariner's hitch is used on the belay line to both help absorb any shock forces to the anchor and rescuer during mainline failure, and to release tension from the tandem prusiks if they are accidentally locked. The Mariner's hitch is used on the "RPM" ahead of the directional change pulley to allow tension on the main line to be released in the event the load becomes caught on a rock or other obstacle and the ratchet prusik is set during a raising operation. It is also used to capture the mainline during a change over from a lowering to raising system, and vice versa.

Equipment needed to make the Mariner's hitch includes:

- Three carabiners (preferably steel)
- One 12' length of 1" webbing

How to Tie the Mariner's Hitch

The 12' length of webbing is folded in half, with no twists, and the two ends are tied together with an overhand bend to create a sling (see diagram). A carabiner is attached to the bight end of the webbing. A second carabiner is attached to both strands of webbing, 12" from the first carabiner. Then the overhand bend is passed through the first carabiner. This captures the second carabiner within a doubled bight of webbing. Wrap the working end of the webbing around the strands between the carabiners (five wraps). A doubled bight is formed in the end of the webbing next to the overhand bend and then passed between the pairs of strands just above the second carabiner. A third carabiner is clipped through the doubled bight and the bight formed at the overhand bend. This secures the end of the webbing

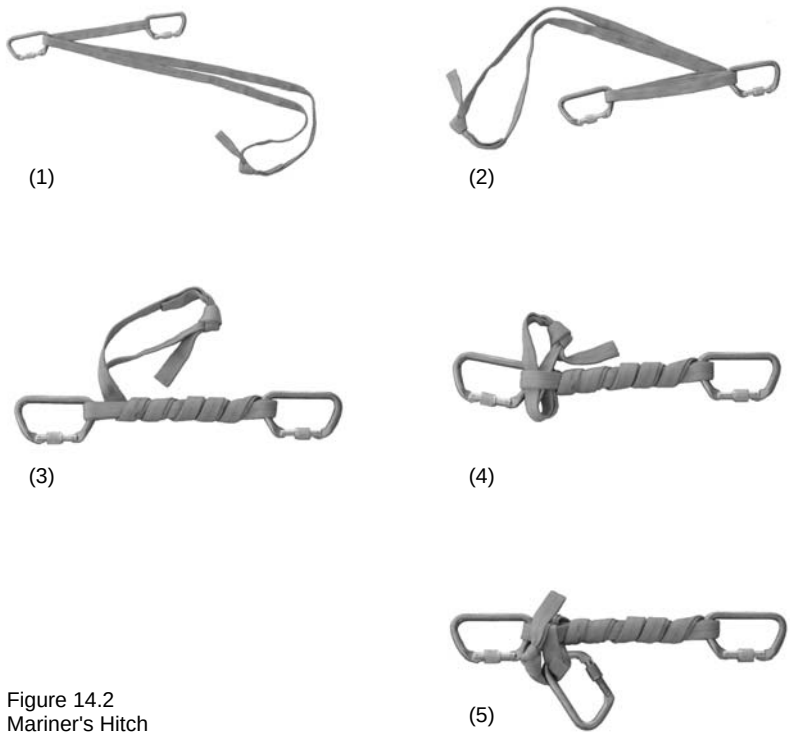


Figure 14.2
Mariner's Hitch

and keeps the hitch from unwinding.

How to Operate the Mariner's Hitch

To operate the Mariner's hitch first remove the carabiner that secures the end of the webbing while maintaining control of the end so that the wraps do not unwind. Slowly unwrap the webbing between the two carabiners until the force on the hitch overcomes the friction created by the remaining wraps. This friction is used in the same manner as any other friction device to overcome the force exerted on it. The Mariner's hitch will allow the load to move about 2' before the webbing runs out. This should be all the movement necessary to release the tension on the system. However, if more length is required an additional length of webbing can be threaded through the bight in the webbing at the overhand bend to extend the release length of the hitch.

CHAPTER 15 - THE BELAY SYSTEM

In the rescue community, the term belay means providing security with a rope. A belay line (also known as a safety line) is a backup system to the main raising or lowering line, which protects the rescuer and victim in the event of a main line failure. The belay line system's anchors and components must be as strong or stronger than the main line system in order to absorb a shock force. A belay line usually is not loaded unless there is a main line failure. Attention must be maintained to keep as much slack out of belay line systems as possible to avoid severe shock forces on the belay line if there is a failure of a main line anchor or component.

BELAY LINE COMPONENTS

There are four important components of a belay line system:

- A **solid anchor** capable of holding a shock force created by the falling load
- A **rescue rop**e attached to the rescuer and/or victim being protected
- A **tandem prusik brake system**
- A **rope handler** called a belay line tender or belayer

Tandem Prusik Brake System

The tandem prusik brake system consists of two different length prusik loops (one short and one long), a Mariner's hitch, an anchor sling, and a "bomb proof" anchor. It is recommended for the most commonly used 2" prusik minding pulleys that the short prusik loops be formed using a 57" piece of 8mm cord and the long prusik loops be formed using a 70" piece of 8mm cord. Tying a double overhand bend in the ends of the cord forms the loop. The bend should have 1"-2" tails to ensure the knot will not become untied. For optimum efficiency, the lengths of the prusik loops can be shortened to custom fit the type of pulley used. Experiment with the cordage so the first prusik hitch is a thumb width away from the pulley, and the second prusik hitch is 4" from the first. If you change ropes or prusik minding pulleys, the relationships may also change. In a belay system, the long loop is placed on a carabiner first, then the short loop, and finally the pulley. This puts the hitch that will catch first closest to the carabiner spine. Before using a prusik minding pulley in a raising belay, ensure that the rope maintains a 180° change in direction to each other and carefully set the prusik hitches against the leading edge of the pulley.

BELAYING

Prior to approaching the point of departure, the rescuer must be attached to the belay line and establish communication with the belayer. When the rescuer begins the descent or ascent, the belayer begins paying out or taking up the line by pulling the rope in one direction or the other through the brake prusiks.

The slack in the belay line must be pulled through the tandem prusik belay as the load is raised. The raising belay may utilize a prusik minding pulley in conjunction with the tandem prusiks to enable the belayer to remove all slack in the belay line while pulling the rope through the pulley, this technique is optional. While the load is being lowered, the belayer must feel resistance while paying out the rope. This will minimize the chance of too much line being payed out. If a main line failure occurs, the slack in the belay system must be minimal to reduce the fall factor.

The use of mechanical rope clamps or ascenders as ratchet belay devices is inappropriate because drop tests have shown that mechanical rope clamps either severely damage the rope or cause it to part.

Once the tandem prusiks have stopped the load, it cannot move any further until the prusiks are released. A load-releasing device (i.e., Mariner's hitch) between the anchor and the tandem prusiks is used to release the prusiks. The load-releasing device serves two purposes. First, it allows the belay device (prusiks) to be released once the raising/lowering system is secured. Second, it absorbs some of the shock force generated, by stretching out, as the prusiks arrest the fall. To release the load-releasing device it is untied and allowed to lengthen out to release the tension on the prusiks.

Figure 15.1
Tandem Prusik Belay

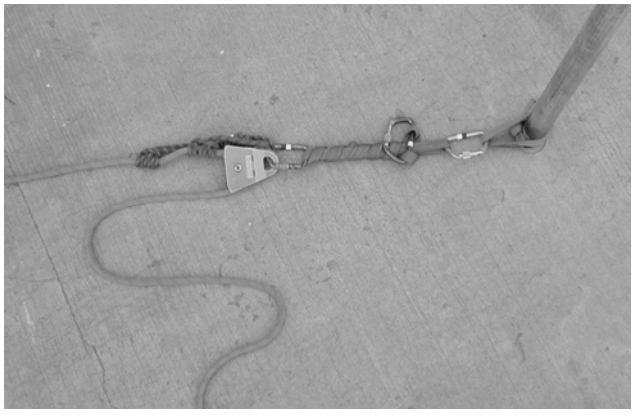


Figure 15.2
Tandem Prusik Belay with Prusik Minding Pulley

CHAPTER 16 - RAPPELLING

Rappelling is an important element of technical rope rescue. In most situations, it is better to lower rescuers to an incident, but on occasion, a rescuer needs to rappel to access the site. Rappelling is a valuable skill that teaches the use of different rescue equipment and builds confidence in the rescuer's ability, equipment, and team capability.

Rappelling is a dangerous activity, however, and must be completed under controlled conditions. A proper rappel is a slow, controlled walk down the face of a building or wall. A slow, steady descent is much easier on ropes and anchors and prevents serious heat buildup from friction that can damage nylon ropes.

A fast, bounding rappel has no place in the rescue service and only serves to abrade and cut rope from an aggressive sawing action over building and cliff edges.

RAPPEL SETUP FOR TRAINING

1. A solid anchor is required for the rappel/main line. The anchor should be located at the appropriate site above or just to the side of the desired destination. Care needs to be taken not to knock debris and other objects down onto the victim and cause further injury. If the rappel ends up too far to the side, a pendulum action must be created to access the victim. Pendulums cause a dangerous sawing action across edges, which can cut ropes and cause a load shift, which the anchor must be capable of handling.
2. Always tie a figure eight stopper knot in the end of any rappel line to prevent accidental rappelling off the end of the line if the rope does not reach all the way to a safe level spot.
3. Additional friction can be obtained by doubling a rope for a double-line rappel. If using a brake bar rack, add bars to increase friction. For training purposes use a rope that is twice as long as the distance to be rappelled. Lower one end of the rope with a figure eight stopper knot until contact with the ground. Attach the standing part of the rope to a figure eight descender or brake bar rack and lock it off. If a student becomes jammed because of clothing or equipment caught in the rappel device, or if the student panics, an instructor can lower the student to the ground. Simply unlock the figure eight/brake bar rack and lower the entire rappel line until the student is safely on the ground.
4. Place edge protection for any line going over an edge. Rappel lines are placed at risk because the same point on the rope will fray on any unprotected edge. Belay lines and other moving lines that run over the edge tend to abrade a little over the entire length of the line.
5. An anchor for a belay line needs to be located as close to the rappel line anchor as possible. This prevents a pendulum action if the main line fails.

6. Use a tandem prusik belay device on the belay line. It is easy to feed rope out, and hauling rope back in is equally fast and easy. If the belay line tender is in a location where there is a risk of falling, he or she should be secured to an anchor by a length of webbing or rope attached to the pelvic harness. This is known as an edge limiter.
7. The person rappelling should attach the end of the belay line to his pelvic and chest harness using a figure eight on a bight on the end of the line.
8. Once the belay line is attached and tended, the figure eight descender can be attached to the rappel line and then snapped into a carabiner on the pelvic harness. If a brake bar rack is used, it can be attached to the pelvic harness first, and then the rappel line reeved through it.
9. Prior to loading the system a safety check should be made to ensure that all knots are properly tied and set and that all carabiners are locked and loaded along the long axis (spine). Finally, check to make sure everyone is wearing helmets and gloves.
10. The start of a rappel is always the most difficult part, especially when starting at the same elevation as the anchor system. Start by sitting on the edge with both legs dangling over the side. Hold the rope in the brake hand. That hand should never leave the rope because that is how you control your descent. Support yourself with the opposite hand and rotate around until only your hip remains on the edge. Now push out until your knees are against the wall and you are facing the anchor. Let rope pass through the friction device until you can get your feet firmly planted against the wall.
11. A common tendency is to remain in a vertical position, which tends to cause the rappeller's feet to slip down the wall. Lean back and let the rescue rope take the weight and it will force your feet against the wall. Once on the ground do a deep knee bend, which will feed enough slack through the figure eight descender to allow you to disconnect from the system. By tying off the figure eight descender, the person on rappel can work with hands free while in mid-rappel.

Locking off

During a rappel, it may be necessary for the rescuer to stop his descent to perform work, package a victim, or to rest. It is necessary to lock off the descender whether it is a figure eight descender or a brake bar rack until the rescuer is ready to continue his descent. Locking off enables the rescuer to hang suspended on the main line and have his hands free to perform a function with a degree of safety. When the rescuer is ready to descend, he or she simply reverses the lock off procedure and continues his descent.

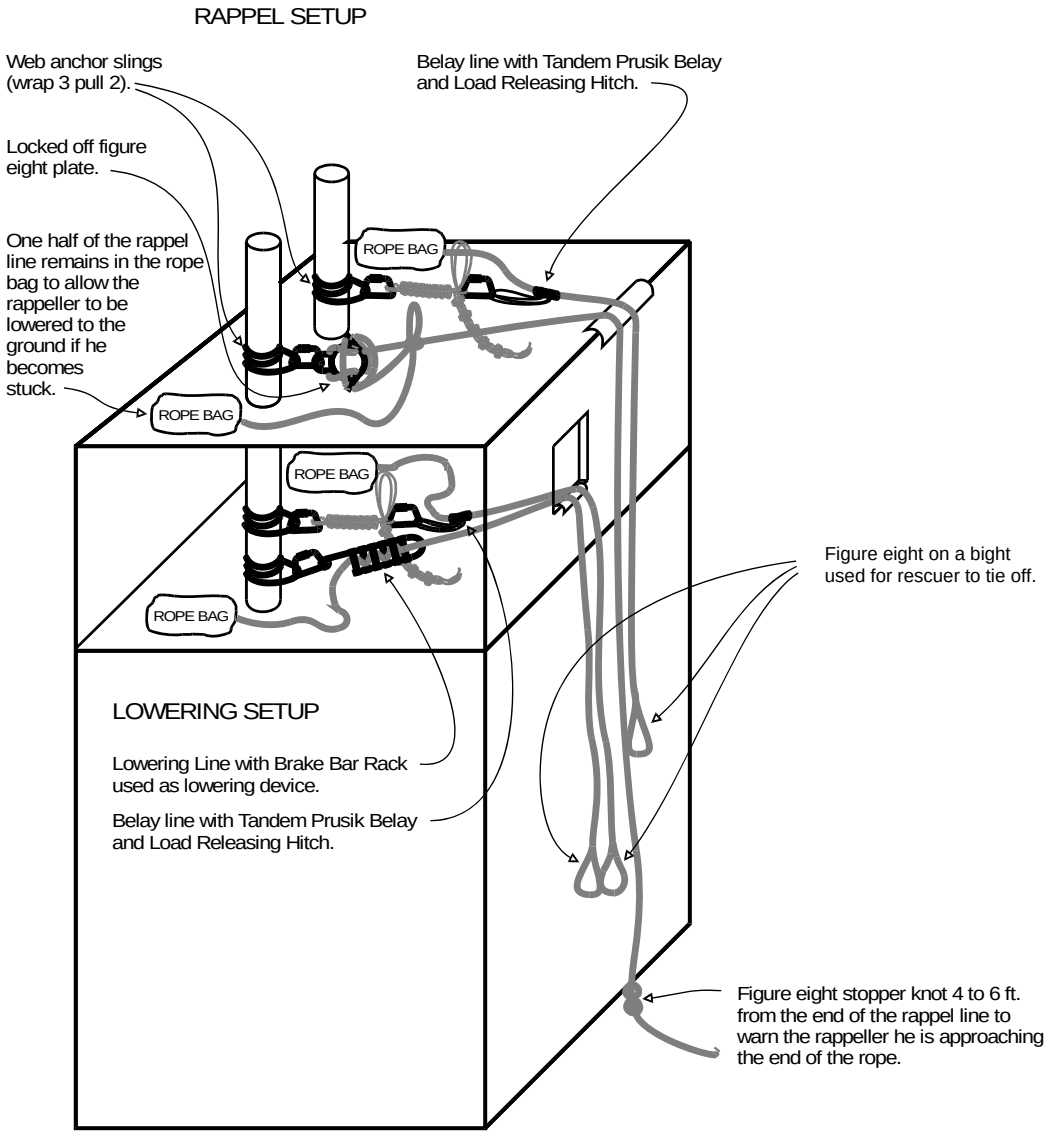


Figure 16.1

Rappel Tower
With Rappel and Lowering Station Setup

CHAPTER 17 - ROPE RESCUE LOWERING AND RAISING SYSTEMS

PULLEY SYSTEMS

Many rescue situations require raising a victim from an accident site. To do this requires knowledge of pulley systems so the rescue can be accomplished more safely and easily. By using pulley systems, the rescue team can spread the weight of the load over distance. A 1:1 mechanical advantage means that a 100-pound load that needs to move 10' will take 100 pounds of force and 10' of rope to move 10'. A 2:1 mechanical advantage means it will take 50 pounds of force to move the object, but it will take 20' of rope to move the object 10'.

Types of Pulley Systems

There are three classes of pulley systems. The Rescue Systems 1 course will work only with simple pulley systems.

1. **Simple**: A simple system has all its pulleys attached to either the anchor or the load. One end of the rope is tied to the anchor or the load and the rope is reeved through the pulleys.

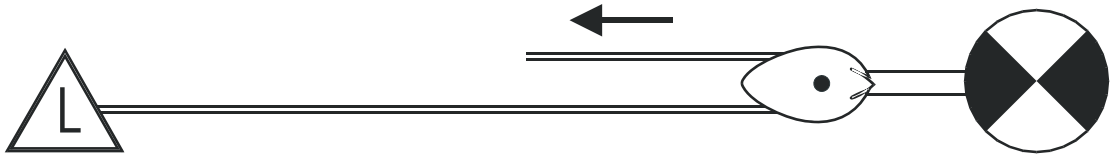


Figure 17.1
Simple Pulley System
1:1 Odd

2. **Compound**: A compound system is one simple system pulling on another simple system.

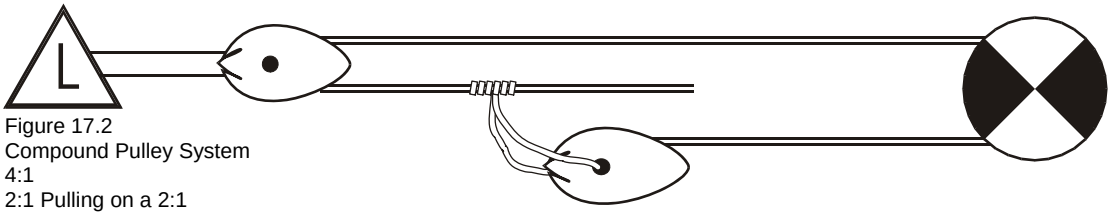


Figure 17.2
Compound Pulley System
4:1
2:1 Pulling on a 2:1

Complex: A complex system is any system that is a combination of simple and compound systems.

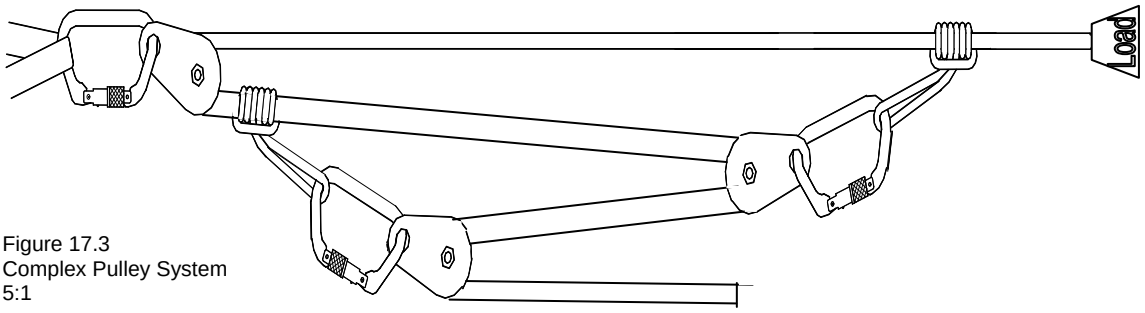


Figure 17.3
Complex Pulley System
5:1

RULES FOR DETERMINING MECHANICAL ADVANTAGE

There are three basic rules for determining the theoretical mechanical advantage of a simple pulley system.

1. If the rope is tied off to the load, and the first pulley the rope goes through is attached to the anchor, the advantage will be odd (1:1, 3:1, 5:1, etc.).
2. If the rope is tied off to the anchor, and the first pulley is attached to the load, the mechanical advantage will be even (2:1, 4:1, 6:1, etc.).
3. If the last pulley in a system is attached to the anchor, it adds no mechanical advantage. It acts only as a change-of-direction pulley.

To determine mechanical advantage, keep rules one through three in mind. Simply count the number of lines between the anchor and the load. Do not count the line if it comes off a change-of-direction pulley.

Components

Components needed to build a pulley system are:

1. Rescue rope
   - Most pulley systems can be built with 75' or 150' lengths of rope
2. Rescue pulleys
3. Prusiks
   - Hauling prusiks, to grab the rope and pull it into motion
   - Ratchet prusiks, to stop the rope from moving and allow the system to be reset
3. Anchor system

SIMPLE 2:1 PULLEY SYSTEM WITH A CHANGE OF DIRECTION: LADDER RIG

This system is used to create lifting capability from anchor points located above the rescue team. It is designed to pull down, toward the load. It is used in conjunction with ladder "A" frames, ladder gins, and other systems where the anchor is above the load. The rope is attached to the anchor, run through a pulley that is attached to the load, and back up to a change of direction pulley attached to the anchor. This rig takes a rescue rope, two carabiners, and two pulleys. It should be operated with a belay line and generally is used for short distance hauling.

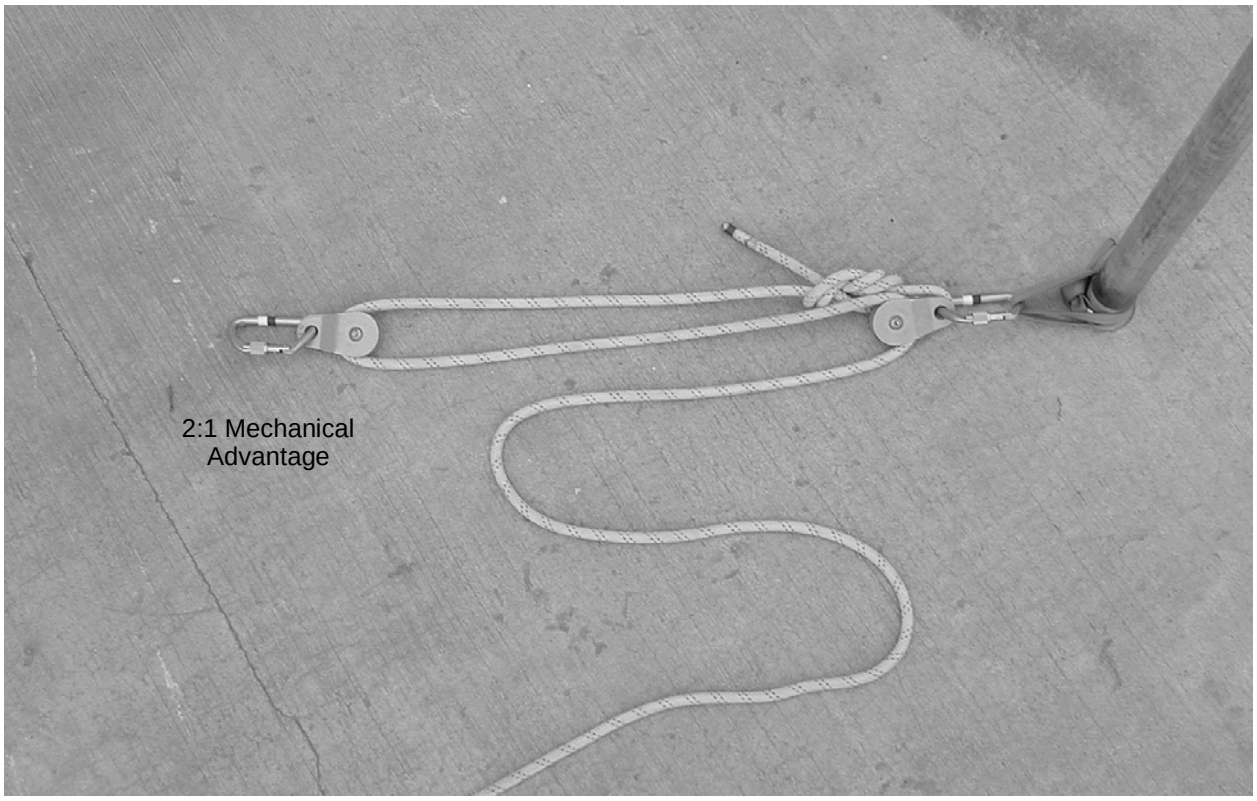


Figure 17.4
Ladder Rig

The actual mechanical advantage is less than 2:1 because of friction in the pulleys, rope abrasion, etc. The mechanical advantage referred to in any system is the theoretical mechanical advantage, and you should always assume that the actual mechanical advantage attained is going to be less in field situations.

SIMPLE 3:1 PULLEY SYSTEM: PIG RIG

This system is built in the same manner as the ladder rig but is used differently. It is designed to be used horizontally rather than vertically. By attaching the rope to the load, then running it through a pulley that is attached to the anchor, then back to a pulley attached to the load, the mechanical advantage becomes 3:1. The pull will be away from the load. This system lends itself to being attached to another rescue line with a hauling prusik. By hauling on the pig rig, the load attached to the other line is raised with a 3:1 mechanical advantage.

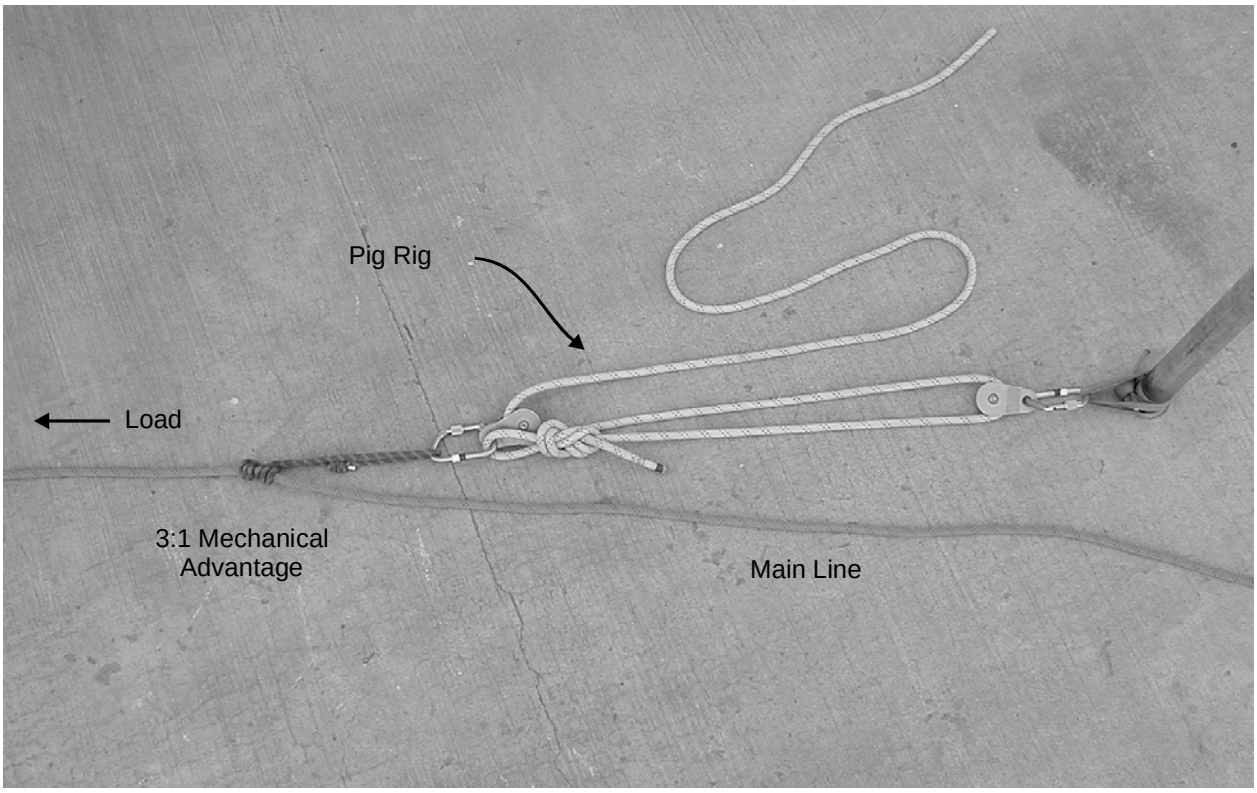


Figure 17.5
Pig Rig

Pig rig is short for piggyback rig. Any system, such as a pulley system, which is attached onto another system, such as a lowering system, creates a piggyback system. The two together are the piggyback system, while the pulley system used to create it is simply called the pig rig.

SIMPLE 3:1 Z-RIG PULLEY SYSTEM

A 3:1 Z-Rig takes a rescue rope, two pulleys, and two prusiks to build. The rope is attached to a load and run through a pulley that is attached to an anchor. The rope is then run back toward the load and runs through a pulley that is attached to the rope with a hauling prusik as close to the load as possible. (In most cliff rescue situations, this will be the edge of the cliff where the rope goes over.) The hauling force is away from the load. This system requires a ratchet prusik located on the load side of the pulley that is attached to the anchor. This ratchet grabs the rope and will not let the load drop back down if the haulers should slip, or if any other component should fail. It also allows the forward hauling prusik and pulley to be reset further down the rope (toward the load) as the load is raised.

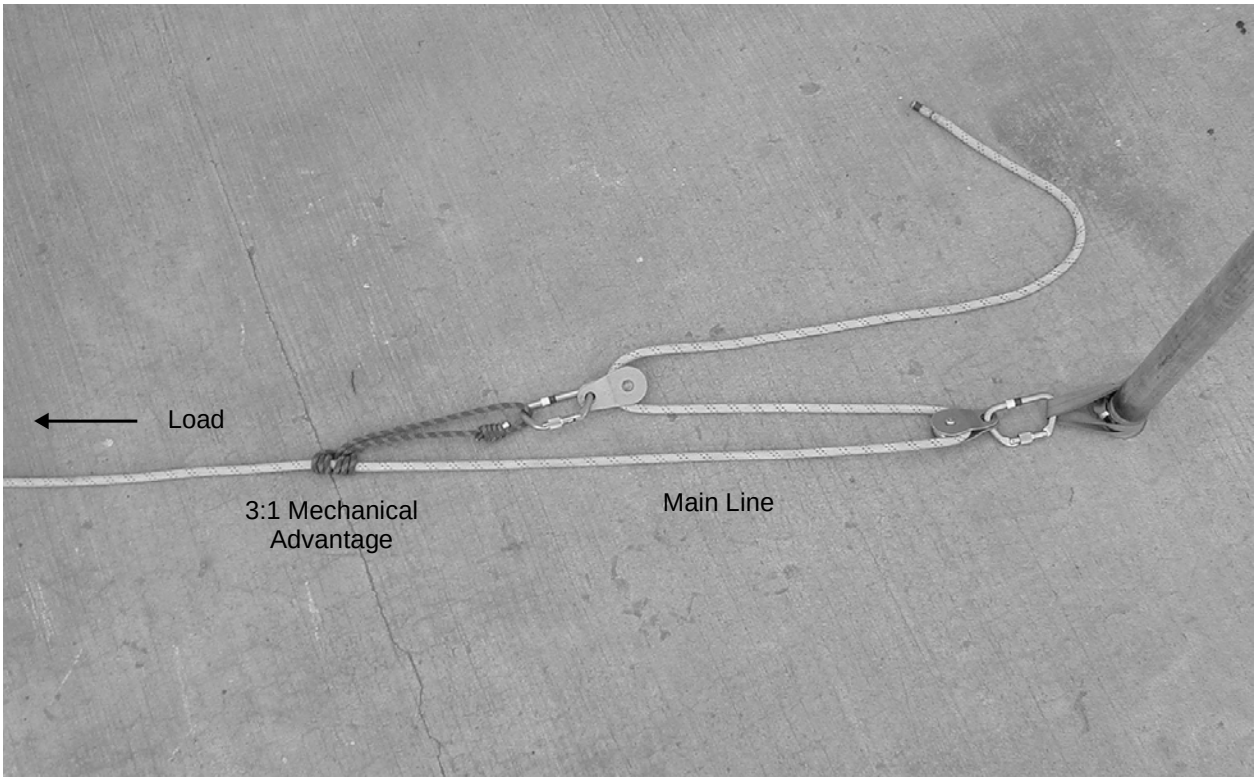
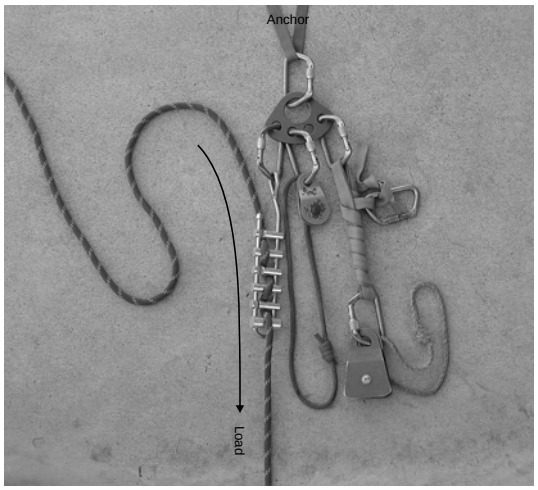


Figure 17.6
Z-Rig



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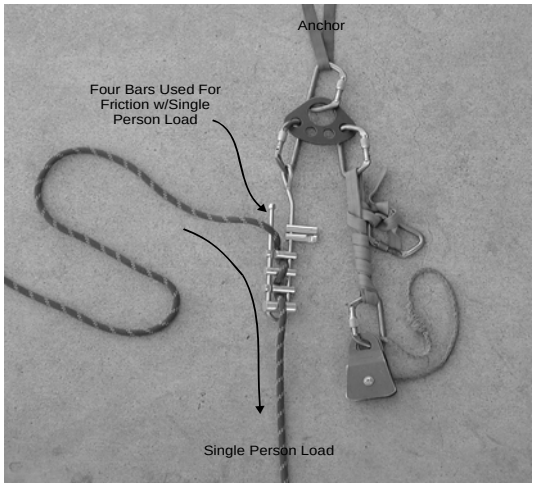

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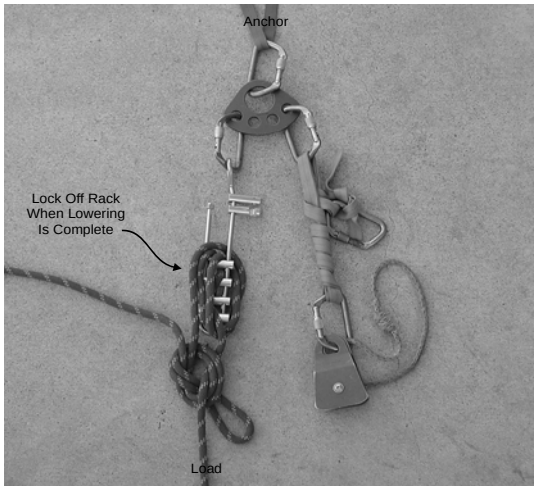

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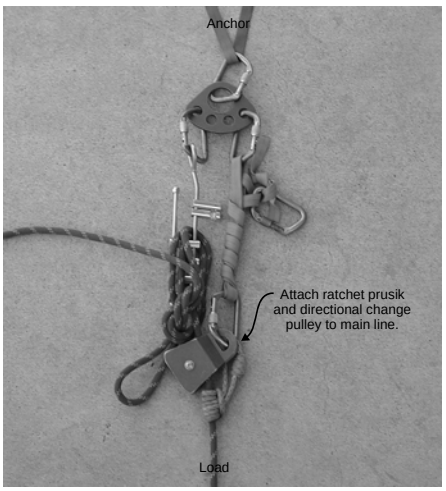
Figure 17.7
RPM Lower



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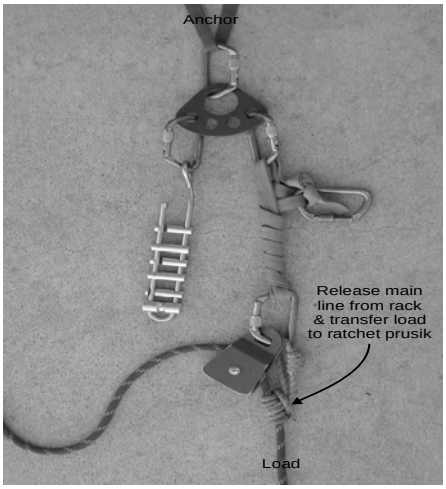

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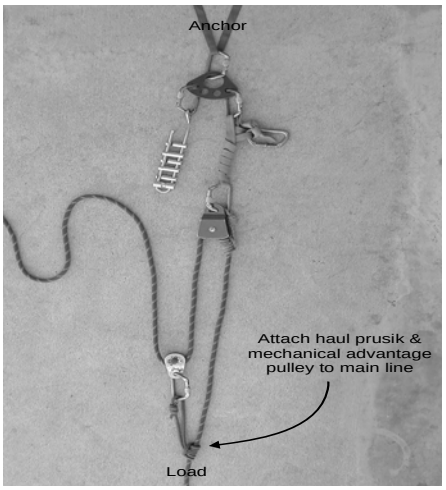

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Figure 17.8
Change Over (No Change of Direction)

CHAPTER 18 - LOW ANGLE RESCUE SYSTEMS

Low angle rescues are among the most common types of rescues performed across the country. Almost every jurisdiction has steep embankments along roads and rivers. Low angle rescues can cause problems because the forces and angles involved require rigging techniques different from those used in vertical rescue systems. The division between high and low angle rescue, where one begins and the other ends, is difficult to define. Low angle rescue usually involves these characteristics:

- Rescue personnel have most of their weight on the ground
- There are 3-4 litter tenders instead of 1
- The weight of the litter is supported by the litter tenders and not the rope
- The litter is attached to the rope at the end of the litter

Low-angle rescue systems should be used whenever rescuers must carry a litter on slopes where the footing is difficult and would be dangerous without the aid of a rope. This could be because the ground below the rescue site slopes away at a steeper angle, or there is a river or other hazardous obstacle below. The terrain could be slippery from mud and wet grass, or underbrush, loose rocks, snow, or ice.

A good rule of thumb to follow is a slope 45° or less is low angle and greater than 45° is high angle. Again, this is just a rule of thumb, and each rescue must be judged by its own unique problems.

LOW ANGLE RESCUE SYSTEM FOR AN AMBULATORY VICTIM

1. Locate suitable anchor(s) near the point of departure.
2. Attach an anchor sling for the mainline and one for the belay line.
3. Attach the RPM system to the mainline anchor and rig it for lowering.
4. Attach and rig belay system to the belay line anchor.
5. Package rescuer:
    - Don pelvic harness
    - Attach mainline and belay line to rescuer's pelvic harness
    - Attach a prusik to the mainline and one on the belay line with three-wrap hitch, one arm's length in front of the rescuer.
    - Attach the adjustable end of the pick-off strap to both prusik hitches
    - Secure the "D" ring end of the pick-off strap to the accessory cord on the pelvic harness
    - Secure the victim's harness to the accessory cord on the pelvic harness

6. Perform safety checks.
7. Lower rescuer down the slope to the point at which the rescuer is even with the victim.
8. Lock off lowering system.
9. Package the victim:
   - Don the victim's pelvic harness
   - Remove the "D" ring end of the pick-off strap from rescuer's harness and attach it to the victim's harness "D" ring.
10. Pull the free end of the pick-off strap to adjust the victim's position just in front of the rescuer.
11. Change the lowering system over to a raising system.

Figure 18.1

12. Perform safety checks.
13. Raise the rescuer and victim up the slope with the rescuer assisting the victim.

Figure 18.2

Figure 18.3

LOW ANGLE RESCUE SYSTEM FOR A NONAMBULATORY VICTIM

1. Locate suitable anchor(s) near the point of departure.
2. Attach an anchor sling for the mainline and one for the belay line.
3. Attach the RPM system to the mainline anchor and rig it for lowering.
4. Attach and rig belay system to the belay line anchor.
5. Rig rescue litter for either 3 or 4 litter tenders.
6. Secure necessary webbing for victim lashing to rescue litter.
7. Package litter tenders:
   - Don pelvic harnesses
   - Attach pre-rig to litter tenders' harnesses
8. Perform safety checks.
9. Lower rescue litter and tenders to victim.
10. Lock off lowering system.
11. Lash victim in rescue litter.

Figure 18.4

12. Change lowering system over to raising system; add change-of-direction pulley and or pig rig if necessary.
13. Perform safety checks.
14. Raise rescue litter and tenders back up.

Figure 18.5

CHAPTER 19 – MOVING AND STABILIZING HEAVY OBJECTS

INTRODUCTION

Long ago, man learned that work done by machine is easier than work done by muscle power alone. One of the most common tasks encountered by a rescue team in a structural collapse is to lift and possibly move a heavy object in order to reach or extricate a victim.

This task may have to be performed without the aid of heavy equipment. Cranes, forklifts, backhoes, and other equipment normally used to move large, heavy objects might not be available. Equipment may not be able to reach the site due to infrastructure collapse, large debris piles, or remoteness of the incident. In some cases, heavy equipment cannot be used because the movement or operation of that equipment may further endanger the victim or rescuers by causing further collapse.

Simple hand tools can be used to create tremendous mechanical advantage to lift, lower, and move large loads safely. Those same loads can be moved with relative ease by reducing friction between the load and the surface it is to be moved across. Basic methods of building crib beds can be utilized to stabilize heavy objects.

TYPES, CAPABILITIES, AND SAFETY CONSIDERATIONS FOR TOOLS USED WHEN LIFTING HEAVY OBJECTS

Levers

The simplest of machines is a lever. A lever is a rigid bar, either straight or bent, that is free to move on a fixed contact point called a fulcrum and works by transferring force from one place to another. There are three classifications of levers determined by the location of the fulcrum as it relates to both the load and the force.

Class 1 Level

The **Class 1 lever** gives the greatest mechanical advantage. A load is located at one end of the lever and the lifting force is placed at the other end with a fulcrum located between the two. Crowbars and pry bars are examples of a first class lever. **They are most useful for lifting objects vertically.** The first-class lever changes the direction of the force. Here the force is applied downward while load moves up.

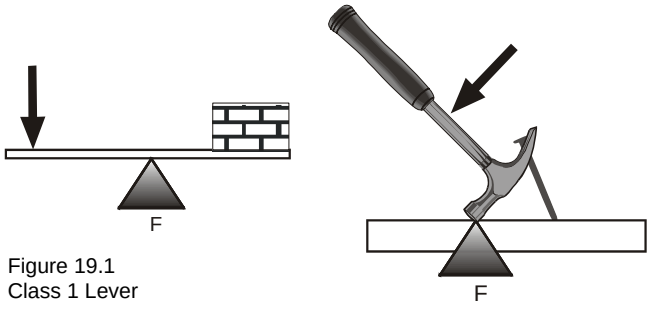


Figure 19.1
Class 1 Lever

The **mechanical advantage** can be calculated by comparing the distance between the load and the fulcrum to the distance between the fulcrum and the force.

If the length of the lever is three times as long on the force side of the fulcrum as on the load side, the lever has a 3:1 mechanical advantage. Thus, if you have a 3-pound load to lift and a 3:1 lever, it will take 1 pound. of force to lift the load.

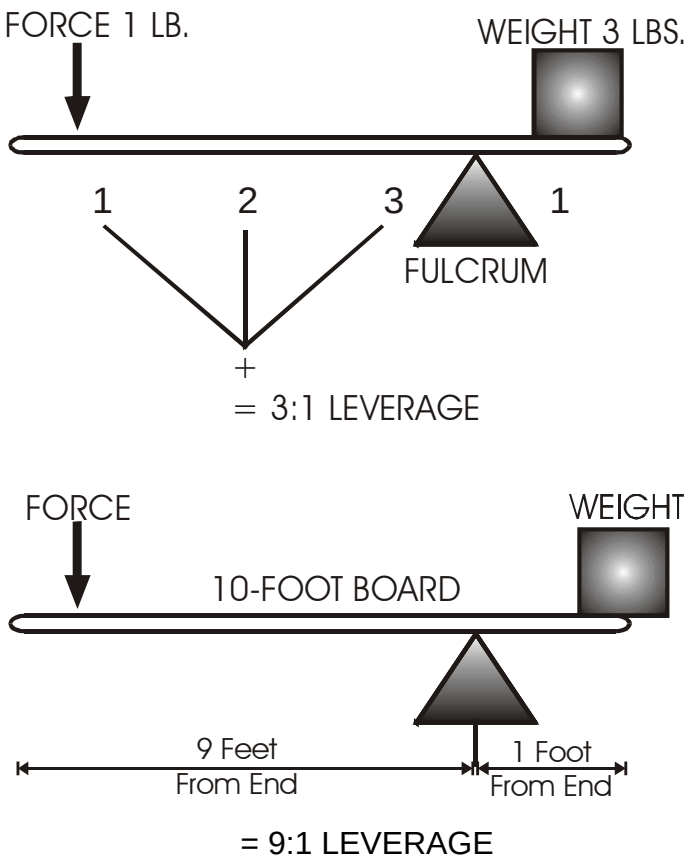


Figure 19.2
Mechanical Advantage

Class 2 Lever

The **Class 2 lever** is the next most useful and efficient lever. It consists of a fulcrum that is at one end of the lever, a load in the middle, and a force on the other end. Wheelbarrows are a type of second-class lever. **This type of lever is useful for moving objects horizontally.**

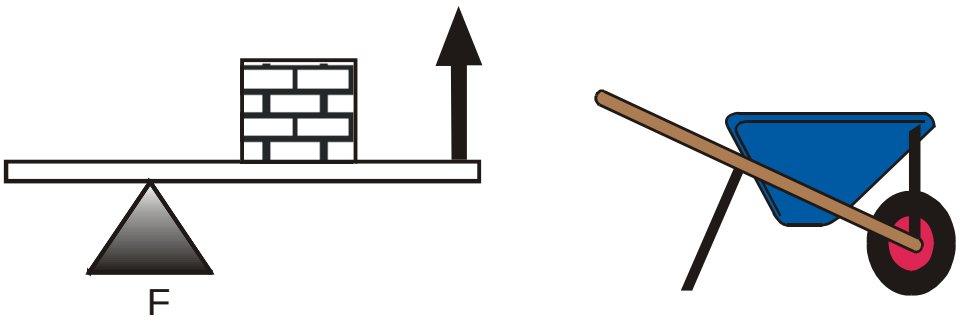


Figure 19.3
Class 2 Lever

Class 3 Lever

The **Class 3 lever** is used when **force may be sacrificed for distance**. It places a load on one end, the fulcrum on the opposite end, and the force in the middle. Shovels and brooms are types of third-class levers commonly used for light debris removal. Third-class levers are not used for lifting or moving heavy objects.

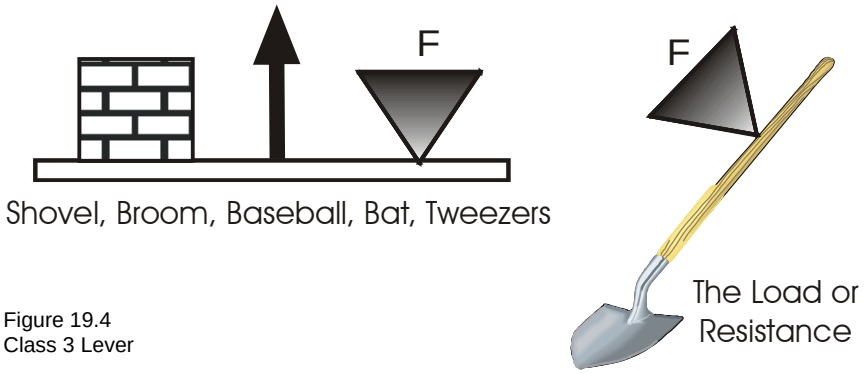


Figure 19.4
Class 3 Lever

When using a lever, considerations must be given to the stability and strength of the fulcrum and the surface upon which the fulcrum rests. The fulcrum and the foundation it rests on must be capable of holding the weight of the load to be lifted.

SAFETY

Personal Protective Equipment

When lifting heavy objects, basic safety equipment (long pants and shirt, gloves, steel-toed safety boots, helmet with chinstrap, and ANSI-approved eye protection) must be worn at all times. This basic compliment of equipment will protect the rescuer from minor cuts, abrasions, and contusions. Small concrete chips and associated debris can fracture off at very high velocities during operations and cause serious injury to unprotected rescuers.

Safety Rules and Considerations

Lifting heavy objects is a slow and tedious process. Great care must be taken to prevent sudden movement or shifting of the load. If the operation is taking place in a structure damaged by earthquake or explosion, the last thing you need is several tons of heavy material sliding sideways or dropping several inches. This dynamic loading would place tremendous strain on an already unstable structure.

Crib and Stabilize as You Lift

Utilize crib beds and wedges as stabilizers to prevent the sudden or accidental movement of the load. Never place any body part under unsupported loads.

Lift Increments

Lift in short controlled increments, approximately 2"-4" at a time, depending on the fulcrum height and distance and the size of the wedge used to support the lift. To prevent unwanted horizontal movement of the object lift in small increments. Use 2"x4" or 4"x4" cribbing for stabilizing and as fulcrum points. If the fulcrum height is greater than 2" or too close to the load, relative to the purchase point, the movement of the object may be horizontal as well as vertical. Horizontal movement will cause crib beds to collapse and may cause serious injury to rescuers and victim(s).

Lifting Techniques

Use proper lifting techniques and body mechanics. Poor lifting technique can cause strains, sprains, and spine related injuries. Use proper body mechanics when working with heavy loads. Keep your legs bent, back straight, and head/face away from pry bar and lift with your legs to prevent injuries.

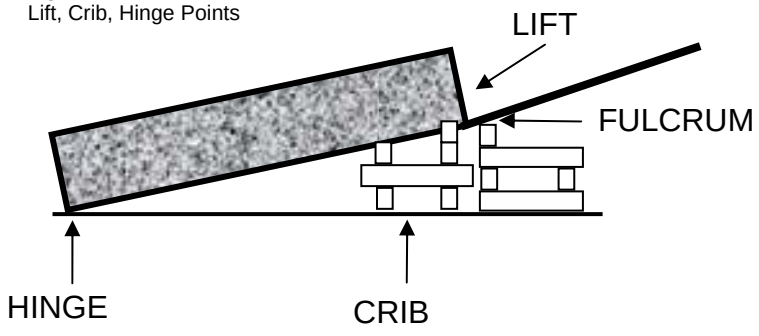
Collapse Size-Up

Utilize the six sided approach when sizing-up a collapse incident. Identify the type of construction, nature of collapse and collapse configuration. Identify void spaces and potential location of victims. Develop an incident action plan based on number and locations of victims. Remove surface victims first, and then work from light to heavily entombed victims. Secure adequate materials and resources to implement and support action plan. Continuous evaluation of planned lifts, moves, and maintaining structural stability are critical to preventing secondary collapse.

Lift, Hinge, and Cribbing Points

The lifting points are where fulcrums can be built and lifting crews are positioned safely to perform their job. The hinge point or points are where the object will hinge opposite the lift force. Crib beds opposite the lifting points commonly become hinge points for the lift. On initial lifts, the hinge point may be the ground surface or another stabilized object. Hinge points will often indicate the direction the load may shift. Cribbing points indicate where the crib beds will be built to support the load and/or provide

Figure 19.5
Lift, Crib, Hinge Points



stable hinge points. Crib beds need to be built in areas that will support the load adequately and not block access/egress to the victim(s).

Medical Precautions

Special precautions must be taken with crush injuries that are common to these kinds of rescue operations. Make sure that proper medical care is given and advanced care is available before removal of a heavy object from a victim.

GROUP DYNAMICS

A group may consist of many very different types of people. In order for a group to come together, they must commit to a goal or objective. Constant feedback and direction must be given for a group to be effective.

Teamwork and Leadership

Teamwork is critical to a safe and efficient operation and requires a strong leader. Leaders either exist by position, or are established during a given situation. The leader sets the tone of how well the objective is met. Leadership involves:

- Developing a plan of action and implementing the plan by coordinating work through others
- Adapting and overcoming problems
- Ensuring overall safety of the operation and personnel involved

Rescue Team Position Descriptions

Squad Leader

- Develops and implements the action plan
- Calls commands
- Maintains safety
  - If the squad is large enough, the squad leader can designate a Safety Officer

Assistant Squad Leader

- This position is filled when a squad of 10-12 students is divided in two to form "A" and "B" squads
- Assists the Squad Leader with developing and implementing the action plan
- Also responsible for squad safety

Safety Officer

- Maintains overall safety of squad members
- Monitors stability of heavy objects and crib beds
- Can terminate any operation deemed unsafe

Bars - Operate pry bars to raise, hold, lower, and move heavy objects

Cribbers - Construct crib beds to support and stabilize heavy objects

Feeders - Supply Cribbers and Bars with materials to construct crib beds or fulcrums

Standard Commands

The verbal commands are used to prevent rescuer injury and develop safe, deliberate movement of heavy objects. Clear text should be utilized. The following are commonly used commands for heavy object operations:

Squad Leader	"READY to RAISE"
	"READY TO LOWER"
	"READY TO MOVE OBJECT"
	All assigned positions will respond "READY"
Squad Leader	"RAISE"
	"LOWER"
	"MOVE OBJECT"
	The Bars will take action as commanded.
Squad Leader	"HOLD"
	This command is used to hold the object until the Cribbers have completed the crib beds to support the load.
Cribbers	"CRIBS SET"
	To state when the crib bed is completed.
Squad Leader	"LOWER OBJECT"
	The Bars will lower the object until it is supported solely by the crib beds.

Any Squad Member	"STICK"
	An emergency command that can be given by any squad member.
	Immediate request for the Cribbers to support the object.
	The Bars may have lost purchase point or control; undesired movement or instability.
Cribbers	"CRIBS SET"
	When the load is secure.

A heavy lift operation takes a lot of people and a lot of equipment. If the team is to be successful, each person must work within their assigned positions and follow commands as given to maintain safety.

Safety Officer

This position is responsible for the following:

- Ensure that personnel are clear of the object while it is being lifted, held, or lowered
- That proper safety equipment is donned by all
- Observe for undesired load movement and load stability

Each lifter should be supported by a Cribber who builds crib beds under the load to prevent any unwanted downward movement. Each crib bed builder (Cribber) should be supported by a Feeder who keeps a supply of crib building materials within arm's reach.

Care must be taken to build stabilizing structures so that the load is supported to the ground through solid wood contact.

DETERMINING THE WEIGHT OF STRUCTURAL COMPONENTS

A rescuer will need to estimate the weight of an object to determine the number of crib beds needed to support the load and the equipment required to lift load.

Weights of Common Building Materials

Weights are recorded as either pounds per cubic foot (PCF) or pounds per square foot (PSF).

- Concrete = 150 PCF
- Masonry = 125 PCF
- Wood = 35 PCF
- Steel = 490 PCF
- Concrete/Masonry Rubble = 10 PSF per inch (of thickness)

Weights of Common Building Construction

- Concrete floors weigh from 90-150 PSF
- Steel beam with concrete-filled metal deck = 50-70 PSF
- Wood floors weigh from 10-25 PSF (floors w/ thin concrete fill are 25 PSF or more)
- Add 10-15 PSF for wood or steel interior walls, each floor level
- Add 10 PSF or more for furniture and contents each floor (more for storage, etc.)

Load Stabilization, Crib Bed Capabilities, and Construction

The purpose of crib beds is for support and stabilization. They should be built beneath the load as it is lifted. There are many materials that can be used for cribbing, but the best and most versatile is 2"x4" and 4"x4" construction-grade lumber. Douglas Fir and Southern Pine are the most commonly used and available species. Both species are rated at 500 PSI (pounds per square inch) perpendicular to the grain. A finished 2"x4" or 4"x4" has an actual flat surface size of 3.5".

Example:

1. One 3.5" piece of cribbing overlapped perpendicular with another 3.5" piece of cribbing = 12.25 square inches of wood surface contact.
2. 12.25 square inches x 500 PSI = a load carrying capacity of 6,125 pounds.
3. Rule of thumb: a 4"x4" crib bed has approximately a 6,000-pound capacity for each overlapped contact point bearing load.
4. 6,000 pounds multiplied by number of contact points = load capacity.
5. Box crib: Four contact points x 6,000 = 24,000 pounds
6. Cross tie crib: By adding one more piece of cribbing to each layer, the number of contact points is increased to 9 and the load carrying capacity of the crib bed to 54,000 pounds.
7. A box crib of 6"x6" lumber has a capacity of 60,000 pounds.

Materials other than wood can be improvised to support loads, but can be subject to sudden crushing and uncertain failure strengths. Wood tends to slowly fail with lots of noise. This warns rescuers of the impending failure.

To maximize crushing failure the tails of each layer of cribbing should extend approximately its dimension past the layer of cribbing below. When the crib bed is loaded to capacity it will crush uniformly, creating saddles similar to Lincoln logs preventing pieces from squirting out. This method only works if the load remains relatively square to the ground. If the object is not square to the ground the cribbing tails or ends will be loaded causing the crib bed to become unstable and reduce its load-carrying capability.

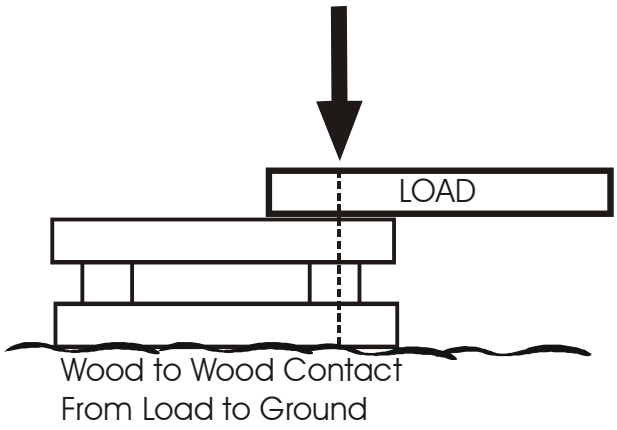


Figure 19.6
Cribbing

When cribbing to sloped surfaces, it may be necessary to place the ends of each piece of cribbing flush to the layer below to increase crib bed stability. When cribbing to sloped surfaces add additional pieces of cribbing to each layer. This provides additional contact points to increase load carrying capacity.

The first layer of a crib bed that is constructed on dirt, asphalt, or any suspect surface should be solid to spread the load and maintain stability.

There are two basic rules that should be followed when determining the allowable height of a crib bed and maintaining load stability:

1. Never build a crib bed higher than three times the length of cribbing in use. To determine the cribbing length in use, measure the shortest side of crib bed from outside of contact point to outside of contact point.
2. This rule is based on the ratio of contact points carrying load (corners of crib bed) to maximum crib bed height.

The contact point to height ratios are as follows:

- 4 contact points = 3 x length of cribbing
- 2 contact points = 1.5 x length of cribbing
- 1 contact point = 1 x length of cribbing

The height ratios are approximates and need to be reduced due to slopes and nature of incident, i.e., earthquake aftershocks, settling, etc.

Precut cribbing in 18"-24" lengths can be stockpiled ahead of time. Prior arrangements and agreements with local lumberyards to supply rescue teams with bulk lumber to cut cribbing into desired lengths is a good idea. This prevents the need to stock pile large amounts of materials ahead of time. During a large-scale disaster, rescuers may be required to reconnaissance the area and utilize materials as located, i.e., construction sites, collapsed structures, fences, etc.

Wedges: 2"x4"x12" and 4"x4"x18" wedges are used to support, stabilize, and shim a load as it is lifted. The wedges need to be inserted as the load is raised. This is to prevent the load from dropping if a purchase point fails and/or if a rescuer cannot hold the load. Insert a full-size 4"x4" piece of cribbing as soon as space allows.

A single 2"x4"x12" wedge should be utilized as a shim to fill voids between the load and crib beds. This increases stability by transferring the load to additional contact points.

Wedges can also be used to change the angle of thrust in order to get the optimum contact with uneven or sloped surfaces. Wedges can be cut in the field with chain or circular saws. Wedges can be difficult to cut in the field. They can be purchased precut from most lumberyards and should be pre-stocked in a rescue cache.

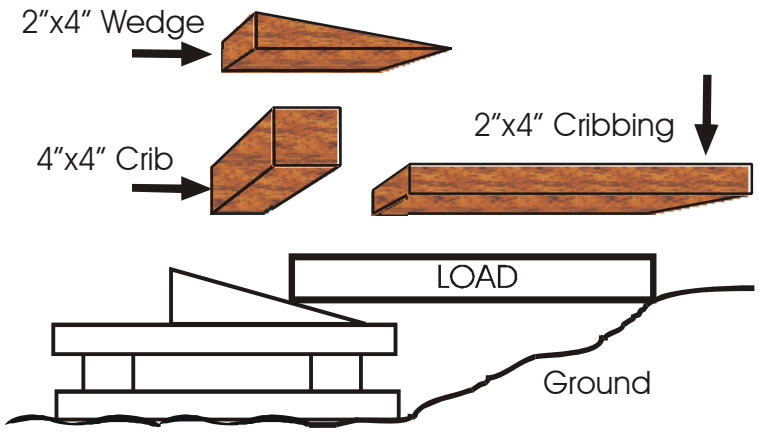


Figure 19.7
Cribbing and Wedges

CRIBBING & CRIB BEDS

CAPACITY IS BASED ON CROSS GRAIN BEARING
(VARIES FROM 200 PSI TO 1000 PSI DEPENDING ON WOOD SPECIES
500 PSI IS USED FOR EMERGENCY SHORING – EXAMPLE 500 X 3.5 X 3.5 X 4 = 24,000)

FOR A 2 MEMBER X 2 MEMBER BOX CRIB
4 X 4 BOX CRIB CAPACITY = 24,000 LBS (12 TONS)
6 X 6 BOX CRIB CAPACITY = 60,000 LBS (30 TONS)

FOR A 3 MEMBER X 3 MEMBER CROSSTIE CRIB
4 X 4 CROSSTIE CAPACITY = 54,000 LBS (27 TONS)
6 X 6 CROSSTIE CAPACITY = 135,000 LBS (67.5 TONS)

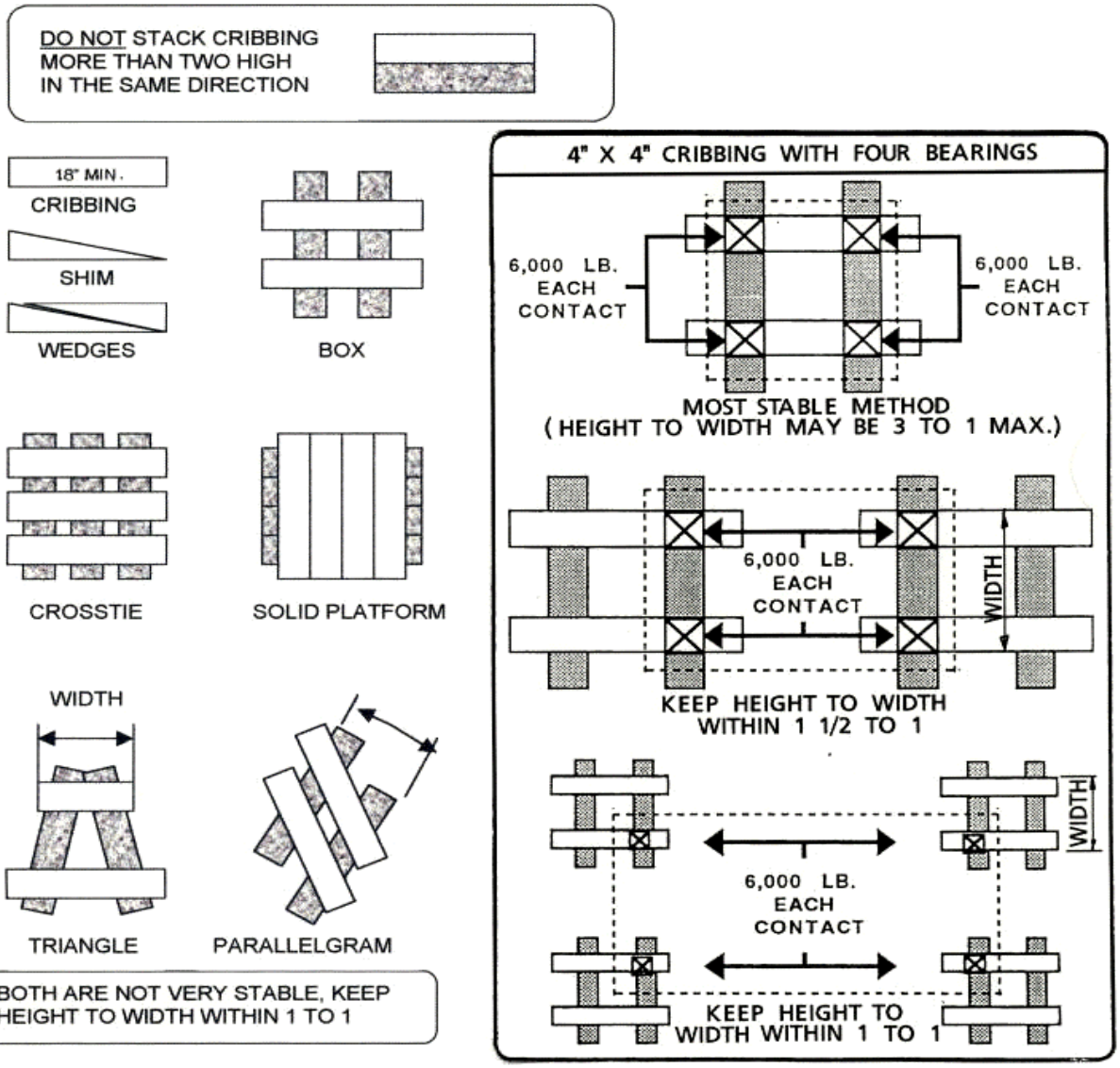


Figure 19.8
Cribbing and Crib Beds

MOVING HEAVY OBJECTS

In addition to vertically lifting heavy objects, it may be necessary to horizontally move objects in order to access a void or extricate a victim.

It is easier to move if it can be placed on rollers. This reduces friction and lessens the effort and time required moving the load. Pickets, steel pipe, and round wood posts can be located and improvised out of debris piles, chain link fence posts, and signposts. If your apparatus permits, carry a small number of pipes for both rollers and pipe screw jacks.

If the ground is soft under the load or if the surface is uneven or broken, it may be necessary to build runners to support the rollers. In effect, you are building a track system. The load will have to be lifted high enough to slide the tracks and the rollers under the load. 4"x4" timbers or 2"x4" or 2"x6" stock laid on its wide axis make good track systems for rollers.

It is important to control the movement of a heavy load; failure to do so could cause injury and/or secondary collapse. Once a load is placed on rollers, the load may move rapidly and with little effort. Therefore, loads should be moved with extreme caution and control. Slow and deliberate movements are the order of the day. A method of braking (having the ability to stop the movement of load) must be in place before lowering the load on rollers. The faster a load is allowed to move, the more difficult it will be to stop. An out of control load cannot be slowed or stopped; it will come to rest on its own.

Here are some methods that can be utilized to help brake or control small loads on a level plane. Remember that all components of any braking system must have the strength to sustain the force of the object in motion.

WEDGES

Wedges can be placed in front of the rollers on both ends where the roller extends beyond the load. This will stop the load as the roller tries to ride up and over the wedge.

Wedges can also be placed at the front or sides of load and are dependent on friction to stop the load. Caution should be used when placing a wedge on top of the runner. It may not create sufficient friction and shove the wedge in front of the moving load. This method increases risk to rescuers because wedges must be set as the load is moving.

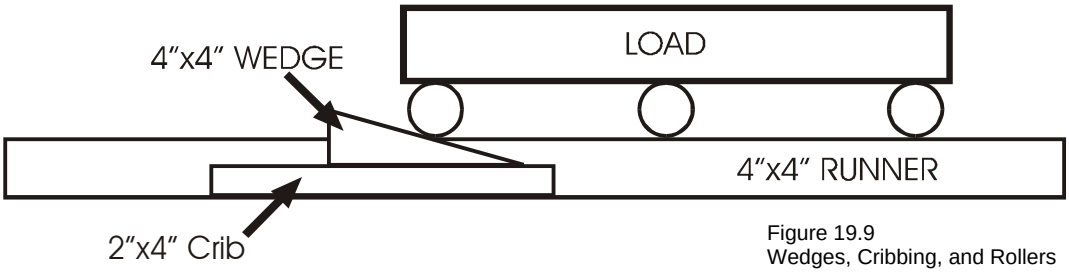


Figure 19.9
Wedges, Cribbing, and Rollers

Class 2 Levers

Class 2 levers can be utilized to control or stop a moving load by lifting from the sides. This method allows the rescuers to stay clear of all moving parts due to the length of the pry bar.

If the speed of a moving load is permitted to move too fast, none of the above methods will work. To prevent serious rescuer injury, it is critical that rescuers not be positioned in front of or on the down hill side of a moving load. If the situation permits, do **not** attempt to stop a load that is out of control. Stay clear of it. The load will roll off the pipes and ground itself.

Equipment to Move Loads

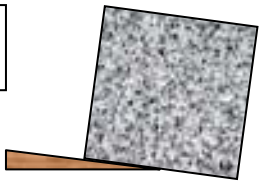
A load may be moved with a come-along, mechanical advantage pulley system, or by using Class 2 levers.

EVOLUTION #1

Raise, Stabilize, Rotate, and Lower A Single Heavy Object

The students will raise, stabilize, rotate, and lower a heavy object. The students will be required to perform size-up, build appropriate crib beds to support, receive, and stabilize loads. The students will need to use both Class 1 and 2 levers to complete the exercise. The students will practice building and adjusting crib beds to the changing angle of an object being raised and lowered. The students will also be limited to cribbing the face of the load from end.

STEP 1



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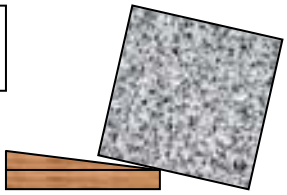

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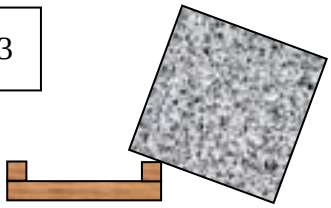

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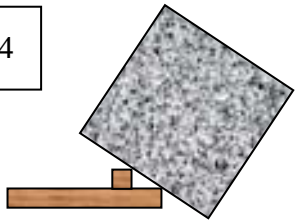
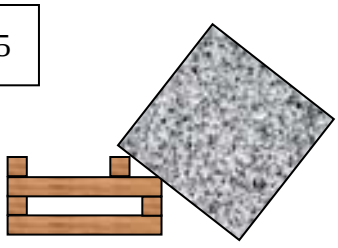
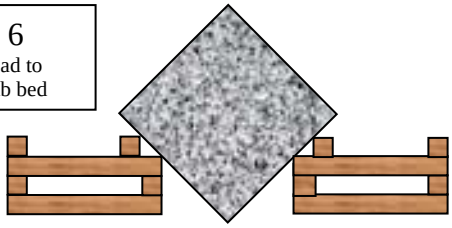


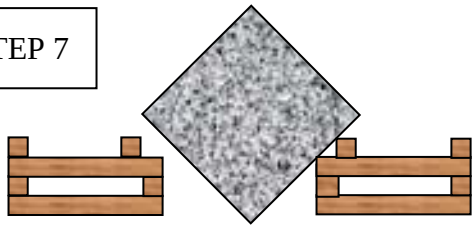
STEP 5



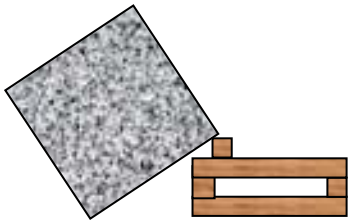
STEP 6
Transfer load to adjacent crib bed



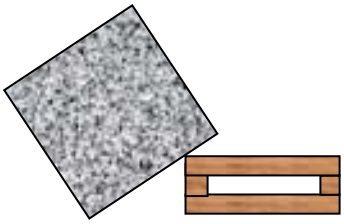
STEP 7



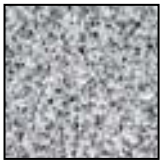
STEP 8



STEP 9



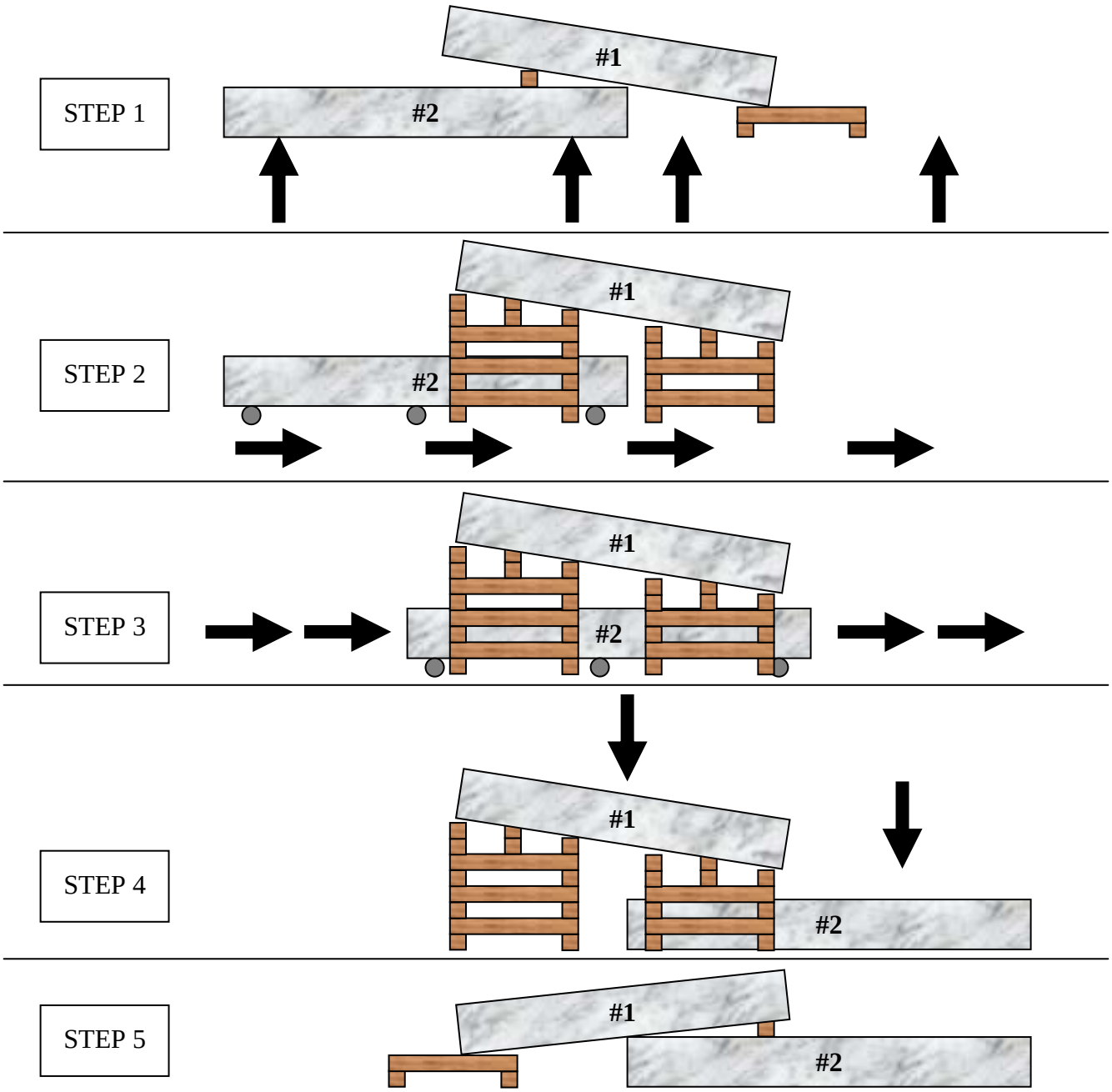
STEP 10
Continue to remove layers of cribbing until block is grounded



EVOLUTION #2

Raise, Stabilize, Move, and Lower Multiple Heavy Objects

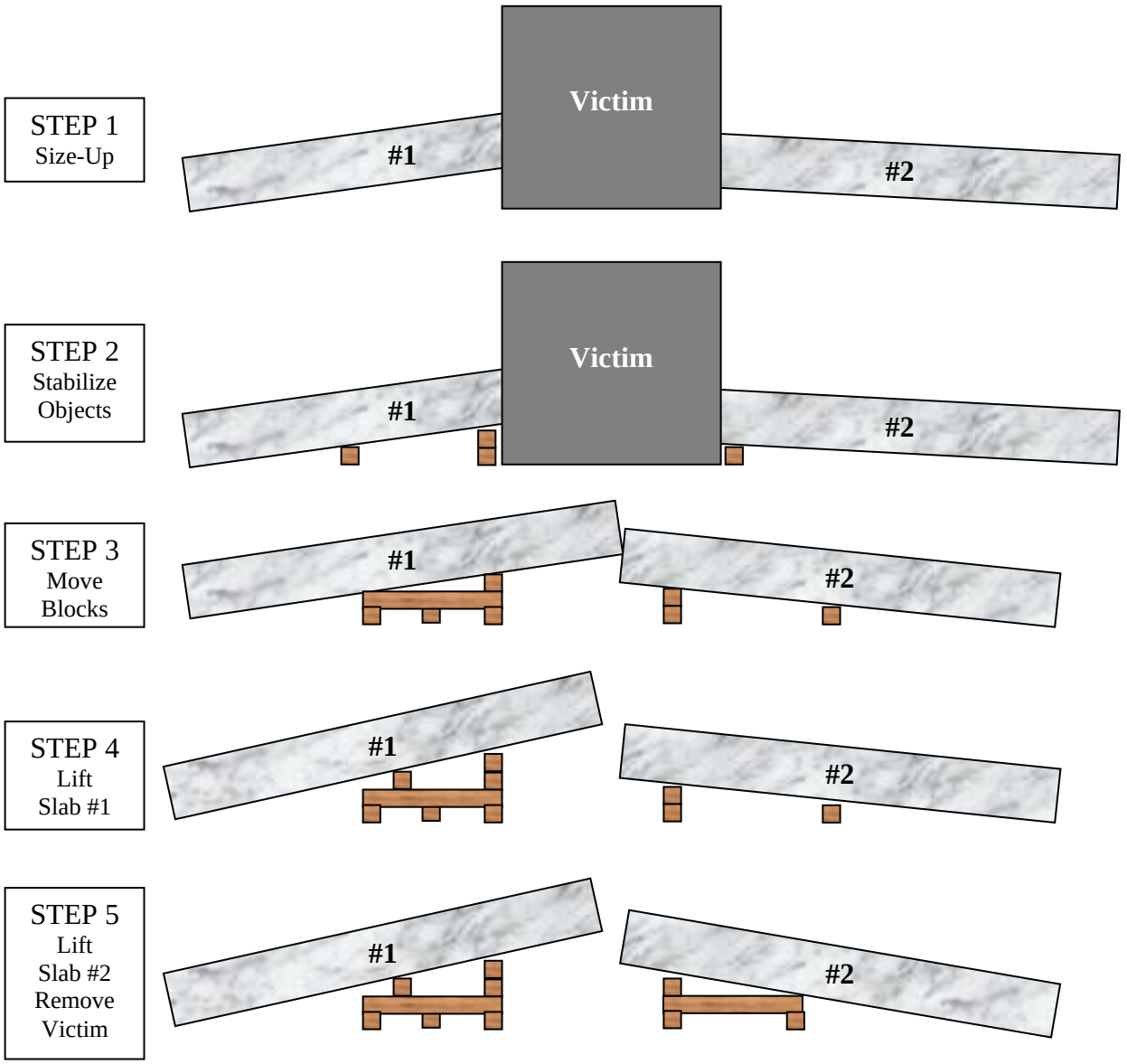
The students will raise, stabilize, move, and lower multiple heavy objects. The students will be required to perform size-up, build appropriate crib beds to support and stabilize loads. The students will need to use both Class 1 and 2 levers to complete the exercise.



EVOLUTION #3

Raise, Stabilize, Move, and Lower Multiple Heavy Objects While Safely Managing and Extricating A Victim From Under the Objects

The students will manage and extricate a victim trapped under multiple heavy objects. The students will lift, stabilize, move, and lower multiple heavy objects. The students will be required to perform, size-up, build appropriate crib beds to support, raise, and stabilize loads. The students will need to use both Class 1 and 2 levers to complete the exercise. The students will practice building and adjusting crib beds to the changing angle of an object being raised and lowered. The students will also be limited to cribbing and lifting from the ends of the void space.



CHAPTER 20 - BREAKING AND BREACHING

Rescue activities at a structural collapse site may require rescuers to force entry through walls, floors, and roof structures in order to gain access to travel corridors, basements, collapse voids, and other areas to search for and rescue trapped victims. Personnel who perform breaking and breaching operations should have an understanding of the structure components and how they are attached and the various tools and techniques required for this operation.

Breaking and breaching discussed in this course will focus on light-frame construction materials such as wood and light gauge metals, unreinforced masonry such as brick veneer, and reinforced masonry such as a cinder block wall.


Figure 20.1

TOOLS AND EQUIPMENT

Breaking and breaching operations will require rescuers to use a variety of hand tools and power tools. Persons performing this work should be familiar with the manufacturer's operating procedures for the power tools used. Personnel should practice and train with these tools in order to become proficient in their use.

Tools and equipment available for breaking and breaching at the US&R Light Operational Level are primarily hand tools that include hammers, handsaws, hack saw, pry bars, crow bars, chisels, hand-held mauls, sledge hammers, bolt cutters, axes, shovels, hydraulic bottle jack and steel pickets. The only power tool is a chain saw. Other hand tools to consider are wire cutters, tin snips, and utility knives.

Power tools **not** included at the US&R Light Operational Level useful for breaking and breaching through a variety of materials found in lightweight building construction include power rotary saws, electric drills, electric saws, hydraulic spreaders and cutters, and pneumatic chisels. Operators must be familiar with the capabilities of these tools and review the safety guidelines established by the manufacturer prior to use.

A pre-operational check of fluid levels, tightness and condition of drive belts and chains, blades, cutting chains, and guide bars should be performed before startup.

LIGHT-FRAME STRUCTURE DESIGN

Foundation

The foundation of a light-frame structure will be either a flush foundation on a concrete slab or a raised foundation on a cripple wall. The cripple wall can be constructed with lumber or masonry materials and may not be secured to the foundation if build before the late 1960s.

Floors

Floor joists support the floor assembly and floor finish materials. Floor joists are usually located every 12" or 16" on center. Floor finish or covering materials may include wood lath, plywood with 1½"-2" thick concrete, carpet, ceramic tile, and linoleum.

Walls

Studs provide support to the upper floors or roof assembly. Wall studs are usually located every 16" on center. Walls are covered with materials such as stucco, lath and plaster, sheet rock or dry wall, or thin paneling. The perimeter walls are usually load bearing, meaning they help to hold up the roof or second floor. Some interior walls are also load bearing and should be checked before cutting any structural members.

Roof

Joists provide support to the perimeter frame and roof covering material. Roof joists are usually located every 16"-24" on center. Roof covering materials include lightweight items such as wood and asphalt shingles, or heavy items such as clay tile or slate.

LIGHT-FRAME CONSTRUCTION MATERIALS

Rescuers must be prepared to safely cut through a variety of construction materials, including:

- Wood
  - Dimensional lumber usually includes a thickness of 2", 4", and 6" with widths of 4", 6", 8", and 12"
  - Plywood thickness includes ½", ¾", and 1⅛" used on floors, shear walls and roofs
- Light gauge aluminum
  - Doors, wall studs, and sheeting

- Light gauge steel
  - Doors and sheeting
- Wood lath and plaster
- Drywall, sheet rock, or gypsum board
- Stucco on wire stucco lath
- Unreinforced masonry
  - Brick veneer and chimney
- Reinforced masonry
  - Cinder block wall and cripple wall
- Lightweight concrete
  - Used for sound insulation and moisture protection on floors and is usually 1½"-2" thick

SAFETY CONSIDERATIONS

Safety considerations should be followed when using any tools. Personal protective equipment such as helmet, eye protection, hearing protection, respiratory protection, safety boots, long sleeve abrasion resistant clothing and gloves should be used consistently. Operators should work within the capabilities of the tool and use the right tool for the job properly. Use and store fuel safely in approved containers. Maintain good ventilation in areas where gas-powered tools are used. Keep aware of your surroundings and continually look for tripping hazards, know the location of other rescuers, maintain firm control of tools at all times, and do not make abrupt turns or movement that could endanger yourself, other rescuers or victims.

When using electrical power tools, care must be taken to avoid crushing or cutting the power cord. Make sure to keep power cords out of pools of water or other liquids.

Rescuers should have a good understanding of the capabilities and limitations of the available tools. Basic hand tools and power tools work well breaking through light-frame building materials, but they will have limited use on unreinforced masonry buildings, and very little success breaching through concrete buildings.

BREAKING AND BREACHING OPERATIONS

Rescue teams need to take the time before beginning operations to evaluate the area any breaking or breaching takes place. They need to determine the collapse potential of the area, what material needs to be cut, and whether the material to be cut supports other objects and will your actions cause additional collapse.

Consider all possible entrances into the structure or void space before starting the breaching operation. There may be a faster or safer way in through natural openings, such as doors or windows, or openings created by the collapse.

Do not break blindly through walls, floors, or the roof. To do so may cause additional injuries to trapped victims or further collapse. Remove floor, wall, or roof finish materials or coverings before cutting the structural elements. Avoid cutting electrical wires and plumbing, if possible. Cut small inspection holes first to check for anyone or anything in close proximity to where the cut is being made.

Work carefully so that building debris is not dislodged during breaching operations. Install shoring systems to stabilize the site before, during, and after a breaching operation if you determine it to be necessary during your assessment.

When removing loose debris from the void space or rescue site, remove smaller pieces first before removing large items. Large pieces of debris may be acting as supports for other structural elements.

Breaking and breaching operations in light-frame buildings may require intricate and difficult hand tool usage to cut through normal household items that are blocking rescuer access or entrapping the victim. These items may include box springs, mattresses, bed linen, appliances such as refrigerators and stoves, carpets and other floor coverings, and furniture such as file cabinets and chest of drawers. Touching nylon or latex clothing materials with the running blade of a chain saw will immediately cause the material to become jammed in the chain and drive gear.

Rescue operations may require the use of hand tools and power tools in very confined areas and may be forced to operate these tools in very difficult positions such as lying on their back, upside down, and lying on their side.

It is acceptable to cut through the walls, floors, and roof of light-frame construction. Interior and exterior structural elements work together to form a stable skeleton that will support holes being cut. Breach finish materials and coverings by initiating openings adjacent to the studs and joists to minimize vibration. Remove one stud and joist after finish materials have been removed. Use extreme caution if required to remove more than two adjacent studs or joists of load bearing walls and floors. Shoring should be considered and installed before cutting and removal of more than two studs or joists.

Breaking masonry and lightweight concrete is best accomplished by enlarging the cracks and fractures caused by the collapse. If no cracks are present, the rescuer should attack the cement joints on the brick veneer and the cells of the cinder block. Remove any loose masonry and concrete from around any reinforcing bars (rebar) and cut or bend out of the way. Enlarge breaching holes by breaking the masonry and concrete away from the edges of the initial hole.

Breaking and breaching operations will be time consuming, labor intensive and can be very frustrating.

SHAPE AND SIZE OF BREACHED OPENINGS

The shape and size of a breached opening will be dependent on the intended use of the hole. Minimum shapes and sizes to allow access of a rescuer wearing proper personal protective equipment have been determined.

Square

Square openings should be 24"x24" minimum. This will provide access for a rescuer and a victim secured to a backboard or wire basket stretcher. It requires four cuts and is not recommended for masonry walls due to reducing the strength at the top of the opening.

Figure 20.2
Square Opening

Figure 20.3
Triangle Opening

Triangle

Triangle openings should be 36"x36"x36" minimum. This will provide access for a rescuer and a victim secured to a backboard or wire basket stretcher. It requires only three cuts and is recommended for masonry walls by not reducing the strength at the top of the opening.

Circle

Circle openings should be 24" diameter minimum. This will provide access for a rescuer and a victim secured to a backboard or wire basket stretcher. It is usually created by enlarging the outer edge of an opening with a sledgehammer or hand maul and is acceptable for masonry walls by not reducing the strength at the top of the opening.

Figure 20.4
Circle Opening

OTHER GENERAL CONSTRUCTION CATEGORIES

During a rescue operation or large incident with limited resources, it may be necessary for rescuers to break and breach construction materials other than light-frame construction. Some general guidelines to follow are:

Heavy Wall Construction

Unreinforced Masonry

Rescuers should avoid cutting through walls. Breaching through unreinforced masonry walls may cause additional collapse or building instability. Instead, rescuers should look for existing natural or created horizontal openings. Rescuers can safely force entry through floors and/or roof sections.

Reinforced Masonry and Concrete Tilt-Up

It is possible to cut through these walls, although they may be 5"-8" thick, which make basic hand tools and power tools almost useless. Reinforcing bars within the concrete will add additional difficulty for rescuers trying to break through. Rescuers should use existing openings in these structures to gain entry whenever possible.

Heavy Floor Construction

It is possible to cut through these walls and floors, although they may be 5"-8" thick, which make basic hand tools and power tools almost useless. Reinforcing bars within the concrete will add additional difficulty for rescuers trying to break through. Rescuers should use existing openings in these structures to gain entry whenever possible.

Precast Concrete Construction

It is possible to cut through wall panels and floors only after assessing the stability of the panel and its connection to the main structure. The concrete floor panels may be 5"-8" thick with metal reinforcing bars or post and pretensioned cables. Cutting these cables can be extremely dangerous and can cause further collapse or injury to the rescuers if certain precautions are not taken. Again, basic hand tools and power tools are very ineffective in attempting to force through this construction. Horizontal entry should be gained through existing openings.

CHAPTER 21 - LADDER RESCUE SYSTEMS

During most disasters, there will be many victims and not enough equipment or rescuers to go around. Rescue from elevated structures will have to be done quickly and efficiently while maintaining a good safety margin for both the rescuers and the victims.

Fire service ladders can be used in a number of ways to move victims quickly and safely, with a minimum of technical knowledge or additional equipment.

The six common ladder rescue systems:

1. Ladder gin
2. Ladder "A" frame
3. Moving ladder slide
4. Ladder slide
5. Exterior and interior leaning ladder
6. Cantilever ladder

All of the ladder rescue systems shown can handle one-person loads safely if rigged properly and used carefully but are not intended for two-person loads.

MECHANICAL ADVANTAGE SYSTEM

A 2:1 mechanical advantage "ladder rig" is attached to the top of the ladder system at the midpoint of the guy line or ladder sling.

BELAY LINE

Option 1

The belay line should go from the tandem prusik belay, along the ground, and into the hole/opening. If the ladder system fails, the belay will not have to fall that distance, thereby preventing any additional shock forces on the belay. This reduces the fall factor if the belay is activated.

The anchor point for the belay line should be located at least 20' from the opening. Situations may arise where a high method directional change in belay will need to be made, which will require careful planning and rigging considerations.

Option 2

Another method used to incorporate a belay line into the system is to use the base of the ladder as an anchor point. This is done by placing a simple ladder sling around the base of the ladder and bring the webbing up between rungs one and two. Attach the load-releasing hitch and tandem prusiks to the webbing. Attach safety rope into system and place the working end of the rope over the top rung or through a carabiner on an independent ladder sling to change the rope's direction at the top of the ladder.

LOW METHOD

PROS	CONS
Placement	Leverage - Difficult to Raise Line When Loaded
Independent	Edge Protection
Fall Factor	Second Anchor Needed

HIGH METHOD

PROS	CONS
Leverage - High Point	Fall Factor
Limited Edge Protection	System Dependent
No Second Anchor Point	Placement
Self-Contained	

Anchor Points

Anchors can be either artificial, such as pickets or vehicles, or natural, such as trees and large rocks. Only two anchors are needed, one on either side located a distance equal to three times the height of the top of the ladder gin and "A" frame. The guy lines are attached to the anchors and are adjusted and tied off using a modified trucker's hitch.

Another method of attaching and adjusting the guy lines is to use a prusik hitch. Tie a three-wrap prusik hitch to the guy lines and attach the prusik sling to the anchor. The guy lines can be easily adjusted by sliding the rope through the prusik hitch. If the prusik hitch is used it must be backed up with a figure eight on a bight.

Anchor points for the ladder gin should be no more than 45° off centerline for the ladder. Anchor points for the "A" frame need to be in a straight line from one side of the opening to the other so system torsion if minimized.

LADDER GINS

A ladder gin is an upright ladder, supported at the top to keep it in a near-vertical position. When a mechanical advantage (pulley) system is added it creates a machine for hoisting equipment, rescuers, or victims.

It can be a very useful rescue device. It requires a minimum of equipment and has numerous applications. It can be constructed in an open field to gain access to open pits, wells, vertical shafts, or utility vaults. It can be built against a building, a vehicle, a curb, or it can be built to extend out a window or off a roof.

- A ladder gin needs to be rigged at the proper climbing angle of 70° in order to support the maximum load

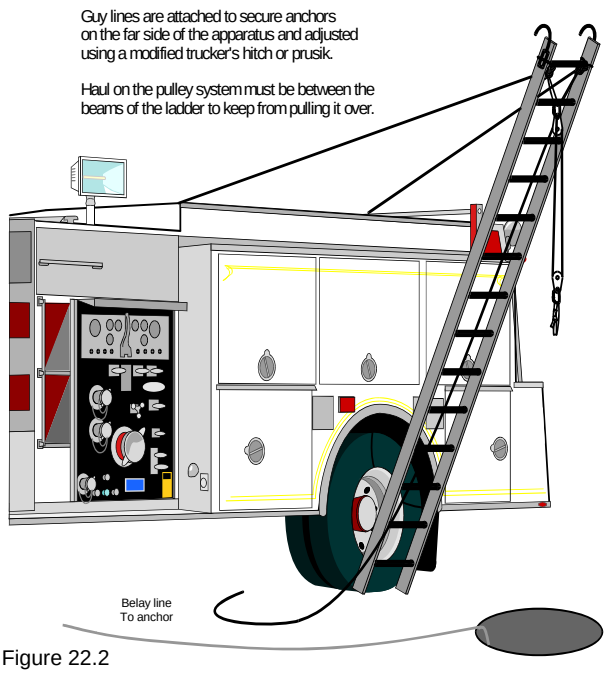
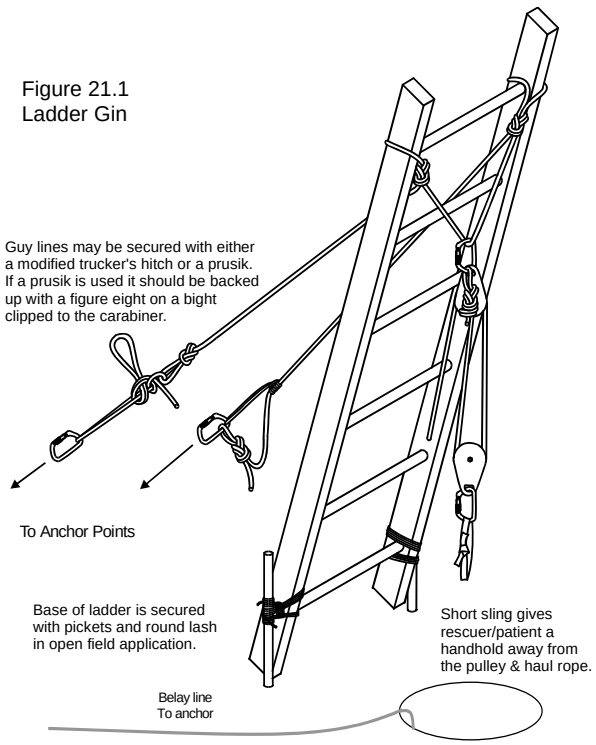


Figure 22.2
Ladder Gin Against A Vehicle

Figure 21.1
Ladder Gin



- All loads must be kept within the ladder beams, since a ladder gin will not accept side loading
- The guy lines are intended to support the ladder and not the load; the ladder beams support the load.

An improper angle, too much weight, improper rigging, or side loading can cause a ladder gin to fail.

A change of direction pulley located on an independent anchor at the foot of the ladder will allow hauling team personnel to move to one side and give them more room to work. This change of direction pulley must be secured to a good anchor so that the force of hauling on the load does not dislodge the base of the ladder or side load the system.

Components of a Ladder Gin

Ground Ladder

A ground ladder must satisfy NFPA standards for fire service ladders (Standards 1931 and 1932) in annual testing and regular, routine maintenance. A 12'-16' straight ladder works best. Extension ladders can also be used when maximum extended height is kept as short as possible.

Guy Lines

Guy lines are rigged from a single lifeline rope, since the main hauling system is attached to the center of this line. Guy lines hold the ladder at or near the 70° climbing angle when the gin is loaded. A guy line rope should be a minimum of 150' long. The guy lines run from the top of a ladder at about a 45° angle to the anchor points in order to create the best support. Guy lines are rigged by tying two figure eight on a bight knots with 12" bights. These knots are tied 12"-18" from either side of the rope's center point, depending on the width of the ladder from beam to beam. Key point: Tie the knot at a distance from the center of the rope that will keep the attachment point angle less than 90° degrees. The bights are placed under the top rung from the backside of the ladder and then looped over the tips.

Lashing

Lashing is used to bind two or more objects together by wrapping and frapping turns using ½" diameter rope or 1" tubular webbing. Lashing is started and finished with one round turn and two half hitches or using a clove hitch. There are two methods of lashing, round lashing and square lashing. Round lashing consist of six or more wraps and two or more fraps. Square lashing consist of four or more wraps and the same number of fraps.

When lashing ladders together or baskets to ladder rungs, only the wrapping portion of the round lash is used. In these applications, surface area contact is desired.

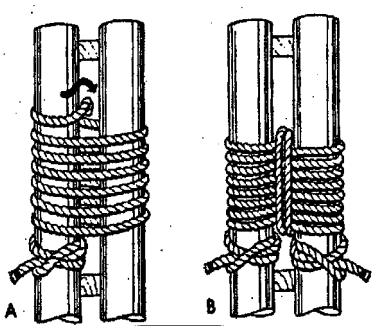


Figure 21.3
Round Lashing

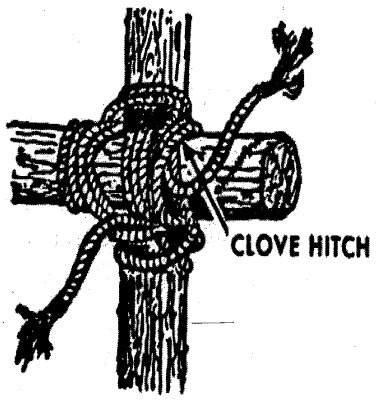


Figure 21.4
Square Lashing

LADDER "A" FRAMES

Ladder "A" frames are very versatile rescue tools. They are easy to set up, easy to operate, and unlike the ladder gin, they can be portable depending on the application. They can be used for high points to access utility vaults, wells, narrow pits, vertical shafts, tanks, and vessels.

- Rig both ladders at 70° angles.
- Keep the load between the ladder beams.
- Raise the load only as high as needed to clear the opening.

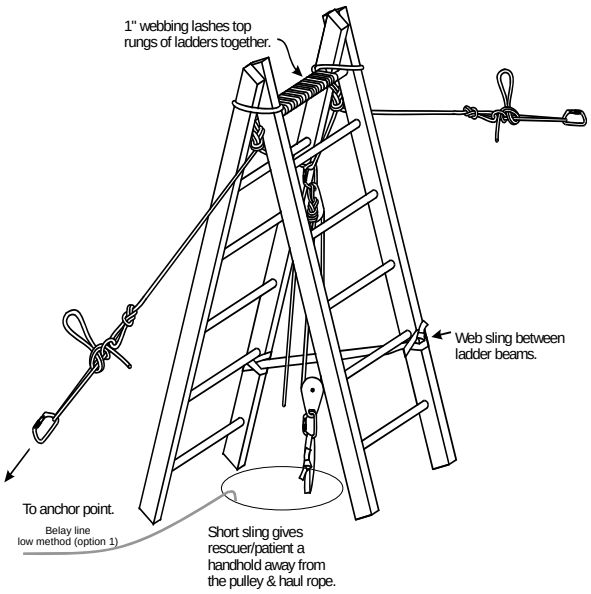


Figure 21.5
Ladder "A" Frame: Ladders of Equal Length

Components of A Ladder "A" Frame

Fire Service Ladders

Two ladders are required. Ladders of equal or unequal length can be used, and extension ladders up to 35' can be used. They need to satisfy NFPA standards for fire service ladders (Standards 1931 and 1932) in annual testing and regular, routine maintenance. Ladders are tightly lashed together at the top using the round lash without the frapping. Once erected, a 20' webbing is tied at the base of each ladder to maintain the 70° climbing angle.

Guy Lines

The guy lines are rigged from a single life safety rope. It is used to stabilize the ladders and to prevent side-to-side movement. The mechanical advantage pulley system is also attached to the guy line as in the ladder gin. The guy line needs to be long enough to extend out to anchors that are located a distance equal to three times the height of the ladders on both sides of the A frame.

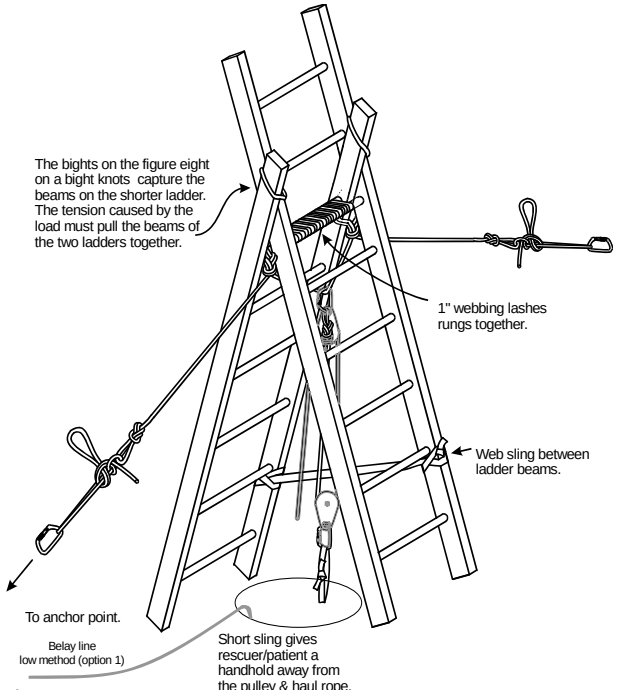


Figure 21.6
Ladder "A" Frame: Ladders of Unequal Length

SIX METHODS OF USING FIRE SERVICE LADDERS

1. Moving Ladder Slide

A rescue litter can be attached to a short roof or straight ladder to create a simple rescue tool. The ladder gives the rescue team an added reach and leverage to help pass a victim up or down and over obstructions that are no higher than the ladder being used. This eliminates the need to construct elaborate rope rescue systems to raise or lower a victim the distance of one floor level or up a short vertical cliff. The rescue litter is attached at the butt end of the ladder by lashing the foot of the rescue litter to the first rung of the ladder and the head of the rescue litter to a corresponding rung. Nylon webbing is used to form round turns from the litter rail to the ladder rungs.

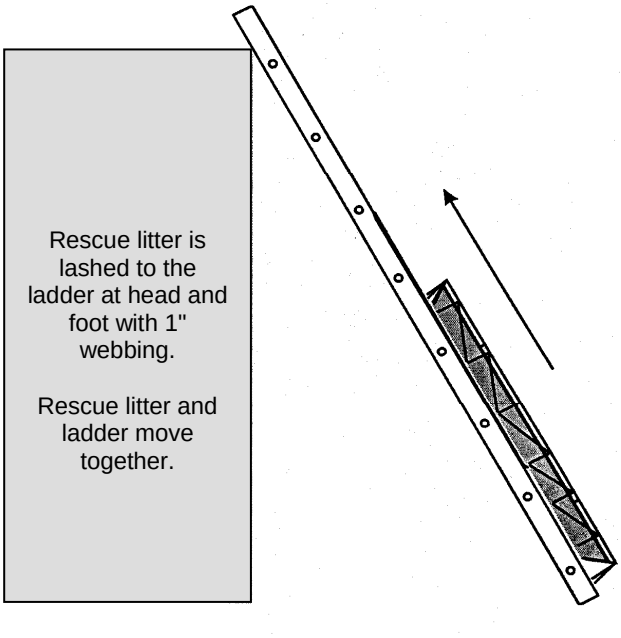


Figure 21.7
Moving Ladder Slide

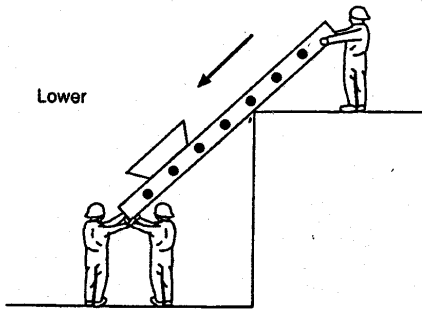
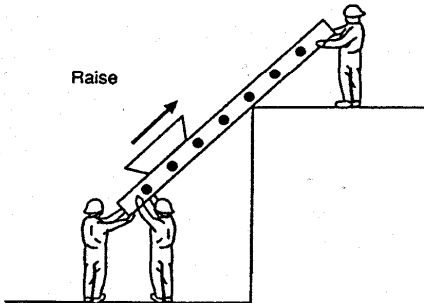


Figure 5.1.8



In the case of the moving ladder slide, no belay is necessary. The ladder with rescue litter attached is passed from hand to hand and no ropes are used.

2. Ladder Slide

A ladder slide is a very useful tool and can be used with any length of ladder. The ladder serves as a guide and supports a large portion of the weight of the victim being lowered. It eliminates the need for elaborate rope rescue systems and turns a high-angle rescue into a low-angle rescue.

A victim in a rescue litter can be raised using a simple 2:1 pulley system, or can be lowered using a friction system. If a victim needs to be lowered from an upper floor of a building and a ladder is available that will reach to the window, a ladder slide is the quickest and easiest method of evacuation.

The belay line on the ladder slide should be attached to a separate anchor point, if possible, and managed with a tandem prusik belay and load-releasing hitch.

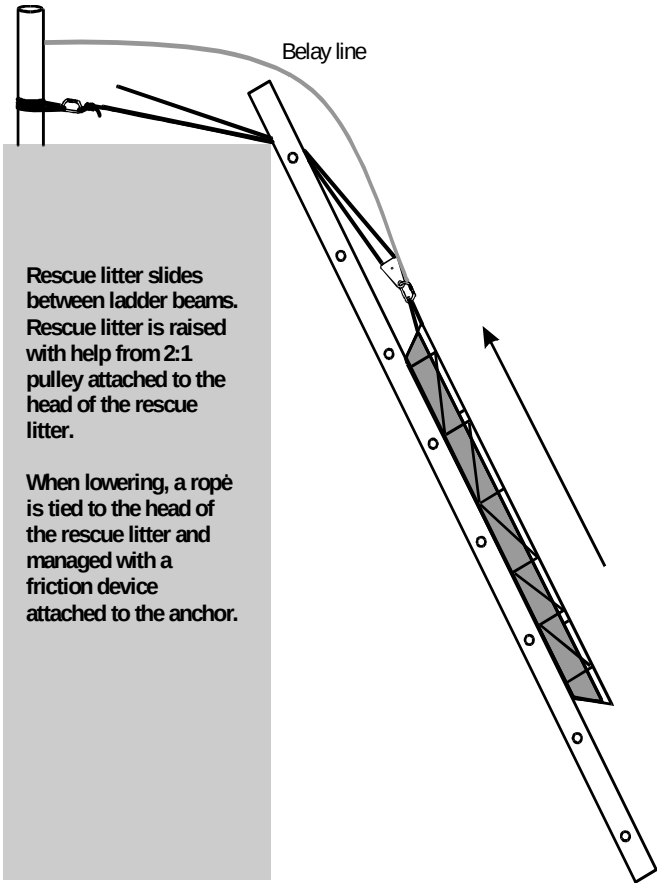


Figure 21.10
Ladder Slide

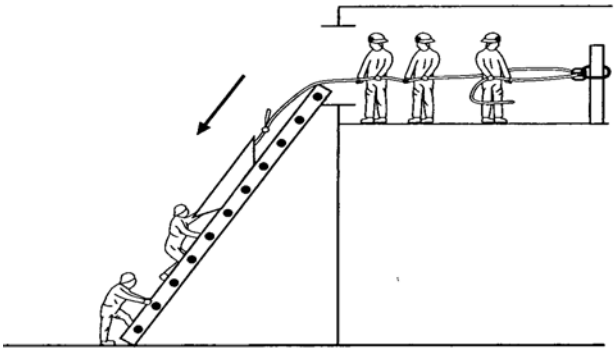


Figure 21.11

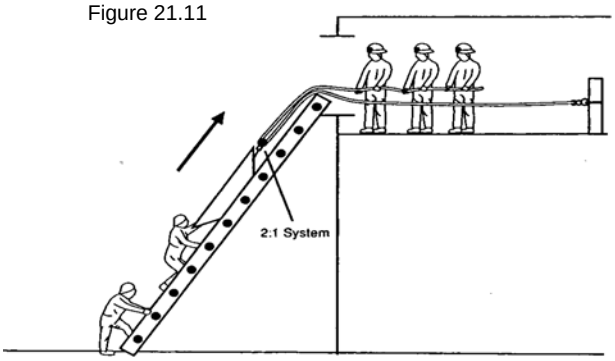


Figure 21.12

Ladder slides should be used when the distance from the victim and the rescuers is within the length of the ladder and the rope to be used. Ladder slides are very efficient when several patients need to be moved from one elevation to another.

3. Ladder Slings

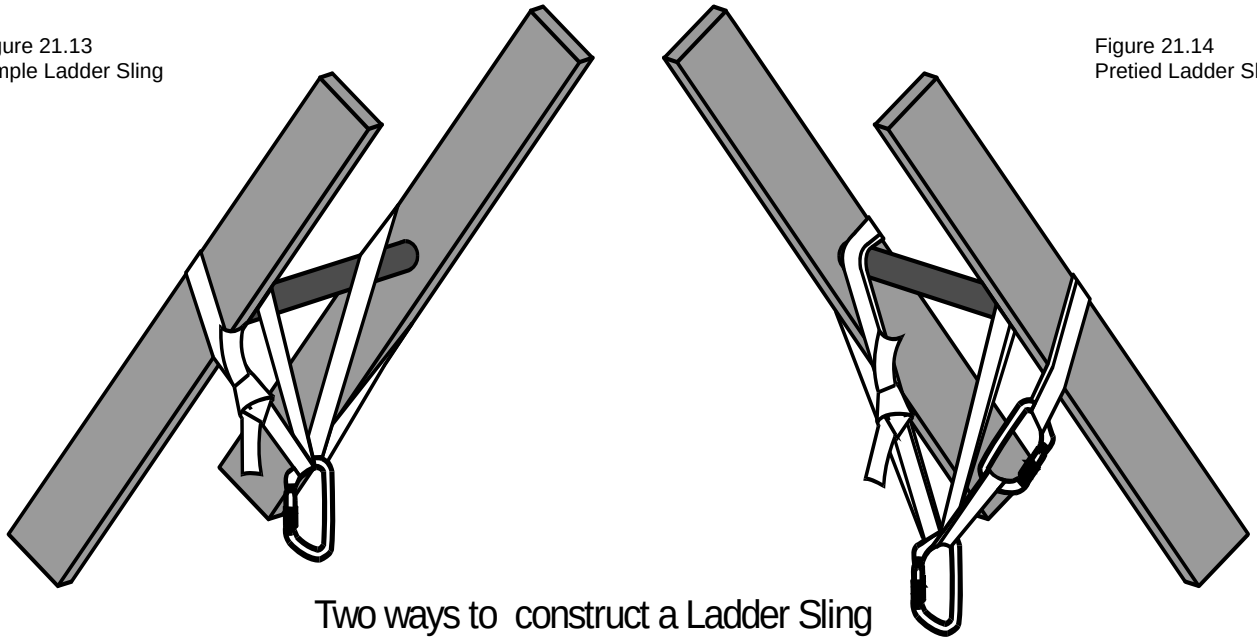
Fire service ladders can provide high anchor points and directional changes for rope rescue systems. Ladder slings provide a secure and convenient method of attaching rope rescue systems to ladders.

A ladder sling is made from 1" tubular webbing in either 12' or 20' lengths. The webbing is wrapped around the ladder and over a rung to create a hanging loop of doubled webbing. There are two ways to tie a ladder sling. One is tied around the ladder, "simple ladder sling," and the other is a "pretied" and then wrapped around the ladder.

To tie a simple ladder sling, a 1" length of webbing is wrapped around both beams of the ladder and the ends are tied together with an overhand bend. The loop can now be positioned by either climbing the ladder, such as in an exterior leaning ladder system, or sliding it into position, such as with an interior or cantilever ladder system. After reaching the position of use, pull both sides of the webbing through the ladder, between the beams, and between the rungs of the ladder. Attach a carabiner to the sling, making sure to capture both sides of the loops.

Figure 21.13
Simple Ladder Sling

Figure 21.14
Pretied Ladder Sling



Two ways to construct a Ladder Sling

A "pretied" ladder sling uses a 20' length of webbing that is tied into a loop with an overhand bend. The loop and two carabiners are then taken to the position of use on the ladder. The "pretied" ladder sling is attached to the ladder by wrapping both bights around the ladder, capturing both beams, and above the rung where the sling will rest. Connect the bights with a carabiner, and pull both sides of the webbing through the ladder, towards the side of use. Attach a carabiner to the sling, making sure to capture both sides of the loops. After attaching either the "pretied" or the "simple ladder sling," you must ensure that the overhand bend knot or the carabiner attaching the bights of the pre-tied sling are positioned, so as not to bind with the ladder beams or interfere with the carabiner that attached the rope system to the sling. Also ensure, that the critical angle of the sling is 90° or less.

4. Exterior Leaning Ladder

An exterior leaning ladder will create an anchor point that will allow access to every floor below the tip of the ladder without repositioning the ladder. If several floors have victims who need to be evacuated and a long enough ladder is available, then an exterior leaning ladder should be considered. Either belay line option can be utilized for the exterior leaning ladder.

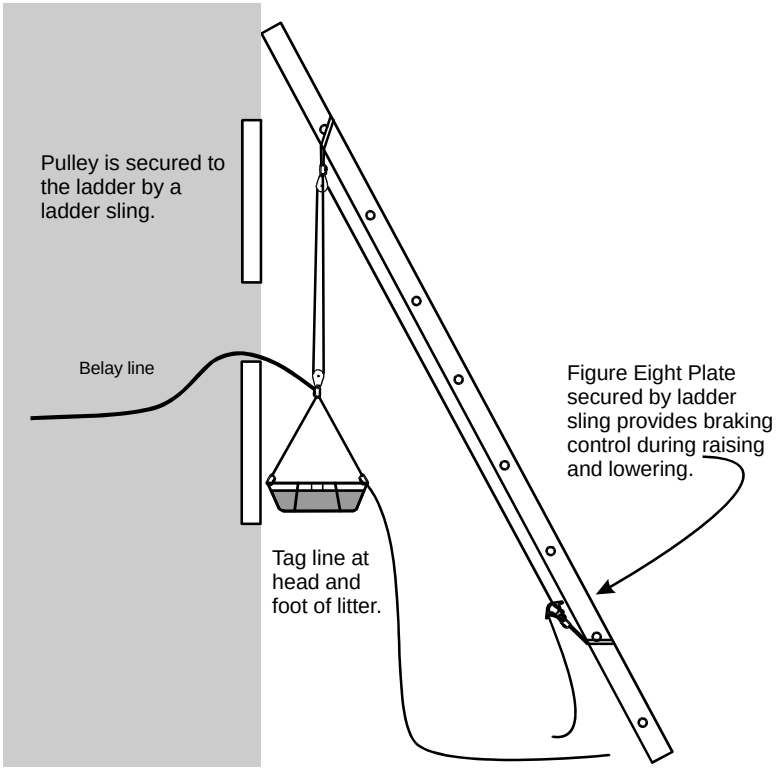


Figure 21.15
Exterior Leaning Ladder

Exterior leaning ladders should be used when the location of the victim is below the length of a long ladder, and there is not enough available personnel for a ladder slide system. This system allows the rescue team to set up the ladder in one location and access or evacuate every floor below the top of the ladder.

5. Slinging a Spar

During a major disaster it may be necessary to construct a rescue system out of debris. The ability to use a 4"x4" piece of lumber or a piece of steel pipe as a spar, and the ability to sling it in order to attach equipment, will be of great use to the rescuer. A slung spar, when done correctly, will create a solid anchor point that can be used inside of a structure to lower victims from upper floors. If a fire service ground ladder is available, it can be used like a spar also.

Slinging a spar requires the rescuer to:

1. Obtain a suitable spar, either a 4"x 4" x approximately 8' piece of lumber (preferably Douglas fir), or a 1½" diameter, schedule 40 or greater piece of steel pipe, approximately 8' in length.
2. Lean the spar against the structure at a 70° climbing angle.
3. Sling the top and bottom of the spar with 12' pieces of webbing, by using the three-wrap prusik hitch.

4. The webbing should be located no more than 12" from each end of the spar.
5. When wrapping is completed, the eye of the webbing should be approximately 6" long.
6. Attach two carabiners to each sling.
7. These will be used for friction to lower the victim(s).
8. Tie a figure eight on a bight in one end of a rescue rope and clip the running end of the rope through one of the carabiners in the top sling.
9. Reeve the standing ends of the rope through both carabiners that are attached to the bottom sling and lock their gates.
10. Clip the standing end of the rope through the remaining unused carabiner attached to the top sling and lock the carabiner creating a 1:2:1.
11. Set up belay system from a different anchor, but on the floor of departure of the victim.
12. The system should be safety checked and then operated.

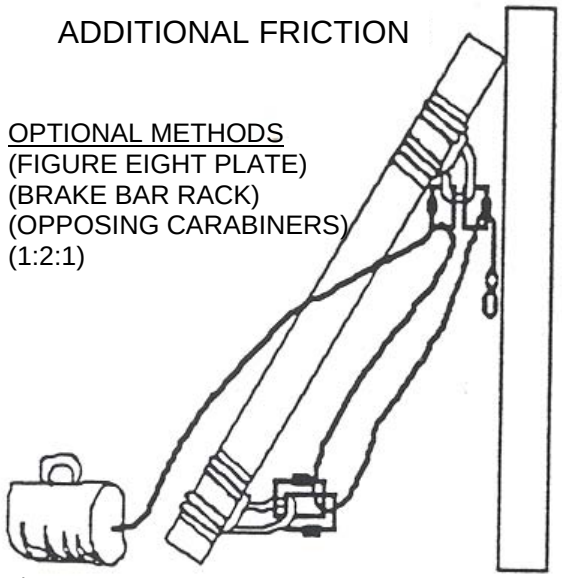


Figure 21.16
Slinging a Spar

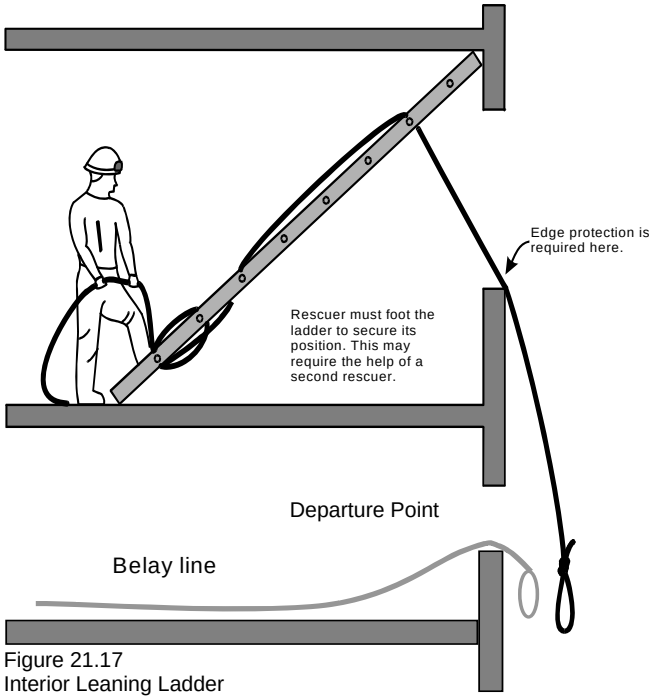


Figure 21.17
Interior Leaning Ladder

6. Interior Leaning Ladder

An interior leaning ladder will create a solid anchor point inside a building that will allow rescue teams to access every floor below them. A roof ladder is wedged between the ceiling and the floor and footed to maintain its position. Unlike an exterior leaning ladder, the only limitation is the length of your rope. The rope is reeved around the ladder rungs for friction. Start with a figure eight on a bight tied in the end of the rope. Pass the knotted end of the rope under the bottom rung and up between the second and third rung. Pass the rope around the bottom rung again then up between the second and third rung. Next pass the rope down between the first and second rung from the top of the ladder. The higher this directional change is, the better. The rope should be positioned so that it runs next to one of the ladder beams

since the rungs are stronger there. For wood ladders, use the fractioning carabiner method of reeving the rope as illustrated in Figure 21.18.

A separate anchor point is used for the belay line on the interior leaning ladder. The belay line should pass out the window and not be reeved through the ladder. Again, a secure anchor, tandem prusik belay, and load-releasing hitch manage the belay. This should be at or above the departure level, never below.

An interior leaning ladder can be used to create an anchor point for lowering patients or rescuers out of a window opening or from any level directly below the ladder position. The only limit is the length of the rope.

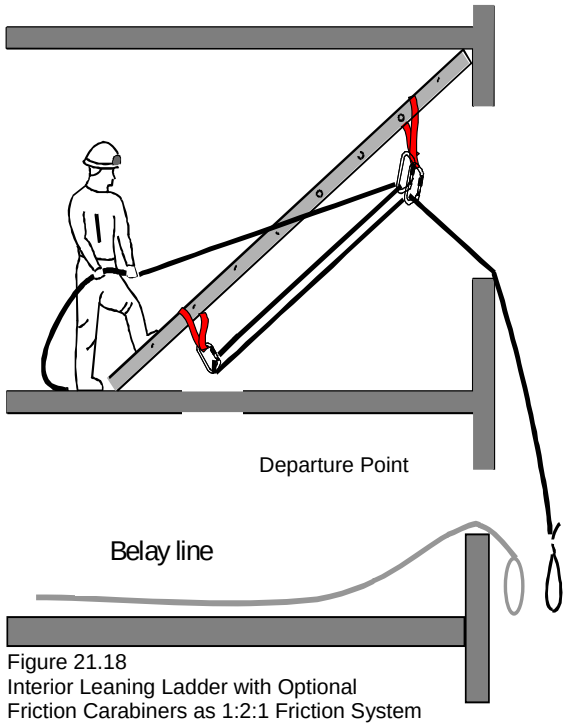


Figure 21.18
Interior Leaning Ladder with Optional Friction Carabiners as 1:2:1 Friction System

7. Cantilever Ladder

Cantilever Ladder (Ladder as Friction)

A cantilever ladder creates an anchor one floor above the point from which the rescue team needs to work. By placing a fire service ladder over a parapet wall, a windowsill, or roof edge a very strong anchor point is created as long as these basic rules are followed:

1. The directional change of the rope or ladder sling on the ladder should be no more than one rung beyond the edge upon which ladder beams rest
2. A counterweight rescuer must be in place, with his/her weight on the butt end of the ladder
3. The counter weight rescuer must not move off the ladder until directed to do so by the team leader, and only after the load is off the ladder.

The cantilever ladder will have the belay line anchored on either the roof or floor that the ladder is on, or on the floor the litter is being passed from. A secure anchor, tandem prusik belay and load-releasing hitch are used.

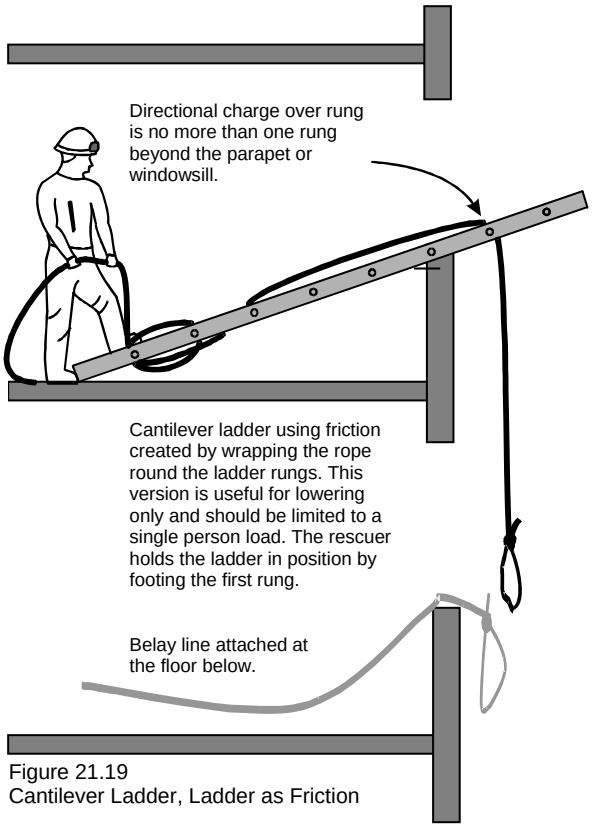


Figure 21.19
Cantilever Ladder, Ladder as Friction

Cantilever Ladder (With Pulley System)

A cantilever ladder creates the same type of anchors when used on flat roofs or floors with no walls or raised edges.

1. The ladder sling on the ladder should not be more than one rung beyond the edge upon which ladder beams rest.
2. The ladder rig pulley system is attached to the ladder sling.
3. A counterweight rescuer must be in place, with his/her weight on the butt end of the ladder.
4. The counterweight rescuer must not move off the ladder until directed to do so by the team leader, and only after the load is off the ladder.

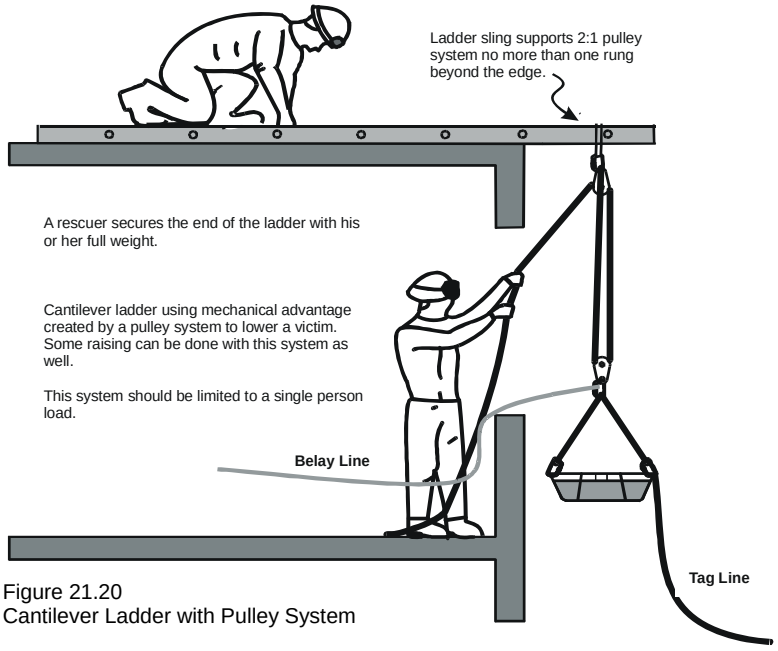
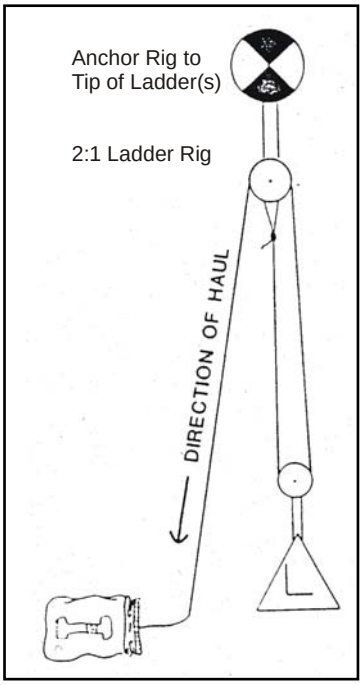


Figure 21.20
Cantilever Ladder with Pulley System



The cantilever ladder is used to create an anchor point above the floor that the rescue team is working from. It is used when the distance from the victim to the rescuers is farther than the length of the ladders, but is within the length of the rope being used and an interior leaning ladder or other suitable anchor is not readily available.

The cantilever ladder does not work as an anchor point if the rescue team has to lower a victim from the level on which the cantilever is set up. It is only designed to provide an anchor point at a location above the position from which the rescue team wishes to work.

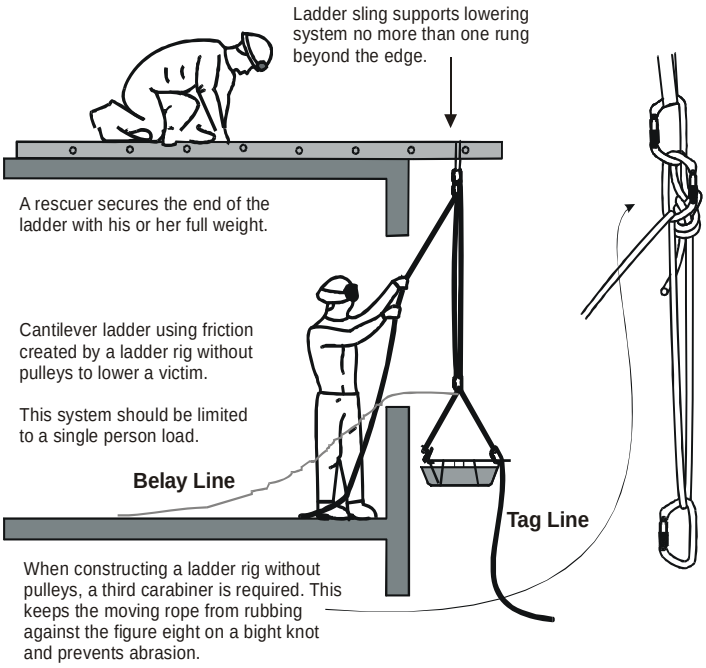


Figure 21.21
Ladder Rig Pulley System

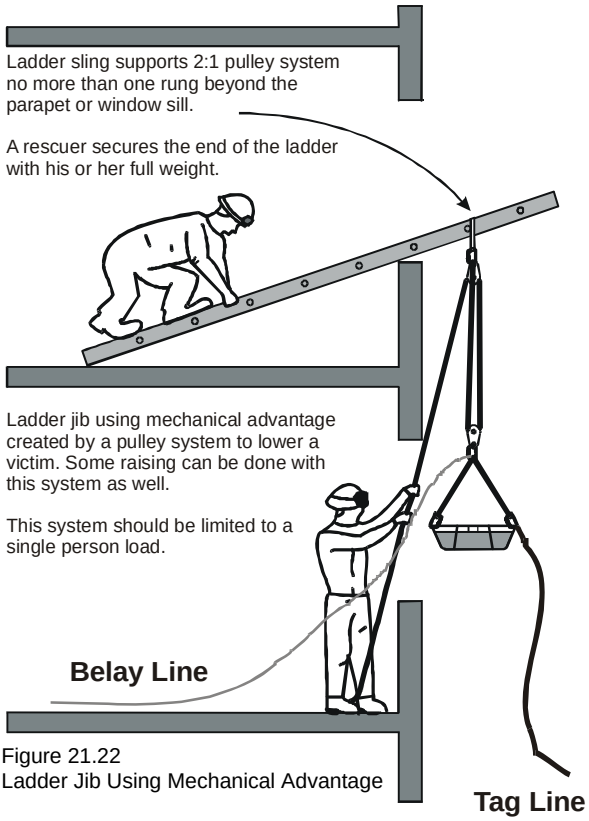


Figure 21.22
Ladder Jib Using Mechanical Advantage

CHAPTER 22 - STRUCTURE SHORING SYSTEMS

Due to the dangerous consequences of structure collapse hazards, every effort should be made to mitigate those hazards. The four methods used to mitigate structure collapse hazards are avoid it, remove it, shore it or monitor it. Each method requires a different amount of time and materials. Restricting access around a collapse hazard is a priority. Using barrier tape or posting guards will eliminate the potential problem of having to manage additional civilian or rescuer injuries that may occur. Rescuers can also remove hazards to minimize collapse hazards. Chimneys or walls can be pulled down safely to prevent further collapse, which may entrap or injure additional victims or rescuers. Constructing shoring systems usually takes the most time and materials. Constant monitoring of the structure and the shoring system should occur throughout the rescue operation to ensure stability and safety.

Figure 22.1
Light-Frame Collapse

Structure shoring systems or emergency building shores (EBS) are temporary building supports used during search and rescue operations after a collapse. EBS systems are necessary when rescue workers must operate in areas of high secondary collapse potential. Rescue operations within void spaces, next to weakened walls, or under overhanging floor slabs, all may require the application of EBS systems.

Figure 22.2
Fall Hazards

In order for EBS systems to be effective, the materials used should be strong, lightweight, and adjustable. The size and type of shoring system depends on the weight and condition of the structural element to be supported by the shore. For example, a wood floor would require a different EBS system than would a broken concrete slab. Unseen fractures, friction forces caused by debris, gravity and the structural components being subjected to forces not designed to withstand, make assessing the collapse structure very complex. A large safety margin to protect the rescuer should be mandatory for all shoring materials and systems due to the complex dynamics of the collapsed structure.

Rescuers should also consider the amount of materials available, the abilities of the personnel on scene and the time it takes to construct and place the shores before beginning the shoring operations. Proper shoring operations can take large amounts of materials and take considerable time to install. The use of more shores than you may think necessary is more appropriate than using fewer shores to gain time.

Figure 22.3
Light-Frame Collapse

SHORING SIZE-UP

The shoring "size-up" provides vital information that can increase safety for victim(s) and rescuer effectiveness during a shoring operation. The size-up identifies structural hazards, damage, potential victim locations, determines hazard mitigation methods, and shoring needs. A thorough size-up will make the rescue operation more efficient. The shoring size-up must be extensive, accurate, and continue throughout the rescue operation.

Victim Consideration

In a disaster such as an earthquake, how much effort rescuers place on a collapsed structure can depend on the potential number of live victims that can be rescue from the collapse. Information leading to how many victims and where they may have been located in a structure prior to the collapse can be of key importance in the efficiency of a rescue operation. Reliable information can be gathered from bystanders, site managers, law enforcement personnel, medical personnel, and most importantly from victims already recovered from the collapse.

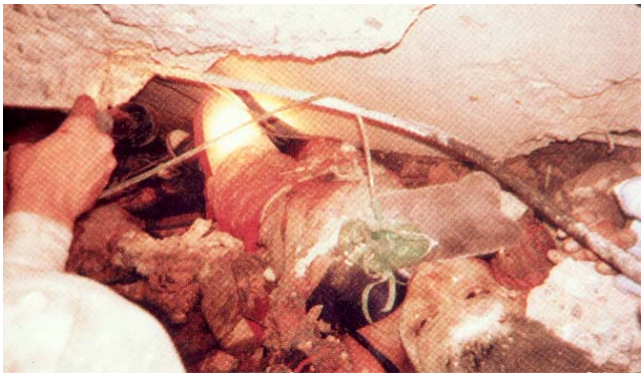


Figure 22.4
Collapse on Victim

Six–Sided Approach

To survey a collapse structure, a six-sided approach should be used -- the four separate sides, the top, and the bottom of the structure. By walking around the collapse, the four sides are easily assessed, however, the sides that are the most critical for the rescuer's consideration are the top and bottom of the collapse. These two "sides" are also the most difficult to access and evaluate.

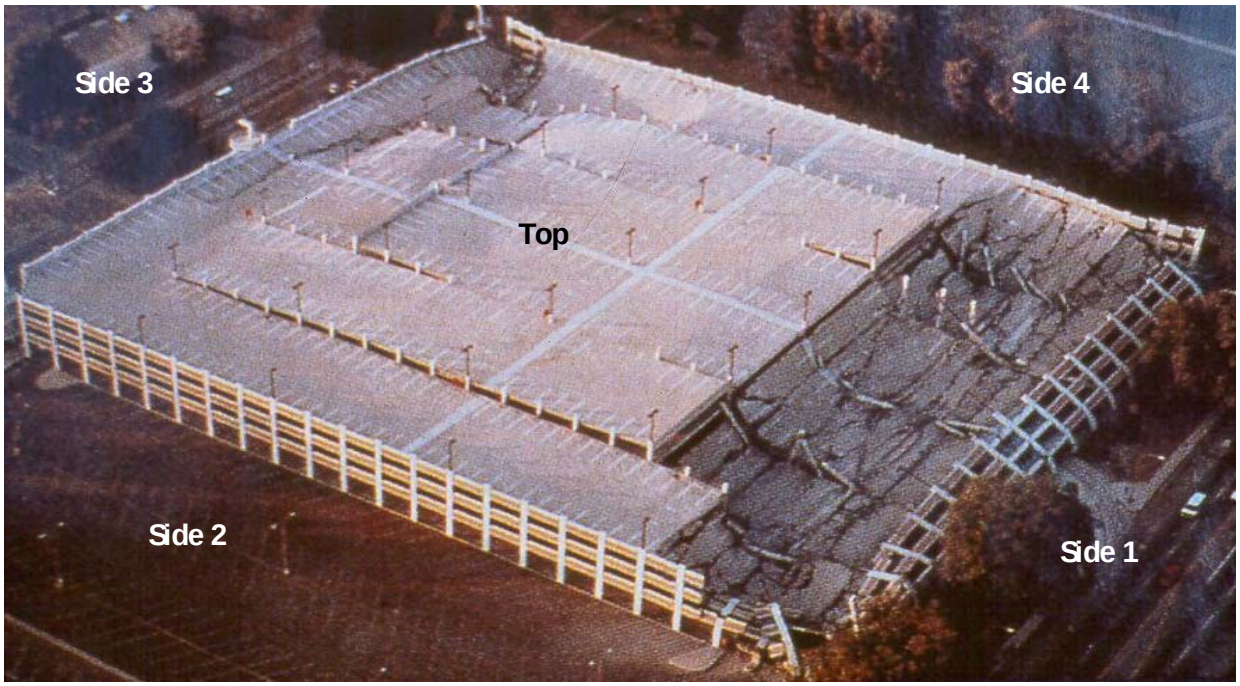


Figure 22.5
Sides of a Collapse

The top of the collapse is considered by some rescuers to be the most dangerous "side." Since gravity is always at work and collapse occurs from above, it is imperative to monitor and survey the overhead area constantly to assess the potential for fall hazards.

The second most important "side" is the bottom of the collapse. Shifting loads and the integrity of the bottom supporting structures or surfaces need to be evaluated. It is important for rescuers to check the condition of floors, building piers, and foundations before installing EBS systems. These areas may have been compromised during the collapse and may require close evaluation before using any shoring operation that applies additional loads to an already compromised condition. Shored loads must be transferred from above structures to stable surfaces for the shoring system to adequately perform.

Figure 22.6
Compromised First Story

Structural Elements

Basic elements of a structure should be evaluated. These elements can be bearing walls, columns, beam, arches, joists, floors, and ceilings.

Bearing walls are one of the most important structural elements especially in an unframed building. Walls out of plumb or damaged by an event can affect the stability of the rest of the structure. Bearing walls usually support floors and roofs but in collapse conditions, non-load bearing walls may become "load supporting walls" that now have a greater chance of failure and further collapse.

Assessment of all beans, columns, arches, joists, and other structural supporting elements under the main debris pile or victim's location should be among the top priorities of the shoring size-up. All severely stressed, broken, missing, bowed, or cracked supporting elements that could affect the rescuer operation must be shored up before any personnel are committed to work in the area.

Figure 22.7
Unsupported Bearing Walls

Age and Condition of an Structure

Like the human body that becomes frail as it gets older, a structure over time fatigues or weakens with age. Structural elements such as concrete or metal hangers can fatigue, loosen, and crack from repetitive loads. Natural conditions like water damage, dry rot, burrowing animals, and insects such as termites reduce the strength of materials. Some "remodel" work can also compromise the integrity of structural elements if completed improperly. Because of the potentials for the strength of structural elements to be compromised, every element should be evaluated before committing resources in a shoring operation.

Figure 22.8
Theodolite

Collapse Warning Signs

Collapse warning indicators often times are the best method to evaluate the condition of the structure. If a structure begins to make noises and "talks" to you, it may indicate an over-stressed or a failing condition. Creaking, moaning, or groaning sounds may be caused by nails being pulled, concrete cracking or sliding, glass breaking, or steel bending. The production of airborne dust not related to wind or rescue operations may also indicate

imminent failure. Rescuers must react to a situation that may require more shoring or immediate evacuation. When this "warning noise" concept is applied to shoring systems, it can serve as an effective method to alert rescuers that a shoring system is being overloaded.

Figure 22.9
Monitoring a Collapse

Sensitive instruments like surveyor transits and theodolites (Figure 22.8) when properly used by trained individuals can be used to detect very small movements of structural elements. Structural engineers, construction personnel, and some public works personnel are trained and may have access to these instruments. If none of these high tech devices are available, low tech methods like drawing chalk lines over cracks and watching the lines move out of alignment or using an observer to watch for simple movement can assist with the monitoring of potential collapse situations.

SHORING PLACEMENT CONSIDERATIONS

The two main objectives for proper shoring placement are maintaining the integrity of the structural elements and properly transmitting or redirecting the collapse loads to a stable surface or structure capable of handling the additional loads. Shoring systems should not increase the damage to either the objective to be shored or to the object the load is being transferred to.

Shoring systems should be applied gently to the structure they are to support. Emergency shores are not designed to move structural elements back to their original positions or design. If rescuers attempt this, they can cause additional collapse or damage to the object they are trying to support.

Collapsed structures can be unstable laterally as well as vertically. Interconnected building parts may depend on each other for support, which may create a difficult shoring situation. A piece of debris that appears to be simply hanging in place may also be providing counter weight or forces that are helping to keep another part of the collapsed structure from moving elsewhere. Careless shoring or removal of the overhead hazard in this situation may cause movement in another part of the collapse. Partial collapses that leave large sections of the building standing (such as freestanding walls, overhanging floors, or large hanging building components) can be very dangerous.

Figure 22.10
Hanging Debris

The type of building construction may dictate the extent of shoring needed to support the compromised structure. In rescue operations occurring in wood or lightweight steel frame structures, shoring should start at least **one (1) floor below** the floor with damage. When dealing with concrete structures, shoring should start at least **two (2) good floors** below the level in which structural damage has occurred.

Placing the shores under primary structural elements such as bearing walls, girders, columns, and arches will more effectively utilize shoring materials and the existing construction features of the building. An example would be to shore a roof span under a collapsed, but intact, girder. Placing a solid supporting shore under a girder will allow the girder to support the attached roof section as it was designed. If the girder connection and roof sections were still connected properly, no other shore may be necessary. If shores were placed to support the same collapsed roof section under the sections and not under the girder, many more shores would be needed to effectively shore and stabilize the collapsed roof area.

The area under the main debris pile and directly underneath victims or the rescuers must be inspected and shored before the start of any operation. Shoring systems must also be located so that they do not interfere with the removal of the victims and the movement of the rescuers and equipment that need to be taken into the collapse area.

Figure 22.11
Alignment of Shore

Some shoring operations may require multiple floors to be shored. Under these situations, shores on different floors or levels need to be aligned above and below each other to ensure the effective transfer of the load to the ground. If the shores do not line up, the shore above can overload the support surface it sits on and cause a failure of the shoring system.

Access into the building may require shoring to be started from the point of entry to where the victim is located in the structure. A primary importance to consider when working in areas with multiple shores is to keep the egress pathways clear for immediate rescuer evacuation if necessary. When clear pathways are not achievable, reinforced safe zones should be constructed.

Figure 22.12
Crowded Accessways

THE SHORING TEAM

To conduct safe and efficient shoring operations a shoring team is formed with a Shore Assembly Team and a Cutting Team. The Shore Assembly Team performs the actual shoring size-up and construction of the shores. The initial responsibility of the Cutting Team is to establish a work site to manage the tools, equipment, and materials to be used. The work site should be set up in a safe location as close as possible to the collapse area. This will minimize the number of personnel needed to relay the materials to the Shore Assembly Team. The work site should have adequate room for laying out the materials and equipment in an organized fashion. A tarp or salvage cover has proved to work well as a ground cover to protect equipment and to help identify the workstation location. A simple cutting table can be constructed on site to enhance the safety and ease of cutting lumber. Shoring materials and tools should be stockpiled in this area for safe access and efficient use

The **Shore Assembly Team** is comprised of:

Figure 22.13
Shore Assembly Team

- The **Shoring Officer** is in charge of the assembly operation and may work with a structure specialist to determine what shore to use and where to place it.
- The **Measure** performs all the measuring required in the construction of the shore and relays all measurements and lumber sizes to the Layout of the Cutting Team. The Measure automatically calculates the deductions needed for the shores (like the wedges, header and sole plates).
- The **Shores** clears away debris and obstructions that could interfere with constructing the shore, assists the Measure as needed, and constructs the shores.
- The **Safety** assists the shoring officer in overall safety due to the larger number of personnel working together.
- The **Runner** is responsible to make sure all the needed tools, equipment, and shoring materials are moved from the access area to the shoring site.

The **Cutting Team** is comprised of:

Figure 22.14
Cutting Team

- The **Cutting Officer** is in charge of the cutting team. This position can be eliminated in a smaller team configuration. The responsibility is then passed to the Layout.
- The **Layout** is in charge of setting up the cutting station, readying the materials to be cut, measures and marks the lumber for the cutter. This position communicates with the Measure on the Shore Assembly Team.
- The **Feeder** moves the lumber to be cut and helps secures the lumber while it is being cut.
- The **Cutter** operates the saw and cuts the lumber marked by the Layout. During down time when no specific lumber sizes need to be cut, the Cutter can cut extra cribbing or wedges.

- **Tools and Equipment** is responsible for the movement of tools and equipment where requested, anticipates any logistical needs for the teams, keeps inventory and maintains the supply of lumber.
- The **Runner** is responsible to make sure all the needed tools, equipment, and shoring materials are moved from the cutting area to the access point.

Less complicated shoring operations can be accomplished by combining positions with three (3) personnel on each team.

Shore Assembly Team	Cutting Team
1. Shoring Officer	1. Layout
2. Measure	2. Cutter
3. Shores	3. Tools and Equipment

More complicated shoring operations can be accomplished with six (6) personnel on each team

Shore Assembly Team	Cutting Team
1. Shoring Officer	1. Cutting Officer
2. Measure	2. Layout
3. Shores (2)	3. Feeder
4. Safety Officer	4. Cutter
5. Runner	5. Tools and Equipment
	6. Runner

Larger and more complex shoring operations may require the Shore Assembly Team and the Cutting Team to be assigned more persons for each position.

SHORING SYSTEMS

A shoring system, as it applies to rescue, is the temporary support of only that part of a damaged, collapsed or partially collapsed structure that is required for conducting search and/or rescue operations at reduced risk to the rescuer and victim.

Double Funnel Principle

Emergency shoring systems must be designed like a double funnel. The systems are designed to:

- Collect the load with a header beam or wall plate
- Support the load with posts, struts, or rakers
- Distribute the load to the supporting structure below or to the opposite side through a sole plate or wall plate over a wide area

Heavily loaded shoring components such as posts or struts can punch through the structural elements they are supporting if the loads are not adequately dispersed.

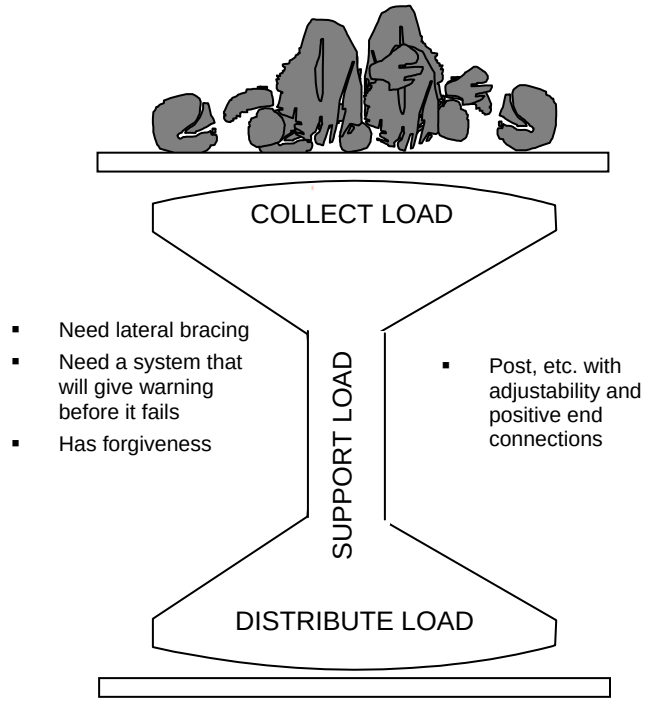


Figure 22.15
Double Funnel

Shoring System Design Principles

All components of the shoring systems must be able to carry the weight of the anticipated load. If one component is weak, the entire shore may fail. These components that collect, transfer and support the load need to be adjustable so that they fit into the uneven surfaces that are produced by the collapse. The shores must also be able to withstand movements in multiple directions caused by the dynamic nature of the collapse situation.

In order for emergency building shores to perform to their best ability, shoring components must be constructed as plumb and level as possible. Damaged and collapsed structures usually have uneven surfaces to shore against. The rescuer must use wedges, shims and back fill material between the compromised structure and the shoring components to keep the shore as plumb and level as possible and maintain full surface contact. Maintaining full surface contact between the shoring components ensures that the load bearing surfaces are capable of supporting their complete capacity.

Common Shore Components

Rescuers should be familiar with the terminology used to describe the shore components.

- **Back fill material** is any material used to take up space or fill gaps between shoring components and the object being shored.
- **Cleats** are small pieces of wood used to secure other parts of a shoring system in place.

- **Diagonal braces or "X" and "V" braces** prevent shores from racking (becoming a parallelogram) and buckling (bending and breaking).
- **Gussets plates** are square or triangular pieces of ¾" plywood nailed to secure shoring component junctions or connections points together
- **Header** is the upper most element of the shore. It collects the load and transfers the load onto the post or strut.
- **Horizontal strut** is the horizontal load-bearing member placed between two wall plates.
- **Raker** is the diagonal strut that collects the load from the wall plate and transfers the load to the sole plate.
- **Sole plate** distributes the transferred load delivered by the posts or struts on to the supporting surface.
- **Vertical post** is the load-bearing member that receives the load from the header and transfers it to the supporting surface.
- **Wall plate** is similar to the header beam but it is applied vertically against wall surfaces.
- **Wedges** are used to snug up loads, pressurize shores, fill in voids, or change the angle of thrust of a crib bed.

CONSIDERATIONS FOR SHORING SYSTEM DESIGN

Prior to the installation of a shoring system, the structure and integrity of primary supporting elements must be evaluated, movement and direction of load forces anticipated and the weight of the area to be shored estimated. The weight or load of the area to be shored is measured in pounds per cubic foot (PCF) or pounds per square foot (PSF). The weight or load of an area may change with the additional weight of transferred loads caused by shoring systems, the number of rescuers or equipment in use, secondary collapse, and the removal of debris or other building contents.

Weights of Common building materials

- Concrete = 150 PCF
- Masonry = 125 PCF
- Wood = 35 PCF
- Steel = 490 PCF
- Concrete, masonry and rubble = 10 PSF per inch of thickness

Weights of Common Building Construction

- Concrete floors = 90-150 PSF
- Steel beam with concrete filled metal deck = 50-70 PSF

- Wood floors = 10-25 PSF
- Wood floors with thin concrete fill = 25+ PSF

*Add 10-15 PSF for wood or metal stud interior wall per each floor level
*Add 10+ PSF for furniture and contents per each floor level

Example: Estimated Floor Weight Calculation

- Size of Wood floor: 20' by 20'
  20x20 = 400 sq. ft.
- Weight of wood floor: 25 PSF
  400x25 = 10,000 pounds
- Weight of contents: 10 PSF
  10x400 = 4,000 pounds
- Total floor weight: 4,000 pounds + 10,000 pounds = 14,000 pounds

+ Add weight of rescuers and equipment (250 pounds each) to total

SHORING SYSTEM MATERIALS

Lumber

Emergency shoring systems can be constructed from metal, a combination of metal and wood or entirely of wooden components. Wood shoring supplies are readily available from lumberyards, home supply stores, or public works departments. Debris lumber can also be acquired from surrounding structures and wood 4"x4" signposts or lumber cut from a nearby fence, deck or porch may also be available.

Douglas Fir and Southern Pine are two of the most common lumber types used. Dimensional lumber is most often used in the following sizes: 2"x4", 2"x6", 4"x4". The actual dimension is ½" less than the "call out" size: 4"x4" = 3.5"x3.5".

Lumber has varying strength characteristics depending on its size and how it is used. Lumber placed on end (end-grain) has different load capabilities than the same lumber orientated with the grain (cross-grain). The average end-grain strength of lumber is 1000 PSI (pounds per square inch). The load capacity of a 4"x4" vertical post with end-grain compression is, however, dependent on its length. The average cross-grain strength is 500 PSI. The load capacity of a 4"x4" used a crib member with cross-grain compression will be able to support approximately 6,000 pounds per contact point. (3.5" x 3.5"= 12.25" x 500 PSI= 6,125 or approximately 6,000 pounds per contact point) Other considerations for lumber strength can include the moisture content, age of the lumber, knots and the density of growth rings.

Bending and breaking characteristics of upright posts also need to be considered. The load capacity of lumber is relative to its length and width ratio. The ratio between the length and width or diameter (L/D) should never exceed a minimum of 50 for normal building construction. The ideal ratio in a rescue operation should be 25 or less. So, the maximum length of a 4"x4" (L/D50) is 50 x 3.5"= 175" or 14.5'. The ideal length of a 4"x4" for rescue operations (L/D25) is 25 x 3.5"= 88" or approximately 8'.

When considering compression loads verses tension loads, it is recommended that 4" lumber minimum be used for compression loads and 2" minimum lumber should be used for tension loads.

Plywood

Plywood is typically composed of multiple thin layers of wood glued together so that the grain direction of each layer is perpendicular to each other. This layering pattern gives plywood its strength and ability to resist splitting like other solid pieces of lumber – thus the reason for plywood being used extensively for shear paneling or decking.

Plywood is usually constructed in 4'x8' panels or sheets with common thickness from ¼"-¾". Plywood sheets are produced in a variety of grades for exterior and interior use. A typical ¾" sheet of plywood is usually made of five layers. Plywood used for shoring material is ¾" thick to provide adequate strength comparable to the other shoring components.

Nails and Nail Patterns

Nails come in different shapes, sizes, and strengths. The nails used in emergency shoring operations can be either single head or double head (duplex) nails. Single head nails can be used when it is desired to have the top of the nail flush with the surface of the lumber; however, it is very difficult to remove these nails after application if necessary. Duplex nails have two heads so that when the nail is hammered into the lumber, the nail stops at the first head and keeps the top nail head still exposed - making these nails much easier to remove if needed.

Nails come in different lengths and thickness. The most common nails used to construct shoring systems are 8 and 16-penny (d) nails. It is estimated that the shear strength of the 8d nail is 75 pounds and the 16d nail is 150 pounds. Use 8d nails on plywood and 16d nails on 2" lumber. The proper size, amount, and spacing of nails must be properly applied when attaching shoring components to insure that the collective strength of the nails is adequate for the design of the shore and to avoid the nails weakening (splitting) the lumber.

A 5-nail pattern system is used in emergency shoring operations. Figure 22.16 illustrates the different variations of the nail pattern when connecting different shoring components.

When nailing lumber such as 2"x4" or 2"x6", the amount of nails used is usually one nail less than the width of the lumber. Example: three (3) nails for a 2"x4" or five (5) nails for a 2"x6".

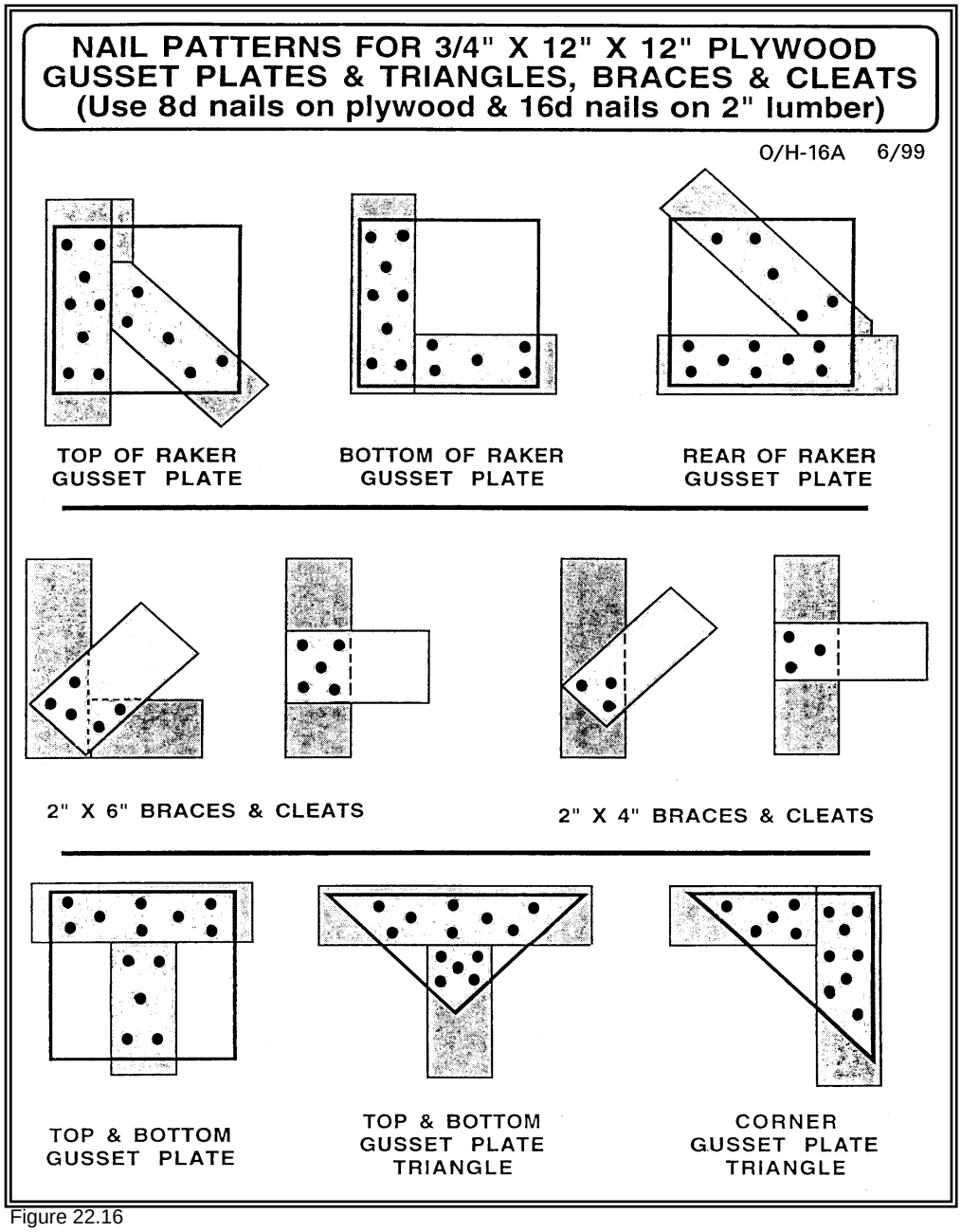


Figure 22.16
Nail Patterns

SHORING SYSTEMS

Spot Shore

The spot shore is used to initially stabilize damaged floors, ceilings, or roofs so that more substantial shoring can be installed at less risk to the rescuers and victims. It is constructed from a single vertical post with a header plate and sole plate to collect and redistribute the load.

The spot shore is basically unstable. If the load shifts and leans the post over to one side or the load is not centered directly over the shore, it has a tendency to tip over. The spot shore needs to be backed up with other shoring systems that provide increased lateral stability and load capacity. Even with its inherent instability, the spot shore is widely used by rescuers as one of the first shores installed.

Figure 22.17
Spot Shore

Figure 22.18
Vertical Shore

Vertical Shore

The vertical shore is used to stabilize damaged floors, ceilings, or roofs. It can be used to replace missing or unstable load bearing walls or columns. It is constructed with multiple posts, a common header plate and sole plate, and diagonal braces to resist lateral forces.

Horizontal Shore

The horizontal shore is used to stabilize damaged walls against an undamaged wall in hallways, corridors or between buildings. It is constructed similar to the vertical shore.

Figure 22.19
Horizontal Shore

Figure 22.20
Window and Door Shore

Window and Door Shore

The window and door shore is used to stabilize windows, doorways, or other access ways. It is usually installed to protect entryways intended for use by rescuers or in openings that have sustained structural damage.

Sloped Surface Shore with Cribbing

Sloped surface shoring can be constructed with cribbing and wedges. It is a quick and effective method of shoring that can be adjusted to various heights and sloped surfaces.

Figure 22.21
Sloped Surface Shore with Cribbing

Raker Shore

The raker shore is used to support leaning or unstable walls and columns by transferring the lateral forces to the ground. They are always installed in series - connecting at least two rakers together. The two general styles of rakers most often used by rescuers are the solid sole and the flying raker.

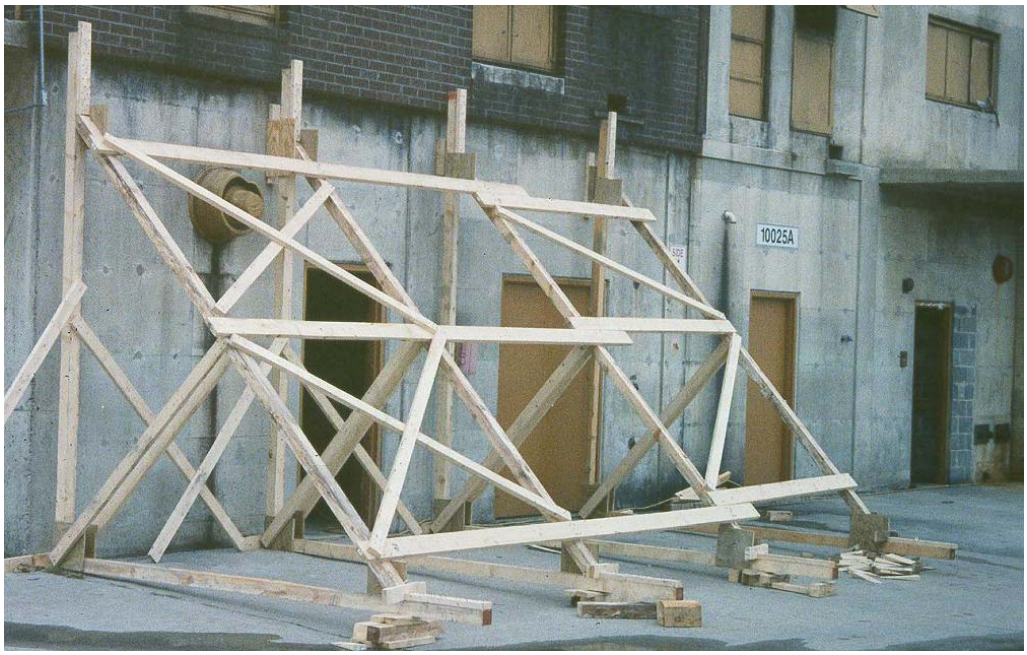


Figure 22.22
Raker Shoring

SHORE EVALUATION AND SAFETY CHECKS

An evaluation and safety check must occur to ensure that all of the shoring components are tight and secure after installation of each shore or after any significant movement from aftershocks or debris removal. Check for level, plumb and fill all shoring component void spaces to ensure full surface contact. Not only do rescuers have to check the shore just installed but should check the rest of the shores that were placed prior to ensure that each is still pressurized and supporting the needed weight in the collapse.

CHAPTER 23 - BASIC TOOLS AND EQUIPMENT FOR EMERGENCY SHORING OPERATIONS

The construction of emergency building shores requires proficiency in the use of carpentry hand tools and power saws. These tools are used to measure, cut, and attach the various components of a shoring system together.

SAFETY CONSIDERATIONS

Some basic safety guidelines must be followed. Rescue personnel should be in full safety gear when working with tools. Safety glasses and hearing protection are necessary. Gloves should be required when handling lumber but when handling tools, it may be better for rescuers to work without gloves. Most personnel can maintain better dexterity and grip on the tools without gloves. Loose clothing can be a hazard and should be secured when using some tools, especially rotary power tools.

Personnel need to be cautious of other workers in the immediate area when cutting with tools, moving lumber and swinging hammers. Tools can slip out of hands, lumber can splinter, saw blades can come apart and shatter or throw teeth.

A majority of injuries is a result of taking short cuts and not enough precautions when using tools. Remember to make sure that all saw blades stop completely before the saw is put down on the ground or pulled away from the lumber. Evaluate the work area for tripping hazards, other workers, or slippery surfaces prior to starting your cutting operation.

HAND TOOLS

Hand tools required to construct shoring systems with wood components include:


Figure 23.1 Hammer

Hammers: framing hammers weighing 20 or 22 ounces are preferred because of their superior nail-driving ability.

Measuring tapes: a 1" wide power-return tape is preferred due to its ease of application and simple-to-read measurements.


Figure 23.2 Tape Measure

Figure 23.3 Mauls/Single Jacks

Hand-held mauls (single jacks): weighing 2-3 pounds each for installing shims, wedges, and demolition work.

Nail pulling bars: wonder bars, crow bars, small wrecking bars. Bars have better leverage than the framing hammer which makes it a tool of choice to pull nails.

Figure 23.4 Nail Pulling Bars

Figure 23.5 Hand Saw

Handsaws: Standard cross cut single edge blade with medium teeth

POWER TOOLS

Power saws are used to cut lumber to the dimensions needed during the construction of shoring systems. Personnel operating these saws must be familiar with the manufacturer's operating instructions and safety requirements. A pre-operational check of any power saw used should be done per the manufacturer's instructions. Some of the items that need to be evaluated during this check are drive belts or chains, fluid levels, blades, cutting chains, and guide bars.

Figure 23.6
Gas-Powered Chain Saw

Operators of power saws must be familiar with the capabilities of these tools and be able to operate them properly. Care should be taken not to bind blades or chains during cutting operations.

Safety procedures for using power saws should be followed. This includes the use of safety equipment such as eye protection, gloves, helmet, and safety shoes. Fuel should be handled and stored in a safe manner in approved containers to eliminate the possibility of fire. Always work in a ventilated area when using and refueling gasoline-powered tools. Operators must always be aware of their surroundings when using power saws.

CHAPTER 24 - THE TIMBER SPOT SHORE

The timber spot shore is a temporary shore constructed entirely of wood components that can be installed quickly in unstable areas so that the rescuers can take time to build more substantial shoring with reduced risk to the rescuers and victims.

COMPONENTS OF THE TIMBER SPOT SHORE

Header: Collects the weight from above and transfers it to the vertical post. The header plate should be level and perpendicular to the post. The minimum lumber size used is 4"x4". The header should be **not longer than 3'** due the weakness that occurs with longer material creating a dangerous overhang (cantilever effect) from the vertical post.

Sole Plate: Supports the weight being transferred from the vertical post to a stable surface. The sole plate should maintain the same length and size requirements as the header.

Vertical Post: Supports and transfers the weight from the header to the sole plate. The vertical post is placed under the header and over the sole plate in line with main structural members in the shored structure. The post should be perpendicular and maintain full surface contact with both the header and sole plate.

Figure 24.1
Spot Shore

The maximum length of a timber spot shore is 10'. The minimum size of the post, header and sole plate should be not less than 4"x4". When calculating the length of the post, deductions for the header, sole plate and wedges need to be factored in. Deducted 3.5" for the 4"x4" header and 3.5" for the 4"x4" sole plate, 1.5" for 2"x4" wedges or 3.5" for 4"x4" wedges.

Wedges: Inclined planes that are used to pressurize the shore or fill gaps between the shore and the structure. Wedges are used in pairs with the cut side of each wedge "married" against each other for better holding capability and for a better striking surface for the hammers when pressurizing.

Gussets Plates: 12"x12"x¾" plywood squares or triangles that secure the connections between the different parts of the shore like the header, sole plate, and the vertical post. They are connected with 8d nails using a five-nail pattern.

Cleats: Short pieces of lumber (2"x4") used to support or secure shoring component parts. Cut in various lengths and secured with nails. Caution should be taken when nailing cleats due to the susceptibility of the lumber to split during the nailing process.

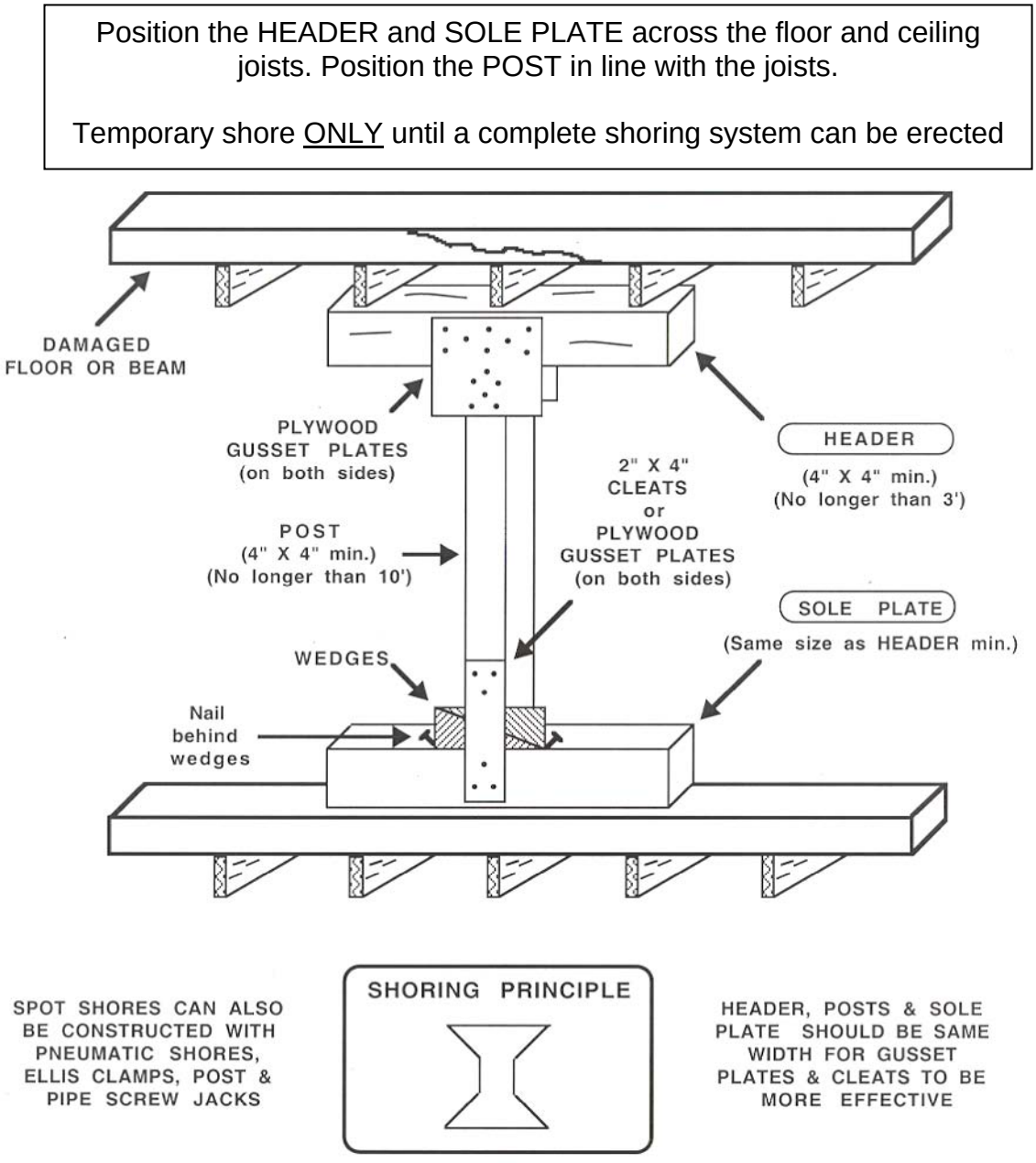


Figure 24.2
Timber Spot Shore

TIMBER SPOT SHORE ASSEMBLY

1. Measure and cut the proper length of the header and sole plate.
2. Measure the overall height to be shored.
3. Deduct the depth for the header, sole plate, and wedges.
4. Measure and cut the vertical post.
5. Nail gusset plates on both sides of the header to secure it to the vertical post.
6. Position shore and sole plate under the load.
7. Pressurize the spot shore with wedges.
8. Tap a duplex nail half way into the sole plate behind each wedge.
9. Nail gusset plates or cleats on both sides of the sole plate to secure it to the vertical post.
10. Evaluate shore and structure.

CHAPTER 25 - THE POST SCREW JACK SPOT SHORE

The post screw jack spot shore is a temporary shore constructed of wood components and a metal base with an adjustable foot that can be installed quickly in unstable areas so that the rescuers can take time to build more substantial shoring with reduced risk to the rescuers and victims.

COMPONENTS OF THE POST SCREW JACK SPOT SHORE

Header: Collects the weight from above and transfers it to the vertical post. The header plate should be level and perpendicular to the post. The minimum lumber size used is 4"x4". The header should be **not longer than 3'** due the weakness that occurs with longer material creating a dangerous overhang (cantilever effect) from the vertical post.


Figure 25.1
Post Screw Jack

Sole Plate: Supports the weight being transferred from the vertical post to a stable surface. The sole plate should maintain the same length and size requirements as the header.

Vertical Post: Supports and transfers the weight from the header to the sole plate. The vertical post is placed under the header and over the sole plate directly in line with main structural members in the shored structure. The post should be perpendicular and maintain full surface contact with both the header and sole plate.

The maximum length of a post screw jack spot shore is 10'. The minimum size of the post, header and sole plate should be not less than 4"x4". When calculating the length of the post, deductions for the header, sole plate and post screw jack need to be factored in. Deducted 3.5" for the 4"x4" header and 3.5" for the 4"x4" sole plate, and 10" for the post screw jack.

Gussets Plates: 12"x12"x¾" plywood squares or triangles that secure the connections between the different parts of the shore like the header, sole plate, and the vertical post. They are connected with 8d nails using a five-nail pattern.

Post Screw Jack: Manufactured metal sleeve with an adjustable screw foot that can be applied to the end of the vertical post to pressurize the shore. These appliances have an 18,000 pounds capacity and replace the wood wedges that can be more difficult to install.

VERTICAL SHORE SCREW JACK by Ellis

- Adjustable metal foot for 4"x4" and 6"x6" wood posts
- 6" total adjustment (set half-way get 3" up and 3" down
- Screw jack is stronger than wood post so the system will be based on values previously given for wood post systems

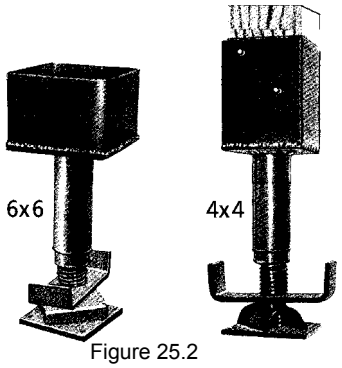


Figure 25.2

POST SCREW JACK SPOT SHORE ASSEMBLY

1. Measure and cut the proper length of the header and sole plate.
2. Measure the overall height to be shored.
3. Deduct the depth for the header, sole plate, and post screw jack.
4. Measure and cut the vertical post.
5. Nail gusset plates on both sides of the header to secure it to the vertical post.
6. Position shore and sole plate under the load.
7. Pressurize the spot shore with the post screw jack.
8. Tap two duplex nails into the sole plate through the nail holes in the screw jack base.
9. Evaluate shore and structure.

CHAPTER 26 - THE ELLIS CLAMP SPOT SHORE

The Ellis clamp spot shore is a temporary shore constructed of wood components and two metal clamps that can be installed quickly in unstable areas so that the rescuers can take time to build more substantial shoring with reduced risk to the rescuers and victims.

COMPONENTS OF THE ELLIS CLAMP SPOT SHORE

Header: Collects the weight from above and transfers it to the vertical post. The header plate should be level and perpendicular to the post. The minimum lumber size used is 4"x4". The header should be **not longer than 3'** due the weakness that occurs with longer material creating a dangerous overhang (cantilever effect) from the vertical post.

Sole Plate: Supports the weight being transferred from the vertical post to a stable surface. The sole plate should maintain the same length and size requirements as the header.

Vertical Posts: Supports and transfers the weight from the header to the sole plate. Two vertical posts are placed under the header and over the sole plate directly in line with main structural members in the shored structure. The posts should be perpendicular and maintain full surface contact with both the header and sole plate.

The maximum length of a Ellis clamp spot shore is 12'. The minimum size of the post, header and sole plate should be not less than 4"x4". When calculating the length of the post, deductions for the header, sole plate and post screw jack need to be factored in. Deducted 3.5" for the 4"x4" header and 3.5" for the 4" x4" sole plate.

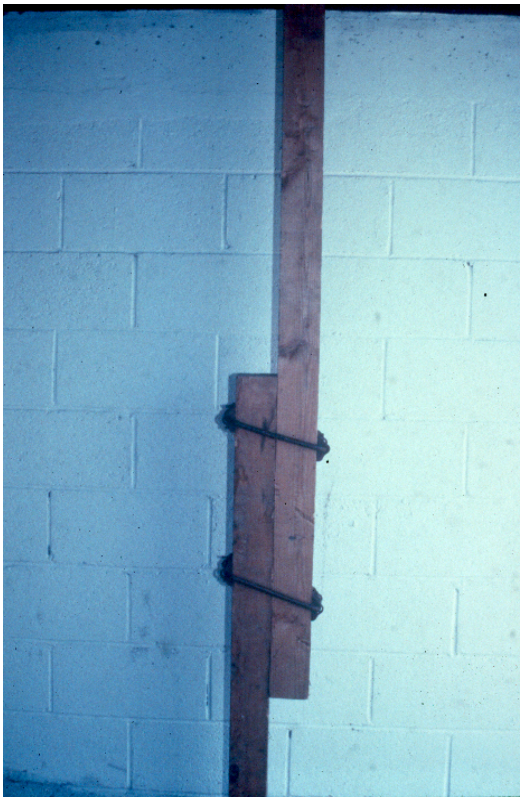


Figure 26.1
Ellis Clamp Shore

Gussets Plates: 12"x12"x¾" plywood squares or triangles that secure the connections between the different parts of the shore like the header, sole plate and the vertical post. They are connected with 8d nails using a five-nail pattern.

Ellis Clamps: A set of metal clamps that allows the use of two smaller pieces of lumber to quickly set up a single spot shore. The clamps are widely used in construction as a temporary shore due to their height adjustment and repetitive use abilities.

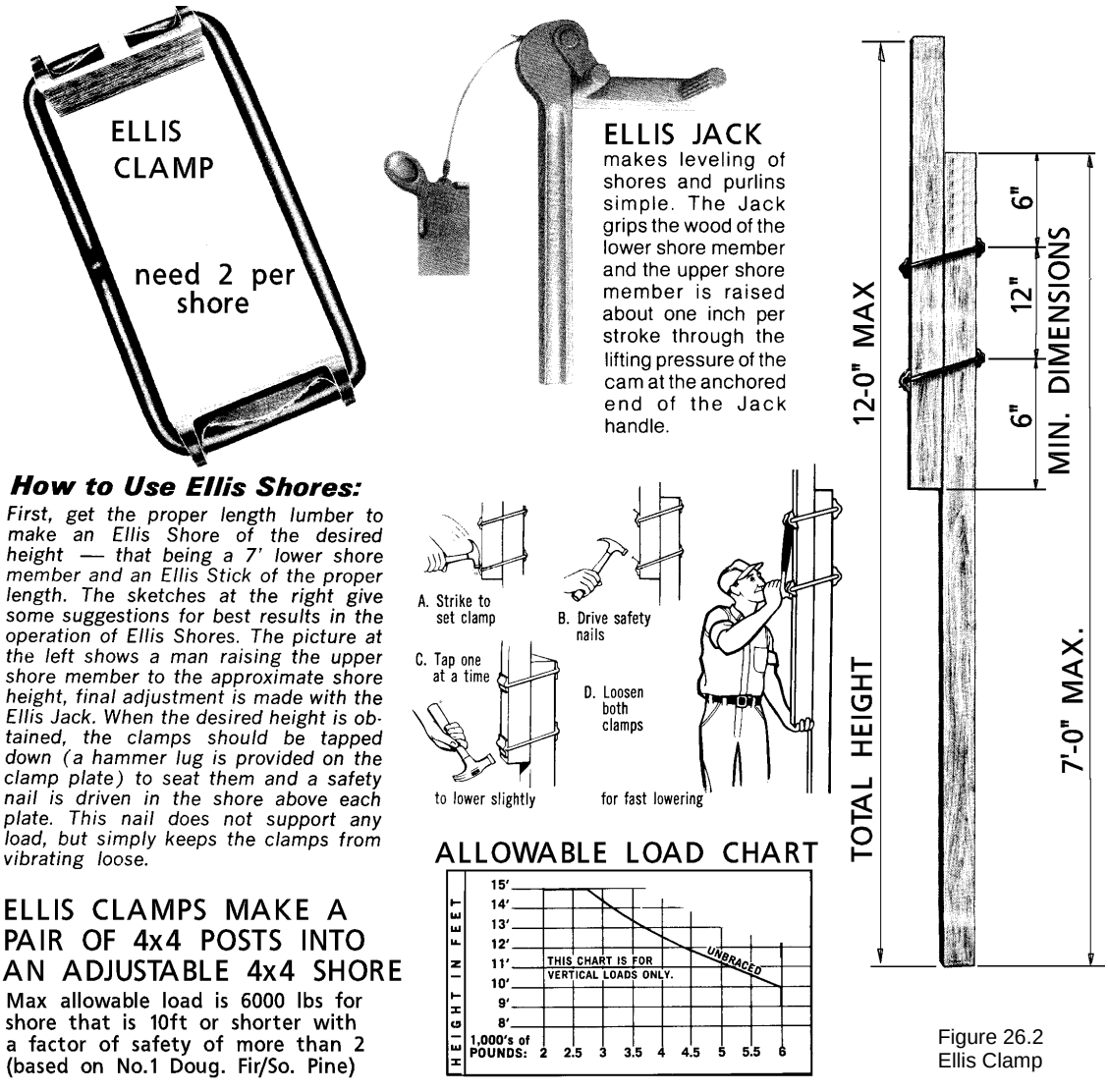


Figure 26.2
Ellis Clamp

ELLIS CLAMP SPOT SHORE ASSEMBLY

1. Measure and cut the proper length of the header and sole plate
2. Measure the overall height to be shored
3. Deduct the depth for the header and sole plate

4. Measure and cut the two vertical posts
5. Position the two clamps onto the two vertical posts
    - Top clamp a minimum of 6" from the top of the lower post
    - Bottom clamp a minimum of 12" from the top clamp
    - Bottom end of the upper post a minimum of 6" below the bottom clamp
6. Secure the two clamps onto the lower post with two duplex nails each
7. Nail gusset plates on both sides of the header to secure it to the upper post
8. Position shore and sole plate under the load
9. Pressurize the spot shore by lifting the bottom of the upper post
10. Pull down on the top clamp until the clamp is snug
11. Position the Ellis Jack on the lower post with the handle against the bottom of the upper post
12. Pressurize the spot shore by lifting the Ellis Jack handle
13. Tap the clamps downward with a hammer while holding pressure on the handle by hitting the top clamp then the bottom clamp
14. Secure the clamps with two duplex nails each
15. Nail gusset plates on both sides the sole plate to secure it to the lower post
16. Evaluate shore and structure

CHAPTER 27 – THE VERTICAL SHORE

The vertical shoring system can be used to support floors and/or roof sections that are in danger of failing. This system is often used to more securely protect rescuers operating inside collapse voids.

A vertical shoring system is comprised of multiple vertical posts under a common header and sole plate, not just a single post.

Figure 27.1
Vertical Shore

The first two posts are installed at opposite ends, 12" from each end of the header and sole plate. This "clearance" provides an area for the diagonal braces to attach too and maintains the maximum length requirement so failure due to the cantilever effect is minimized.

Header: Collects the weight from above and transfers it to the vertical post. The header plate should be level and perpendicular to the post. The minimum lumber size used is 4"x4".

Sole Plate: Supports the weight being transferred from the vertical posts to a stable surface. The sole plate should maintain the same requirements as the header.

Vertical Posts: Supports and transfers the weight from the header to the sole plate. The posts should be placed under the header and over the sole plate directly in line with main structural members in the shored structure (floor and ceiling joists). The posts should be separated no greater than 4' on center. They should be perpendicular and maintain full surface contact with both the header and sole plate. The maximum length for the vertical post should be 8' unless midpoint bracing is used. The dimension and size of posts should be the same as the header and sole plate. A pipe screw jack post or a post screw jack set can be used in place of the wooden post if necessary. If these types of posts are used, securing the midpoint and diagonal braces will become more difficult.

Wedges: Inclined planes used to pressurize the shore or fill gaps between the shore and the structure. Wedges are used in pairs with the cut side of each wedge "married" against each other for better holding capability and for a better striking surface for the hammers when pressurizing.

Gussets Plates: 12"x12"x¾" plywood squares or triangles that secure the connections between the different parts of the shore like the header and the vertical post. They are connected with 8-penny nails using a five-nail pattern. Gussets are used in joint areas that are ***not*** secured by the diagonal bracing.

Cleats: Short pieces of lumber used to support or secure shoring component parts. 2"x 4" material in various lengths are usually used and secured with nails. Caution should be taken when nailing cleats due to the susceptibility of the lumber to split during the nailing process.

Diagonal Bracing: Locks the entire shore together so that the posts all work as one unit. The diagonal braces provide lateral stability and prevent the shore from failing like a collapsing parallelogram. They span the entire length of the shore and connect the top of the header on one side to the bottom of the sole plate on the other side. A diagonal brace should be placed on each side of the shore in an "X" configuration. The top and bottom of the diagonal brace should cover the header, sole plate and post connection point.

Midpoint Brace: Used when the 4"x4" posts are greater than 8' long or when 6"x6" posts are greater than 12' long. Midpoint braces increase the load bearing capacity by resisting the buckling effect and the tendency for long posts to bend and break when put under pressure. ¾" x 6" plywood, 1"x6", 2"x6", or twin 2"x4" on each side can be used for midpoint braces.

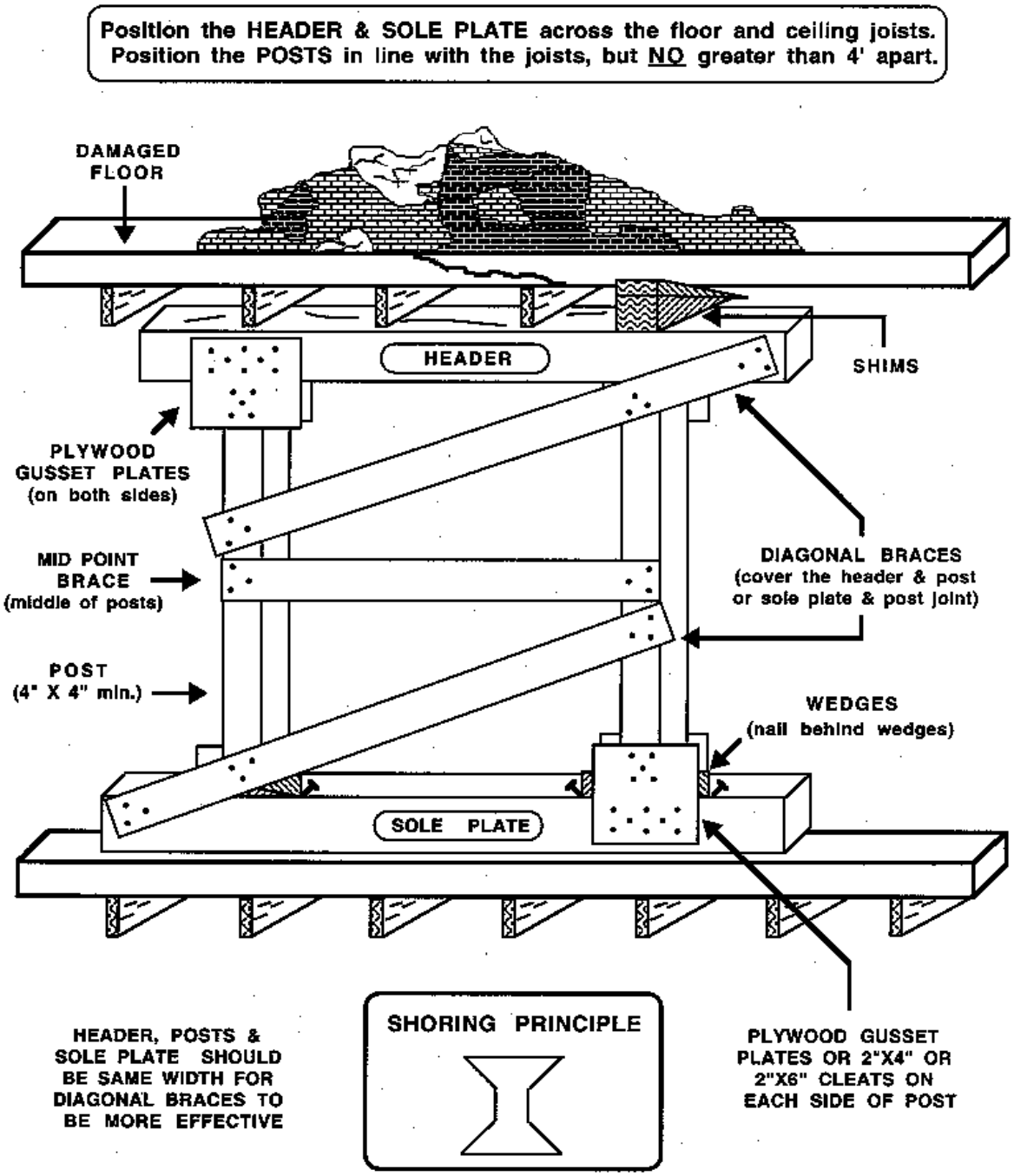


Figure 27.2
Two Post Vertical Shore

TWO POST VERTICAL SHORE ASSEMBLY

1. Measure and cut the proper length of the header and sole plate.
2. Measure the overall height to be shored; use the shortest length measure if area is uneven.
3. Deduct the depth for the header, sole plate, and pressurizing devices.
4. Measure and cut the two vertical posts.
5. Position the two posts under the header in proper location and toenail in place.
6. Measure, cut, and install the midpoint brace.
7. Secure the header to one vertical post with a gusset plate.
8. Measure, cut, and install the top diagonal brace to secure the header to the other vertical post.
9. Position shore and sole plate under the load - align the ends of the header and sole plate.
10. Pressurize the posts.
11. Secure the sole plate to one vertical post with a gusset plate.
12. Measure, cut, and install the bottom diagonal brace to secure the sole plate to the other vertical post.
13. Nail gusset plates and/or cleats on both sides of post joints not covered by a diagonal brace to secure all joint connections.
14. Evaluate shore and structure.

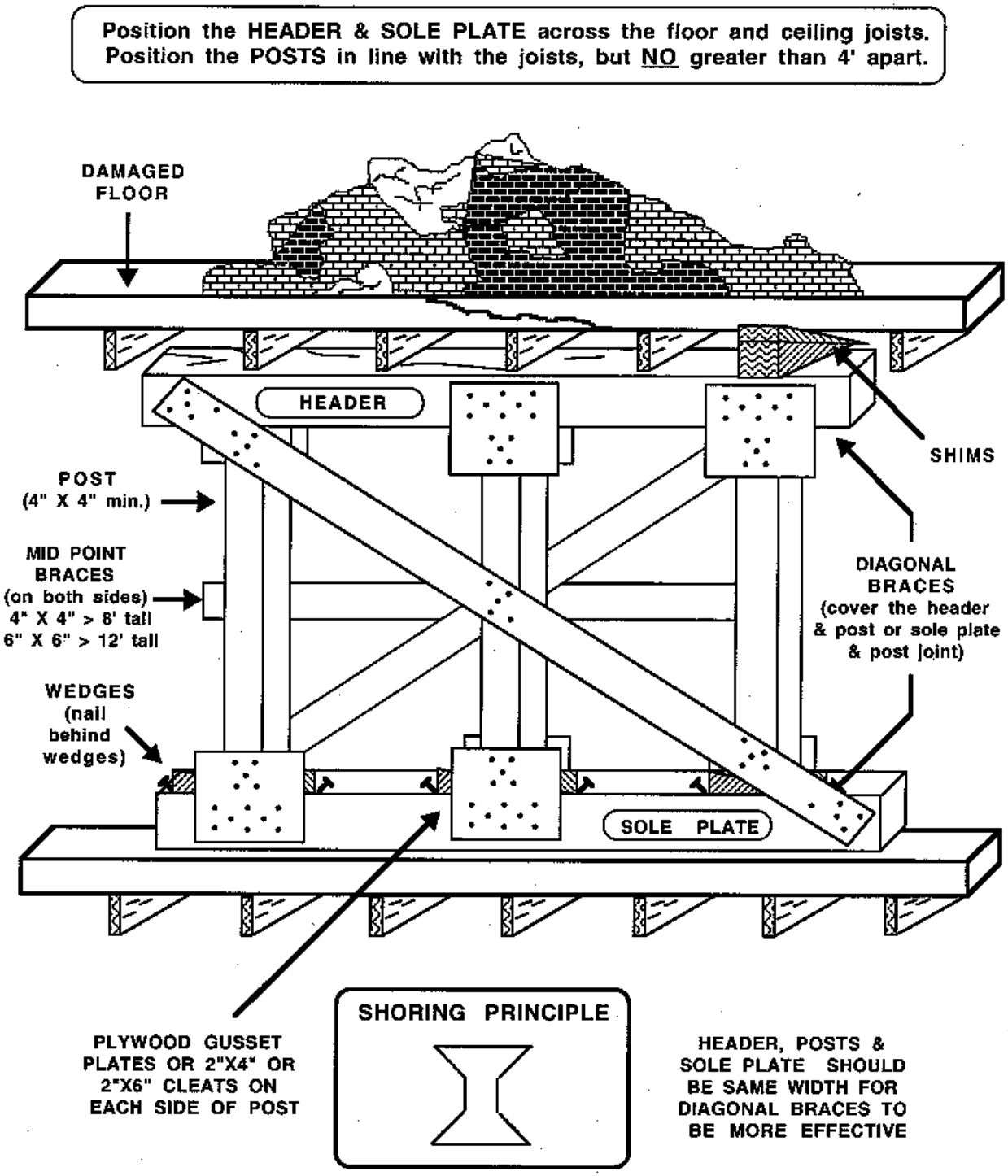


Figure 27.3
Multiple Post Vertical Shore

MULTIPLE POST VERTICAL SHORE ASSEMBLY

1. Measure and cut the proper length of the header and sole plate.
2. Measure the overall height to be shored; use the shortest length measure if area is uneven.
3. Deduct the depth for the header, sole plate, and pressurizing devices.
4. Measure and cut the vertical posts.
5. Secure the header to the two end vertical posts.
6. Position shore and sole plate under the load; align the ends of the header and sole plate.
7. Pressurize the posts.
8. Install other vertical posts, as needed.
9. Pressurize the posts.
    - Recheck the all posts for adequate pressure.
10. Install diagonal braces.
11. Install midpoint braces, if needed.
12. Nail gusset plates and cleats to secure all joint connections.
13. Evaluate shore and structure.

CHAPTER 28 - THE HORIZONTAL SHORE

A horizontal shoring system can be applied to weakened walls that are in close proximity to other walls. They are limited in capacity by the cross-grain loading of the wall plates where they contact the struts, and may cause these components of the shore to fail prior to the strut buckling.

These shores work well to support hallways and corridors. The 4"x 4" lumber used in these systems should not be longer than 8' due to the potential of sudden failure from the strut buckling.

Figure 28.1
Horizontal Shore

COMPONENTS OF THE HORIZONTAL SHORE

Wall Plates: Collects the weight being transferred laterally and spreads it to the horizontal struts. The wall plate should be as plumb and flush to the wall surfaces as possible. Backfill material can be used if needed between the wall plates and shored structure. The minimum size lumber that should be used is 4"x4" material.

Similar to the vertical shore header, the ends of the wall plates should not extend more than 12" from the top and bottom struts. This "clearance" provides an area for the diagonal braces to attach too and maintains the maximum length requirement so failure of the strut due to the cantilever effect is minimized. The plates should be positioned directly inline with main structural elements.

Struts: Supports the weight being transferred laterally from one wall plate to the other wall plate. They should be perpendicular and maintain full surface contact with the wall plates.

Usually two struts per shore are used. If the span between the top and bottom strut is greater than 4', a middle strut may be required. However, when more than two struts are used, full access of the opening becomes limited.

The capacity of each strut with 4"x4" wall plates on 4' centers is approximately 4,000 pounds This is based on the buckling effect of the wall plate and not due to the bending and breaking of the strut itself. Struts should be no greater than 8' long.

Pipe Screw Jack: (AKA Trench Jack) A screw shaft unit on each end of a steel pipe. This jack can be used in place of a wood strut to pressurize the shore. 1½" or 2" Schedule 40 pipe is used between the jacks.

- 1½" pipe diameter x 7' = 5,000 pounds
- 2" pipe diameter x 10' = 6,000 pounds

Post Screw Jack: A metal sleeve with an adjustable screw foot. Used like the vertical shore post but side ways between the wall plates.

- 4"x 4" post screw jack = 18,000 pounds
- 6"x 6" post screw jack = 36,000 pounds

Wedges: Inclined planes used to pressurize the shore or fill gaps between the shore and the structure. Wedges are used in pairs with the cut side of each wedge "married" against each other for better holding capability and for a better striking surface for the hammers when pressurizing.

Gussets Plates: Are 12"x12"x¾" plywood squares or triangles that secure the connections between the different parts of the shore like the header and the vertical post. They are connected with 8-penny nails using a five-nail pattern. Gussets are used in joint areas that are ***not*** secured by the diagonal bracing.

Cleats: Are short pieces of lumber used to support or secure shoring component parts. 2"x 4" material in various lengths are usually used and secured with nails. Caution should be taken when nailing cleats due to the susceptibility of the lumber to split during the nailing process.

Diagonal Bracing: Locks the entire shore together so that the posts all work as one unit. The diagonal braces provide lateral stability and prevent the shore from failing like a collapsing parallelogram. They span the entire length of the shore and connect the top of a wall plate on one side to the bottom of the wall plate on the other side. A diagonal brace should be placed on each side of the shore in an "X" configuration. The top and bottom of the diagonal brace should cover the wall plate and strut connection point.

Midpoint Brace: Used when the 4"x4" struts are greater than 8' long or when 6"x6" struts are greater than 12' long. Midpoint bracing increases the load bearing capacity by resisting the buckling effect and the tendency for long struts to bend and break when put under pressure. ¾"x6", 1"x6"s, 2"x6"s or twin 2"x4"s on each side can be used for midpoint braces.

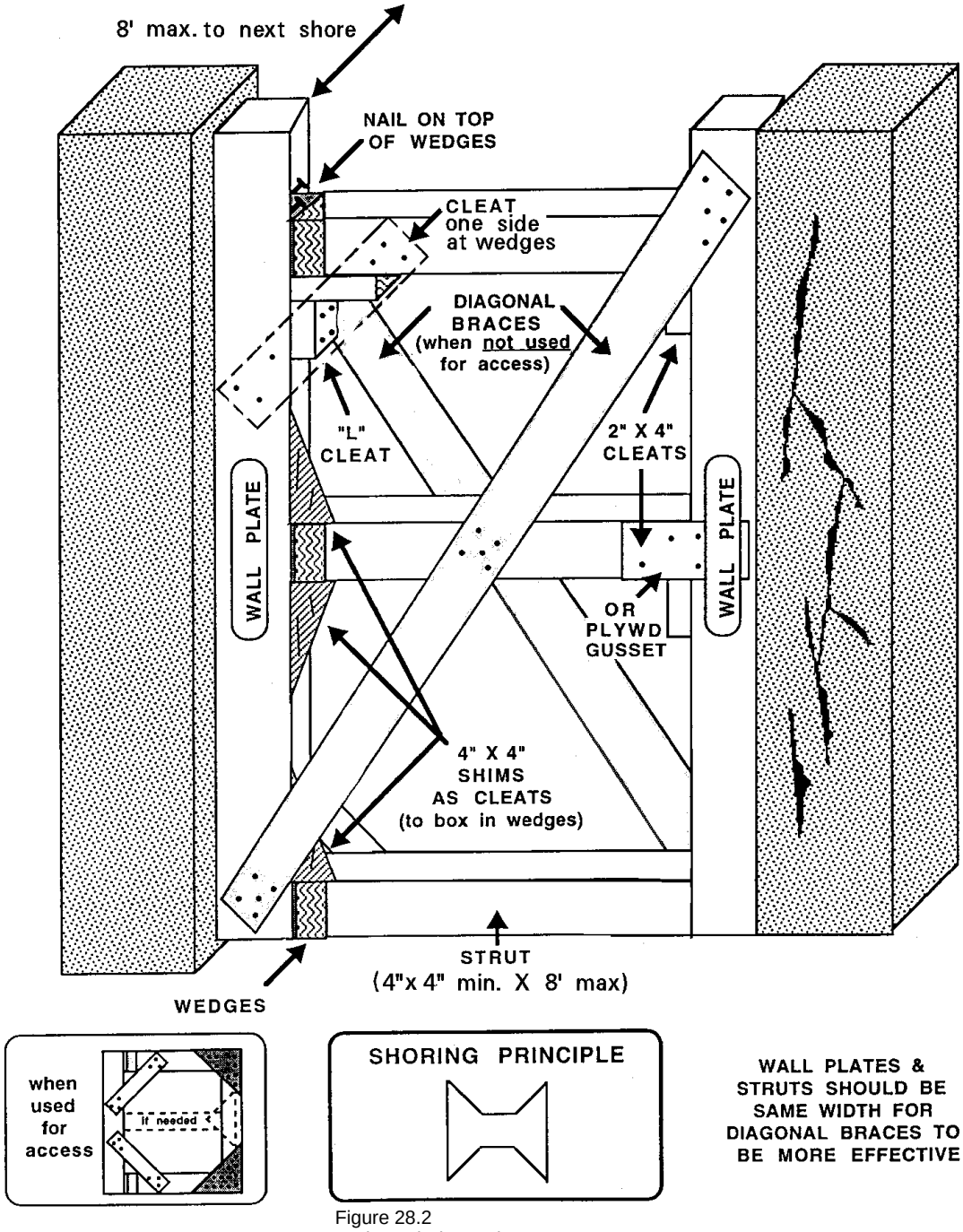


Figure 28.2
Horizontal Shore Diagram

HORIZONTAL SHORE ASSEMBLY

1. Measure and cut proper length of wall plates.
2. Mark wall plate for struts.
3. Attach cleats to aid strut placement.
4. Measure for struts; deduct pressurizing devices.
5. Cut the struts.
6. Position shore and align the ends of the wall plates.
7. Install and pressurize the bottom strut.
8. Install and pressurize the top strut.
9. Install diagonal braces, if needed.
10. Install and pressurize the middle strut, if needed.
11. Nail gusset plates and cleats to secure all joint connections.
12. Evaluate shore and structure.

CHAPTER 29 - THE WINDOW AND DOOR SHORE

Window and door shores are used by rescuers to stabilize damaged window, doorway, and other access ways within a weakened wall system. Any time rescuers use an opening as a means of access and egress they should shore the opening if it has been damaged or weakened from the collapse. Areas of forced entry through walls should also be shored to provide stability to the damaged wall and protection to rescuers who must enter the area.

The shore that is usually installed to protect openings can also be installed to protect the integrity of the wall. If the openings are not protected the failure of the opening can lead to failure of the wall section.

Window and door shores are multi-directional shores that are pressurized in all directions unlike most emergency shoring systems that are pressurized only in one direction. If load stresses are obviously exerted from one particular direction, the shore should be built to support the direction of failure. If the collapse is from above, the shore should be build similar to a vertical shore and if the collapse is from the sides, the shore should be built like a horizontal shore.

Figure 29.1
Window and Door Shore

Window and door shores can be assembled using one of two methods. The **Preconstruction Method** builds the complete shore at least 1½" less than the opening in each direction. Plywood triangle gussets nailed at each corner on both sides. After inserting the frame into the opening wedges pressurize the top and on one side. Additional shims are added to the top as needed to increase surface contact. The primary advantages to this assembly method are allowing preconstruction away from the dangerous wall or opening and simplicity to build. Severely racked or otherwise deformed openings may prevent this method from being used. The **Construct In-Place Method** builds the shore by measuring, cutting, and installing individual shoring components one piece at a time in the opening.

When these shores are installed, consideration must be given not to the compromise of the opening for access and egress with shore components, especially if diagonal braces are used to reinforce the shore.

COMPONENTS OF THE WINDOW AND DOOR SHORE

Header: Collects the weight from above and transfers it to the vertical posts. The header plate should be level and perpendicular to the vertical posts. 4"x4" lumber is the usual minimum size used in most rescue operations.

A rule of thumb is used to calculate the maximum span for the 4"x4" in an opening. For every 1' of span, 1" of material is needed. So, if a 4"x4" is used, a span of approximately 4' can be obtained with out additional support. If a longer span is required, rescuers can increase the thickness of the header by doubling the lumber and stacking two pieces together or by placing additional vertical posts. Additional vertical posts will impact the overall size of the opening.

Sole Plate: Supports the weight being transferred from above and distributes it over a wide area. The sole plate should maintain the same requirements as the header.

Posts: Supports the weight being collected by the header and transfers it to the sole plate. The posts should be perpendicular and maintain full surface contact with both the header and sole plate. The maximum length for the vertical posts should be no longer than 8'.

Wedges: Inclined planes used to pressurize the shore or fill gaps between the shore and the structure. Wedges are used in pairs with the cut side of each wedge "married" against each other for better holding capability and for a better striking surface for the hammers when pressurizing.

Gusset Plates: 12"x12"x17"x¾" plywood triangles that secure the connections between the different parts of the shore like the header and the vertical post. They are connected with 8d nails using a five-nail pattern. Gussets are used in joint areas that are ***not*** secured by the diagonal bracing.

Cleats: Are short pieces of lumber used to support or secure shoring component parts. 2"x4" material in various lengths are usually used and secured with nails. Caution should be taken when nailing cleats due to the susceptibility of the lumber to split during the nailing process.

Diagonal Bracing: Locks the entire shore together so that the posts work as one unit. The diagonal protects the shore from shifting and failing like a collapsing parallelogram. They span the entire length of the shore and connect the top of one vertical post to the bottom of the post on the other side. Diagonals should be place on each side of the shore in an "X" configuration only if access is ***not*** needed. The top and bottom of the diagonal brace should cover the header, sole plate, and post connection point

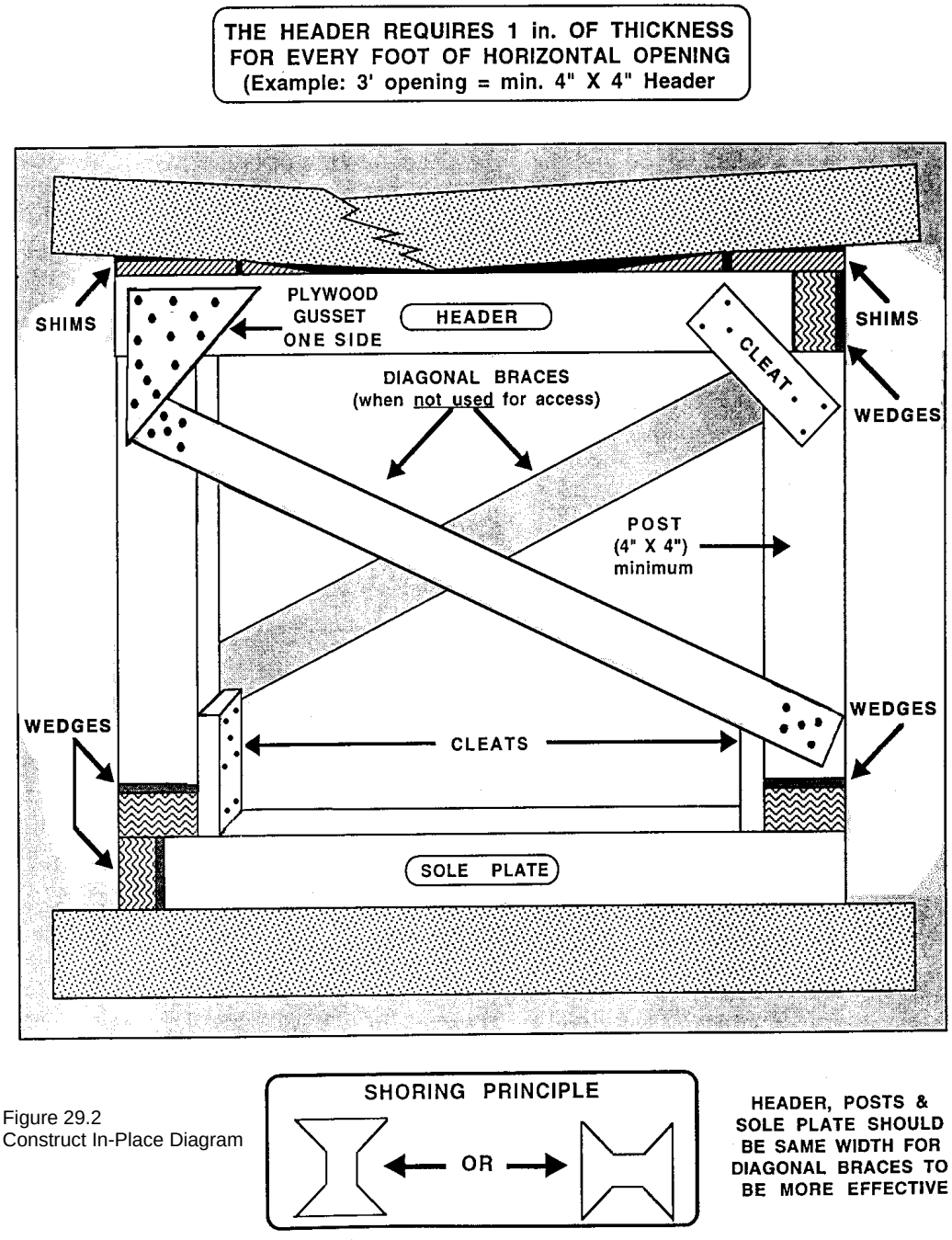


Figure 29.2
Construct In-Place Diagram

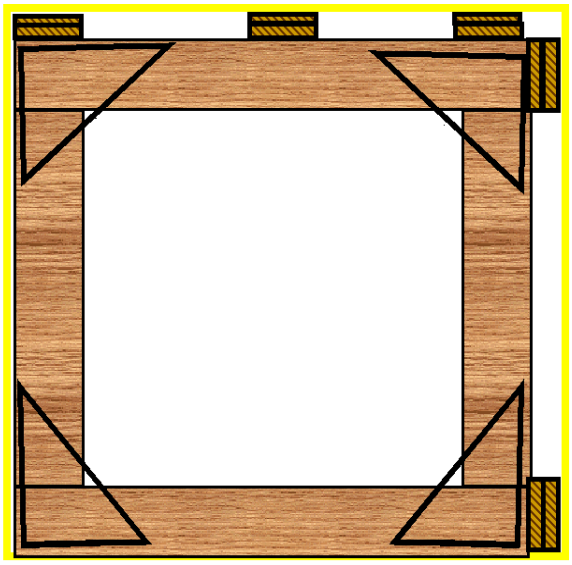


Figure 29.3
Preconstructed

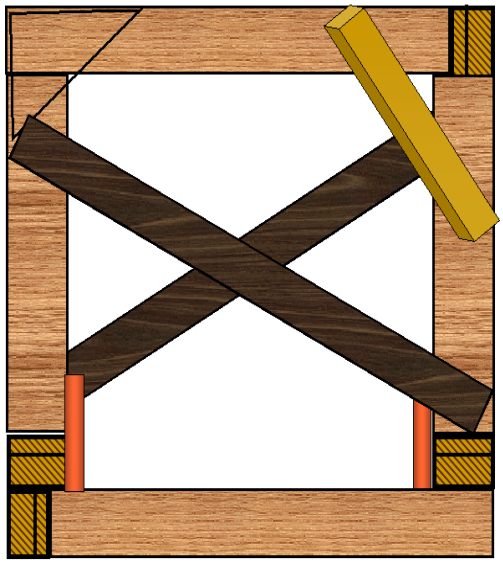


Figure 29.4
Construct In-Place

WINDOW AND DOOR SHORE ASSEMBLY

Preconstructed Method

When load is from above, construct similar to a vertical shore

When load is from the side. construct similar

1. Measure and cut the proper length of the header and sole plate.
2. Measure the overall height to be shored; use the shortest length measure if area is uneven.
3. Deduct the depth for the header, sole plate, and pressurizing devices.
4. Measure and cut the vertical posts.
5. Install the posts between the ends of the header and sole plate.
6. Nail triangle gusset plates at the corners on both sides.
7. Place shore in opening.
8. Pressurize the posts with wedges between the header and opening.
9. Pressurize the header and sole plate with wedges between the ends of the header and sole plate and opening.
10. Install shims between the header and the opening as needed to increase surface contact.
11. Install diagonal braces if the opening is not used for access or egress.
12. Position shore and sole plate under the load; align the ends of the header and sole plate.
13. Evaluate shore and structure.

CHAPTER 30 - SLOPED SURFACE SHORE WITH CRIBBING

The use of cribbing as shoring is very advantageous and one of the most effective and simplest stabilization methods. It can be easily adjusted to proper height and can be applied to sloped surfaces. Cribbing can be diagonally braced to increase lateral support and it can be used to brace crossbeams that support a large area of a structure. Crib shoring, when applied, is relatively wide and stable. It effectively transfers the collected loads over multiple shoring elements that are working together to hold the load.

Figure 30.1
Sloped Floor Shoring

Since the crib shoring system uses basic lumber materials that can be precut and ready for immediate use even in small confined areas, the process of making measurements, cutting, and nailing to install the shore up can be eliminated unlike with the process of installation with the other shoring systems.

The greatest advantage of cribbing shoring systems over all other systems is that when they start to fail, they fail from crushing. This failure will be slow and noisy which act as a warning system for rescuers that the shoring system is overloaded. Although there are advantages of using cribbing, there are some disadvantages that rescuers need to consider. Cribbing uses a large amount of materials and requires a fairly level base to build on.

Cribbing shores can be built in a box using two members per layer or crosstie configuration using three members per layer for increased capacity. The capacity of a two-member box crib using 4"x4" lumber is 24,000 pounds and three-member crosstie crib using 4"x4" lumber is 55,000 pounds

To maximize crushing failure of cribbing, the tails of each layer should extend approximately its dimension past the layer of cribbing below. When the crib bed is loaded to capacity it will crush uniformly, creating saddles similar to Lincoln logs preventing pieces from squirting out. This method only works if the load remains relatively square to the ground. If the object is not square to the ground the cribbing tails or ends will be loaded and cause a cantilever effect. The crib bed can become unstable and reduce its load-carrying capability.

When cribbing to sloped surfaces, place the ends of the cribbing closest to the load flush with the layer below to increase crib bed stability and reduce the cantilever effect.

Cribbing shoring systems used to support floor and roof assemblies or buildings, lateral stability of the crib bed must be considered. Lateral stability will be dependent on the width-to- height ratio of the assembly.

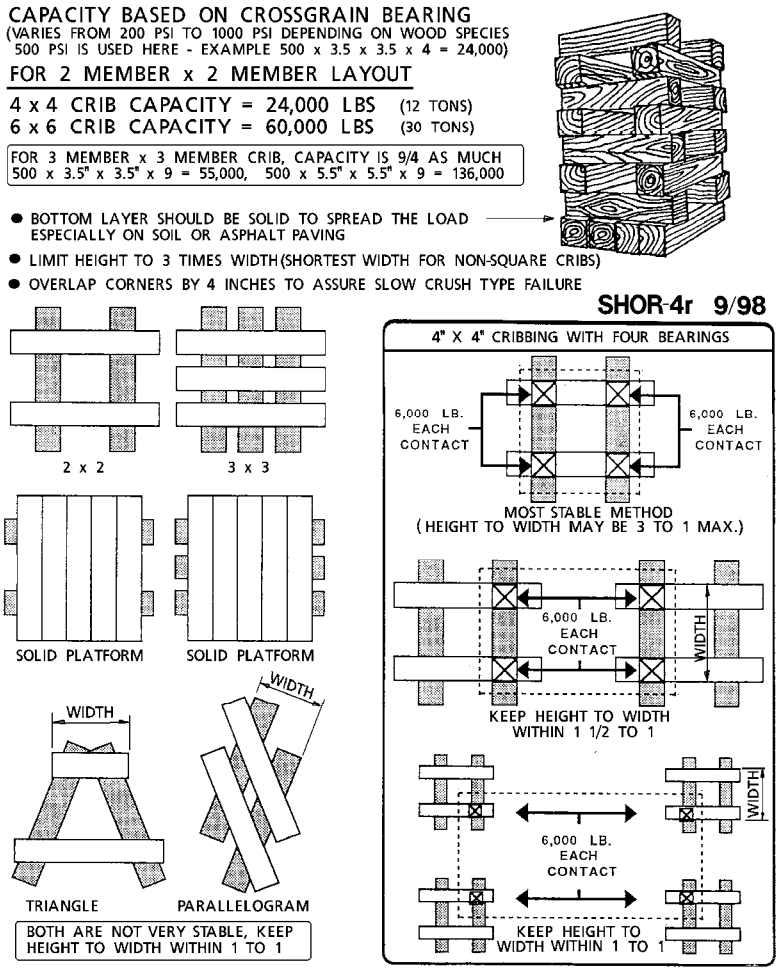


Figure 30.2

A rule of thumb is that you can build a crib bed three times as high as the width of the crib area for **level surfaces**. Example: If the width of the crib area is 3', then the crib can be built 9' high and still maintain stability.

When shoring **sloped surfaces** with 2' cribbing pieces, the maximum allowable height is 3'. The maximum angle that cribbing can be used for sloped surfaces is 15° or 30% (3' elevation within a 10' distance). The potential for large slabs to slip off the crib beds increases when steeper surfaces are shored.

COMPONENTS OF THE SLOPED SURFACE SHORE

Cribbing: Lumber size and minimum length:

- 2"x4"x18"
- 2"x4"x2'
- 4"x4"x18"
- 4"x4"x2'
- 6"x6"x2'

Many departments use 18" long cribbing. This size makes it convenient for storage and allows more pieces per 8' lumber stock but is limiting to shoring operations due to a shorter overall shoring height that can be reached.

A maximum of 8' between cribbing systems under a sloped surface is allowed under most conditions. If the sloped surface is severely damaged or is heavily weighted, the maximum space allowed between crib beds should be reduced to 4' or less.

Wedges: Usual size:

- 2"x4"x12"
- 4"x4"x18"

Wedges are used primarily as single pieces to fill voids spaces and to change the angle of cribbing surface contact. The crib bed is built flat and level with the angle change occurring at the top of the bed next to the sloped surface.

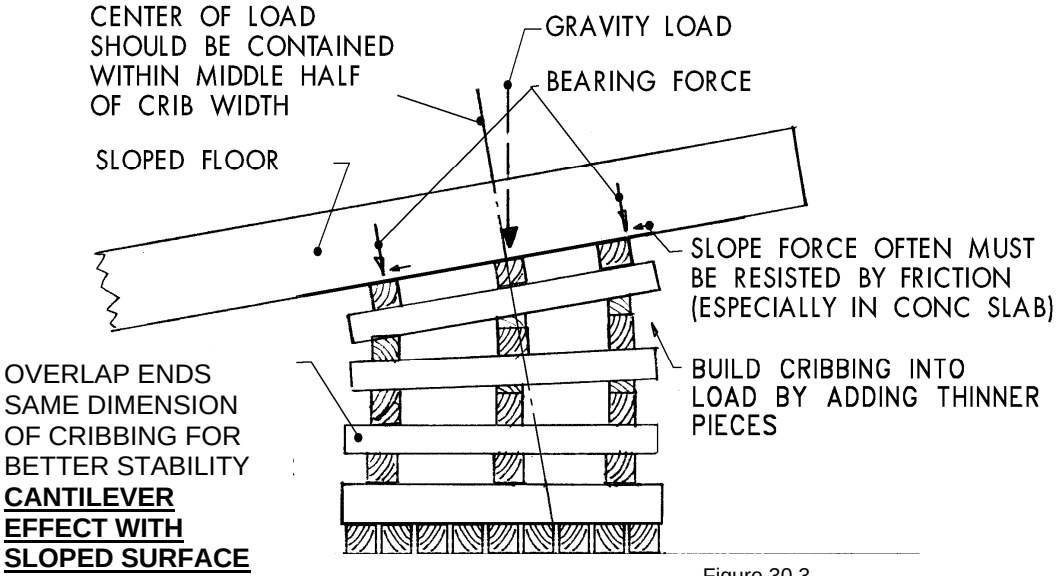


Figure 30.3
Sloped Floor Shore with Cribbing

Header: Used to collect the weight from the structural element shored and to spread it throughout multiple crib beds in the shoring system. The minimum lumber size used is a 4"x4".

SLOPED SURFACE SHORE WITH CRIBBING ASSEMBLY

No body parts are placed under unsupported loads during the assembly of the sloped surface shore.


Figure 30.4

Prior to assembly or installation, rescuers must consider the access and egress pathways. A crib bed can take up significant access space that may get in the way of rescue operations and personnel movement. Well-placed shores will ensure maximum level of safety and access possible in the collapsed structure.

When placing cribs or wedges, no more than two parallel layers of the same material should be stacked on top of each other. Stacking more than two parallel layers in the same direction greatly reduces the stability of the shore.

1. Place first layer of cribs.
    - Ends of crib perpendicular to the object.
    - On soft surfaces, use a solid layer of cribbing parallel to the object.
    - Lay cribs level to the ground.
2. Place second layer of cribs.
    - Perpendicular to the first layer.
    - Maintain 3½" overlap from ends of the first layer.
    - Use another crib to push the crib members into position under the unsupported sloped surface.
3. Place additional layers.
    - Continue alternating direction on each layer until the crib bed components are in near contact with the object to be shored.
4. Change the angle.
    - Use the last two crib layers to change the angle of the shore to make contact with the shored surface.

- Thinner cribbing material can be used under the sloped surface area farthest away from the rescuer.

5. Fill void spaces.
   - Fill all void spaces to ensure full surface contact.
   - Gently tap the wedges to "snug" up the shore.
6. Evaluate shore and structure.

CHAPTER 31 - THE RAKER SHORE

RAKER SHORES

Raker shores are used to support leaning or unstable walls and columns. The two types of raker shores used in the Rescue Systems 1 course are the solid sole raker shore and the flying raker shore. These 4"x4" raker shores are impractical to use on high walls (above two stories) due to the tremendous weights involved. In the case of high, unstable walls, it is best to avoid the area. Have unstable sections carefully removed or have commercial shore systems installed.

The raker shore leaning against the wall exerts a vertical force that at times tends to make the shore assembly creep up the wall. The horizontal force being applied by the wall in an outward direction is resisted by the shore being secured by anchors at the base of the shore.

Both the solid sole plate and flying raker shore can be constructed at 45°-60° angles. They are always installed in a series of at least two with a maximum separation of 8' and are braced together for additional stability.

Placement of the raker tip is to be within 2' at or below floor level on the outside of the compromised wall (commonly referred to as the insertion support point).

Solid Sole Plate Raker Shore

- Provides maximum stability
- All shoring components attached together
- Full triangle design most often constructed for rescue operations
- Can be used in suburban and rural environments
- Has a maximum load rating of 2,400 pounds per raker shore

Figure 31.1
Raker Shores

Flying Raker Shore

- Used as initial temporary shore
- Fewer components and easy to construct
- Can be used in urban environments where concrete/asphalt commonly cover the ground
- Stability increased when attached to wall or column
- Should be reinforced with full triangle raker shores in proximity
- Has a maximum load rating of 1,000 pounds per raker

Figure 31.2
Flying Raker Shore

Components of the Solid Sole Plate and Flying Raker Shore

Wall Plate: Collects the weight being transferred horizontally and spreads it throughout the shoring system. The minimum lumber size that should be used is a 4"x4". The length is measured from the insertion point to ground level, adding 2' minimum for cleat (plus thickness of the sole plate) if being used on a solid sole raker. Backing can be made of 2" lumber or ¾" plywood to widen surface contact, if needed.

Top Cleat: A short piece of 2" lumber that is nailed to the top of the wall plate to keep the raker from riding up the wall plate. The tip of the raker will be in full contact with the bottom of the top cleat when erected. A 2' cleat is used for 45° rakers and a 3' cleat is used for 60° rakers.

Sole Plate: If used on a solid sole raker, the sole plate collects the weight being transferred laterally and distributes it to the ground or other structural supporting member. Mostly used in urban environments where concrete/asphalt commonly cover the ground. The minimum lumber size that should be used is a 4"x4". The length is measured from the face of the wall plate to where the bottom of the raker will contact the sole plate on the wedge side, adding 2' plus the thickness of the wedges to the length to allow for the attachment of the bottom cleat.

The sole plate can be long enough to contact a solid object or minimum 4"x4" curb secured with two 1" cold rolled steel stakes to prevent the shore from sliding backwards.

U-Channel Sole Plate: If used on a split sole raker, the U-channel sole plate collects the weight being transferred laterally and distributes it to the ground or other structural supporting member. Mostly used in suburban and rural environments where open ground is available.

Bottom Cleat: Is used on a solid sole raker and is a short piece of 2" lumber that is nailed to the rear of the sole plate to keep the raker from riding back on the sole plate. A gap the width of the wedges is left between the bottom cleat and the raker to later pressurize the shore. Similar to the top cleat, a 2' cleat is used for 45° rakers and for 60° rakers.

Raker: Is the main member of the shore, it supports the weight being collected by the wall plate and transfers it to the sole plate. The minimum lumber size that should be used is a 4"x4". The width of the raker should be the same as the wall plate and sole plate for a more secure attachment of gusset plates, cleats, or braces.

- On a solid sole raker, the length is measured from the insertion point on the wall plate to the contact point on the sole plate (wedge side).
- On a flying raker, the length is measured from the insertion point on the wall plate to the contact point on the U-channel subtracting for the wedges.
- On either raker, the length is best determined by using the factor method to determine length.

Wedges: Inclined planes used to pressurize the shore or fill gaps between the shore and the structure. Wedges are used in pairs with the cut side of each wedge "married" against each other for better holding capability and for a better striking surface for the hammers when pressurizing.

Gusset Plates: 12"x12"x¾" plywood squares or triangles that secure the connections between the different parts of the shore like the wall plate and sole plate. They are connected with nails using a five-nail pattern. Gusset plates should be kept at least a ¼" away from the outside edge of the framing members in order to prevent pressurizing them. On the raker shore, they should be placed on both sides of the joints.

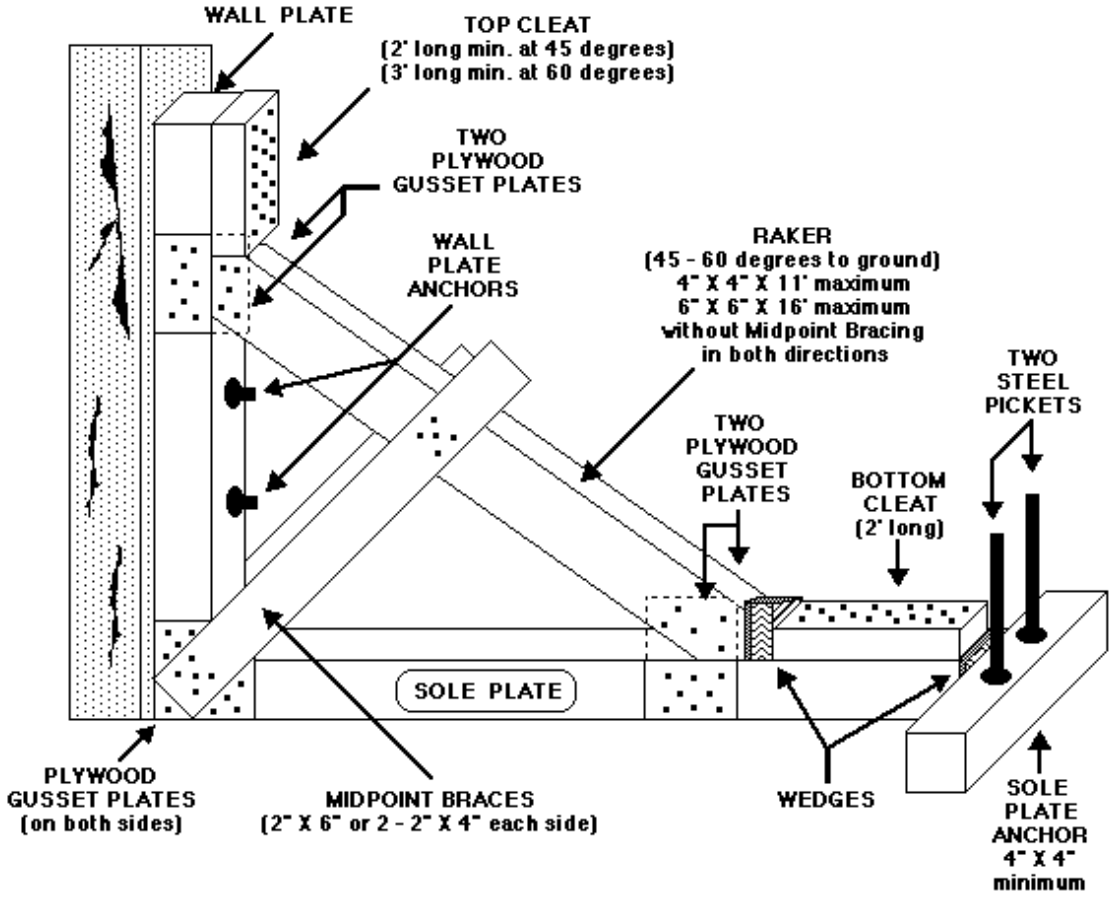
Bottom Braces: Connects the wall plate to the raker. Maintains distance and provides strength for the shore by preventing separation of raker shore components. The minimum size lumber to be used is one 2"x6" or two 2"x4"s.

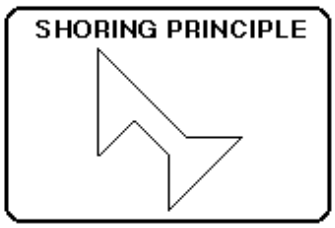
Midpoint Braces: Are used to increase the raker load bearing capability by resisting the "buckling" effect. These are required when the 4"x4" raker is greater than 11' in length or 6"x6" greater than 16' in length. They are attached to both sides near the midpoint of the raker and connected to the wall plate at a right angle. The minimum size lumber to be used is one 2"x6" or two 2"x4"s.

Horizontal Braces: Connect the raker shores together near the top and bottom of the raker to provide additional stability. Also attached to the raker midpoint to increase the raker load bearing capability by resisting the "buckling" effect when 4"x4" raker is greater than 11' long or 6"x6" greater than 16'. They

are attached and perpendicular to the rakers at the top, bottom and if needed, the midpoint. The minimum size lumber to be used is one 2"x6" or two 2"x4"s.

"X" and "V" Braces: Provide additional stability and resists lateral deflection of the shores. They are used at the end of each raker shore system and no further than 40' apart. They are attached near the bottom half and top half of the raker shores when using an "X" between two shores or "V" between three shores. If a midpoint brace is used the "X" will be placed above and below the brace. The minimum size lumber to be used is one 2"x6" or two 2"x4"s.





WALL PLATE, RAKER & SOLE PLATE SHOULD BE SAME WIDTH FOR BRACES TO BE MORE EFFECTIVE

Figure 31.3
Full Triangle Raker Shore
Solid Sole Plate Method

SOLID SOLE PLATE RAKER SHORE ASSEMBLY

1. Measure the height from ground to insertion support point.
2. Measure and cut wall plate allowing for cleat length and sole plate thickness.
3. Measure and cut sole plate allowing for cleat length, wedges, and anchoring devices.
4. Measure and cut raker using "factor method."
5. Gather and layout components to pre-assemble raker shore.
6. Align wall plate, raker, and sole plate on ground.
7. Attach cleats to wall plate and sole plate.
8. Attach wall plate to sole plate.
9. Attach raker to wall plate and sole plate.
10. Attach gusset plates to raker, wall plate, and sole plate connections.
11. Position raker assembly against wall and anchor the sole plate to the ground.
12. Place wedges between raker end and cleat on sole plate.
13. Pressurize the raker shore.
14. Measure, cut, attach midpoint braces and complete nailing patterns.
15. Measure and attach horizontal braces.
16. Measure and attach "X" or "V" braces.
17. Attach wall plates to walls, if possible.
18. Evaluate shoring system.

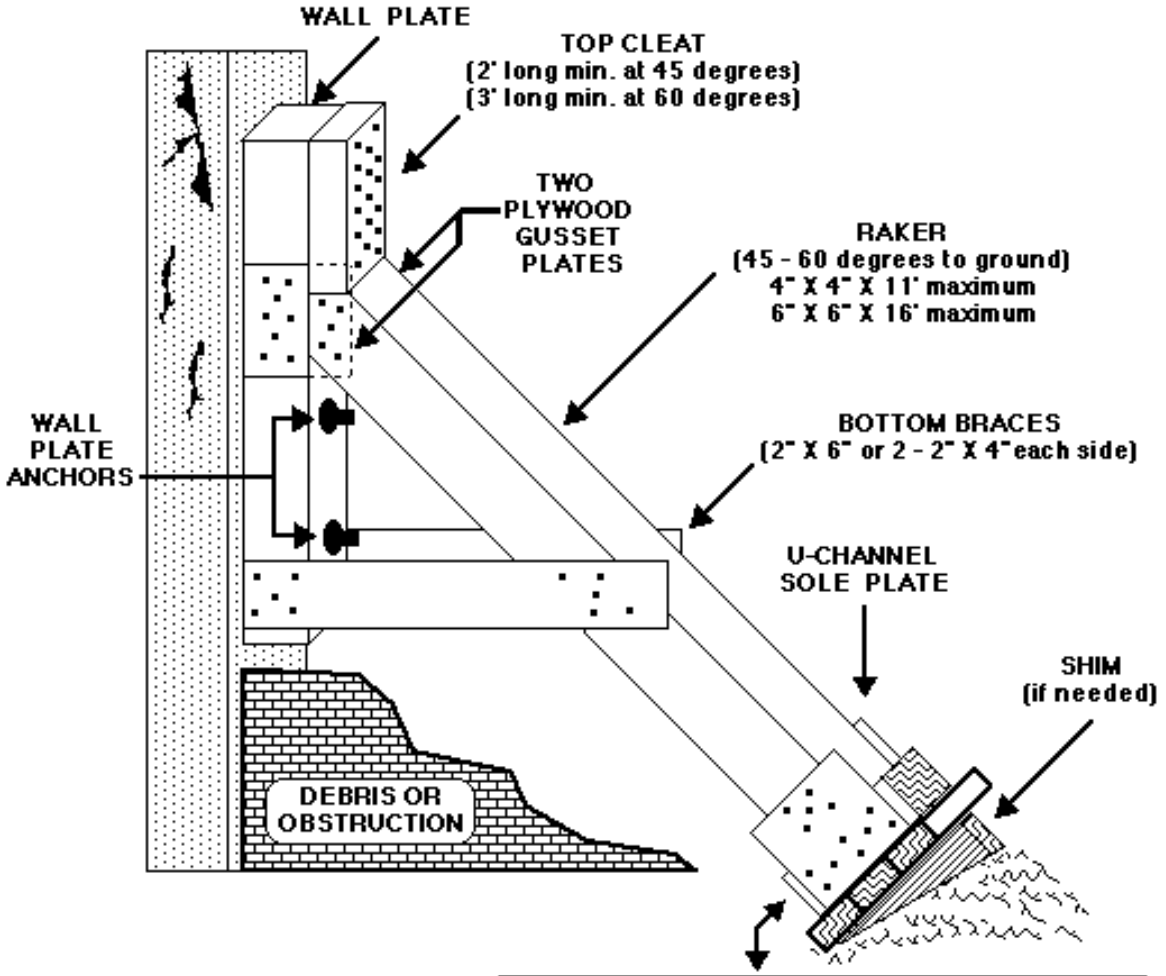


Figure 31.4
Flying Raker Shore
U-Channel Sole Plate Method

FLYING RAKER SHORE ASSEMBLY

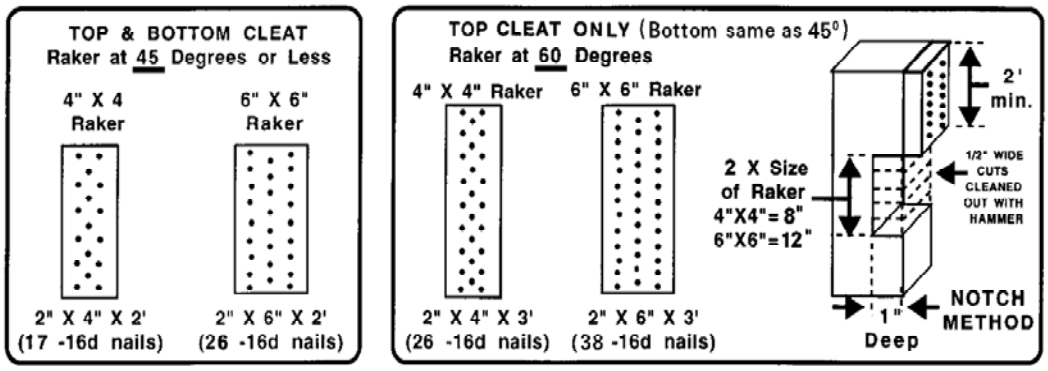
1. Measure height from ground to insertion support point.
2. Measure and cut wall plate allowing for cleat length and debris.
3. When using U-channel sole plate method, fabricate a U-channel sole plate .

   OR

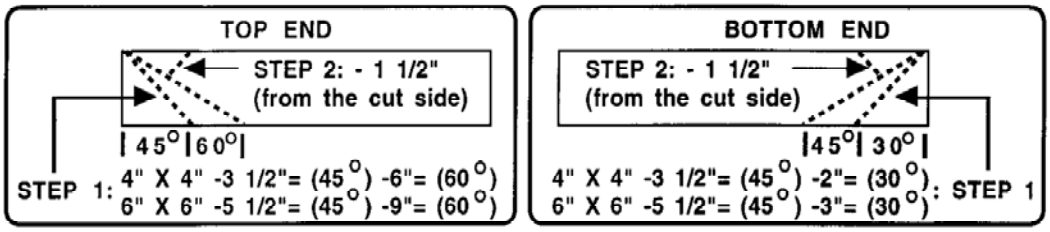
   When using solid sole plate method, measure and cut sole plate allowing for cleat length, wedges, and anchoring devices.
4. Measure and cut bottom braces.
5. Gather and layout components to pre-assemble raker shore.
6. Align wall plate, raker, and bottom braces.
7. Attach cleat to wall plate.
8. Attach raker to wall plate.
9. Attach gusset plates to raker and wall plate connection.
10. Attach bottom braces.
11. When using U-channel sole plate method, position assembled raker against wall and dig hole in ground at proper angle then install wedges in hole under U-channel sole plate or between end of raker and U-channel sole plate.

    OR

    When using solid sole plate method, attach cleat to sole plate, position assembled raker against wall and on top of sole plate, anchor the sole plate to ground, place wedges between raker end and cleat on sole plate.
12. Pressurize the raker shore and complete nailing patterns.
13. Measure and attach horizontal braces.
14. Measure and attach "X" or "V" braces.
15. Attach wall plates to walls, if possible.
16. Evaluate shoring system.



HOW TO CUT THE TOP & BOTTOM ENDS OF THE RAKER



HOW TO ANCHOR THE WALL PLATE & SOLE PLATE OF A RAKER SHORE

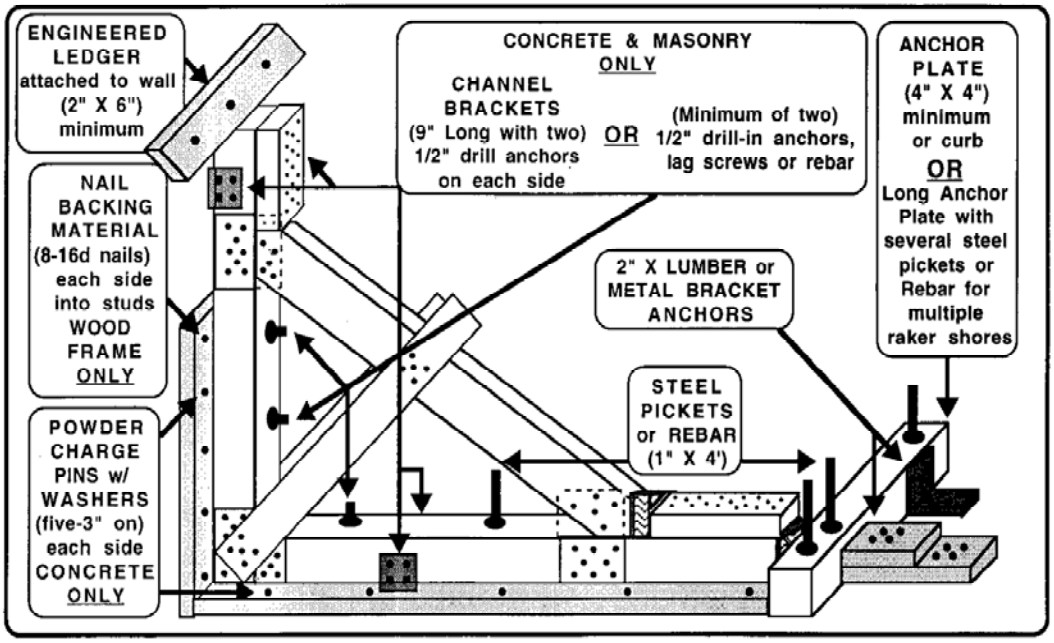


Figure 31.5
Raker Shore: Cleats, Cuts, and Anchors

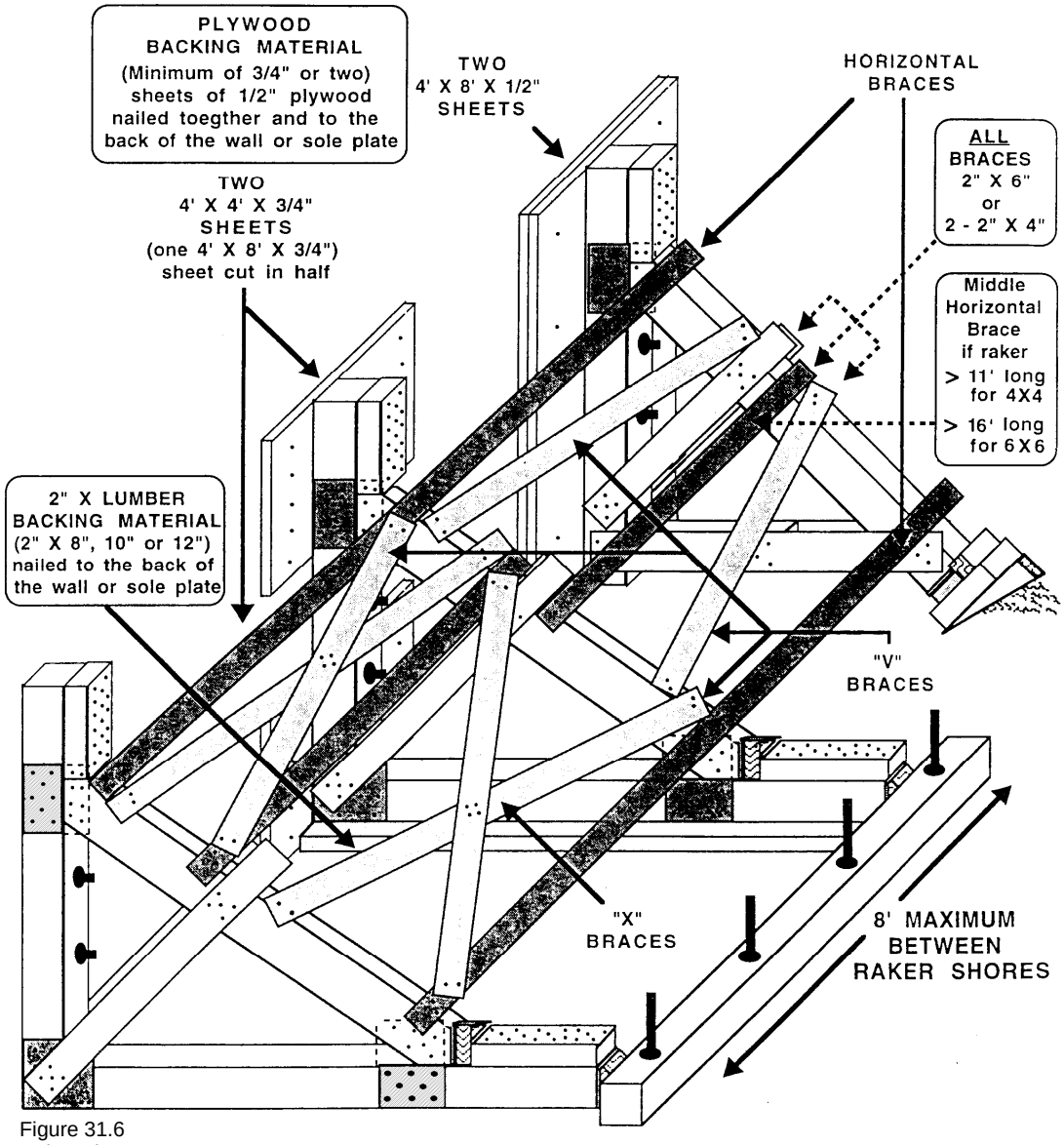


Figure 31.6
Raker Shore
Braces and Backing Material

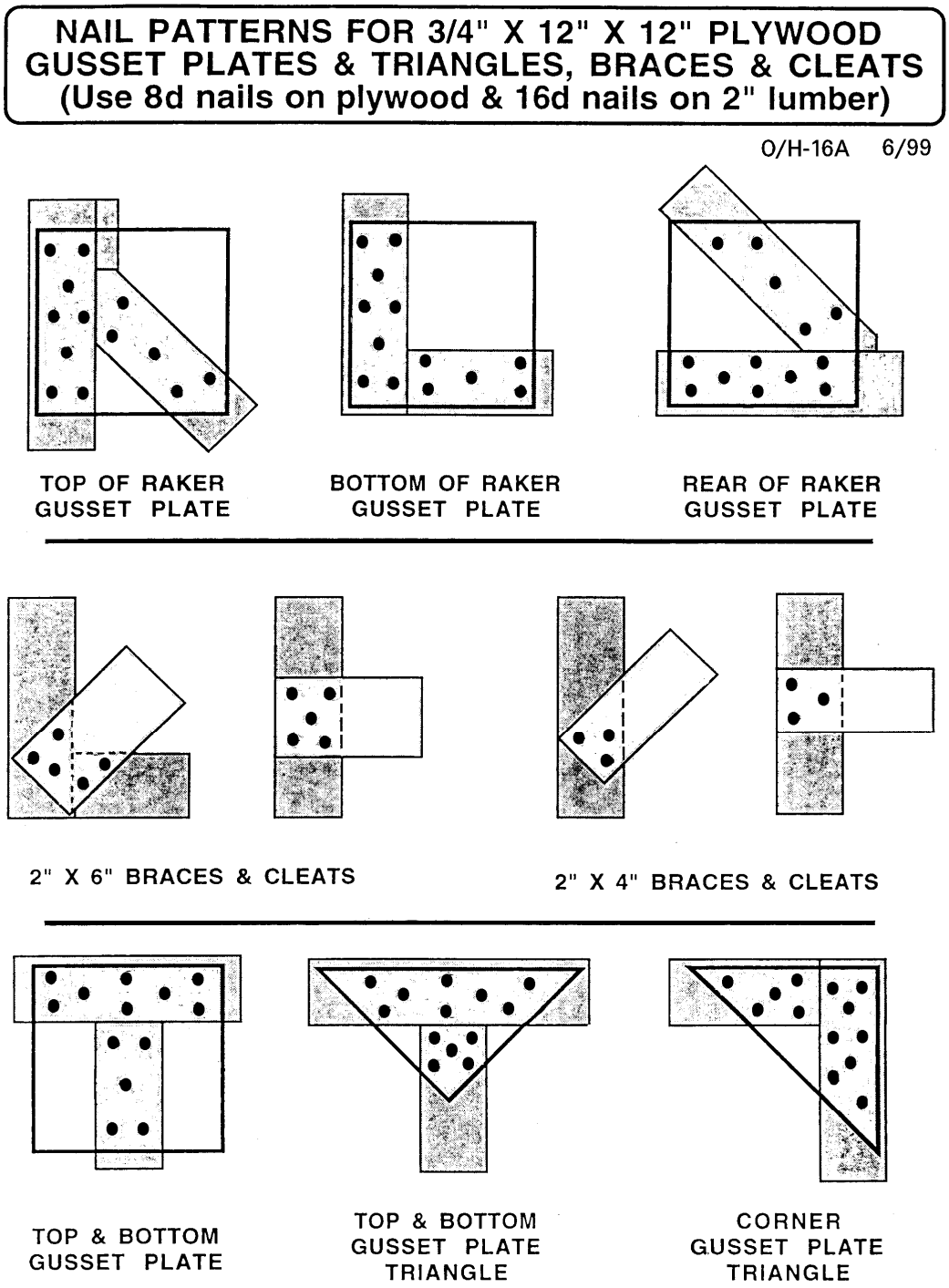


Figure 31.7
Nail Patterns

CHAPTER 32 - THE CUTTING STATION

CUTTING STATION SET-UP

The cutting station is central to shoring operations and is constructed with available materials to provide a template or jig for the preparation of shoring materials. It should be located in a secure, safe area, close to the shoring objective and near material supply.

The cutting station's advantages are the use of fewer personnel to achieve goals and speeds ability to produce shoring components.

Figure 32.1
Cutting Table

COMPONENTS OF THE CUTTING TABLE

Top: Provides a flat surface and support for marking, calculations, and cutting materials. Minimum size of the top should be 4'x4'x¾" plywood.

Guides: Provides template and jig for lumber to be cut in varying lengths and dimensions. They are premarked with measurements to reduce the time used to measure and mark shoring materials. Minimum lumber size is 2"x4" spaced at 1½", 3½", and 5½" apart. Be sure to allow an extra ¼" for irregular or wet lumber.

Cribbing: Provides support for the top and maintains 6" height minimum required. These are attached perpendicular to the guides under the plywood top.

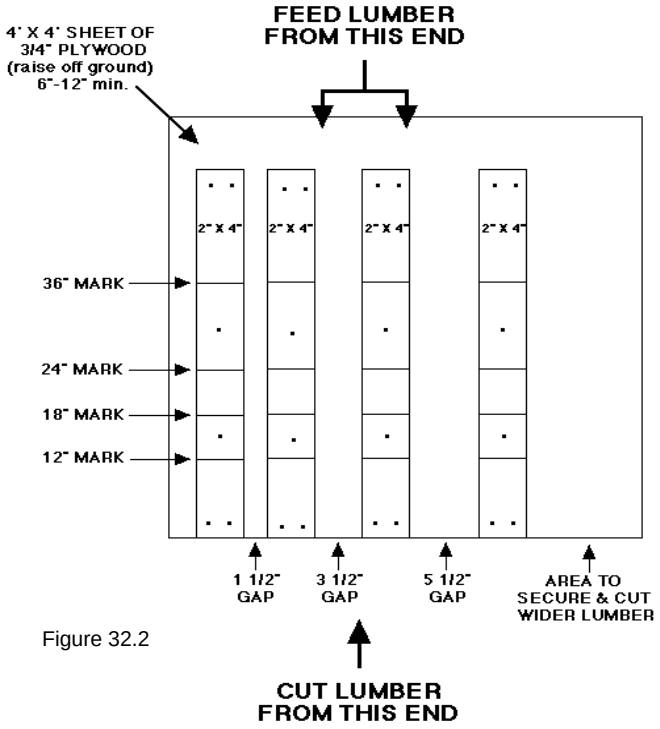


Figure 32.2

CUTTING STATION ASSEMBLY

1. Measure and cut top to proper size.
2. Measure and cut guides to proper length.
3. Gather the correct amount of cribbing and materials.
4. Layout cribbing on a flat surface within a 4'x4' area.
5. Place top on cribbing and nail into place
6. Place guides on top at proper spacing and nail through guides and plywood into cribbing base with 16d nails.
7. Mark guides at 12", 18", 24", and every foot thereafter.

CLEATS, WEDGES, AND GUSSET PLATES

Cleats provide support or secure shoring component connections. Wedges provide the essential surface contact and the ability to adjust our shores. Gusset plates provide strong connections at component joints and shoring system stability.

Cutting a Cleat

1. Place 2"x4" into 3½" slot and slide to end of top.
2. Mark length desired using the premarking on the runners.
3. Cut to length with handsaw or chainsaw.

Cutting a Set of Wedges

1. Place 4"x4" into 3½" slot and slide to end of top.
2. Mark length desired using the premarking on the runners.
3. Mark a diagonal line with 2"x4" provided as a straight edge from the top edge of one 18" line to the bottom edge of the opposite 18" line.
4. Align the saw bar with the diagonal line pointing towards the cutting table and cut lumber
5. Cut remaining half off at the 18" line.
6. Repeat process for 2"x4" using 1½" slot and 12" length.

Cutting a Gusset Plate

1. Place a full 4'x8'x¾" sheet of plywood on cutting station table.
2. Mark into 12"x12" squares using a chalk line or straight edge and measuring tape.
3. Cut with chain saw along 8' length lines from top to bottom.
4. Stack 12"x8' lengths of plywood on top of each other with all edges aligned and marked piece on top.
5. Cut every 12" on lines provided
6. For a triangle gusset, mark a single 12"x12"x¾" gusset plate diagonally from corner to corner with a straight edge or chalk line.
7. Cut on diagonal line with chain saw, creating two 12"x12"x17" gusset plates.

MEASURING TOOLS TO DETERMINE RAKER LENGTH AND ANGLE

The most common tool used to determine lumber length is a tape measure with a 1" wide steel tape and power return for ease of use and simple-to-read measurements. During construction of emergency shoring systems, a good practice used by several rescue teams is to measure and report all measurements in inches. This will reduce the chance of not understanding a measurement being reported via radio or in person by someone other than the person doing the measuring. An example of this would be requesting a 4"x4" with a length of 9'6". If the measurement is reported over the radio as "one four by four by nine six" the lumber could be cut at 96" or 114" (9'6") which is the actual size being requested. It is easier to understand 114" than 9'6". The tape measure can also be used to determine the angle of a raker.

A steel framing square, although not part of the California Emergency Services US&R Light Equipment cache, can also be used to determine the length and angle of a raker. The Diagonal Method and the Step-Off Method are just two ways in which to determine the proper length and angle of a raker. It is also useful in determining other angles and ensuring shoring components are square 90° angles.

The speed square resembles a triangle and can be made of metal or plastic. It is used primarily to ensure that shoring components are square at 90° angles. It is also useful to determine the angle of a raker.

USING THE STEEL FRAMING SQUARE TO DETERMINE THE LENGTH OF A RAKE

Figure:1

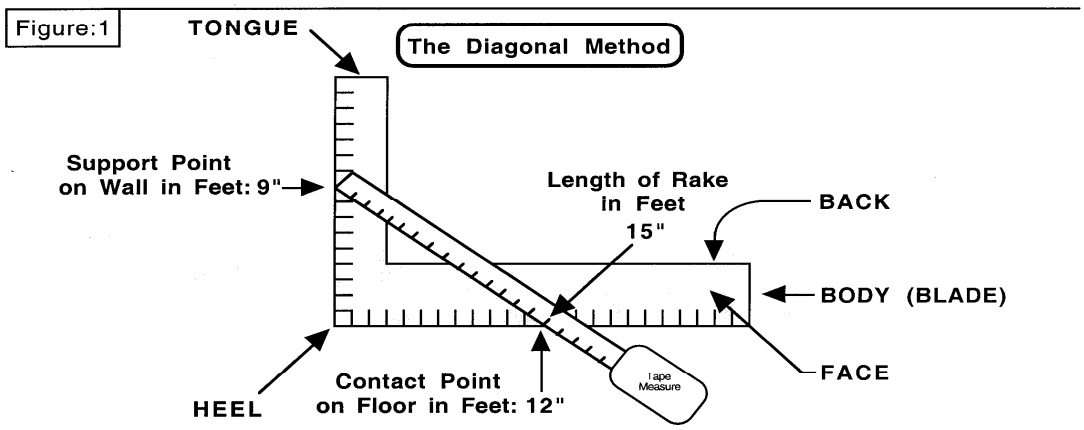


Figure:2

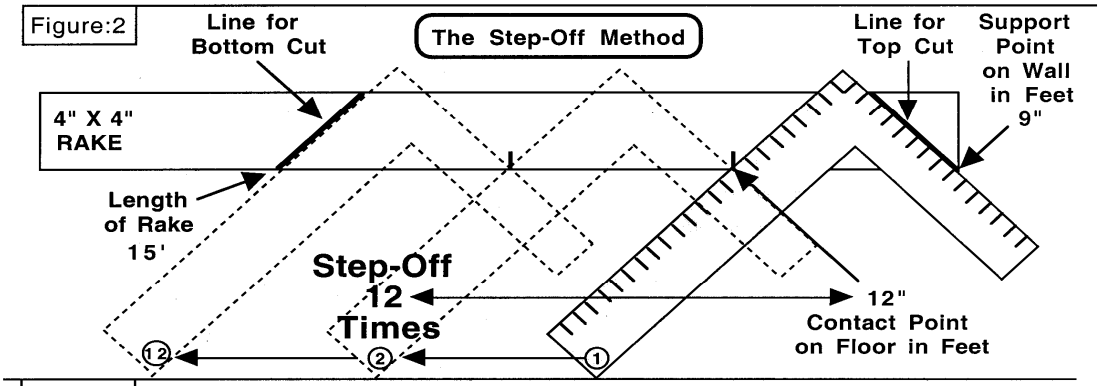
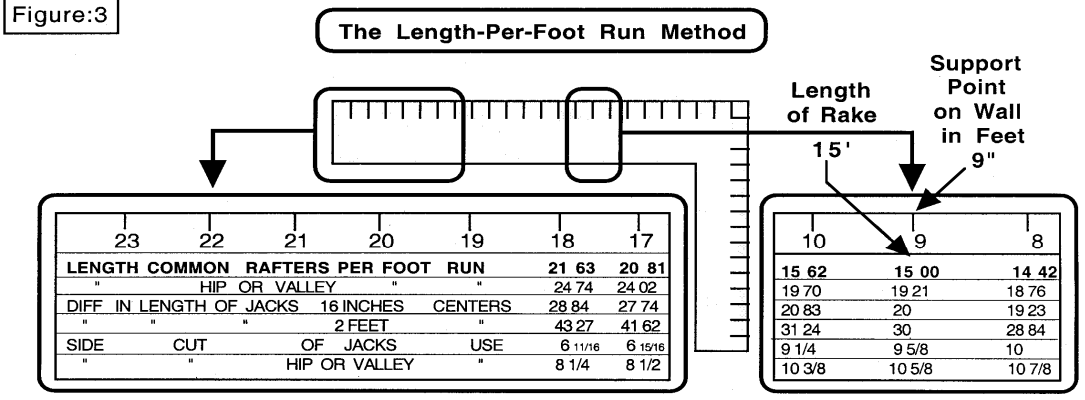


Figure:3



23	22	21	20	19	18	17
LENGTH COMMON RAFTERS PER FOOT RUN					21 63	20 81
" HIP OR VALLEY " "					24 74	24 02
DIFF IN LENGTH OF JACKS 16 INCHES CENTERS					28 84	27 74
" " " 2 FEET "					43 27	41 62
SIDE CUT OF JACKS USE					6 11/16	6 15/16
" " HIP OR VALLEY "					8 1/4	8 1/2

10	9	8
15 62	15 00	14 42
19 70	19 21	18 76
20 83	20	19 23
31 24	30	28 84
9 1/4	9 5/8	10
10 3/8	10 5/8	10 7/8

Figure 32.3
Steel Frame Square

45° AND 60° RAKER ANGLES

The raker is the most important component of the raker shore. It supports the most weight being collected by the wall plate and transfers it to the sole plate.

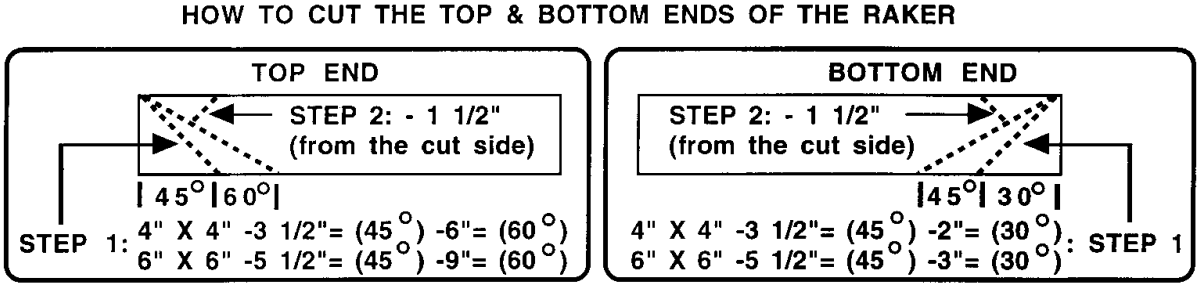


Figure 32.4
Cutting the Raker

Cutting a 45° Raker

1. Place a 4"x4" into 3½" space and slide to edge of top.
2. Make a mark 3½" back from the end on the outside edge of lumber.
3. Draw a diagonal line from the end of the 4" x4" upper corner to the 3.5" mark on the outside edge of the lumber.
4. Cut this 45° line with a chainsaw.
5. Place tape measure on raker tip with hook flush against the cut.
6. Move tape measure until 1½" is on outside edge of lumber 90° to cut.
7. Draw a line along the tape measure edge.
8. Cut this line.
9. Determine length of the raker multiplying a factor of 17 times the height in feet to insertion point.
10. Using tape measure, hook tape on raker tip and measure length of lumber desired.
11. Mark length and repeat procedure for cutting 45° angle opposite the one just cut and no further than the length just marked.

    * Keep bottom of raker at 90° angle plus 12" for "U"-channel sole plate method.

Cutting a 60° raker

1. Place a 4"x4" into 3½" space and slide to edge of top.
2. Place speed square on 4"x4" with guide edge against lumber.

3. To determine 60° angle, place pivot point in fixed position and rotate speed square away from lumber until the 60° mark aligns with outside edge of lumber.
4. Mark leading edge.
5. Cut this line with a chainsaw.
6. Place the guide edge of speed square on the 60° angle just cut.
7. Slide speed square on angle just cut until 1½" is measured on leading edge and outside edge of lumber.
8. Mark leading edge.
9. Cut this line.
10. Determine length of the raker multiplying a factor of 14 times the height in feet to insertion point.
11. Using tape measure, hook tape on raker tip and measure length of lumber desired.
12. Mark length and repeat procedure for cutting angle using 30° angle opposite the one just cut and no further than the length just marked.

    * Keep bottom of raker at 90° angle plus 12" for "U"-channel sole plate method.

RESCUE SYSTEMS 1

STUDENT MANUAL

Published by

State Fire Training
PO Box 944246
Sacramento, CA 94244-2460
Third Edition, December 2000

TABLE OF CONTENTS

SFT MISSION STATEMENT

The mission of State Fire Training is to enable the California fire service to safely protect life and property through education, training, and certification.

ACKNOWLEDGMENTS

The State Fire Training Curriculum Development Division coordinated the development of the material contained in this guide. Before its publication, the Statewide Training and Education Advisory Committee (STEAC) and the State Board of Fire Services (SBFS) approved this guide. This guide is appropriate for fire service personnel and for personnel in related occupations.

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Curriculum Development Division

ART COTA
Division Chief
Course Delivery and Certification Division

Special acknowledgement and thanks are extended to the following members of CDF/State Fire Training Curriculum Development Division for their diligent efforts and contributions that made the final publication of this document possible.

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LISA POWELL
Office Technician

The material contained in this document was compiled and organized through the cooperative effort of numerous professionals within, and associated with, the California fire service. We gratefully acknowledge these individuals who served as principal developers for this document.

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This 2000 edition of Rescue Systems 1 represents a collaborative effort that started in 1996. We gratefully acknowledge the following individuals who also served as principal developers and consultants for this manual.

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Half Moon Bay Fire Department

TERRY KOEPER
Southern California Training Officers
Crafton Hills College

HAROLD SCHAPELHOUMAN
Menlo Park Fire Department

T.J. WELCH
Northern California Training Officers
Alameda County Fire Department

"We gratefully acknowledge the hard work and accomplishments of those before us who built the solid foundation on which this program continues to grow."

COURSE STRUCTURE

The revision and suggested standardization of the Rescue Systems 1 curriculum was a massive undertaking, geographically as well as organizationally. It required the commitment of numerous individuals and their departments throughout California as well as the input of fire service professionals and practitioners.

The Rescue Systems 1 curriculum was updated and developed to provide rescue professionals with the base level of knowledge necessary to perform successfully in the future, as well as refresh/enhance the skill levels of those currently employed. All involved have freely shared their expertise to create an updated, standardized curriculum.

Evaluations are included with the course materials sent by State Fire Training and are required at the end of the class.

State Fire Training gladly accepts your comments and suggestions for future enhancements or revisions to this document. Please forward to:

CDF/STATE FIRE TRAINING
Curriculum Development Division
4501 State Highway 104
Ione, California 95640-9705

COURSE OUTLINE

COURSE TITLE: RESCUE SYSTEMS 1

COURSE OBJECTIVES:

a) To provide information and training on urban search and rescue planning, management, and operations.
b) To provide information and training on rope rescue and related equipment.
c) To provide information and training on anchor systems.
d) To provide information and training on rescue litters and harnesses.
e) To provide information and training on the RPM, belay lines, and rappelling.
f) To provide information and training on lowering and raising systems.
g) To provide information and training on low angle rescue.
h) To provide information and training on moving heavy objects.
i) To provide information and training on breaking and breaching.
j) To provide information and training on ladder rescue.
k) To provide information and training on emergency shoring.
l) To provide the opportunity for students to demonstrate and apply rescue techniques.

COURSE CONTENT: ..... 40 - 42 HOURS

UNIT 1: INTRODUCTION TO RESCUE SYSTEMS

1-1 Course Objectives and Overview 0:30
1-2 Urban Search and Rescue Planning 0:30
1-3 Rescue Scene Organization and Management 0:15
1-4 The Urban Search and Rescue Operational System Description *(Time Permitting)* 1:00
1-5 Overview of US&R Standards, Mandates, and Regulations *(Time Permitting)* . 0:15
1-6 Rescuer Safety in US&R Operations..... 0:45
1-7 US&R Search Terminology, Procedures, and Resources *(Time Permitting)* 0:30
1-8 US&R Medical Care and Safety for Victims *(Time Permitting)* 0:15

UNIT 2: RESCUE ROPE AND RELATED EQUIPMENT

2-1 Introduction to Rescue Rope and Related Equipment 1:00
2-2 Introduction to Rescue Knots 0:10
2-3 How to Tie a Figure Eight Stopper 0:10
2-4 How to Tie a Figure Eight on a Bight..... 0:10

Anchors

Rescuer and Victim Packaging

RPM

TEXTS & REFERENCES

- ANSI Standards
- Basic Urban Search and Rescue Awareness, Hone, 1990

- CCR Title 8 Section 1670, State of California, 1998
- Essentials of Fire Fighting, IFSTA, Fourth Edition
- Field Operations Guide, FIRESCOPE, current edition
- Government Code Section 8607
- NFPA 1006, 2000
- NFPA 1931, 1994
- NFPA 1932, 1994
- NFPA Standards
- OSHA Regulations
- Rescue Specialist Training Manual, FEMA US&R Response System, 1995
- Rescue Systems 1 Student Manual, SFT, 2000
- Rescue Systems 1, National Fire Academy, 1993
- Rescue Systems One, Ventura County California Fire Chief's Association, 1996
- Rigging, Department of the Army, Technical Manual 5-725, 1968
- Rope Rescue Manual, California Mountain Company, Third Edition
- Urban Search and Rescue Operational System Description, ICS-US&R-120-1, February 1995

RESCUE SYSTEMS 1

STUDENT MANUAL

STUDENT TASK BOOK

The Rescue Systems 1 Student Task Book lists every requirement that will be evaluated. Each student's performance will be observed and recorded by the instructor. The grades will then be evaluated and the instructor will determine if the student successfully met the performance standards for this course and should be issued a course completion certificate.

RESPONSIBILITIES

(A) State Fire Training is responsible for:

(1) Ensuring the Rescue Systems 1 training site meets all site requirements.

(2) Ensuring the course instructor(s) are registered for the level and subject of instruction to be taught.

(3) Issuing certificates for successful course completion.

(B) The student is responsible for:

(1) Reviewing and understanding instructions in the student manual.

(2) Satisfactorily completing all course requirements.

(3) Ensuring their Rescue Systems 1 Student Task Book is accurately recorded and maintained.

(4) Filing and keeping their Rescue Systems 1 Student Task Book with their other personal or career records.

(C) The Primary Instructor(s) is responsible for:

(1) Being qualified and proficient

(2) Explaining to the students the purpose of and process for completing the Rescue Systems 1 Student Task Book.

(3) Explaining to the students their responsibilities.

(4) Accurately evaluating and recording on the Rescue Systems 1 Student Task Book all course requirements completed by the students.

INSTRUCTION FOR COMPLETING THE TASK BOOK

The Rescue Systems 1 Student Task Book allows the instructor to record a student's performance for both technical and manipulative jobs. These evaluations are made

by observing the student's participation in the classroom and their manipulative performance at each skill station.

Task Book Headings

Student: Enter your name.

Class Dates: Enter the beginning and ending date of the class.

Module: Lists the module name and the technical and manipulative performance requirements by lesson plan number and topic.

Time Frame: Lists the estimated time frame for teaching the job.

SM Page #: Lists the corresponding page number from the student manual.

Grade Code: Area to record the student's performance.

Instructor #: The evaluating instructors enter their State Fire Training registration number.

Instructor Initials: The evaluating instructors enter their initials.

Date: The evaluating instructor enters the date the instructor trainee was evaluated.

Grade Codes

"A" The student successfully completed the performance standard.

"B" The student did not complete certain portions of the performance standard and additional guidance is required.

"C" The individual is severely deficient in the performance standard and must remediate this job.

"D" The student missed more than _____ hours of instruction.

STUDENT: **CLASS DATE:**

ORIENTATION MODULE		Time Frame	SM Chapter	Grade Code	Evaluating Ins. # and Initials	Date
Introduction To Rescue Systems		**2:00 to 4:00**				
1-1	Course Objectives & Overview	0:30	Chapter 1			
1-2	Urban Search & Rescue Planning	0:30	Chapter 2			
1-3	Rescue Scene Organization & Management	0:15	Chapter 3			
1-4	The Urban Search & Rescue Operational System (Optional)	1:00	Chapter 4			
1-5	Overview Of US&R Standards, Mandates, & Regulations (Optional)	0:15	Chapter 5			
1-6	Rescuer Safety In US&R Operations	0:45	Chapter 6			
1-7	US&R Search Terminology, Procedures, & Resources (Optional)	0:30	Chapter 7			
1-8	US&R Medical Care & Safety For Victims (Optional)	0:15	Chapter 8			
Rescue Rope & Related Equipment		**1:00**				
2-1	Rescue Rope & Related Equipment	1:00	Chapter 9			
Knots		**1:30**				
2-2	Introduction To Rescue Knots	0:10	Chapter 10			
2-3	How To Tie A Figure Eight Stopper	0:10				
2-4	How To Tie A Figure Eight On A Bight	0:10				
2-5	How To Tie A Figure Eight Follow Through	0:10				
2-6	How To Tie A Figure Eight Bend	0:10				
2-7	How To Tie An In-Line Figure Eight	0:10				
2-8	How To Tie An Overhand Bend	0:10				
2-9	How To Tie A Double Overhand Bend	0:10				
2-10	How To Attach A 3-Wrap Prusik Hitch To A Rescue Rope	0:10				
Rescuer & Victim Packaging		**2:20**				
2-12	How To Tie Two Half Hitches	0:10	Chapter 10			
2-13	How To Tie A Round Turn & Two Half Hitches	0:10				
2-28	How To Tie & Attach The Rescue Chest Harness	0:15	Chapter 12			
2-29	How To Don & Attach A CMC ProSeries Rescue Harness	0:15				
2-31	Introduction To The Rescue Litter	0:30	Chapter 13			
2-32	How To Secure A Victim To A Rescue Litter	0:30				
2-33	How To Rig A Rescue Litter For Low Angle Rescue, 3-Person Method	0:15				
2-34	How To Rig A Rescue Litter For Low Angle Rescue, 4-Person Method	0:15				
Rack Pulley Mariner's Hitch		**1:10**				
2-37	Introduction To The RPM	0:10	Chapter 14			
2-38	How To Attach & Operate A Brake Bar Rack As Part Of A RPM	0:15				

STUDENT: **CLASS DATE:**

ORIENTATION MODULE		Time Frame	SM Chapter	Grade Code	Evaluating Ins. # and Initials	Date
2-39	How To Attach & Operate A Figure Eight Descender As Part Of A RPM	0:15				
2-40	How To Construct & Operate A Mariner's Hitch As Part Of A RPM	0:20				
2-41	How To Attach A Prusik Loop To A RPM For Use As A Ratchet Device In A Haul System	0:10				
	TOTAL HOURS:	**6:00 to 8:00**				

COMMENTS:

STUDENT: **CLASS DATES:**

ROPE/LOW ANGLE MODULE		Time Frame	SM Chapter	Grade Code	Evaluating Ins. # and Initials	Date
Introduction to Anchor Systems		**2:30**				
2-14	Daily Overview & Safety Briefing	0:10	---			
2-15	Introduction To Anchor Systems	0:30	Chapter 11			
2-16	How To Tie A Tensionless Anchor	0:10				
2-17	How To Tie A Single Loop Anchor Sling	0:10				
2-18	How To Tie A Multi-Loop Anchor Sling (also in Ladder Module)	0:10				
2-19	How To Tie A Three Bight Anchor Sling	0:10				
2-20	How To Tie A Lark's Foot Anchor Sling	0:10				
2-21	How To Construct A Back-Tied Anchor System	0:10				
2-22	How To Construct A Two-Point Self-Adjusting Anchor System	0:20				
2-23	How To Construct A Three-Point Self-Adjusting Anchor System	0:20				
2-24	How To Construct A Two-Point Load Sharing Anchor System	0:10				
Introduction To Rappelling		**0:30**				
2-44	Introduction To Rappelling	0:30	Chapter 16			
Introduction To The Belay System		**0:15**				
2-42	Introduction To The Belay System (also in Ladder Module)	0:15	Chapter 15			
Rappelling		**1:15**				
2-43	How To Construct & Operate A Belay System (also in Ladder Module)	0:15	Chapter 15			
2-45	How To Rappel Using A Figure Eight Descender - High & Low Anchor Point	0:30	Chapter 16			
2-46	How To Rappel Using A Brake Bar Rack - High & Low Anchor Point	0:30				
Lowering & Raising Systems		**1:45**				
2-47	Introduction To Rope Rescue Lowering & Raising Systems	0:15	Chapter 17			
2-48	Mechanical Advantage Systems Utilizing The 3:1 Piggy Back, 2:1 Ladder Rig, & 3:1 Z-Rig, Including Directional Changes	0:15				
2-49	How To Construct & Operate A Lowering System To Lower An Ambulatory Person	0:30				
2-50	How To Change A Lowering System To A Raising System (Z-Rig) With & Without A Change Of Direction	0:15				
2-51	How To Construct & Operate A Z-Rig Raising System To Raise An Ambulatory Person	0:30				
Low Angle Rescue		**2:45**				
2-52	Introduction To Low Angle Rescue Systems	0:30	Chapter 18			
2-53	How To Attach An Ambulatory Victim To A Low Angle Rescue System	0:15				

STUDENT: **CLASS DATES:**

ROPE/LOW ANGLE MODULE		Time Frame	SM Chapter	Grade Code	Evaluating Ins. # and Initials	Date
2-54	How To Construct & Operate A Lowering System To Lower An Ambulatory Person For Low Angle Rescue	0:30				
2-55	How To Construct & Operate A Z-Rig Raising System To Raise A Rescuer & An Ambulatory Victim For Low Angle Rescue	0:30				
2-56	How To Construct & Operate A Z-Rig Raising System With A Change Of Direction To Raise Three Rescuers & A Nonambulatory Victim For Low Angle Rescue	0:30				
2-57	How To Construct & Operate A 3:1 Piggy Back Raising System With A Change Of Direction To Raise Four Rescuers & A Nonambulatory Victim For Low Angle Rescue	0:30				
	Total Hours:	**8:20 to 9:00**				

COMMENTS:

STUDENT: **CLASS DATES:**

HEAVY OBJECTS/BREAKING & BREACHING MODULE		Time Frame	SM Chapter	Grade Code	Evaluating Ins. # and Initials	Date
Heavy Objects		**5:15**				
3-1	Introduction To Heavy Objects Operations	0:20	Chapter 19			
3-2	Levers, Cribbing, Wedges, & Rollers	0:20				
3-3	How To Construct Crib Beds	0:20				
3-4	How To Raise & Lower A Heavy Object Using Pry Bars	1:00				
3-5	How To Use Rollers & Pry Bars To Move A Heavy Object	0:30				
E 3-1	Raise, Stabilize, Move, & Lower A Single Heavy Object	0:30	---			
E 3-2	Raise, Stabilize, Move, & Lower Multiple Heavy Objects	1:15	---			
E 3-3	Raise, Stabilize, Move, & Lower Multiple Heavy Objects While Safely Managing & Extricating A Victim	1:00	---			
Breaking & Breaching		**2:30**				
4-1	Introduction To Breaking & Breaching	0:30	Chapter 20			
4-2	How To Breach Plywood & Wood Frame Construction Materials	0:30	---			
4-3	How To Breach Drywall, Stucco Lath & Wood Frame Construction Materials	0:45	---			
4-4	How To Breach Light Weight Concrete Construction Materials	0:45	---			
	TOTAL HOURS:	**7:45**				

COMMENTS:

STUDENT: **CLASS DATES:**

LADDER MODULE		Time Frame	SM Chapter	Grade Code	Evaluating Ins. # and Initials	Date
Ladder Rescue		**0:10**				
5-1	Daily Overview & Safety Briefing	0:10	---			
ANCHORS		**2:00**				
2-11	How To Tie A Clove Hitch	0:10	Chapter 2			
2-18	How To Tie A Multi-Loop Anchor Sling (also in Rope/Low Angle Module)	0:10				
2-25	Introduction To Picket Holdfast Anchors	0:10				
2-26	How To Construct A 1-1 Picket Holdfast Anchor	0:30				
2-27	How To Construct A 1-1-1 Picket Holdfast Anchor	0:30				
5-2	Introduction To Lashing	0:10	Chapter 21			
5-3	How To Form A Round Lash	0:10				
5-4	How To Form A Square Lash	0:10				
Belay System		**0:30**				
2-42	Introduction To The Belay System (also in Rope/Low Angle Module)	0:15	Chapter 15			
2-43	How To Construct & Operate A Belay System (also in Rope/Low Angle Module)	0:15				
Ladder Rig		**0:15**				
5-21	How To Construct & Operate A 2:1 Ladder Rig With Pulleys	0:15	Chapter 21			
Ladder Gin		**1:15**				
5-8	Introduction To The Ladder Gin	0:15	Chapter 21			
5-9	How To Construct & Operate A Ladder Gin - Open Field	0:30				
5-10	How To Construct & Operate A Ladder Gin Against A Vehicle	0:30				
Ladder "A" Frame		**1:35**				
5-11	Introduction To The Ladder "A" Frame	0:15	Chapter 21			
2-35	How To Rig A Rescue Litter For Raising & Lowering In A Vertical Position	0:15	Chapter 17			
5-12	How To Construct & Operate A Ladder "A" Frame	0:50	Chapter 21			
2-30	How To Tie & Attach A Hasty Harness	0:15	Chapter 12			
Ladder Rescue Systems		**3:50**				
5-13	Introduction To Ladder Rescue Systems	1:00	Chapter 21			
5-14	How To Construct & Operate A Moving Ladder Slide	0:15				
5-15	How To Construct & Operate A Ladder Slide	0:15				
5-16	How To Construct & Operate An Exterior Leaning Ladder	0:15				
5-5	Introduction To Ladder Slings	0:10				
5-6	How To Construct & Attach Slings To A Ladder	0:15				

STUDENT: **CLASS DATES:**

LADDER MODULE		Time Frame	SM Chapter	Grade Code	Evaluating Ins. # and Initials	Date
2-36	How To Rig A Rescue Litter For Raising Or Lowering In A Horizontal Position	0:15	Chapter 17			
5-20	How To Construct & Operate An Interior Leaning Ladder Using The Ladder As Friction	0:15	Chapter 21			
5-19	How To Construct & Operate An Interior Leaning Ladder Using Carabiners As Friction	0:15				
5-7	How To Sling A Spar & Operate As A Lowering System	0:10				
5-17	How To Construct & Operate A Cantilever Ladder Rescue System Using A Ladder Rig	0:30				
5-18	How To Construct & Operate A Cantilever Ladder Rescue System Using A Ladder As Friction	0:15				
5-22	How To Construct & Operate A 2:1 Ladder Rig Without Pulleys	0:15				
	Total Hours:	**9:15 to 9:45**				

COMMENTS:

STUDENT: **CLASS DATES:**

SHORING MODULE		Time Frame	SM Chapter	Grade Code	Evaluating Ins. # and Initials	Date
Emergency Shoring						
6-1	Introduction To Structure Shoring Systems	0:45	Chapter 22			
6-2	Introduction To Basic Tools & Equipment For Emergency Shoring Operations	0:15	Chapter 23			
6-3	Introduction To Spot Shores Utilizing Timber, Post Screw Jacks, & Ellis Clamps	0:15	Chapter 24			
6-4	How To Construct A Timber Spot Shore	0:10				
6-5	How To Construct A Post Screw Jack Spot Shore	0:10	Chapter 25			
6-6	How To Construct An Ellis Clamp Spot Shore	0:10	Chapter 26			
6-7	Introduction To The Vertical Shore	0:15	Chapter 27			
6-8	How To Construct A Vertical Shore	0:30				
6-9	Introduction To The Horizontal Shore	0:15	Chapter 28			
6-10	How To Construct A Horizontal Shore	0:15				
6-11	Introduction To The Window & Door Shore	0:15	Chapter 29			
6-12	How To Construct A Window & Door Shore	0:15				
6-13	Introduction To A Sloped Surface Shore With Cribbing	0:15	Chapter 30			
6-14	How To Construct A Sloped Surface Shore With Cribbing	0:15				
6-15	Introduction To The Solid Sole Plate Raker Shore System	0:15	Chapter 31			
6-16	Introduction To The Flying Raker Shore System	0:15				
6-17	How To Construct A Solid Sole Plate Raker Shore System	0:45				
6-18	How To Construct A Flying Raker Shore System	0:45				
6-19	Introduction To The Cutting Station	0:15	Chapter 32			
6-20	How To Cut Wedges & Gusset Plates	0:15				
6-21	Introduction To Measuring Tools Used To Determine Raker Length & Angle	0:30				
6-22	How To Cut A 45° Angle Raker	0:30				
6-23	How To Cut A 60° Angle Raker	0:30				
	TOTAL HOURS:	**8:00**				

COMMENTS: