TITLE: TRAINING GUIDE #10-4
STRUCTURAL COLLAPSE AND EMERGENCY BUILDING SHORING

Purpose:

1. To comply with Safety Standards for Firefighters WAC 296-305

2. To provide guidelines for Structural Collapse and Emergency Building Shoring Operations.

3. To provide Fire Department members with the necessary knowledge to safely conduct assessment and rescue operations.

4. To familiarize the Seattle Fire Department Personnel with procedures which will **enhance the safety of both Rescuer and Patient**.

5. To introduce basic Building Shoring Techniques to members who may undertake these tasks.

References:

1. WAC 296-305 Safety Standards for Firefighters

2. FEMA Rescue Specialist Manual (1995)

3. FEMA Field Operations Guide (1993)

4. California O.E.S. Rescue Systems II (1996)

5. CMC Rescue School, Structural Collapse and Emergency Building Shoring

6. Building Construction Review (Seattle Fire Department)

Definitions:

Assessment - A wide view of the affected area which includes potential hazards, specific geographical location, specific building locations, obvious damage, approximate number and exact location of walking wounded and surface casualties.

Building Assessment - A method designed to help identify, select, and prioritize buildings with the highest probability of success with respect to finding and rescuing live victims.

Building Marking - A system designed to identify specific information pertinent to each affected building.

Cold Zone - A safe area at the rescue incident; outside the warm and hot zones. The area where apparatus personnel and equipment not actively involved in the rescue are placed. Base should be located in this area. Members of the media, bystanders and non-essential personnel will also be in this zone.

Warm Zone - The area between the hot and cold zones that contain personnel and equipment essential to the rescue effort. This area may contain the command post and staging area. Control of this area is essential for management of the rescue operation.

Hot Zone - The area of a rescue operations where designated personnel may be placed at high risk. Only rescue personnel with proper safety equipment that are directly involved with the operation should be allowed in this area.

Emergency Building Shores - Generally constructed of wood and used to temporarily support potentially unstable loads where rescue workers must operate, in, under or around such hazards. Emergency Building Shores will help to protect both rescuer and victim from subsequent collapse problems.

Personal Protective Equipment (PPE) - The equipment needed to shield or isolate personnel form the chemical, physical, thermal, or other hazards that may be encountered at a technical rescue incident. This includes protective clothing and respiratory protection.

Recovery - Operations undertaken by responders to recover victims, their remains, or property. Operations should only be implemented when the risk to responders has been reduced to the lowest possible level.

Rescue - Operations undertaken by responders to remove victims from hazardous situations in which the victims able to offer little or no assistance due to their physical condition or their immediate environment.

Risk/Benefit Analysis - The decision making process that weighs the hazards encountered by the responder against the potential benefit from that exposure.

Safety Zone - The area of protection offered by a shore. Two feet on wither side of the shore.

Search Marking - A separate and distinct marking system necessary to conspicuously denote information.

Spontaneous Civilian Rescue Effort - Actions taken by the general public to locate or rescue others immediately after a catastrophic event.

Surface Victim - One who has any portion of their person visible above or outside the hazard.

Technical Rescue - The application of special knowledge, skills, and equipment to safely resolve unique, and or complex rescue situations.

Victim Marking - A marking system designed to identify the presence and condition of victims inside a collapsed structure.

RESPONSE LEVELS

Awareness Level - The level that represents the minimum capability needed to identify technical emergencies, their hazards, and to recognize the need for additional resources necessary to safely and successfully conduct an operation. Members trained to this level should be competent in recognizing the need for technical rescue operations, conducting a scene assessment and resource management. Members will be able to initiate ICS (Incident Command System) and begin an initial Risk/Benefit analysis along with understanding the limits of the training and equipment provided. Actions taken by responders at the Awareness Level may place the rescuer at low risk. All Seattle Fire Department Operations Division members will be trained to this level.

Operations Level - In addition to Awareness Level capabilities, the Operational Level represents the minimum capability needed to conduct limited technical rescue operations safely and effectively. Members will be able to conduct a more in-depth risk/benefit analysis based on the hazards, availability of trained personnel and equipment. Actions taken at the Operational Level may place the rescuer at a low to moderate risk. All Seattle Fire Department Ladder Companies are trained and equipped to this level.

Technical Level - In addition to Awareness and Operational Level capabilities, the Technical Level represents the minimum capability needed to conduct safe and effective complex operations. Operations conducted at the Technical Level may place the rescuer at moderate to high risk. Seattle Fire Department Technical Rescue Units are trained and equipped to this level.

GENERAL INFORMATION

The object of this material is to provide members with a resource to assist them in dealing with the problems associated with structural collapse. Structural collapse can be the result of a variety of causes. Natural disasters such as earthquake, flood, landslide, and fire may present collapse problems. Construction accidents and terrorist acts may also contribute to structural collapse. Depending on the nature of the event and the potential for further loss of life, some collapse problems may have to be passed over by rescuers in favor of areas where work can safely begin immediately. During instances of wide spread disaster individual fire companies may be forced to work alone for hours or possibly days. Personal safety is of prime importance. Company officers as well as individual members should insure the use of appropriate Personal Protective Equipment as circumstances dictate. Helmets, gloves, and steel toed boots are required. Additional protective clothing and equipment may be necessary based on environmental or physical hazards.

Anytime a structure collapses for any reason, there may be a variety of secondary hazards created. Natural gas, Propane, live electrical wires, water or hazardous chemicals may be present. These associated problems must be addressed and mitigated before any work is begun.

There are several issues which must be addressed before and during every collapse operation:

- Scene Assessment
- Building Assessment
- Recognize the need for paitient safety and care
- Building Marking
- Potential Shoring Operations
- Search Marking
- Victim Marking
- Rescue Operations
- Operation Termination

THINK PLAN ACT

Scene Assessment

Visual Survey of affected area

- Hazards making entry and/or egress from the area unsafe
- overhead hazards such as hanging debris
- downed electrical wires
- hazardous materials concerns
- water
- secondary event such as aftershock

Scene organization

- Initiate ICS
- Identify immediate hazards
- Determine need for additional resources
- Organize First Aid triage and treatment area
- Organize spontaneous civilian rescue effort
- Assign additional resources as they arrive

Identify the area

- By geographical location
  - actual intersections if possible
- Identify individual buildings
  - by actual address
  - by approximate distance from a known point
  - by unique design characteristics
  - by describing the building's current condition

Conduct brief interview of witnesses

- Witnesses can provide valuable information to rescuers regarding the location and number of potential victims. However, when considering this information, use good judgment as reports may also be inaccurate or even invalid.

Location and rescue of viable surface victims

- Identify victim locations
- How will patient location affect rescue
- Only low hazard rescues are performed at this stage.

Building Assessment

The number of potential victims and the possibility of successful rescues in a given building are dependent on several factors:

- Type of Occupancy
- Time of Day
- Construction Type
- Mechanism

Type of Occupancy	Highest probability of occupants
• School	weekdays - 0700-1600 hours
• Office	weekdays - 0600-1800 hours
• Retail	weekdays/weekends - 0900-2300 hours
• Residential	evenings - 1600-0800 hours
• Hospital	24 hours per day

Construction Types most likely to be damaged

- Unreinforced masonry including buildings with masonry infills or veneers
- Pre-1947 concrete construction
- Precast concrete buildings including Tilt-up and Lift slab
- Pre-1970 concrete construction multi-story residential, parking or commercial
- Non-uniform buildings such as “soft” first story, odd shapes or corner buildings

Types of Collapse

Pancake V-shape Lean to Cantilever

Any one or all of these collapse patterns may occur in any given building. Try to identify the collapse type as it will give you clues to the location of possible void spaces.

Collapse Mechanism

- Earthquake - widespread damage and aftershocks
- Bombing - possibility of more or is it a single event?
- Mechanical failure - probable single event
- Extent of collapse - complete, partial, pancake, tip over, etc.

Indications of further collapse

- Walls out of plumb
- Smoke, Dust, or Water through bricks
- Beams pulling away from connection points
- Buckled steel support members
- Falling plaster, bricks, or other surface treatments
- Unequal expansion or large cracks specifically X cracks
- Heavy involvement
- Age of structure
- Overloaded condition [stock, machinery, water]
- Noise [creaking, groaning, etc.]
- Explosions

Immediate hazards[each building must be evaluated individually]

- Fire
- Falling objects
- Haz Mat
- Electrical
- Water
- Sewer
- Natural Gas
- Debris

- ♦ Note location of safest access into structure
- ♦ Prior intelligence from pre-fires or personal knowledge
- ♦ Availability of resources trained personnel and equipment
- ♦ Location and condition of surface victims
- ♦ Attempt to identify location of other victims

After these steps[s have been accomplished a Risk/Benefit analysis must be performed based on their results. The Risk/Benefit analysis is an ongoing process through the termination phase.

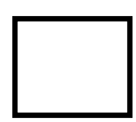
Risk/Benefit Analysis

1. Emphasize the importance of personal safety.
2. If the information is available, determine if it is a rescue or recovery operation.
3. All personnel should be made aware of the potential impact of their operations on the safety and welfare of other rescuers and victims as well as other operations at the rescue site.
4. Perform evaluation of the environmental and physical factors affecting the incident:
   - Seismic activity
   - Ground condition (mud, rubble, sand)
   - Weather
   - General condition of structure
   - Other hazards
5. Identify the types of internal resources immediately available
   - Trained personnel
   - Equipment
   - Response time

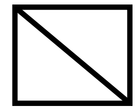
Building Marking

There are five markings that can be used to identify the structural stability of a specific building.

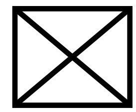
1. Structure is accessible and safe for search and rescue operations. Damage is minor with little danger of further collapse.



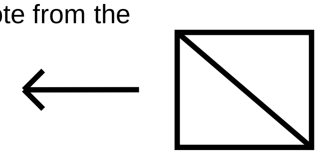
2. Structure is significantly damaged. Same areas are relatively safe, but other areas may need shoring or removal of other hazards. The structure may be completely pancaked.



3. Structure is not safe for search and rescue operations, may be subject to sudden additional collapse. Remote search operations may proceed at significant risk. If rescue operations are undertaken, safe areas and rapid evacuation routes must be established.



4. Arrow located next to a marking box indicates the direction to the safe entrance in the event the marking box must be made remote from the indicated entrance



5. Indicates Haz Mat condition exists in or near the structure. Personnel may be in jeopardy Operations should only be undertaken under advisement of a Haz Mat specialist. The specific condition may be noted near this mark.

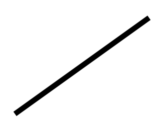
HM NAT GAS

Search Marking

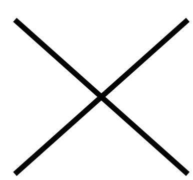
1. The search marking system is designed to be used in conjunction with the Building marking system. Leave ample room between markings so notations from one are not confused with the other

2. An "x" that is 2'x 2' in size will be constructed in two operations:

   A. One slash drawn upon entry into the structure, room or hallway, etc.

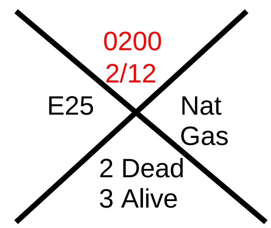


   B. A second crossing slash drawn upon exiting the area.



C. Distinct markings should be made inside the four quadrants of the "X" to clearly denote the search status and findings at the time of this assessment.

- Left quadrant- identify company making the search
- Top quadrant- time and date that company left the structure
- Right quadrant- hazards to personnel
- Bottom quadrant- number of live and dead victims still inside structure

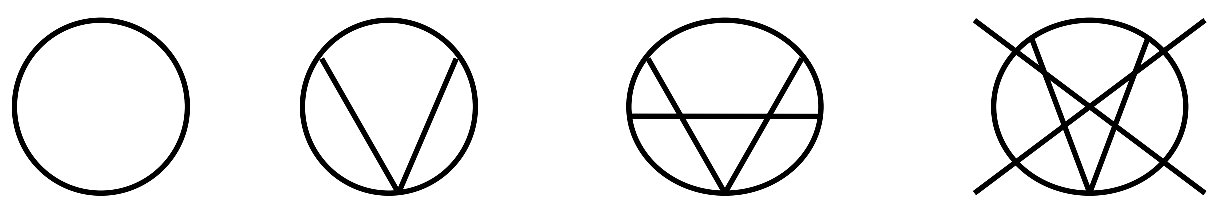


D. Markings should be made specific to each area of entry or separate part of the structure. If no victims are found it should be noted with a"0" in bottom quadrant. Situation updates should be noted as they are available Previous markings may be crossed out and new markings placed below or next to them with the most current information.

Victim Marking

1. When a victim is located the rescuer must mark the exact location. There are several methods for victim marking - For the purpose of the Seattle Fire Department the "“V” mark should be used. In the event that no marking device is available a piece of flagging or caution tape attached to a pipe or stick should be used. When it is not possible to mark on or immediately adjacent to the victim, specific directions to the location should be included.

1 2 3 4



Possible Victim **Confirmed Victim** **Confirmed Dead** **Victim Removed**

Rescue Operations

Fire Department members should engage only in operations that are within their level of training, equipment and expertise. During your ongoing Risk/Benefit analysis keep the odds in favor of the -rescuer

Awareness Level Rescue Operations for structural collapse may include:

- Immediate rescue of surface victims
- Organizing of civilian efforts
- Low risk debris removal to expose victims

Operational Level Rescue Operations for structural collapse may include:

- All awareness level operations
- The limited use of lifting, breaching, and shoring devices to mitigate moderate risk hazards

Technical Level Rescue Operations for structural collapse may include:
All awareness and operational level operations

- Advanced shoring requiring the assistance of structural engineers
- Higher risk debris removal
- Heavy breaching and breaking
- Use of heavy equipment and rigging

Debris Removal

After structural collapse there are two stages of debris removal. Selected debris removal assumes that viable victims still remain General debris removal assumes that viable victims have been removed

Selected debris removal - is based on information gathered from witnesses and victims, other rescuers, victim locating devices and building plans. During this stage it is important to remember that actions taken in one location may adversely affect other areas of the structure This stage should be conducted carefully and systematically from the top down

General debris removal - often using heavy equipment, general debris removal is normally for body recovery and takes place after it has been determined that the probability of finding live victims has been reduced as far as possible. During this stage bodies are sorted from debris and removed by the proper authorities. Rescues during this phase are improbable but not impossible Government studies based on worldwide incidents of structural collapse indicate that after twenty four hours the incidence of victim survival drops off sharply.

Incident Termination

Accountability

- Ensure all personnel both fire and civilian are accounted for

Equipment retrieval

- When possible retrieve all equipment involved in the rescue
- At no time will members be placed at risk to recover equipment
- Make note of missing or damaged equipment

Conduct Post Incident Debriefing

Conduct Critical Incident Stress Debriefing

LIFTING AND MOVING HEAVY OBJECTS

When dealing with incidents of structural collapse the lifting and moving of heavy objects may be necessary. Large pieces of concrete, wood beams, structural steel, or even vehicles may prevent the rescuer from accessing victims. There are several techniques available to help rescue personnel mitigate these situations.

Objects weighing ten thousand pounds can be lifted and moved by as few as three or four people if the proper techniques are used. Simple levers and fulcrums are readily available to most rescue personnel. Mechanical devices such as air bags, pulley systems, winches, and cranes may also be available.

As we discuss the topics of lifting and moving there are several principles which should always be considered. The main reason we are lifting a heavy objects is to free entrapped victims. From earlier discussion we know that our focus is on surface victims. Surface victims are those who have some portion of their body visible above or outside the rubble. There may be more than one way to approach each lifting scenario. When working on or around collapsed structures every operation we undertake may have a significant impact on another operation being conducted elsewhere. Rescuer and victim safety is of the greatest importance. Try to choose the one that requires the smallest time commitment and the least impact on other areas.

After it has been determined that a lift is necessary we must make a careful examination of the problem. Some questions to ask are:

- Rescue or Recovery?
- Can it be accomplished safely?
- Do we have the equipment and materials we will need?

Remember that the Risk/Benefit analysis is an on going process.

GRAVITY

Gravity is a constant. Gravity is part of the reason structures collapse. Prior to collapse, a structure has a center of gravity. After collapse, the components of a structure have many centers of gravity. When sizing up a lift consider the center of gravity of the object being moved as well as any other pieces which impact it.

FRICTION

If it necessary to move a heavy object up a plane, friction may hinder this effort. Friction may also be the only thing preventing a heavy object from sliding down a plane. The amount of surface areas which are in contact as well as the types of surfaces are determining factors in how much friction exists.

Examples: Smooth concrete to smooth concrete
Concrete to asphalt
Wood to asphalt
Steel to concrete

STABILITY

Stability is defined as: firmness in position, the ability to resist forces which try to move it. Stability or the lack there of are prime concerns when sizing up and executing lifts or moves of heavy objects. Flat slabs or blocks resting on a level surface are generally very stable. Irregular shapes resting on each other or on a slope will usually be fairly unstable. Before any work to lift or move an object is begun the object must be stabilized.

LEVERS AND LEVERAGE

The simplest and often times most useful tools for lifting and moving are simple levers. A long bar and a block of wood allow rescuers the ability to move objects many times their own weight. Several members working together can effectively lift and stabilize objects weighing several thousand pounds.

Levers are divided into three classes:

Class one- Fulcrum is placed between applied force and load
Example: crowbar, pry ax, long bar, scissors

Class two- Load is between fulcrum and applied force
Example: wheelbarrow, pulley

Class three- Applied force is placed between load and fulcrum
Example: shovel, broom, tweezer

MECHANICAL DEVICES

Mechanical devices such as air bags, pulley systems, rescue tools, come-alongs, and even cranes may be available to rescue workers. These devices may allow workers to move weights which are greater than can be handled with simple levers. Often times these devices will allow rescuers to accomplish a given task in a much shorter time. Because these tools can lift and move tremendous amounts of weight quickly, extra care should be exercised. Support structures such as cribbing should always be placed. The lift should proceed no faster than the cribbing can be placed. “Lift an inch/ Crib an inch”. Do not depend on the lifting system to support the load, only to move it. As with any mechanical device, failures happen.

THINGS TO REMEMBER

- Stabilize the load
- Be sure the surface your working on can support the anticipated load
- Never work under an unsupported load (air bag without cribbing, for example)
- Try not to work on downhill side of load
- Lift only high enough to free victim
- Lift an inch/ crib an inch
- Always provide mid-span support on long objects

Definition

Emergency Building Shoring is used to temporarily support unstable loads where rescue workers must operate in, under or around such hazards. Emergency Building Shores will help to protect both rescuer and victim from secondary collapse danger

Material Selection

The most commonly available material for shoring is wood. Lumber from retail and wholesale distributors is readily available in most areas. Size up of a given incident is critical in determining the amount and size of lumber needed. Make your requests for supplies as soon as possible and intentionally over-estimate the amounts needed. In extreme circumstances and in the event that supplies will be significantly delayed, materials may be commandeered from a variety of sources including nearby construction sites, home improvement stores7 fences, bulkheads and even street signs. (do not use intersection -signs as they will be needed for locating specific sites).

Lumber selected for use should be as free as possible from defects. Flaws in the wood significantly reduce its bearing capacity Dimensional lumber and plywood prove to be the easiest to work with. Four by four and six by six are the most useful sizes for weight bearing. Two by four, six and eight are the materials of choice for bracing and lacing individual shores into systems Three quarter inch plywood is the preferred material for gussets and for spreading out the "“footprint” of certain shores in specific situations. Dimensional lumber may be cut into matching wedge sets known as a shim -A shim consists of two wedges driven together from opposite sides.
Wedges should be used with their cut faces together
-Shims will be used in all shoring applications to tighten and to provide adjustability.

Other material shapes may be used for shoring if necessary such as round or odd shaped posts7 blocks and bricks. Materials other than dimensional lumber however, are generally more difficult to work with and provide uncertain bearing capacities. The exception to this is commercially manufactured shores. Often made of pipe they provide excellent bearing strength and adjustability. When a shoring problem exceeds the training, equipment or material available to the rescuer commercial shores in-stalled by technical level personnel or private contractors are a viable option.

Size up

When sizing up a given shoring problem several issues must be addressed. Much like a fire scenario, life hazard is the primary consideration. As the rescuers make decisions as to the method they will use to accomplish their task they must look at the "big picture". This involves seeing as many sides of the problem as possible. Potential hazards around the work site such as hanging debris, out of plumb walls, major cracks in the support structures, hazardous materials and water may all need to be dealt with before the specific task can be safely undertaken. There will be times when these associated hazards will preclude any rescue attempt at all. In the event of wide spread damage, areas such as these may receive low priority in favor of areas where work can begin immediately.

Other questions to ask when making a good size up:

- Rescue of victims or recovery of remains?
- How does victim entrapment and/or obstacles impact patient care?
- Is shoring necessary or can the hazard be removed?

- Is there adequate staffing available?

- What is the likelihood of secondary collapse?
- What is the overall determination of risk Vs potential success?

After these questions have been answered, and it has been determined that shoring is to be put in place, the next consideration is how much weight the shores will be asked to support. The figures in the following list have a built in safety margin of approximately two to one. Do not factor this into your calculations as it would defeat its purpose.

LOAD BEARING CAPACITIES OF COMMON SHORING MATERIALS

Listed capacities assume good Douglas Fir or Southern Pine
Cribbing capacities are determined by assuming perpendicular to grain load on the sum of all bearing surfaces.

4x4 crib = 24,000 lbs. 6,000 lbs. per bearing point
6x6 crib = 60,000 lbs. 15,000 lbs. per bearing point

3 member x 3 member configuration doubles bearing capacity of crib bed
The height of the crib bed should never exceed three times its width

Vertical post capacities assume unbraced height of no more than:

- Five Feet (5') for 4 x 4 Material
- Seven Feet (7') for 6 x 6 Material

4 x 4 = 12,000 lbs. @ Six Feet
4 x 4 = 8,400 lbs. @ Eight Feet
4 x 4 = 5,200 lbs. @ Ten Feet
4 x 4 = 3,600 lbs @ Twelve Feet

Example: 4 x 4 Vertical post ten feet high without bracing will bear 5,200 lbs. If braced in the center, the unbraced height is reduced to five feet and the post will support 12,000 lbs.

6 x 6 = 30,000 lbs. @ Six Feet
6 x 6 = 22,000 lbs. @ Twelve Feet
6 x 6 = 6,000 lbs @ Fourteen Feet
6 x 6 = 12,000 lbs. @ Sixteen feet
Example: 6 x 6 Vertical post Fourteen feet high without bracing will bear 16,000 lbs. If braced in the center, the unbraced height is reduced to Seven feet and the post will support approx. 30,000 lbs.

Considerations for selection of shoring materials

Weights of common building materials

- Concrete **--** 150 pounds per Cu. ft.
- Masonry -- 125 pounds per Cu. ft.

- Wood -- 35 pounds per cubic foot.
- Steel -- 90 pounds per Cu. ft.
- Assorted Rubble -- 10 pounds per sq. ft. per inch of thickness

Add minimum of 10 pounds per sq. ft. for average content load

The structure may not be done moving i.e.: aftershocks, wind, rain

Be aware that significant point loads may be present due to heavy machinery or equipment, large piles of stored goods or automobiles. These items may be difficult to see from the exterior which makes a good size important. when considering content load be sure to identify the occupancy if possible.

Tools.

In order to construct a quality shore or shoring system rescue crews must have a minimum compliment of hand and power tools available. The following list outlines the basics:

- I "x 25' power return tape or other measuring device
- Hammers including: Framing hammer, 2 lb. Maul (2 ea.), 10 lb. sledge
- Pry bars, Nail pulling bars, Crow bars
- Framing square, Speed square
- Circular saw
- Extension cords
- Power source (generator or domestic power)
- Pencils or other marking device
- Nails including: 16d and 8d
- Shovels including: spade and square point

In an emergency situation some of these basic tools may not be available and the rescuer will have to adapt. For example, an ax may have to serve as a sledge hammer or maul. A chain saw, if used carefully, can substitute for a circular saw. It is necessary to become proficient in the use of these tools to effect a safe operation.

Constructing the shores

All of the shores we will discuss have similar component parts. Each type of shore may have the parts configured differently. The exception to this is cribbing, which will be addressed later

The components:

> **The shoring member** or post: May be vertical, horizontal, or at an angle. This is the component that bears the weight and transmits the load.
>
> **Header:** The component that that collects the load in vertical shoring applications.

Sole plate: The component that distributes the load in vertical shoring applications.

Gussets: 3M" plywood cut into l2” x 12”' sections used to connect shoring components to each other.

Cleats: 2x4 or 2x6 material used to tie structural members together

Bracing: 2x4 or 2x6 material used to prevent deflection of structural components.

Lacing: 2x4 or 2x6 material used to tie individual shores together forming shoring systems.

Shim/Wedge Set: May be any size material dependent on need. One set of wedges equal one shim. Shims will be used in every shoring application to allow for tightening and adjustability. One wedge, or half a shim, may be used to fill a void, as a stake in the ground, or an aid in leveling a shore.

In horizontal shoring applications there are two other components:

Wall plate: Also known as a spreader, is used to coiled the load in horizontal applications.

Raker: Describes the component which transmits the load from wall plate to sole plate when installed at an angle.

Fill material: Any material used to fill void spaces between the shore and the surface being sup-ported. Fill material increases the amount of contact area and subsequently the amount of friction being generated.

Shoring team organization

Every shoring operation needs to be organized to operate effectively. This means dividing the available personnel into groups with specific functions. There are two main tasks to be performed.

Procurement and cutting of materials

This includes organizing a work station and the measuring and cutting of material as called for by the crew responsible for the installation.

Assembly and installation of shores

The installation crew is responsible for calling out precise measurements of the needed shoring components and any other material necessary to accomplish the given task. They are then responsible for assembling and putting the shores into place.

If staffing permits, a third crew consisting of one person, should act as a 'runner" between the cutting operation and the installation crew. This person may carry a list of dimensions from one to the other or be

used to transport material from the cutting station to the shoring site. Communication between the shoring groups is the key to a successful operation.

The Shores

As we prepare to look at examples of each shore there are several rules that must be discussed first.

Collect, Support and Distribute: Every shore that is installed must follow this rule.

Support the load but do not move it: Shoring systems need to-be applied gently so as not to move or place additional strain. Every shore must translate its load to the ground or to an undamaged floor

Work from a safe zone: As each individual shore is placed it offers a safe from which to work. The rule of thumb for a safe zone is four feet. As subsequent shores are placed they should be braced and laced together to form a shoring system. Placement of shores should be accomplished in straight lines or at right angles when possible to make lacing and bracing easier Spend as little time in the hazard area as possible with the fewest number of people.

Cribbing

For maximum stability, crib beds should be no taller than twice the length of the material being used. The height of a crib bed should never exceed three times the length of the material being used.

Example: 18 inch cribbing material should not he stacked any higher than 36 inches.
Example: 24 inch cribbing material should not be stacked any higher than 48 inches.

The stability of cribbing depends a great deal on the surface on which it rests. Soft soil or uneven surfaces may require some preparation work. Plywood or boards may be used under the crib.

Constructing box cribbing

All cribbing shores have a few things in common. Each layer should be laid perpendicular to the previous layer This known as cross-tie". Individual members should be neatly arranged to provide solid contact with each other and the ground. Cribbing should be as perpendicular to the toad as possible. Crib beds should rest on a surface capable of supporting the expected load.

The standard configuration for cribbing is two members per layer When material is in good supply the three member per layer configuration is desirable. The three member method offers approximately twice the bearing capacity of the two member method.

Cribbing may also be adjusted into a parallelogram for use in tight spaces. It is important however to maintain a solid wood to wood to ground fit.

Wedges may be used to change the direction of support if needed. No more than one row of wedges per layer is acceptable. If the angle of the crib bed becomes to severe the bed will fail. The use of nails to secure layers to each other will prevent the bed from falling apart as you build it.

Two Member

Change in direction

Three member

Vertical Shores

The "T" shore is **the most** commonly used configuration. More than one "T" can be laced and braced together into a shoring system. There are several variations of this shore making it very versatile.
The "T" shore consists of a header (collect), shore or post (support), sole plate (distribute) and an assortment of gussets and braces depending on the application.

Combination Shores may be used in instances where both vertical and horizontal shoring is required in the same opening or area. Special care must be given to assure that both follow the 'collect, support and distribute rule." A greater amount of forethought is required with this shore in relation to the placement of gussets and shims. Shims and gussets of one must not interfere with the other.

The Standard Vertical Shore is most commonly used to support an overhead load such as in a doorway, down the center of a room, or in a window. There also many variations of this shore which are acceptable as long as the basic "collect support and distribute rule" is observed. Notice the horizontal and diagonal bracing in the drawing below. This bracing is mandatory to prevent deflection of components as they are loaded as well as stabilizing the shore against movement after it is installed.

The Horizontal Shore is used to bear loads applied from the sides. Most commonly used in doors, hallways, and windows. The horizontal shore may also be used to retain soil, debris, or rubble. The horizontal shore employs the same principles as previous shores but has slightly different names for its components. The component which gathers the load is referred to as a wall plate or plate. The components which bear the load are called spreaders or shores. A horizontally applied shore must be braced and cross braced in the same manner as the vertical applications Likewise an ample amount of gussets and cleats must he used

Raker Shoring

See appendix 1-4

Raker shoring is used to support vertical or near vertical walls. Raker, or diagonal shoring is the most time consuming shore to construct and to put in place.

When considering if raker shoring is indicated ask the following questions:

- Can we remove the hazard instead of shoring it?
- Is there another means of entrance or egress that does not require shoring?
- Do we have adequate material and trained personnel?
- And finally, Do we have the time?

If it has been determined that raker shoring is required, there are several rules which must be followed. Regardless of which raker method is used, the angle at which the diagonal component (raker) is installed will be no less than 30 degrees and no more than 60 degrees. Exceeding these limits places excessive pressure on other shoring components potentially causing failure.

Raker Shores should be installed so that the intersection of the raker and the wall plate contact the wall at approximately 2/3 of the way up. Some deviation is allowed to avoid conduit, power service or other protrusions from the wall. Bear in mind that small protrusions may be best handled by filler material placed in the voids. Rakers should always be constructed from 4' x 4' or larger material. 4' x 6' or 6' x 6' are preferable. Raker shores are not intended to stand alone, they should always be installed in pairs, braced and laced together after installation.

There are three major types of raker shores.

- **Solid Sole**
- **Split Sole**
- **Flying Raker**

All of these shores have common components but are arranged in different fashions**.**

The solid sole method incorporates a solid sole plate to affix the other components. This sole plate creates friction against the surface on which it rests helping the shore to resist movement. For our purposes will not rely on friction alone to retain the shore. Anytime it is feasible, spikes or pickets will be driven through the sole plate into the underlying surface. The sole plate may also be abutted to a curb or other solid protrusion when spiking is not possible.

The split sole method relies on ground contact by the diagonal component. This shore might be used when the surface over which it must pass is irregular or very soft. To capture the end of the raker a hole must be dug and plywood or blocking is used to spread the load over the back of the hole. A shim is then used to tighten the raker against the other components. Wedges may be used behind the acking material to achieve a square fit to the shim and raker.

The Flying Raker is much the same as the split sole method. The main difference being the wall plate section. When it is impossible to erect a frill length wall plate due to debris or uneven terrain the flying raker may be the solution. It too spans uneven ground or other obstacles by eliminating the sole plate. The wall plate portion of the flying raker must be attached to the wall as the friction it creates is unreliable.

All three methods can utilize plywood as a backing material to the wall plates. The plywood, is of little structural value, but is useful in retaining loose brick or other debris. As with all shores, adequate bracing, gussets and cleats must be placed.

Cutting the raker

The optimum angle for raker shoring is forty-five degrees. This is halfway between the minimum of thirty and the maximum of sixty. The forty-five degree raker is the easiest to calculate as well as the easiest to cut. It provides for the greatest amount of stability as it distributes equal pressure to both ends of the shore. When conditions permit the forty-five degree raker is the shore of choice. There are several methods available to calculate and cut the angles on a raker and to pre-determine its length. The desired method will be the **factor method**. The factor method assigns a factor to each of the common angles we used to cut a raker.

The Factor Method:

45 degree raker = factor 17
60 degree raker = factor 14
53 degree raker = factor 15

These factors, when multiplied by the height of support will yield the length of the raker.

Example: To support a wall that is thirty feet in height, the correct point to place our shore is approximately 2/3 of the way up this wall or about 20 feet.

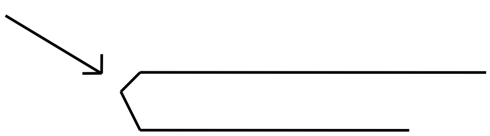
For a forty-five degree raker the calculation looks like this: 20' x factor 17 = 340"

Notice that the result of this equation is expressed in inches.

For a sixty degree raker the calculation looks like this: 20' x factor 14 = 280"

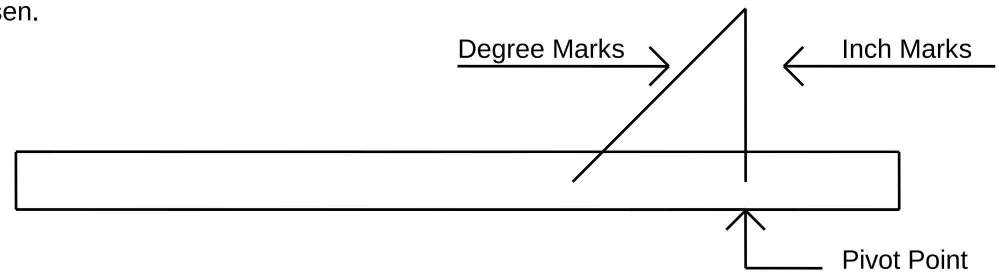
As you can see, the appropriate factor is multiplied by the height in feet of our point of support and expressed as raker length in inches This method calculates the length of the raker from point to point of the cut angles.

The finished product will have to be cut back by 1 3/4" to provide a flat spot to bear against our cleats.



Once the proper length for the raker has been determined we will need to cut the correct angles on each end If we have chosen a sixty degree raker one end will be cut to sixty degrees and the other to thirty degrees totaling ninety degrees. For a forty-five degree raker the angles on each end are cut the same totaling ninety degrees The exception to this is if the wall is out of plumb or if the wall is leaning ten degrees the sum of our angles must now total eighty degrees. This might be accomplished with a forty-five and a thirty-five totaling eighty. Remember to stay within the limits of thirty and sixty degrees. A sixty and a <u>twenty</u> would not be acceptable.

In order to cut the appropriate angles we will use a speed square. The speed square has degrees marked out along one edge. The other edge has inch increments and a pivot point To find and mark the correct angle for each application, lay the square on the material being cut. Be sure that the raised edge of the square rest firmly against the edge of the material. Place the pivot point on the mark for the length you have chosen.



The speed square can now be pivoted until the correct number of degrees lines up with the edge of the material.

The same operation can be repeated on the other end of the material to achieve the desired angle. Be sure to always work from the same side of the material for both cuts.

Once the length has been determined and both ends of the raker have been cut to the appropriate angles it is time to assemble the components into a shore.

It is generally advisable to assemble as much of the shore as possible away from the hazard area.

ASSEMBLING A RAKER SHORE

- Determine lengths of wall plate and sole plate.
- Attach gussets to end of the sole plate that will intersect wall plate.
- Slide sole plate into position.
- Attach cleat to wall plate at appropriate height- cleat must be at least 24" long.
- Attach gussets to wall plate at point which raker will intersect.
- Position wall plate on top of sole plate and slide toward wall until the base engages the gussets on the sole plate.
- Use the raker to position the wall plate by engaging the raker in the gussets, against the cleat on the wall plate. Quickly slide the raker and wall plate assembly to the vertical position. Be sure to keep the bottom end of the raker sliding along the sole plate. This method will help to maintain control of the assembly until it is secured.
- Position cleat on sole plate leaving approximately 3" between end of cleat and end of raker This space allows room for a shim.
- Attach the cleat.
- Place shim between raker end and cleat then tighten.
- Place and attach gussets at bottom intersection of raker and sole plate. Do not place gussets in such a way that they interfere with the ability to tighten or adjust the shim.
- Secure the gusset at the intersection of wall plate and sole plate.
- Secure the gusset at the intersection of the wall plate and the raker
- Attach horizontal bracing.
- Secure the shore to the ground and building if possible.

See illustrations next page