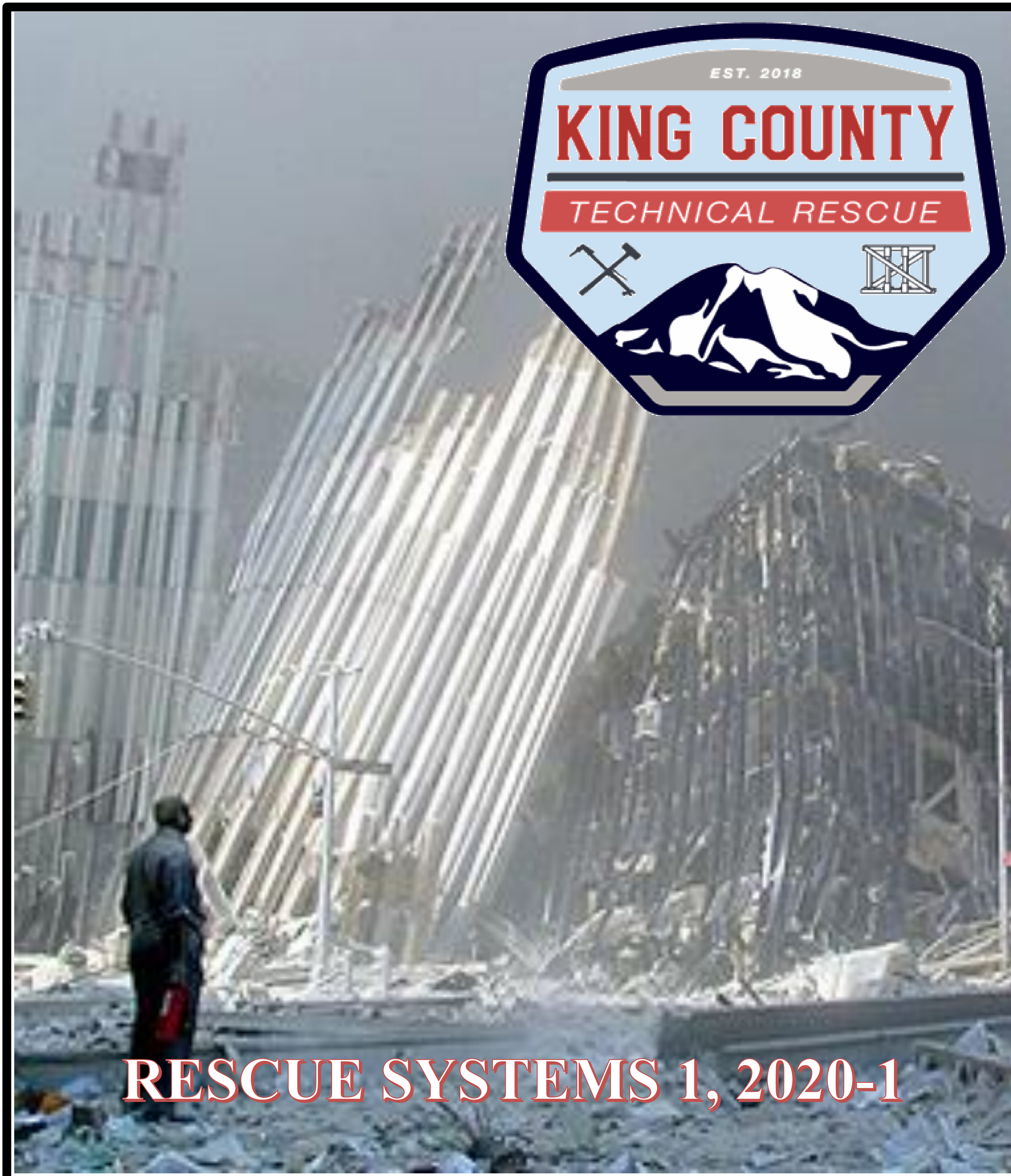

EST. 2018

KING COUNTY

TECHNICAL RESCUE

RESCUE SYSTEMS 1, 2020-1

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UNIT 1 - *INTRO TO URBAN SEARCH AND RESCUE*

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 Marshals, State Fire Training. Pierce County, in an effort to create greater local capability to rescue persons trapped as the result of a disaster developed Rescue Systems Washington in 1989.

The Rescue Systems 1 course was developed to have a baseline Rescue training level, that would help from the smallest Fire Department all the way to largest Fire Department. It also provides Fire Departments with the basic skills and equipment knowledge found on their apparatus to perform Rescues after Large disasters. The Rescue Systems 1 course has been used as a model rescue course throughout the nation and abroad.

COURSE OBJECTIVES

The Rescue Systems 1 Course is designed to:

1. Provide training in the subject elements required for the Washington and California Urban Search & Rescue (USAR) 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.

INTRODUCTION TO URBAN SEARCH AND RESCUE

Terminal Objectives

1. Recognize structural collapse as a special rescue situation requiring knowledge, skills and equipment beyond that of the normal first responder.

2. Recognize the difference between normal emergency operations and disaster response.

3. Explain the need for and the importance of community wide planning for disaster response.

4. Identify existing local, state, and federal resources and how to obtain them.

5. Describe what an Emergency Operations Center is and how it operates.

6. Identify possible causes of structural collapse.

7. Identify the four phases of structural collapse.

8. Understand the four levels of USAR operational capabilities.

Notes:

History

What is Urban Search and Rescue? In some areas it is also called Heavy Rescue or Special Rescue. The history of Urban Search and Rescue has its roots in the large metropolitan cities of the country. In most large departments special rescue units within the fire departments outfitted large vehicles with all sorts of equipment for the purpose of responding to a variety of rescue calls ranging from auto accidents to construction accidents. These vehicles became heavy rescue units since they were large and carried a heavy load. It was only natural that these units responded to structural collapse incidents where people were trapped.

It wasn't until 1989, and the Loma Prieta Earthquake that the ability to rescue persons trapped in heavy reinforced concrete structures and our ability to respond during, disaster situations with adequate resources came into question.

The Mexico City Earthquake of 1985, the Philippines and Armenia earthquakes, where thousands were killed and injured, pointed out the need for highly trained, well equipped, rapid response, urban search and rescue teams that could be on scene within hours of a disaster.

California, with its recognized earthquake hazard, realized the need and began training large numbers of emergency responders in the late 1980's. With practical experience in international response to the Philippines and Soviet Armenia, the east coast also began training and planning for large scale rescues from collapsed structures. After the 1989 Loma Prieta Earthquake, under the direction of the Federal Emergency Management Administration, a National Urban Search and Rescue program was established.

Notes:

Since 1989 great strides have been made in training, equipment, and tactics in the area of Urban Search and Rescue. Much practical experience was gained after the Northridge earthquake and again following the tragic Oklahoma City Bombing.

A great deal has been learned, but much more needs to be done in the area of planning and education. The one thing that stands out in all such situations is that a rapid response of well trained and equipped rescue personnel that can work closely with local responders, can and does save lives.

SPECIAL RESCUE

Special rescue is an incident where a person is stranded or trapped and skills and equipment that are not normally available with the first responders are needed to safely perform the rescue or recovery. These situations can occur at any time of any day in any jurisdiction. People who attempt to rescue – victims from these situations without the proper equipment or training often create a bigger problem when they become injured or-are killed by their rescue efforts.

In almost all incidents where rescuers were killed or injured during a special rescue attempt, there are several common factors leading to injury or death.

- Good people
- Good intentions
- Poor training, no training, or inadequate outdated training
- Wrong equipment or poorly maintained equipment or equipment used improperly
- Failure to recognize the hazards
- Failure to evaluate the risk verses the benefit of the rescue

Notes:

TYPES OF SPECIAL RESCUE

There are many examples of special rescue situations:

- Water rescue
- Rope rescue
- Confined space rescue
- Trench collapse
- Hazardous material spills
- Wilderness or mountain rescue
- Ice rescue
- Structural collapse

All of these situations require special knowledge, training and specialized personal protective equipment, in order to safely perform rescue operations. Many special rescues are performed every day across the country by well meaning but ill prepared responders. Most of the time, the rescues are successful despite the dangers and problems encountered due in large part to luck and the professionalism of the responders. Most of the time those efforts are followed by an energetic training and purchasing binge to correct the recognized deficiency. Unfortunately, some of the rescuers are killed or injured along with the initial victims because the rescue effort failed. Many of the over 9000 drowning victims in the country each year are well intentioned rescuers.

Over 60% of all confined space fatalities are well intentioned but poorly trained rescuers. Many victims of a trench collapse are friends and co-workers and rescuers- who enter the hazard area to rescue a victim, only to become entrapped by a secondary collapse. Many of the victims of the 1985 Mexico City earthquake were civilian rescuers working in unstable buildings that collapsed or contained fatal hazards during rescue operations.

Notes:

One rescuer died during rescue efforts in Oklahoma City due to inadequate personal protective equipment.

- As the result of numerous deaths and serious injuries to rescue personnel at Hazmat spills, OSHA now requires all first responders to have Awareness Level training for hazardous material response.

- As the result of the unacceptable number of rescuers involved in confined space fatalities, OSHA now has passed laws governing the entry of confined space even for rescue personnel.

Special rescue requires advanced knowledge of the hazards involved and special skills and tools to overcome those hazards. If you do not have those skills and tools then you should not attempt the rescue. You should:

Identify the problem.
Provide basic recognition and awareness training for all responders. Most incidents escalate when responders fail to recognize the hazard until it is too late.

Stabilize the situation prevent it from getting worse.
Do not allow others to become victims. Cordon off the area, establishing safe areas.

Know who in your area has the skills and tools to perform the rescue.
If no one in the area is capable of performing a particular type of rescue and your vulnerability assessment indicates you are at risk, then a training program needs to be undertaken to address the issue.

Call for help as soon as possible and have them enroute sooner.

Notes:

STRUCTURAL COLLAPSE

Structural collapse is a special rescue situation. Skill to deal with building collapse needs to be developed for the everyday emergency as well as a major disaster. This course will concentrate on structural collapse rescue and its associated hazards in a disaster setting. The most likely cause of structural collapse is thought to be earthquakes. A large quake will cause widespread damage and we can expect numerous structural collapse incidents all at the same time with a large number of casualties needing help at the same time. A rapid and organized response of a large number of trained rescuers is essential for the -high survival rate of trapped victims.

There are other reasons why structures collapse, and lessons learned in preparation for disaster response can be used when there is a single incident of structural collapse within a community. Structural collapse incidents may be the most hazardous of all special rescue situations.

The collapse may be the result of flooding and require water rescue skills. It may involve elevated rescue sites and rope rescue skills may be needed. It most likely will involve working in confined spaces with all the associated hazards. Expect hazardous material spills with any collapsed building. Secondary collapse and cave in is highly likely. Other than earthquakes, buildings can collapse as the result of;

Floods	Building Age	Accidents
Explosion	Poor Design	Sinkholes
Poor Construction	Overloading	Earthquakes
Remodeling Efforts	Landslide	Wind

Plan and train for the worst-case scenario, and single site incidents of structural collapse will be easier to deal with.

DISASTER

A disaster is any incident that is so large that it overwhelms the normal day to day emergency service capabilities for a. given jurisdiction. Disasters involve entire communities, not just the emergency service organizations.

Disasters can be manmade or natural.
OSO mudslide March 22, 2014 at 10:37 am
May 18, 1980, eruption of Mt. St. Helens
World Trade Center bombing
Oklahoma City Bombing, April 19, 1995

They can come with or without warning.
Hurricane Andrew
Loma Prieta earthquake

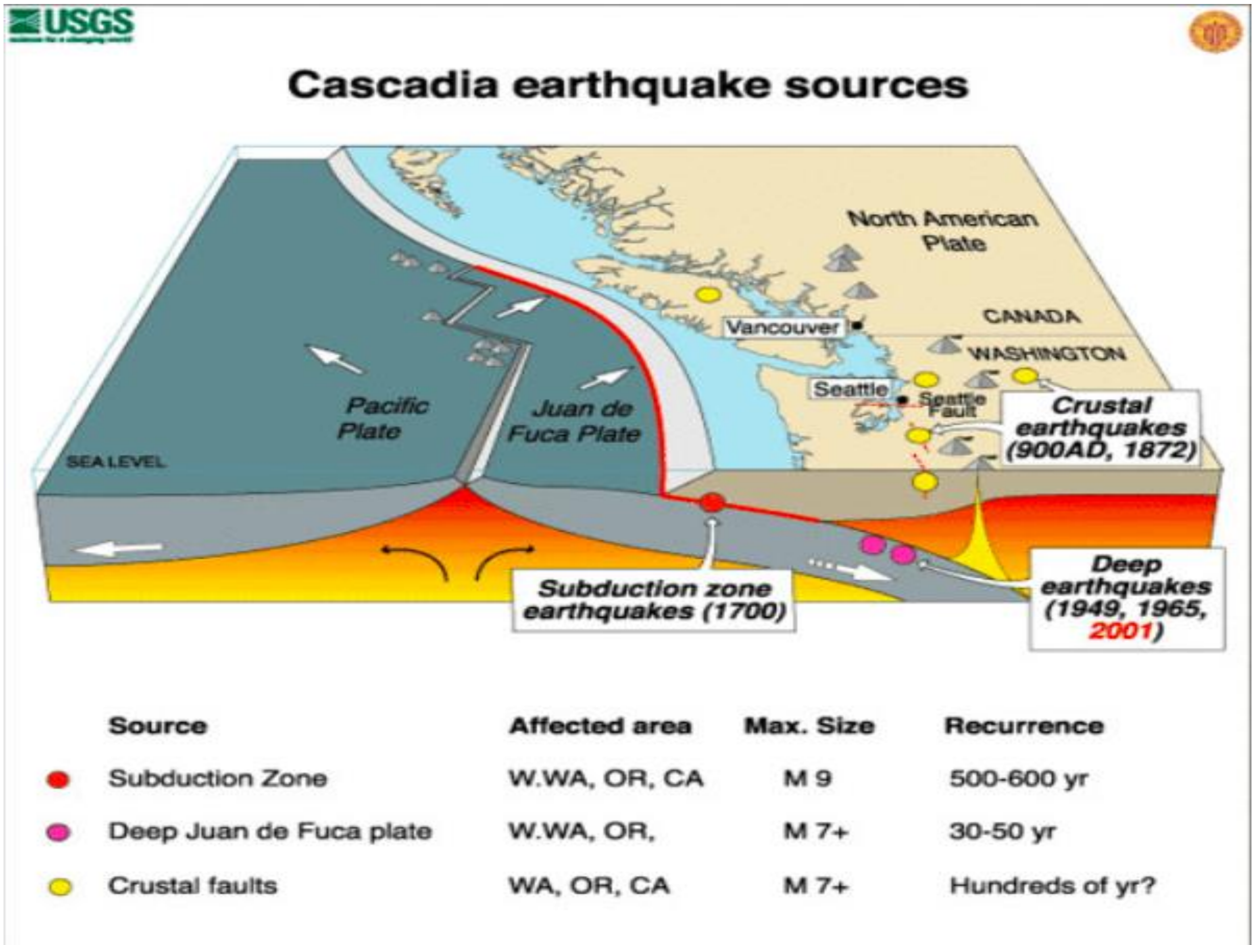
They can be relatively small scale or cover large areas.
Sioux City Airliner Crash
Mississippi Valley Floods

DISASTERS IN THE NORTHWEST REGION

The Pacific Northwest has been identified as having the potential for large and very damaging earthquakes. All recent studies and records show that the area suffers a large earthquake in the 6.0 to 7.5 magnitude range every 25 to 30 years.

Large quakes occurred in 1949 when a 7.1 magnitude quake struck the Olympia area. In 1965 a 6.5 magnitude quake struck the Tacoma area and then again in Feb 2001, measuring 7.0.

The 1949 Olympia quake and 1965 Tacoma quake were considered to be deep quakes. Both quakes caused millions of dollars in damage and several deaths. The greatest difference between those quakes and the next large quake in the region will be in today's population and urban density. Another quake of equal magnitude occurring today could be expected to cause billions of dollars in damage and possibly hundreds of injuries and deaths. Scientific studies indicate that we are overdue for one of these large and damaging earthquakes. Recent quakes in Northridge, California and Kobe, Japan clearly show the potential for



damage in a heavy urban environment from moderate to large quakes.

Even more disturbing, is the scientific evidence of great quakes that have occurred off the Washington/Oregon coast. These quakes appear to occur every 1500 years or so and may be expected to be in the magnitude of 8.0 or 9.0. The large quakes that occurred in 1965 and 1949 were considered deep quakes that occurred in the North American tectonic plate and lasted for less than a minute. Damage, to some extent, was limited due to the depth of the quake. The great quake described by scientists would be a subduction quake much like the 1964 Good Friday quake in Alaska that registered a 9.1 magnitude and lasted as long as five minutes. A subduction quake off the Washington/Oregon coast where the

Juan De Fuca plate is diving under the North American Plate would be a shallow quake. Shallow plates of great magnitude are capable of causing widespread damage and could be followed by numerous large intensity aftershock quakes in the magnitude range of 6 or 7. Scientific studies show we may be nearing the time for a great subduction quake. Damage from such a great quake could result in thousands of deaths and extensive damage throughout the region. Recovery time from such an event would be measured in years.

The Cascade Subduction zone lies about 50 miles off the Washington coast and runs form the northern tip of Vancouver Island to Cape Mendocino, in Northern California. Research indicates there have been at least 13 great subduction quakes over the last 7000 years. Return rates vary from as little as 150 years to the longest interval of about 1150 years. The average return time is 500 years. The last great quake occurred over 300 years ago.

There are other possible disasters we should be aware of. We have several active volcanoes in the Cascades, any of which could become active and cause major damage to heavily populated river valleys. Prior to the May 18, 1980 eruption of Mt. St. Helens, volcanic activity and its associated hazards were given little thought. An eruption of Mt. Rainier could cause extensive flooding to several major populated industrial valleys in western Washington. Mudflows from this mountain have reached all the way to Puget Sound in the past, and in some cases may have been totally spontaneous with no associated volcanic activity triggering the flows.

Other events such as major weather systems can be expected that will cause flooding of our river valleys and winds have been clocked at hurricane force inour area. These storms come with little or no prior warning and often with sub freezing temperatures.

We do not have enough disasters to get good at responding to them. We need to plan for them, train together as a community, and learn from other people's disasters. When they occur here, we can do the best job possible and help the most people with what limited resources are available to us.

PLANNING CONSIDERATIONS

Planning is the single most important thing we can do to prepare ourselves our families, and our organizations, for a disaster. Once the disaster has occurred it is too late. Without a plan, recovery efforts will be slower and much more expensive.

Does your organization have a disaster plan? Does your family have a disaster plan? If you do have a plan does everyone in the family and in the organization know what it says? Your plan should address the following critical points:

- What should you do during the event?
- What should you, your family, or your employees do immediately after a disaster?
- What are your priorities?
- Do you and your employees know what to expect following a disaster?
- Do your off duty employees know what to do after the event?
- Do you have a plan for reuniting families of employees?
- How are you going to communicate?
- Where will your command center be?
- Who is in command?
- What information do you need to operate and how do you get it?

A good disaster plan will address all of these issues and answer as many questions ahead of time as possible. The more you can do before the disaster means the less you have to do during and after. A disaster plan needs to be short, simple, and available to everyone. Checklists are a good idea because you won't have time to read the entire plan. A check list is an easy way to remind people of important things that need to be done when they are under stress.

Notes:

Disaster response differs from normal day to day operations. Many things that we take for granted are not going to work. People expect to be able to pick up a phone and dial 911 for help and expect it to respond in an emergency. A disaster affects community resources and will disrupt emergency responders' ability to respond. Those emergency responders that can still respond will be overwhelmed and remain overwhelmed for some time after a disaster.

People tend to take much of our modem conveniences for granted and don't think about how to operate without those conveniences until they are gone. Plan for the following:

- Phone lines will be damaged or overloaded and unusable.
- Radio systems will be damaged or overloaded and unusable.
- Power will be out and the ability to heat, power, recharge, fuel, and operate many devices we take for granted will be gone.
- Normal routes of travel may be damaged. Critical facilities may not be available for use such as hospitals, fire and police stations, government facilities, jails, etc.

Other critical facilities such as dams, chemical plants, dikes and levies, fuel storage farms, and pipe lines, if damaged, may create significant secondary problems. Normal operating policy may have to be changed to deal with a disaster environment. Plans need to be made in advance to allow for things such as:

- Changes in work hours and schedules.
- Allowing children and family members of employees to come to work with critical employees.
- Schools and childcare may not operate for several days and without them many employees must remain home to care for dependents unless plans are made for daycare at work sites during a disaster.
- Dispatch policy on how many units you send to any particular call may have to change in order not to deplete limited resources.
- Use of untrained or unconventional resources and civilian help to solve problems.

Notes:

Develop a Vulnerability Assessment

A pre-plan will allow you to find out how vulnerable your community is to all forms of disasters. What could happen in the future?

- Windstorms
- Earthquakes
- Floods
- Landslides

Determine community vulnerability by researching what has happened in the past. If it has happened once it will probably happen again. Take the opportunity to learn from historical events that have occurred within your community and neighboring communities. Once you figure out what potential problems exist, you can start planning how to deal with a problem when it happens.

Study what has happened in other areas and learn from their misfortune and don't make the same mistakes again.

Check with the building department about building codes and existing hazardous structures.

Survey your community for potential hazards such as industrial and other potentially dangerous facilities, dams, power generating stations, chemical plants, etc.

Identifying Resources

By identifying potential problems you can identify available resources to solve the problem. Determine what local capabilities you have to deal with emergencies, and if no resource exists, either locates an already existing resource in neighboring communities or train local resources to adequate levels to deal with potential problems.

Notes:

Resource lists, which are available to response agencies and the emergency operations centers, (EOC) should be included within the pre-plan. The list should contain:

- Who or what the resource is,
- What their/its capabilities are,
- Where they can be contacted,
- How long it takes for them to respond,
- And any other pertinent information.

Training and Equipment
Preplanning will also identify training shortfalls and budgeting requirements.

Establish Legal Authority
One of the most common problems at a major incident is the time wasted trying to decide who is in charge and who is responsible. If those questions are answered ahead of time, confusion, duplication of effort, and frustration will be reduced. By deciding, ahead of time, the key players in any major incident can get together before the incident and meet and greet and break down any barriers to communication which in the end becomes the biggest obstacle to running a successful disaster response.

Establish Responsibility
Planning will help identify responsible agencies. Disasters are community affairs. No one agency can hope to manage and resolve all the myriad problems that will face a community after a disaster of any magnitude.

Traditional expectations are that the emergency services, Fire, Law Enforcement, and Medical Service will respond and handle disasters. Though they have a major lifesaving role to play, their role is relatively limited in the long-range recovery aspects of disasters. Many other organizations will be still working on disaster recovery long after the last victim has been rescued and treated. Public works, utilities, public health, transportation, building inspectors and many others all must be involved for a complete recovery.

Notes:

Fire services are traditionally responsible for fire suppression. No other agency can perform that function, so it becomes the fire service's primary responsibility. If a community decides to rely entirely on the fire service for Urban Search and Rescue and there are major fires burning at the same time, the rescue of victims from the collapsed structure may wait until the fire hazard is gone. That may not be acceptable. Fire service is also traditionally responsible for emergency medical services, hazardous material control, and many forms of specialized rescue. Their hands will be full in the hours immediately after a disaster.

Law Enforcement is responsible for security, site control, and maintenance of law and order. They are also tasked with the responsibility for Search and Rescue in Washington State per R.C.W. 83.52.400. That statute identifies search and rescue activity from natural disasters as part of that responsibility.

Regardless of who is responsible for USAR, it must be, by its very nature, a multi agency response. Fire, law enforcement, EMS, public works, utilities, health, ecology, medical examiners, building inspectors, engineers, private contractors) and others will be involved before the last victim is recovered. Decide ahead of time how your community is going to conduct the business of Urban Search and Rescue before the incident occurs.

EXITSTING L0CAL, STATE, AND FEDERAL RESOURCES.

Local Resources

Local jurisdictions need to respond to disasters with their available local resources first. Once those resources are exhausted or the incident is so large that it overwhelms local. Capabilities, requests should go to the state for additional resources. Local authorities maintain command and control of local problems even when state and federal resources are requested.

Notes:

Local Resources

Local resources may include all the normal emergency response organizations such as law enforcement, fire and public works as well as volunteer search and rescue teams and community disaster response teams and light rescue teams from business and industry.

State Resources

The state may utilize State Patrol or National Guard to assist local authority. Once state assets are overwhelmed, the governor may request a declaration of disaster from the President. If he declares a disaster, Federal aid becomes immediately available.

Federal Resources

F.E.M.A. The Federal Emergency Management Agency, coordinates the Federal response into a declared disaster. There are 12 support functions identified in the federal disaster response plan. These support functions are called ESF 1-12

ESF1	Transportation	Department of Transportation
ESF2	Communications	National Communications System
ESF3	Public Works/Engineering	US Army Corp of Engineers
ESF4	Firefighting	US Forest Service
ESF5	Information/Planning	FEMA
ESF6	Mass Care	American Red Cross
ESF7	Resource Support	General Services Administration
ESF8	Health/Medical	Public Health Service
ESF9	Search and Rescue	FEMA
ESF10	Hazardous Materials	Environmental Protection Agency
ESF11	Food	Department of Agriculture
ESF12	Energy	Department of Energy

Urban Search and Rescue falls under ESF9 and FEMA. Since 1991 FEMA has established 28 USAR task forces that are located geographically across the United States. These task forces are capable of being enroute to a disaster I area within six hours of activation. They are self sufficient for up to ten days and are trained and equipped for heavy urban search and rescue operations. Each task force is comprised of four components, Search, Rescue, Medical, and Technical staffing for the four components totals 72 persons including a task force leader and assistants.

The search team consists of a team leader, an assistant team leader, four search dog teams and two technical search specialists. Each search dog team, consists of a dog handler and a search dog.

The rescue team has a team leader, assistant, and a four to six person rescue teams. Each rescue squad consists of a rescue squad officer and five rescue specialists.

The medical team also has a team leader and an assistant who are medics. The remaining four members are two doctors and two medics who have specialized confined space and crush injury training.

The technical team is the most diverse team of the task force. It consists of two team managers and specialists in different functional areas. These are structural engineering, hazardous materials, heavy equipment and rigging operations, technical information, communications, and logistics. Logistics is responsible for, equipment accountability and inventory management.

Each task force is fully self sufficient upon arrival in order to not create a burden on an already impacted community. Each task force is capable of deploying within 6 hours of activation by the Federal Government. The task force comes prepared for 72 hours of operations before re-supply becomes necessary by FEMA. Transportation of the task force is the responsibility of the Department of Transportation and the Department of Defense.

Notes:

Four Levels of US&R Operational Capability

US&R Companies and Crews are “typed” 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 five general construction categories and an increasing capability of conducting a rescue at specified emergency situations with an identified minimum amount of training and equipment.

The US&R Type-4 (basic) operational level represents the minimum capability to conduct safe and effective search and rescue operations at incidents involving nonstructural entrapment in non-collapsed structures.

The US&R Type-3 (light) operational 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 low-angle or one-person–load rope rescue.

The US&R Type-2 (medium) operational level represents the minimum capability to conduct safe and effective search and rescue operations at structure collapse incidents involving the collapse or failure of Heavy Wall Construction, high-angle rope rescue (not including high-line systems), confined space rescue (no permit required), and trench and excavation rescue.

The US&R Type-1 (heavy) operational level represents the minimum capability to conduct safe and effective search and rescue operations at structure collapse incidents involving the collapse or failure of heavy floor, precast concrete and steel-frame construction, high-angle rope rescue (including high-line systems), confined space rescue (permit required), and mass transportation rescue.

The Regional US&R Task Force Level is composed of 29 people specially trained and equipped for large or complex Urban Search and Rescue operations. The multidisciplinary organization provides five functional elements that include Supervision, Search, Rescue, Medical, and Logistics. The Regional US&R Task Force is totally self-sufficient for the first 24 hours. Transportation and logistical support are provided by the sponsoring agency and may be supported by the requesting agency.

The State/National US&R Task Force is composed of 70 people specially trained and equipped for large or complex Urban Search and Rescue operations. The multidisciplinary organization provides seven functional elements that include Supervision, Search, Rescue, Hazmat, Medical, Logistics, and Planning. The State/ National US&R Task Force is designed to be used as a single resource. However, each element of the Task Force is modularized into functional components and can be independently requested and used.

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.

Minimum Training

Each increasing level of US&R operational capability requires an increase in training. The OSD does not dictate that Rescue Systems 1 training is a requirement; however, Rescue Systems 1 does fulfill the training requirements for the Basic and Light operational levels.

US&R Type-4 (basic) Operational Level

Personnel shall be trained in hazard recognition, equipment use, and techniques required to operate safely and effectively at incidents involving nonstructural entrapment. 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 damaged but non-collapsed structures. Training at the basic level should at a minimum include the following:

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

❒ Process for implementing the ICS

❒ Procedures for the acquisition, coordination, and use of resources

❒ Procedures for implementing site control and scene management

❒ Identification, use, and proper care of personal protective equipment required for operations at structural collapse or failure incidents

❒ Identification of five general construction categories, characteristics, and expected behavior of each category in a collapse or failure situation

❒ Identification of four types of collapse patterns and potential victim locations

❒ Recognition of the potential for secondary collapse

❒ Recognition of the general hazards associated with a structure collapse or failure situation and the actions necessary for the safe mitigation of those hazards

❒ Procedures for implementing the structure/hazard marking system r Procedures for conducting searches at non-collapsed structures using appropriate methods for the type of building configuration

❒ Procedures for implementing the search marking system

❒ Recognition and response to the emergency signaling system

❒ Procedures for the extrication of easily accessible victims from nonstructural entrapments involving minimal removal of debris and building contents

❒ Procedures for providing disaster first aid medical care to victims

❒ Training to the Hazardous Materials First Responder Awareness Level (FRA)

US&R Type-3 (Light) Operational Level

Personnel shall meet all US&R Type-4 (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 low-angle or one-person–load rope rescue as specified below:

❒ Personnel shall be trained to recognize, evaluate, and communicate the unique hazards associated with the collapse or failure of light-frame construction . Training should include but not be limited to the following:

- ■ Site safety, hazard assessment, and personal protective equipment required for site
- ■ Recognition of the building materials and structural components associated with light frame construction
- ■ Recognition of unstable collapse and failure zones of light-frame construction
- ■ Recognition of collapse patterns and probable victim locations associated with light-frame construction
- ■ Procedures for implementing the emergency signaling system

❒ Personnel shall have an awareness of the resources and the ability to perform 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:

- ■ Procedures for conducting nontechnical searches
- ■ Procedures for implementing the victim marking system
- ■ Capabilities and procedures for requesting US&R canine search team and technical search equipment such as video and optical visual search devices and seismic or acoustic electronic listening devices

❒ 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:

¡ Lifting techniques to safely and efficiently lift structural components of walls, floors, or roofs

■ Developing and communicating a shoring plan to safely and efficiently construct temporary structures needed to stabilize and support structural components to prevent movement of walls, floors, or roofs

■Breaching techniques to safely and efficiently create openings in structural components of walls, floors, or roofs

■ Operating appropriate tools and equipment to safely and efficiently accomplish the above tasks

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

■ Packaging victims within confined areas

■ Removing victims from elevated or below-grade areas

■ Providing medical treatment to victims at a minimum to the basic life support (BLS) level

■ Operating appropriate tools and equipment to safely and efficiently accomplish the above tasks

❒ Personnel shall be trained in the procedures for performing low-angle or one-person–load rope rescue involving accessing, packaging, treating, and removing victims. Training should include but not be limited to the following:

■ Rope system anchors

■ Evacuation litters

■ Rescuer and patient packaging

■ Lowering and raising systems

■ Mechanical advantage systems

US&R Type-2 (Medium) Operational Level

Personnel shall meet all US&R Type-3 (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 heavy wall construction, high-angle rope rescue (not including highline systems), confined space rescue (no permit required), and trench and excavation rescue as specified below:

❒ Personnel shall be trained to recognize, evaluate, and communicate the unique hazards associated with the collapse or failure of heavy wall construction. Training should include but not be limited to the following:

■ Site safety: atmospheric monitoring, hazard assessment, and personal protective equipment required for site

■ Recognition of the building materials and structural components associated with heavy wall construction

¡ Recognition of unstable collapse and failure zones of heavy wall construction

■ Recognition of collapse patterns and probable victim locations associated with heavy wall construction

❒ 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 heavy wall construction.

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

■ Lifting techniques to safely and efficiently lift structural components of walls, floors, or roofs

■ Developing and communicating a shoring plan to safely and efficiently construct temporary structures needed to stabilize and support structural components to prevent movement of walls, floors, or roofs

■ Breaching techniques to safely and efficiently create openings in structural components of walls, floors, or roofs

■ Operating appropriate tools and equipment to safely and efficiently accomplish the above tasks

❒ Personnel shall be trained in the procedures for performing extrication operations involving packaging, treatment, and removal of victims trapped inside and beneath debris associated with heavy wall construction. Training should include but not be limited to the following:

■ Packaging victims within confined areas

■ Removing victims from elevated or below-grade areas

■ Operating appropriate tools and equipment to safely and efficiently accomplish the above tasks

❒ Personnel shall be trained in the procedures for performing high-angle rescue (not including highline systems) involving accessing, packaging, treating, and removing victims. Training should include but not be limited to the following:

¡ Rope system anchors

■ Evacuation litters

■ Rescuer and victim packaging

■ Lowering and raising systems

■ Mechanical advantage systems

■ Fall protection and/or limiter system

❒ Personnel shall be trained in the procedures for performing confined space rescue (no permit required) operations. Training shall include but not be limited to the following:

■ Familiarity with California Code of Regulations, Title 8, Sections 5156, 5157, and 5158

■ Site safety: atmospheric monitoring, hazard recognition, and hazard assessment

■ Containing and controlling hazards within the rescue site

■ Packaging and removal of victims within confined spaces

❒ Personnel shall be trained in the procedures for performing trench and excavation rescue operations. Training shall include but not be limited to the following:

■ Familiarity with the California Code of Regulations, Title 8, Sections 1540, 1541, and 1541 .1

■ Site safety: atmospheric monitoring, hazard recognition, and hazard assessment

■ Containing or controlling hazards within the rescue site

■ Providing a recognized “protective system” for victims and rescuers in individual trenches

■ Packaging and removal of victims from within rescue site

r Members shall be trained to the Hazardous Materials First Responder Operational Level (FRO).

❒ Members shall be trained in appropriate response procedures for incidents involving weapons of mass destruction (WMD).

US&R Type-1 (heavy) Operational Level

Personnel shall meet all US&R Type-2 (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 heavy floor, precast concrete and steel- frame construction, high-angle rope rescue (including highline systems), confined space rescue (permit required), and mass transportation rescue.

❒ Personnel shall be trained to recognize, evaluate, and communicate the unique hazards associated with the collapse or failure of heavy floor, precast concrete, and steel-frame construction. Training should include but not be limited to the following:

■ Site safety: atmospheric monitoring, hazard assessment, and personal protective equipment required for site

■ Recognition of the building materials and structural components associated with heavy floor, precast concrete, and steel-frame construction

¡ Recognition of unstable collapse and failure zones of heavy floor, precast concrete, and steel-frame construction

■ Recognition of collapse patterns and probable victim locations associated with heavy floor, precast concrete, and steel-frame construction

❒ 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 heavy floor, precast concrete, and steel-frame construction.

❒ Personnel shall be trained in the procedures for performing access operations intended to reach victims trapped inside and beneath debris associated with heavy floor, precast concrete, and steel-frame construction. Training should include but not be limited to the following:

■ Lifting techniques to safely and efficiently lift structural components of walls, floors, or roofs

■ Developing and communicating a shoring plan to safely and efficiently construct temporary structures needed to stabilize and support structural components to prevent movement of walls, floors, or roofs

■ Breaching techniques to safely and efficiently create openings in structural components of walls, floors, or roofs

■ Operating appropriate tools and equipment to safely and efficiently accomplish the above task

❒ Personnel shall be trained in the procedures for performing extrication operations involving packaging, treatment, and removal of victims trapped inside and beneath debris associated with heavy floor, precast concrete, and steel-frame construction. Training should include but not be limited to the following:

■ Packaging victims within confined areas

■ Removing victims from elevated or below-grade areas

■ Operating appropriate tools and equipment to safely and efficiently accomplish the above tasks

r Personnel shall be trained in the procedures for performing high-angle rescue (including highline systems) involving accessing, packaging, treating, and removing victims. Training should include but not be limited to the following:

■ Rope system anchors

■ Evacuation litters

■ Rescuer and victim packaging

■ Lowering and raising systems

■ Mechanical advantage systems

■ Fall protection and/or limiter system

❒ Personnel shall be trained in the procedures for performing confined space rescue (permit required) operations. Training shall include but not be limited to the following:

■ Site safety: atmospheric monitoring, hazard recognition, and hazard assessment in permit- required confined spaces, tunnels, or other long remote entries, high vertical access, and hazardous environmental entries

■ Containing and controlling hazards within the rescue site

■ Packaging and removal of victims within confined spaces

❒ Personnel shall be trained in the procedures for performing extrication operations involving packaging, treating, and removing victims trapped within mass transportation systems. Training should include but not limited to the following:

■ Procedures to conduct a size-up of existing and potential hazards

■ Recognition of special hazards, safety systems, and construction of transportation systems

■ Packaging and removal of victims from within rescue site

■ Extrication techniques to safely and efficiently gain access to trapped victims

■ Procedures to safely and efficiently stabilize, support, and lift different types of transportation vehicles

¡ Operating specialized tools and equipment to safely and efficiently accomplish the above tasks

EMERGENCY OPERATIONS CENTER (EOC)

Emergency operations centers are an essential part of disaster response and recovery. Every large institution or business should have an EOC and a trained staff to facilitate a rapid recovery and an efficient use of resources. Other I areas and jurisdictions call them other things such as, command post, or disaster operations centers. Whatever the name, it is a facility designed for gathering information for disaster analysis.

An EOC may 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. It is where executive decisions concerning emergency policy are made that result in resource coordination and response. It is where command staff from the various involved response agencies gathers with the political leaders of a jurisdiction during a disaster to coordinate the overall response.

In a multiple site incident, each individual incident site will have its own incident commander (IC) and its own command post (CP). The EOC is where each IC will report his/her status and where they will make requests for additional resources and information.

At an EOC, priorities are established

At the EOC the overall disaster priorities are established and resources are allocated based on those priorities. It provides a single point for collection, evaluation, display, and dissemination of information. It facilitates verification of information which helps control rumors.

An EOC is an information collection point

It gathers information from the field about:

- What are the problems?
- Where are the problems?
- What is being, done?
- What needs to be done?
- What resources are needed and where are they needed?
- What resources are committed?

An EOC is an information dissemination point

It relays information up to the next layer of support. The local EOC advises the state EOC on the local situation and local needs and then can relay information back down to the local incident commanders about what the situation is like elsewhere and if and when additional assistance will be coming. The state EOC then does the same when they contact the Federal support agencies and can direct assistance to those areas that most need the assistance. The EOC can also disseminate information to:

- Responding resources
- Civilian populations
- Media
- Politicians
- Agencies requesting assistance
- State arid Federal authorities

An EOC is a resource locator.

Incident commanders need to request additional resources from the EOC rather than attempting to freelance and locate what they need on their own. An EOC, if properly used, will limit duplication of effort, wasted or misdirected resources, and a eat deal of confusion and frustration from duplication of efforts and competition for limited resources.

An EOC is a place where policy is made.

This is where the political leaders of a jurisdiction should gather in order to have the best and latest information regarding the incident. They need this information so they can make policy decisions about how to respond and what to respond with. Decisions that affect the community as a whole can then be disseminated from a central location with a single voice to the entire community.

An EOC is where plans are developed.

EOC staff plan for the future by taking incoming information and trying to predict what will be needed in the next few hours, next several days, or in the weeks ahead.

An EOC is a documentation center.

Personnel keep track of all radio and telephone traffic and record activities and expenditures for the community. Without proper documentation it is difficult to get reimbursed for the expenses incurred during a disaster, if, the area is declared a disaster by the President of the United States.

Notes:

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 as complicated as involving recon of the entire community. Quite often the size-up function is not performed because the tendency in a disaster situation is to 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 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 Emergency Operations Center (EOC), if needed. An Incident Action Plan (IAP) and a backup 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 non-collapsed buildings, and account for approximately 50 percent 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 non-collapsed and collapsed buildings.

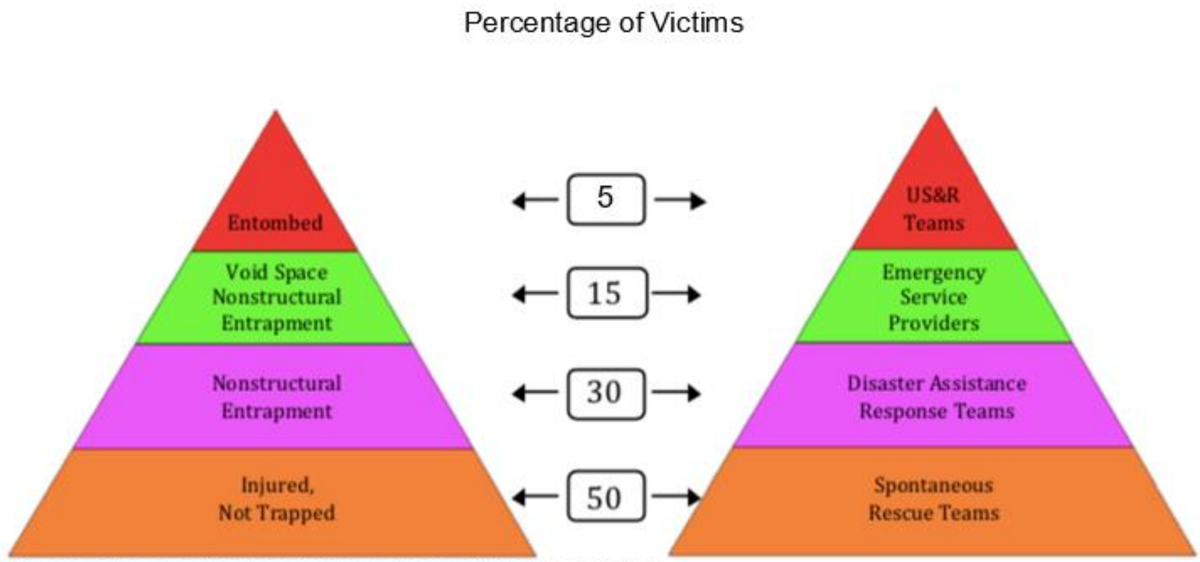


Figure 1:1 Structural Collapse Victim to Rescue Skills Needed Ratio

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 and Rescue dog teams, and specialized listening and looking devices.

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

Approximately 15 percent 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.

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 percent 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 advice from an on-site structural engineer and the highest probability of finding live victims.
3. Maintain at all times constant coordination and communications with all heavy equipment and rescue team members.
4. If possible, remove the debris from the top toward 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 coroner officials.

SUMMARY

Planning is vital to the success of any structural collapse response. It identifies who has the legal authority to perform search and rescue, and spells out specific responsibilities ahead of time, saving time when peoples' lives are in question. It also identifies special resources that may be needed and how to obtain those resources.

An EOC serves a critical role in a large incident by providing a location where personnel can help obtain resources, control information, and disseminate important information to those who need it most. EOC personnel will greatly aid in recovery by documenting efforts for future funding and future response.

By understanding the four phases of a structural collapse incident, rescue personnel can respond properly and do the most good for the most people with the limited resources on hand. Good reconnaissance and size up will allow the incident command staff to use its resources in the safest and most efficient manner.

UNIT 2 - *RESCUE SCENE ORGANIZATION*

Terminal Objectives

1. Operate within the ICS.
2. Assess simulated situations using size up factors and considerations.
3. Secure and limit access to the site.
4. Use on scene materials and local resources to perform basic rescue operations.

Enabling Objectives

1. Identify the need to operate within the ICS.
2. Describe the major functions within the ICS.
3. Explain the need for size up in order to establish action priorities.
4. Explain the need for establishing effective communications.
5. Identify the need to establish control of a structural collapse incident scene.
6. Describe the elements involved in gaining control of a scene.
7. Explain the importance of materials, equipment, and personnel using available resources (including mutual aid).
8. Describe the importance of working effectively with other responders.

Notes:

The Incident Command System (ICS) Organized Approach to Managing Any Incident

The 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 multiagency and multidiscipline 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 ensure 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 that 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 IC. This position is filled during every incident, whether it is a single-unit response or a multiagency, multidiscipline response. ICS ensures 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.

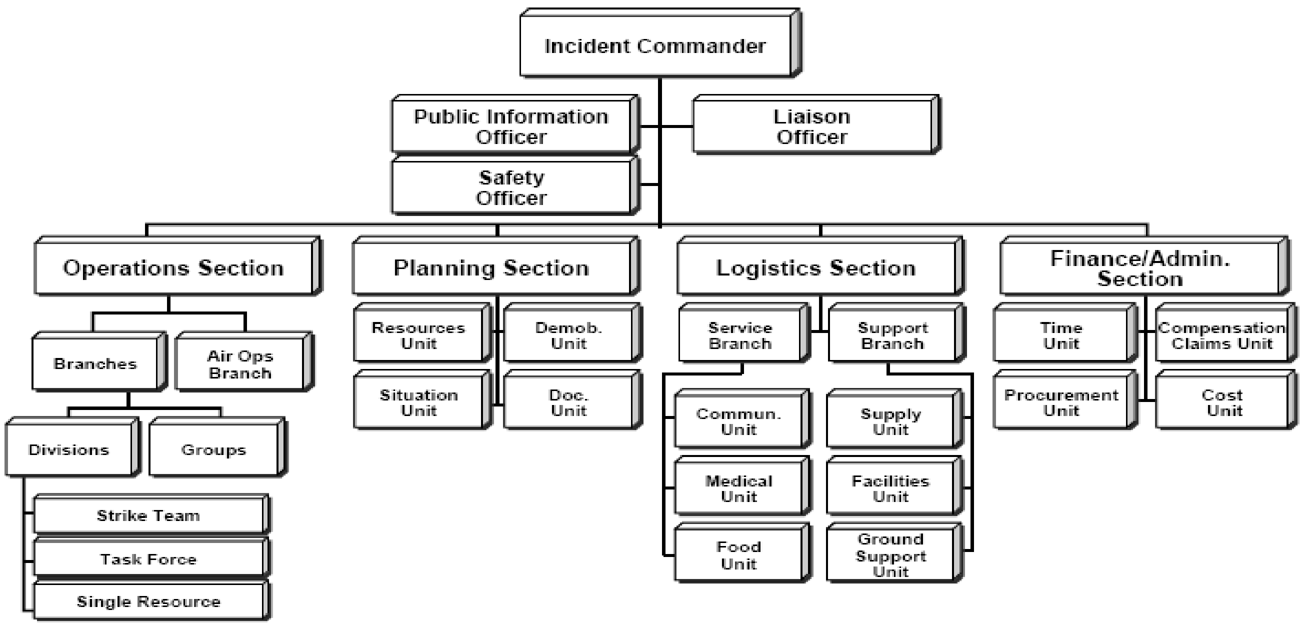
Groups are resources assembled at an incident to perform a special function in a branch, if activated. As an example, a Rescue Branch may be further divided into groups that include the Search Group and the Rescue Group. A group is managed by a Group Supervisor.

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 established only 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 the information pertaining to the incident and developing the IAP for each operational period. The Planning Section helps 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.



The National Incident Management System

On February 28, 2003, President Bush issued the Homeland Security Presidential Directive (HSPD- 5), which directs the Secretary of Homeland Security to develop and administer a National Incident Management System (NIMS).

According to HSPD-5, this system will provide a consistent nationwide approach for federal, state, and local governments to work effectively and efficiently together to prepare for, respond to, and recover from domestic incidents, regardless of cause, size, or complexity.

Six Major Components

❒ Command and management

❒ Preparedness

❒ Resource management

❒ Communication and information management

❒ Supporting technologies

❒ Ongoing management and maintenance

The NIMS integrates the existing best practices into a consistent nationwide approach to domestic incident management that is applicable at all jurisdictional levels and across functional disciplines in an all-hazard context.

WHAT IS SIZE-UP?

Size-up is the process of determining the problem. It is essentially triage, or sorting of the situation. Without size-up the incident may not be handled in an organized manner. Problems and possible solutions may be missed.

Size-up allows the establishment of action priorities. It assists in determining the order in which actions are accomplished. Examples include assessing the hazards before performing search, and deciding to stabilize the victim before removing him/her.

Size-up also helps establish a logical approach to the problem. By determining what the problem is and establishing what needs to be accomplished, you can determine a step-by-step approach to the solution.

Considerations for Size-up

The most important consideration during size-up is safety. The safety of rescuers should be addressed during the size-up process. Additionally, the safety of the victims and of others at the site is considered throughout the size-up process.

Size-up must be performed using an organized approach. This will assure that no areas of concern are overlooked and that the information gathered is as complete as possible to assist in solving the overall problem.

Look for existing preplan information. This information may come from a fire department preplan, a community building permit, information from an actual building involved, or information from architects and engineers.

Information should be gathered from witnesses to the incident or persons familiar with the occupancy or structure. Neighbors, survivors, and other involved persons may provide useful information. Information may include the potential number of victims and possibly where they are located or where they were last seen.

The next step in size-up is to gather additional information during reconnaissance (recon). The size-up information gathered up to now has not been obtained from personal inspection by walking around the structure. Reconnaissance is an organized walk around an involved structure. All sides should be evaluated during recon: the top of the structure, the bottom of the structure, and each side of the structure.

Throughout the recon phase rescue personnel should be calling out and listening for victims to respond. This procedure will quickly help determine if there are any survivors and help to identify their location.

You should note your findings during, recon and present this information to the IC. Personnel must remember that structural stability and other safety concerns of the structure have not necessarily been established at this point. Extreme caution must be exercised, and proper protective gear must be worn by personnel involved in recon.

Size-up Factors

Persons familiar with the structure may also be able to provide information on building layout and design. Important information includes the location of stairwells, elevator shafts, access to the basement and the roof, and other parts of the structure. These persons may also be able to assist with the location of hazards within the structure such as hazardous materials, utility shutoffs, or other concerns.

Determining the building characteristics is an important pattern of size-up. Considerations include the function of the structure and the type of occupancy, such as a school, hospital, nursing home, or factory. Additionally, it is important to determine if hazardous materials are present in the structure. This information may be included in the preplan.

The type of construction also affects the potential for victim survival and provides insight into the resources required to stabilize the structure and solve the problem. Specifics regarding the type of construction will be described in Unit 3.

During recon you should note any visible voids that may have provided survivable areas for victims. These voids will be fully searched during the search phase of the incident. Recon personnel do not enter unsafe or questionable areas.

The time of day of the incident will affect the number of potential victims. An incident involving a school during school hours has the potential to involve a large number of victims. The same holds true for a factory or an office building during business hours.

While performing recon, you may see obvious surface victims. Surface victims are victims who are not trapped in the structure and are generally on top of the debris in an accessible location. Contact victims and assess their medical condition. You should also note what maybe required to remove these victims from the structure.

Hazards are a major concern during recon; you should identify and document any hazards found. Hazards must be stabilized or removed before rescuers enter a hazard area.

Categories of hazards include structural instability, which may be noted by recon personnel or may require evaluation by specifically trained personnel such as a structural engineer. Don't enter the structure until it is stabilized properly. Some examples of concern include leaning walls, fractured support columns, or shifting noises.

Overhead hazards must be identified during recon. These include problems with overhead utilities as well as loose debris on the structure, damaged chimneys, and the weight and movement of rescuers above the recon team.

Surface hazards include debris on the ground, trip hazards, and unstable footing. Examples of below grade hazards include open pits creating flooding, or contaminated atmospheres. Utilities create a hazard to rescuers if they are not controlled. Examples include wires or utility lines down or damaged, and underground utility vaults, as well as escaping gas or exposed electrical hazards.

Hazardous materials may be found anywhere and at any point during the recon. Rescuers must be careful to monitor the atmosphere during recon, and to be aware of the potential for hazardous materials from the information gathered prior to the recon-such as type of occupancy and witnesses.

Note the type of collapse that has occurred. It is important to remember that this may vary throughout the structure. This information will assist in determining the most likely areas for survivors. Examples of the types of collapse are lean-to, cantilever, pancake, and V. These will be described in Unit 4.

Four Types of Structural Collapse Rescue Situations

There are four types of rescue situations in structural collapses. During recon, rescue personnel should determine and note the status of each identified victim.

In one situation, the victim is injured but not trapped. The injury may have been caused by falling, debris striking the victim, or by the victim falling. The appropriate action for these victims is removal to a safe location for treatment.

Remember, victim removal, is not necessarily done by the recon team. Its primary objective is to establish the problem and potential solutions to the problem. The recon team is performing triage to establish the order of priorities. If members are stuck on the solution of one specific problem, they may not grasp the whole situation.

Victims who are injured but not trapped account for about 50 percent of all urban search and rescue victims, in most cases these victims are rescued by civilians on the scene.

Another frequently occurring situation is nonstructural entrapment. In this case victims are trapped by debris such as furniture. In most cases, the locating of victims and the removal of cause of entrapment can be handled by common tools. The most appropriate action is removing the victim to a safe location for treatment.

Nonstructural entrapment occurs in about 30 percent of all urban search and rescue situations. Nonstructural entrapment victims are often rescued by organized community rescue teams, such as, industry, business, and school teams.

Void space (a type of nonstructural entrapment) occurs in both partial and complete structural collapses. The victims are trapped by the building contents and small debris, but are located within void spaces. In this case the structure must be stabilized with shoring, and the victim may be located using special resources. If possible, the victim should be removed to a safe location for treatment of injury.

Rescues in void spaces usually take less than four hours but may be lengthy depending on resources and situation. Approximately 15 percent of all urban search and rescue victims fall into this category. In most cases, rescue operations are performed by light rescue teams, i.e., teams that have *Rescue Systems I* training. These include local fire departments, police, medical, military, industrial, and volunteer S&R teams.

The final situation that might be encountered is the entombed victim. The victims are trapped by parts of the structure. The structure must be stabilized with shoring, and the victim may be located by lifting, moving, breaching, or breaking structural components in order to gain access. The victim may be removed to a safe area for injury treatment but, in many cases, much of the treatment must be performed in the structure.

Rescues of entombed victims usually take more than four hours and in many cases more than eight hours. About five percent of all urban search and rescue victims fall into this category. These victims are rescued by highly trained and equipped specialized rescue teams such as the FEMA Urban Search and Rescue (US&R) response team.

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 percent of those who can be saved will usually be rescued within that time period.

Typical survival rates of trapped victims:

❑ 30 minutes . . . . .91% survive

q 1 day . . . . .81% survive

❑ 2 days . . . . .36.7% survive

❑ 3 days . . . . .33.7% survive

❑ 4 days . . . . .19% survive

❑ 5 days . . . . .7.4% survive

Identify Safe Zones and Danger Zones

During or immediately following recon, the involved personnel should diagram their findings of the surveyed area or, if possible, use existing building plans to indicate their findings. They should document the size of the structure and the type of construction, as well as indicate any possible access points for rescue activities.

The location and general condition of any victims should be noted. Any voids noted during recon should be identified on the drawing. Any site hazards or areas containing hazardous materials should be clearly marked.

Establish Priorities

As a result of the size-up and recon, the IC will have access to the information necessary to establish priorities. It is imperative that this information be considered in an expeditious and organized manner.

The IC must determine the risks associated with each phase of the potential operation. Specific concerns include the stability of the structure, hazards, and natural conditions such as aftershocks or flooding.

Based on this information the IC must determine the need for, and commitment of, personnel and resources. In some cases, this commitment may be affected by other needs in the surrounding community, especially when multiple structures are affected.

Size-up and recon allow for an organized approach to any incident, no matter how small or large. These functions allow rescuers to establish what the problem is, and to form an organized approach to solving it.

ESTABLISH COMMUNICATIONS

Communication, both on and off the scene, is an important part of organization. Communication allows resources to be used 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 multisite operation. 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 the assurance that safety issues are identified and documented by all concerned.

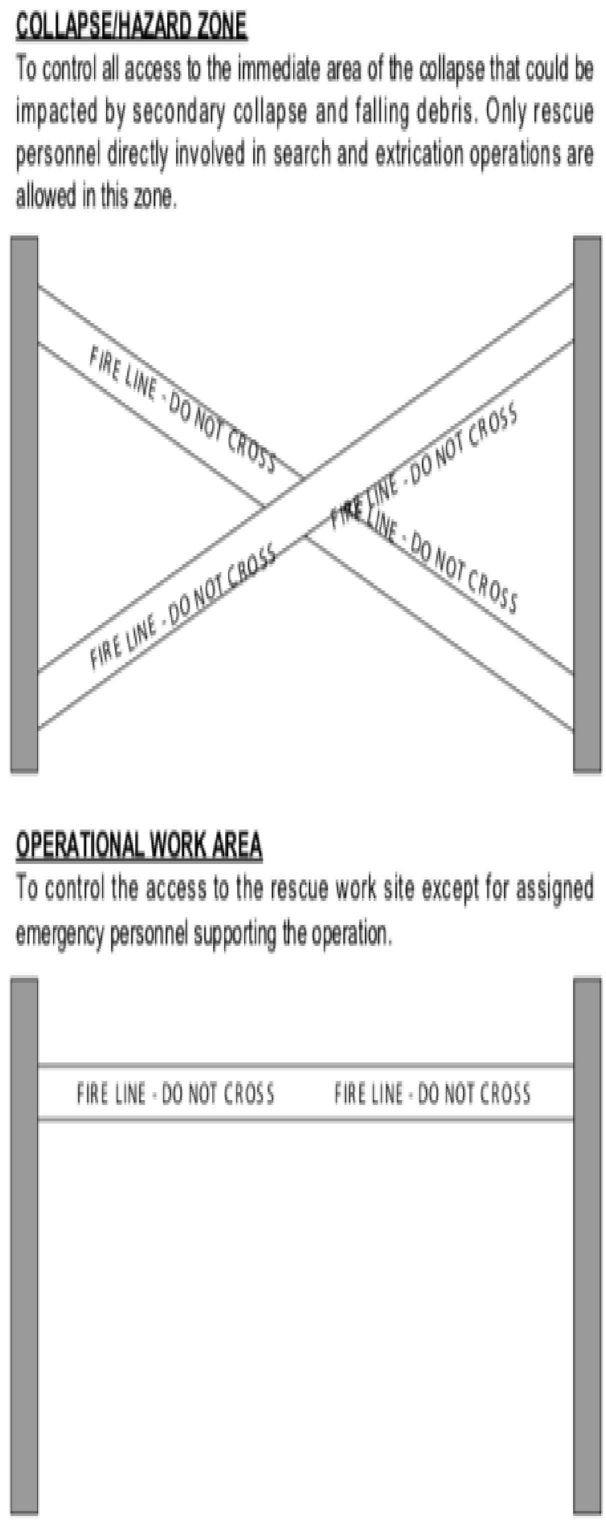


Figure 1:20 Rescue work site set up

Reasons for Communications

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

Communication Methods

Communication methods include the vehicle or portable radio, hardwire 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, may also 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 and 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 may be overloaded due to a lack of available lines. The hardwire telephone limits movement. A cellular system can also be down with no available or full cellular receiver and transmission sites.

Runners may not communicate the message accurately and are subjected to hazards traveling across the rescue site. Using a runner is possible only 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 multiagency, 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 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 multiagency, multidisciplinary, and multi-jurisdictional response may not be your usual designation. The designation to be used will be assigned and 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 with 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, 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.

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 and 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 and use of resources.

Establish the Incident Command Post

The location of the Incident Command Post 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 and egress ensures 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 ensures 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.

OBTAIN RESOURCES

Once the rescuers have determined their resource needs, it is necessary to determine how those needs will be met. Other resources, in addition to the materials which the rescuers have brought with them, are often required.

Use On-scene Materials

On-scene materials area readily available resources. Be certain that you document the use of any resources over which you do not have direct control.

Timbers and other construction materials are frequently found at collapse sites as a result of existing construction. Material such as steel and machinery may be available on site. Examples of other resources include fuel, electricity, telephones, and shelter.

Use Local Resources

Your ability to use local (personnel) resources can be enhanced by preplanning Knowing the capability of your community resources can greatly enhance your ability to respond to structural collapse incidents. Your preplanned resource list should include contact names and phone numbers both during and after normal work hours.

Developing a relationship with community resources can also assist in training for structural collapse incidents. Training with local (personnel) resources will help develop a working relationship with them.

Use Mutual Aid/Outside Resources

Develop a relationship with mutual-aid companies and other outside resources. Learn their capabilities and how to access them during the day and after hours. Develop a preplan and a resource list which will include mutual aid and other outside resources.

Establish a relationship with these (personnel) resources. Training is an appropriate avenue to further the relationship.

Preplanning is the key to a functional program. Develop a relationship with other disciplines. Learn their capabilities and how to access them during the day and after hours. Training is an appropriate avenue to further the relationship.

Examples of other resources include:

- structural engineers
- local utilities
- below-grade contractors (sewer, cable, telephone)
- concrete contractors
- heavy rigging contractors
- heavy equipment contractors
- lumberyards
- public works
- building engineers
- house-moving contractors
- architects

SUMMARY

Rescue scene organization completed Phase I (size-up/recon) of the four phases of structural collapse rescue. We have determined the extent of the problem, whether we can handle it with available resources, and what additional resources we need; determined existing hazards, located obvious victims, and establish ed ICS. It is imperative that these actions have been taken and systems are in place to allow control of the incident to continue in an organized manner.

UNIT 3 - *SAFETY*

Terminal Objectives

The students will be able to:

1. Identify types of hazards associated with each of the categories of hazards.
2. Identify four basic types of collapse.
3. Evaluate hazards associated with each construction type.
4. Decide if the risk to rescuers is worth taking to effect a rescue.

Enabling Objectives

The students will:

1. List the categories of hazards.
2. Identify four types of construction and list their characteristics in a collapse.
3. Describe the likelihood of survival in a specific structural collapse situation.
4. Identify the minimum personal protective equipment (PPE) necessary to operate safely in a structural collapse environment.
5 Identify safety procedures necessary to operate in a structural collapse situation.
6. Identify safety considerations necessary to operate in a structural collapse situation.

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 be possible only 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.

CATEGORIES OF HAZARDS

Structural Instability

The aftermath of a building collapse will present a variety of structural instability hazards for rescuers. These might 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 can 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 or 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. For this reason 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 that 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; they can lead to 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 soften 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 lead to secondary collapse. Engine noise can drown out communication and other sounds that 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 may also cause difficulties for rescuers by obscuring the view of the walking surface and reducing friction; other hazards include 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, electricity, 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 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 a hazardous material 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 identify potential hazardous materials that may be released during a collapse. Rescuers must be cognizant of this potential at residential dwellings as well as 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 stores, and sporting goods stores

- Paint and paint thinners
- Caustic paint removers and oven cleaners
- Pesticides and herbicides
- Aerosol cans
- Liquid and powdered chlorine
- Muriatic acid flammable gases
- Gunpowder and ammunition

❒ Schools

- Gases and flammable liquids
- Cleaning supplies
- Poisons
- 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 in 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 the fire 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 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.

BUILDING CONSTRUCTION TYPES AND CHARACTERISTICS

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. Because of 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 because of disrupted utilities and high surface-to-mass ratio of splintered wood and other light-frame materials.

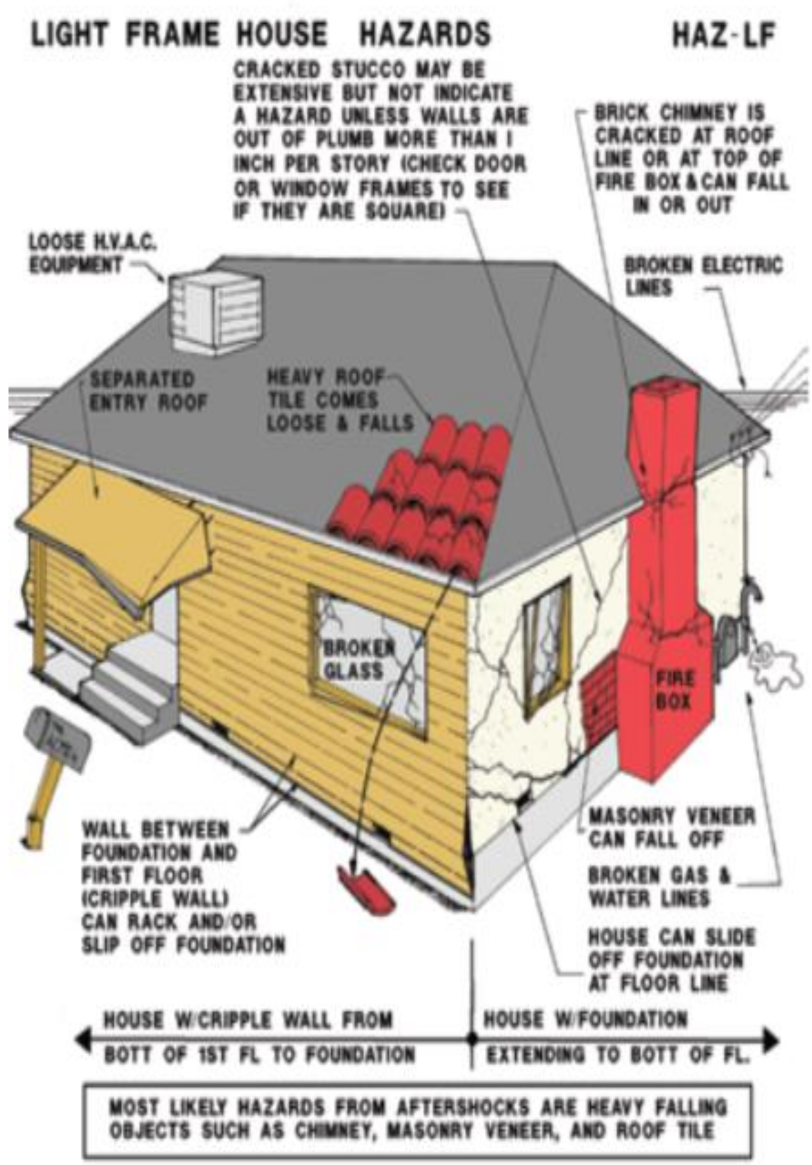


Figure 1:12 Light Frame Construction

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.

Heavy Wall Construction

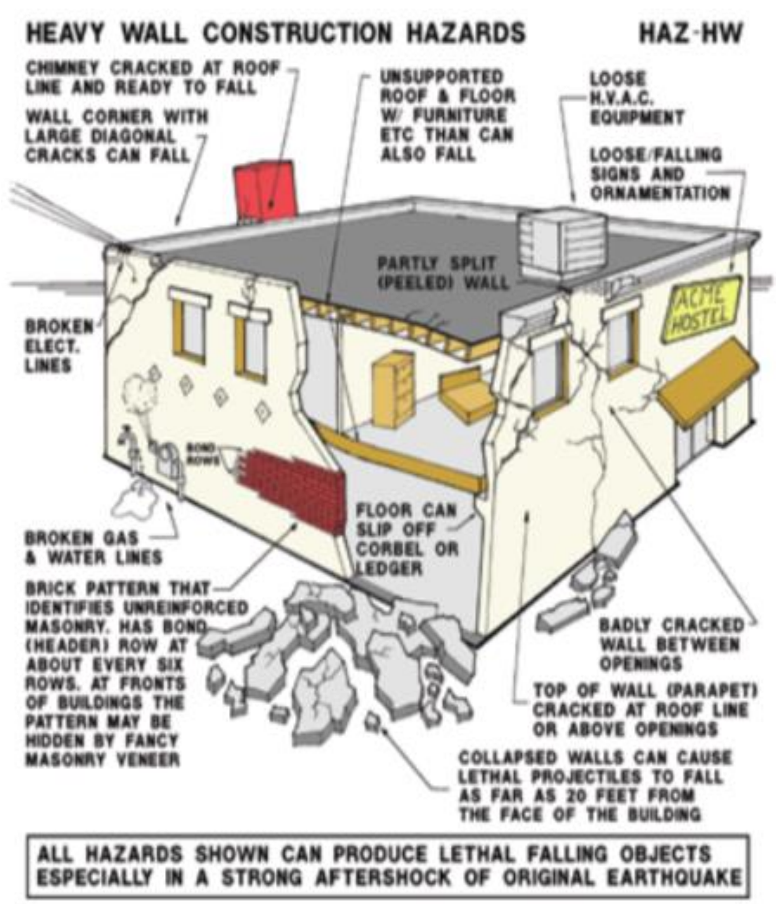


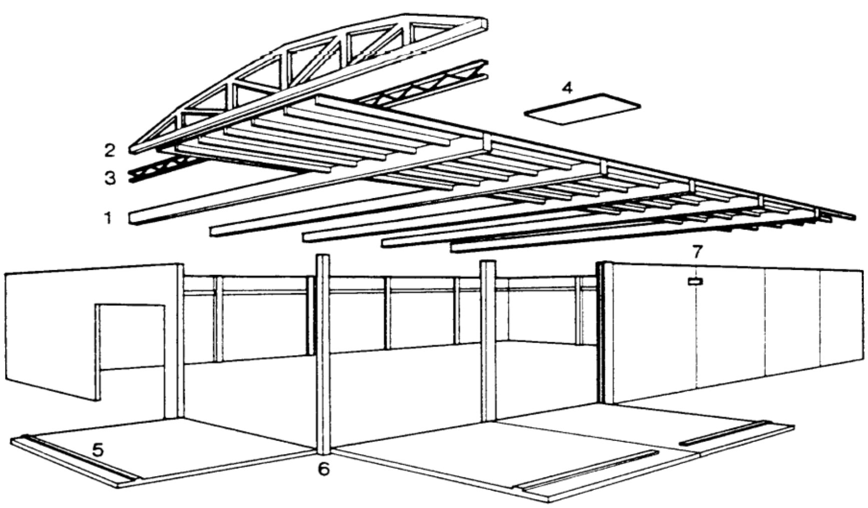
Figure 1:13 Heavy Wall Construction

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.

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 between the wall and the roof. Also, check the connection between beams and columns, and look for badly cracked walls or columns.

Tilt- Up Concrete Building

Typical heavy wall tilt up building features



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;

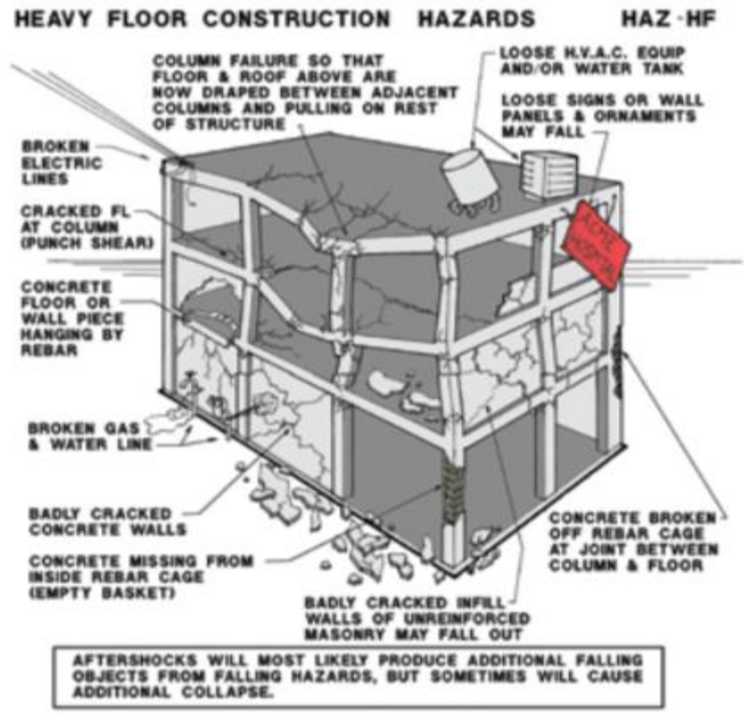
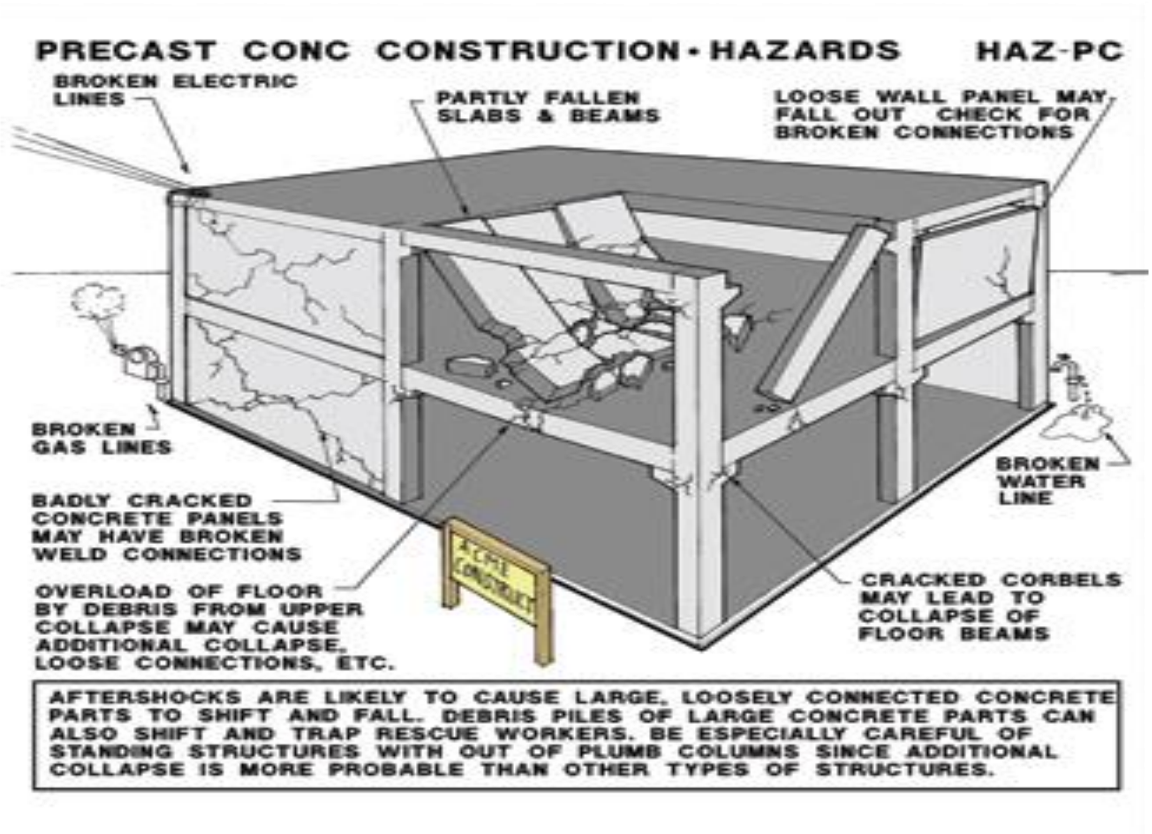


Figure 1:14 : Heavy Floor Construction

3) diagonal shear cracking in major beams adjacent to supporting columns; and
4) cracks in shear walls.

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

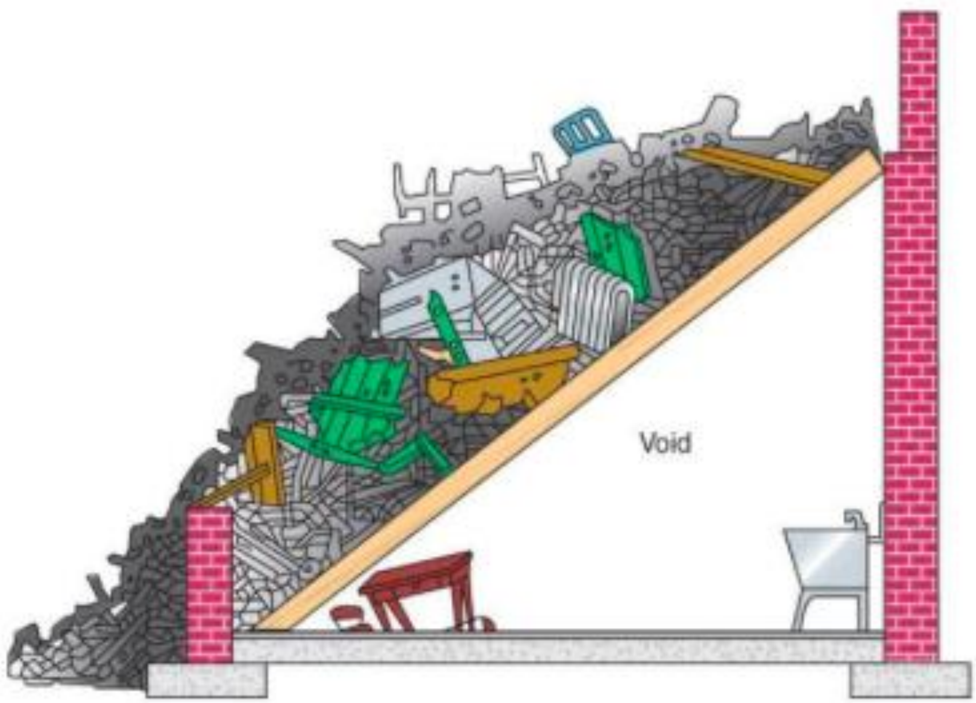


cracked corbels. Column cracking at top and bottom joints, as well as wall panel connections and shear wall connections at floor areas, must be checked to determine the stability of the structure. Other hazards include broken utility connections, loose signs, HVAC, or solar equipment.

Four Types of Collapse Patterns

Most collapses result in the original shape of the building being significantly changed. The rescuer can find anyone 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

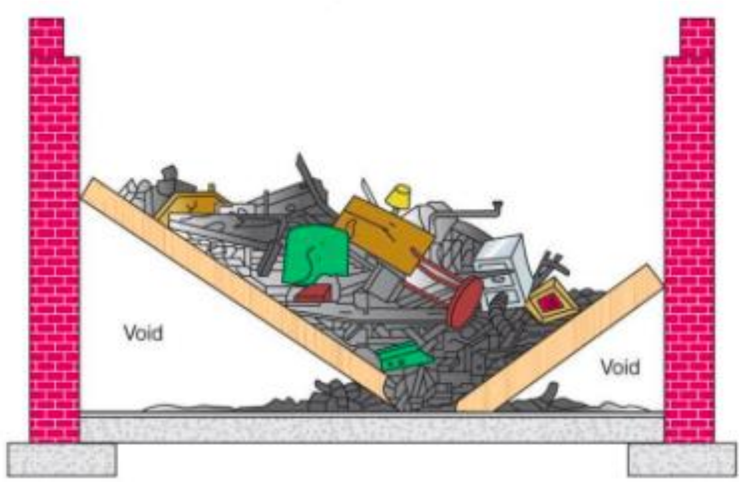


The lean-to collapse pattern is often formed when a wall failure causes a floor or roof section to fall completely on one side, while the other end remains supported. This collapse usually results in a triangular-shaped void that is considered a survivable void space. A survivable void is an area where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

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 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.

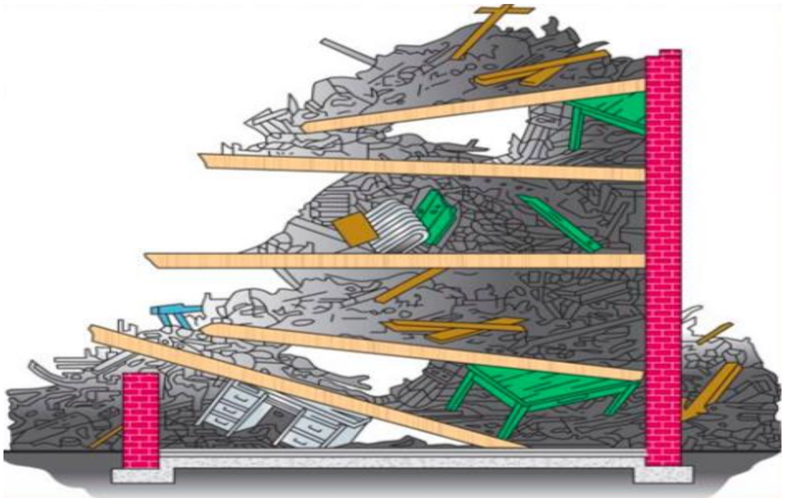


Pancake Collapse Pattern

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.

Cantilever Collapse Pattern



The cantilever collapse pattern is formed when a wall collapse results in one end of the floor(s) and/or roof hanging 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 or roof.

Survivability Profile

It is extremely important that rescuers and rescue team leaders understand what factors constitute a high likelihood of survival for structural collapse victims. It must be emphasized that operations at building collapses are personnel intensive. Many collapse rescue operations have proved to be of long duration, requiring multiple staff hours. Multi-hour operations will quickly drain even the best rescue teams.

For these reasons, informed decisions must be made concerning the assignment of rescue resources. Assigning personnel and equipment randomly will result in counterproductive operations. Rescue managers must know where victims' survival is likely within a collapsed structure. Resources then can be assigned to search those locations. Victims are likely to survive in the following locations.

- Collapse voids: survivors have been rescued from these voids.
- Access corridors: strongly built areas within buildings that generally remain intact after a collapse. These include hallways, stairwells, and elevator shafts.
- Basements: strong and survivable, may lead up or down to other voids areas.
- Underground parking garages: strong, survivable.

When deciding where to assign search and rescue resources, you should consider:

- Hazardous materials/Atmospheric conditions: Determine to what chemicals or dangerous atmospheres trapped persons may be exposed. What are their chances for survival? What are the risks to rescuers? Are they acceptable?

Personal Protective Equipment

The first response to a structural collapse will bring a wide variety of willing rescuers to the scene, including law enforcement officers, firefighters, emergency medical personnel, hospital employees, public works employees, private sector contractors, and 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 percent. Self-contained breathing apparatus has 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.

q **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 firefighter clothing is often too confining and hot and will quickly tire the rescue worker.

❑ **Flashlight or Headlamp**. 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 firefighter 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.

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 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 ensures 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: 02 Toxic Explosive	____________	______________

Reassess Atmosphere:	Time/Status	Time/Status	Time/Status
02	____________	____________	____________
Toxic	____________	____________	____________
Explosive			

PERSONNEL CONTROL/ACCOUNTABILITY

Assess Entry Team Readiness:

	Checkoff
• Proper level of protection	_________
• Personal lighting	_________
• Communications adequate	_________

Assess Backup Team Readiness:

• Proper level of protection	_________
• Personal lighting	_________
• Communications adequate	_________

Evacuation Signal Reviewed and Understood _________

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, in a 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.

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

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

Lookouts

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

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 (IC). This is especially important for personnel operating in hazard areas. A formal radio communications plan must be developed so 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 is also important that predetermined hand signals are known, recognized, and practiced by all team members.

ENTRY/EXIT TIMES	Enter	Exit
Team ________	______	______
Team ________	______	______
Team ________	______	______
Team ________	______	______
Team ________	______	______

REHABILITATION/MEDICAL ASSESSMENT

	Assigned	Status
Team ________	________	________
Team ________	________	________
Team ________	________	________
Team ________	________	________
Team		

SAFETY SUPPORT	Assessed	Status
Lighting	______	______
Structural Stability Monitors	______	______
Areas Cordoned Off	______	______
Additional Protective Gear Needed	______	______
Additional Shoring Needed	______	______
Ventilation	______	______

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 of 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 loud and identifiable and sounded when conditions require immediate attention. Emergency signals can be made using devices such as a whistle, air horn, vehicle horn, or bell. In order to reduce confusion, each structure or larger area of operations may need to have its own distinct emergency signal device when multiple rescue operations are taking place in the same area.

Supervisors should identify and inform assigned personnel of a designated place of assembly or safe zone for a Personal Accountability Report (PAR) to be conducted should an evacuation signal be sounded. A place of assembly is usually a safe location outside the evacuation area. A safe zone is usually a safe location within a building or disaster site that can be entered within the evacuation area. When an evacuation signal is sounded, all supervisors must conduct a roll call of their assigned personnel and communicate the results of the PAR to their supervisor.

If rescuers become trapped, they should immediately attempt to communicate with other team members, team leaders, a supervisor, the IC, 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 a personal alarm device. A suggested entrapped signal is the same

Evacuate the area	Short signals repeated for 10 seconds, pause for 10 seconds, and repeat for 3 repetitions. Total signal time – 50 seconds.
Cease operations/all quiet	One long signal (8 to 10 seconds).
Resume operations	One long and one short signal.

that the hailing search method uses, which is a continuous five taps – pause – five taps – pause.

Escape Routes

Rescuers must preestablish 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 preestablished 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.

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 operations 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 person's usual personality, withdrawing from the group, inability to sleep, nightmares, loss of appetite, and 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

SUMMARY

Rescues at a collapsed building site will include multiple hazards for first responding personnel. In order for personnel to operate effectively, they must initiate actions to protect themselves from injury. These actions will be possible only if they have an understanding of the potential hazards present, and a knowledge of the types of buildings and their collapse characteristics. In order to mitigate these hazards, rescue workers must use proper safety equipment and follow proper safety procedures. Remember, rescue safety is the number one priority. Enforce safety precautions.

UNIT 4 - SEARCH

Terminal Objectives

The students will be able to:
1. Implement the building marking system.

2. Implement search to contact and locate victims.

Enabling Objectives

1. Summarize kinds of information needed to organize the search.

2. Identify where needed information can be obtained.

3. Identify the symbols in the suggested FEMA marking system.
4. Describe three types of search procedures.
5. Identify other search resources.

WHY SEARCH?
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.

In order for any rescue operation to be a success, the victims must be located. The rescue is dependent upon the completion of a thorough and successful search operation. 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 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 which should be placed on the actual structure during multisite 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 are the beginning of 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 and factory) provides valuable information regarding the expected number of occupants. 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.

Data gathered from persons on the site or familiar with the site can provide useful search information. Witnesses to the incident may be able to provide information about where victims were last seen. Persons who have escaped from the structure also can provide useful location and structure condition information.

Contractors who were involved in building maintenance or construction and building engineers 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.

Before and during the search, rescuers should determine the type of collapse void that has occurred. This will assist in locating probable victim survival areas within the structure. Keep in mind the characteristics of the four types of collapse as they relate to the potential void created.

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

Prior to beginning the search, it is important that any identifiable hazards are stabilized or removed. Rescuers should be looking for and noting hazards to victims as well as hazards to themselves.

TYPE OF SEARCH

Three methods of search may be implemented. For the most complete search, a combination of all three should be used. Two of the search methods require specific resources and a significant commitment to training.

Physical Search

The physical search can be performed by rescuers without outside search specific resources. It involves an organized approach to checking all areas of the structure. This is the most easily implemented type of search as it can be done with available resources. The primary 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.

The procedure for the physical search should begin with organized personnel walking around the site to be searched. Rescuers should look for surface victims and make verbal contact with them. Surface victims should be removed if possible. At the same time the location of non-surface victims, who can’t be readily accessed or who are trapped should be noted during the walk around.

During the walk around, time should be taken to call out and listen for victims. The "hailing” procedure is very simple. Place rescuers around the site to call out (one at a time) and listen. Work should stop, and the area should be silenced. As each rescuer calls out, the others listen and try to establish possible location of victims.

Responses should be verified by additional calls to pinpoint the exact victim location. This method assumes that victims can respond to the call; this will not be possible when victims are unconscious or seriously injured.

At this point the structure should be entered if it is safe to do so. Structural stability and hazard concerns should be verified before entry.

Search the accessible interior of the structure in an organized manner. Areas should not be skipped unless for safety reasons, and any area skipped should be documented.

Search the most probable survival areas. Likely areas include voids created by lean-to, V, and cantilever collapses. Halls, basements, stairwells and parking garages also are areas where surviving victims may be found. Search debris piles, but use caution when moving materials as the unorganized movement of rubble may cause additional failure of the structure.

Identified victims should be contacted and, if possible, contact should be maintained until they are rescued. Explain the situation to the victim, and at the same time establish the victim's general condition and distress. Have the victim describe his/her position and how he/she is trapped. This information may assist in determining the extrication approach. Also, question the victim regarding other known occupants of the structure.

All findings form the physical search should be reported to the IC. Information should include the location and general condition of identified victims, and how they are trapped.

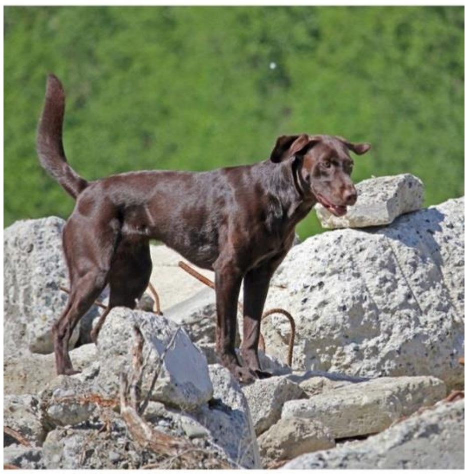
The general condition of the structure and any identified hazards must be noted. Information regarding the best access to the structure by rescuers should be noted. The best access for victim removal also should be noted, and any other specific safe access information should be passed on--such as additional escape routes or access to areas below or above the victim.

Canine Search

The canine search requires additional search resources as well as a great deal of training, and continuing education. The canine search should be performed by US&R disaster-trained dogs and handlers, if available. The effectiveness of the canine search may vary according to the individual handler and canine capabilities.

Extreme caution should be used if attempting to use dogs and handlers with other types of training. Police dogs, drug dogs, and wilderness dogs lack the specific experience for the mission at hand. Dogs must have experience and confidence working, in and around rubble, and must be able to work around, in, and on any number of hazards and unstable situations.

Canine search should be used in conjunction with physical search (and technical search if available). Each type of search should enhance the other. Canine search can be confirmed by physical search, or hailing can be confirmed by canine search.



Technical Search

Technical search requires specific specialized equipment and technically trained operators. Once again, it must be remembered that no one search method should be used alone.

There are several types of technical search that may be of use. Listening devices monitor seismic and acoustic responses of victims. These devices require the victim to respond to instructions by the device operator. They also require the site to be quiet while the listening device is operating. Generally, these devices can be carried by a single rescuer and set up in a few minutes. The cost of these devices ranges from four to ten thousand dollars.

Fiber-optic and other small cameras can be placed in small openings or rescuer-drilled holes to determine victim location in inaccessible areas. These cameras typically have a self contained light source and are hand held. Frequently these devices can be acquired from below-grade contractors or utility companies. The cost of these devices ranges from eight to fifteen thousand dollars.

Heat-sensing, infrared devices seem to have limited capability for locating victims in structural collapse. They cannot detect heat differentials through a solid medium, and sources of heat other than victims create confusion. They are more readily available than other search devices. Local fire departments may have them.

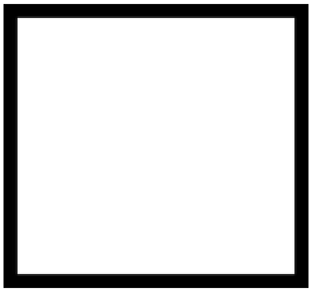
Remember: The most complete search involves a combination of all available methods. No one system is 100 percent effective. The site must be continually researched until all potential victims are located. As walls are breached or debris is removed, more victims may be found. All search personnel must, report in and out of the structure to assure accountability.

STRUCTURE / HAZARDS MARKING BOX

Structure Hazards Evaluation Marking System

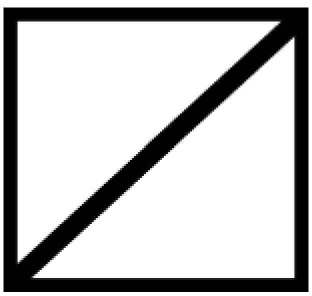
The structure hazards marking consists of a 2’x2’ square box painted or drawn on the structure. This box indicates that the structure has been evaluated.

LOW RISK



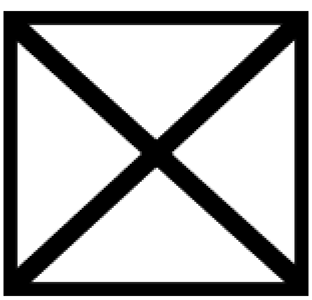
Structure relatively safe for S&R ops. There is little chance of further Collapse. – Victims could be trapped by contents or could be unconscious.

MEDIUM RISK



Structure is significantly damaged. May need shoring, bracing, removal and monitoring of hazards. The structure may be partially collapsed.

HIGH RISK



Structure may be subject to sudden collapse. Search operations may proceed at significant risk. If rescue operations are undertaken, significant time consuming shoring and mitigation should be done.

ADDITIONAL MARKINGS

Arrows located next to a marking box indicates the direction to the lowest risk entrance into the compromised structure.

HM
Indicates a hazardous materials condition exists in or adjected to the structure.

SEARCH MARKINGS

A separate and distinct marking system is necessary to articulate information relating to the victim location and condition in the areas search.

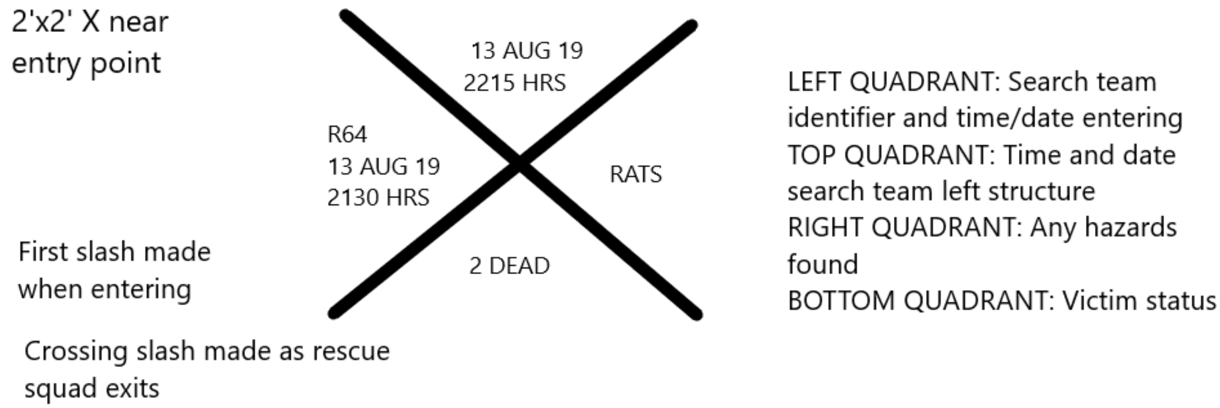
The personnel performing the search function will draw an X that is 2' x 2' in size with spray paint or construction crayon. This X will be constructed in two operations. One slash will be drawn upon entry into the structure or room and a second crossing slash will be drawn upon the team's exit.

A single slash drawn upon entry to a structure or area indicates search operations are currently in progress.

A crossing slash is drawn upon search personnel's exit from the structure or room.

Distinct markings will be made inside the four quadrants of the X to clearly denote the search status and findings at the time of this assessment. The following illustrations define the search assessment marks:

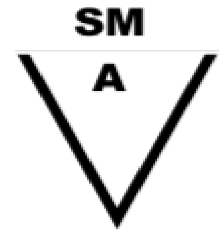
SEARCH ASSSESMENT MARK



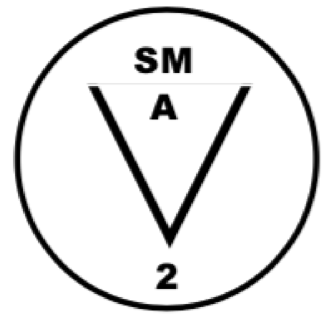
Victim Location Marking System

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 rescue 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.

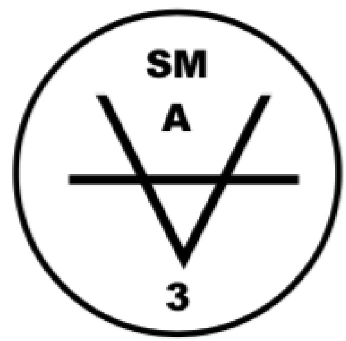
Make a large “V” (2' x 2') with orange spray paint near the location of a **potential** victim. Mark the name of the Search Team or Crew identifier in the top part of the “V” with paint or lumber chalk or crayon.



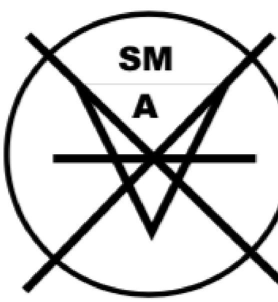
Paint a circle around the “V” when a potential victim is **confirmed** to be **alive** either visually, vocally, or hearing specific sounds that would indicate a high probability of a live victim. If more than one confirmed live victim, mark the total number of victims under the “V”.



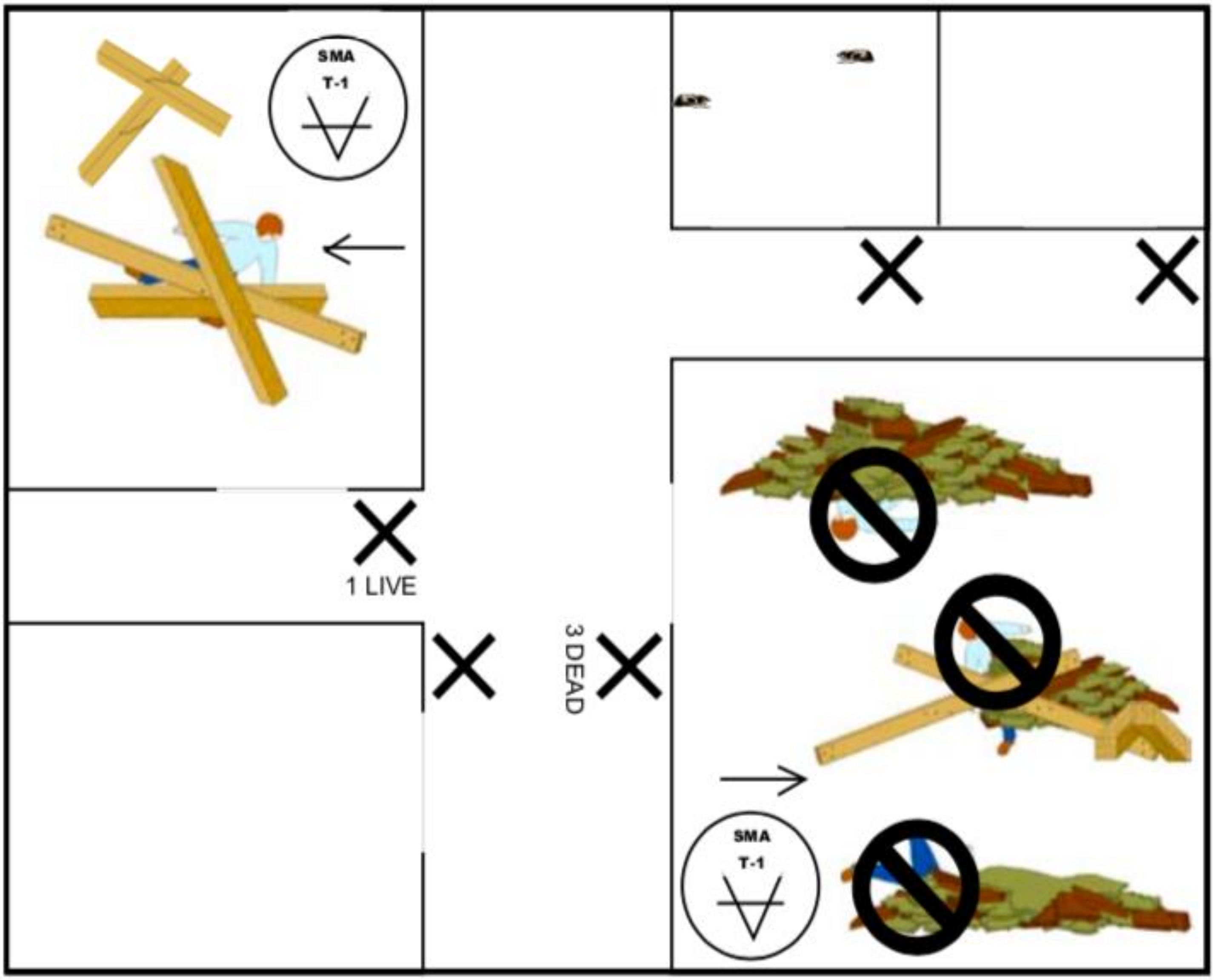
Paint a horizontal line through the middle of the “V” when a **confirmed** victim is determined to be **deceased**. If more than one confirmed deceased victim, mark the total number of victims under the “V”. Use both the live and deceased victim-marking symbols when combinations of live and deceased victims are determined to be in the same location.



Paint an “X” through the confirmed victim symbol after **all** victims have been removed from the specific location identified by the marking.



An arrow may need to be painted next to the “V” pointing toward the victim when the victim’s location is not immediately near where the “V” is painted.



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.

UNIT 5 ROPES AND KNOTS

Objectives

The students will be able to:

1. Identify and operate basic rope equipment.
2. Tie the following knots:
   - Figure eight knot
   - Figure eight on a bight
   - Figure eight follow through
   - In-line figure eight
   - Overhand safety knot
   - Square bend
   - Double fisherman's bend
   - Prusik hitch
   - Bowline
   - Inter-woven longtail bowline
   - Inter-locking longtail bowline

3. Properly tie rescuer harness and attach to a safety line.
   - Pelvic harness
   - Chest harness
4. Set up a Decent Control Device (DCD) for lowering operations (Scarab, MPD, or break bar rack).
5. Set up and operate belay system using 540 or tandem Prusik systems
6. Using appropriate belay lines, climb ladder and traverse an elevated structure.
7. Recognize and build appropriate anchor systems with an understanding of critical angles.
8. Construct three types of picket anchor systems
   - Single picket
   - Double picket
   - Combination picket
9. Set up and operate simple 2:1 and 3:1 mechanical advantage pulley system for application with ladder rescue systems.
10. Construct and operate a vertical lowering system which includes a decent control device (DCD), a belay line and a properly packaged patient.

ROPES, WEBBING AND KNOTS


Figure Eight On A Bight

TERM

KNOT - when a strand of material is tied to itself (e.g. Figure 8)

(“knot”, is a general term for all knots, bends, and hitches.)

BEND - when two or more strands of rope are tied to each other. (e.g. Flemish)


Figure Eight (Flemish) Bend

HITCH - when a strand or strands is tied around another object.

BIGHT - a 180° turn, U-shaped bend in a strand of rope.

LOOP - a 360° turn in a strand of rope.

KNOT - DEFINITIONS

Clove Hitch

BACK-UP KNOT: A knot used to back-up the main load-bearing knot. Back- up knots should be nestled against the main knot to limit shock-load. Typically, a double overhand is used as a back-up.

BOWLINE KNOT: A knot used throughout the fire service. The advantage of this knot is that it is easy to untie after being loaded, which is why a back-up knot is required. The Yosemite finish is preferred. The variations that will be used in this class consist of long tail, interwoven and the interlocking long tail.

DOUBLE OVERHAND BEND: Also known as a double fisherman’s knot. Used to join two ends of rope together, commonly used for joining the ends of Prusik loops.

DOUBLE OVERHAND KNOT: Preferred back-up knot.

DIRECTIONAL EIGHT OR IN-LINE EIGHT: This knot is used for re- directing a rope. Used for tensioning or securing a system. The directional knot enables the rope to stay inline while securing the load.

FIGURE EIGHT FOLLOW THROUGH: Used extensively in rope rescue. This knot is used to tie around an object.

FIGURE EIGHT ON A BIGHT: Used to tie a loop in the end of a rope.

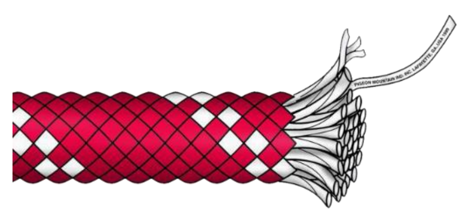
Round Turn

Round Turn with a Half Hitch

Round Turn with Two Half Hitches

KERNMANTLE ROPE

Kernmantle rope construction is a braided style in which the kern, a high strength inner core, is covered by the mantle, an outer braided sheath. The core supports the major portion of the load; and may be of parallel, braided or twisted strands. The sheath serves primarily to protect the core and also supports a portion of the load.



Static Rope: Manufactured by cavers beginning in 1966 (BlueWater) for the purpose of rappelling and ascending ropes that had little stretch and did not spin in comparison to laid rope construction. A static rope may have a stretch of about 2%

with a 300lb load but it will have a maximum elongation of 6% at 10% of its minimum breaking strength. Static rope is the most common classification of rope employed by rope rescue teams.

A static rope should not be used when a leader fall is possible.

Low-Stretch Kernmantle Ropes: A rope with an elongation greater than 6% and less than 10% at 10% of its minimum breaking strength. The core fibers are parallel for minimum elongation. Low-stretch rope should not be used when a leader fall is possible.

Dynamic: High stretch rope that is primarily used for lead climbing and can stretch up to 60% of its breaking load. Due to its stretching properties this type of rope should not be used for Rescue loads.

ROPE DIAMETER: The fire service routinely employs STATIC 12.5 mm (1/2 inch), which is required by NFPA 1983 to have minimum breaking strength of 40 kN (9,000 lbf).

ROPE LENGTH: Rescue teams typically develop preferred lengths locally based upon their operating area. Although there is no industry standard, common working rope lengths by rescue teams include 150, 200, 300 and 600 ft (46, 61, 91 and 183 m). Longer lengths are employed; however transport to remote incident sites becomes problematic. Teams will cut short 50 ft (15.2 m) sections as "anchor ropes" to assist with topside rigging applications, including edge lines, back-ties, and anchor point extensions. Recreational climbing or incidents that require dynamic rope typically employ dynamic ropes ranging in length from 30 to 80 m (98-262 ft) long, with the most common length being 60m (195 ft).

Rope should be stuffed in a protective bag for easy deployment and protection from elements and abrasion. They should be stored in a cool dry place that is well ventilated and away from harmful chemicals and solvents. Storage in direct sunlight should always be avoided due to synthetic fibers deteriorating under ultra violet light.

Life Safety Rope

We generally use ½’’ diameter kernmantle and meet NFPA 1983 standards as well as having the following minimum information affixed to both ends of the rope:

An identifier that matches the rope to its bag
Rope Length
Date the rope was placed in service
“A” and “B” designator on each end
Whether the rope is Dynamic

A Rope log shall be kept for the duration of the service life. Specifics of the rope log shall include at a minimum:

The Manufacturer
Lot Number
Date manufactured and date placed in service
Color of rope
Diameter and length
Static or Dynamic
Minimum breaking strength
History of rope
Inspection Information
Inspectors name and date

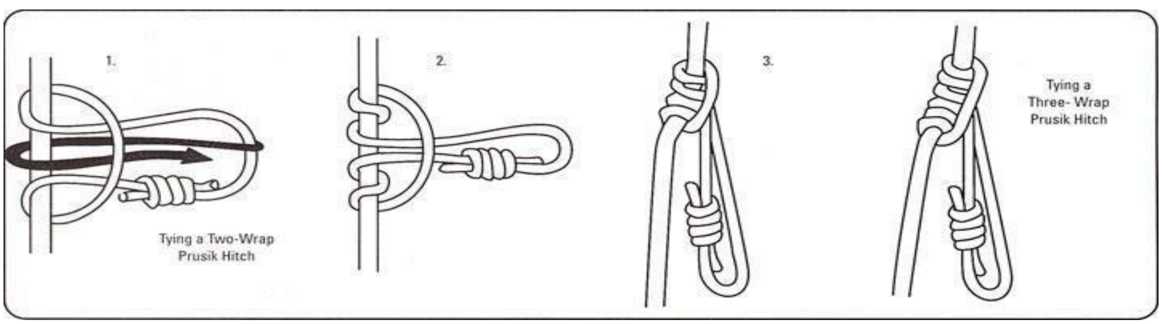
Proper care, use, inspection, and maintenance shall follow the manufacturer’s recommendations. All life safety rope shall be inspected after purchase and prior to being placed in service, after each use and at least semi- annually.

WEBBING

Tubular webbing which is easier to tie and is more commonly used in rescue. There are two types of tubular webbing. They are edge stitched formed from flat webbing folded and stitched together or spiral weave formed by weaving the tube as a unit.

1'' nylon tubular webbing: minimum breaking strength 4000lbs Lengths

Green	5 feet
Yellow	12 feet
Blue	15 feet
Red	20 feet



8mm low stretch Static kernmantle with a breaking strength of 2875 lbs (may also vary depending on manufacturer).

Common lengths to form a "Match Set" are 54'' (untied) for the short and 65'' (untied) for the long.

When tied using a double overhand knot, tails must protrude a minimum 2'.

Prusik sheath material may not be compatible with other manufacturer's rope, thorough testing must be done to determine whether the prusik will perform as designed when using different manufactured ropes.

Prusik cord utilized for a Radium Release Hitch is commonly cut at 33’

Prusik cord utilized in a system receives above average wear and should be inspected after each use and semi-annually.

Sewn Prusik loops will have the same minimum breaking strength (2875).The double overhand knot is replaced by the manufacturers sewing process Rope logs should be kept on these types of prusik

KNOTS

Factors that make certain knots or ties superior to others includes the ability of the knot to remain tied, the ease of untying and the relative strength. As a general rule, *a knot in rope reduces the strength of the rope by one third.* (A knot in tubular webbing decreases the strength by at least 45%). This is due to sharp bends in the rope created by the knot. The strength of the knot will be affected by the sharpness of these bends and the angle at which the rope leaves the knot. NOTE: Additional knots in a line do not decrease rope strength by another third.

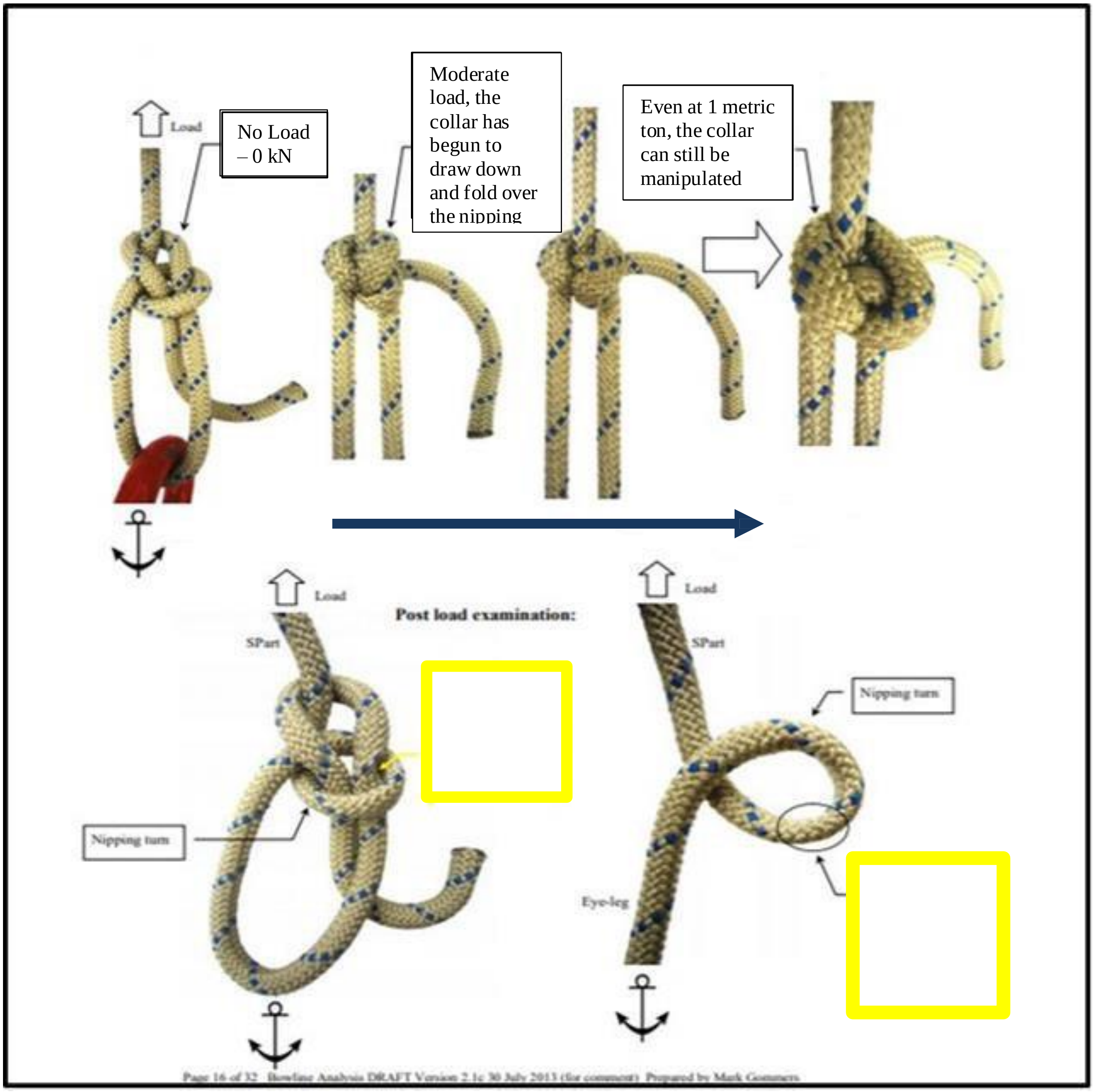

Load
No Load
– 0 kN
Moderate
load, the
collar has
begun to
draw down
and fold over
the nipping
Even at 1 metric
ton, the collar
can still be
manipulated
Load
Post load examination:
SPart
Nipping turn
Load
SPart
Nipping turn
Eye-leg
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FIGURE 8's

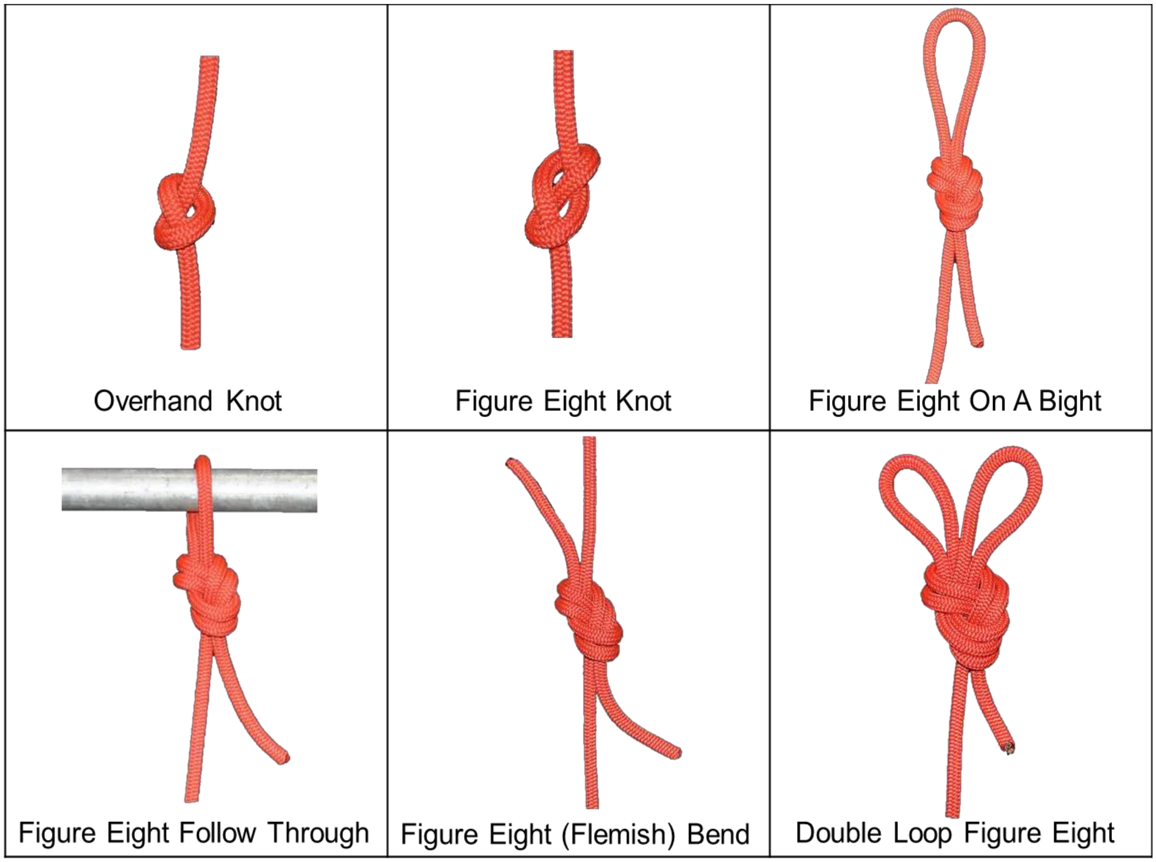
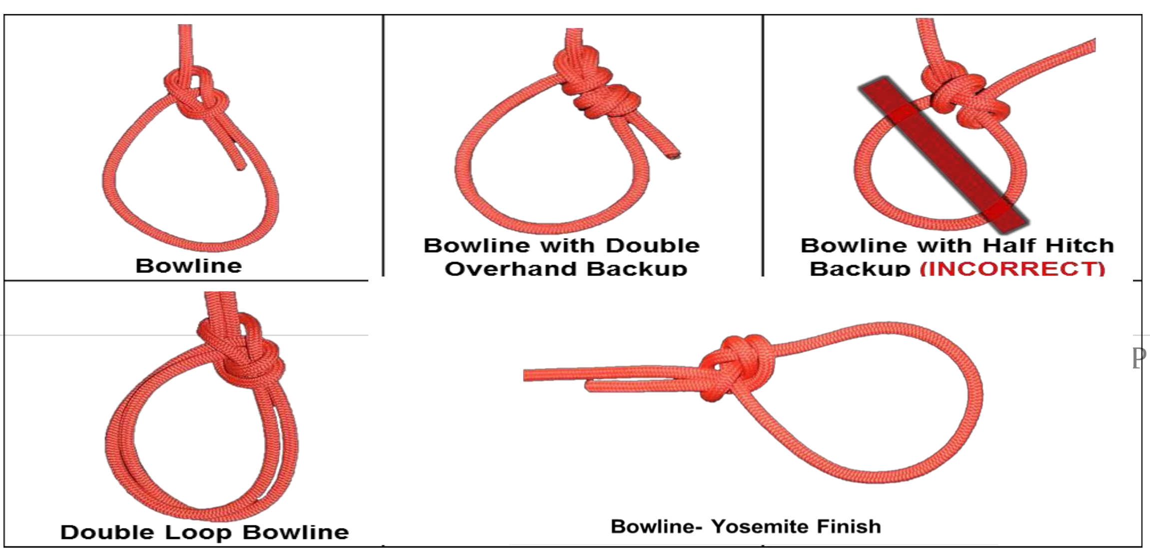


Figure 8 Knot- Forms a stopper knot that can be easily untied.

Figure 8 On A Bight- A bight at the terminus of a rope which can be attached to an anchor. Figure 8 Follow Through "Bend" - Useful for joining two rope ends together. Double Loop Figure 8 - Two bights at the terminus of a rope for rigging, which can be identically sized or different depending on rigging requirements.

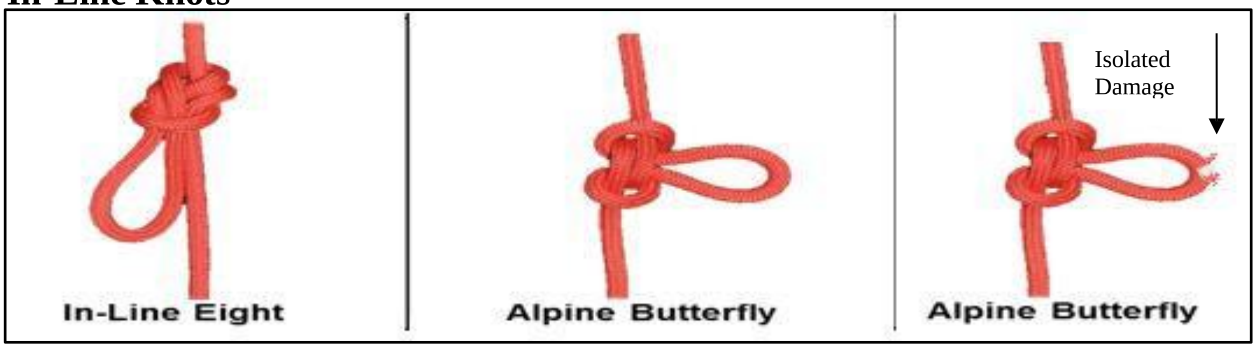
THE BOWLINE



The Bowline

Although the Bowline is an efficient knot, it can work itself loose under repeated loading, therefore it is essential to tie a backup knot to secure the tail. **It is recommended that a Double Overhand Knot be used for this backup application due to instances of a single Overhand Knot coming loose**. An advantage of the bowline is that it is easier to untie after being tensioned.

In-Line Knots



In Line Figure 8 - Creates a load-bearing loop in the middle of a rope which can take a load in one direction only.

Alpine Butterfly is used to form a fixed loop in the middle of a rope. It can be tied without access to either of the ropes ends. It handles multi-directional loading well and has a symmetrical shape which makes it easy to inspect.

Isolating a damaged section of rope during an operation can be accomplished by incorporating the damaged section into an inline knot such as, an In-Line 8 or Alpine Butterfly.

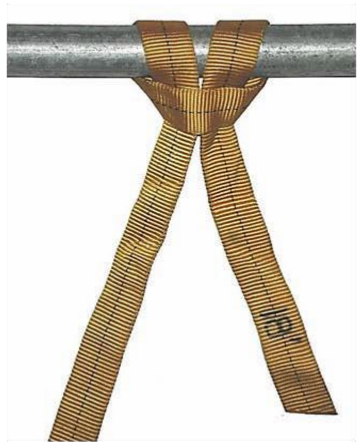
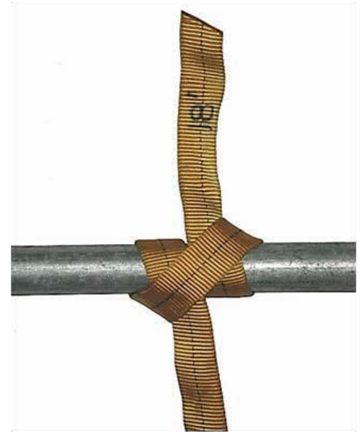
BENDS


Double Fisherman's Bend

Double Fisherman's Bend. The Double Overhand Bend is a bend used to join two lengths of rope. The knot is formed by tying a Double Overhand Knot, with each end around the opposite line's standing part.

Water Knot (aka, Tape Knot, Ring Bend, Grass Knot, or Overhand Follow- Through) is used for joining two ends of webbing together to construct a sling. It is tied by forming an Overhand Knot in one end and then following it with the other end, feeding in the opposite direction. The knot should be "set" by tightening it with under tension prior to use.

HITCHES

 Ring Bend (Water Knot)	 Girth Hitch	 Clove Hitch
 Munter Hitch	 Double Munter Hitch	 Prusik Hitch (3 wrap)

HITCHES

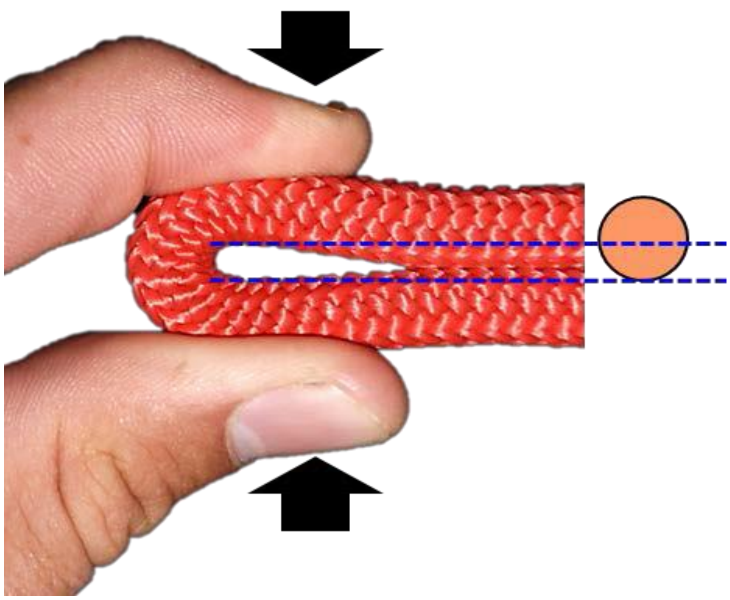
Clove Hitch. A Clove Hitch is two successive Half Hitches around an object. This knot is particularly useful where the length of the running end needs to be adjustable.

Girth Hitch. The Girth Hitch (Cow Hitch) is a tie used to attach a rope to an object, which is comprised of a pair of Half Hitches tied in opposing directions, as compared to the Clove Hitch in which the Half Hitches are tied in the same direction.

Münter Hitch (AKA- Italian Hitch, [MB Mezzo Barcaiolo] The Munter Hitch may be used for belaying or lowering in an emergency although, it provides limited holding power. It is also known as HMS, the abbreviation for the German term Halbmastwurfsicherung, meaning half Clove Hitch Belay.

Prusik Hitch (three wraps for rescue load applications, which forms six coils). The hitch is formed by applying it to a host rope.

Note: To ensure that Prusik cord moves and grips properly, the diameter relationship between the standing line and the Prusik loop cord diameter should follow the general rule of 60-80% ratio. Not all manufactured Prusik cord behaves in the same manner and any new cord should be tested prior to actual field use. Be careful not to employ Prusik cord that is too stiff. Check the Prusik Hitches prior to the belay being put into service, to be certain they will grab! Use a "pinch test" for optimal cordage, that when pinched between two fingers in a bight will leave a gap 1/2 the diameter of the material. A secure Prusik loop is formed by joining the ends of the cordage with a Double Fisherman's Bend.



Inter-LOCKING and Inter-WOVEN Longtail Knots

Typically applied with a Bowline however, this could be applied to a Inline Figure Eight as well.

Inter locking Long-Tail Bowlines- used to interconnect the main line and belay line An initial Bowline is tied with a small loop and extra-long tail. The other rope is tied through the loop of the bowline in the first line. The connection point of the Bowlines is a redundant attachment point for a rescue load and the long tails become secondary attachment points for the rescuer and subject.

Inter woven Long-Tail Bowlines- used to interconnect the main line and belay line. The knot is tied with both lines together as if it were one line. A couple advantages are that only one knot instead of two are tied, saving time. Also, once the knot is interwoven the long tails lose any need to be differentiated between a main and a belay. They become neither and both.

Interwoven Bowlines appear to perform better in pull testing for ring loading. A disadvantage is that some may find it cumbersome to tie. Also, both lines are needed to tie, implying that rigging may be delayed if waiting for one of the lines to be brought to you.

<u>Both methods are acceptable</u>.

STRENGTH OF KNOTS

In 2016 Thomas Evans of SAR3 presented at the International Technical Rescue Symposium. His research was a data mining compilation of 1440 knot strength tests from 114 sources. Below is the combined data from those results.

Knot	***Low %***	***Median %***	***High %***
Bowline	41.8	56.3	70.7
Figure 8 On a Bight	64.8	75.6	86.3
Inline 8	62.5	68.6	74.7
Alpine Butterfly	60.7	70.7	80.6
Scaffold Knot	68.5	74.9	81.3
Double Fisherman	73.5	76.9	80.3
Figure 8 Bend (Flemish)	56.8	68.8	80.7

The Table below was collected from the CMC Rope Rescue Manual 4th ED 2013.

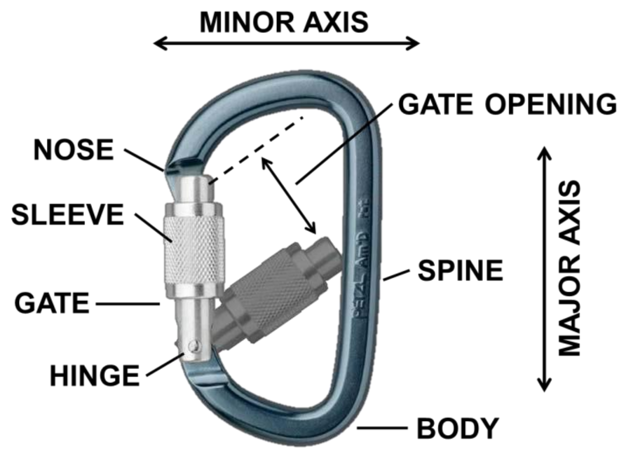
Knot	%
No Knot at All	100
High Strength Tie-Off	100
Figure 8	77
Alpine Butterfly	75
Scaffold Knot	69
Double Overhand Bend (Double Fisherman’s	68
Bowline	67
Figure 8 Bend	51
Water Knot (in webbing)	64
James A. Frank, 2013 CMC Rope Rescue Manual	

Note: Values will vary with rope type and are based upon static pull testing, not dynamic loading.

Field Rule: A general belief is that a knot will reduce rope strength by one third (33%) and webbing strength by 45%

EQUIPMENT AND HARDWARE

CARABINERS



Metal connectors with spring loaded gates, which are used to attach components in rigging. The name is derived from "Karabinerhaken", which is German for "spring hook."

Rescue applications require carabiners to be stronger than the more lightweight designs used in recreational climbing. They are constructed of aluminum, alloy steel and stainless steel. Steel carabiners are stronger, more durable against wear, but also much heavier than aluminum carabiners.The specific parts of a carabiner include thebody, spine, gate, nose, hinge and sleeve. The major axis of a carabiner refers to an orientation end-to-end along the spine, while the minor axis refers to an alignment across the carabiner side-to-side

LOCKING STYLES

Non-locking- Used in limited applications during rescue operations for non-life-safety loads, which include securing edge protection and securing equipment to a harness or a litter.

Screw Lock- features a threaded sleeve that must be manually screwed open or closed in order to release the gate. They have fewer moving parts than spring-loaded mechanisms, are less prone to malfunctioning due to contamination or component fatigue. They are more time- consuming to operate than twist-lock.

Auto-Locking (Twist Lock)- Have a security sleeve which must be manually rotated to disengage with a spring-loaded collar that automatically springs closed upon release. Manufacturers offer some proprietary auto-locking design mechanisms including Petzl Ball-Lock and Triact-Lock, ISC Supersafe and Quadlock, Omega Pacific Quik-Lok and Rock Exotica ORCA 3-stage auto- locking system. It is important to recognize that dirt, ice, or other contamination can inhibit the auto locking mechanism and prevent it from functioning properly.

NFPA Standard 1983 (2017) Fire Service Life Safety Rope and Equipment defines two classes of rescue carabiners; technical use (T rating) and general use (G rating).

Major Axis		Minor Axis:	Gate Open Major
“T”- Technical Use	27 kN (6,069 lbf)	7 kN (1,574 lbf)	7 kN (1,574 lbf)
“G”- General Use	40 kN (8,992 lbf)	11kN (2,473 lbf)	11kN (2,473 lbf)

118 | P a g e

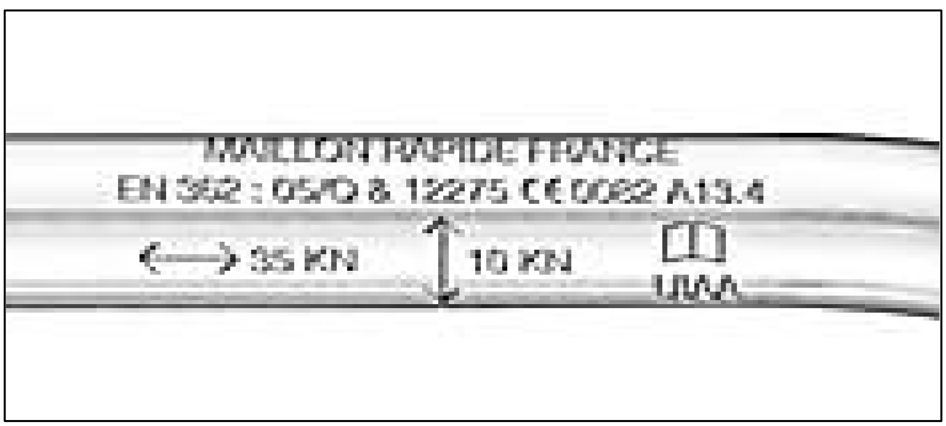
SCREW LINKS

Screw links provide a compact, lightweight alternative to carabiners for a semi-permanent attachment. Maillon Rapide (translates quick link), produced in France by the manufacturing firm Péguet, have become the industry standard for highly secure life-safety load connections in rescue.

Inferior screw links are commonly sold in hardware stores, which should not be employed for rescue applications.

The most common screw link shapes employed for rescue include oval, demi-round (D-shape) and delta (triangular). Maillon Rapide links, which are marked with the brand name, are constructed of zinc plated steel, stainless steel, and zicral (aluminum and zinc alloy). Do not exceed the working load limit (WLL) engraved in kg on the screw link.The screw link gate requires numerous revolutions to close securely. For semi- permanent connections, it may be tightened with a wrench for security. They are designed to handle multi-directional loading applications.

Minimum breaking strength for all shapes certified for climbing and mountaineering applications (CE EN 362 and EN 12275) in the closed and locked position; major axis 25 kN and minor axis 10 kN.



RESCUE PULLEYS

A rescue pulley has rotating side plates and is constructed with a sheave (wheel) mounted on a bearing or bushing. Pulleys constructed with sealed bearings are superior and more efficient in handling rescue loads than those containing bushings. When using a pulley as a directional, keep in mind that the force on the pulley anchor may be twice the force on the rope!

The tread diameter of the pulley sheave, where the rope lays, is important to note. For efficiency, the optimum rescue pulley size would be a tread diameter of at least three times the diameter of the rope being used on it. Some manufacturers will state the outside diameter (OD), which could be misleading. Pay attention to the tread diameter which relates directly to performance.

Prusik-Minding Pulley. CMC Rescue ProSeries® Pulley with side plates shaped to tend Prusik Hitches.

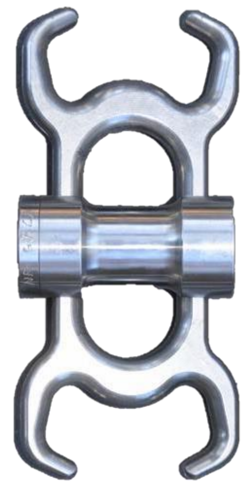
Double Sheave Pulley. Rock Exotica Omni-Block Swivel Pulley. Design allows opening the side plate while clipped to an anchor and has becket attachment point at the base.

Rock Exotica Kootenay Ultra. Specialized pulley with wide sheave to permit knot passing or serve as travelling carriage in a highline system.

Knot Passing Pulley- The wide sheave The Kootenay Ultra by Rock Exotica permits knot passing and has a locking sheave to create a high strength tie-off. It is also purpose-designed for highlines as there are separate connection holes for tag-lines and hoist-lines, with a sheave that is wide enough to run over multiple track-ropes.

DESCENT CONTROL DEVICES

SCARAB®

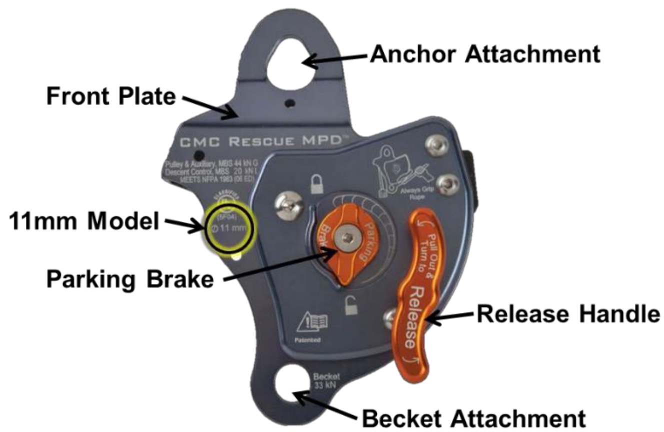


The Scarab® is a compact variable friction descent control device (DCD) developed by Rick Lipke, Conterra Technical Systems, which does not twist the rope during use. In comparison to the rappel rack, the Scarab provides a very compact rescue DCD. A rope can be attached to the device without unclipping the device from the anchor and variable friction is accomplished by adding or removing wraps of individual horns on the frame. The Scarab easily manages lowering of a 600 lb. rescue load and the basic "boat cleat" style of the frame permits easy lock off during an operation. The device is available in stainless steel or titanium models. Scarab FR is manufactured from stainless steel and works with 9mm to 13 mm rope. Weight 385g (13.8 oz). Scarab TI is machined from solid Titanium and operates with 6mm to 11 mm rope. Weight 185g (6.6 oz). The Scarab model SFR-1 is certified to NFPA 1983 General Use for 12.5mm rope.

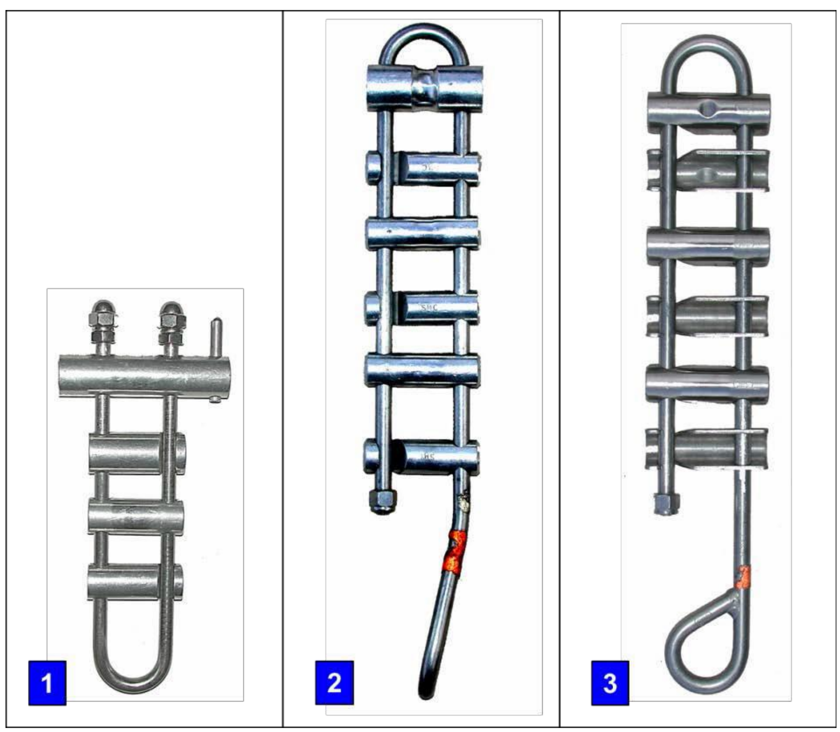
According to Conterra, the frame and crossbar's strength is greater than 40kN (8,992 lbf). However, during destructive testing nylon ropes would fail at the nose of the Scarab close to their knotted strength. When pulling a 12.7mm (1/2 inch) rescue rope on a locked off Scarab, the rope broke a t about 27kN (6,070 lbf), which easily exceeds the 22kN (4,946 lbf) strength rating that NFPA calls out for to rate class "G" for a DCD.

CMC RESCUE MPD™ (MULTI-PURPOSE DEVICE)

MPD™ (Multi- Purpose Device) is manufactured by Rock Exotica and sold exclusively by CMC Rescue. This device serves as high-efficiency pulley, DCD and a belay device that permits immediately switching from lowering to raising without any change in hardware. The MPD pulley has an integral rope-grab mechanism allowing it to be used as a lowering device on the main line or for belaying on a belay line systems. The MPD allows for a quick change from lowering to a raising system without switching out hardware.There are 2 sizes. Be certain to use rope meetingthe diameter requirements of the device. Additionally, wet, icy or muddy ropes could affect the proper function of the device, and additional friction may need to be applied by the operator.



RAPPEL RACKS



Invented by John Cole in 1966 to allow variable friction during a descent. A very popular device among cavers and a very efficient tool for rescue loads. The rappel rack does not twist the rope during use as it applies friction in an "in-line" fashion. Two rappel rack styles include the standard inverted "J". shape (open style), which has attachment eye along one of the legs of the inverted "U" frame. The second popular style is the closed rack, which is also "U" shaped, but the base of the "U" serves as the attachment point

The amount of friction can be easily adjusted during use and the device dissipates heat well.

Always have a minimum of four bars in the system. Start with all bars incorporated and reduce the number of bars after getting past the edge.

Figure Eight

Although once a very popular friction device in technical rescue, the Figure Eight ("Rescue Eight") has lost its acceptance as a rescue DCD with the development of much more versatile and appropriate appliances. It is shown here for comparison only and is no longer considered a recommended tool for rope rescue. This classic friction device is an efficient personal descender, however it does not provide the necessary utility required to handle a rescue load. The device is loaded by feeding a bight of rope through the large hole and looped down around the outside of the small end till it rests on the "neck" of the Figure Eight. The bottom small hole is clipped to the rescuer or anchor. The "rescue eight" design (Figure 49) incorporates protruding ears, which prevent the rope from sliding up to the top of the device and forming a Girth Hitch during a rappel, which immediately stops further descent. A very significant drawback of the Figure Eight is that it twists the rope during use. Although the Figure Eight can be double wrapped during setup to increase friction, it however cannot be varied during an operation, which limits its overall usefulness.

BELAY DEVICES

540°™ RESCUE BELAY

The 540 Rescue Belay was designed by Kirk Mauthner of Basecamp Innovations Ltd. and is manufactured by Traverse Rescue. This self-locking device is capable of holding a falling rescue load quickly, while limiting the peak force applied to the rope. The device has a symmetrical internal design which permits bi-directional loading. A built- in release lever releases the tension on the belay rope, which eliminates the need for a release hitch.

It is available in Small (GREEN) for ropes, 10.6 – 11.5 mm. and Large (BLUE) for ropes, 11.5 – 13m

RIGGING PLATES

- The focal point of anchor system can be kept organized with the use of a rigging plate. This simplifies multiple tasks or connections occurring at a single location and helps to keep lines orderly. Numerous sizes of rigging plates are now commercially available, providing numerous connection point configuration to meet different needs. Rig plates are tested and rated between two holes. Do not exceed the safe working load of a single hole with rigging. Shifting equipment, particularly when tension is released and then reestablished, creates the potential for a rigging plate to lever against a carabiner, causing failure. Be aware of this hazardous scenario and keep a watchful eye on all rigging during use.

Rigging Plates. 1.) Petzl Paw S (small) 2.) Rock Exotica PentaPlate 3.) Rock Exotica UFO (Universal Focusing Object)

RESCUE LITTER

- Rescue litters, which are also referred to as stretchers. The classic Stokes Stretcher was the forerunner appliance which led to the evolution of basket style litters used in technical rescue within North America. The original “Stokes Splint Stretcher” was developed and patented by Dr. Charles F. Stokes, fourteenth Surgeon General of the Navy, in 1905. As a surgeon and medical officer on a hospital ship, Dr. Stokes relied on his experience to develop the litter design. There are now, several variations of the litter.

These are specs from a particular stainless steel CMC litter to provide just a general idea of specifications.

- Vertical MBS: 30.2 (kN)
- Horizontal MBS: 14.1 (kN)
- Weight: 31 lb (14.1 kg)
- Load Rating: 11 kN (2,473 lbf)

MISCELLANEOUS

• **The AZTEK** is first and foremost, a personal travel restraint that utilizes various lengths typically between 30 and 50 feet of 9mm as the main support mechanism.The AZTEK addresses energy absorption through the use of a shock absorber. This shock absorber is a purcell fashioned from 8 feet of 6mm accessory cord hitched to the 9mm rope. By employing a unique five wrap, 3 over 2, prusik at all the connecting and adjustments points, it was found to have effective energy absorption. The second basic tool of the AZTEK is a pre-rigged 5:1 pulley system or *"Set of 4's" (SOFs)*, a fitting nickname given to us from the lineman industry. This 5:1 pulley system uses two mini double sheave pulleys rigged on 9mm rope at the opposite end from the travel restraint system.

• **Mechanical Ascenders-** For long ascents mechanical ascenders outperform Prusiks. Handled ascenders are designed to be easily attached to and removed from a fixed rope, providing an efficient personal rope ascending tool. Mechanical ascenders are rated by manufacturers only for one-person loads.

• **Bypass Lanyards** – A versatile piece of fall protection equipment for "Leading" on structures such as towers. The double tie off lanyard, also known as the Y-lanyard. The Y-lanyard attaches two lanyard legs to a shock absorber, which is recommended as to limit the force of a fall to 8kn. Fall factors of .25 are considered unacceptable. They can also allow rescuers to move horizontally from one area to another while being continuously attached.

- **Evacuation Triangle-** The Petzl Bermude or Pitagor are evacuation triangles, used when the subject will be suspended rather than climbing. They can be rapidly secured around a subject for a pick-off situation. The Pitagor model has shoulder straps, which prevent the device from dropping down around a subject's ankles when not supported under tension. The three connection rings should be joined together with a wide (HMS style) locking carabiner and for proper balance should be positioned just above a line between the subject's armpits. Weight (Pitagor) 1.29 kg (2.84 lbs)

MANUFACTURER BREAKING STRENGTHS OF RESCUE EQUIPMENT

Note: All strength ratings shown reflect ideal conditions with new products. Remember that rope, cordage and webbing loose significant strength when wet or rigged with knots.

Force ITEM	kN	pounds
CORDAGE/ROPE:		
4 mm Accessory Cord (PMI)	3.8 kN	854 lbf
5 mm Accessory Cord (PMI)	5.8 kN	1,304 lbf
5.9 mm PowerCORD (Technora core) (Sterling Rope)	19 kN	4,271 lbf
6 mm Accessory Cord (PMI)	7.5 kN	1,686 lbf
7 mm Prusik Cord (PMI)	10.7 kN	2,405 lbf
8 mm Prusik Cord (PMI)	13.4 kN	3,012 lbf
11 mm Static Nylon Rope (PMI Pro Classic Max-Wear)	28.6 kN	6,430 lbf
11mm HTP (High Tenacity Polyester) (Sterling)	30.5 kN	6,856 lbf
WEBBING:		
1 inch Mil-Spec Tubular Webbing (PMI)	18 kN	4,000 lbf
1 inch Type 18 Woven Flat Webbing (PMI)	27 kN	6,000 lbf
Climb Spec Webbing, 15mm (9/16") (BlueWater)	10.2 kN	2,300 lbf
Spectra™ Sewn Titan Sling, 13mm (1/2") (BlueWater)	27 kN	6,069 lbf
HARDWARE:		
Petzl Minder (Prusik-Minding) Pulley (P60A) (97% efficiency)	36 kN	8,093 lbf
Rock Exotica 2.0 Prusik Minding Pulley	36 kN	8,093 lbf
Rock Exotica Omni-Block 2.0 Pulley	36 kN	8,093 lbf
Traverse Rescue 5 ^{0}™ Rescue Belay 40	40 kN	8,992 lbf
CMC MPD	44 kN	9,891 lbf
Conterra Scarab *(rope breaks at 27kN)*	40kN	8,992 lbf
CMI Mini Hyper Rack	62 kN	14,000 lbf
SMC Figure Eight with Ears, NFPA128701	32kN	7,194 lbf
Petzl Delta Triangular Screw-Link, 10 mm (P11)	25 kN	5,620 lbf

Source: Manufacturer websites

EQUIPMENT CARE AND RETIREMENT

- Proper storage and general treatment will greatly extend the useful service life of all rescue equipment. Keep in mind that life safety equipment is designed to keep you safe. Develop a strong discipline of good housekeeping and storage of all equipment in a response-ready state.

- Store equipment in a well-ventilated area out of direct sunlight, to avoid the possibility of degradation from ultra-violet exposure. Do not store near corrosive substances or acids (vehicle battery acid). Avoid storing equipment in a damp place where mold can develop (damp closets, bags and waterproof containers with moisture inside).

- The following recommendation regarding retirement timeframes is made by Petzl, regarding the lifetime of their equipment; "The maximum lifetime is up to ten years from the date of manufacture for plastic and textile products. The lifetime is indefinite for metal products. Warning: An unusual event may require you to retire a product after only one use. This may involve the type and intensity of use, or the environment in which it is used: aggressive environments, sharp edges, extreme temperatures, chemicals."

- When determining the age of equipment, recognize that manufacturers who meet EN (CE) requirements, mark the year of production and lot number on an item in some manner. Etched marking indicates this carabiner was manufactured in 2010. Marking arrangements vary between manufacturers.

GEAR **RETIRE WHEN**

NECESSARY, INCLUDING:

- Over ten years old and made of plastic or textiles
- When subjected to a major fall or impact force
- When it fails to pass an inspection
- If the reliability of the equipment is in question
- The usage history is unknown (e.g. not marked, missing rope log, etc.)
- Obsolete design due to changes in standards, technique, or equipment compatibility
- Destroy any retired equipment to prevent further use in a life safety application
- Check all carabiner surfaces regularly for cracks, sharp edges, corrosion, burrs or excessive wear. Hairline cracks can result in significantly reduced carabiner strength.
- Check carabiners gates to make certain they open and close quickly and easily. Be sure all gates, as well as any locking mechanisms, close freely and properly. Retire any carabiner, if the gate does not function properly, or is out of alignment.
- Carabiners that have been dropped a significant distance should be retired. A dropped carabiner can suffer significant damage yet still appear visually intact. When in doubt, remove it from service.

CARABINER CLEANING

- Clean gates by blowing dust and dirt from the hinge area.
- For a sticky gate, wash in warm soapy water, rinse thoroughly, and allow to dry.
- Lubricate carabiners with a <u>general purpose lubricating oil</u> (e.g. 3-IN-ONE®) or Teflon based (PTFE) lubricant (e.g. Tri-Flow®) around the hinge area, the spring hole and the locking mechanism. Wipe off excess lubricant.
- <u>Do not</u> use WD-40 as it can dry out the hinge and spring, accelerating aging.
- <u>Do not</u> use graphite based lubricants, which promotes corrosion in aluminum.
- Remove any sharp burrs that can damage rope, sand them using fine grit sandpaper. <u>Do not</u> file carabiners to remove a burr.
- Clean and lube carabiners after contact with saltwater or salt air.

HELMET CARE AND CLEANING

- Manufactures oppose numerous decals or paint, due to the possible degradation.
- Do not compress a helmet inside a pack
- Do not sit on a helmet.
- Clean a helmet with household soap and rinse with water.
- Do not use solvents, stain removers, degreasers, etc. that are not compatible with polycarbonate, polystyrene, or nylon, and can degrade the helmet.
- Shell of ABS helmets can be cleaned with a cloth moistened with rubbing alcohol.

HARNESS CARE AND CLEANING

- Inspect the stitching and condition of the straps on a clean textile product.
- After use in a salty environment (seaside), rinse with fresh water.
- Wash a harness in lukewarm soapy water, then rinse thoroughly with fresh water.
- Use a small brush to remove stubborn spots (oily dirt or mud).
- Clean in washer on delicate setting (max 86°F or 30°C), without spin cycle.
- Wash in a cloth bag to avoid damaging machine drum from metal harness parts.
- Use only household face or body soap (Do not use laundry detergent). Solvents, stain removers, or degreasers are incompatible and can degrade nylon.
- Hang harness on a line to dry

ROPE CARE AND CLEANING

- Do not walk or stand on ropes.
- Aggressively protect ropes from edge abrasion, by using rope protectors and rollers.
- Avoid descending too fast on a rope as this heats the sheath and accelerates wear.
- Rapid descents can cause a rappel device to heat up (446°F or 230 °C) and melt nylon rope fibers.
- Store ropes uncoiled in a bag to protect them from dirt.
- Keep rope away from contact with sharp objects.
- Keep your ropes clean. A rope's condition can have an impact on the wear of other gear.
  - For example, a muddy rope can inhibit the proper function of an ascender. A

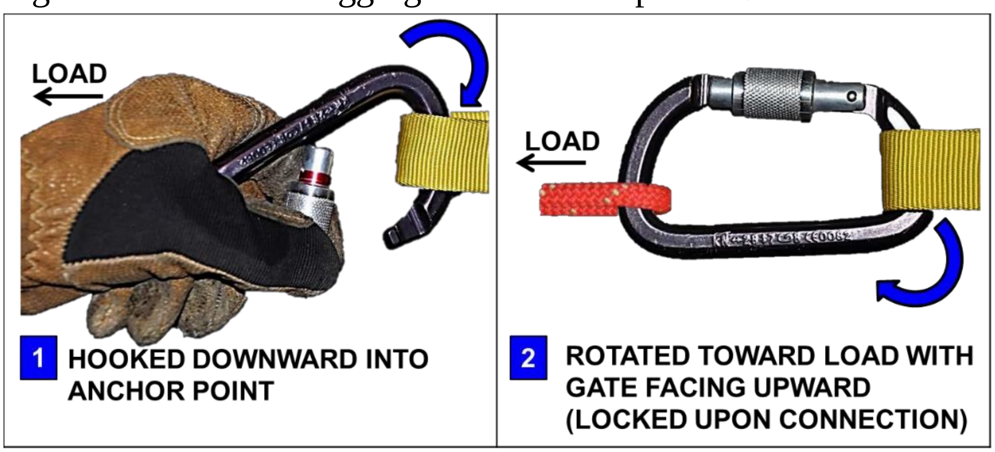
wet, sandy rope can cause premature wear of ascenders, descenders and carabiners.

- Use a hot knife to get a neat, clean cut.
- Mark each rope end with in-service date, diameter, and rope length.
- Use labels or adhesive tape to record information and protect the label with a heat-shrink tubing (WARNING: do not exceed 176°F or 80 °C).
- After use in a salty environment, rinse with fresh water.
- Wash ropes in lukewarm soapy water (ph neutral, 86°F or 30°C maximum), and rinse thoroughly with water.
- Clean in washer on a delicate setting (max 86°F or 30°C), without spin cycle.
- Use only household face or body soap (Do not use laundry detergent).
- Solvents, stain removers, or degreasers are incompatible and can degrade nylon.
- Hang to air dry.

GENERAL RIGGING CONSIDERATIONS

Orientation of Carabiners in Rigging

Consistently orienting carabiners in the same manner during rigging provides efficiency and reliability for a secure connection point. A recommended practice is to hook a carabiner into a connection point in a downward motion and rotate the body around so that the gate is facing upward with the nose of the gate oriented away from the connection point. This procedure places the spine against the ground and keeps the gate accessible for rigging and visual inspection.

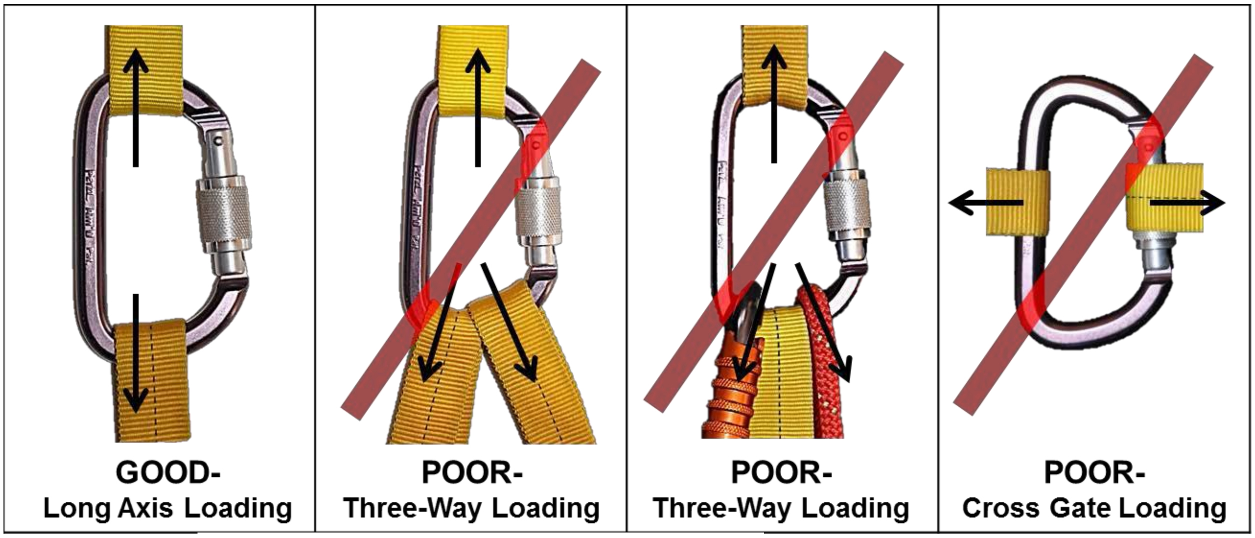


NOTE: Be cautious that this manner of rigging, when untensioned and then tensioned again with a suspended carabiner, can promote diagonal rigging of the carabiner, resulting in 50-60% strength loss. In such cases, rotation of the heavier gate downward can be appropriate, however it should be away from terrain.

CARABINER RIGGING

- For safety at a critical rig point, consider using one locking carabiner or two non- locking carabiners that are placed with their gates opposite and opposed.
- Tension along the major axis of a carabiner- be aware to prevent the primary force going onto or across the minor axis (cross-gate forces).
- Tension carabiners along the spine and avoid three-way loading of carabiners. A three-way load across the major axis results in approximately the same strength reduction as tying a knot in a rope, which is a 1/3 loss in strength. A three-way loading across the minor axis can result in up to an 80% loss in strength. Finally diagonal tensioning a carabiner results in about a 50- 60% loss in strength.
- Keep straps, lanyards, and other carabiners away from the gate.
- A carabiner's gate-open strength is usually less than half of its gate-closed strength.
- Remember locking carabiners can unlock themselves! Recheck them during use.
- Do not allow the rope to run against the locking sleeve of a locking carabiner.

- Do not over tighten a locking carabiner while it is loaded. After the tension is released it will be difficult to unlock. To unlock such a "stuck" carabiner it may



Do not open a loaded carabiner supporting a life safety load in a rescue system.
Think about your actions and the possible consequences. This could create a pathway for a catastrophic accident.

be necessary to re-tension it in order to loosen the gate.
- Avoid linking carabiners in a “chain.”
- Avoid rigging a carabiner over a sharp edge.

OTHER RIGGING

Nylon quickly moving across stationary nylon generates tremendous friction that results in heat. This heat can quickly melt through a piece of nylon in a short amount of time resulting in failure of the stationary component. Avoid rigging in a manner that permits nylon components to rub against

one another. Introduce a carabiner or other intermediate rigging component to separate the nylon items.

SAFETY INSPECTIONS

Once a rigging task is completed by a rescuer, it should be completely inspected by a safety officer or another rescuer. Newly constructed rigging or a system that has been re-rigged, needs to have a safety inspection completed. All rescuers receive a safety inspection prior to entering the hazard zone at an exposed edge. This disciplined process provides a redundancy for safety, which can catch natural rigging errors that do occur.

Inspections are conducted in a systematic manner, such as from head-to-toe or anchor point to rescue load. If a person is interrupted during a safety inspection, the distraction could lead to an omission. Start the inspection of a system over to ensure thoroughness for complete safety. For thoroughness, the actual safety inspection should involve three distinct actions by the inspector, including looking, touching and talking.

- LOOK- Visually inspect all rigging; Rigging meets acceptable techniques. Knots are correctly tied and dressed. Carabiners are locked. Buckles are secure. PPE is being completely employed. Housekeeping of all rigging has been addressed.

- TOUCH- Physically touch and trace the rigging; Squeeze carabiners to verify security with a “press check.” Pull on harnesses. Pull on anchor points and systems for confirmation.

- TALK- Verbally talk (even if it is only to yourself) about what you are inspecting; State what you observe and what you are looking for. Ask questions of the rigger.

ANCHOR SYSTEMS

GUIDELINES FOR ANCHOR SYSTEM CONSTRUCTION:

Technical rescue employs anchor points rigged together into an anchor system. Constructing a rescue anchor system does not require an engineering degree, however a solid understanding of sound anchor rigging concepts is essential to be a competent rescuer. Upon arriving at a rescue scene, the following considerations for team leaders are useful to assist in maintaining efficient scene management.

In the Fire service we typically use single point anchors. They must be "Solid" all by themselves.

Rocks, Bollards, Columns, Beams, Cars, Trees, etc….

- Whatever is used it must be bombproof beyond doubt.
- Check edges where webbing or rope will be up against and confirm no sharp edges that could damage the nylon under great loads.
- Cars can slide if on ice or loose gravel.
- Rocks can roll.
- Trees can break or topple over especially if under wind or snow load. Is it live? Is it in good soil? Is the soil saturated? Are the roots exposed?

ANCHOR CONSTRUCTION DEFINITIONS:

ANCHOR POINT- Single connection point (e.g. tree, boulder, camming device, etc.).

ANCHOR SYSTEM- Multiple anchor points rigged together creating redundant system. **DEVIATION-** Redirects the natural fall line of the rope on the rock face. A deviation point may or may not to be subjected to the same force as the primary rig point.

DIRECTIONAL- Rigging technique to change the natural line of a rope with a carabiner or pulley attached to an alternative anchor.

FOCAL POINT- A location, floating or fixed, where all rigging is directed for anchor points. This concept disciplines rescuers to construct rigging which joins together at an efficient point, rather than unwittingly resorting to wherever the knot that joins all anchor points ends up due to the length of material used; the latter can result in an awkward spot to manage rope handling tasks.

ANCHOR SELECTION

Where do you need to go?

- Select an efficient fall line in order to reach the victim.
- Don't fall into the trap of rappelling directly down on top of fallen subject (non- pickoff situation) in a manner that might cause rockfall injury. Generally, a descent adjacent to the patient's location makes more sense. Packaging the patient can occur at their resting point and then the litter can be traversed to the raising or lowering system.
- Lowering route selection should avoid additional hazardous terrain if possible.
- Is a *deviation* pulley required to redirect the fall line of the rope?
- What rescue tasks need to be accomplished (e.g. edge management, lowering, raising or a traverse)?

Where should the anchor "focal point" be located?

- Raising the focal point off the ground increases efficiency of belayer/attendant.
- Is a floating focal point necessary?
- Does the focal point require pretensioned back-ties or front-ties?
- Focal point prevents extension of an anchor point in a load-sharing anchor system.

What anchor points should be used?

- Pad anchor points with sharp edges.
- Evaluate the integrity of the anchor points being utilized.
- Anchor point should not be hot to the touch or expose the rope to Haz-Mat.
- Seek system-wide redundancy, which can require use of more than one anchor point.
  Avoid overreliance on a single feature or placement of one piece of artificial protection

(e.g. bolt or camming device).

- Attach at the base of an "anchor point" to prevent a leverage situation.

What directionals are available if needed?

- A directional may be needed for the use of certain anchor points.

- Is an artificial high directional needed at the edge?
- Rig the focal point high to take advantage of any natural high directional (e.g. stair-stepped edge) and allow for more efficient edge management with a litter.

EARNEST'R- RESCUE ANCHOR ACRONYM

Rescue anchor system construction requires addressing a few important considerations. Rigging for Rescue modified a similar acronym over to EARNEST'R.

E - Equalized– Anchor systems should be constructed so that each anchor point carries an equal amount of the load.

A- Angle/Alignment

R - Redundant– Anchor systems should consist of multiple components in case one or more components fail.

NE - No Extension– Anchors should be built so that if one or more of the components fail the remaining components won't be shock loaded S - Strong (or Solid)– Select anchor points that are capable of holding the load.

T - Timely– Anchor systems should be as timely

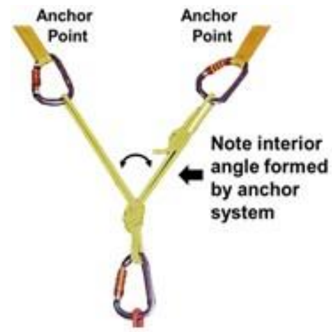
as possible without giving up any of the other qualities.

R – Rigid– When possible, slack is removed from the anchor system through pre-tensioning.

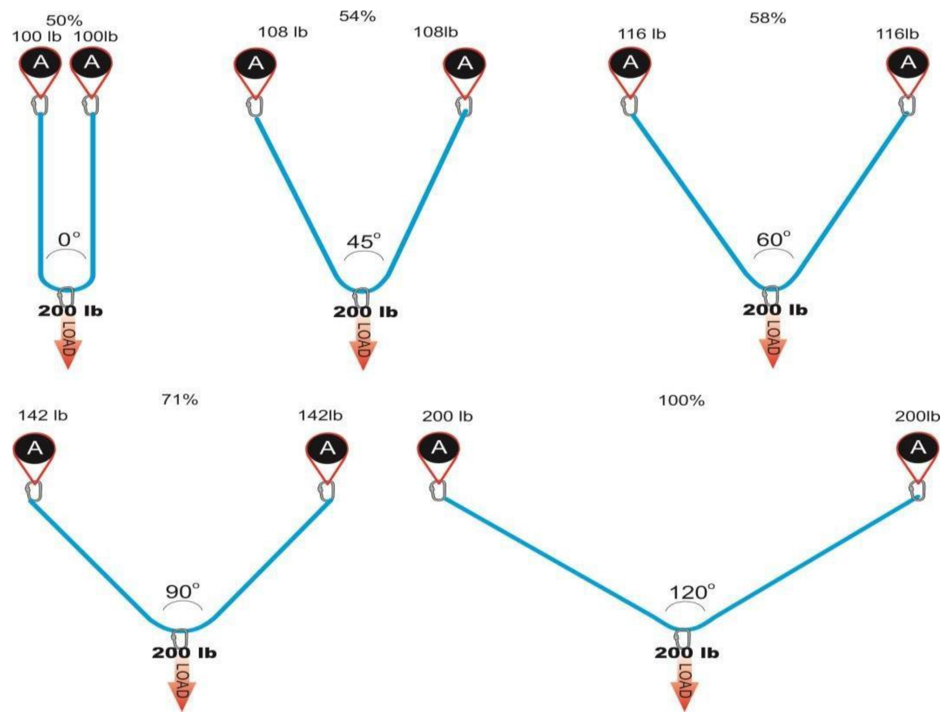
LOCATING ANCHOR FOCAL POINTS

During the initial size-up of a rescue incident, determine the focal point locations for both rope systems (main and belay lines). Using mental projection to predict how ropes lines will run when they are set up assists in avoiding a rigging nightmare. Take a moment to carefully strategize at the outset, which will pay off in the long run in not having to de-rig later because of a poor selection. The focal points should be situated far from the edge to allow for construction of a haul system (if required), which does not place the haul team inside the hazard zone. A constricted location at the top of a cliff can be employed with the use of a change of direction that still permits the focal points to have some distance from the edge. Ultimately, both focal points need to be situated outside the hazard zone. There are advantages to having the focal points of both ropes side by side. Communication between the two rope systems is far better and each rope operator can more easily monitor what the other rope system is doing. On-the-job detection and correction of technique is far better.

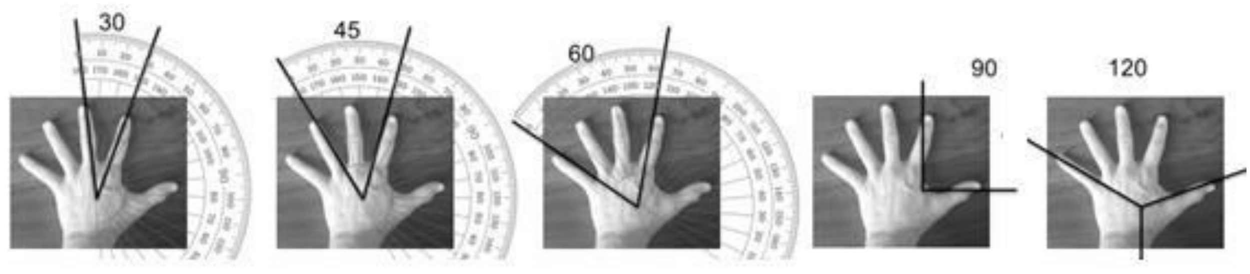
CRITICAL ANGLE IN ANCHOR SYSTEMS



The connection of two or more anchor points and a load is placed upon it forms a critical angle. This interior angle can act as a force multiplier. As the angle increases, the force directed along each anchor leg is increased. At 120°, the force on each anchor leg is equal to the load. Beyond this point, such as a tensioned highline system, the force applied to each leg of the anchor rapidly increases.



ROUGH ESTIMATE OF ANGLES



Anchor Forces 200 Lb Load

Angle	% of Load at Anchor	Actual Load at Anchor
0°	50	100
60°	58	115
90°	71	141
120°	100	200
150°	193	386

One-Inch Webbing Anchors: Minimum Breaking Strength of Common Configurations

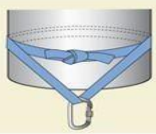
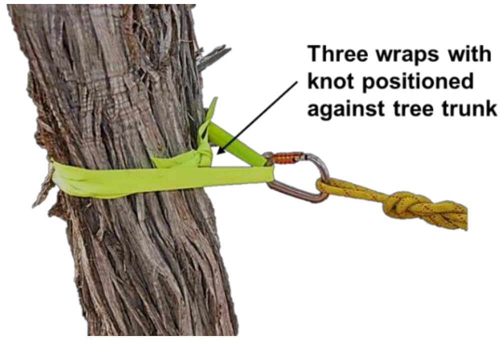
		Tubular Web lbf (kN)	Flat Web lbf (kN)
Web Strength		4,340 (19.31)	6,000 (26.00)
Girth Hitch		4,799 (21.35)	8,776 (39.04)
Single Loop (90° Internal Angle)		4,832 (21.50)	6,130 (27.27)
Wrap 2, Pull 1 (90° Internal Angle)		5,510 (24.51)	8,098 (36.02)
Redundant Double Loop (90° Internal Angle)		7,777 (34.59)	10,786 (47.98)
Wrap 3, Pull 2 (90° Internal Angle)		7,899 (35.14)	10,507 (46.74)
Basket (90° Internal Angle)		8,464 (37.65)	12,989 (57.78)
Double Loop (90° Internal Angle)		8,716 (38.77)	10,538 (46.88)
Redundant Wrap 2, Pull 1 (90° Internal Angle)		9,700 (43.15)	11,458 (50.97)

Figure 8-7: MBS of Common Configurations

Wrap 3 Pull 2 (7,899 lbs)



Provides Friction around the object so, it may stay when tensioned or unweighted.
Probably the best anchor if you expect movement from the carabiner as in a change of direction, because the carabiner is free to slide on the nylon and the friction will help keep the anchor webbing in its place.

Drawbacks: Takes a little longer to build.

Reminder – the TSO is expecting that the knot will be facing the load!!

3-**Bight aka Basket (8,464 lbs)**

Fast.
Pretty Strong.

Drawbacks: Not the best for directional or change of directions as the carabiner is unable to slide so the webbing may rub against the object as it pendulums from being loaded, relaxed, loaded etc…

Reminder - Subject to tri-loading if not out far enough, even at 90 Degrees.

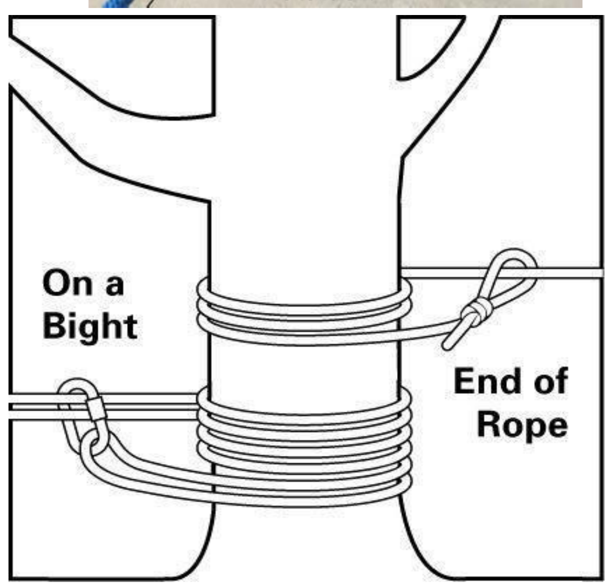
Double Loop aka Wrap 2 Pull 2(8,716 lbs)

Strongest of the three. Pretty Quick to tie.
A pretty good knot if you expect movement from the carabiner as in a change of direction because, the carabiner is free to slide on the nylon.

Drawbacks: Provides no friction around the object so, it will most likely slide down when unweighted. Not ideal.

HIGH STRENGTH TIE-OFF:

The high strength tie-off, which is also referred to as a Tensionless Hitch, is a method of attaching a line to an anchor point, which provides for most of the original rope strength to still be available. The end of the line is wrapped at least three times around the anchor point and then finally attached back to the main line at a 90° angle. The number of wraps is dependent upon the anchor point and the amount of friction provided by the surface. Canvas wrapped around a tree trunk can be used to protect the bark from damage and the line can be protected in this manner from sap on the tree. This was formerly referred to as a tensionless anchor.



CMC Anchor Strap

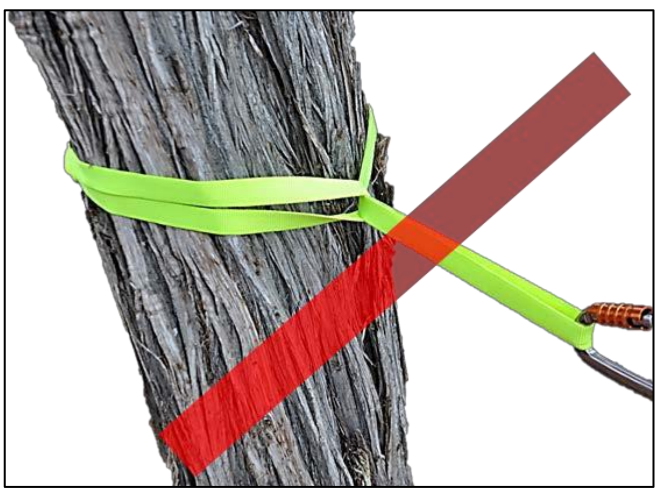
Basket (U) Configuration: 85 kN (19,108 lbf)

Reminder - Subject to tri-loading if not out far enough, even at 90 Degrees.

End-to-End Configuration: 46 kN (10,341 lbf)

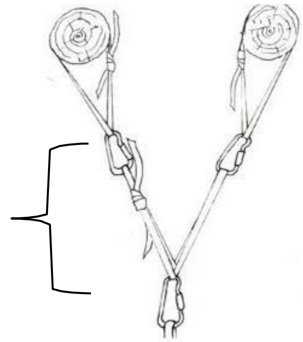
Choker Configuration: 48 kN (10,790 lbf)

It is recommended that a Girth Hitch or a tied single loop of webbing be avoided as an attachment to an anchor point, due to the significantly weaker rated strength

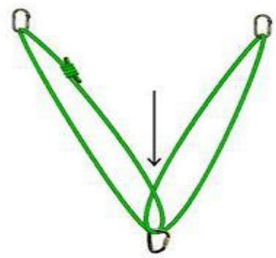


LOAD DISTRIBUTING ANCHOR

Load distributing anchor systems are designed to tie two or more anchors together to distribute the weight of the load evenly between the anchors. If there is a shift in direction of the load, or a failure of one of the anchor points, the load will be redistributed among the remaining anchor points.



Load distributing anchor systems must be tied in a manner that keeps the actual "load distributing" system itself, small in size. This is accomplished by extending from each anchor point to the small load distributing system (green webbing). If a leg were to fail, the load will drop the length of the slack in the collapsed leg creating a large dynamic force that will impact the remaining anchor points. By keeping the size of the load distributing portion as small as possible you can minimize the impact caused by the collapsed leg. Keep all interior angles in a load distributing system less than 90 degrees.



A twist MUST be made for the carabiner to be clipped through. If a leg were to fail, the carabiner would remain captured in the loop.




LOAD SHARING ANCHOR

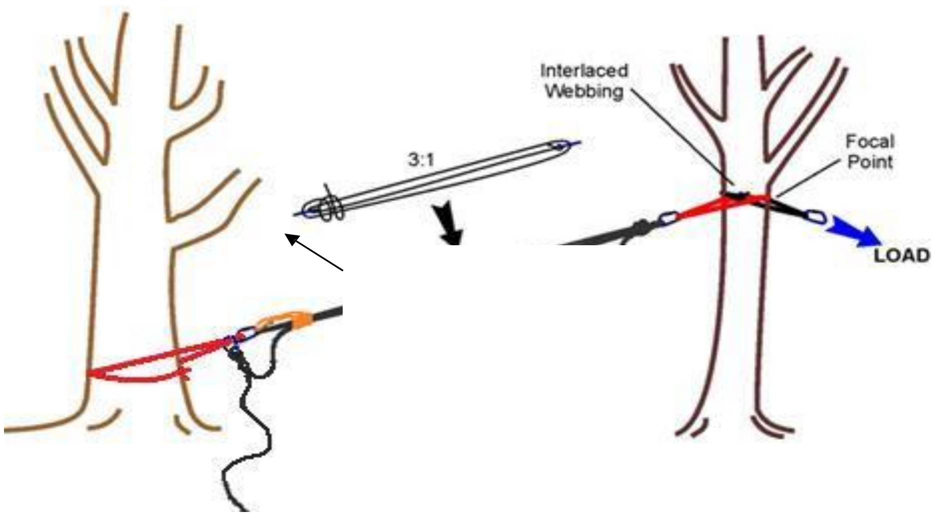
Load sharing anchor systems are designed to tie two or more anchors together to distribute the weight of the load between the anchors. Due to the nature of how load sharing anchors are rigged, the load will only be equalized when the load remains inline with the shared anchors. Any shift in the direction that the load applies to the anchors can result in the entire weight of the load shifting to one of the anchors only.

A load sharing anchor system distributes the load between two or more anchor points, but not precisely evenly. The key distinction from a load-distributing anchor is that the <u>legs of the anchor system are a fixed length</u> and will not adjust once rigged. This distinction makes it a superior technique for rigging rescue anchor systems, because it provides for no extension of the focal point in the event one leg (single point) fails, thereby reducing the potential for a shock force to be generated within the anchor system.

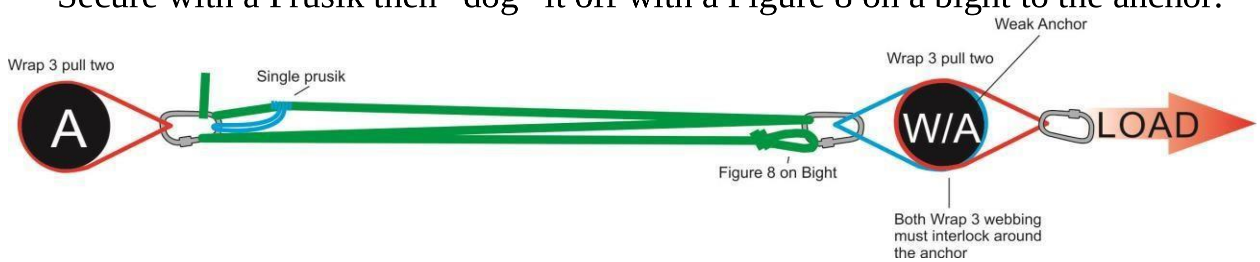
The load-sharing anchor system or "cordelette" is easily constructed with a ten meter (33 feet) length of 8 mm cord. It may also be constructed with nylon webbing. Once all anchor points are clipped in and the load is distributed evenly, the middle of the load-sharing anchor is tied off with a Figure Eight Knot or Overhand Knot.

PRETENSIONED BACK-TIE

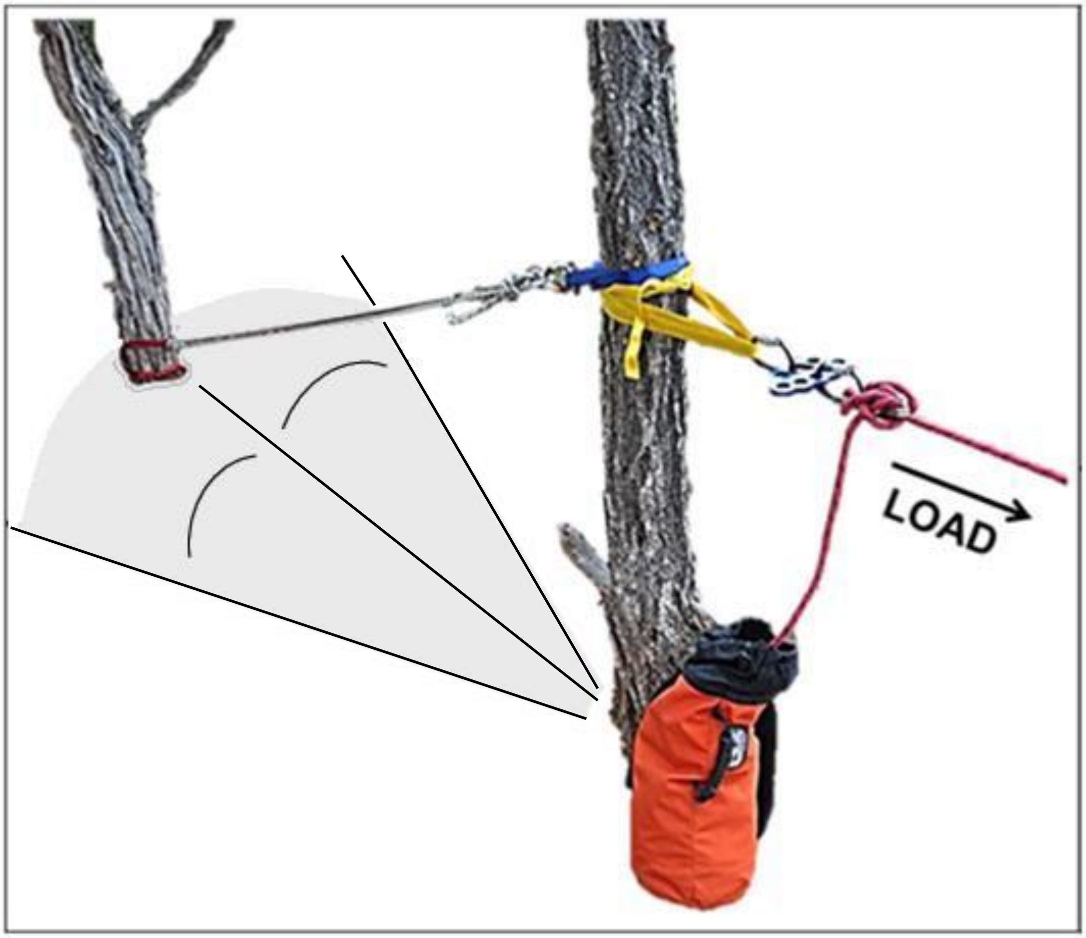
The purpose of a pretensioned back-tie, constructed to back up an anchor point, serves to prevent movement in the main anchor and provide for redundancy in the anchor system. The webbing wraps of the focal point need to be interwoven with at least one wrap of the webbing connecting to the back-tie connection in order to have integrity with the back-tie anchor point. If the objective is to create a solid rigid link between the focal point and the rear anchor point, then a three stranded back-tie is used. When properly tensioned it creates a 3:1 mechanical advantage system between the front and rear anchor points using carabiners instead of pulleys. If the line is constructed with one end starting at the rear anchor, then the tie will be finished at the front anchor leaving the remaining line to be flaked nearby and available for the edge if needed.

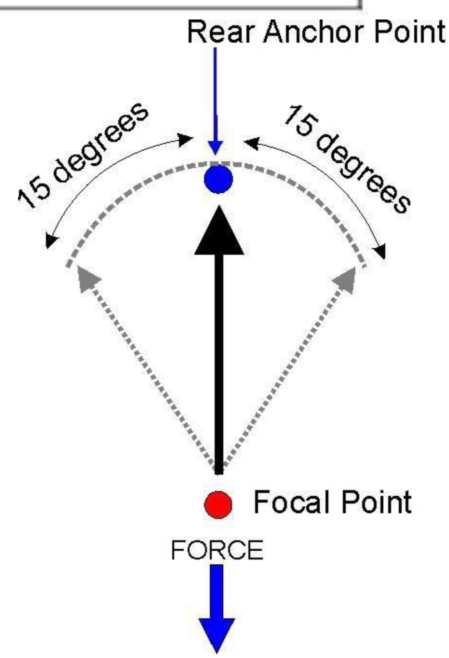


Secure with a Prusik then "dog" it off with a Figure 8 on a bight to the anchor.



To tension the back-tie the 3:1 hauling system is pulled tight by at least two people. After the bundle of strands is sufficiently tight, push sideways on the rigging to "vector" it for additional tensioning in order to get any remaining stretch out of the rope. Finish with a prusik to lock it off then, "dogged" to the anchor. A variation eliminates the prusik, if not available, with two half hitches.

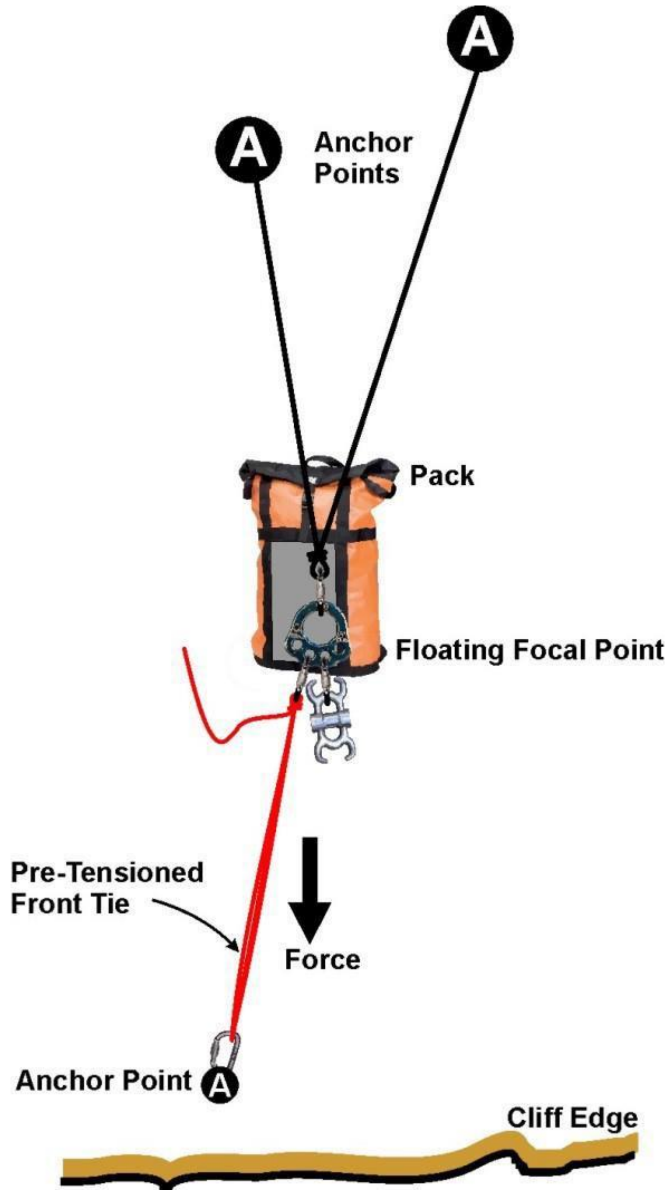




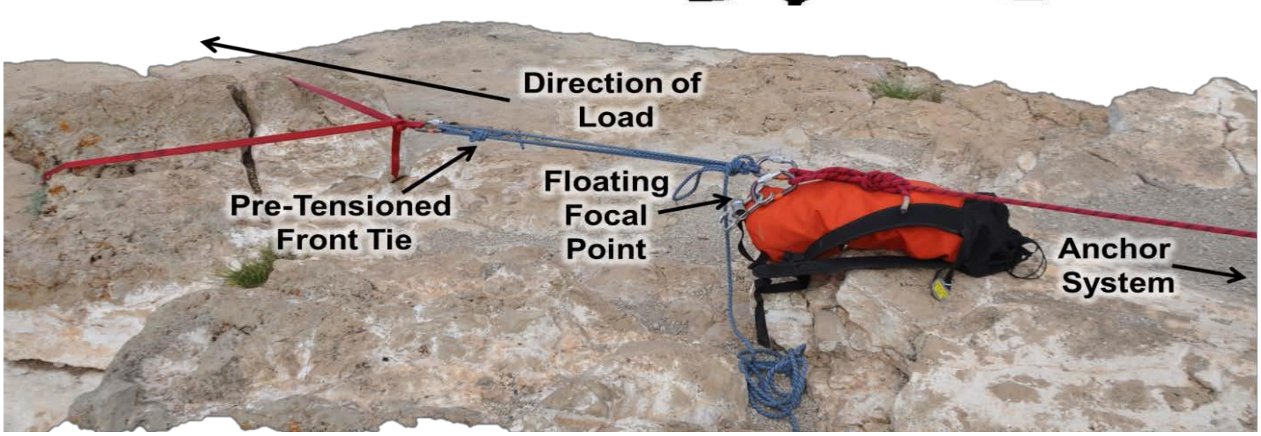
The alignment of the front and rear anchor points need to be within 15° either side of in-line to the fall line (30° total width) If the angle of offset is greater than 15° out of alignment, then employ two pretensioned back- ties to balance the offset forces. This creates a separate back-tie on either side of the horizontal alignment line.

Two pretensioned back-ties can be constructed with a single rope if the distances are not too great, by starting at the focal point and splitting the rope to use half the line rearward on each back-tie.

PRE-TENSIONED - **FRONT TIE**



A pre-tensioned front tie is employed when anchor points have been extended a significant distance to a focal point, where substantial slack can be generated when the anchor system is not tensioned. To "pre- tension" and remove the slack from the system, a front tie is constructed that is simply strong enough to apply tension to the focal point. This is not a life safety load and a much weaker anchor point and smaller cordage can accomplish this task if required. The front tie tends to pull the focal point down into the dirt at ground level, which is a poor location to manage a rescue load. Placing an object, such a pack, under the focal point allows it to float and creates a much better working environment for rescuers.



NATURAL ANCHORS

Natural anchors include trees and boulders, referred o as “BFT” and “BFR” (Big friendly trees and rocks). Make certain to pad sharp edges and protect ropes from sap with canvas. When considering the use of a single anchor point evaluate it for the potential to fail. Question strength and integrity of boulders lying on slabs or partially buried in soil. Many trees appear sturdy, but in reality, have shallow root systems.

Below is the result of research performed by PNW local SAR, John Morton and presented to international technical rescue symposium. According to Mr. Morton’s paper the acceptable diameter could range from 6”-10”. To keep it simple, let’s say that tree anchor – Main, Belay or, Directional must be at least 10” in diameter, about the size of your helmet.

CAUTION: CONSIDER WIND AND SNOW LOADING, SOIL, HEALTH OF TREE AND ROOT SYSTEM.

Trees smaller than helmet-sized (28 in circumference) may be used as rescue anchors by following these criteria.

If in doubt about anchor integrity, use other material or back up anchors as appropriate.

- ☑ Tree is living & structurally sound
- ☑ Tree has vertical trunk, including base
- ☑ Rooted in normal soil (not sand or gravel), without voids
- ☑ Tree has symmetrical base at ground level

Measure circumference around tree @ 2 ft above ground (incl for

Ratings based on ANCHOR @ 2 ft and HIGH-D @ 7 ft

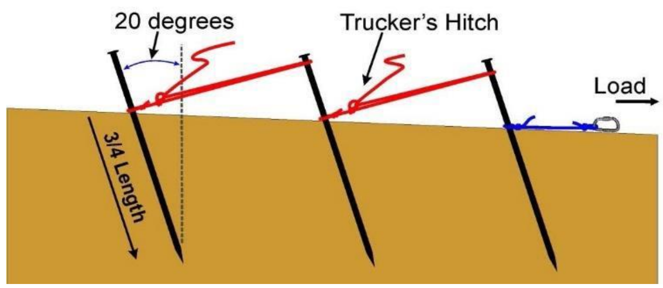
Wind rating data applies *[location description defining region familiar to rescue team].*

Applies from Mmm-20xx through Mmm-20xx

Identify tree species, or use largest Circumference	Minimum Circumference for ANCHOR	Approx Dia. for ANCHOR	Minimum Circumference for HIGH-D	Approx Dia. for HIGH-D
W.Red_Cedar or UNKNOWN species	>24in	8	>32in	10
Ponderosa_Pine	>24in		>30in	
Bigleaf_Maple	>23in		>30in	
W.Hemlock	>23in		>29in	
Engelmann_Spruce	>22in		>28in	
Red_Alder	>22in		>28in	
Smooth_Hickory	>21in		>27in	
Water_Oak	>21in		>26in	
Loblolly_Pine	>21in		>26in	
Douglas_Fir	>20in		>26in	
Quake_Aspen	>18in		>22in	
White_Ash	>18in		>22in	

PICKETS

Pickets are utilized in soil where no rocks or other natural anchors are available. Although very dependable, a picket system is only as strong as the soil conditions allow. In light, dry soils it may pull out very easily and not support a rescue load, while an anchor rigged in heavy, dense soil may have a large safety factor for a normal rescue load. Soil moisture content and compactness will affect the holding power. An understanding the existing soil conditions is essential to achieving a safe working load when utilizing picket systems. Pickets must employ quality steel stakes as opposed to steel rebar which can bend. Ideal material is 1 in diameter rolled steel pointed at one end. Utilize eye protection and gloves when pounding steel stakes. Minimum length of 3-foot metal stake with 3/4 of the length driven into the ground. Common configuration is three pickets oriented in a straight line away from the direction of the load. Each picket is spaced one picket length away from the other. Pickets should be driven into the ground at a 20° angle away from the load. Lash top of front picket to the base of rear picket. Tension picket cordage using a Trucker's Hitch or a Spanish Windlass. Spanish Windlass is constructed by placing a smaller stake between the multiple strands of connecting cordage and twisting to create tension. The smaller stake is then driven in the ground to secure it.



Picket anchor system constructed with a set of SMC Rescue StayK.

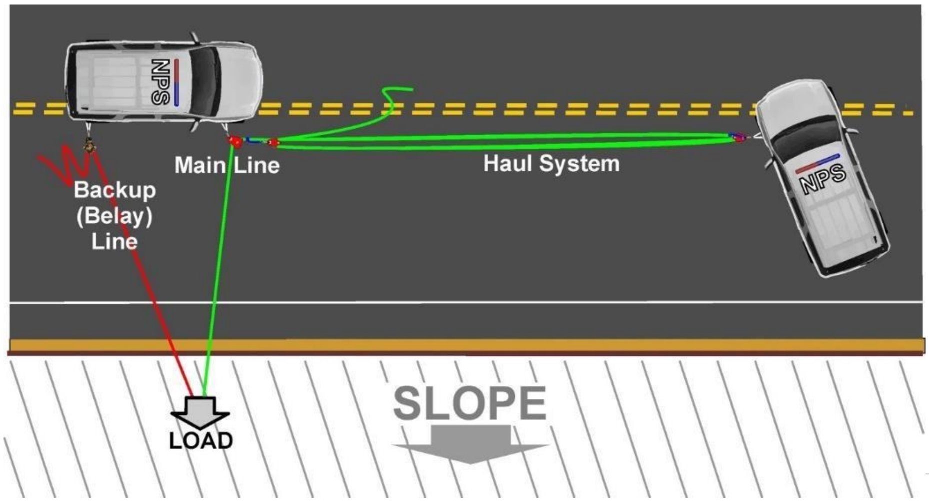
VEHICLE ANCHORS

Vehicles can be utilized very effectively as anchor points. They can be placed in a position that is advantageous to the rescue rigging at a scene. Depending upon the size of the vehicle or application, rigging may be performed at the end of the vehicle (long axis) or to the side (short axis). Consider that the weight of the vehicle being utilized in relation to the surface it is sitting upon must provide sufficient friction to prevent the vehicle from sliding once a rescue load is applied. The frame and axle provide the most reliable points for connection points. Some considerations include keeping ropes away from hot (exhaust) or greasy parts. When rigging to wheels, avoid entangling nearby brake lines. Check the mounting bolts and connection points of hooks or brackets to ensure tightness and a lack of unsafe corrosion.

Some examples of vehicle anchor points. L to R. Open hook which requires constant tension to prevent detachment, welded bracket with connection point and attachment directly to a wheel rim (avoiding brake lines) at a right angle.

Example of vehicles positioned for rigging placement as anchors in a slope rescue.

When employing vehicles as anchors, set the brake and chock the wheels, particularly when the direction of pull will be in the long axis. To prevent accidental movement of the vehicle by an operator, remove and secure the vehicle ignition keys.



DIRECTIONALS

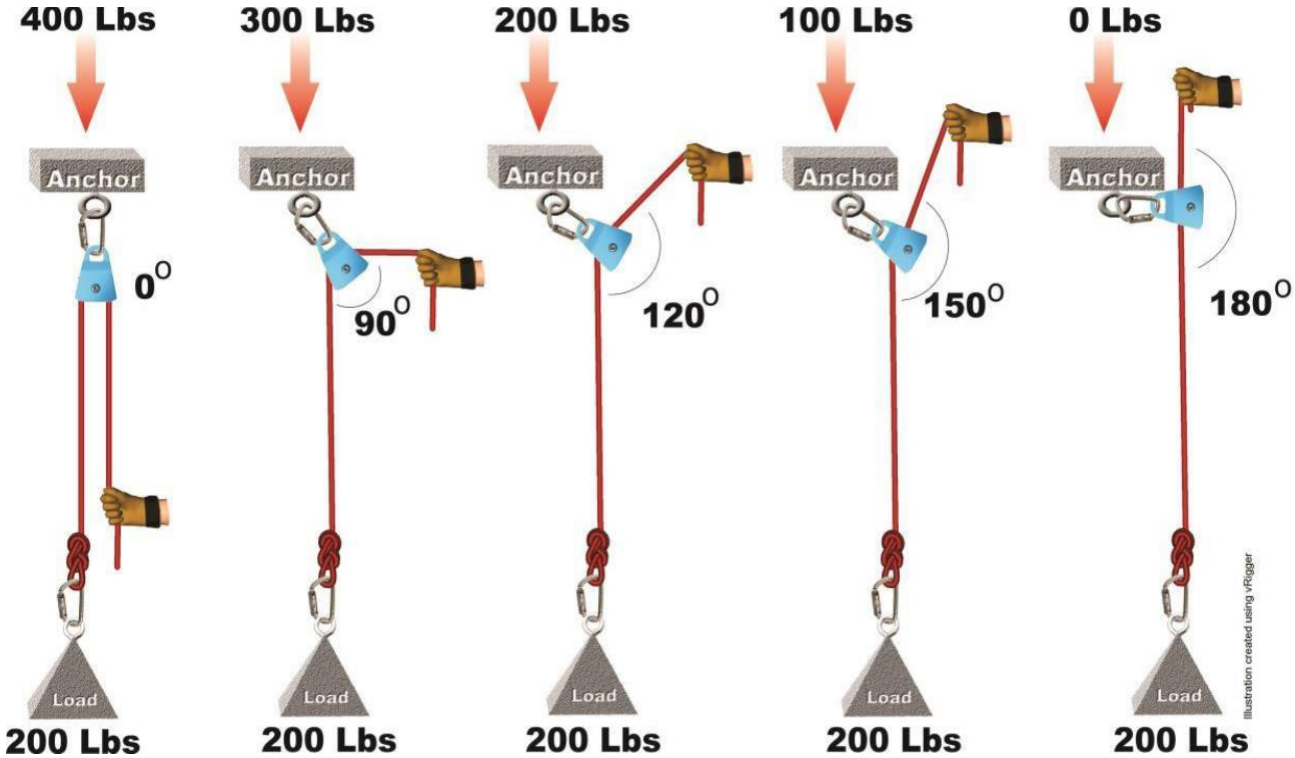
Forces placed on change of direction pulleys or directional pulleys often compound the force on the pulley and its associated anchor or anchor system. This force is usually greater than we would expect on the basis of the weight of the load. The force on the pulley is a function of the interior angle of the lines feeding into and out of the pulley.

A directional provides a means of redirecting the path of a rope under tension. This may be necessary to avoid contact with vegetation or a large rock, as well as providing better alignment at a cliff edge.

A pulley rigged on a fixed tether to a separate anchor point does not permit adjustment if the distance has been improperly estimated.

Constructing a directional with a tether that is adjustable by means of a jigger or adjustable hitch allows greater flexibility permitting the pulley to be placed in the proper point of alignment. Both the main and belay can be directed for alignment with a double-sheave directional pulley.

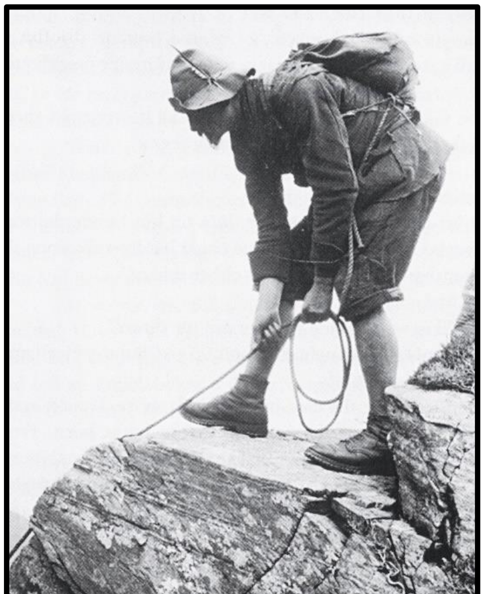
DIRECTIONALS AND CRITICAL ANGLES



Change of Direction Anchor Forces 200 Lb Load

Angle	% of Load at Anchor	Actual Load at Anchor
0°	200	400
90°	141	282
120°	100	200
150°	52	104
180°	0	0

BELAYING TECHNIQUES



The term "belay" is derived from the old English word "belecgan". The original meaning is to surround an object with things. Later, surrounding an object with things became a way to secure them. The earliest surviving sense of the word is from the Dutch "beleggen", used in the early 1500's, is the nautical one of "to coil a rope around a cleat or pin to secure it".

Per the WAC and NFPA, in rescue work a separate belay line is employed when ascending or descending. There are limited exceptions that may dictate deviation from the use of a separate belay line. Rescuers need to practice good sound judgment in deciding what is warranted.

Single rope technique (SRT) means the rope completely supports the load and there is not a separate rope as a belay. In rope rescue, the standard practice is to employ a separate belay for safety. That being understood, there are a few situations where single rope technique may be employed. These include a solo rescuer taking immediate action to reach a stranded subject in danger, rescue team travelling past a slot canyon or pour-off that requires rappelling and pulling the rope, and helicopter hoist or short-haul operations. SRT is commonly predicated by the likelihood and consequences of a mainline failure.

BELAY TERMINOLOGY

Independent Belay-In two rope systems, it is a separate rope managed by someone other than the attendant.

Self-Belay Protection provided by the rescuer themselves moving their connection point along a fixed rope. (e.g. Prusik or autoblock).

Conditional Belay- Fall protection is provided through the use of a rope, that is already under tension from part or all of the load, to hold the load should failure occur in some other part of the system (e.g. mirrored rope system, bottom belay on rappel).

Auto Belay- A positive auto locking device (deadman) that does not require a positive action to engage it (e.g. Tandem Prusik Belay)
-*adapted from Belay Definitions, originally prepared by Arnör Larson, Rigging For Rescue.*

Currently the most consistently reliable techniques for belaying a rescue load are;
540°™ Rescue Belay
Tandem Prusik Belay Technique

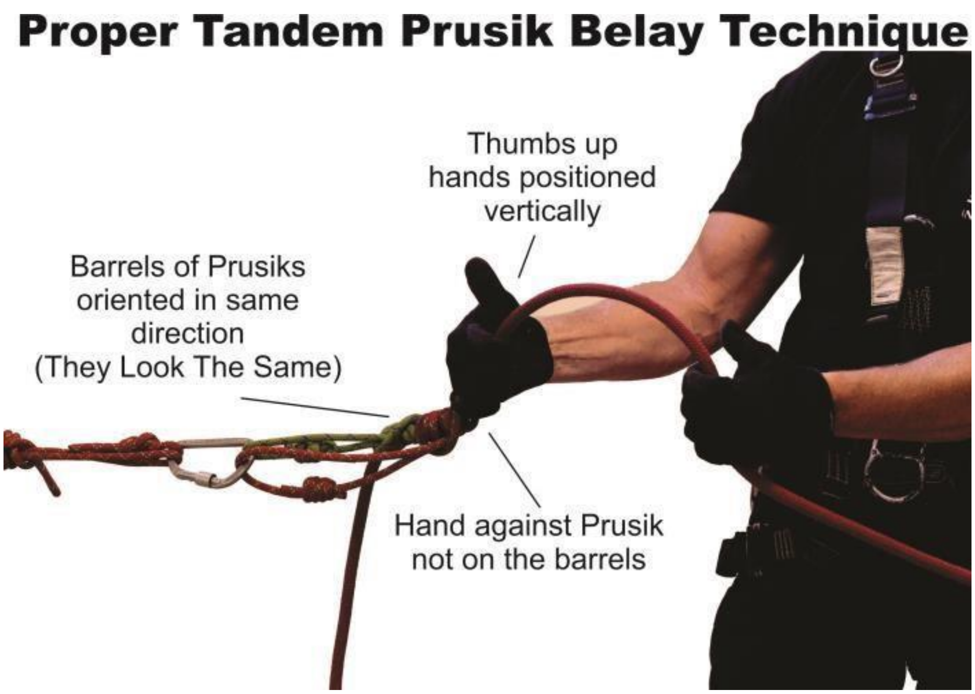
TANDEM PRUSIK BELAY

The Tandem Prusik Belay was developed as a field practical alternative in order to provide a reliable rescue load belay technique. During the tests, the Prusik Hitches typically "settled in" with a slipping clutch effect and glazed the host rope. If they did slip, they melted slightly before holding the fall, but left the belay line intact. This technique utilizes two triple-wrapped Prusik Hitches attached between the belay anchor and the belay rope.

The short Prusik of the pair will typically be the first one to catch and the longer one is available for redundancy in addition to providing better heat dissipation in the event of a sudden shock force being applied. The Tandem Prusik Belay consistently held falls of one meter on three meters of rope without damage to the main line and almost no damage to the prusik.

Prusik Hitches need to be monitored throughout an operation and requires constant attention by the belayer to keep the Prusiks snug but free-running. A mini 4:1 unit must be present at the "MAIN LINE" station as the tool of choice to resolve a stuck set of Prusiks on the belay line.

Another important note is that we no longer utilize a prusik minding pulley to belay a package up. It was an item of convenience. It was observed to have led to complacency in the belayer leading to several near miss situations.



On a lowering, the belayer should hold both hitches BEHIND one hand and pull out some slack in the belay rope with the other hand as they attempt to "feel the load". As the load takes the slack, the back hand remains perpendicular and stationary. The other hand rotates and slides back to pull another bight of slack. The Prusiks should be held (with fingers open in event belay activation) perpendicular to the plane of the belay line, which provides greater chance for the Prusik Hitches to grab, as opposed to an in-line position. The belayer also coordinates their actions through the Edge Manager and slows down the movement if needed.

Considerations for Belay

- Have a plan for releasing tension back onto the Main Line if the belay is activated.
- Have an assistant assigned with you, if able, for rope management and relief.
- Be an ATTENTIVE belayer. Do not leave belay system unattended.
- Do not wrap thumb around belay line when using a Tandem Prusik belay.
- Maintain a twist of the wrist, (S), when belaying with tandem Prusiks to ensure some slack (less than 1 meter), in the belay line.
- Belayer should build their belay system at a height and position so that they can operate it comfortably, efficiently and safely.
- Prusiks are not foolproof. They must be constantly properly tended. Verify they have not become too loose and will work in their intended manner of function.
- NEVER use metal cammed ascenders in any part of a belay system for rescue loads.
- NEVER let go of the rope with either hand. When you need to move your hands, slide them along the rope instead. In the event of main line failure, the belayer lets go.

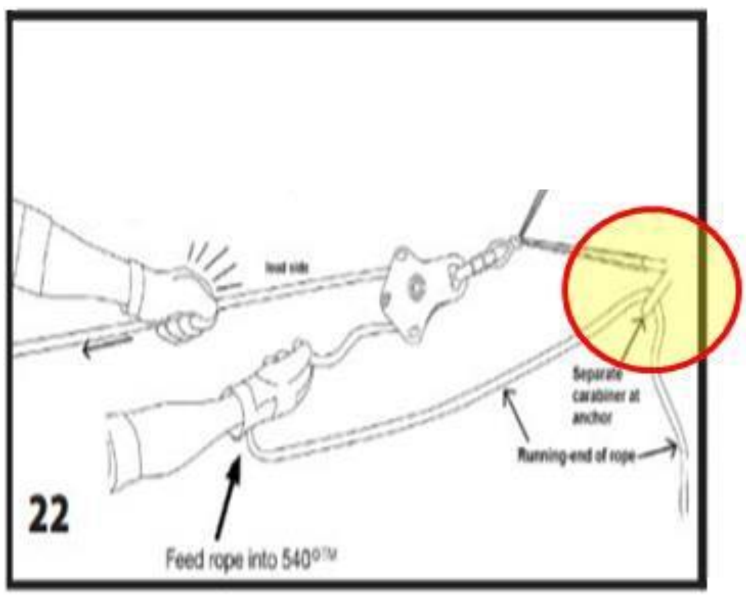
The 540°™ Rescue Belay

To load the 540º ™ Rescue Belay, remove the front plate by depressing the push-pin. Wrap the rope around the obround (defined as form of a flattened cylinder with the sides parallel and the ends hemispherical) pulley one- and- a-half (11/2) times,or 540 degrees Since the 540º is symmetrical and bi-directional in design, the wraps may start
from either side of the pulley. Ensure that the 11/2 wraps are divided by the rope

guide pins, located on each side of the pulley. The device will not work if only half of a wrap is placed over the pulley. Replace the front plate and confirm that the push-pin balls have completely seated correctly in their locked position. Also ensure that both the running end (free or loose end) and standing part (load-side rope) are in-between the two stationary wedges and exiting below the pulley. The keeper cord connecting the front and back plates must be in-between the two ropes exiting the device. Use a locking carabiner to attach the 540º to an anchor system.

Belaying with the 540°™ Rescue Belay

Self-Locking will occur with sudden drops. It is important to understand that a "slow" fall on a supple rope will require resistance being applied to the running end of the rope in order to ensure locking. Self-locking for "slow-falls" can be improved by clipping the running end of the belay rope through a separate carabiner attached to the anchor, behind the 540°™. Do not belay a load using the Release Lever to manage the feed, as this may prevent rope-locking if the load were to suddenly drop. While lowering or raising, feed the rope straight into the 540º™, in order to prevent accidental locking of the device. This is especially important with wet, dirty, muddy, fuzzy or stiff ropes. While lowering with a gloved hand, provide resistance to the standing part (load-side and with the other hand, simultaneously feed the running end of the rope into the device (During a raising, do not attempt to pull the belay line through the device with both hands hauling on the running end opposite of the loaded side. This will only result in a lock-up of the device. While raising, with each hand on separate strands, pull up on the standing part and feed it



into the device, while pulling out the running end with the opposite hand.

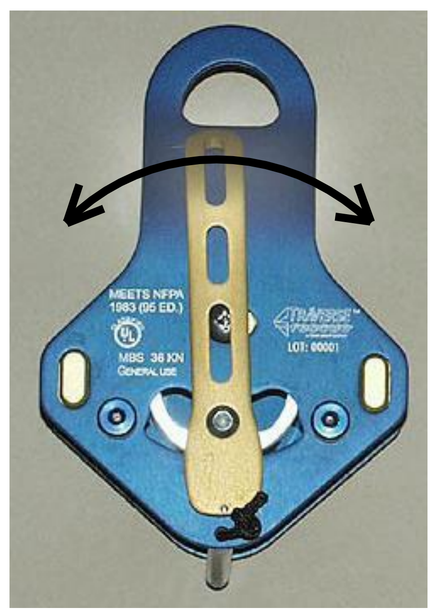
From the product manual, a carabiner must be added on the "brake hand" side to assist with the whistle test during "slow" fall scenarios.

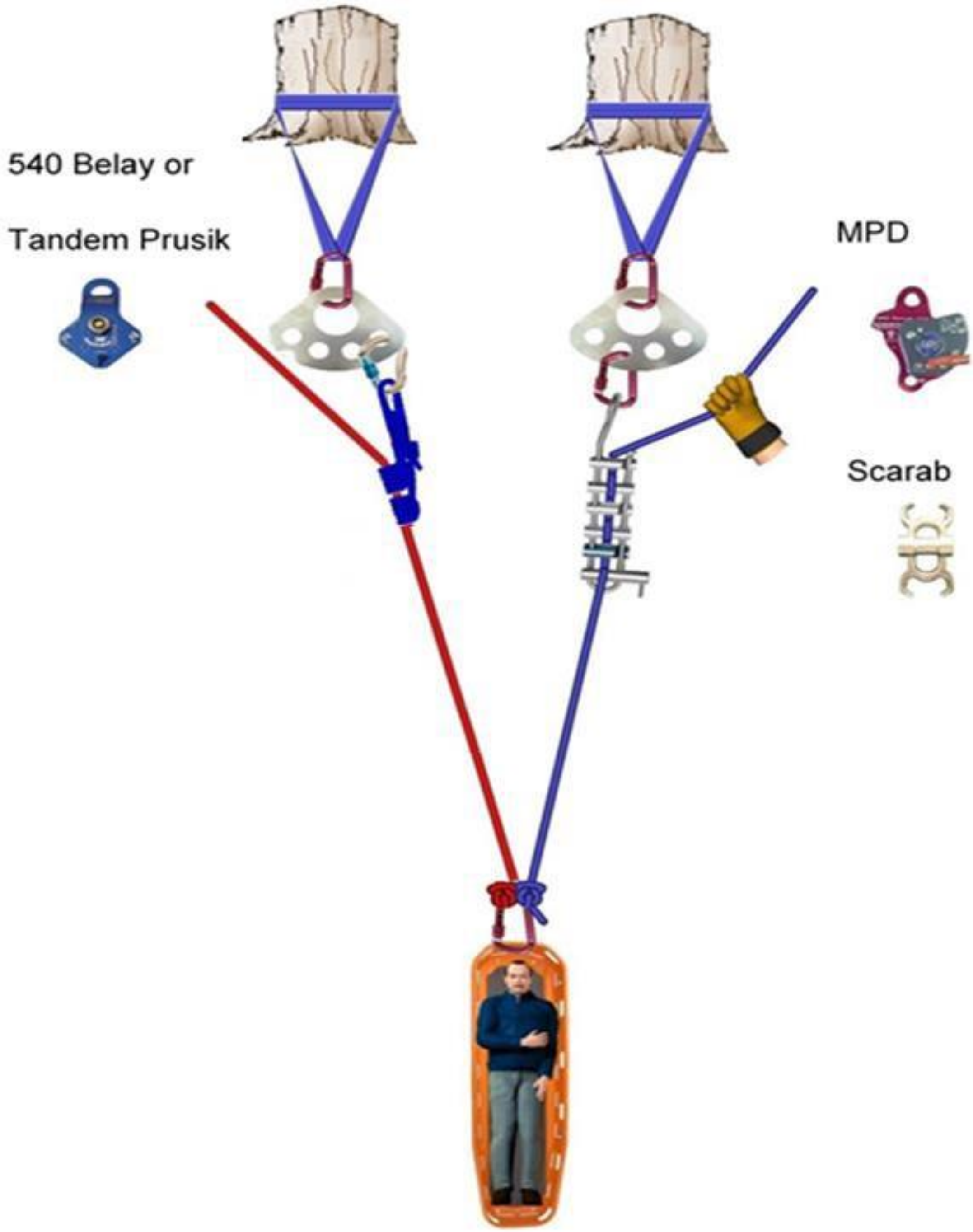
To Lock Off the Belay Manually

In a situation where the belayer needs to manually lock off the 540º™, it is accomplished by firmly holding the running end and with the opposite hand sharply tugging on the standing part. Additional security can be achieved by tying a bight of the running end off around the around the standing part with a Half Hitch and an Overhand Knot. This should be done anytime the device will be left unattended.

Releasing a Locked Belay

If the belay rope is only lightly locked, then a quick reversing of the direction of rope feed can return the pulley to its neutral, or centered position. If this cannot be accomplished, first confirm the main line is locked off. Using the release lever, slowly transfer tension back to the main line. If the 540º catches a rescue-sized load and receives significant shock force, the rope within the device may "stiffen" during fall arrest. Initially releasing the device handle may be more problematic. Traverse Rescue recommends threading a webbing sling through the top of the Release Handle to make pulling easier. Once the load is released remove the webbing.





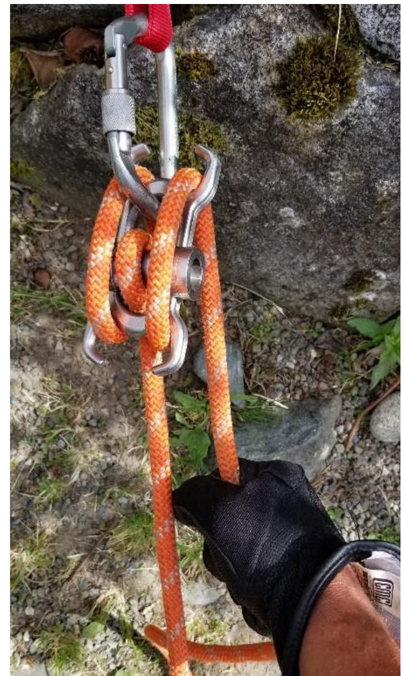
LOWERING

The devices currently “approved” in our Zones for lowering rescue loads are:

- The Scarab.
- The Brake Bar Rack.
- The MPD.

THE SCARAB:

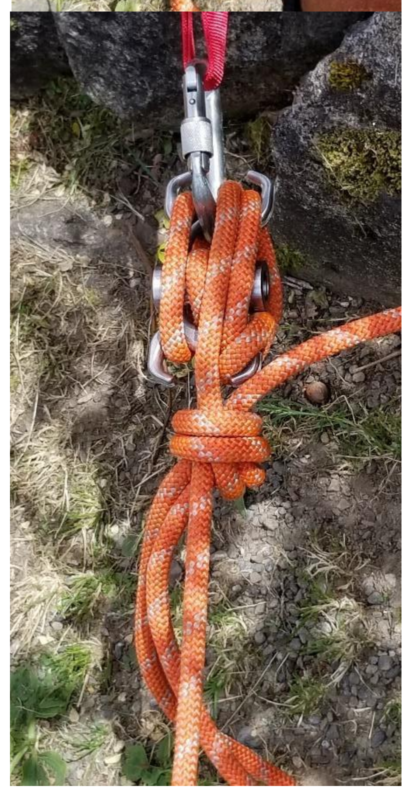
LOWERING



Begin each lowering evolution with all four cleats engaged. Once loaded, cleats may be taken off to facilitate a smooth and controlled operation.

“Main Line ready” is defined as:

- Safety Check is complete.
- All the slack is out of the system.
- All four cleats are engaged.
- Brake hand has control of the rope.
- You are ready to take the load the instant you reply that you are ready.



Soft Tie and Hard Ties are identical to rappelling

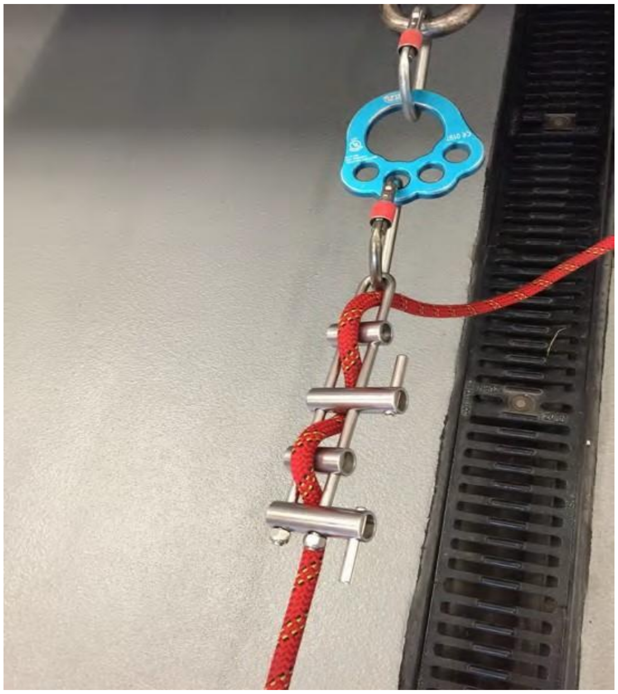
For an extended stop, lock off a Scarab by wrapping all four hyper-horns, then place a bight with a twist over a forward horn. This is a “Soft Lock”.

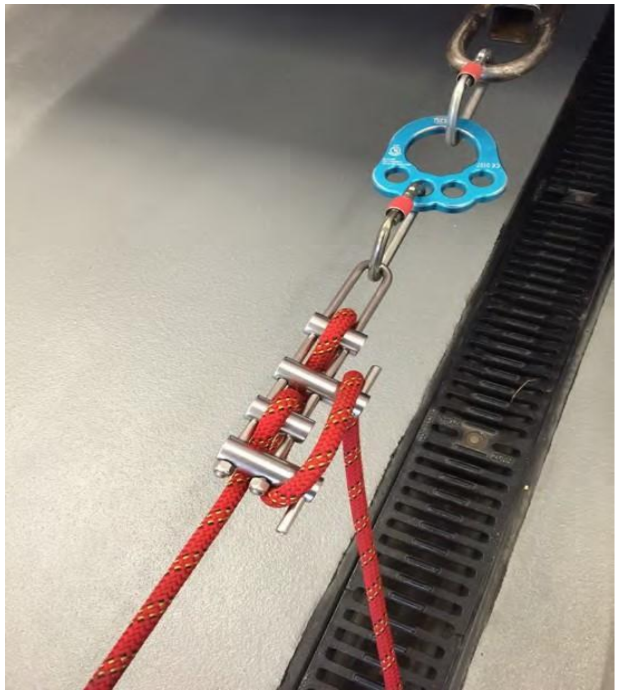
For extending stops or when your attention is focused elsewhere, or the system must be left unattended a “Hard Lock” is required.

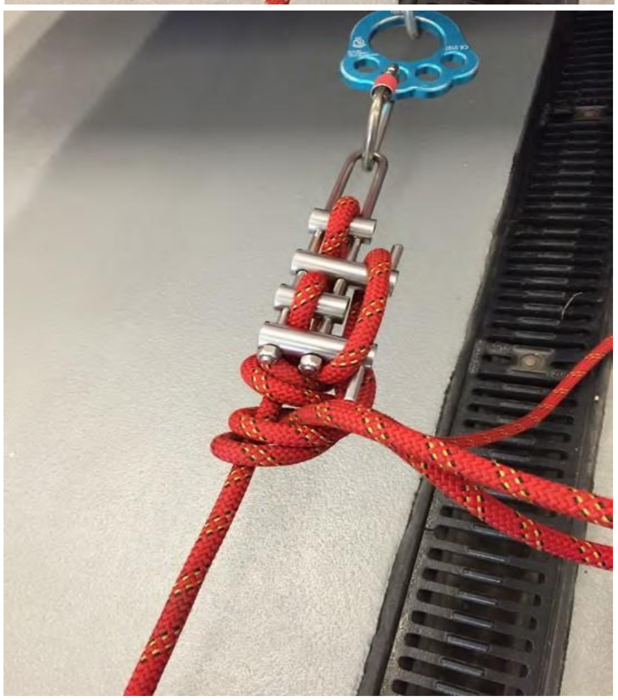
After completing the soft lock continue the rope around the horn and tie an overhand around the main line.

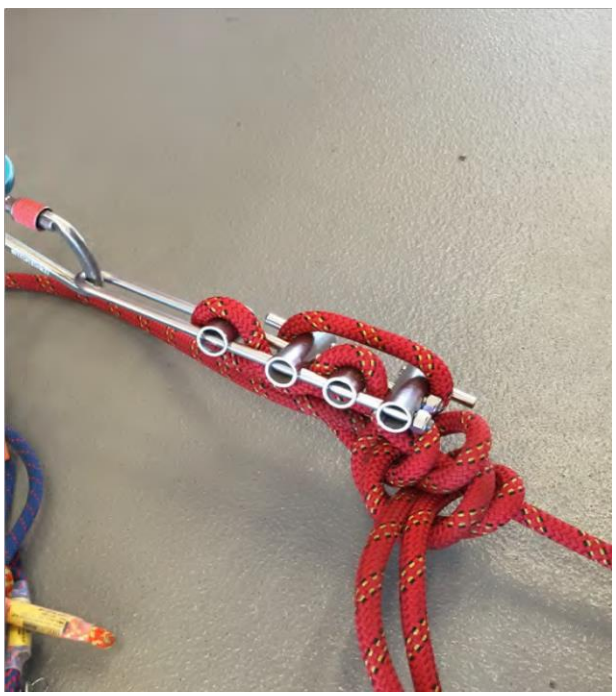
THE BRAKE BAR RACK

The amount of friction can be easily adjusted during use and the device dissipates heat well. Always have a minimum of FOUR - 4 - bars in the system**. Start with all bars incorporated and reduce the number of bars after getting**









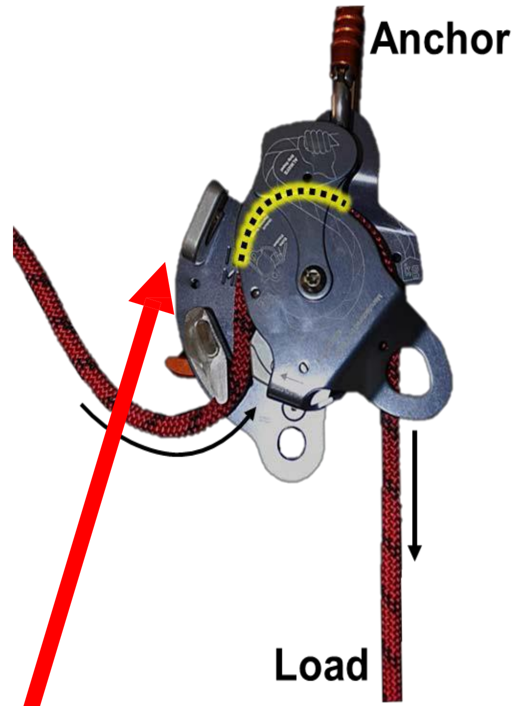
past the edge rope to ensure it activates as intended.

MPD

Prior to any use of the MPD, perform a safety check with the Parking Brake unlocked and tug on the load end of the rope.

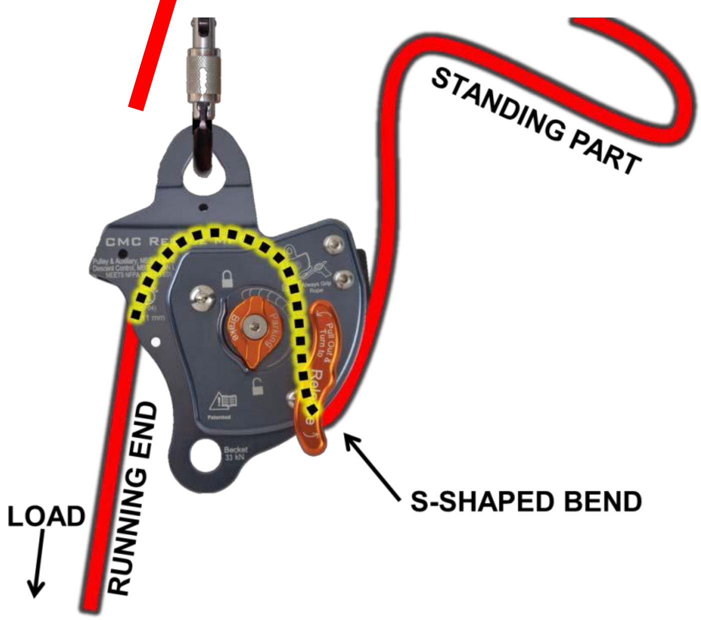
OPERATING THE MPD

Firmly grip the rope tail entering the back side of the MPD and apply friction over the Fixed Brake V-Groove, bringing the running end of the rope back toward the anchor in an S-shaped bend.



The release handle is used to rotate the internal moving brake off the rope, which permits rope movement through the MPD to lower a load or release tension.

The manufacturer specifically advises that the **Release Handle be fully turned counterclockwise in order to completely unseat the moving brake** from rope and control primarily maintained with the friction of the rope applied through the Fixed Brake V-Grove on the back side.

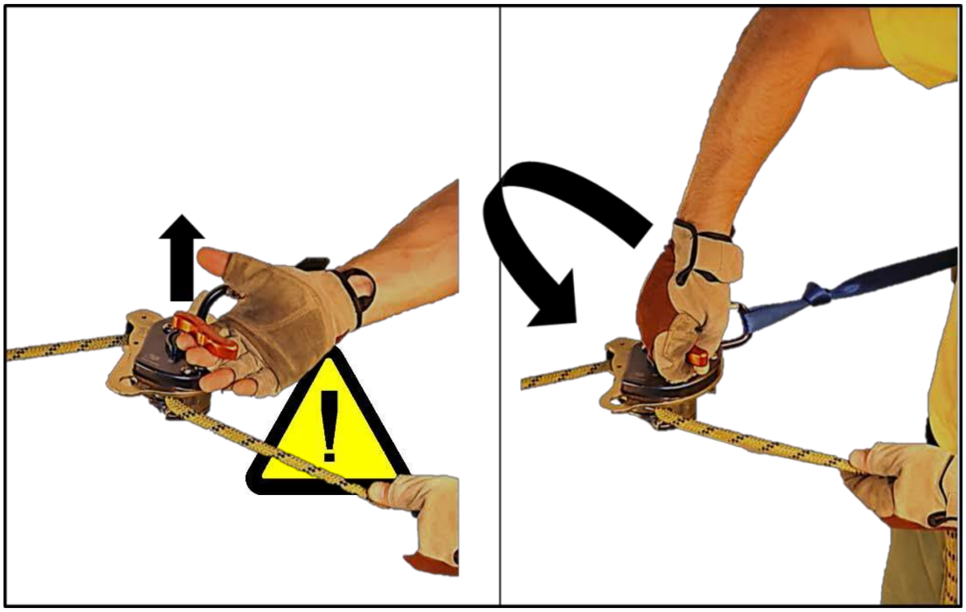


For heavier loads, maximum friction is achieved by using the Secondary Friction Post. To stop lowering and lock the rope in place, disengage the Release Handle.

The lowering speed is controlled by the friction applied to the V- Groove. Initially start with the running end of the rope held back toward the anchor in an aggressive s-shaped bend in order to maximize the range of available friction. Friction is reduced by changing the entry angle of the rope into the MPD and moving it forward.

Activating the Release Handle of the MPD with a lift and turning counterclockwise.

To maintain control during a lowering, always maintain an s- shaped bend in the rope. Do not permit the entry angle of rope feeding into the MPD to be less that 90° to the load end.

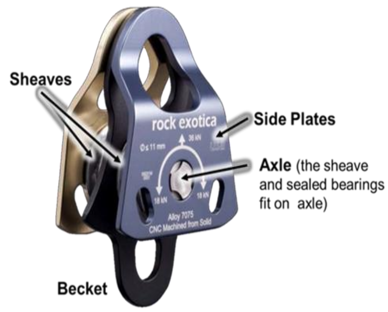


Locking the MPD off

When a loaded MPD is left unattended, secure the device with a tie-off at the device with an overhand knot around the load end of the rope.

MECHANICAL ADVANTAGE AND PULLEY SYSTEMS

PULLEY SYSTEMS



The mechanical advantage of a pulley system is calculated as the ratio of the load in comparison to the amount of force required to move the load. If a pulley system employs a 1 kN force to move a 2kN mass, then the mechanical advantage is calculated as 2:1.

Mechanical advantage is gained at the expense of endurance. Even though less force is required, it must be employed over a greater distance

Pulley efficiency is reduced as a result of friction loss and other factors, such as bending and unbending of the rope. The measure of pulley efficiency is calculated by the output force coming out of a pulley over the input force going into a pulley, which is expressed as a percent. As an example, if a 95N force is required on one side of a pulley to hold a 100N load, then the efficiency of the pulley is calculated to be 95% (95/100). 90- 95% is the typical efficiency of a rescue pulley.

The origin of the pulley system is unknown. It is thought that by 1500 BC, people in Mesopotamia were using rope pulleys. The overall configuration of a pulley has remained unchanged for thousands of years. The first documented use of compound pulleys in the block and tackle system is that of Archimedes

Pulleys are force magnifiers! When the two weighted legs of the rope passing through a pulley are maintained in a parallel configuration, the forces brought to bear on the pulley's point of attachment are doubled! Important for change of direction anchors!

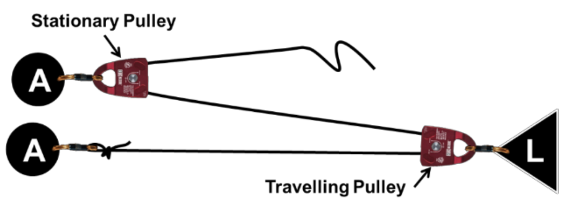
Ideal Mechanical Advantage (IMA)- estimated mechanical advantage without taking into consideration any friction loss in the system. When we refer to a pulley system as 3:1, 5:1, 9:1 and so forth, we are referring to the IMA.

Theoretical Mechanical Advantage (TMA)- refers to the mechanical advantage that has some calculation of efficiency losses, however it not measured.

Actual Mechanical Advantage (AMA)- measured mechanical advantage that will be actually experienced or observed when friction loss is taken into account.

Within a pulley system, travelling pulleys move toward the anchor when the system is being pulled on to move a load. The pulleys which remain fixed and do not move when a pulley system is being pulled upon are known as stationary (standing) pulleys. As a pulley system is employed to move a load it will collapse to the point where one or more travelling pulleys will make contact with a stationary pulley. The pulley system is then re-expanded, through a "reset", to the original size or throw distance, so that hauling may continue.

Simple pulley system. Simple 2:1 MA with change of direction



PULLEY SYSTEM RIGGING:

Prusiks are utilized as haul and ratchet rope connections since they can handle shock forces without catastrophically failing a line.

Do not use a mechanical ascender in a pulley system in place of a haul or ratchet Prusik.

Haul Prusik- the Prusik closest to the load which serves to attach the pulley system to the main line going to the load (e.g. Prusik initially extended to achieve maximum throw distance). This Prusik can also serve as a force governor for the whole system, the canary-in-the-coalmine so to speak. Tests indicate that an 8 mm, 3-wrap Prusik, on a 1/2" rescue rope may begin to slip at between 7 and 9.5 kN (1,575- 2,125 lb.). For this reason, it is wise to task someone with keeping a watchful eye on that Prusik and instruct them to call a halt at the first sign of slippage. Remember: keep an eye on that lead Prusik!

Ratchet Prusik- also referred to as a *progress capture device* (PCD), the ratchet Prusik within a pulley system works in conjunction with a pulley to advance it up a line during movement of a load. A ratchet Prusik holds tension on the line during a reset, preventing it from going backward, so that progress is not lost. A ratchet Prusik used in conjunction with a Prusik minding pulley creates a self-minding ratchet, which will tend itself during operation of the pulley system.

PULLEY SYSTEM CLASSIFICATIONS.

SIMPLE PULLEY SYSTEM

All pulleys on the load side (known as travelling pulleys) move toward the anchor at the same speed. All pulleys at the anchor remain stationary and tension in the rope is constant throughout the pulley system.

In a simple pulley system, when the rope end terminates and is attached at the anchor, then the TMA will result in an even number (e.g. 2:1, 4:1, 6:1, etc.). When the rope end terminates and is attached at the load, then the resulting TMA will be an odd number (e.g. 3:1, 5:1, etc.).

COMPOUND PULLEY SYSTEM

Compound pulley systems are identified as one simple pulley system acting on another simple pulley system. Travelling pulleys in the system move towards the anchor at different speeds. Compound pulleys systems are useful because they can provide greater mechanical advantage than simple systems for the same number of pulleys.

The TMA of a compound pulley system is calculated by multiplying the individual TMA of each simple pulley system together. A simple 2:1 pulling on a simple 3:1, results in a compound pulley system with 6:1TMA.

To achieve the highest MA with the least number of pulleys requires constructing a compounded system of a 2:1 simple pulley system acting on a 2:1 simple pulley system, acting on a 2:1 and so forth. As each pulley is added to such a system, the mechanical advantage increases exponentially (e.g. 2:1, 4:1, 8:1, 16:1, 32:1, etc.).

COMPLEX PULLEY SYSTEM

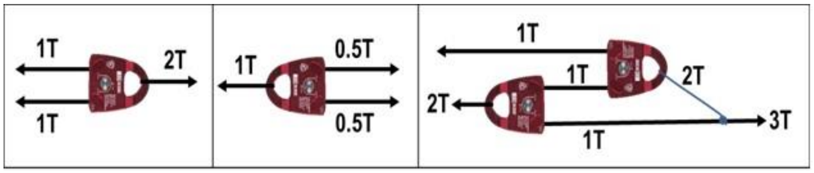
Complex pulley systems do not meet the definition of either a simple or compound system; rather they involve more variables in rigging. Complex pulley systems can have pulleys moving toward the load and the anchor at the same time (Figure 178). With some rare exceptions, complex pulley systems are employed less frequently within rescue. Fortunately, the same objective can be achieved with simple or compound systems which are easier for rescuers to understand and rig.

CALCULATING MECHANICAL ADVANTAGE

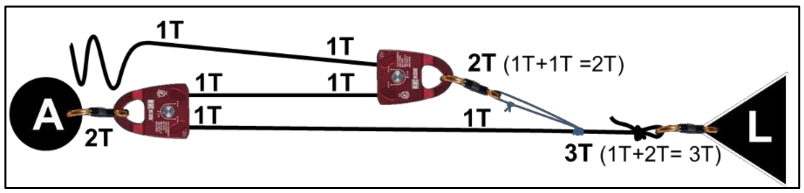
Mechanical advantage in a pulley system is achieved by increasing the number of times an initial input force applied upon the load. The input force is the tension applied by pulling on the system and it is expressed as one unit of tension. Understanding how this one unit is transferred through a pulley system permits calculating the TMA, which is referred to as the "T-Method" (Tension Method).

By assigning one unit of tension (T) to where the pull is applied to the system, then following the path of the rope through the pulley system to the load itself, the TMA can be determined by keeping track of how that initial unit of tension is distributed throughout the system. Simply compare the amount of tension that is applied to the load with the input unit of tension.

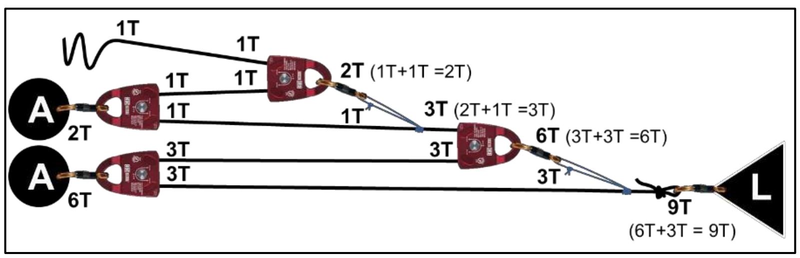
Understand that wherever a junction occurs with the ropes of the pulley system, such as one rope acting on another or one rope acts upon more than one rope, then the tension on one side of the junction must be equal to the tension on the other side of the junction. Additionally, on each side of the junction, the tension must be distributed appropriately (not always equally) to each rope. As an example, if a rope having one unit of tension makes a 180° change of direction through a pulley (considered a junction), then whatever that pulley is connected to receives two units of tension. In other words, two ropes each having a tension of one (two total units of tension) are acting on and opposed by what the pulley is connected to.



T Method Examples



Simple 3:1 Pulley System illustrating T-method



Compound 9:1 Pulley System illustrating T-method

Mechanical Advantage Systems

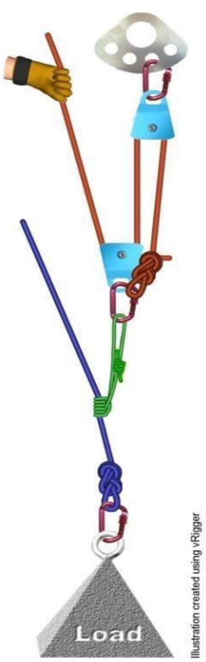
2:1

2:1 MPD

3:1 Simple

3:1 MPD Pulley

3:1 Piggyback

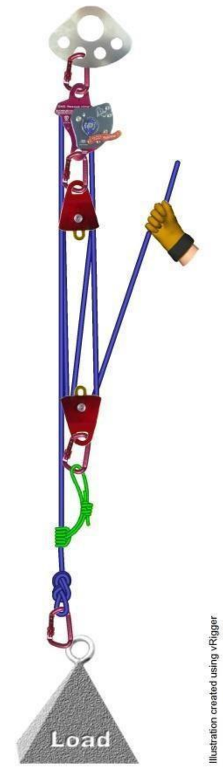


4:1 (Simple) Double Sheave

5:1 Complex

5:1 Complex

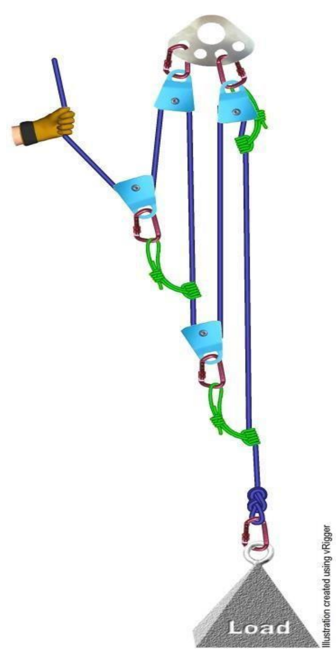
5:1 Complex MPD



5:1 Complex

5:1 MPD

9:1 Compound



HAUL FACTOR

Caution must be used when selecting an MA system, the chance of overloading a system or one of its components are increased as the MA increases.

A rule of thumb to keep forces within our safety factor is to take the number of haul team members times the ratio of the MA system i.e (5 members X 3:1) 5 X 3 = 15.

<u>The goal is to keep the sum of this equation between 12 -18.</u>

This goal is merely a guiding principle that can be adjusted based on environmental conditions, soil traction, haul path obstacles, vegetation, weather or, a slippery rope due to water or mud.

⚠ If you exceed this number, it must be a calculated decision and not an unwitting oversight. It is possible to deliver so much force that the haul team would never feel the rescuers stuck leg explode in an exposed root system.

As a general guideline, the average person can provide 209 Newtons (46 lbs) of gripping ability per hand (combination of grip strength and coefficient of friction of the item being gripped) on a rope. This is useful to know in planning a raising system and determining how many haulers will be needed. By simply rounding off to 50 lbs of force (222 Newtons) per hauler and multiplying by the mechanical advantage of the pulley system, the theoretical output (not accounting for friction loss) of the pulley system can be determined.

A common error is pulling too hard and too fast, which is very dangerous since the load can be jammed in a crevice or injure rescuers on the line. The goal is to generate a smooth raising effort on the line. Avoid a "heave-ho" pull on the haul system. This can cause the litter to bounce and create excess abrasion on the main line. If a heave-ho is occurring increase the mechanical advantage or increase the number of haulers.

Have a single person giving the commands and restrict all excess verbal bantering among topside personnel.

CHANGEOVER TECHNIQUE- RESCUE LOAD

LOWERING TO RAISING

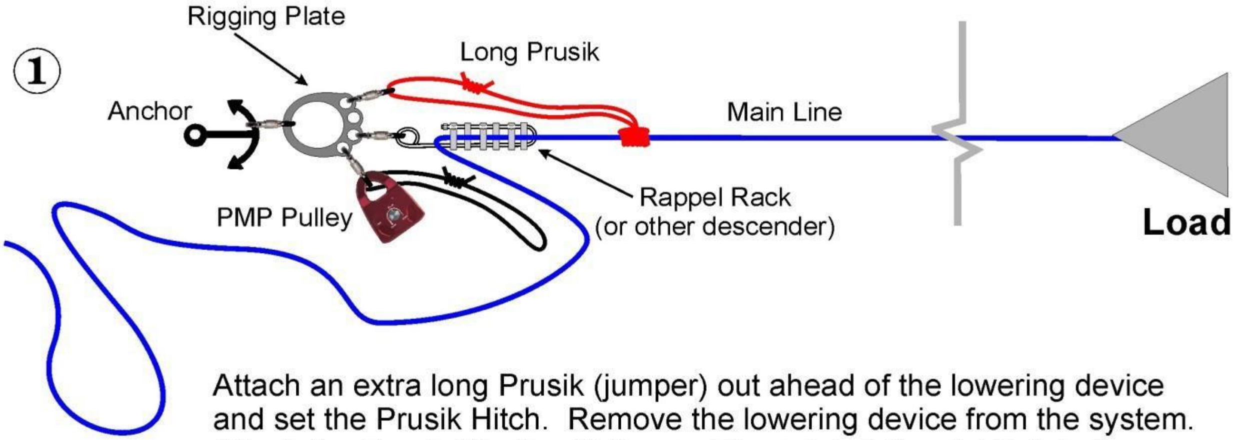
Conducting a changeover from lowering to raising involves transferring tension off the DCD. This can be accomplished through the use of an extended long Prusik, referred to as a "jumper," which bypasses the DCD. The attendant calls for a "stop" and communicates "rig for raise." The DCD is manually held at full stop without a tie-off. The Jumper is rigged on the line and attached to the rigging plate at focal point. The attendant is advised to "prepare for settling." The main line is lowered out, which transfers tension to the Jumper. As additional rope is fed through the DCD, the device becomes slackened and can be removed from the system. Once the rope is released from the lowering device, the pulley system is constructed for the raise. As the raise is initiated, the Jumper is removed, while the raising operation continues.

RAISING TO LOWERING

During a raising operation the load can be quickly lowered back down a short distance by the haul team simply letting out on the main line with the ratchet on the haul system held open, so it does not set. Although less commonly employed during a rescue, a complete changeover from a raising to lowering operation is accomplished through another transfer of tension maneuver. When a "stop" is called on the raising operation, a Jumper, with a LRH attaching it to the rigging plate, is rigged on the tensioned line in front of the Ratchet Prusik Hitch with enough distance to rig the DCD after the line is slackened. The attendant is advised to "prepare for settling," as the haul system is lowered back out while the ratchet is manually held open. This allows the tension to settle on to the Jumper. This will permit the haul system to be slackened and removed. The DCD is rigged to the slackened line behind the Jumper and tied off. The LRH is then let out to transfer tension over to the descender.

Note: The use of a CMC MPD™ preconfigures a lowering or raising system for an immediate changeover without having to complete the steps shown above.

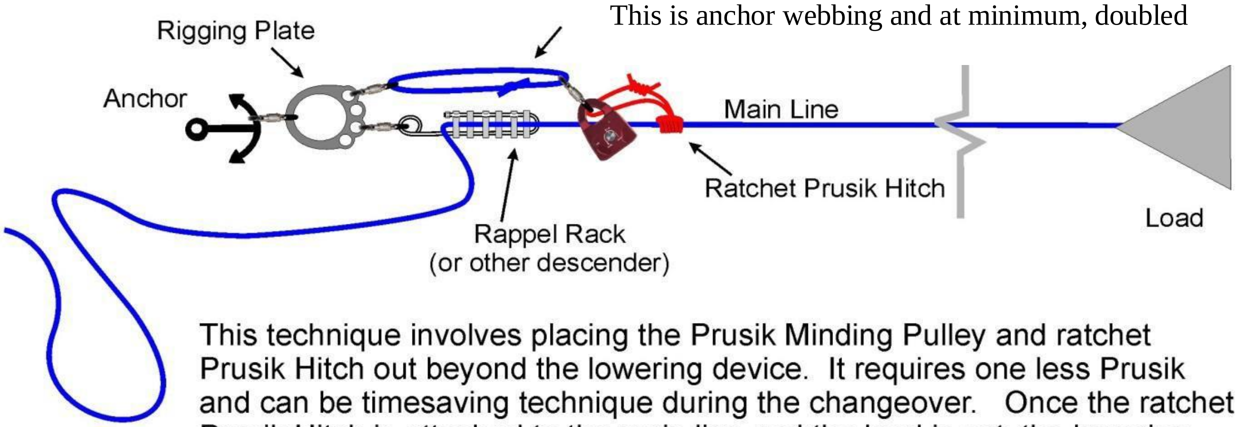
CHANGEOVER TECHNIQUE (LOWERING TO RAISING)



Attach an extra long Prusik (jumper) out ahead of the lowering device and set the Prusik Hitch. Remove the lowering device from the system. Attach the Prusik Minding Pulley and the ratchet Prusik Hitch to the main line. Finish constructing the remainder of the haul system. During the initial part of the raise, remove the extra long Prusik from the system. Continue the raising operation. Employ a rigging plate at the anchor focal point to keep the rigging organized and increase efficiency.

② ALTERNATE METHOD (from Arnor Larson)

This is anchor webbing and at minimum, doubled



This technique involves placing the Prusik Minding Pulley and ratchet Prusik Hitch out beyond the lowering device. It requires one less Prusik and can be timesaving technique during the changeover. Once the ratchet Prusik Hitch is attached to the main line and the load is set, the lowering device can then be removed from the system. Finish constructing the hauling system and begin the raise. If the Prusik Minding Pulley and ratchet Prusik Hitch are attached during the lowering to expedite the changeover, make certain that they are tended as rope is being feed out.

EDGE PROTECTION

Using canvas padding or edge rollers are the most common techniques to protect a rope running over a sharp edge. This is a crucial task, since protecting the rope on sharp edge is essential to prevent rope damage or failure. Edge rollers provide greater efficiency during a raising operation; however, they are heavier and bulkier than many other related products. A directional may be used to keep the ropes from encountering the edge. Using a rock hammer to dull an edge may also be employed if considered appropriate for the site. Tie-in edge rollers and pads or Prusik them to a separate line so they are secure and adjustable.

RIGGING NOTE: In settings employing a dedicated main line and a dedicated belay line, the main line should be placed directly on edge rollers, while the belay line is left out of edge rollers. This is to utilize friction in the event the belay is activated. Edge rollers can cause the belay device to actually receive higher peak forces. Friction at the edge reduces these forces. On a sharp edge use padding for the belay line

PATIENT PACKAGING

RESCUE HARNESSES

Purpose

You will package yourselves in pelvic and chest harnesses and secure yourselves to a belay line.

Directions

Step 1: Pelvic Harness

1. Take a red 20 foot or black 25 foot piece of webbing and find its midpoint.

2. Place the midpoint in the small of your back and bring the 2 ends around your waist to the front.

3. Cross the ends over and tie a surgeons knot, pull snug. A surgeons knot is an overhand knot with an extra twist in it.

4. Drop the 2 ends so they are lying on the floor between your feet.

5. Reach around from behind and grab the ends. Pull the ends through, between the legs, front to back, and around the upper thighs without crossing the ends. The webbing should now encircle the upper thighs.

6. Tuck the end under itself where it hangs down from the original surgeons knot, between the webbing and your thigh.

7. Pull so the wrap around the thigh is snug, but not so tight that it cuts off circulation in the legs.

8. Pull back on the ends so that after they form a bight around the strand hanging down they run back around the waist. Refer to the diagram at this point for clarity.

9. Wrap the ends around the waist at least twice. Be sure each time it passes in front to pass the end through the collection point.

10. Tie the ends off in a square bend and then -back up the square bend with one overhand knot on each end of the square bend.

11. There should be a single strand of webbing around each thigh, and 3 strands around the waist if the harness is properly tied.

If there is not enough tail remaining to tie overhand knots to back up the square bend, a longer piece of webbing must be used.

System Safety Check

A safety check includes:

- a visual scan looking for properly tied and properly backed up 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 a system.

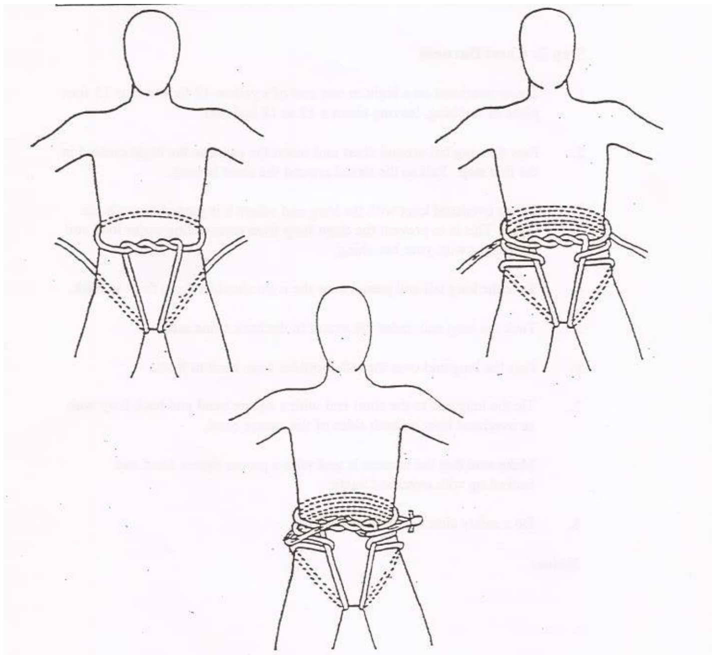


Figure 5.59 - Pelvic Harness

Step 2: Chest Harness

1. Tie an overhand on a bight in one end of a yellow 12 foot or blue 15 foot piece of webbing, leaving about a 12 to 18 inch tail.

2. Pass the long tail around chest and insert the end into the bight created in the first step. Pull so the strand around the chest is snug.

3. Tie an overhand knot with the long end where it is passed through the bight. This is to prevent the chest loop from constricting under load and interfering with your breathing.

4. Take the long tail and pass it over the right shoulder from front to back.

5. Tuck the long end under the strand in the back spine area.

6. Pass the long end over the left shoulder from back to front.

7. Tie the long end to the short end with a square bend and back it up with an overhand knot on both sides of the square bend.

   Make sure that the harness is tied with a proper square bend and backed up with overhand knots.

8. Do a safety check on fellow students.

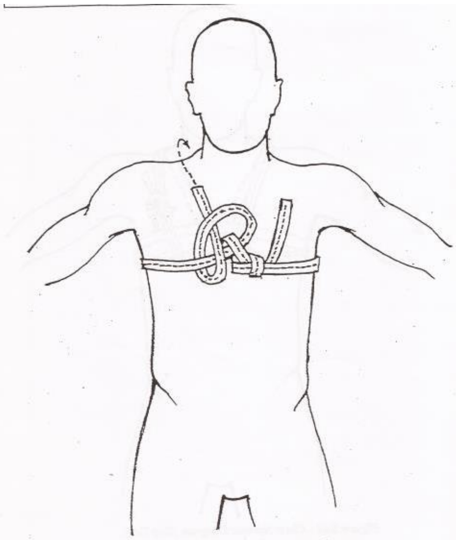


Figure 5.60 - Chest Harness Diagram (Step One)

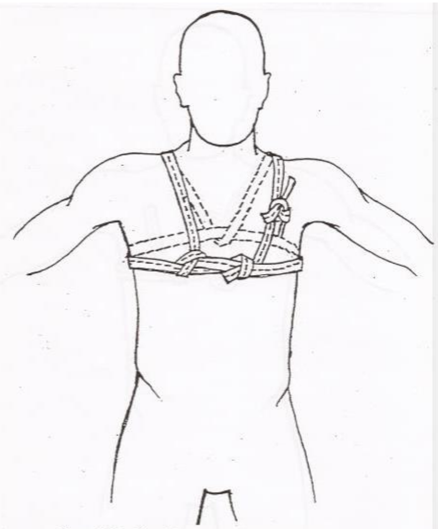


Figure 5.61 - Chest Harness Diagram (Step Two)

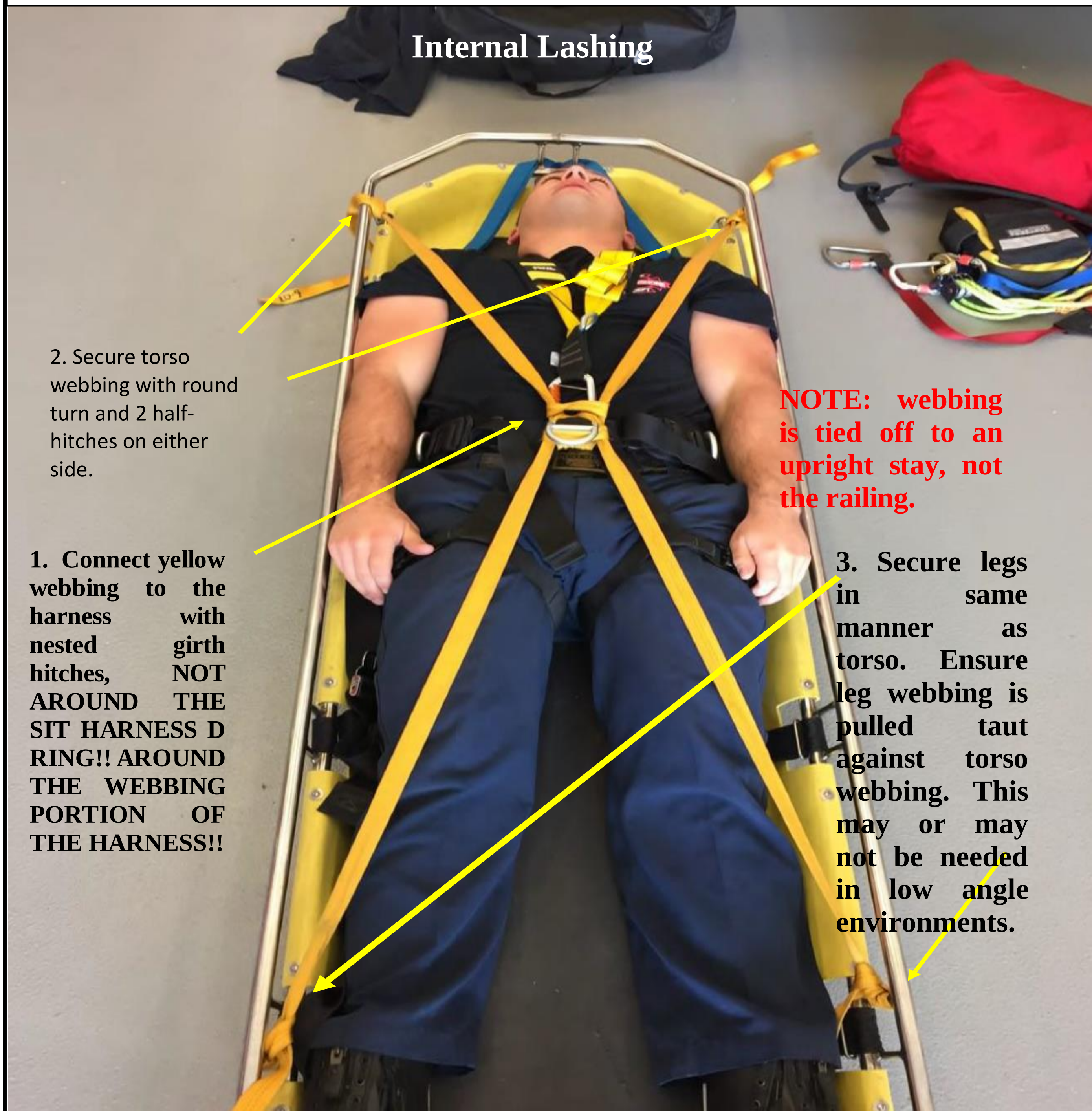
LITTER
PATIENT PACKAGING.
SAFETY

- Patient(s) must be internally lashed to protect them from ejection out of the ends of the litter. They must also be externally lashed to prevent them from moving within the litter.
- All carabiners should have gates opening down and toward the "inside" of the litter basket. Ensure carabiners are properly loaded and will not torque or side load.

- Never tie patient lashing around top rail of the litter: Always weave webbing between uprights of the stokes or to internal areas of plastic stretchers.

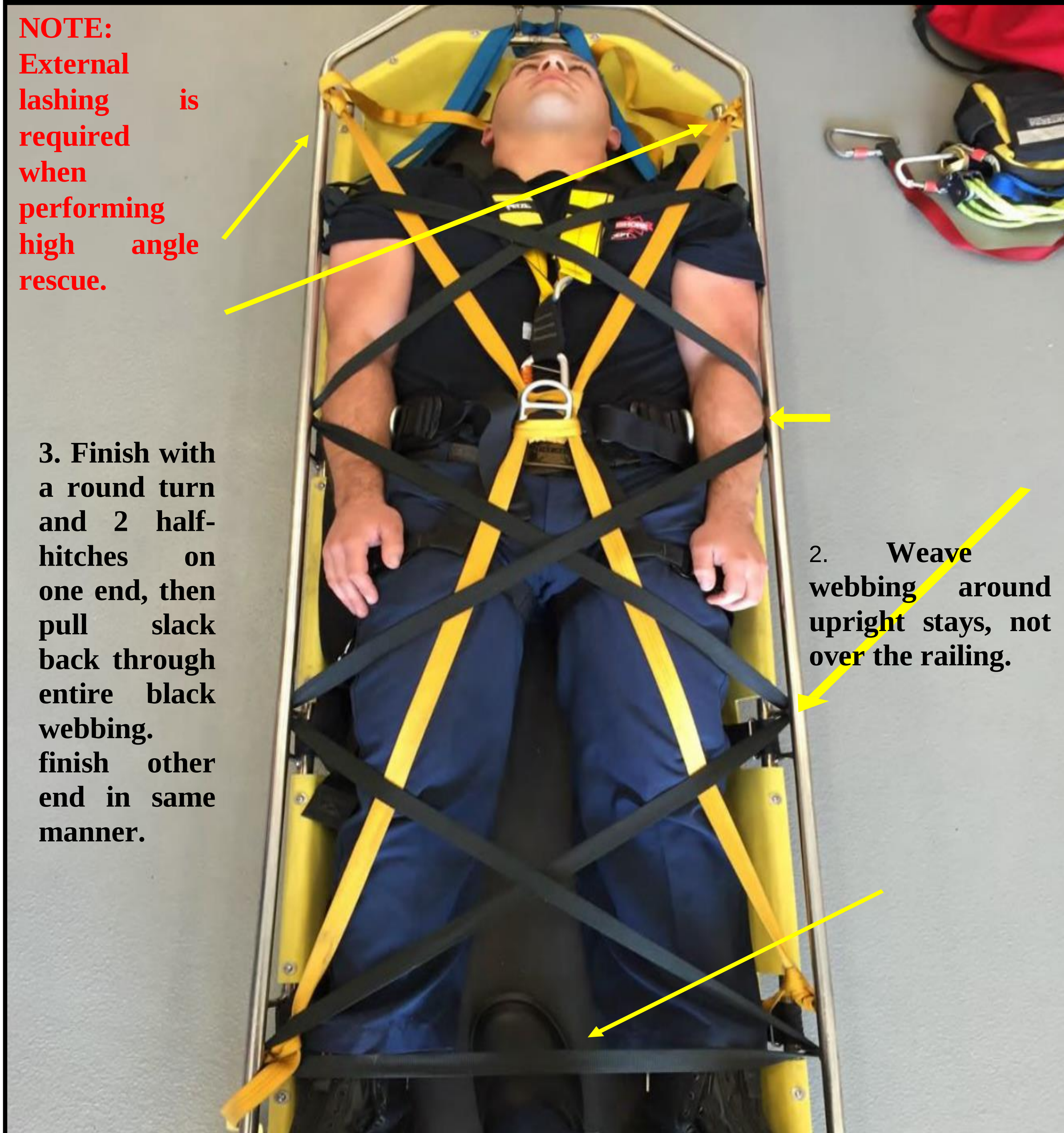
STEPS TO PATIENT PACKAGING:

1. Stabilize the patient before loading;
2. Head/eye/face protection
3. Sit harness (for steep & high angle, maybe considered during Low angle)
4. C-collar, backboard, bandaging, splinting
5. Prepare the litter to receive the patient
6. Load the patient
7. Lash the patient into the litter securely
8. Internal lashing (two 12-foot yellow webbings)
9. External lashing (If litter is not equipped with seatbelt type external lashing us a 25-foot black webbing to establish external lashing)



NOTE: In a LOW ANGLE environment internal lashing is all that be needed to keep the patient from sliding out.

EXTERNAL LASHING



1. **Start with middle of black webbing he**

LEADER PROTECTION / LEAD CLIMBING

This is an introduction to lead climbing and the equipment used. The objective of the station will be on the basics of lead climbing; it's something briefly covered in rescue systems 1 but is not discussed in any other tech rescue discipline. Lead climbing comes from the rock climbing and mountaineering sports but is has been modified for our rescue purposes. The main goal of a lead climb operation is to <u>set up a "highway system" for multiple rescuers to safely enter a hazardous location to perform rescue work.</u>

Equipment

The lead climbing bag carries 200 feet of Ten mill dynamic rope (8.6 KN which is a 10:1 safety factor for the average adult or 190lbs person). The rope construction is kernmantel, the same as are other static ropes, except the dynamic rope will absorb the shock load of a fall much like a big rubber band. Lead climbing is different from our normal training operations in that it will not use 2 ropes, instead we will just use 1 belay line. However there still redundancy built into the lead climbing system. There is redundancy because it is a kernmantel rope (If questioned why, explain this: The rope's core holds 75% of the strength, and the sheath holds 25% of the strength, in the rare event that the core is broke, the sheath alone is still strong enough to hold a climber).

If a rescuer is still uncomfortable with this concept another option is using the Pretzel Absorbicas as a secondary means of attachment well climbing. However, the Absorbicas may not be available for use in every climbing situation. You can also construct cow tails with yellow webbing in place of the Absorbicas. (Safety note: a class one or class 2 fall will potentially break a static cow-tail if there is nothing in the system to absorb the impact)

The typical lead climb bag will carry a few G rated carabiners,18-20 slings/draws (with single load carabiners), webbing for anchors, a tandem prusik set and belay device ("ATC" / DCD) for a body belay/belay alternative in the event a bomb-proof anchor cannot be found.

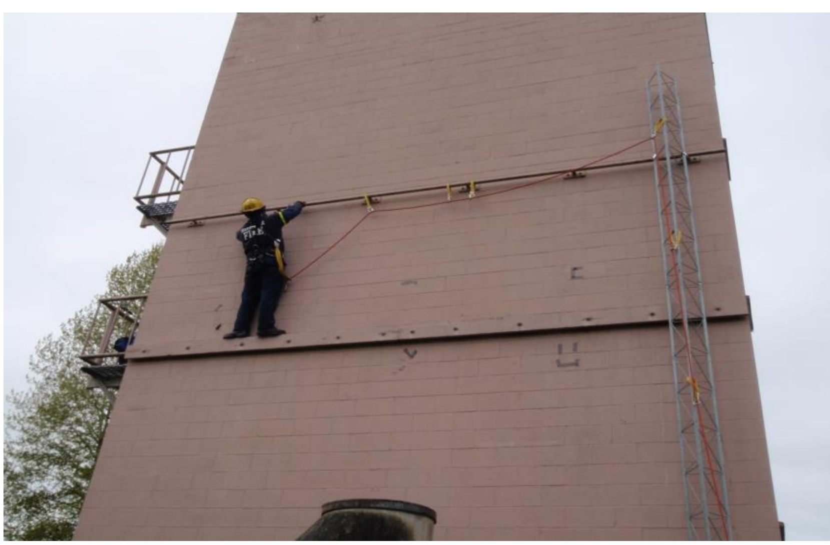
Safety Awareness during Lead Climbing

Protection placement can range from 5’ to 6’ apart to 10' to 15' depending on the circumstances. Keep in mind the higher you go above your last piece of protection you will fall double the distance (class 2 fall); this is normal, and the rope will handle it without a problem. In the emergency setting you will not be climbing something benign like a rock wall but something more like a radio tower, a rubble

pile or a "racked structure," like in today's exercise. Our main hazard or injury potential will not be from falling but more so from hitting something on your way down.
If a body belay is being utilized in our emergency setting, It would be preferred to have the lighter person be the climber due to the unusual environment we will typically be climbing in (as mentioned above). This is important because if the climber is close to the belayer’s weight and the climber takes a big enough fall the belayer can easily go airborne. If a belayer anticipates this, he or she can jump just before they get pulled off their feet. This technique is used to soften the blow that the belayer will feel. We will not be covering the techniques for body belaying in class. If your department carries a body belay device, they will train you on their specific equipment. A local climbing gym will also have a class on basic belaying for lead climbing.

Directions

1. Attach 5 or 6 green 5 foot webbing slings with carabiners onto a Prusik sling and hang it over your head and off one shoulder.
2. Tie the safety line to your pelvic and chest harness.
3. When the belayer advises they are ready, start to climb.
4. Attach a point of protection as shown by the instructor, using a girth hitch around one of the ladder rungs, when you are about 5 feet up. Attach your rope to the carabiner and lock the carabiner.
5. Repeat this process every 5 to 6 feet.
6. When you reach the traverse, continue to protect your movement by placing green slings every 5 to 6 feet.



ROLES AND RESPONSIBILTIES

Rescue Group Supervisor (RGS):

- Reports directly to the on-scene Incident Commander.
- Is responsible for direct supervision of the rescue team operations. (1670)
- Determines RESCUE or RECOVERY mode. Performs a continuous hazard analysis and risk assessment.
- Provides passport accountability and maintains an ongoing awareness of the location and condition of all members. (1500)
- Provides and maintains safety and scene security. (1500) Makes key assignments of personnel:
    - *Technical Safety Officer*
    - *Rigging Team Leader*
    - *Entry Team Leader*
    - *Support Team Leader*
    - *Back-Up Team (as required)*
- Determines an action plan, communicates the plan, and ensures that the plan is adhered to.
- Develops a back-up contingency plan. (1500)
- Ensures that the appropriate PPE is utilized and equipment to provide protection from those hazards to which personnel are exposed or could be exposed is provided. (1670)
- Initiates, maintains, and controls incident communications. (1500)
- Ensures that medical care at a minimum level of basic life support (BLS) is provided. (1670) Conducts pre-entry briefing with the entry team.
- Ensures that all rope systems have been safety checked by the Technical Safety Officer and Rigging Team Leader prior to operation.
- The RGS is the only person at a rope rescue incident who can initiate motion of the rope system or restart the rope system if stopped or re-set. The RGS may delegate this function to the Entry Team Leader.)

Technical Safety Officer (TSO):

- Reports directly to the Rescue Group Leader.
- Performs a continuous hazard analysis and risk assessment.
- Provides direction with respect to the overall safety of personnel. (1670) Ensures scene security.
- Ensures that the appropriate PPE is utilized and equipment to provide protection from those hazards to which personnel are exposed or could be exposed is provided.
- (1670) Ensures passport accountability and maintains an ongoing awareness of the
- location and condition of all members. (1500)
- Is aware of and approves the action plan and ensures that the plan is adhered to. Is aware of and approves the back-up contingency plan.
- Ensures that medical care at a minimum level of basic life support (BLS) is provided. (1670) Is present at the pre-entry briefing with the entry team.
- Ensures that all rope systems have been safety checked by the Rigging Team Leader then double-checked prior to operation by the TSO.
- Ensures that the Entry Team has been safety checked by the Entry Team Leader then double-checked by the TSO prior to deployment.
- Ensure that the Entry Team is properly equipped, properly secured, and all equipment and medical supplies necessary for the treatment and packaging of the patient(s) is present and secured.

Rigging Team Leader:

- Reports directly to the Rescue Group Supervisor.
- Assists the RGS in determining:
- The type of rope system(s) to be utilized.
- The location from which the rope system(s) are to be based from.
- Selecting the location and type of the anchor point(s).

- Responsible for direct supervision and safety of personnel assigned to the Rigging Team. (Main Line and Belay Line Team).
- Understands the action plan and communicates the plan to personnel assigned to the Rigging Team.
- Responsible for the engineering, construction, and operation of all rope based systems utilized during the operation. This responsibility includes "visualizing" the integrity of the rope system(s) in motion, and its effect or potential effect to all personnel who depend on the rope system(s) for their safety as well as to personnel working on or around the rope system(s).
- Determines a contingency plan prior to the initial operation of the rope system(s) that addresses the utilization of additional rope systems in case of an emergency. This plan shall be worked out in advance with the RGL and approved by the TSO.
- Ensures that all rope systems have been safety checked then double checked by the TSO prior to operation.

Entry Team Leader (ETL):

- Reports directly to the Rescue Group Leader.
- Responsible for direct supervision and safety of all personnel on the Entry Team and Backup Team.
- Understands the action plan and communicates the plan to personnel assigned to the Entry Team and Backup Team.
- Responsible for ensuring that all personnel on the Entry Team and Backup Team (if utilized) have proper PPE and have the ability to communicate with the Entry Team Leader or RGL.
- Responsible for ensuring that the Entry Team is properly secured to the rope system(s) prior to deployment.
- Ensures that any necessary PPE and/or medical equipment necessary for the patient is available and properly secured prior to deployment.
- Maintains an ongoing awareness of the location and condition of all Entry Team members.

- Ensures that the Entry Teams PPE and their attachment to the rope system has been safety checked and approved by the TSO prior to deployment.
- The properly secured Entry Team Leader should position himself/herself in such a manner as to have continuous line of sight (if at all possible) with the Entry Team as well as with the Main and Belay Line Teams to facilitate communicating the starting, stopping, re-setting, and speed of the rope systems.
- The Entry Team Leader (or RGS) is the only person at a rope rescue incident who can initiate motion of the rope system or restart the rope system if stopped or re-set.
- The RGS may elect to perform the duties of Entry Team Leader in addition to the role of RGS. This may occur on a simplistic rope rescue evolution or in the event that a sufficient number of rope rescue based, technician level personnel are not available to support all positions that require the presence of technician level personnel.

Support Team Leader:

- Reports directly to the Rescue Group Supervisor.
- Responsible for direct supervision and safety of all personnel on the Support Team.
- Responsible for completing assignments given by the RGS that supports the overall technical rescue incident. These assignments may include but are not limited to:
- Providing scene security
- Removing brush, trees, or any obstacles that may hinder the rope systems.
- Securing utilities.
- Setting up an equipment staging area.
- Acquiring equipment from apparatus necessary to support the technical rescue incident.
- Providing edge protection as required.
- Provide staffing for the Haul Team.

UNIT 6 - EMERGENCY BUILDING SHORES

Terminal Objectives

The students will be able to:

- Determine how and where to build emergency shoring
- Measure, cut, and construct five types of shoring systems
- Window and Door shore
- Vertical shore
- Horizontal shore
- T-shore
- Double T-shore
- Raker shore
- To organize and manage a cutting team/station
- Maintain the integrity of all structurally unstable elements
- Properly transmit or redirect the collapse loads to stable ground or other suitable structural elements capable of handling the additional loads

Enabling Objectives

The students will:

- Have a basic understanding of how to conduct a proper shoring size- up
- Be able to identify locations for proper shoring placement
- Understand the shoring team concept and identify positions & purpose
- Describe types, capabilities, and safety considerations for tools used in making emergency building shores.
- Describe materials, their capabilities, and limitations of emergency building shores.
- List the five types and proper application of shores and their component parts.

INTRODUCTION

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 emergency shoring systems.

In order for EBS systems to be effective, the materials used should be strong lightweight, and adjustable. Shoring systems should be applied allowing a large margin of safety. The use of more shores than you may think necessary is more appropriate than using fewer shores to gain time. The size and type of shoring system depends on the weight of area to be supported and the condition of the element to be stabilized. For example, a solid concrete slab requires a different EBS system that would a broken slab or masonry rubble. The shores' spreading requirements differ in these examples.

It is important for rescuers to check the condition of floors, building piers, and foundations prior to installing EBS systems. These areas may have been compromised during the collapse and may not support a heavily loaded shore.

A shoring system must be designed to act like a double funnel. The system collects the load over a wide area, funnels it into the struts, and then distributes the load out into the supporting elements on the opposite side of the shore.

Shoring systems should be applied gently to the structure they are to support. They are not designed to move structural elements back to their original positions or design. If rescuers attempt this action, they may cause additional collapse of the object they are trying to support.

Collapsed structures can be horizontal as well as vertically unstable. Hanging structural parts, such as pieces of concrete, that are applying tension -to the object they are attached to also may be creating horizontal forces on parts of the building. This is difficult to stabilize with EBS.

Interconnected building parts may depend on each other for support. This creates difficult stability problems. Partial collapses that leave large sections of the building standing (such as free-standing walls, overhanging floors, or large hanging building components) can be very dangerous.

Shoring Size-Up

The shoring size-up provides vital information that can increase rescuer and victim safety and rescuer effectiveness during a shoring operation. The size-up identifies structural hazards, damage, and potential victim locations and 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

continuous throughout the rescue operation.

Victim Consideration

In a disaster such as an earthquake, how much time and effort rescuers place on a collapsed structure can depend on the potential number of live victims that can be rescued from the collapse. Information leading to the number of 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.

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 the easiest to assess. 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.

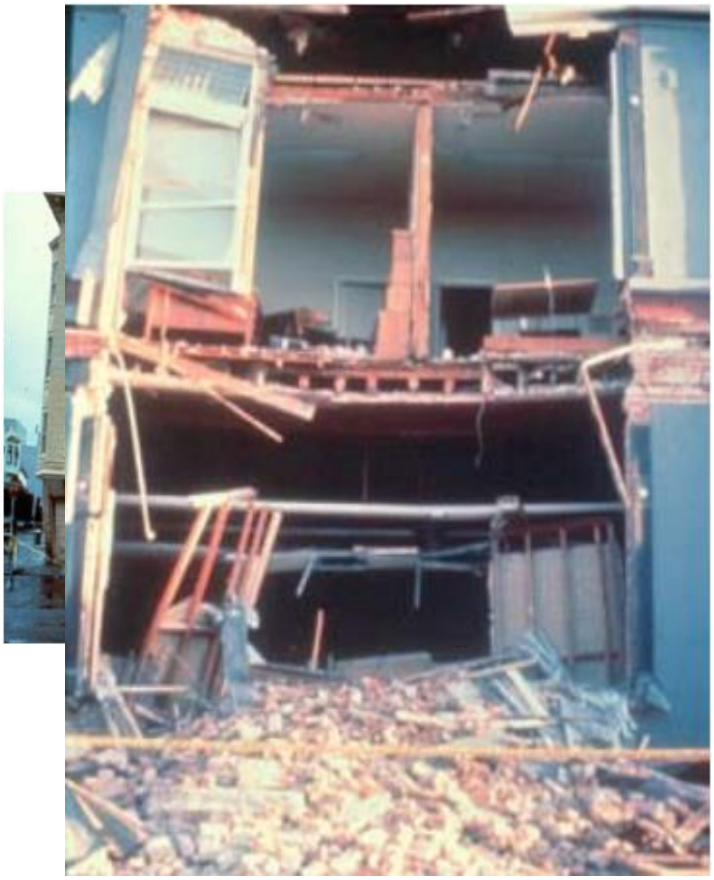
The top of the collapse is considered by some rescuers to be the most dangerous "side". Since gravity is always at work and collapse occurs from above, it is imperative to monitor and survey the overhead area constantly to assess the potential for fall hazards or secondary movement.

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, basements, 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 to stable surfaces for the shoring system to adequately perform.

Structural Elements

Basic elements of a structure should be evaluated. These elements can be bearing walls, columns, beams, 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 beams, columns, arches, joists, and other structural supporting elements under the main debris pile or victim's location should be the top priorities of the shoring size-up. All severely stressed, broken, missing, bowed, or cracked supporting elements that could affect the rescue operation must be shored up before any personnel are committed to work in the area.

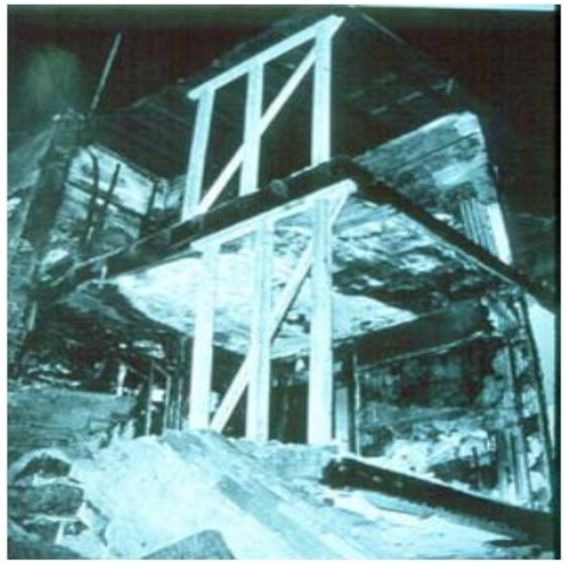
Age and Condition of a Structure

Like the human body that becomes frail as it gets older, a structure 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 potential for the strength of structural elements to be compromised, every element should be evaluated before committing resources in a shoring operation.

Collapse Warning Signs

Collapse warning indicators are often 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 overstressed 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.

Sensitive instruments like surveyor transits and theodolites when properly used by trained individuals, can 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.

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 counterweight 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.

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 **three (3) good floors** below the level in which structural damage has occurred.

Placing the shores under primary structural elements such as bearing walls, beams, columns, and arches will more effectively use shoring materials and the existing construction features of the building. An example would be to shore a roof span under a damaged, but intact, beam. Placing a solid supporting shore under a beam will allow the beam to support the attached roof section as it was designed. If the beam connection and roof sections are 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 beam, 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 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.

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, takes measurements, and clears the area and constructs 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

❒ The **Shoring Officer** is in charge of the assembly operation and may work with a Structures Specialist to determine what shore to use and where to place it.

❒ The **Safety Officer** is assigned by the Shoring Officer as needed.

❒ The **Shore Assembly Team** performs the following duties:

- Performs all measuring, deducts for component pieces, relays information to the Cutting Team
- Clears debris, builds the shore
- Moves lumber and equipment as needed
- Communicates with the Cutting Team

The Cutting Team

❒ The **Cutting Officer** is in charge of the Cutting Team. This position can be eliminated in a smaller team configuration.

❒ The **Cutting Team** performs the following duties:

- Sets up cutting station and lumber cache
- Equipment and logistical needs
- Measures, marks and cuts lumber
- Moves lumber and equipment to the Shoring Team
- Communicates with the Shoring Team

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 rescue operations at reduced risk to the rescuer and victim.

Double Funnel Principle

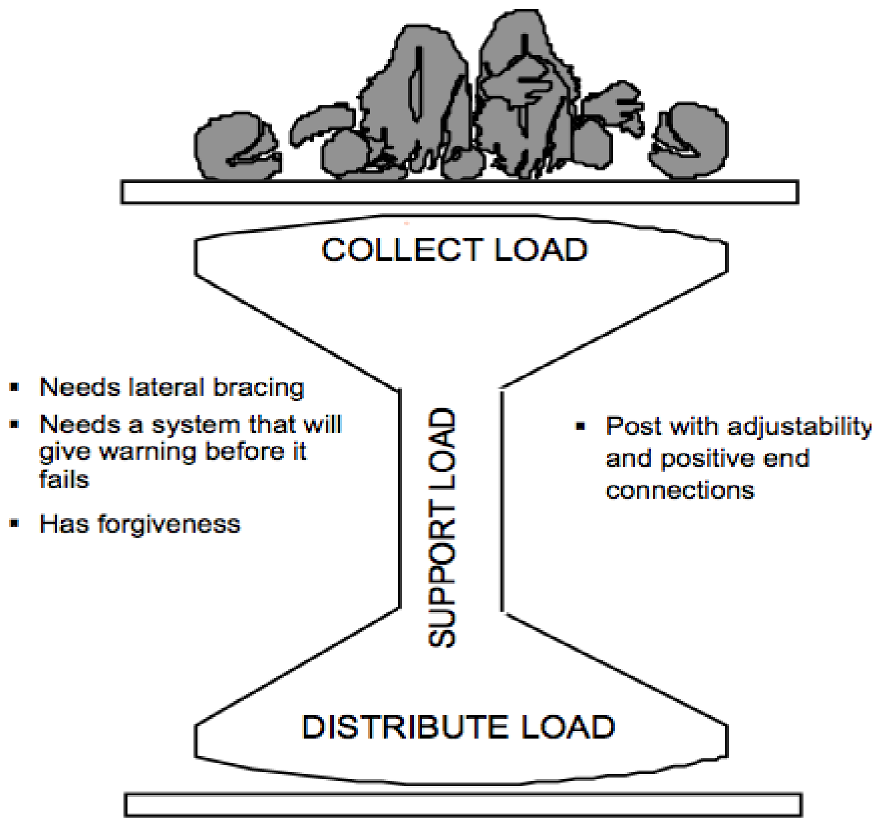
Emergency shoring systems must be designed like a double funnel. The systems are designed to:

❒ 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 distributed.



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, support, and distribute the load need to be adjustable so 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 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).

❒ **Gusset plates** are square, rectangular or triangular pieces of 3⁄4" plywood nailed to secure shoring component junctions or connection points together.

❒ **Header** is the uppermost 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 supports the load from the wall plate and transfers the load to the sole plate, trough or u-channel.

❒ **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 a crib bed.

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 4x4 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: 2x4, 2x6, 4x4. The actual dimension is 1⁄2" less than the "call out" size: 4x4 = 3.5 x 3.5

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 on its side orientated with the grain (cross-grain). The average end-grain strength of lumber is 1,000 PSI (pounds per square inch). The load capacity of a 4"x4" vertical post with end-grain compression is, however, dependent on its length. Bending and breaking characteristics of upright posts 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 4x4 (L/D50) is 50 x 3.5" = 175" or 14.5'. The ideal length of a 4x4 for rescue operations (L/D25) is 25 x 3.5" = 88" or approximately 8'. The average cross-grain strength is 500 PSI. The load capacity of a 4x4 used as 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.

When considering compression loads versus 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

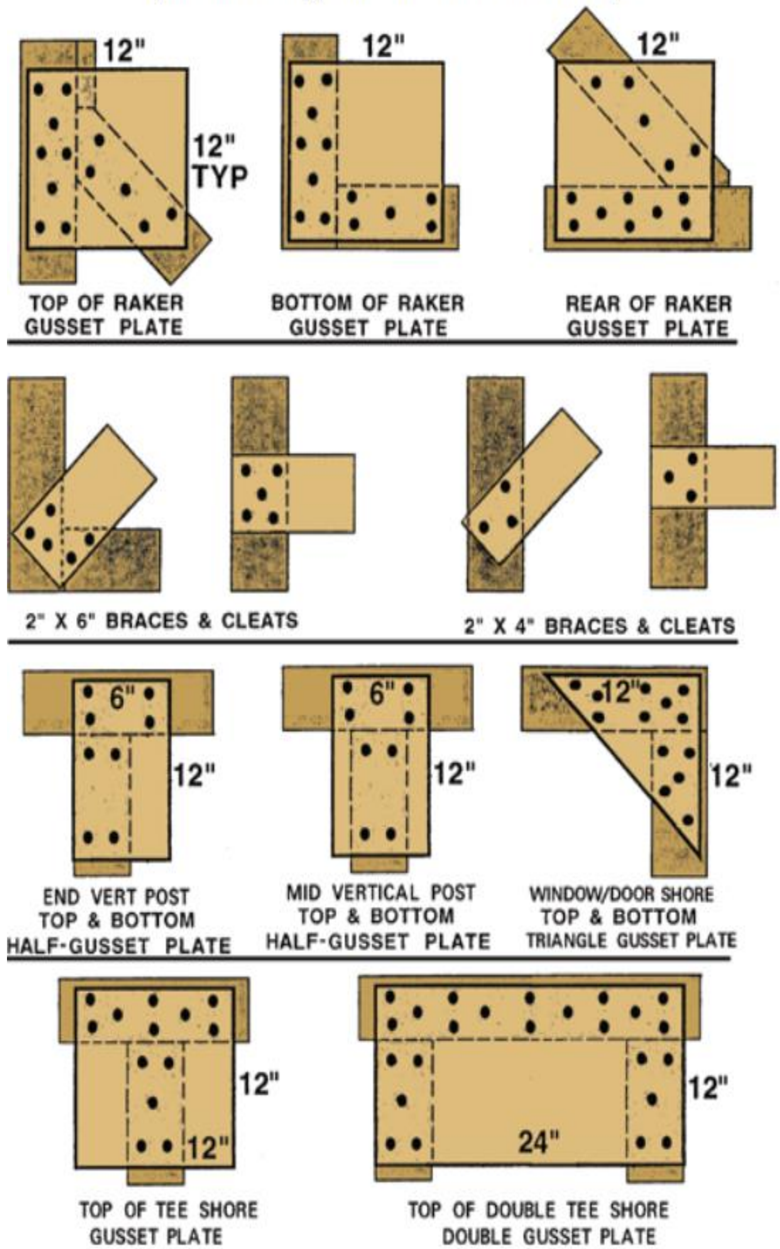
Plywood is typically composed of multiple thin layers of wood glued together so the grain direction of each layer is perpendicular to the adjacent layer. This layering pattern gives plywood its strength and ability to resist splitting like other solid pieces of lumber—thus the reason for plywood being used extensively for shear paneling or decking.

Plywood is usually constructed in 4' x 8' panels or sheets with common thickness from 1⁄4" to 3⁄4". Plywood sheets are produced in a variety of grades for exterior and interior use. A typical 3⁄4" sheet of plywood is usually made of five layers. Plywood used for shoring material is 3⁄4" 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 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.

Figure 6:16
Nail Patterns for
3/4"x12"x12" & 3/4"x6"x12" Plywood
Gusset Plates and Triangles / Braces and Cleats
(Use 8d nails on plywood and 16d nails on 2" lumber)



Nails come in different lengths and thickness The most common nails used to construct shoring systems are 8-penny and 16-penny (d) nails. It is estimated that the shear/pulling strength of the 8d nail is 150 pounds and the 16d nail is 225 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 ensure that the collective strength of the nails is adequate for the design of the shore and to prevent the nails from weakening (splitting) the lumber.

A 3-nail or 5-nail pattern system is used in emergency shoring operations Figure 6:16 illustrates the different variations of the nail pattern when connecting different shoring components. When nailing lumber such as 2x4 or 2x6, the amount of nails used is usually one nail less than the width of the lumber. Example: three (3) nails for a 2x4 or five (5) nails for a 2x6.

Shoring Systems

Spot Shore – Class I

The spot shore is used to initially stabilize damaged floors, ceilings, or roofs so 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.

Two-Post Vertical Shore – Class II

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 two posts, a common header plate and sole plate, and midpoint and diagonal braces to resist lateral forces.

Horizontal Shore – Class II

The horizontal shore is used to stabilize damaged walls against an undamaged wall in hallways, in corridors, or between buildings. It is constructed similar to the vertical shore, in the horizontal position.

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 with Cribbing

A sloped surface crib bed 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.

Raker Shore – Class III

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 split sole raker.

Components of the Timber Spot Shore

Header: Plate that 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 4x4. The header should be **no longer than 3'** due to the instability that occurs with longer material creating a dangerous overhang (cantilever effect) from the vertical post.

Sole Plate: Plate that distributes 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: Post that 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 to and maintain full surface contact with both the header and sole plate. 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 4x4. When calculating the length of the post, deductions for the thickness of the header, sole plate, and wedges need to be factored in.

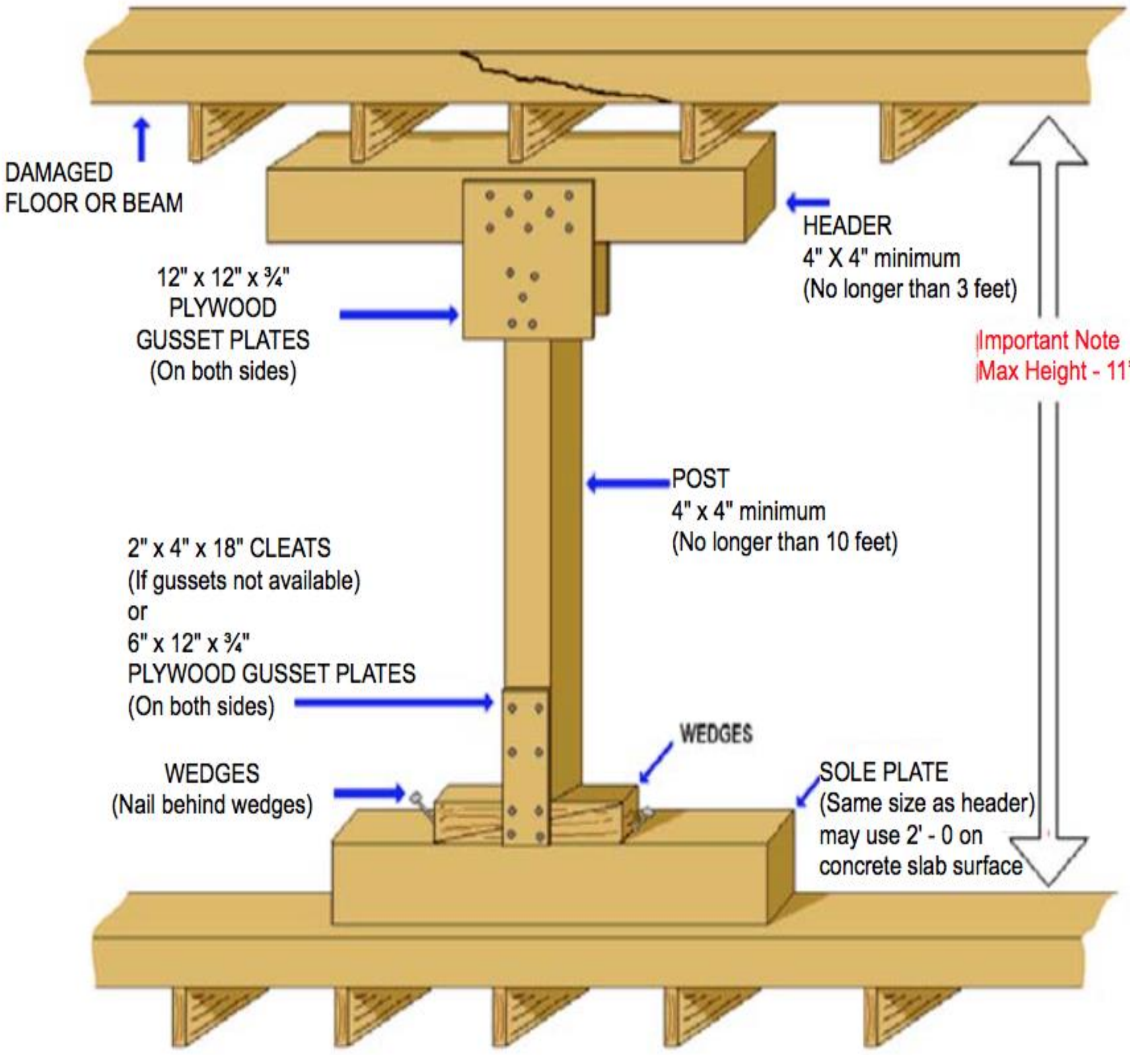
Wedges: Inclined planes that are used to pressurize the shore or fill gaps between the shore and the structure. Wedges are used in pairs with the cut side of each wedge "married" against each other for better holding capability and for a better striking surface for the hammers when pressurizing. Deduct 1 1⁄2" for 2x4 wedges and 3 1⁄2" for 4x4 wedges from the length of the post.

Gusset Plates: 12”x12"x 3⁄4" or 6”x12"x 3⁄4" plywood pieces 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 to the post, header, and sole plate.

Cleats: Short pieces of lumber (2x4) 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.

Timber Spot Shore

Position the HEADER and SOLE PLATE across the floor and ceiling joists. Position the POST in line with the joists. Temporary shore until a complete shoring system can be erected or for temporary access to the hazard area.
(Prefabricate post and header, then install on sole.)
Temporary shore only until a complete shoring system can be erected.



Design Load*
1,000 to 4,000 pounds based on unknown stability.
*Load must be centered on the post.

To be more effective, header, posts, and sole plate must be the same width for gusset plates and cleats.

Timber Spot Shore Assembly

1. Determine where the spot shore should be built in order to reduce risk.
2. Determine the overall height of the shore area and remove the least amount of debris necessary in order to place the shore.
3. Measure and cut the proper length of the header and sole plate.
4. Measure the overall height to be shored.
5. Deduct the thickness for the header, sole plate, and wedges.
6. Measure and cut the vertical post.
7. Nail 12”x12"x 3⁄4" gusset plates on both sides of the header and post to secure the two together.
8. Position the shore and sole plate under the load.
9. Ensure the post is plumb.
10. Pressurize the spot shore with wedges.
11. Tap a duplex nail halfway into the sole plate behind each wedge.
12. Nail 6”x12"x 3⁄4" gusset plates or cleats on both sides of the sole plate to secure it to the vertical post.
13. Evaluate shore and structure.

Components of the Two-Post Vertical Shore

Header: Plate that collects the weight from above and transfers it to the vertical post. The header plate should be level and perpendicular to the ceiling or roof joists. The minimum lumber size used is 4x4.

Sole Plate: Plate that distributes 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: Posts that support and transfer 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 to 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.

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. Deduct 1 1⁄2" for 2x4 wedges and 3 1⁄2" for 4x4 wedges from the length of the post.

Gusset Plates: 6”x12"x 3⁄4" plywood squares that secure the connections between the different parts of the shore such as 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.

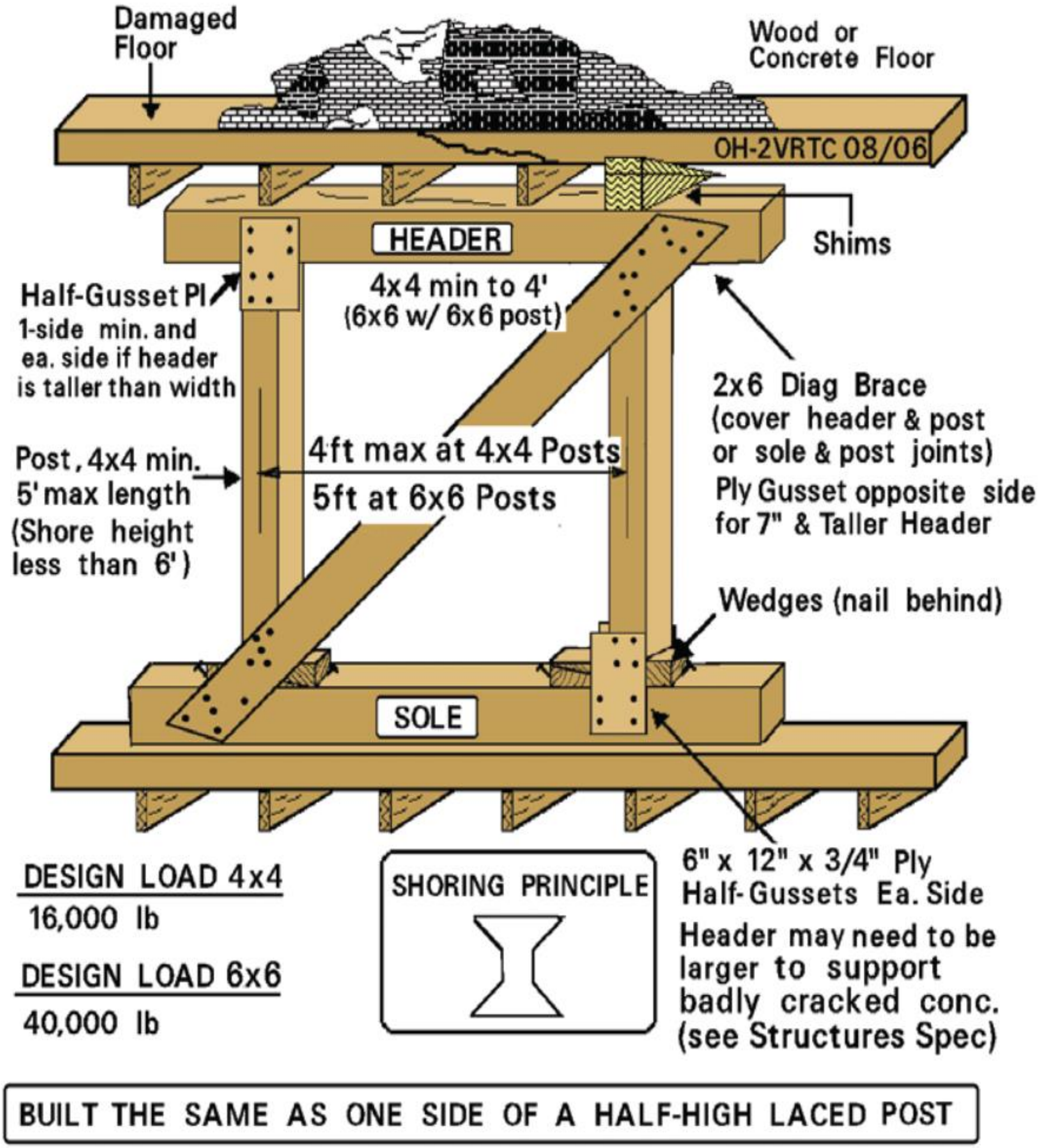
Cleats: Short pieces of lumber used to support or secure shoring component parts. 2x4 material in various lengths is usually used and secured with nails. Caution should be taken when nailing cleats due to the susceptibility of the lumber to split during the nailing process.

Diagonal bracing: Braces that connect the entire shore together so the posts all work as one unit The diagonal braces provide lateral stability and prevent the shore from failing like a collapsing parallelogram. Two-post vertical shore diagonal braces span the header and post joint to the midpoint brace in one direction and the midpoint brace to the sole plate and post joint in the opposite direction on the same side of the shore. The diagonal braces would form a “K” configuration. A two-post vertical shore with posts less than or equal to 7'6" long can use a single diagonal brace spanning the entire length of the shore connecting the header and post and sole plate and post joint without a midpoint brace.

Midpoint brace: Brace that increases the load-bearing capacity of the posts by resisting the buckling effect and the tendency for long posts to bend and break when put under pressure. Two-post vertical shores with 4x4 posts greater than 6' and less than 12' long require a single midpoint brace on one side of the shore. Two-post vertical shores with 12' posts require two midpoint braces and three diagonal braces. The two-post vertical shore midpoint brace should be constructed with 2x4 lumber.

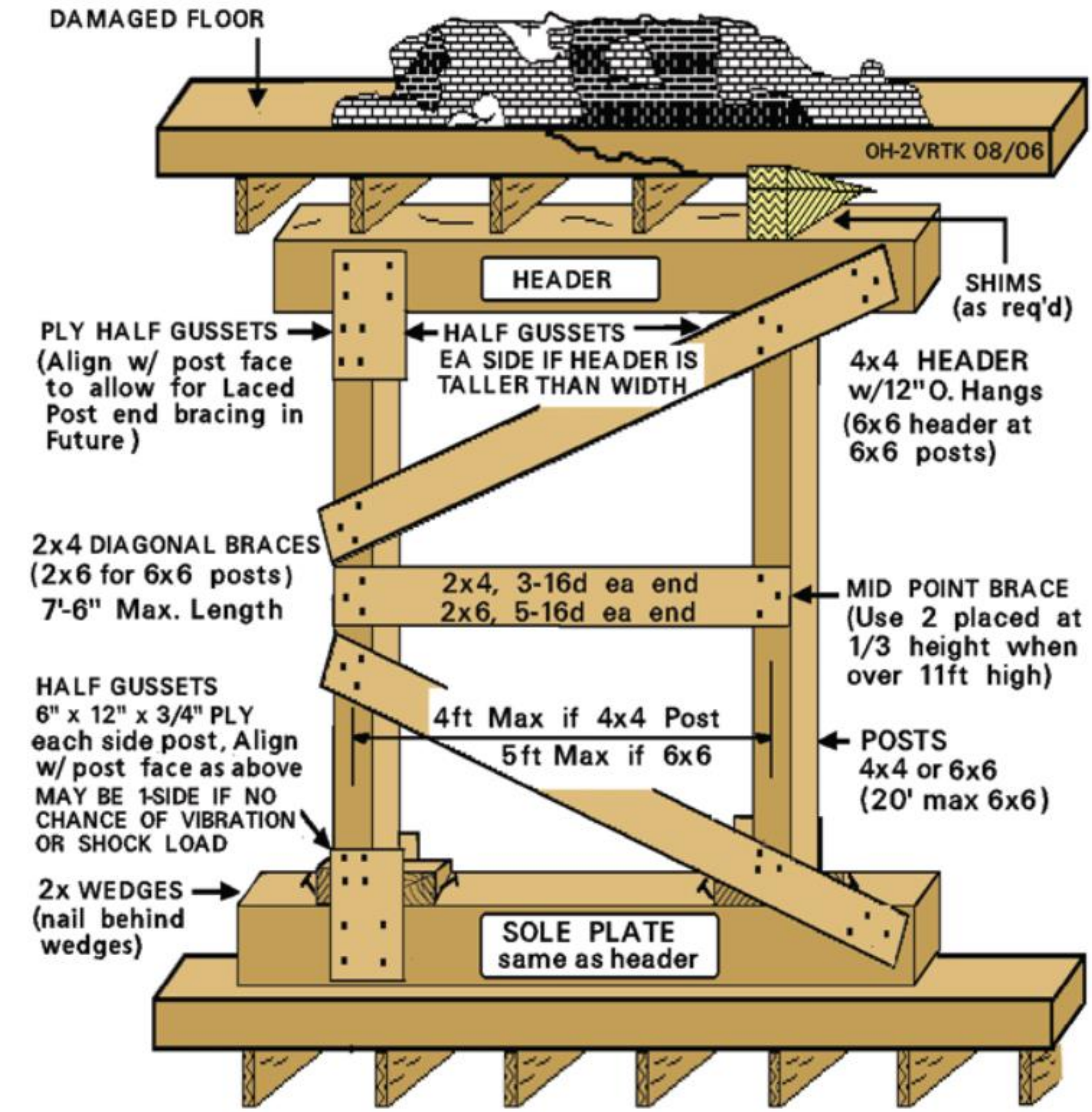
Two-Post Vertical Shore for Limited Height Area

Position the HEADER and SOLE PLATE across the floor and ceiling joists. Position the POSTS in line with the joists, but no greater than 5 feet off-center. The header may slope 6" in 110 feet, which equals approximately 3 degrees.



Two-Post Vertical Shore

Position the HEADER and SOLE PLATE across the floor and ceiling joists. Position the POSTS in line with the joists, but no greater than 4 feet apart.



DESIGN LOAD (Shore Height)

4x4 POST	6x6 POST
16,000 lb for 8 ft	40,000 lb for 12 ft
10,000 lb for 10 ft	29,000 lb for 14 ft
7,000 lb for 12 ft	24,000 lb for 16 ft

SHORING PRINCIPLE

Header may need to be larger for supporting badly cracked concrete (see Structures Spec)

Max 4x4 Shore Height is 12 ft unless built as part of Laced Post

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 thickness for the header, sole plate, and wedges.
4. Measure and cut the two vertical posts.
5. Nail gusset plates to one side of the header and posts to secure the two together.
6. Turn the shore over to the other side.
7. Measure, cut, and install the midpoint brace, if needed.
8. Measure, cut, and install the top diagonal brace to secure the header to the vertical posts.
9. Position shore and sole plate under the load; align the ends of the header and sole plate.
10. Ensure the shore is plumb.
11. Pressurize the posts with wedges.
12. Measure, cut, and install the bottom diagonal brace to secure the sole plate to the vertical posts.
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.

Components of the Horizontal Shore

Wall Plates: Plates that collect the weight being transferred laterally on one side, spread it to the horizontal struts, and distribute it to the wall plate on the opposite side. The wall plate should be as plumb and flush to the wall surfaces as possible. Back fill material can be used if needed between the wall plates and shored structure. The minimum size lumber that should be used is 4x4 material.

Similar to the vertical shore header, the ends of the wall plates should not extend more than 12" past the top and bottom struts. This clearance provides an area for the diagonal braces to attach to and maintain the maximum length requirement so failure of the strut due to the cantilever effect is minimized. The plates should be positioned directly in line with main structural elements.

Struts: Components that support the weight being transferred laterally from one wall plate to the other wall plate. They should be perpendicular to 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 4x4 wall plates on 4-foot centers is approximately 6,000 pounds. This is based on the crushing effect of the wall plate and not due to the bending and breaking of the strut itself. The 4x4 struts used in these systems should not be longer than 8' due to the potential of sudden failure from the strut buckling unless diagonal and midpoint braces are attached.

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: 6”x12"x 3⁄4" plywood squares that secure the connections between the different parts of the shore such as the header and the horizontal posts. They are connected with 8d nails using a four-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. 2x4 material in various lengths is 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.

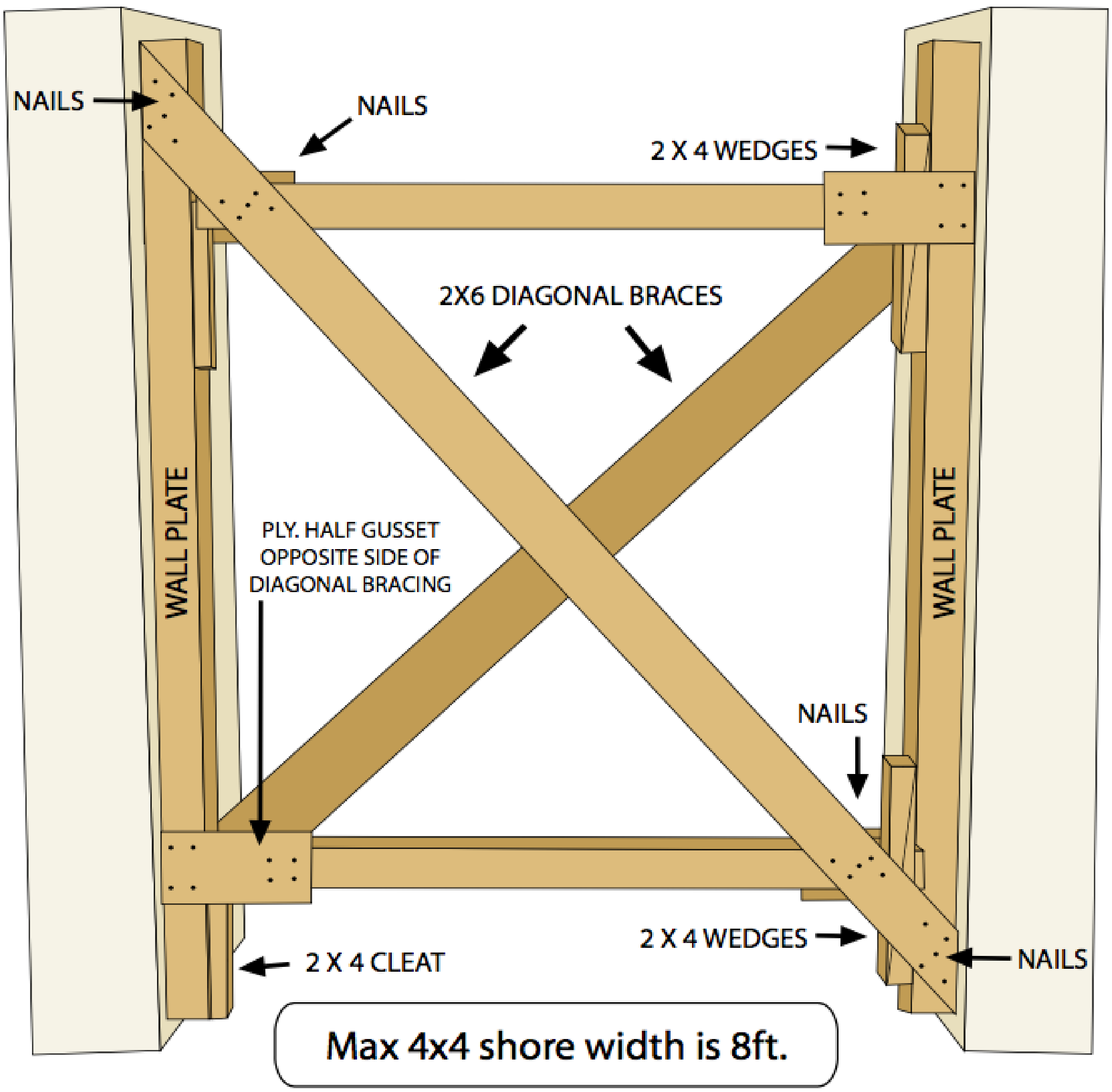
Diagonal bracing: Braces that lock the entire shore together so the posts all work as one unit. The diagonal braces provide lateral stability and prevent the shore from failing like a collapsing parallelogram. Horizontal shore diagonal braces span the entire length of the shore and connect the top of the wall plate and strut joint on one side to the bottom of the wall plate and post joint on the other side of the shore forming an “X” configuration. The top and bottom of the diagonal braces should cover part of the wall plate and strut connection points or joints.

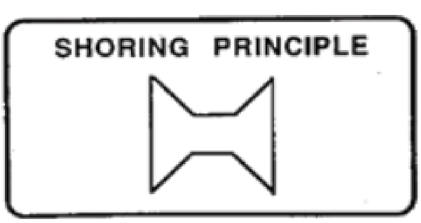
Midpoint brace: Brace that resists the buckling effect and the tendency for long struts to bend and break when put under pressure. Horizontal shores with 4x4 struts greater than 8' long require midpoint braces on both sides of the shore. Horizontal shore midpoint braces can be constructed with 2x6 or twin 2x4 lumber.

Horizontal Shore Assembly

1. Measure and cut proper length of wall plates.
2. Measure the overall width to be shored; use the shortest length measure if area is uneven.
3. Deduct the thickness of the wall plates and wedges.
4. Measure and cut the struts.
5. Measure and mark strut location on wall plates.
6. Attach cleats to aid in strut placement, if needed.
7. Position the shore and align the ends of the wall plates.
8. Install and pressurize the top strut.
9. Install and pressurize the bottom strut.
10. Install diagonal braces if posts are 4' or greater unless access or egress is required.
11. Install midpoint braces if posts are 8' or greater.
12. Nail gusset plates and/or cleats on both sides of the post joints not covered by a diagonal brace to.
13. Secure all joint connections.
14. Evaluate the shore and structure.

TWO POST HORIZONTAL SHORE





WALL PLATES & STRUTS SHOULD BE SAME WIDTH FOR DIAGONAL BRACES TO BE MORE EFFECTIVE

Window and door shores are used by rescuers to stabilize damaged windows, doorways, and other access ways within a weakened wall system. Anytime 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 multidirectional 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 built similar to a vertical shore, and if the collapse is from the sides, the shore should be built like a horizontal shore

Window and door shores can be assembled using one of two methods. The **Construct-in-Place Method** builds the shore by measuring, cutting, and installing individual shoring components one piece at a time in the opening.

The **Preconstruction Method** builds the complete shore 1 1⁄2" less than the size of the opening in each direction. Plywood triangle gussets are nailed at each corner on both sides. After inserting the shore into the opening, wedges pressurize the bottom and one side. Additional wedges 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.

When these shores are installed, consideration must be given not to compromise 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: Plate that collects the weight from above and transfers it to the vertical posts. The header plate should be level and perpendicular to the vertical posts 4x4 lumber is the usual minimum size used in most rescue operations.

A rule of thumb is used to calculate the maximum span for the 4x4 in an opening. For every 1' of span, 1" of material is needed. So, if a 4x4 is used, a span of approximately 4' can be obtained without additional support. If a longer span is required, rescuers can increase the dimension of the header by adding additional vertical posts. These additional posts will impact the overall size of the opening.

Sole Plate: Plate that distributes the weight being transferred from above and spreads it over a wide area. The sole plate should maintain the same requirements as the header.

Posts: Posts that support the weight being collected by the header and transfer it to the sole plate. The posts should be perpendicular to and maintain full surface contact with both the header and sole plate.

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. Deduct 1 1⁄2" for 2x4 wedges.

Gusset Plates: 12”x12"x17"x 3⁄4" 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: Short pieces of lumber used to support or secure shoring component parts. 2x4 material in various lengths is 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: Braces that lock the entire shore together so the posts work as one unit. The diagonal brace protects the shore from shifting and failing like a collapsing parallelogram and is installed when the opening is **not used** for access. The diagonal braces connect the top of one vertical post or wall plate on one side to the bottom of the vertical post or wall plate on the other side of the shore, forming an “X” configuration.

Preconstructed Window and Door Shore

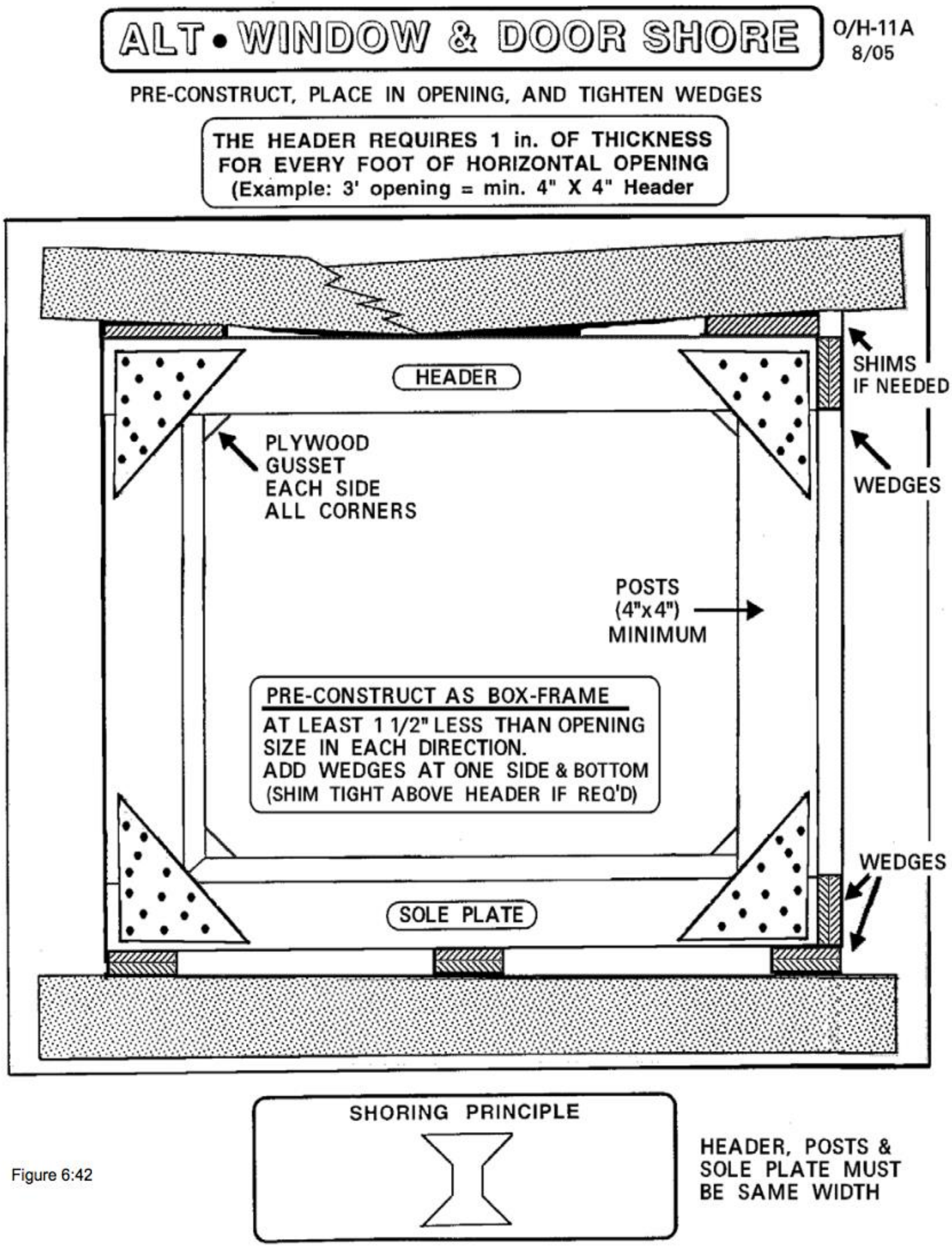


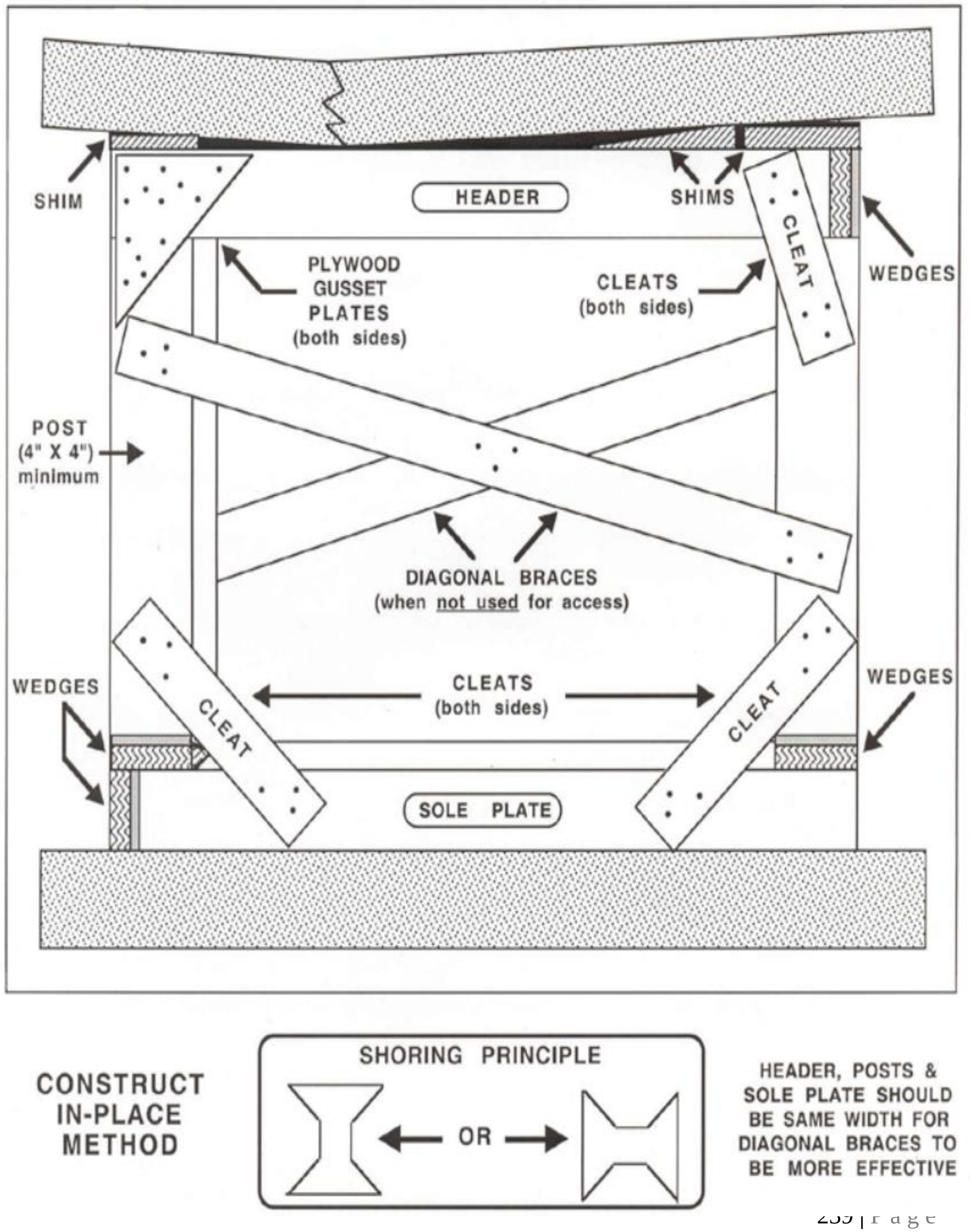
Figure 6:42

Preconstructed Method

1. Measure the proper length of the header and sole plate using the shortest length measured if the opening is uneven.
2. Deduct 1 1⁄2" from the length of the header and sole plate.
3. Cut the header and sole plate to desired length.
4. Measure the overall height to be shored using the shortest length measured if the opening is uneven.
5. Deduct the depth for the header and sole plate.
6. Deduct 1 1⁄2" from the height to allow for pressurization with wedges.
7. Cut the vertical posts to desired length.
8. Lay out the cut components of the shore on the ground.
9. Place vertical posts between the header and sole plate.
10. Secure the top and bottom of the vertical posts to the header and sole plate using triangular gusset plates.
11. Turn the shore over to the other side.
12. Secure the top and bottom of the vertical posts to the header and sole plate using triangular gusset plates.

13. Install the shore into the window opening.
14. Pressurize the shore with 1 1⁄2" wedges under the sole plate using two sets of wedges.
15. Pressurize the shore with 1 1⁄2" wedges to the side of one vertical post using three sets of wedges.
16. Install diagonal braces if the opening is not used for access or egress.
17. Evaluate the shore and structure.

Construct in Place Window and Door Shore



Window and Door Shore Assembly

Construct-in-Place Method

1. Measure and cut the proper length of the header and sole plate, deducting 1 1⁄2" for the wedges.
2. Measure the overall height to be shored using the shortest length measure if opening is uneven.
3. Deduct the thickness of the header, sole plate, and 1 1⁄2" for the wedges.
4. Measure and cut the vertical posts.
5. Install the sole plate and pressurize the 2x4 wedges.
6. Install the header and pressurize the 1 1⁄2" wedges. Install header and sole plate wedges in opposite corners.
7. Install one post under the header wedges to prevent movement and pressurize with 2x4 wedges.
8. Install the other post at the other end of the header and pressurize the wedges.
9. Attach triangular gusset plates to both sides of the corners without wedges to secure the post and header.
10. Attach cleats to both sides of the other corners to box in the wedges and secure the post, sole plate, and header joint.
11. Install wedges between the header and the opening, as needed, to increase surface contact.
12. Install diagonal braces from post to post if the opening is not used for access or egress.
13. Evaluate the shore and structure.

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 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 is relatively wide and stable. It effectively transfers the collected loads over multiple shoring elements that are working together to hold the load.

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 can be eliminated, unlike the process of installing other shoring systems.

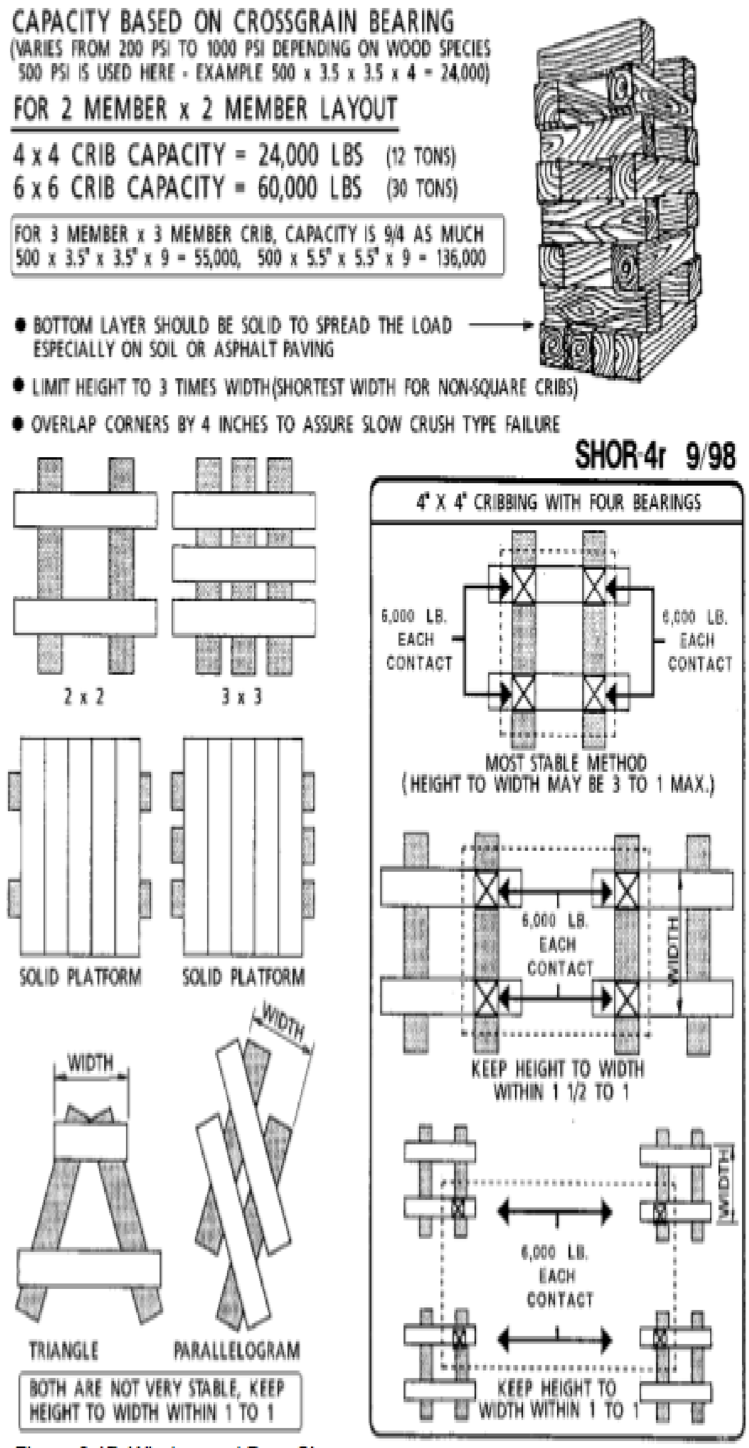
When loaded vertically, an advantage of crib shoring systems is that when they start to fail, they fail from crushing. This failure will be slow and noisy, which acts as a warning system for rescuers that the shoring system is overloaded. Although there are advantages to using cribbing, there are some disadvantages that rescuers need to consider. Cribbing uses a large amount of material and requires a fairly level base to build on.

Cribbing shores can be built in a box using two members per layer or in a cross-tie configuration using three members per layer for increased capacity and stability The

capacity of a two-member box crib using 4x4 lumber is 24,000 pounds and that of a three-member cross-tie crib using 4x4 lumber is 54,000 pounds.

To maximize crushing failure of cribbing, the tails of each layer should extend approximately its dimension past the layer of the cribbing below. When the crib bed is loaded to capacity, it will crush, creating saddles similar to Lincoln Logs, preventing pieces from squirting out. This method works only 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 sloped load flush with the layer below to increase crib bed stability and reduce the cantilever effect.



When using cribbing shoring systems, lateral stability of the crib bed must be considered. Lateral stability will be dependent on the width-to-height ratio of the crib bed.

A rule of thumb is that you can build a crib bed three times as high as the width of the crib contact points. Example: If the width of the crib contact points is 3’, then the crib bed can be built 9' high and still maintain stability **if built on level surfaces.** This width to height ratio is only a guideline for the maximum height of the crib bed. A reduced height must be considered if the load proves to be unstable.

When shoring **sloped surfaces** with cribbing, the maximum allowable height is 1 1⁄2 times the crib contact points. The maximum angle at which cribbing can be used for sloped surfaces is 15° or 30 percent (3' elevation within a 10' distance). The potential for large slabs to slip off the crib bed increases when steeper surfaces are shored. A sloped crib has the potential to slip or fail laterally.

Components of the Sloped Surface Crib bed

Cribbing: Lumber size and minimum length:

❒ 2x4x18"

❒ 2x4x2'

❒ 4x4x18”

❒ 4x4x2'

❒ 6x6x2'

Many departments use 18"-long cribbing. This size is convenient for storage and allows more pieces per 8' lumber stock. Shoring operations on sloped surfaces are limited and less stable 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:

❒ 2x4x12"

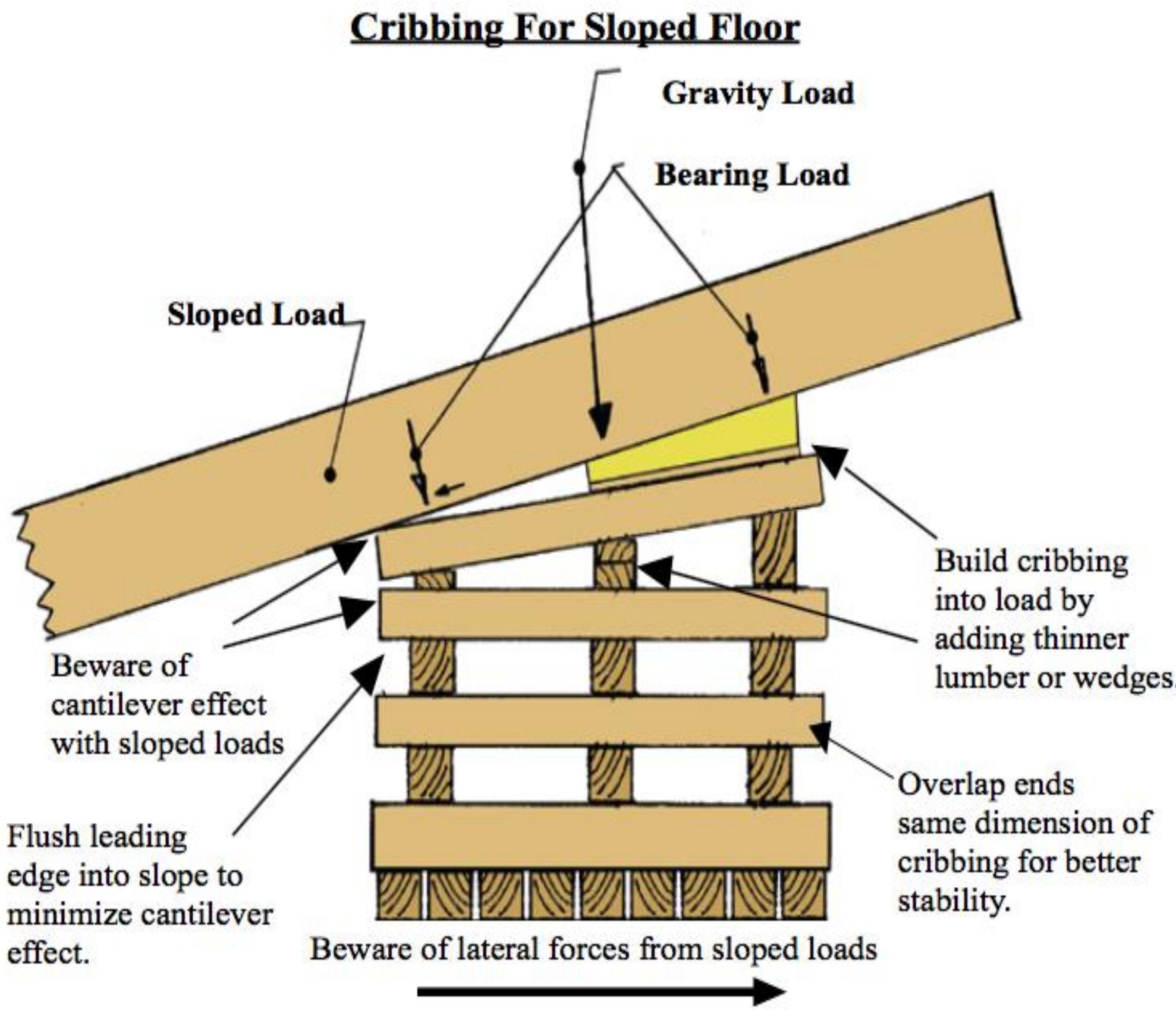
❒ 4x4x18"

Wedges are used primarily as single pieces to fill void spaces and to change the angle of cribbing surface contact. The crib bed is built at and level, with the angle change occurring at the top of the bed next to the sloped surface.

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 is a 4x4.

No body parts are placed under unsupported loads during the assembly of the sloped surface crib bed. **Remember**—to lift an inch, crib an inch.

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.

Sloped Surface Crib Bed

Place first Layers of crib.

Place 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

Place second layer of cribs

Lay it perpendicular to the first layer

Maintain a 3 1/2” overlap from ends of the first layer

When cribbing to sloped surfaces, place the ends of the cribbing closest to the load in line with the layer below. This increases crib bed stability and reduces the cantilever effect.

Place additional layers. Continue alternating the direction on each layer until the crib bed components are in near contact with the object to be shored.

Change the angle

Use the last two crib layers to change the angle of the shore to make contact with the shored surface.

Thinning cribbing material or wedges can be used under the sloped surface area to change the angle of the crib bed.

Fill void spaces

Fill all void spaces to ensure full surface contact.

Gently tap the wedges to snug up the shore.

Evaluate the shore and structure

Rakers

Raker shores are used to support leaning or unstable walls and columns. The two types of raker shores built are the solid sole raker shore and the split sole raker shore. The Rescue Systems 1 course will focus on the split sole raker .These 4x4 raker shores are impractical to use on high walls (above two stories) due to the tremendous weights involved and length of available lumber. In the case of high, unstable walls, it is best to avoid the area. Unstable sections may be carefully removed, have engineered shores installed, or have commercial shore systems installed.

The raker shore pushing 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.

The split sole raker shore can be constructed at 45° to 60° angles. They are always installed in a series of at least two rakers with a maximum separation of 8' and are braced together for additional stability.

Placement of the raker tip is to be within 2' above or below the floor or roof level on the outside of the compromised wall. This placement is commonly referred to as the **Insertion Point.**

❒ Rakers are used when shoring over debris on even or uneven ground.

❒ They can be used in urban environments where concrete or asphalt commonly covers the ground.

❒ Stability is increased when rakers are attached to wall or column.

r The maximum load rating is 2,500 pounds per raker.

Components of the Split Sole Raker Shore

Wall Plate: Plate that collects the weight being transferred horizontally and spreads it throughout the shoring system. The minimum lumber size that should be used is a 4x4. The length is measured from the insertion point to ground level, plus the length of the top cleat. Backing can be made of 2" lumber or 3⁄4" plywood to widen surface contact, if needed. If being constructed over debris, the wall plate will need to be shortened to the depth of the debris pile.

Top Cleat: A short piece of 2x4 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-foot cleat with fourteen 16d nails is used for 45° rakers and a 2 1⁄2-foot cleat with twenty 16d nails is used for 60° rakers.

Trough base: Base that is used on a split raker shore. The Trough Base distributes the weight being transferred laterally and distributes it to the ground. These are mostly used in urban environments where concrete and asphalt commonly cover the ground. The Trough Base is pressurized by wedges contacting a solid object or minimum 4" x 4" deadman secured with steel pickets to prevent the shore from sliding backwards. Use two 1" pickets in concrete or asphalt, and four pickets in soil.

U-Channel Sole Plate: Plate that is used on a split sole raker shore built on soft ground. The U-channel sole plate captures the weight being transferred laterally and distributes it to the ground. These are mostly used in suburban and rural environments where open ground is available.

Raker: The main member of the shore. It supports the weight being collected by the wall plate and transfers it to the trough or U-channel. The minimum lumber size that should be used is a 4x4. The width of the raker should be the same as the wall plate and short sole plate for a more secure attachment of gusset plates, cleats, or braces.

- ❑ On a split sole raker, the length is measured from the insertion point on the wall plate to the contact point on the short sole plate or the contact point on the U-channel.

- ❑ The length of the raker is best determined by using the factor method.

- ❑ If using a U-channel for distribution, add 12" to the length of the raker.

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.

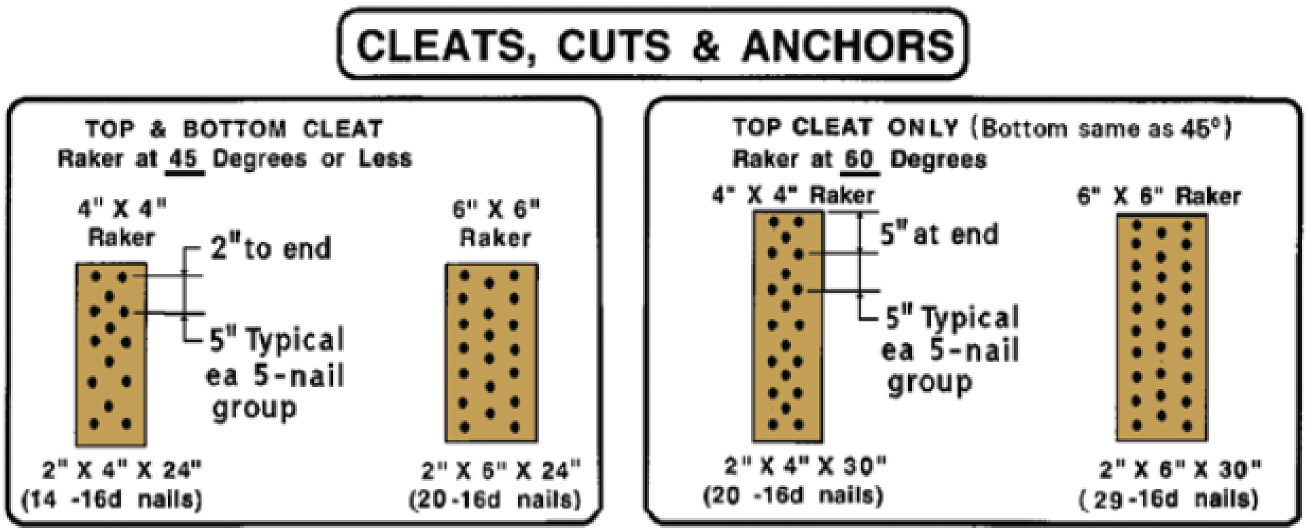
Gusset Plates: 12"x12"x 3⁄4" plywood squares or triangles that secure the connections between the different parts of the shore such as the wall plate and raker. They are connected with nails using a five-nail pattern. Gusset plates should be kept at least a 1⁄4" away from the outside edge of the framing members in order to prevent pressurizing them. On the raker shore, they should be placed on both sides of the joints.

Bottom braces: Braces that connect the wall plate to the raker. One end of the bottom brace is nailed to the bottom of the wall plate. The other end is nailed as close to the bottom end of the raker as possible. The minimum size lumber to be used is one 2x6 or two 2x4s on both sides of the raker.

Midpoint braces: Braces that are used to resist the "buckling" effect. These are required when the 4x4 raker is greater than 11' in length or the 6x6 raker is greater than 16' in length. They are attached to both sides near the midpoint of the raker and connected to the wall plate just above the bottom braces. The minimum size lumber to be used is one 2x6 or two 2x4s.

Horizontal Braces: Braces that connect the raker shores together near the top and bottom of the raker to provide additional stability. Horizontal braces are also placed at the middle of the raker if midpoint braces are used. The minimum size lumber to be used is one 2x6 or two 2x4s.

“x” and “V” braces: Braces that provide additional stability and resist lateral deflection of the shores. They are used at the end of each raker shore system and no farther than 40' apart. They are attached between the top and bottom of two raker shores when using an “X ”. If a midpoint brace is used, an “X” will be placed above and below the midpoint brace. The minimum size lumber to be used is one 2x6 or



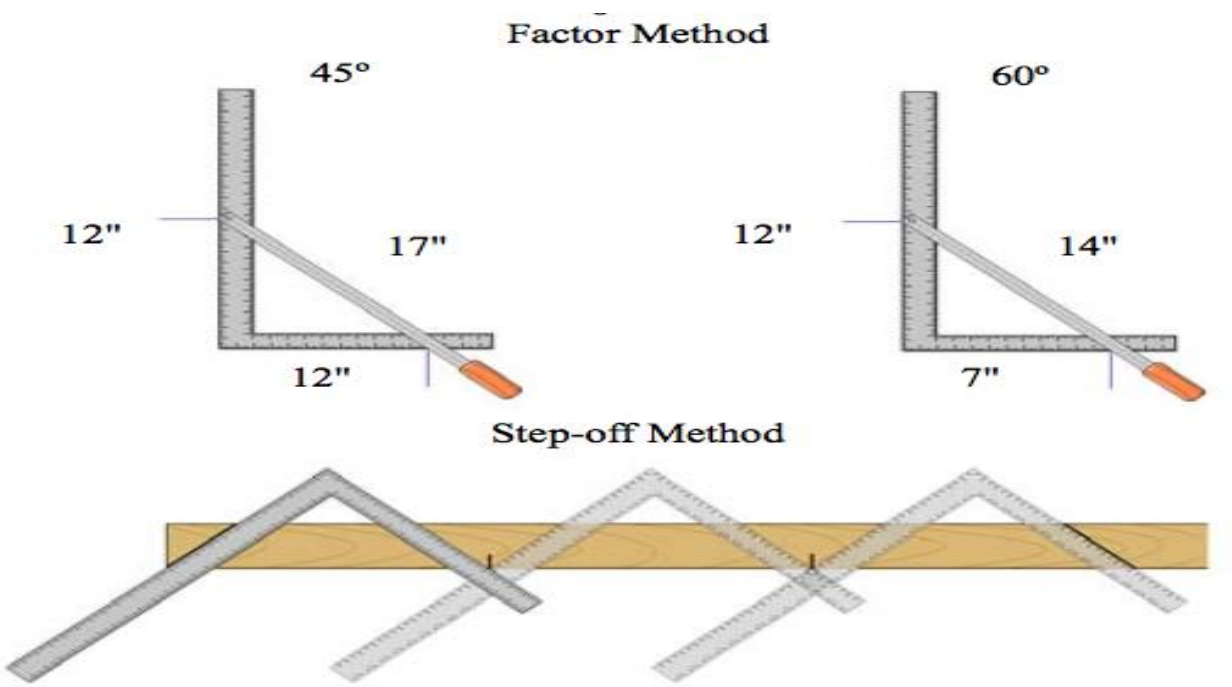
two 2x4s.

Ledger board: A piece of 2x4 lumber that is nailed to the wall above the wall plate. The ledger board prevents the raker shore from riding up the wall. The minimum size lumber to be used is one 2x6 or two 2x4s, 36" in length. Option: A 36"-wide piece of plywood can be nailed to the backside of the wall plate and nailed to the wall studs.

Anchors for Raker Systems: Must be deadman with pickets, and an optional ledger board nailed to studs above the wall plate, or plywood that is nailed to the back of the wall plate, then nailed into the wall studs.

Measuring Tools to Determine Raker Length and Angle

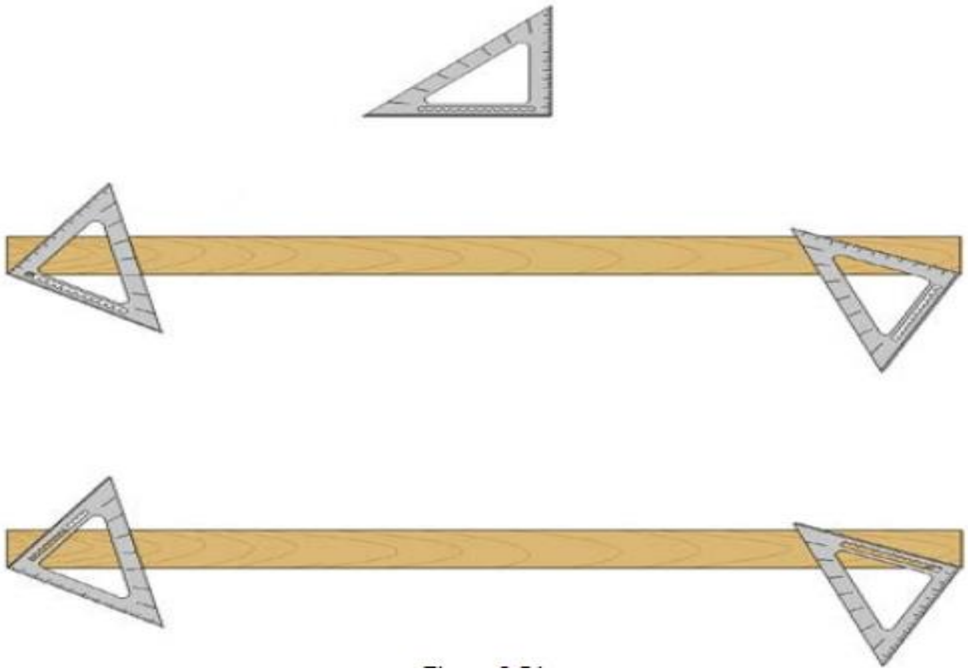
Tape Measure: The most common tool used to determine lumber length is a tape measure with a 1"-wide steel tape with power return for ease of use and simple-to-read measurements. During construction of emergency shoring systems, a good practice is to measure and report all measurements in inches. This 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 4x4 with a length of 9'6". If the measurement is reported over the radio as "one 4 by 4 by 9 6" 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 length of a raker

Framing Square: A steel framing square can also be used to determine the length and angle of a raker The Factor 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.

Speed Square: The speed square resembles a triangle and can be made of metal or plastic. It is used to ensure that shoring components are square at 90° angles. It is also



useful to determine the angle of a raker.

How to Determine Length of Raker and Wall Plate

Length of Raker: Insertion Point in feet, times the factor, equals length of raker in inches.

Factors: 45 degree Raker = 17

60 degree Raker = 14

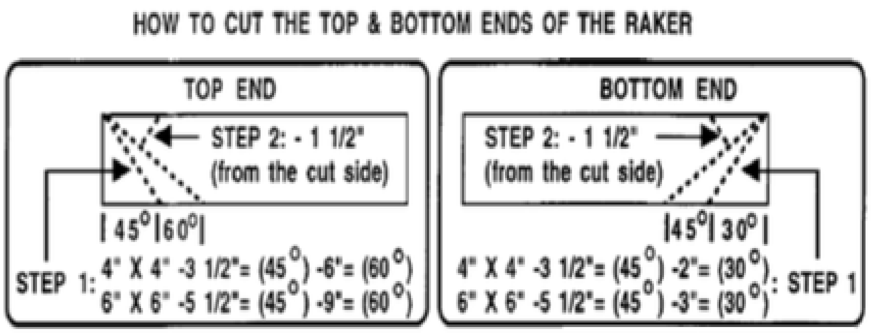
Length of Wall Plate: Insertion Point in feet, plus the cleat length, equals length of wall plate.

Factors: 45 degree Raker = 24" cleat

60 degree Raker = 30" cleat

45° and 60° Raker Angles

The raker is the most important component of the raker shore. It supports the weight being collected by the wall plate and transfers it to the trough base or U-channel base.



Cutting the Raker (Cut angles on the same side of the raker)

Cutting a 45° Raker (Tape Measure Method)

1. Place a 4x4 into the 31⁄2" space of the cutting table and slide to edge of table.

2. Place a mark 31⁄2" back from the end of the 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 saw.

5. Place tape measure on raker tip with hook flush against the cut.

6. Move tape measure until 1 1⁄2" is on outside edge of lumber 90° to cut (back cut line).

7. Draw a line along the tape measure edge.

8. Cut this line

9. Determine length of the raker by multiplying a factor of 17 times the height in feet to the insertion point. Example: 10-foot insertion point times 17 equals a 170" raker

10. Using tape measure, hook tape on raker tip and measure length of raker desired.

11. Repeat points 2 to 8 for the other end of the raker.

> NOTE: Add 12" to the length of the raker if a U-channel is used for the sole plate Keep the bottom end of the raker at 90 degrees.

> NOTE: Always cut top and bottom angles on the same side of the lumber.

Cutting a 60° Raker (Tape Measure Method)

1. Place a 4x4 into the 3 1⁄2" space on the cutting table and slide to edge of table.
2. Place a mark 6" back from the end of the lumber.
3. Draw a diagonal line from the end of the 4x4 upper corner to the 6" mark on the outside edge of the lumber.
4. Cut the 60 degree line with a saw.
5. Place the tape measure on the raker tip with the hook flush against the cut.
6. Move the tape measure until 1 1⁄2" is on the outside edge of the lumber 90 degrees to cut.
7. Draw a line along the tape measure's edge.
8. Cut this line.
9. To determine the length of the raker, multiply factor of 14 times the height in feet to insertion point. Example: 10' insertion point x 14 = 140" raker.
10. Using a tape measure, hook the tape on the raker tip and measure the length of desired raker and mark.
11. Place a mark 2" back from this end of the marker.
12. Draw a diagonal line from the end of the 4x4 upper corner to the 2" mark on the outside edge of the lumber.
13. Cut this 30° line with a saw.

14. Place the tape measure on the raker tip with the hook flush against the cut.
15. Move the tape measure until 1 1⁄2" is on the outside edge of the lumber 90 degrees to cut.
16. Draw a line along the tape measure's edge.
17. Cut this line.

NOTE: Always cut top and bottom angles on the same side of the raker.

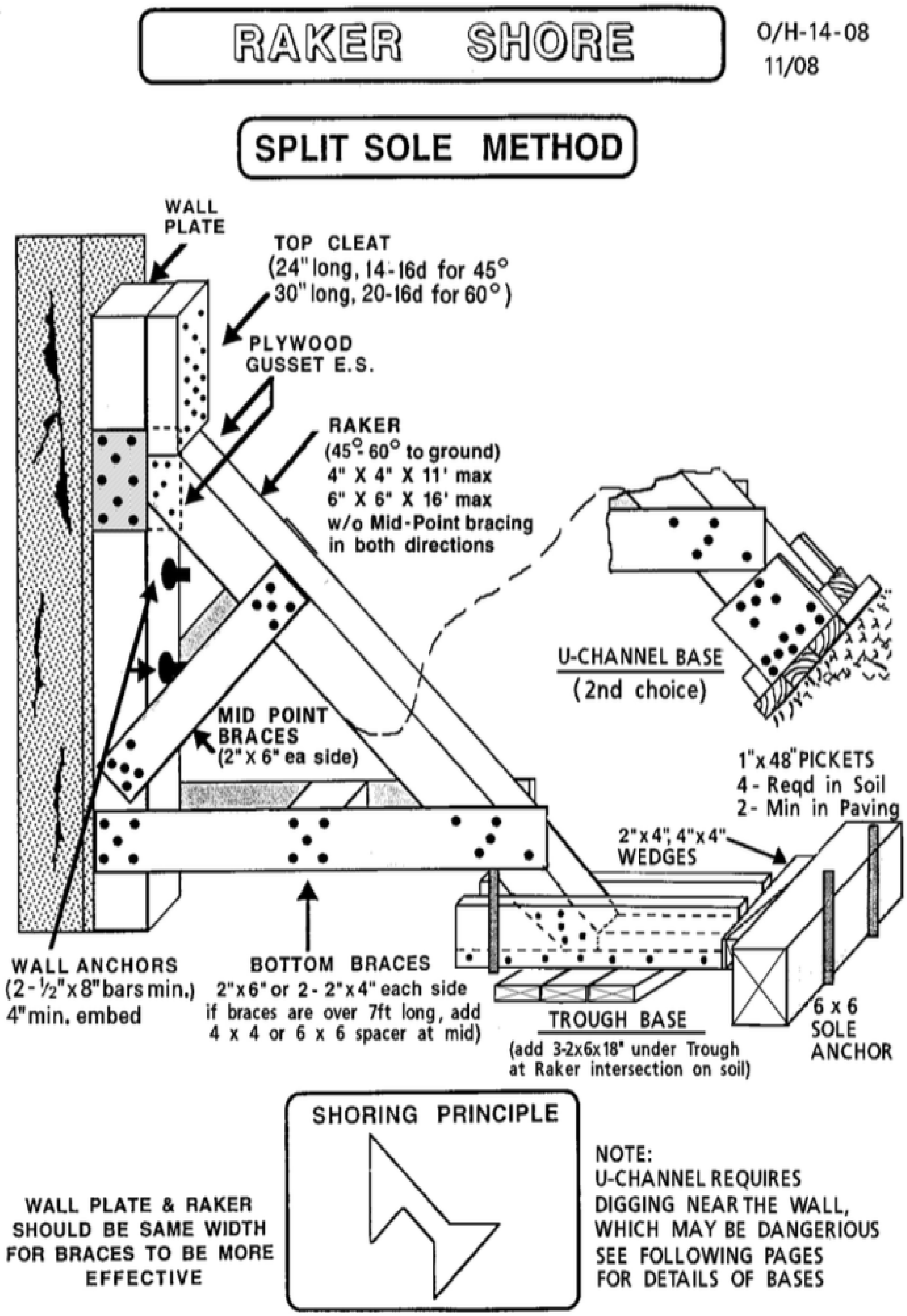
Cutting a 60° Raker (Speed Square Method)

1. Place a 4x4 into the 3 1⁄2" space on the cutting table and slide to top edge.
2. Place a speed square on the 4x4 with the guide edge against the lumber.
3. Slide the speed square to the end of the lumber.
4. To determine the 60° angle, place the pivot point in a fixed position at the end of the lumber and rotate the speed square away from the lumber until the 60° mark aligns with outside edge of the lumber.
5. Draw the angle on the ruler side of the speed square.
6. Cut this line.
7. Place the guide edge of the speed square on the 60° angle just cut.
8. Slide the speed square on the angle just cut until 1 1⁄2" is measured on the ruler side, across the angle of the lumber (backcut line).
9. Draw a line on the ruler side of the speed square.
10. Cut this line.
11. Determine the length of the raker multiplying a factor of 14 times the height in feet to the insertion point.
12. Using a tape measure, hook the tape on the raker tip and measure the length of the desired raker.
13. Cut to measured length.
14. Place the speed square on the raker with the guide edge against the lumber.
15. Slide the speed square to the other end of the lumber.

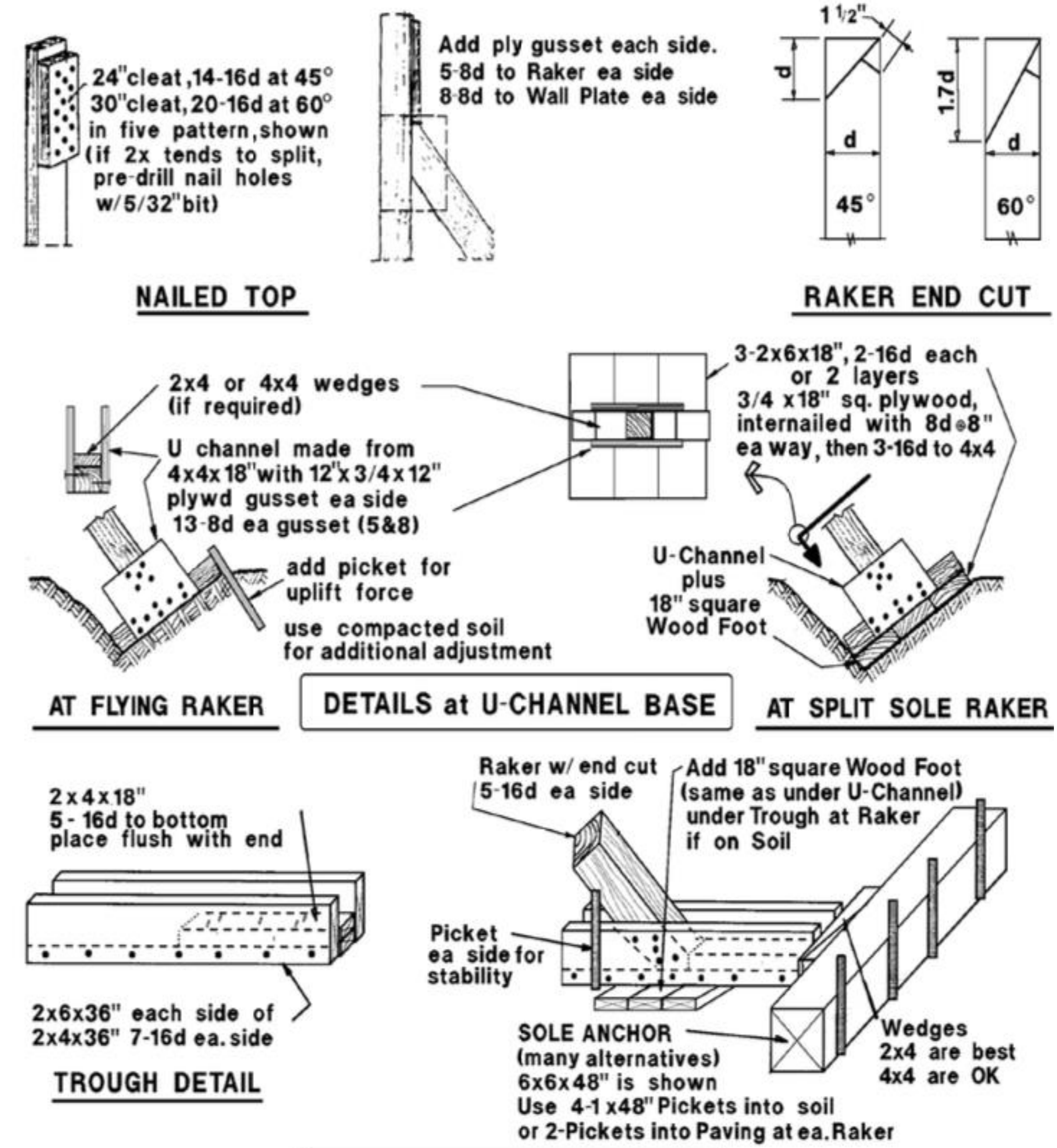
16. To determine the 30° angle, place the pivot point in a fixed position at the end of the lumber and rotate the speed square away from the lumber until the 30° mark aligns with outside edge of the lumber.
17. Draw the angle on the ruler side of the speed square.
18. Cut this line.
19. Place the guide edge of the speed square on the 30° angle just cut.
20. Slide the speed square on the angle just cut until 1 1⁄2" is measured on the ruler side, across the angle of the lumber (backcut line).
21. Draw a line on the ruler side of the speed square.
22. Cut this line.

NOTE: If a U-channel is to be used at the bottom end of the raker, keep the bottom end of the raker at a 90 degree angle. Add 12" to the length of the raker.

NOTE: Always cut top and bottom angles on the same side of the raker.


RAKER SHORE
O/H-14-08
11/08
SPLIT SOLE METHOD
WALL PLATE
TOP CLEAT
(24" long, 14-16d for 45°
30" long, 20-16d for 60°)
PLYWOOD GUSSET E.S.
RAKER
(45°- 60° to ground)
4" X 4" X 11' max
6" X 6" X 16' max
w/o Mid-Point bracing
in both directions
U-CHANNEL BASE
(2nd choice)
MID POINT BRACES
(2" X 6" ea side)
1"x48" PICKETS
4 - Reqd in Soil
2 - Min in Paving
2"x4", 4"x4" WEDGES
WALL ANCHORS
(2-½"x8" bars min.)
4" min. embed
BOTTOM BRACES
2"x6" or 2 - 2"x4" each side
if braces are over 7ft long, add
4 x 4 or 6 x 6 spacer at mid)
TROUGH BASE
(add 3-2x6x18" under Trough
at Raker intersection on soil)
6 x 6 SOLE ANCHOR
SHORING PRINCIPLE
WALL PLATE & RAKER
SHOULD BE SAME WIDTH
FOR BRACES TO BE MORE
EFFECTIVE
NOTE:
U-CHANNEL REQUIRES
DIGGING NEAR THE WALL,
WHICH MAY BE DANGERIOUS
SEE FOLLOWING PAGES
FOR DETAILS OF BASES

RAKER SHORE CONNECTIONS



DETAILS at TROUGH BASE

Preferred Base at Split Sole & Flying Rakers. No need for digging

FABRICATION AND ERECTION

- ALL RAKERS SHOULD BE FABRICATED IN AN AREA AWAY FROM A DAMAGED MASONRY WALL, SINCE AFTERSHOCK COULD CAUSE COLLAPSE
- AFTER FABRICATION, THE RAKERS NEED TO BE CARRIED OR WALKED TO THE WALL, AND ADJUSTED FOR TIGHT FIT.

Cutting a 45 Raker (Speed Square Method)

1 Place a 4" x 4" into the 3 1/2" space and slide to top edge.

2 Place a speed square on the 4" x 4" with the guide edge against the lumber.

3 Slide the speed square to the end of the lumber.

4 For a 45 degree angle, slide the fixed 45 degree angle of the speed square to the end of the lumber.

5 Draw a line along this angle of the speed square.

6 Slide the speed square on the angle, just cut until 1 1/2" is measured on the ruler side, across the angle of the lumber (backcut line).

7 Draw a line on the ruler side of the speed square.

8 Cut this line.

9 Determine the length of the raker by multiplying a factor of 17 times the height in feet to the insertion point.

10 Using a tape measure, hook the tape on the end of the raker tip and measure the length of the desired raker.

11 Cut to measured length.

12 Place the speed square on the raker with the guide edge against the lumber.

13 Repeat points 3 - 6 for the other end of the raker.

NOTE: Always cut top and bottom angles on the same side of the raker.

Refer to the Army Core of Engineers shoring manual for more detailed information on Raker shores and many other shores.

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Tie Backs

Raker shores have a place in the shoring environment however they take a considerable amount of time to build and require an abundance of material.

TIEBACKS

- When URM walls are over thirty feet tall it is probably impractical to attempt to brace them with raker shores.
- Vertical and/or horizontal strongbacks could be placed on the face of a hazardous wall and tied across the structure to a floor beam or the opposite side wall. (see Shor-16a on next page)
- The strongbacks could be made from double 2x6 wood members with the tie being placed between them. Solid 4x or 6x members could also be used.
- The ties that have been placed by contractors were steel rods with turnbuckles, bearing washers etc. Cables with come-along could also be used as well as utility rope, chain, etc. One may need to be creative to obtain an adequate tie, but climbing rope, used by firefighters should be considered only as a last resort. (Climbing rope is considered unreliable with the rough treatment of this type of application and would be discarded)

Another option that should be considered is a tie back.

<u>Introduction to the Cutting Station</u>

Cutting Station Setup

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 materials supply.

The cutting station's advantages are that it uses fewer personnel to achieve goals and speeds ability to produce shoring components.

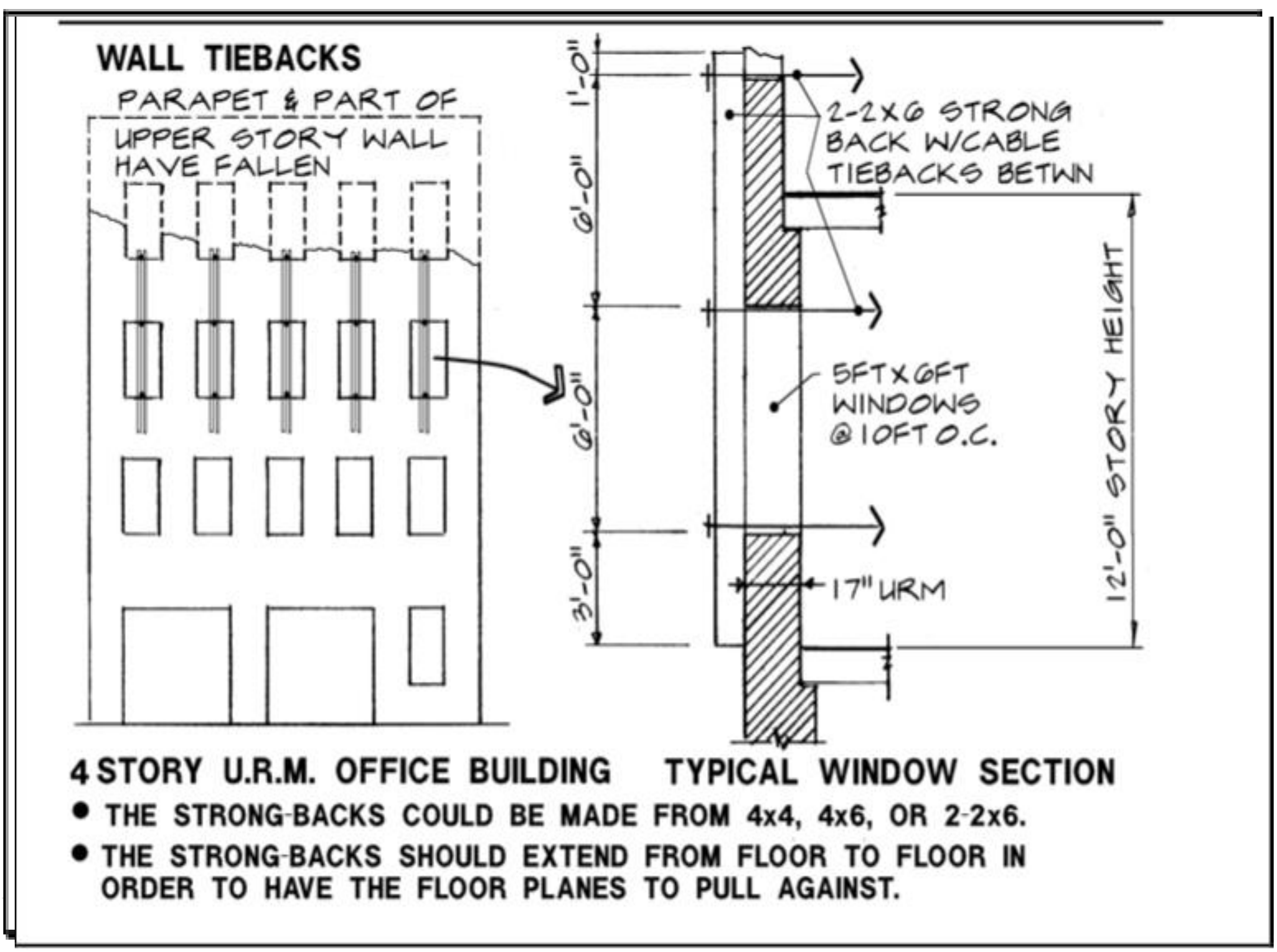
Improvised Cutting Table

An improvised cutting table is assembled with cribbing or available building materials that are stacked so cuts can be made off the ground.

The cribbing should be secured with toenails and guides can be mounted to the top piece of cribbing to hold the lumber being cut.

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'x 3⁄4" plywood.

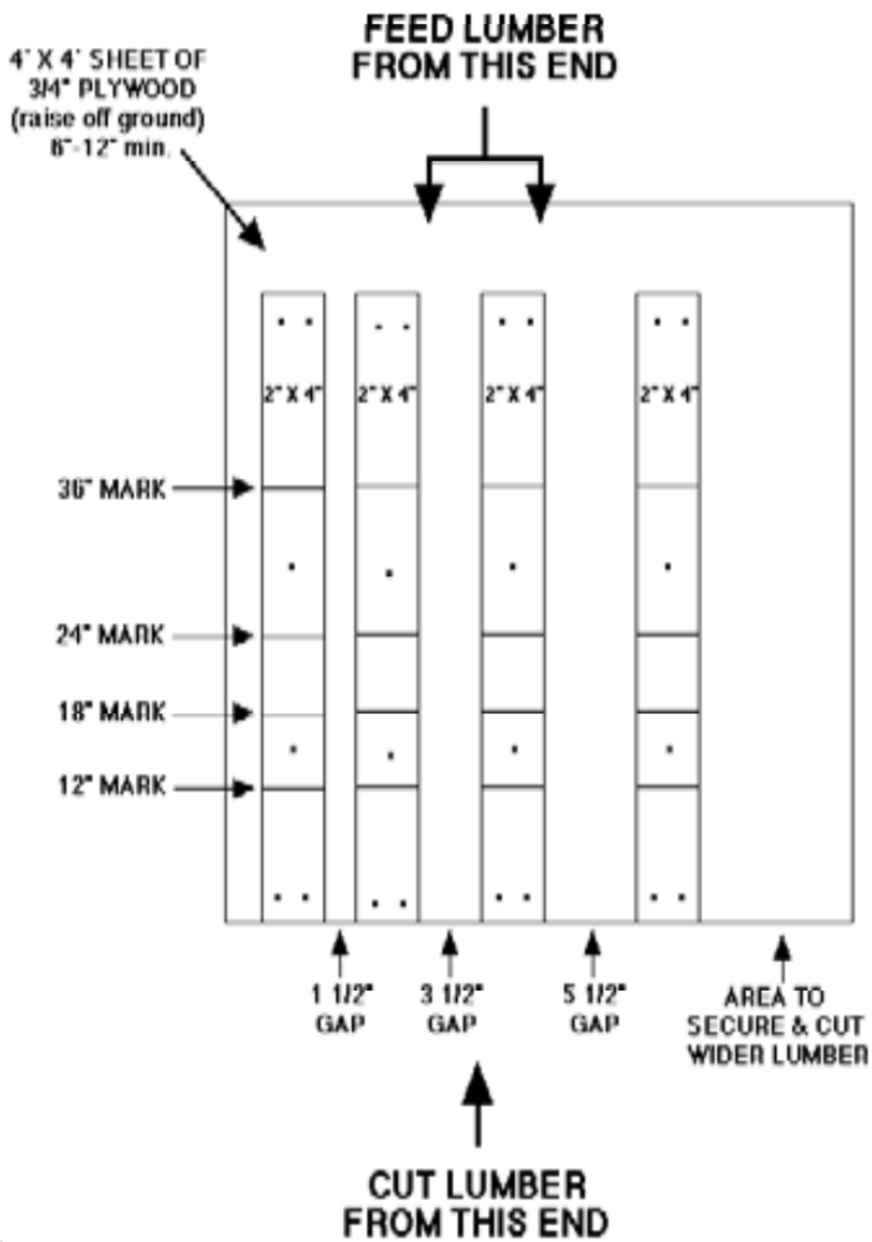


Guides: Provide template and jig for lumber to be cut in varying lengths and dimensions. They are pre-marked with measurements to reduce the time used to measure and mark shoring materials. Minimum lumber size is 2x4 spaced 1 1⁄2", 3 1⁄2", and 5 1⁄2" apart. Be sure to allow an extra 1⁄4" for irregular or wet lumber.

Cribbing: Provides support for the top and maintains required 6" minimum height. Cribbing is attached perpendicular to the guides under the plywood top. Legs may be added to bring the cutting table to a comfortable height.

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. Lay out cribbing on a flat surface within a 4'x4' area.
5. Place top on cribbing and nail into place. Add legs if desired.
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 2x4 into 3 1⁄2" slot and slide to end of table.
2. Mark length desired using the pre-marking on the runners.
3. Cut to length with handsaw or chainsaw.

Cutting a Set of Wedges

1. Place 2x4 into 1 1⁄2" slot and slide to the end of the table.
2. Mark 12" length using the pre-marking on the runners.
3. Mark a diagonal line with a straight edge from one side of 12" line to the opposite side at the end of the 2x4.
4. Align the saw bar with the diagonal line pointing toward the cutting table and cut lumber.
5. Cut remaining half off at the 12" line.
6. Repeat process for 4x4 using 3 1⁄2" slot and 18" length.

Cutting a Gusset Plate

1. Place a full 4'x8'x 3⁄4" sheet of plywood on cutting station table.
2. Mark into 6"x12" and 12"x12" squares using a chalk line or straight edge and measuring tape.
3. Cut with chainsaw along 8' length lines from end to end.
4. Stack 12"x 8' lengths of plywood on top of each other with all edges aligned and marked piece on top.
5. Cut on 6" or 12" lines provided.
6. For a triangle gusset, mark a single 12"x12"x 3⁄4" gusset plate diagonally from corner to corner with a straight edge or chalk line.
7. Cut on diagonal line with chainsaw, creating two 12"x 12"x 17" gusset plates.

SUMMARY FOR EMERGENCY BUILDING SHORES

Rescue Operations in and around a collapsed structure require responders to operate in areas where secondary collapse is possible. Rescuers should use tools, equipment, and materials to safeguard these areas effectively through the application of emergency building shores. An understanding of the various types of shores, their limitations, and their proper application is necessary for using these systems to help stabilize structural components during rescue operations.

Shore need to be strong, light portable, adjustable, and must reliably support the structure as gently as possible.

Systems should be used that are positively interconnected, laterally braced, and have slow, predictable failure mode.

Cribbing is one of the best systems since they are:

Made from light pieces that are adjustable and can be built onto sloped surfaces
Relatively wide and stable, will spread the load

In a disaster, consideration must be given of any viable system based on availability of material, special contractors, and special equipment. The basic principles of engineering will always apply, but creative thinking and cooperation between all members of the rescue effort is essential.

UNIT 7 - BREACHING AND BREAKING

Terminal Objectives

1. Breach light-frame construction materials.
2. Break un-reinforced masonry and reinforced concrete.

Enabling Objectives

The students will:

1. Describe types, capabilities, and safety considerations for tools used when breaching and breaking.
2. Explain the importance of appropriate stabilization techniques prior to breaching.
3. Identify appropriate techniques and considerations for breaching and breaking

.

INTRODUCTION

Rescue activities at a structural collapse site will 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 breaching and breaking operations should have an understanding of the various techniques required for this operation and should be familiar with the tools needed for effective application.

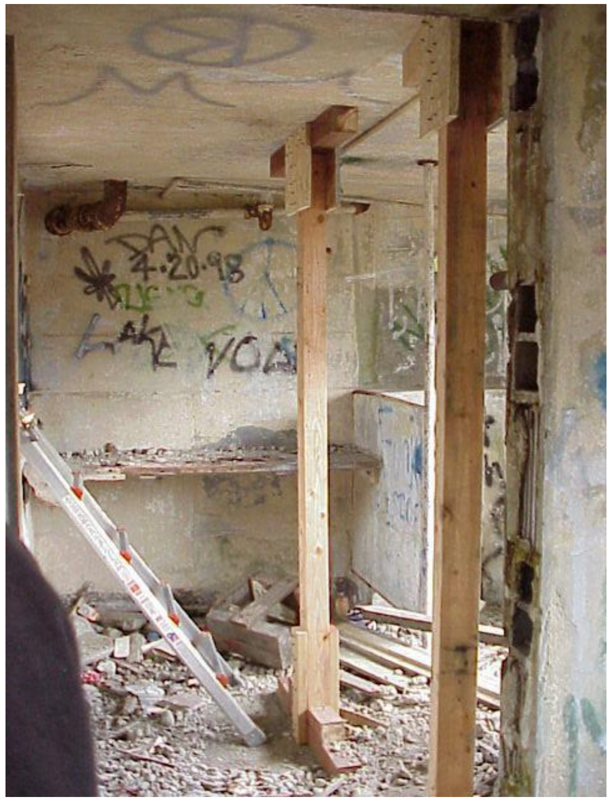
BREACHING/BREAKING THR0UGH COLLAPSED STRUCTURAL ELEMENTS

Tools and Equipment

Breaching and breaking 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.

Hand tools used include hammers, handsaws, breaking bars, chisels, hand-held mauls, sledgehammers, tin snips, and knives. These items are needed to cut and/or break through a variety of materials found in lightweight building construction.

Power tools used include power saws, electric drills, 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 prior to startup.

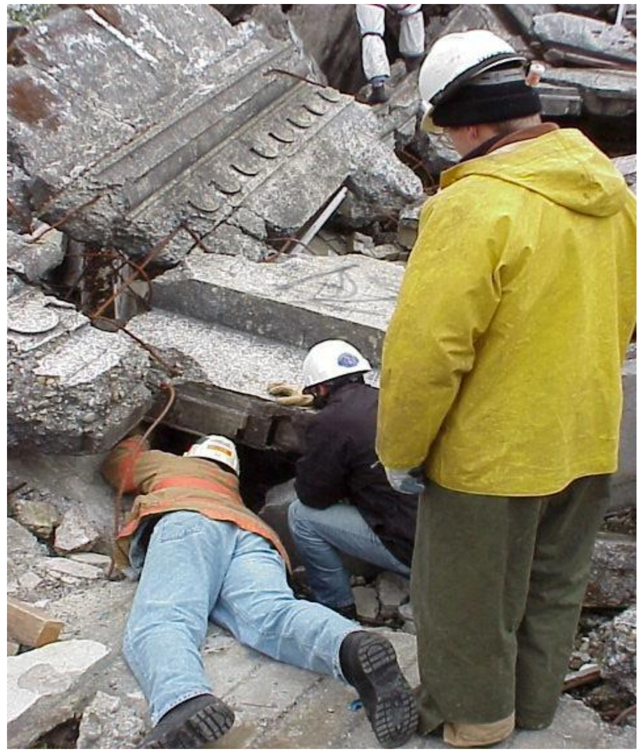
Safety considerations should be followed when using any tools. Personal protective equipment such as eye protection, gloves, helmet, and work shoes should be used consistently. Operators should work within the capabilities of the tool and use the tool properly. Take car in handling fuel; it should be stored safely in approved containers, and good ventilation should be maintained in areas where gas-powered tools are used.

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 un-reinforced masonry buildings, and very little success breaching through concrete buildings.

Consider the need for shoring prior to the start breaching operations. Always use small inspection holes to determine if a victim is close to the area you intend to *force ent7y through.*

Work carefully so that building debris is not dislodged during breaching operations. Install shoring systems to stabilize the site where you breach if you determine during your assessment that they are needed. Strut wall openings that you breach to stabilize the wall and to protect openings that are used for access. 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.



Breaching Procedures

Rescue teams need to take the time prior to beginning operations to evaluate the area where breaching will take 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. These questions should be answered prior to commencing cut-through operations.

Consider all possible entrances into a void prior to 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 or floors, this may cause additional injuries to trapped victims. To check for the possible presence of someone lying in close proximity to where you need to cut, cut small inspection holes first.

Pre-cast Concrete Buildings

It is possible to cut through wall panels only after assessing the stability of the panel and its connection to the main structure. 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.

Basic Concrete Breaking and Breaching

Rescue personnel will have limited success attempting to gain access through concrete walls and floor assemblies. There are basic techniques they can use to assist them in this endeavor.

Rescuers should weaken small sections of the concrete by using battering tools such as sledgehammers, breaking bars, or hammer and chisel. Set up a plane of weakness in the concrete by chiseling or battering a series of holes around the area to be broken. Continue to weaken the area inside this plane of weakness with additional battering and/or chiseling. Remove loose sections of concrete from around any reinforcing bars that are present, and cut the rebar with a hacksaw or cutters.

After the rebar is cut, continue to enlarge the hole, alternately breaking concrete and cutting rebar until the opening is large enough to operate through safely. It must be recognized that this operation will be very time-consuming and very taxing on the rescue personnel.

Light-Frame Buildings

Rescuers can safely cut through the walls of a light-frame building. They should be prepared to cut through a variety of materials, including:

- Wood
- Light-gauge metal
- Plaster
- Drywall
- Plastics
- Linoleum
- Ceramic tiles
- Fabrics
- Masonry elements

Breaching and breaking actions in light-frame buildings may require intricate and difficult hand tool usage to cut through normal household items that are blocking access. These items may include mattresses, appliances, carpets, floor coverings, and furniture.

Un-reinforced Masonry Buildings

Rescuers should avoid cutting through wall s. Breaching through un-reinforced 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, taking care not to cut more than one two-inch joist.

Heavy Wall--Tilt-Up/Reinforced

It is possible to cut through these walls, although they may be five to eight inches 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.

SUMMARY

Breaching and breaking, operations commonly will be needed to effect rescues at a building collapse site. In order for rescue teams to perform these procedures safely and effectively they must be proficient with the tools and equipment needed, they must evaluate the scene prior to action, and they must know the breaching characteristics of the type of building construction involved.

Unit 8 - Ladder Systems

Ladder Rescue Systems

At the end of this chapter, the student will be familiar with the skills and techniques to move patients from a low place to a high place, a high place to a low place, or across uneven terrain. Rescuers will use fire service ladders and rope rescue equipment to build systems to accomplish this transport quickly and safely.

Learning Objectives:

1. Describe the components and operational functions of the <u>Six Ladder Systems</u>.

- Moving ladder slide
- Fixed Ladder slide
- Exterior leaning ladder
- Interior leaning ladder
- Cantilever ladder
- Ladder jib

<u>Self supporting systems</u>

- Ladder gin
- Ladder “A” frame

2. Describe the components and operational functions of the mechanical advantage system used in a ladder rescue system.

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

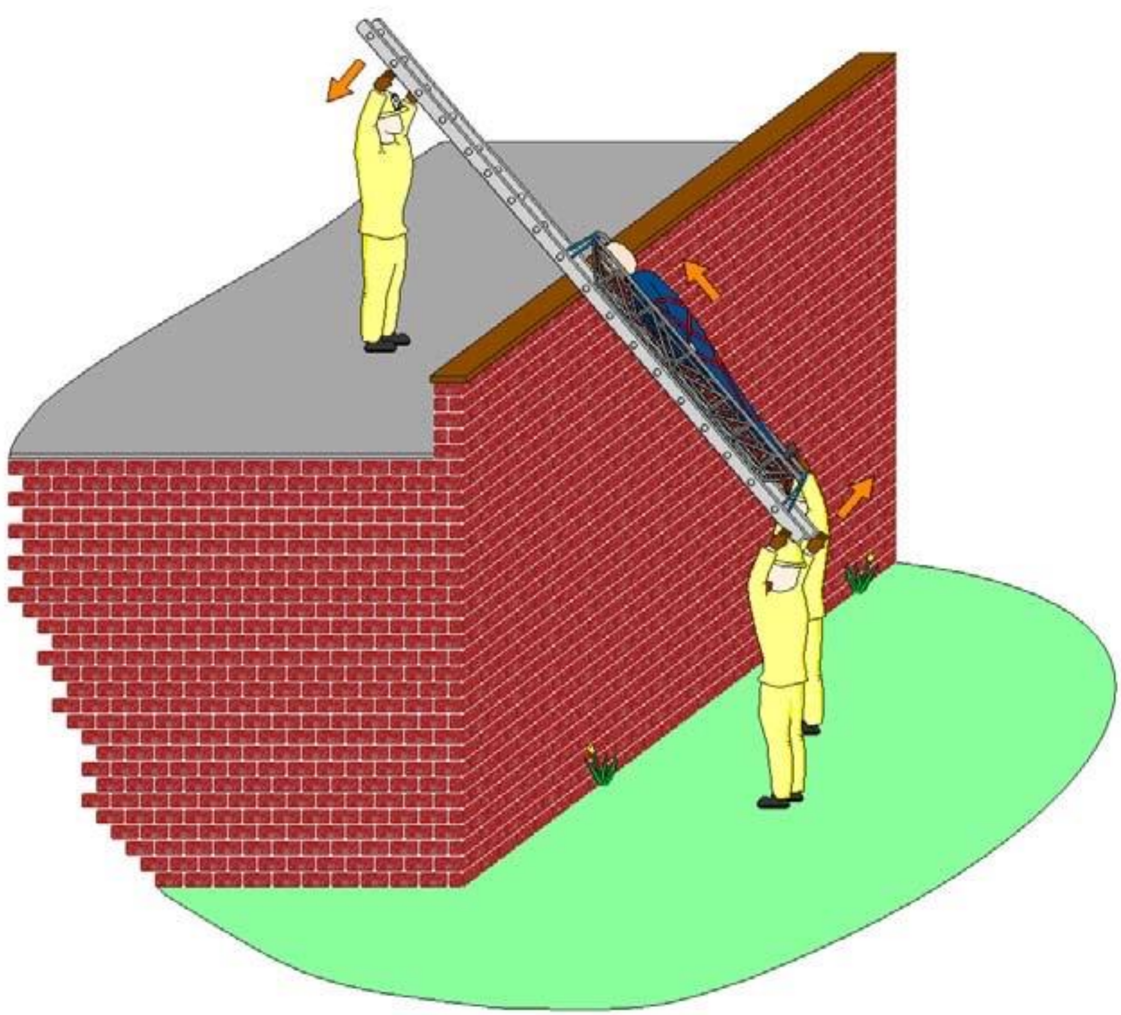
<u>Ground Ladders</u>

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

All ladders used for ladder rescue systems must satisfy NFPA standards for fire service ladders (Standards 1931 and 1932) in design, use, maintenance, and annual testing. A 12' to 16' straight ladder works best. Extension ladders up to 35' can also be used when building ground ladder systems. It is best when the extension ladder height is kept to an absolute minimum.

1. Moving Ladder Slide

The litter may be lashed at the butt end of the ladder when negotiating grade changes or obstacles. When operating on level ground, the litter is lashed at the center of the ladder. The ladder gives the rescue team an added reach to help pass a victim up or down and over obstacles that are No Higher than the ladder being used.



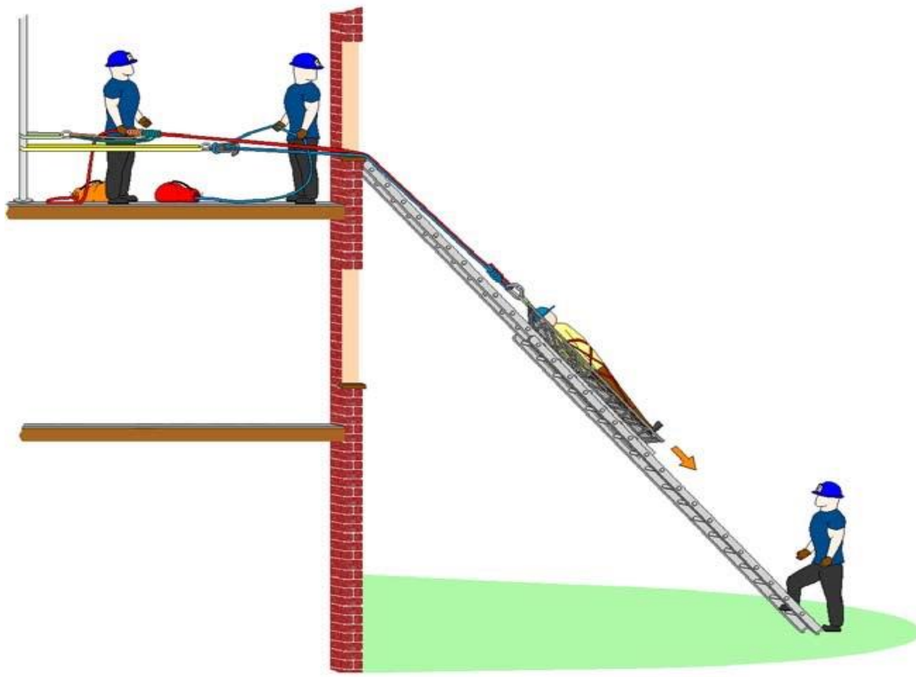
2. Fixed Ladder Slide

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.

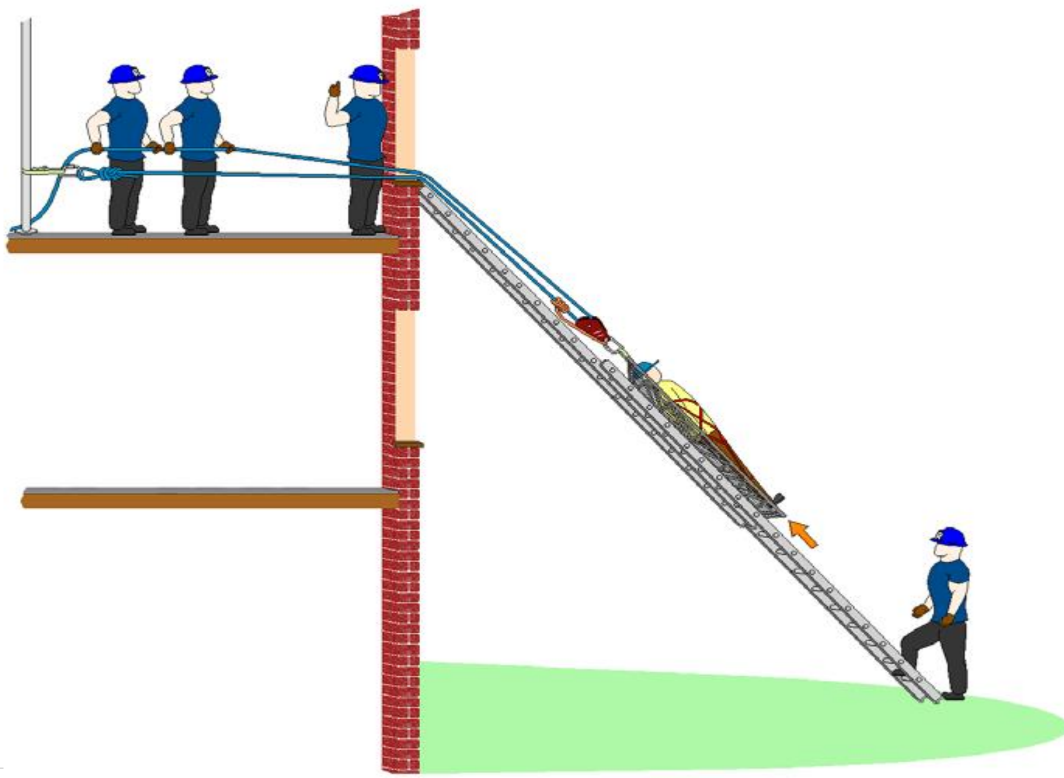
A victim in a rescue litter can be raised using a simple 2:1 pulley system or can be lowered using a friction system. If a victim needs to be lowered from an upper floor of a building and a ladder is available that will reach to the window, a ladder slide is the quickest and easiest method of evacuation.

The belay/safety 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. If an extension ladder is used, the bed and fly sections should be secured together to prevent them from shifting during positioning or raising and lowering operations.

Fixed Ladder Slide: Lowering



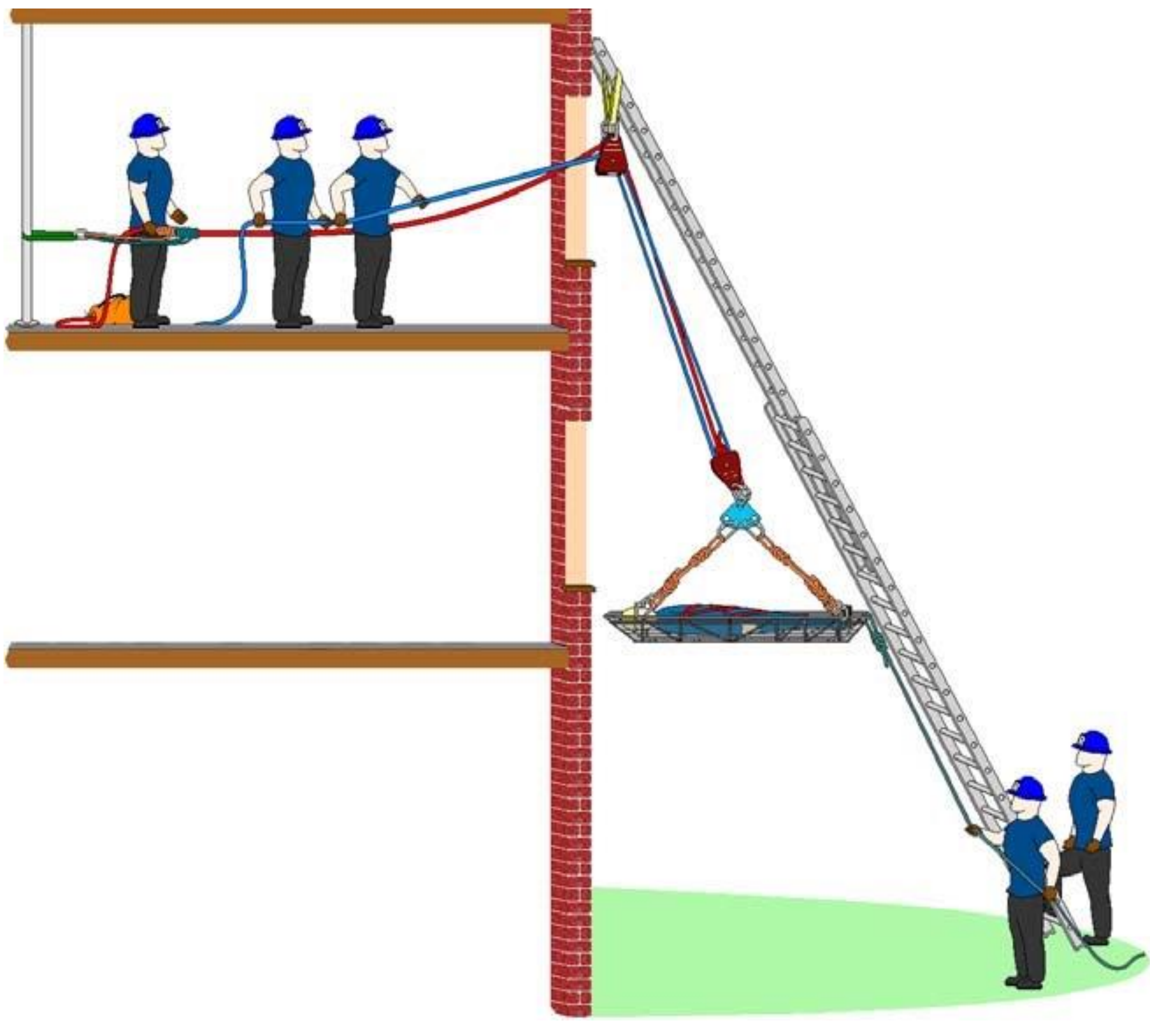
Fixed Ladder Slide: Raising



3. 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/safety line option can be used for the 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 are 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.



4. 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. 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 the better. The rope should be positioned so it runs next to one of the ladder beams since the rungs are stronger there. A rescuer must foot the ladder to secure its position.

A separate anchor point is used for the belay/safety line on the interior leaning ladder. The belay/safety 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 victims 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.

5. Ladder Jib / Cantilever Ladder

The ladder jib or 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.

Both ladder jib and 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 designed only to provide an anchor point at a location above the position from which the rescue team wishes 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.

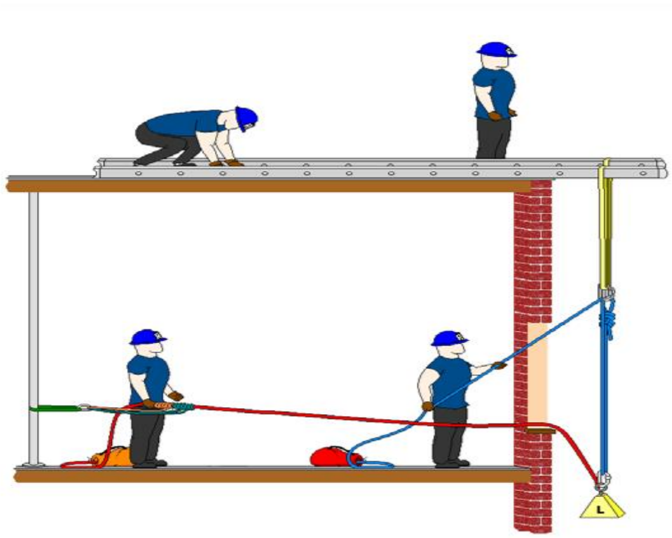
2. A counterweight rescuer must be in place, with his or her weight on the butt end of the ladder.

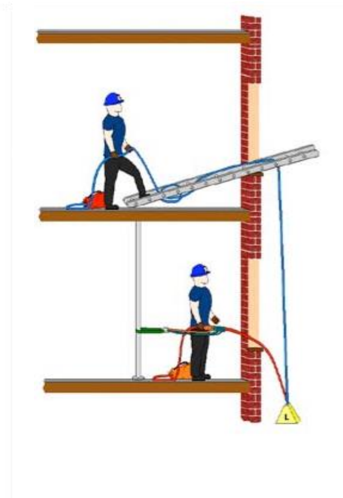
3. To maintain the correct counterweight loading, the ladder must have a minimum of seven (7) rungs inside the building from its point of contact.

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.

The ladder jib/ cantilever ladder will have the belay/safety 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.

Ladder Jib with 2:1 Ladder Rig without Pulley(s)





A cantilever ladder creates the same type of anchors when used on flat roofs or floors with no walls or raised edges.

- The ladder sling on the ladder should not be more than one rung beyond the edge upon which ladder beams rest.
- The ladder rig pulley system is attached to the ladder sling.

Cantilever Ladder

A counterweight rescuer must be in place, with his/her weight on the butt end of the ladder.

- To maintain correct counterweight loading, the ladder must have a minimum of seven (7) rungs back from the edge or contact point.
- 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.

6. Ladder Gin

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, one rescuer, or one victim.

It can be a very useful rescue device, since 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, or 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 75° in order to support the maximum load.
- 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 the force of hauling on the load does not dislodge the base of the ladder or side-load the system.

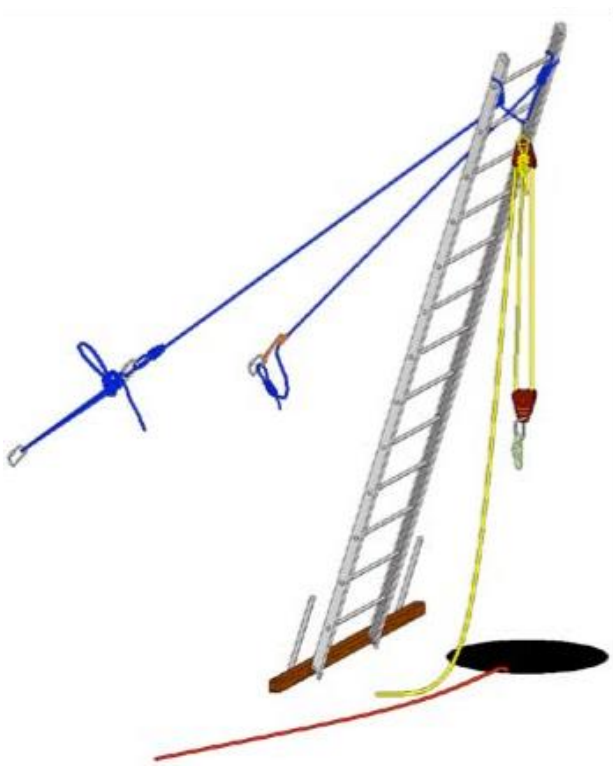
Components of a Ladder Gin

- *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- to 16-foot 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 75° 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" to 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 of the ladder from the backside and then looped over the tips . The guy lines are tensioned using a modified Trucker's hitch or a prusik hitch that is backed up with a Figure Eight on a Bight clipped to the carabiner.



- *Anchor Points*

Base of ladder is rested against a "deadman" anchor to maintain system alignment and stability in the open field.

Anchor points for ladder gins should be located at a distance equal to three times the length of the ladder and away from the base of the ladder.

Guy lines are attached to the pump suction ports on each side of the apparatus using the modified trucker's hitch or prusik.

A ladder gin is not designed to support a side load. Therefore, both the load and the haul must be kept in line between the ladder beams.

7. Ladder "A" Frame

Ladder "A" frames are versatile rescue tools. They are easy to set up, easy to operate, and, unlike the ladder gin, 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 75° angles.

❒ Keep the load between the ladder beams.

❒ Raise the load only as high as needed to clear the opening.

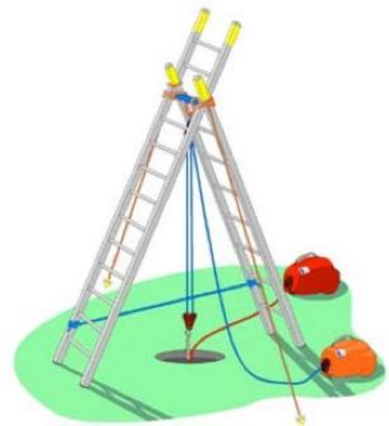
Ladder "A" Frame Components

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-foot webbing is tied at the base of each ladder to maintain the 75° climbing angle.

Guy Lines

The guy lines are rigged from a single life safety rope and used to stabilize the ladders and to prevent side-to-side movement. Guy lines are rigged by tying two Figure Eight on a Bight knots with 12" bights. These knots are tied 12" to 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 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 at a distance equal to three times the height of the ladders on both sides of the "A" frame. These are tensioned using a modified Trucker's hitch or a prusik hitch that is backed up with a Figure Eight on a Bight.



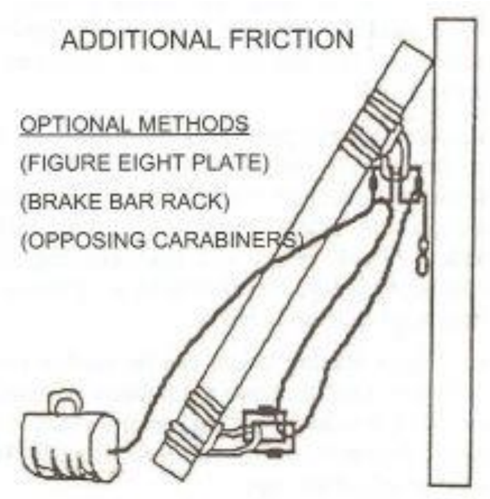
Slinging a Spar (Optional)

During a major disaster, it may be necessary to construct a rescue system out of debris. The ability to use a 4x4 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 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:

- Obtain a suitable spar, either a 4x4 x approximately 8-foot piece of lumber (preferably Douglas fir), or a 1 1⁄2"-diameter, Schedule 40 or greater piece of steel pipe, approximately 8' in length.
- Lean the spar against the structure at a 75° climbing angle.
- Sling the top and bottom of the spar with 12' pieces of webbing, by using the three-wrap prusik hitch.
- The webbing should be located no more than 12" from each end of the spar.
- When wrapping is completed, the eye of the webbing should be approximately 6" long.
- Attach two carabiners to each sling.
- These will be used for friction to lower the victims.
- 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 and lock the gate.

- Reeve the standing end of the rope through both carabiners that are attached to the bottom sling and lock their gates.
- 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.
- Set up belay/safety system from a different anchor, but on the floor of departure of the victim.
- The system should be safety checked and then operated.



Slinging a Spar

UNIT 9 - LIFTING HEAVY OBJECTS

Terminal Objectives

Lift an object weighing approximately 2,000 pounds 18 inches and stabilize it as it is lifted.

Lift approximately one cubic yard of concrete and tip it onto its side using appropriate supports as it is moved.

Lift an object weighing approximately 6,000 pounds and move it using friction- reducing methods.

Enabling Objectives

The students will:

1. Describe types, capabilities, and safety considerations or tools used when lifting and moving heavy objects.
2. Estimate the weight of concrete and light-frame structural components.
3. Explain the capability of load stabilization materials.
4. Describe and demonstrate proper load stabilization techniques.

Notes:

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.

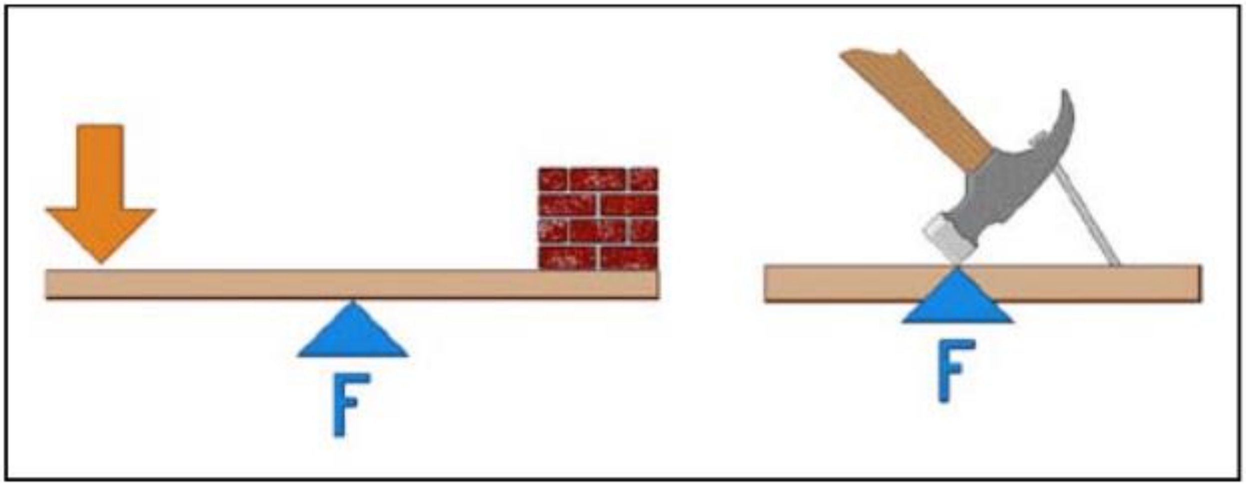
Simple hand tools can be used to create tremendous mechanical advantage to lift, lower, and move large loads safely. Those same loads can be moved with relative ease by reducing friction between the load and the surface it is to be moved across. Basic methods of building crib beds can be used to stabilize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

Types, Capabilities, and Safety Considerations for Tools Used When Lifting heavy Objects

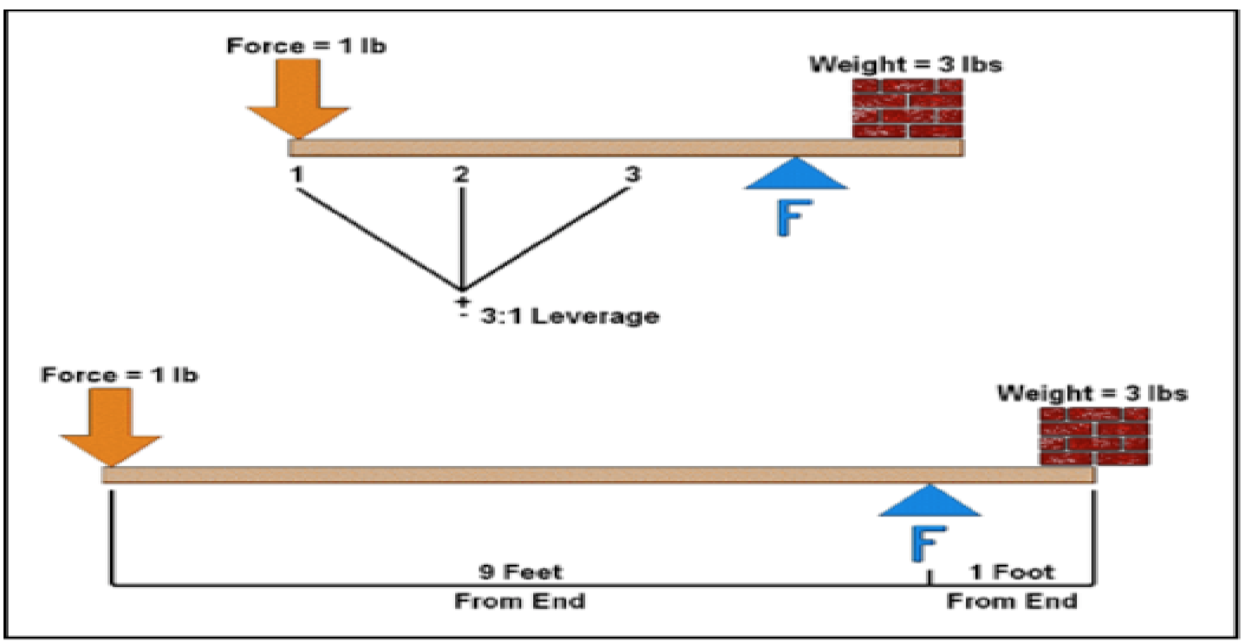
The simplest of machines is a lever. A lever is a rigid bar, either straight or bent, that is free to move on a fixed contact point called a fulcrum and works by transferring force from one place to another. There are three classifications of levers determined by the location of the fulcrum as it relates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

Class 1 Lever

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 Class 1 levers. **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 the load moves up.



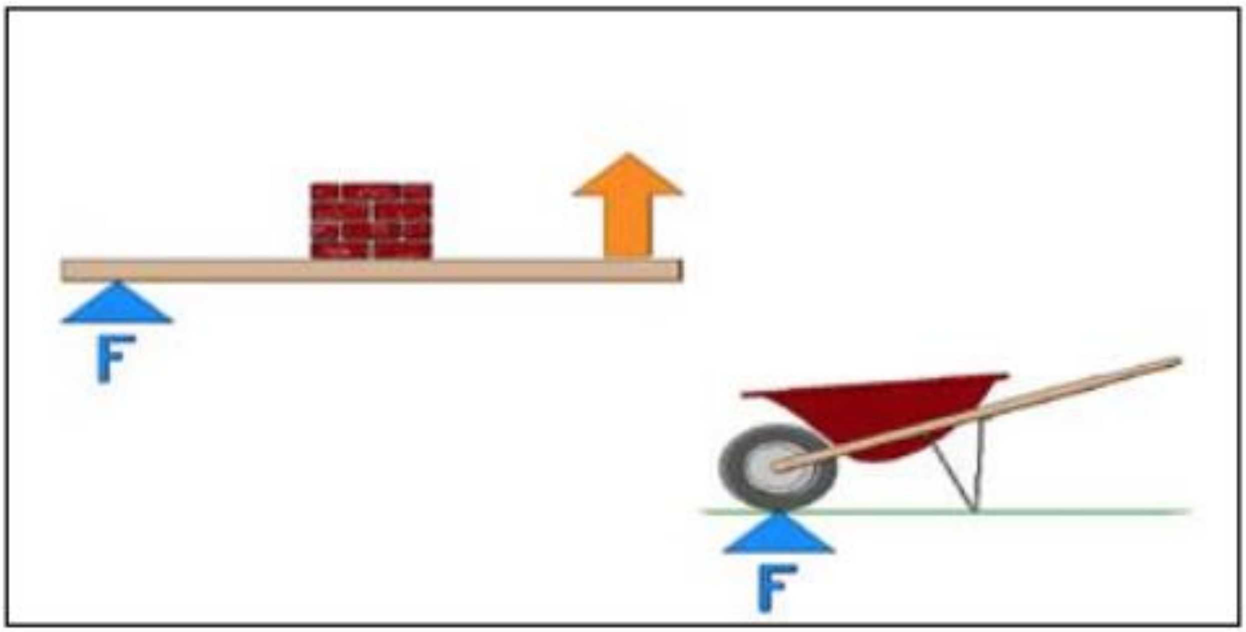
The **mechanical advantage** can be calculated by comparing the distance between the load and the fulcrum to the distance between the fulcrum and the force



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.

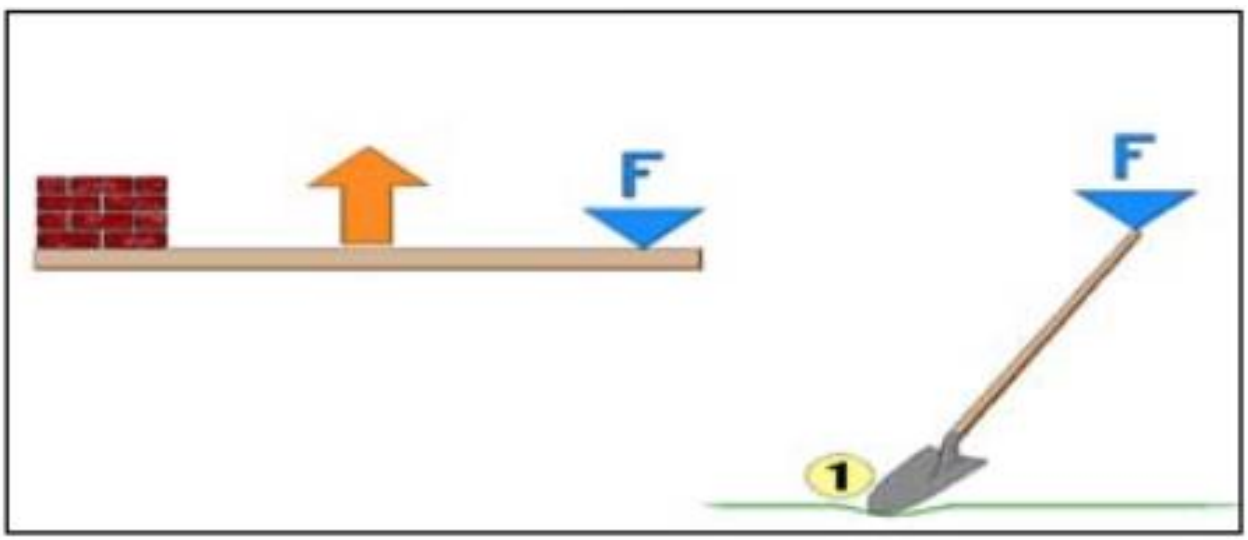
Class 2 Lever

The **Class 2 lever** is the next most useful and efficient lever. It consists of a fulcrum 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.**



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.

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 complement 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

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

Lift Increments

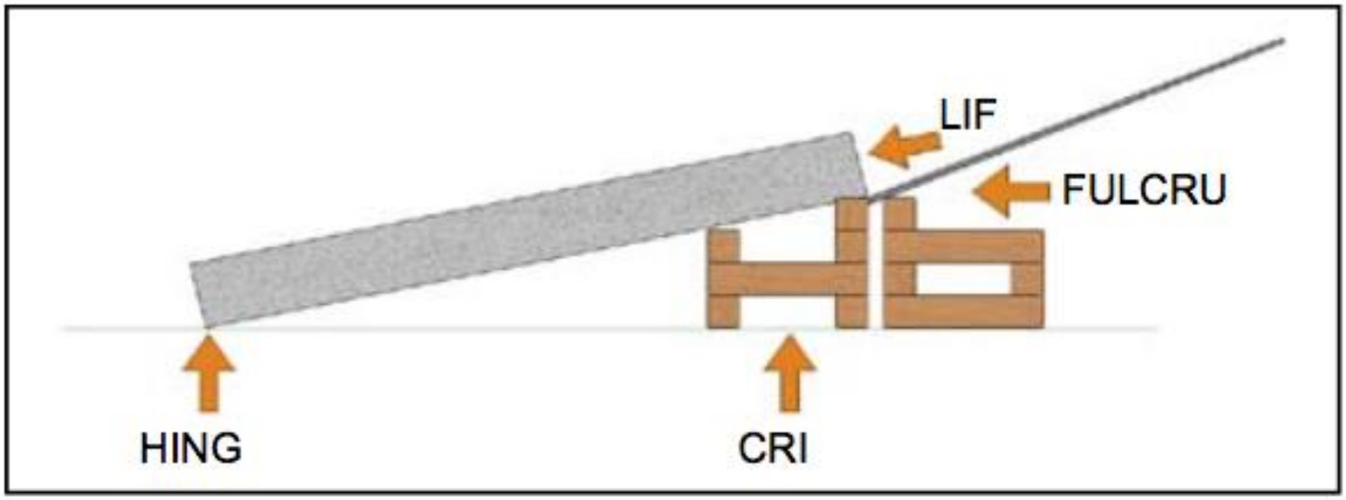
Lift in short controlled increments, approximately 2" to 4" at a time, depending on the fulcrum height and distance and the size of the wedge used to support the lift. To prevent unwanted horizontal movement of the object, lift in small increments. Use 2x4 or 4x4 cribbing for stabilizing and as fulcrum 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 victims.

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.

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

Load Stabilization, Crib Bed Capabilities, and Construction

The purpose of crib beds is 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 2x4 and 4x4 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 2x4 or 4x4 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 4x4 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 increased to 54,000 pounds.

7. A box crib of 6x6 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 works only 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.

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. The additional interior pieces of cribbing can be adjusted or floated from side to side to increase the capacity and improve the load path. In Figure 3:6, the interior piece of cribbing is shaded to identify its adjustability with the crib bed

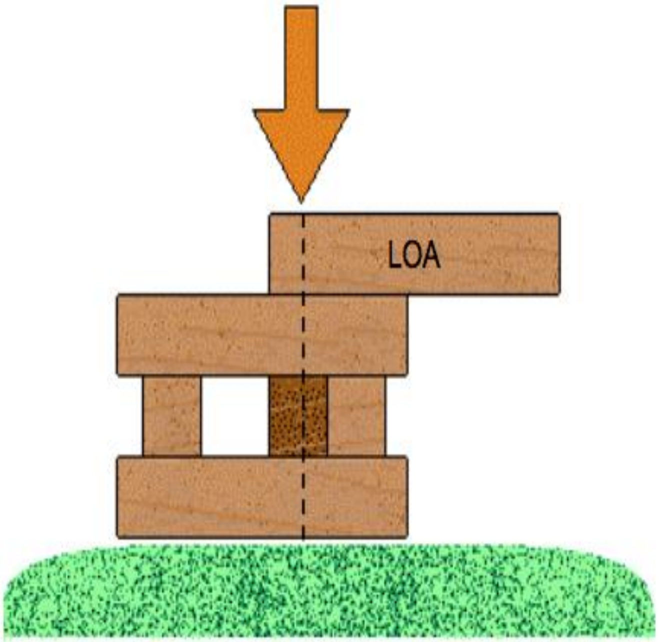


Figure 3:6 Wood-to-wood contact from load to ground

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 approximate and need to be reduced due to slopes and nature of incident, i.e. earthquake aftershocks, settling, etc.

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

Wedges: 2x4x12" and 4x4x18" 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 or if a rescuer cannot hold the load. Insert a full-size 4x4 piece of cribbing as soon as space allows.

A single 2x4x12" wedge should be used 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, but that can be difficult to do. They can be purchased precut from most lumberyards and should be prestocked in a rescue cache.

Cribbing and Crib beds

Capacity varies from 200 psi to 1,000 psi depending on wood species. 500 psi is used for emergency shoring. Example: 500 x 2.5 x 3.5 x 4 = 24,000.

<u>For a 2-Member x 2-Member Box Crib</u>

4 x 4 box crib capacity = 24,000 lbs (12 tons)

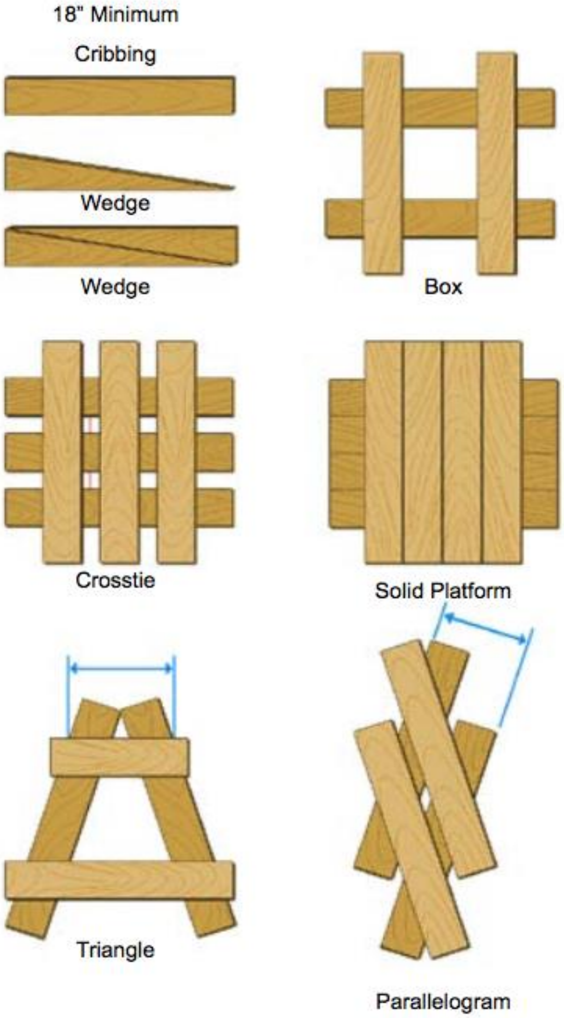
4 x 4 cross-tie capacity = 54,000 lbs (27 tons)

For a 3-Member x 3-Member Cross-tie Crib

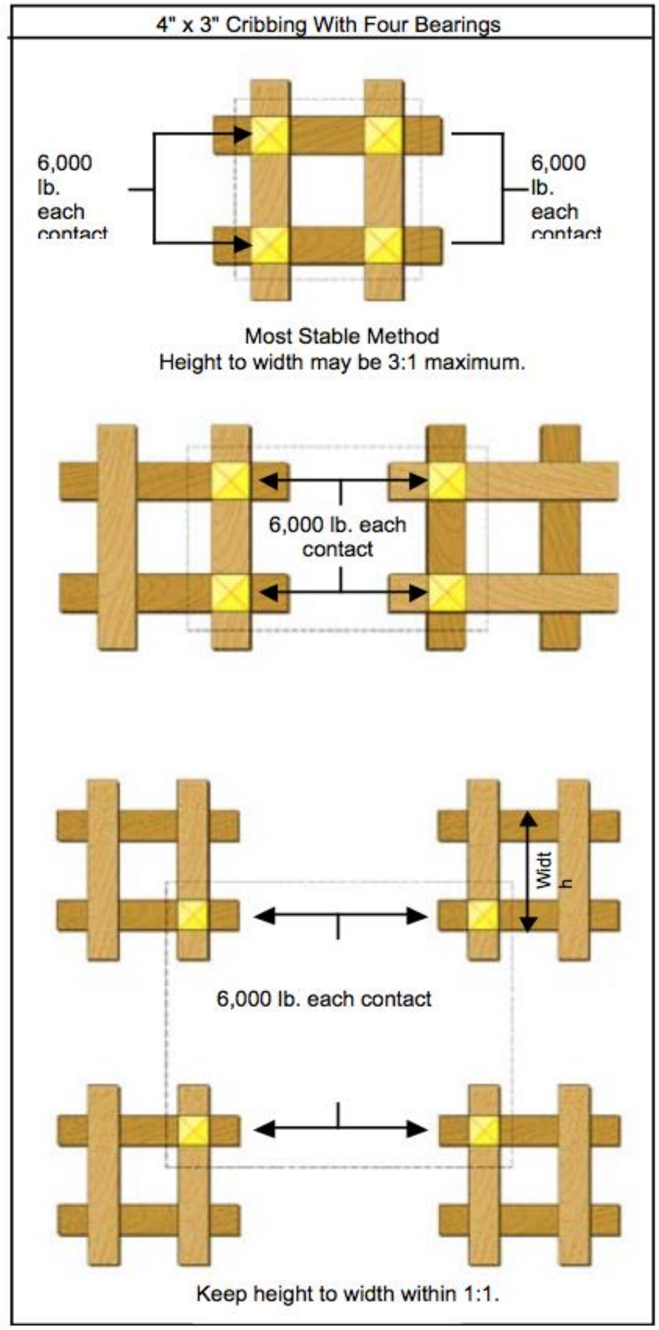
6 x 6 box crib capacity = 60,000 lbs (30 tons)

6 x 6 cross-tie capacity = 135,000 lbs (67 ½)

Do not stack cribbing more than two high in the same direction



Both are not very stable. Keep height to width within 1:1



Moving heavy Objects

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

An object 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, chainlink fence posts, and signposts. If your apparatus permits, carry a small number of pipes for both rollers and pipe screw jacks.

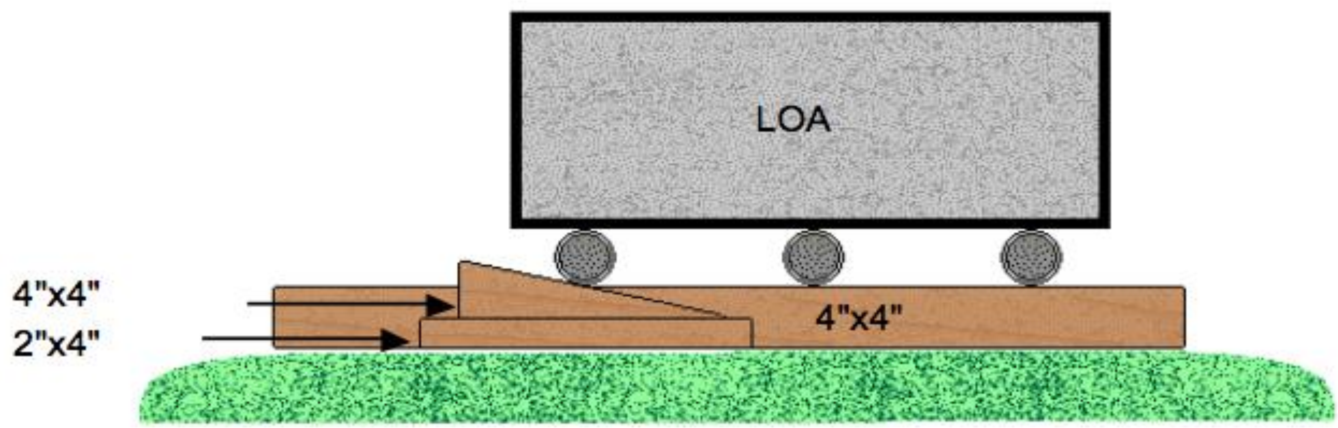
If the ground is soft under the load or if the surface is uneven or broken, it may be necessary to build tracks to support the rollers. In effect, you are building a track system The load will have to be lifted high enough to slide the tracks and the rollers under the load. Good track systems for rollers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

It is important to control the movement of a heavy load; failure to do so could cause injury 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 used 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 the load and are dependent on friction to stop the load. Caution should be used when placing wedges on top of the tracks. This may not create sufficient friction and might 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.

Class 2 Levers

Class 2 levers can be used 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 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 downhill 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.

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	90-150 PSF
Steel beam with concrete-filled metal deck	50-70 PSF
Wood floors	10-25 PSF
Floors with thin concrete fill	25 PSF or more
Wood or steel interior walls	Add 10-15 PSF each floor level
Furniture and contents (more for storage, etc.)	Add 10 PSF or more each floor

Plan ahead. Take a look at what is around the lifting site. What other parts of the structure are involved? What will happen when the load is moved? Will the movement cause other movement within the structure? Make sure you have enough cribbing on hand. Take special care with crush injuries. Make sure medical care is given and advanced care is available prior to removal of a heavy object from a victim in order to prevent death soon after the object is removed from the victim.

Team Leader should direct the effort and give the lift command. Only one person should have authority to give a lift command. Only after he/she has ensured that everyone is ready to proceed and that everyone is in a safe position should the team leader give the command. Anyone can halt if he/she sees something going wrong. A heavy lift operation takes a lot of people and a lot of equipment. It is critical to a safe and efficient operation.

A safety officer should be appointed to do nothing but watch over everyone and make sure hands and feet are clear of the object while it is being lifted, and that all safety equipment is being worn. **Never place your hands under a non-supported load.** They also will monitors stability of heavy load and crib bed. They can terminate any operation deemed unsafe.

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

"Lifters" (Bars) operate pry bars to raise, hold, lower, and move heavy objects.

"Cribbers" construct crib beds to support and stabilize heavy objects.

"Feeders" or "Go-fers" supply cribbers and lifters with materials to construct crib beds and 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.

Team leader

STAND BY TO LIFT!

Lifters ready?

Cribbers ready?

* All assigned positions will respond "READY"

Team leader LIFTERS "LIFT" LIFTERS "HOLD"

*Lifters will take action together as commanded.

After Cribbers are complete, they say “CRIB SET”

Team leader

“LOWER”

*The bars will lower the object until it is supported solely by the crib beds.

In some cases you have to lower a load.

Team Leader

STAND BY TO LOWER!

Lifters Ready? Cribbers Ready?

* All assigned positions will respond “READY”

Team Leader

LIFTERS “LIFT”

Lifters “HOLD”

*Lifters will take action together as commanded.

Team Leader

LIFTERS LOWER

Cribbers

Will start removing Cribbing as the load lowers, they will have wedges ready to s top the load if anyone says **STICK IT**.

Lifters Will tell the Cribbers to **STICK IT**, when Lifters feel the load is going to slip off the end of their bars.

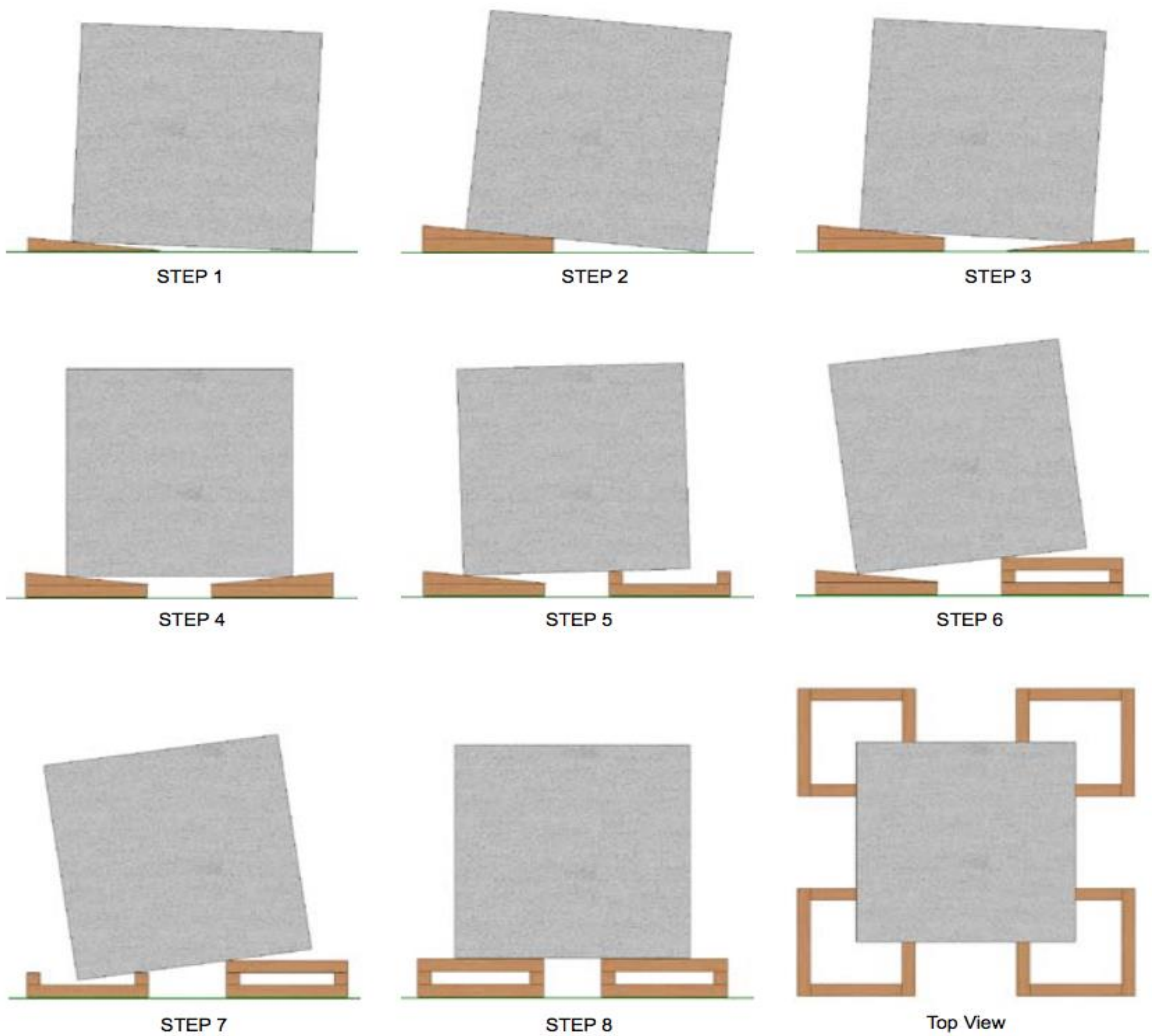
Any team member can say "STICK IT"

"STICK IT" is an emergency command that can be given by any squad member and is an immediate request for cribbers to support the Load. The bars may have lost purchase there purchase point or control; presence of undesired movement or instability.

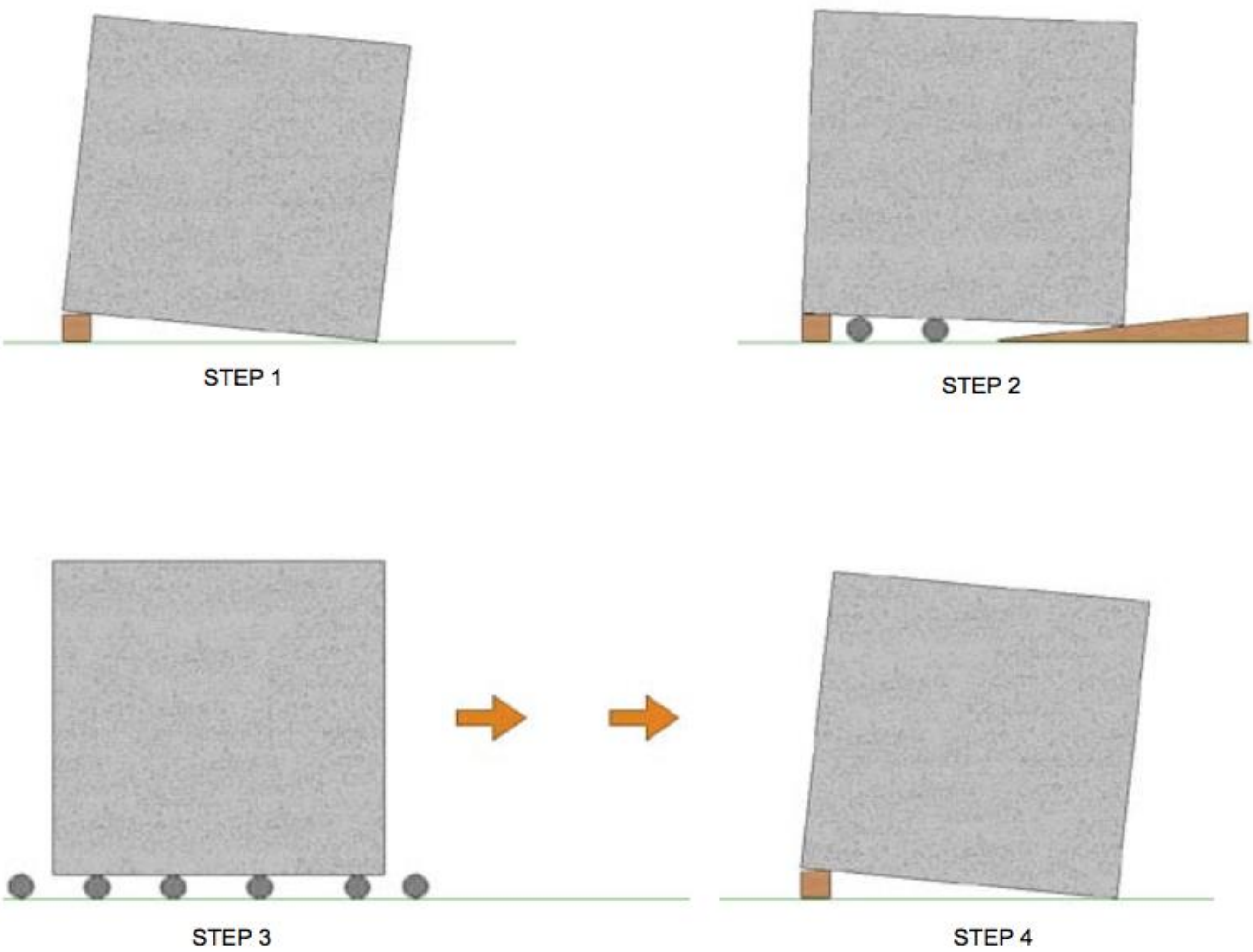
Evolution #1

Raise, Stabilize, and Lower a Single Heavy Object

The students will raise, stabilize, and lower a heavy object. The students will be required to perform size- up and build appropriate crib beds to support and stabilize loads. They will need to use Class 1 levers to complete the exercise and will practice building and adjusting crib beds to the changing angle of an object being raised and lowered.



Evolution #2



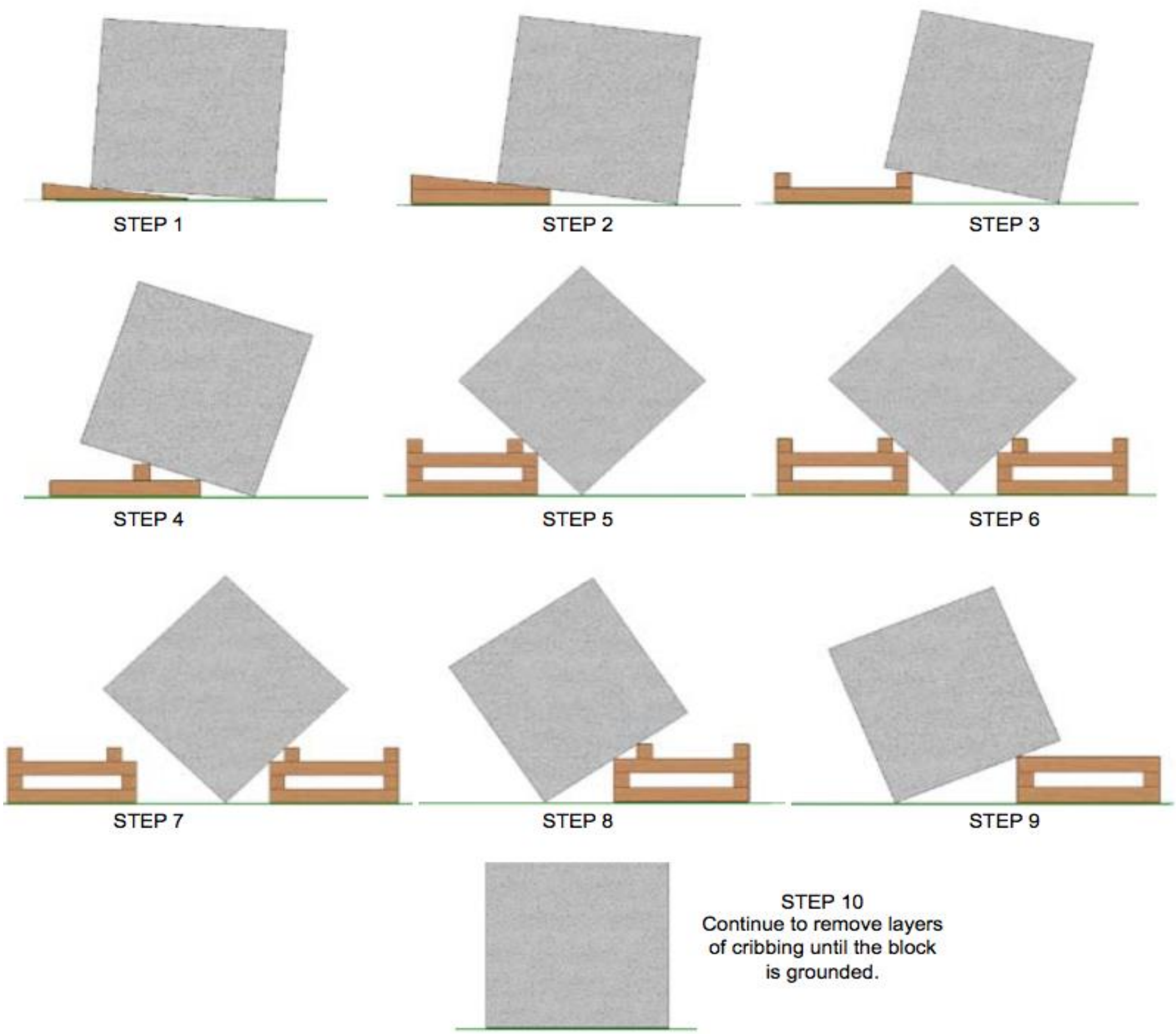
Raise, Stabilize, Move, and Lower a Single Heavy Object

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

Evolution #3

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 and build appropriate crib beds to support, receive,

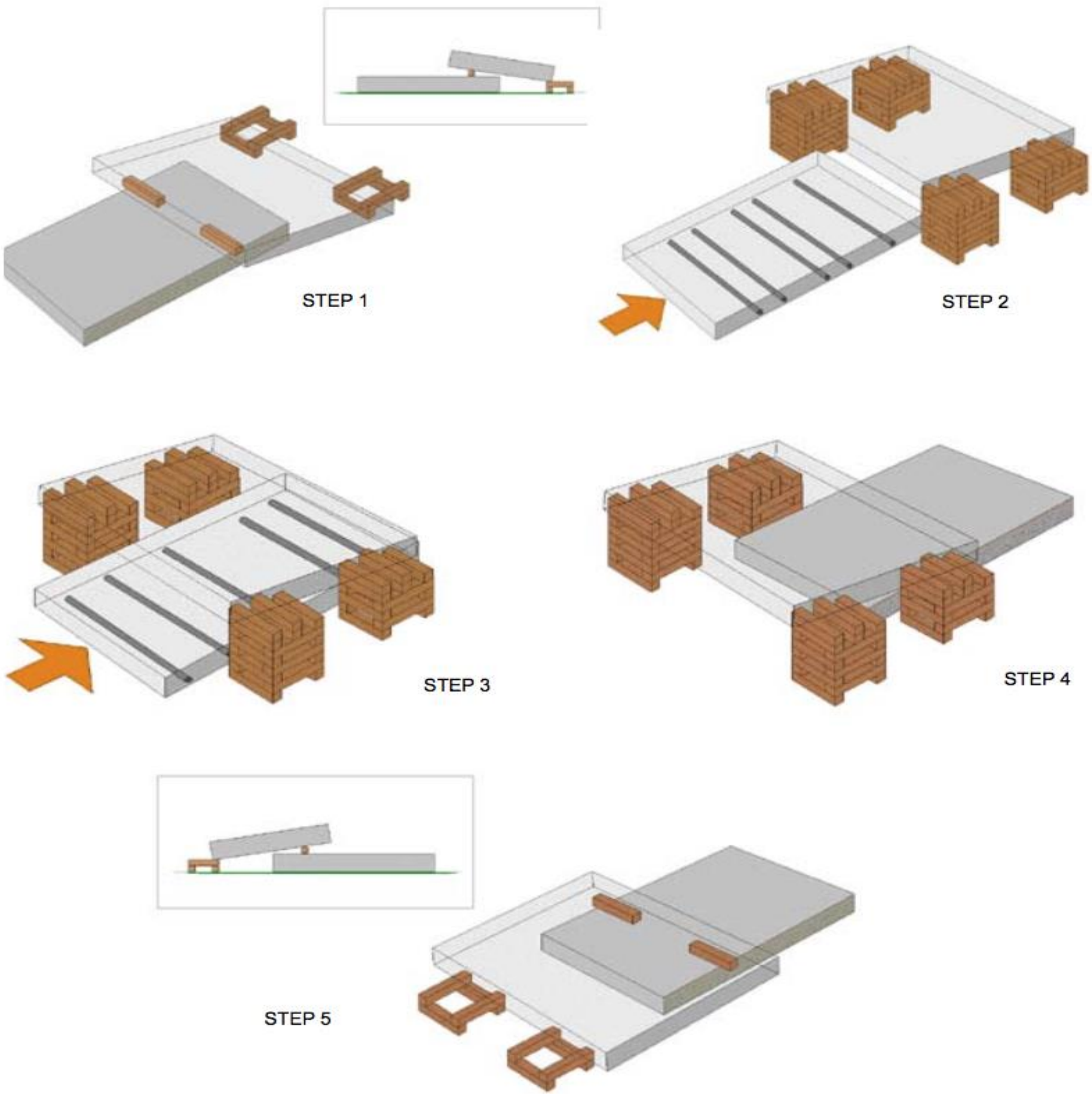


and stabilize loads. They will need to use both Class 1 and Class 2 levers to complete the exercise and will practice building and adjusting crib beds to the changing angle of an object being raised and lowered. The students will also be limited to cribbing the face of the load from end.

Evolution #4

Raise, Stabilize, Move, and Lower Multiple Heavy Objects

The students will raise, stabilize, move, and lower multiple heavy objects. They will be required to perform size-up and build appropriate crib beds to support and stabilize



loads. The students will need to use both Class 1 and Class 2 levers to complete the exercise.