VI. EXTRICATION OPERATIONS

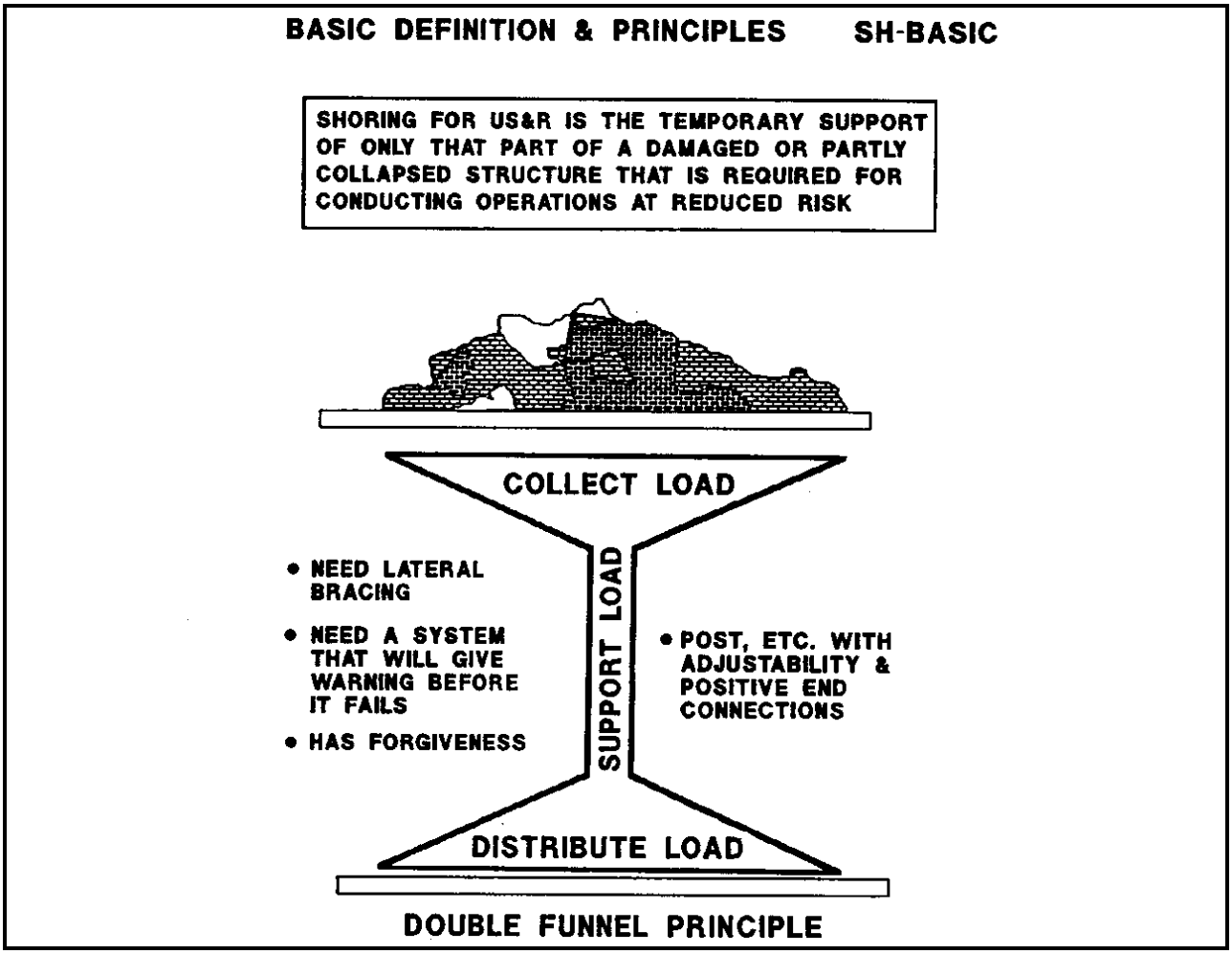
MODULE ONE: A — SHORING

BASIC DEFINITION AND PRINCIPALS

Shoring is normally the temporary support of structures during construction, demolition, reconstruction, etc. in order to provide the stability that will protect property as well as workers and the public.

SHORING FOR US&R IS THE TEMPORARY SUPPORT OF ONLY THAT PART OF A DAMAGED, COLLAPSED, OR PARTLY COLLAPSED STRUCTURE THAT IS REQUIRED FOR CONDUCTING SEARCH AND/OR RESCUE OPERATIONS AT REDUCED RISK TO THE VICTIMS AND US&R FORCES

Shoring system is like double funnel. One needs to collect load thru beams/sheathing, get it into the post/struts, then distribute safely into the supporting structure below. **A heavily loaded wood post can punch thru a concrete slab etc.**



VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

BASIC DEFINITION AND PRINCIPALS (continued)

Shoring should be built as a system that has the following:
- ! Header beam, wallplate, other element collects load
- ! Post or other load carrying element that has adjust ability and positive end connections
- ! Sole plate, bearing plate, or other element to spread the load into the ground or other structure below.
- ! Lateral bracing to prevent system from racking (becoming parallelogram), and prevent system from buckling (moving sideways).
- ! Built-in forgiveness (will give warning before failure) **Example: If vertical shore is proportioned properly, (posts with length to width ratio of 25 or less) one can hear the header or sole crush against the post prior to the post starting to fail.**

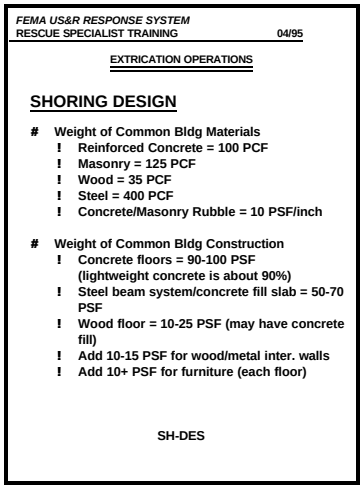
Minimum level of lateral strength in any vertical support system should be 2 % of vertical load, but 10% is desirable where aftershocks are expected.

Trench Shores provide opposing lateral support - to keep trench/hole etc. from filling in. Design is normally based on at least half the pressure of water (equivalent fluid weight of at least 30PSF per ft. of depth, PCF)

CONSIDERATIONS FOR DESIGN AND SELECTION

WEIGHTS OF COMMON BUILDING MATERIALS.
- ! Concrete = 150 PCF **PCF = lbs per cubic ft**
- ! Masonry = 125 PCF **PSF = lbs per square ft**
- ! Wood = 35 PCF
- ! Steel = 490 PCF
- ! Conc/Masonry Rubble=10PSF PER INCH (of thickness)

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


FEMA US&R RESPONSE SYSTEM
RESCUE SPECIALIST TRAINING 04/95

EXTRICATION OPERATIONS

SHORING DESIGN

Weight of Common Bldg Materials
- ! Reinforced Concrete = 100 PCF
- ! Masonry = 125 PCF
- ! Wood = 35 PCF
- ! Steel = 400 PCF
- ! Concrete/Masonry Rubble = 10 PSF/inch

Weight of Common Bldg Construction
- ! Concrete floors = 90-100 PSF (lightweight concrete is about 90%)
- ! Steel beam system/concrete fill slab = 50-70 PSF
- ! Wood floor = 10-25 PSF (may have concrete fill)
- ! Add 10-15 PSF for wood/metal inter. walls
- ! Add 10+ PSF for furniture (each floor)

SH-DES

VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

BASIC DEFINITION AND PRINCIPALS (continued)

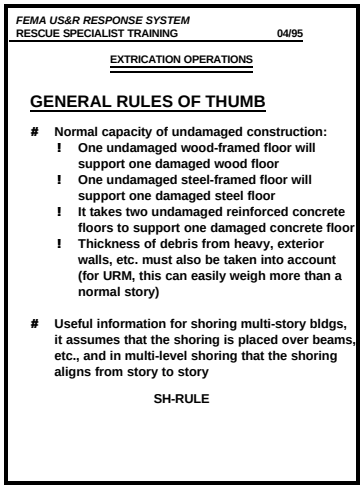
- # Normal capacity of undamaged, existing construction.
  - ! One undamaged wood or steel framed floor will support one damaged floor
  - ! It normally takes two undamaged concrete floors to support one damaged floor
  - ! The thickness of rubble/debris on damaged floor must also be taken into account.

- # Condition of structure to be supported -concrete beams, solid concrete slab, broken slab, masonry rubble - determines spreading system needs.

- # The condition of foundation/support of shoring - solid/soft ground, slab on ground, floor over basement below, rubble, number of un-damaged stories below, determines extent of system.

- # Availability of shoring materials - pre-plan, local contractors, foreign location.
  - ! For collapsed structures want light, portable, adjustable, reliable, and forgiving shoring system.

- # Damaged/Collapsed buildings often contain lateral as well as vertical instability.
  - ! Building with cracked (damaged) and out of plumb walls/columns require lateral support in proportion to the offset story, (as much as 20 % of weight of building).
  - ! If structure is partly supported by tension structure-like system, horizontal forces are often induced in remaining structure.
  - ! Collapses that have large remaining pieces can be extra dangerous. Interconnected pieces may depend on each other for support. A complicated balancing act to be wary about.
  - ! Collapsed structures containing sloped surfaces are especially difficult, since loads are vertical due to gravity, but contact surfaces are sloped, and therefore, vertical and lateral forces induced in shoring are both very large.

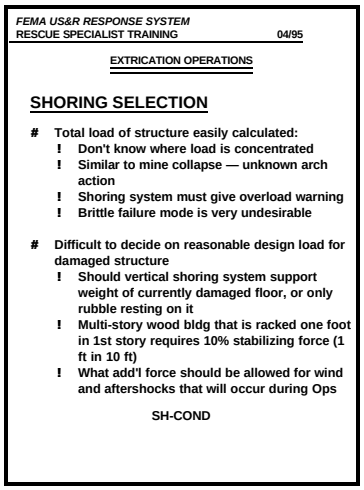

FEMA US&R RESPONSE SYSTEM
RESCUE SPECIALIST TRAINING 04/95

EXTRICATION OPERATIONS

GENERAL RULES OF THUMB

- # Normal capacity of undamaged construction:
  - ! One undamaged wood-framed floor will support one damaged wood floor
  - ! One undamaged steel-framed floor will support one damaged steel floor
  - ! It takes two undamaged reinforced concrete floors to support one damaged concrete floor
  - ! Thickness of debris from heavy, exterior walls, etc. must also be taken into account (for URM, this can easily weigh more than a normal story)
- # Useful information for shoring multi-story bldgs, it assumes that the shoring is placed over beams, etc., and in multi-level shoring that the shoring aligns from story to story

SH-RULE


FEMA US&R RESPONSE SYSTEM
RESCUE SPECIALIST TRAINING 04/95

EXTRICATION OPERATIONS

SHORING SELECTION

- # Total load of structure easily calculated:
  - ! Don't know where load is concentrated
  - ! Similar to mine collapse — unknown arch action
  - ! Shoring system must give overload warning
  - ! Brittle failure mode is very undesirable
- # Difficult to decide on reasonable design load for damaged structure
  - ! Should vertical shoring system support weight of currently damaged floor, or only rubble resting on it
  - ! Multi-story wood bldg that is racked one foot in 1st story requires 10% stabilizing force (1 ft in 10 ft)
  - ! What add'l force should be allowed for wind and aftershocks that will occur during Ops

SH-COND

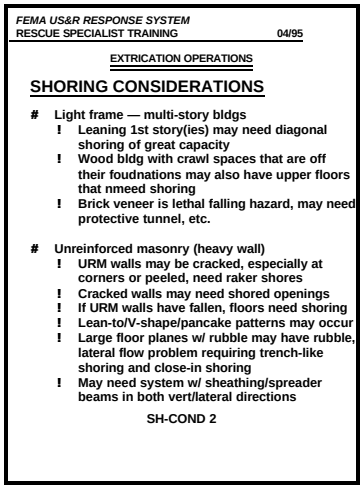
VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

BASIC DEFINITION AND PRINCIPALS (continued)

! Total load of structure above can be relatively easily calculated, but where individual load concentrations are being applied is often difficult to determine. A shoring system that will give warning of overload is therefore most desirable.

! It is difficult to decide on the design load when a damaged structure is at rest, but of questionable stability.
- Should vertical shoring support the weight of the damaged but currently stable floor, or only the weight of rubble resting on it?
- A four story wood building that is offset one foot in ten in the lower story will require a ten percent stabilizing force, but what additional force should be allowed for wind or aftershock?


FEMA US&R RESPONSE SYSTEM
RESCUE SPECIALIST TRAINING 04/95

EXTRICATION OPERATIONS

SHORING CONSIDERATIONS

Light frame — multi-story bldgs
! Leaning 1st story(ies) may need diagonal shoring of great capacity
! Wood bldg with crawl spaces that are off their foudnations may also have upper floors that nmeed shoring
! Brick veneer is lethal falling hazard, may need protective tunnel, etc.

Unreinforced masonry (heavy wall)
! URM walls may be cracked, especially at corners or peeled, need raker shores
! Cracked walls may need shored openings
! If URM walls have fallen, floors need shoring
! Lean-to/V-shape/pancake patterns may occur
! Large floor planes w/ rubble may have rubble, lateral flow problem requiring trench-like shoring and close-in shoring
! May need system w/ sheathing/spreader beams in both vert/lateral directions

SH-COND 2

VERTICAL SHORING SYSTEMS

These systems are primarily intended to provide vertical support, but should all have some lateral bracing for stability. (2% min., 10% reasonable) However, often, individual vertical supports are initially installed without lateral bracing, in order reduce risk while constructing a well braced system.

Wood Post Systems

Unless very short, post strength depends on buckling and varies relative to its length and the modulus of elasticity (E).

! Square Posts P/A allow = .3E/(L/D) squared

! Round Posts P/A allow = .23E/(L/D) squared.

! (E varies from 1M to 1.8M PSI depending on wood species. P/A = compression stress) PSI=lbs/sq inch

! (L = Length, D = Least width or Dia., L/D max = 50)
As stated on pg. 2, if want to hear warning of failure, it is better to limit L/D of posts in vertical shores to 25.
Example 4x4 max. length = 50x3.5 =175" = 14.5ft
4x4 length for L/D of 25 = 25x3.5 = 88" = 8ft

VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

VERTICAL SHORING SYSTEMS

Wood Post Systems (continued)

The strength of a wood post system is determined by:
- **!** Perpendicular to grain bearing on the header or sole plate (allowable bearing stress varies from 300 PSI to 700PSI depending on wood species.
- **!** Vertical capacity of the posts.
- **!** Strength of header beam and/or sole plate.
- **!** Strength of ground or structure below sole plate.
- **!** If posts are kept short **(8 ft for 4x4, 12 ft for 6x6)** the system will give warning of failure by crushing the softer crossgrain (spring wood) at the bearing of the post on the sill or header.

Douglas Fir or Southern Pine are the most common types of structural timber used in the U.S. Average values for these species are:
- **!** E = 1,600,000 PSI
- **!** Compression parallel to grain = 1100 PSI
- **!** Compression perpendicular to grain = 600 PSI

These systems are normally made adjustable by cutting and shimming with full bearing, opposing wood wedges. All posts should be positively attached at top and bottom, using plywood gussets or metal clips. This requirement must be considered along with the need to readjust the shims when making the connections.

The capacity of header beam and sole plate are determined by bending an/or horizontal shear strength. Average values for Douglas Fir and Southern Pine are:
- **!** Fb = extreme fiber bending stress = 1500 PSI
- **!** Fh = horizontal shear stress = 90 PSI

The capacity of a system supported on the ground may be limited by the soil bearing capacity and transverse spreading of load may be desirable to avoid excess settlement.

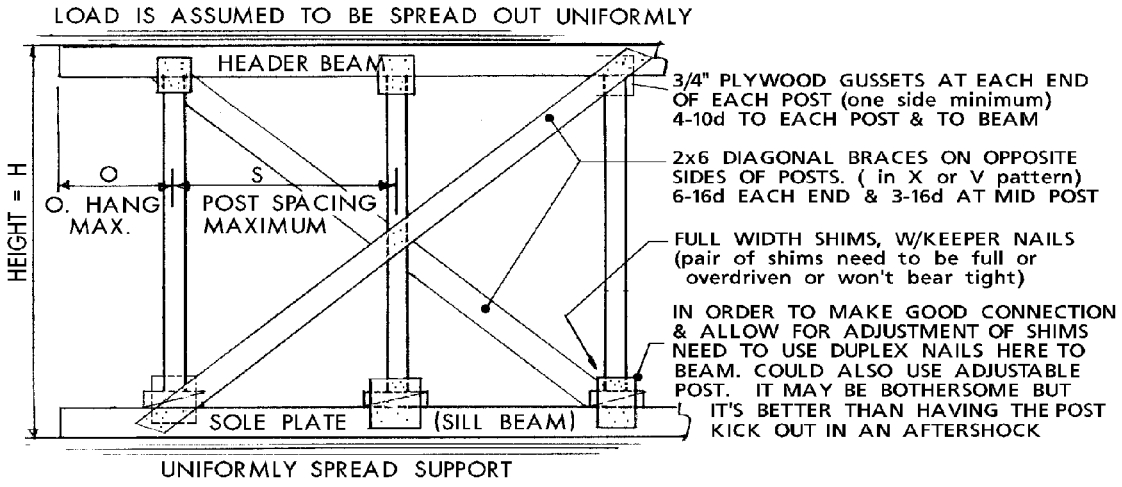
VI. EXTRICATION OPERATIONS
MODULE ONE: A — SHORING

VERTICAL SHORING SYSTEMS

Wood Post Systems (continued)

All wood post systems should have diagonal wood bracing, in north-south and east-west direction if possible. Bracing should be designed for at least 2%, of the vertical capacity of the shoring system. (10% if aftershocks are possible.)

VERTICAL WOOD SHORING SHOR-1



4x4 POST SYSTEM W/4x8 HEADER BEAM & SOLE PLATES

HEIGHT = H	POST SPACING = S	OVERHANG = O	CAPACITY OF EACH POST
8'-0"	4'-0"	2'-0"	8,000 LB
10'-0"	5'-0"	2'-6"	5,000 LB
12'-0"	6'-0"	3'-0"	3,500 LB

6x6 POST SYSTEM W/6x12 HEADER BEAM & SOLE PLATES

HEIGHT = H	POST SPACING = S	OVERHANG = O	CAPACITY OF EACH POST
12'-0"	4'-0"	2'-0"	20,000 LB
16'-0"	5'-0"	2'-6"	12,000 LB
20'-0"	6'-0"	3'-0"	7,500 LB

BASIC ASSUMPTIONS:

- Configurations shown are for MAXIMUM spacing of posts so that capacity of header & sole plate just matches capacity of posts.
- Spacing of POSTS may be closer than shown to increase system capacity (per foot)
- If HEADER/SOLE is reduced, the capacity of each POST should be reduced in proportion to the reduction in HEADER DEPTH (change 6x12 to 6x6, capacity is 1/2)

VALUES GIVEN FOR ALL WOOD SHORES IN THIS TEXT HAVE AN APPROXIMATE FACTOR OF SAFETY OF 2 TO 1 IF NO. 1 DOUGLAS FIR OR SOUTHERN PINE ARE USED. PIECES SHOULD BE SELECTED FOR GOOD GRAIN (MIN. OF 8 RINGS PER INCH, SLOPE OF GRAIN NOT GREATER THAN 8 TO 1, AND HAVING 1 1/2 INCH OR SMALLER TIGHT KNOTS / 3/4" MAX LOOSE KNOTS)

VI. EXTRICATION OPERATIONS

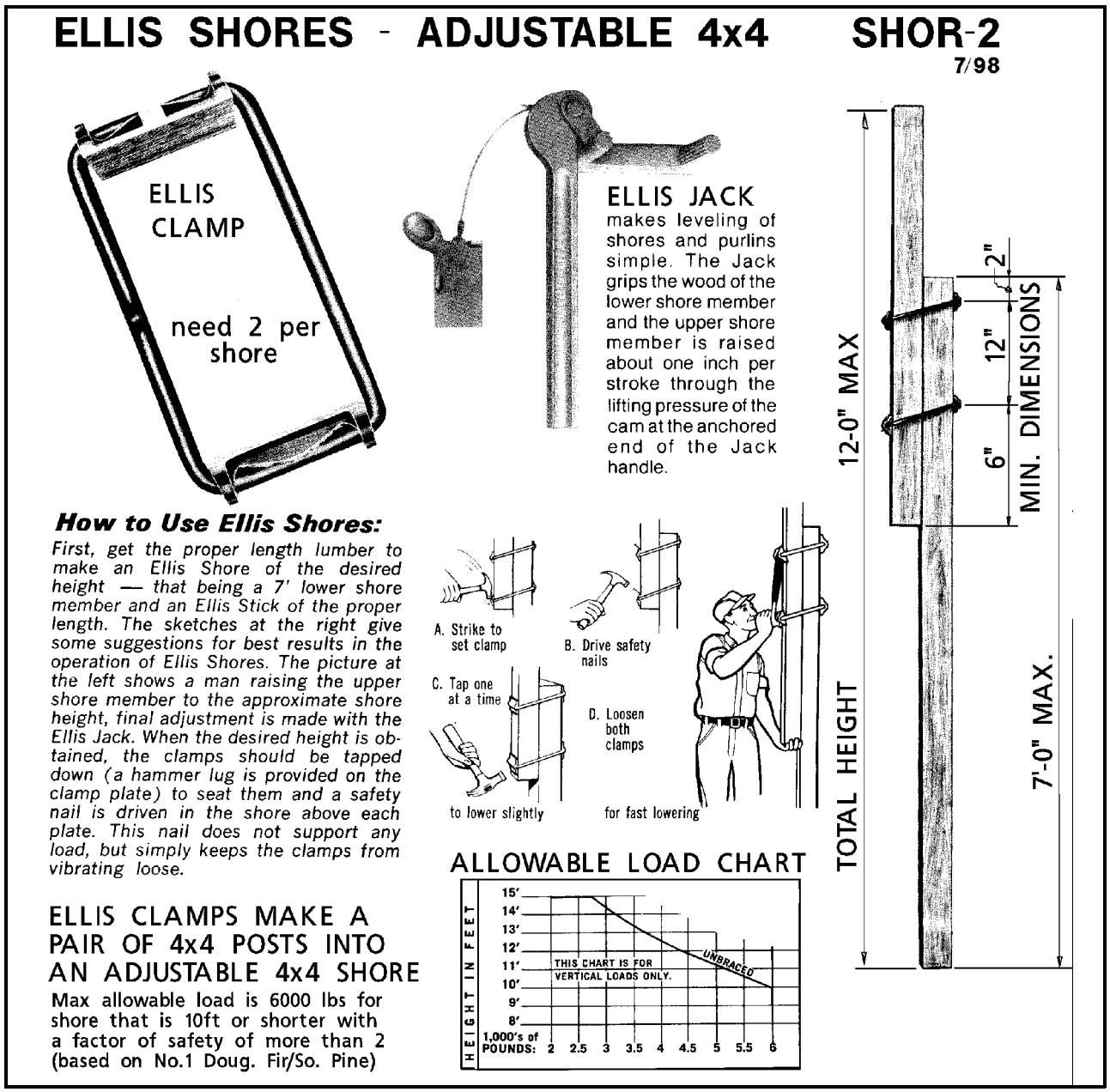
MODULE ONE: A — SHORING

VERTICAL SHORING SYSTEMS (continued)

Wood Post Systems (continued)

4 x 4 posts can be assembled with Ellis Clamps that give them adjustable length. The failure mode of these assemblies is usually indicated by the crushing of the wood under the clamps, which gives the system some forgiveness. (If shores 8 ft. or less)

! These shores use more lumber than single posts, but they can be very useful when working with short 4x4's.



VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

VERTICAL SHORING SYSTEMS (continued)

Wood Post Systems (continued)

Metal, adjustable post feet for 4 x 4 & 6 x 6 are made by Ellis and called Screw Jacks. The foot base plate has nail holes for positive attachment.

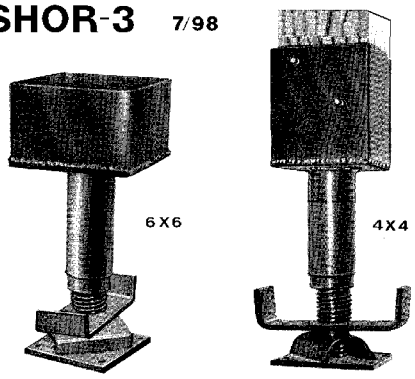
Laced Posts

Four posts may be placed in a square pattern and laced together with 1x4 or 2x4 horizontal and diagonal bracing (laced).
The strength of each post may then be calculated on the basis of the length/height between lateral braces (horizontal members)
Spreader beams and sills may be required to collect and distribute the load, as with any system.
The space inside the laced posts may be useful as a safe haven, since it is relatively strong and one may climb in relatively quickly

VERTICAL SHORES **SHOR-3** 7/98

SCREW JACK by Ellis

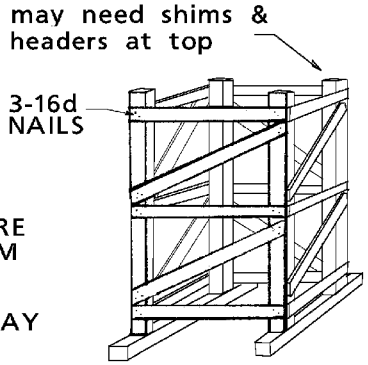
- ADJUSTABLE METAL FOOT FOR 4x4 & 6x6 WOOD POSTS
- 6" TOTAL ADJUSTMENT (set half-way get 3" up & 3" down
- SCREW JACK IS STRONGER THAN WOOD POST, SO SYSTEM WILL BE BASED ON VALUES PREVIOUSLY GIVEN FOR WOOD POST SYSTEMS (use header beam & sole plate)



LACED POSTS

- FOUR WOOD POSTS PLACED 3' TO 6' APART EACH WAY IN SQUARE
- WAY TO INCREASE THE CAPACITY OF 4x4 POST THAT ARE OVER 8' LONG
- ADD 1x4 OR 2x4 LACING (need 2x if posts are more than 3'-6" apart)
- FOR STRENGTH CALCULATION, THE POSTS ARE FIGURED ON THE BASIS OF THE HEIGHT FROM CROSS PIECE TO CROSS PIECE
- SHOULD USE HEADER BEAM & SOLE PLATE + MAY ALSO NEED SHIMS
- TOTAL HEIGHT SHOULD NOT EXCEED THREE TIMES TOTAL WIDTH
- SYSTEM COULD BE USED AS SAFE HAVEN
- 4-4x4 POSTS UP TO 16'-0" = 30,000 LB MAX.* CAPACITY
  4-6x6 " 24'-0" = 72,000 LB " "

(* capacity may be less depending on spreaders, support below, etc.)



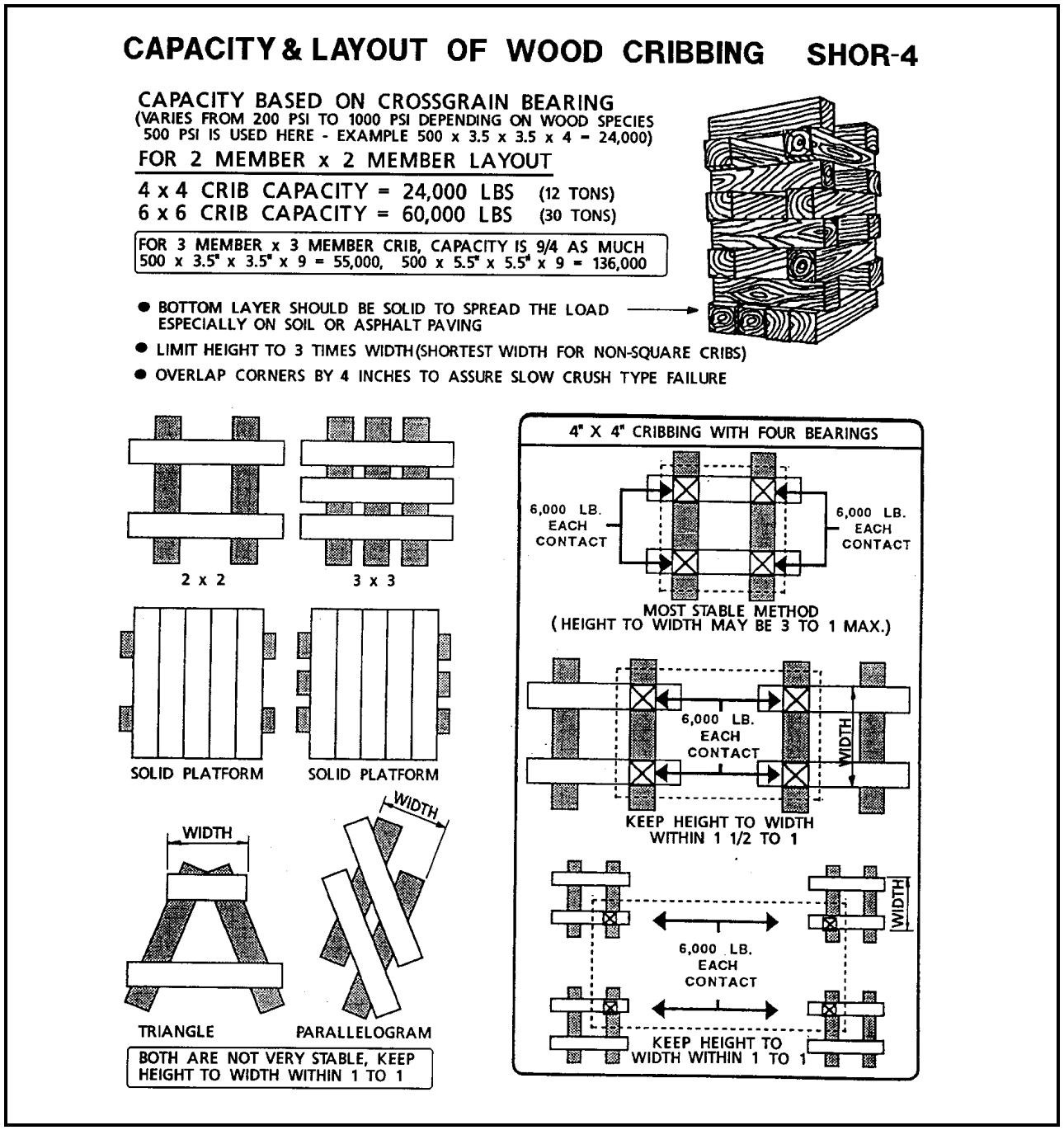
VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

VERTICAL SHORING SYSTEMS (continued)

Cribbing

Multi member lay-up of 4x4 to 8x8 lumber in two or three member per layer configuration.
Capacity is determined by perpendicular to grain load on sum of all bearing surfaces.



VI. EXTRICATION OPERATIONS
MODULE ONE: A — SHORING

VERTICAL SHORING SYSTEMS (continued)

Stability is dependent on height to width of crib and should not exceed 3 to 1.

Cribs used by contractors (or in short term emergencies) often rely only on the friction between bearings for lateral strength, not sufficient for aftershocks.

Individual pieces may be notched like lincoln logs, to provide lateral resistance in addition to the friction between pieces. Metal clips may also be used to improve lateral strength, as well as diagonal braces between pairs of cribs.

Failure is slow, noisy crushing of softer spring wood fibers, which make system very desirable for unknown loading of US&R work. In order to assure this desirable failure mode the crib corners must be made by overlapping the individual pieces by three or four inches.

Solid levels can be placed within the crib to support a jack or spread the load at the ground level.

Shrinkage of green lumber will cause crib to shorten and they should be checked daily for tightness.

Cribs may be used to support sloped surfaces as will be discussed later

Steel Pipe Systems

Pipe capacity depends on buckling strength.

P/A allow = 0.5E/(L/R) squared

E = 29,000,000 PSI

(L = length; R = radius of gyration = average radius of pipe)

Retractable pipe shores are normally adjustable by screw end and/or sleeve and pin. They may have square steel feet that may even have slope adjustment and nail holes for attachment.

Pipe shores used for bracing tilt-up concrete walls come in lengths up to 30 feet and have rated capacities listed in tables supplied by rental companies.

Pipe systems are often used with wood spreader beams and sills, which could limit their capacity. Engineers should be used to design these systems.

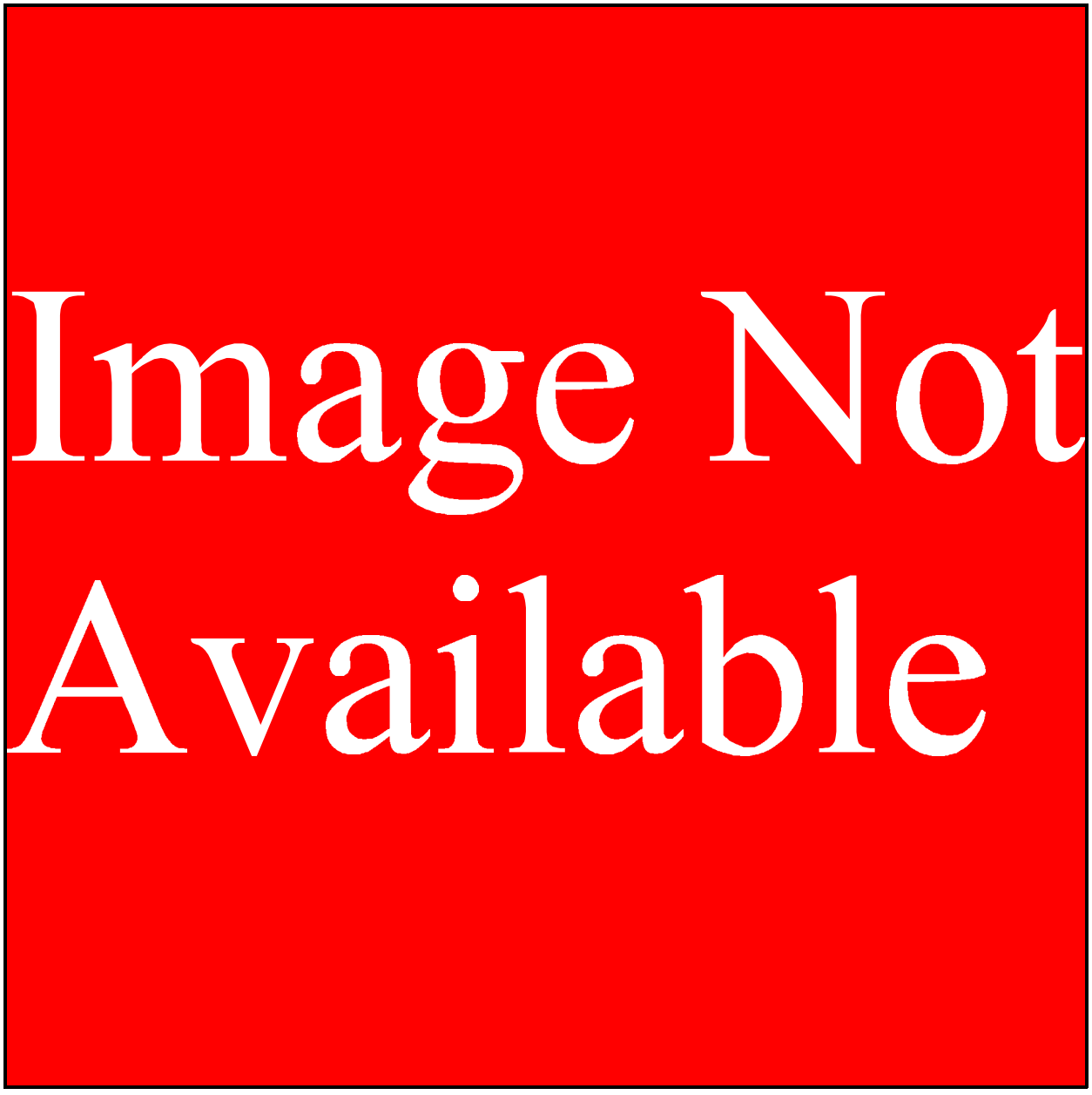
VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

VERTICAL SHORING SYSTEMS (continued)

Trench Jacks (SHOR-5)

- Vary from about two to more than eight feet long and normally have a rated capacity. They are intended to support the opposing sides of a trench, with the addition of spreaders & sheathing
- May be used as initial, unbraced shoring to permit building of more stable system.
- If used as only system they will need to be connected to spreaders at top and bottom and should be laterally braced.



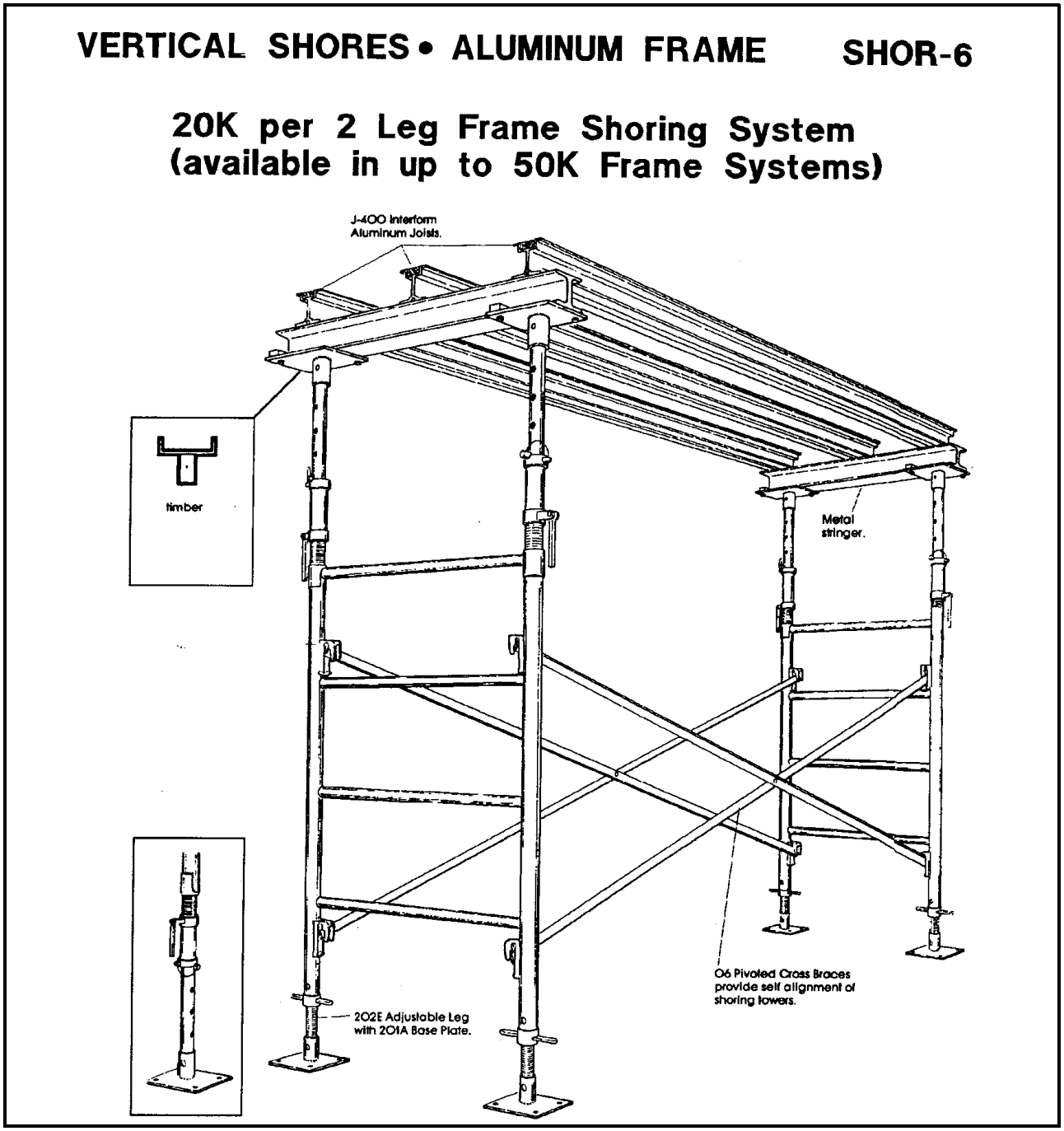
VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

VERTICAL SHORING SYSTEMS (continued)

Diagonally Braced Metal Frame Systems (SHOR-6)

! Steel and aluminum tubular frames are available in capacities up to 50,000lb. per two post frame. They have adjustable height and spreader systems. They may be stacked and guyed to reach great heights, and have diagonal bracing members.



VI. EXTRICATION OPERATIONS
MODULE ONE: A — SHORING

VERTICAL SHORING SYSTEMS (continued)

Pneumatic Shores (SHOR-7)

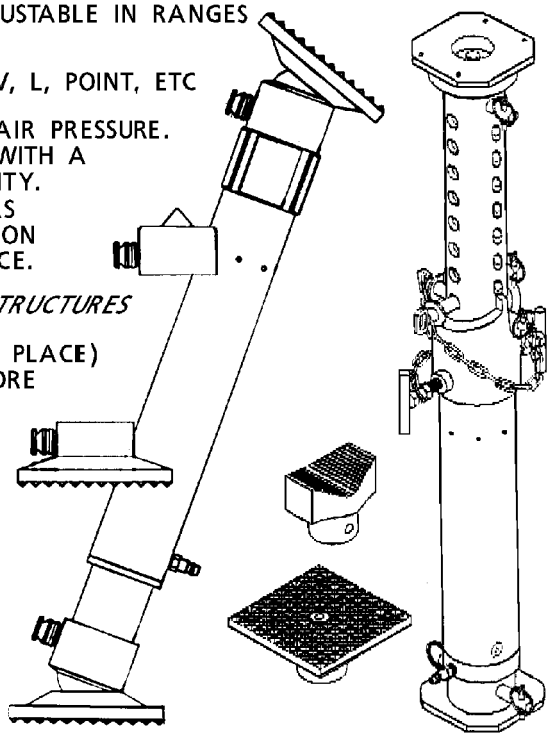
Light weight aluminum pneumatic piston ram shore which is highly adjustable with ranges up to 16 ft. They can be configured with various end connections (see below).

When used in trenches, these shores are initially set with pressurized air. After securing the shore in place with a large locking nut or steel pins with collar, the safe working load can range from 20,000 lbs. for four foot shore to 3500 lbs. for ten foot shore. Load charts for the two leading manufactures are listed in the 1998 rev. of the US&R Structural Specialist FOG. (Safe loading should be based on Pinned/swivel end connections)

These shores are used without air in US&R, so as not to apply any sudden pressure to a damaged structure. The sleeve nut or steel pins are used to adjust length. They may be included in a system with headers, sole plate, & beam and bracing, but are considered most useful as individual, temporary shores that allow a braced system to be installed at reduced risk.

PNEUMATIC SHORES **SHOR-7** 8/98

- MADE FROM TWO ALUMINUM TUBES, ONE SLIDES INSIDE OTHER AND CAN ACT AS PISTON RAM. HIGHLY ADJUSTABLE IN RANGES FROM 2FT TO AS MUCH AS 16FT.
- CAN BE CONFIGURED W/FLAT ENDS, SWIVEL, V, L, POINT, ETC
- CAN BE INITIALLY SET MANUALLY OR WITH AIR PRESSURE. AFTER INITIAL SET, THEY MUST BE SECURED WITH A LOCKING DEVICE TO ACHIEVE LISTED CAPACITY. SOME USE A LARGE SLEEVE NUT AND OTHERS USE PINS THRU THE INNER TUBE THAT BEAR ON A SLOPING COLLAR AS THEIR LOCKING DEVICE.
- *DO NOT USE AIR FOR INITIAL SET IN US&R STRUCTURES*
- SAFE WORKING CAPACITY (WHEN LOCKED IN PLACE) CAN BE AS MUCH AS 20,000LB FOR 4 FT SHORE TO AS LITTLE AS 3500LB FOR 10FT SHORE *(see Struct Spec FOG for LOAD TABLES based on pinned/swivel ends)*
- PNEUMATIC SHORES MAY BE INCLUDED IN SYSTEM WITH HEADER/SPREADER BEAMS + BRACING, BUT ARE CONSIDERED MOST USEFUL TO INITIALLY ACCESS THE DAMAGED STRUCTURE
- CAN BE CONFIGURED AS TEMPORARY RAKER SHORES USING AVAILABLE ALUMINUM RAILS AND PINNED BASES THAT CAN BE SECURED TO PAVING OR THE GROUND



VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

SPECIALTY SHORES (Airbags are lifting device - not shores)

Airbags - tough neoprene bags that come in sizes from six inches to thirty-six inches square. They can be pressurized to lift very heavy objects a short distance and often are helpful in releasing an entrapped victim. One must be careful to remember that they can be punctured by rebar, and that objects that are lifted must be laterally restrained by other means, since the bags have little lateral strength. Airbags should always be used while being backed-up with some other system to protect against a puncture failure.

Aluma Beams -are light gage, shaped, aluminum joist or beams that are normally used as shoring for wet concrete. (See page 12 , shown spanning between the Aluminum Frames) They have been used to construct shelters from falling debris, as plywood sheathing can be placed between the Aluma Beams and nailed too them to provide a surface that is quite flexible but strong. The flexibility of the aluminum (3 times that of a similar steel structure) is ideal for catching falling objects, since the flexibility reduces the strength required for the CATCH structure.

Steel and/or reinforced concrete culvert sections could be considered as a protection device for entry thru an area where protection from smaller falling hazards was required.

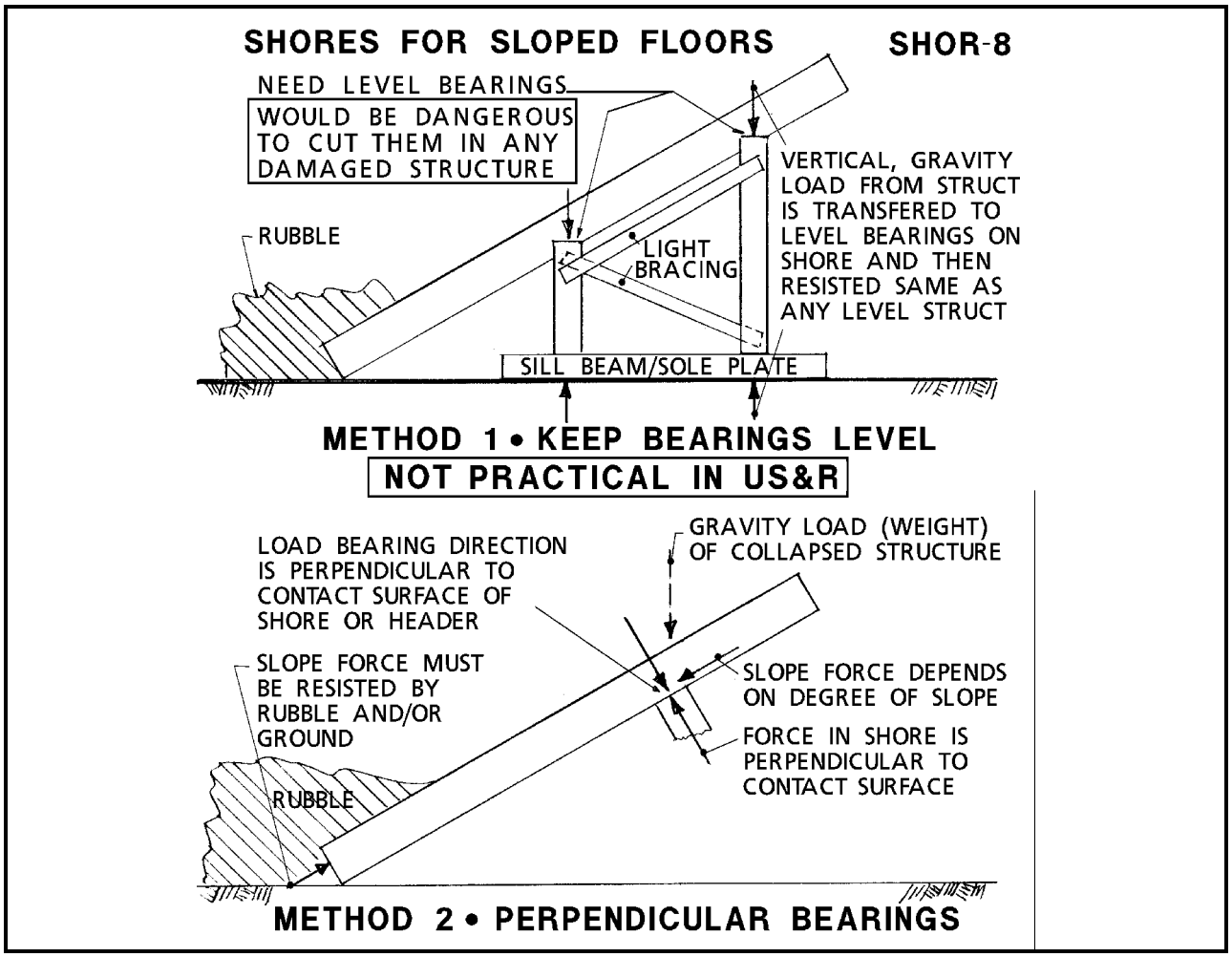
Shoring At Column/Slab Connections - The danger of a punching shear failure occurring at a flat slab/column joint is often present due to heavy debris loading on slabs that do not collapse initially. Since most of the cracking that warns of this type of collapse hazard is on the top of the slab and may be covered by the debris, it may be prudent to increase the column's periphery by adding vertical shoring on all four sides. Shoring consisting of vertical posts could be used and laterally braced back to the column. All the normal problems i.e. what's the load, supporting system etc. need to be considered.

VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

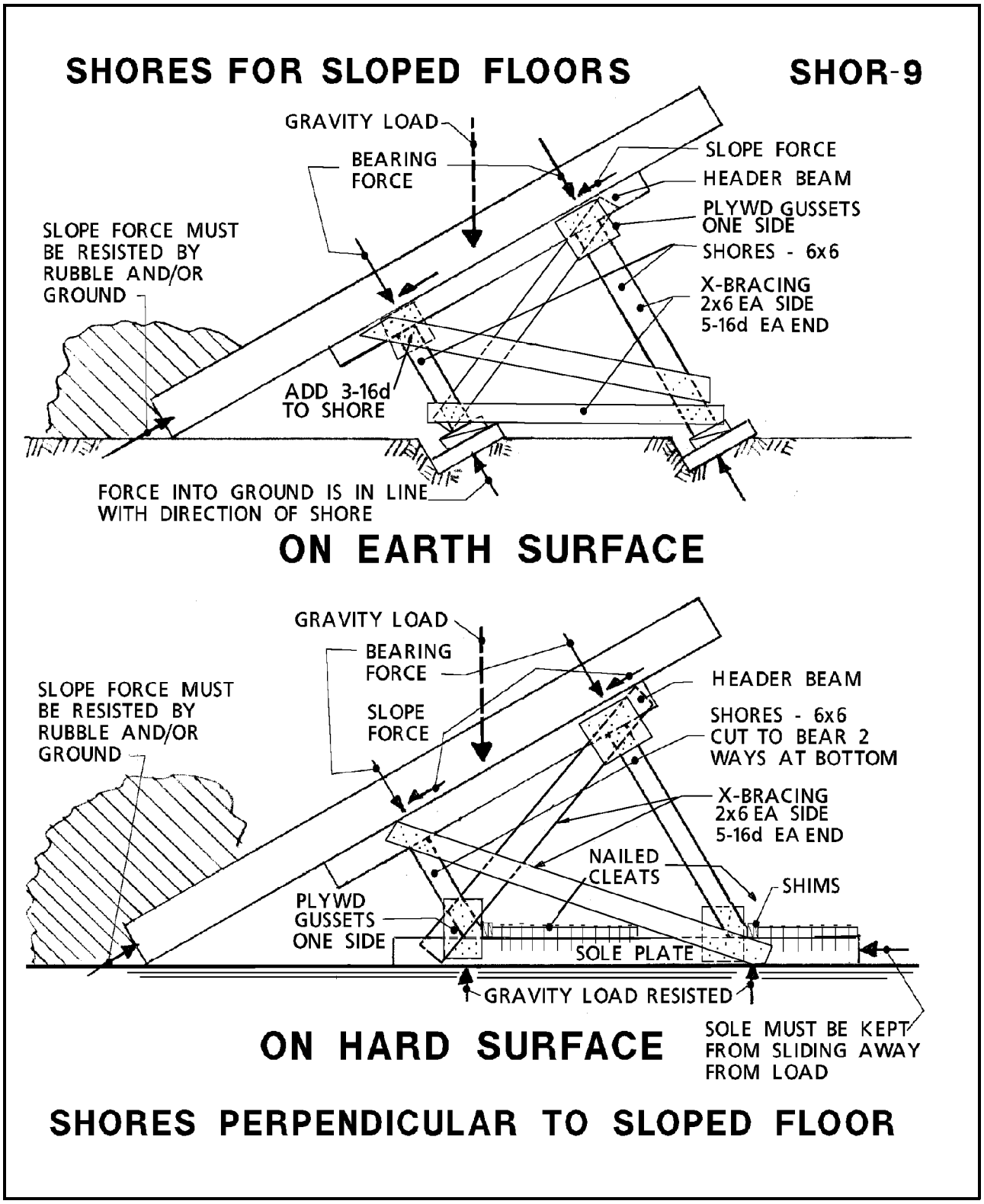
VERTICAL SHORES ON SLOPED SURFACES

- # If load is transferred from structure to shoring thru sloped surface the direction of the load will be perpendicular to the sloped surface and not vertical.
- # This type of loading will cause both horizontal and vertical loading in the shoring system, since horizontal bearings should not be cut into the structure.
- # Shoring systems for sloped surfaces should normally be constructed with header beams, vertical, diagonals, and sole plates connected together in a system.
- # The shores/posts should be placed on a slope perpendicular to the sloped floor, and diagonal bracing should be designed for atleast 10% (preferably more) of the weight of the shored structure. Two types of these shores are shown in SHOR-9, pg. 16, one supported on an earth surface and one on pavement. The earth can be cut to provide perpendicular bearing to the shores, but on pavement surfaces, nailed thrust blocks (cleats) are used to transfer the horizontal component of the shore's force.
- # Cribbing can be used in this condition, as long as the slope isn't too great. Cribs can be built into the slope, and notched crib members should be used since they can transfer more lateral load than the usual friction interconnection.



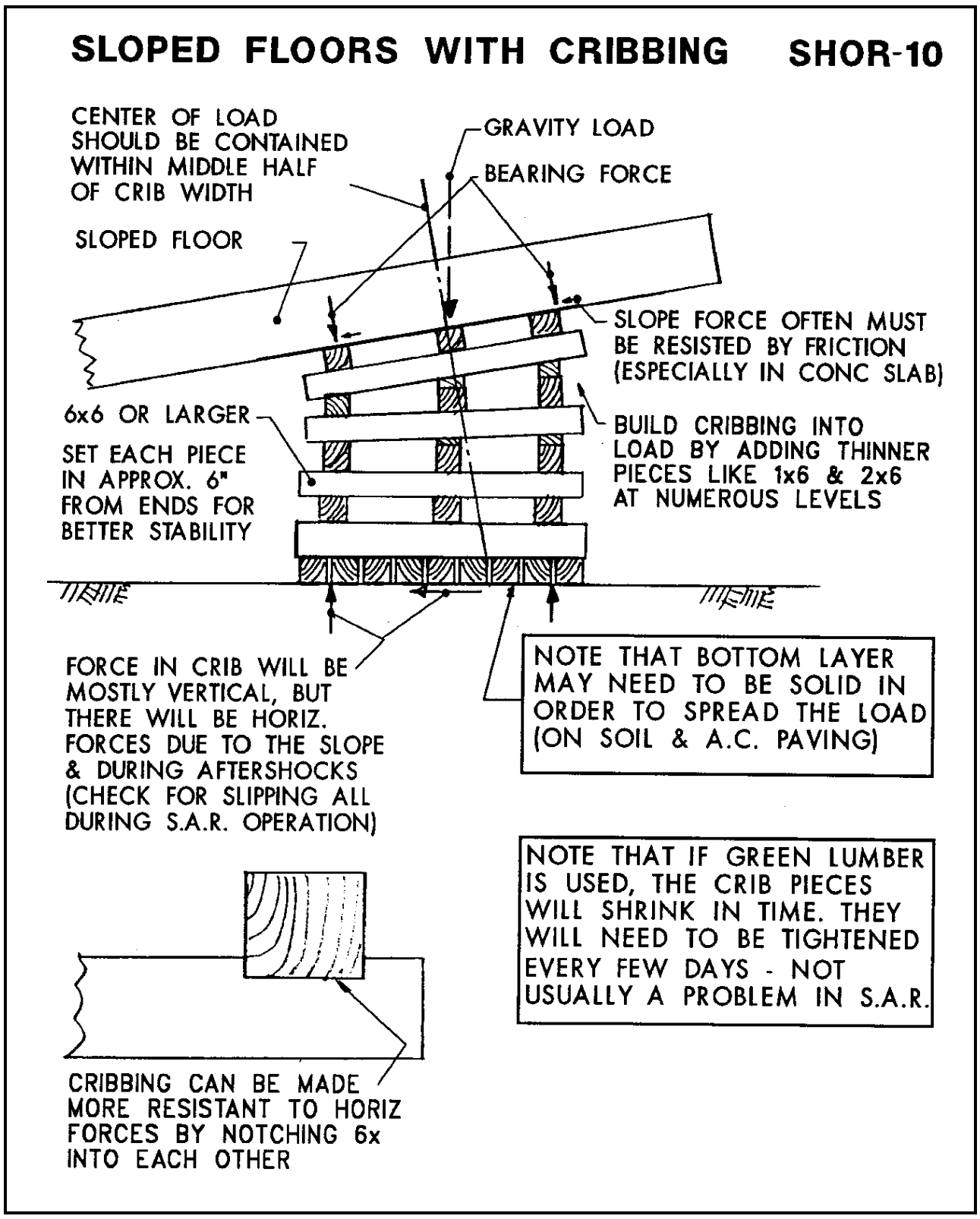
VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING



VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING



VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

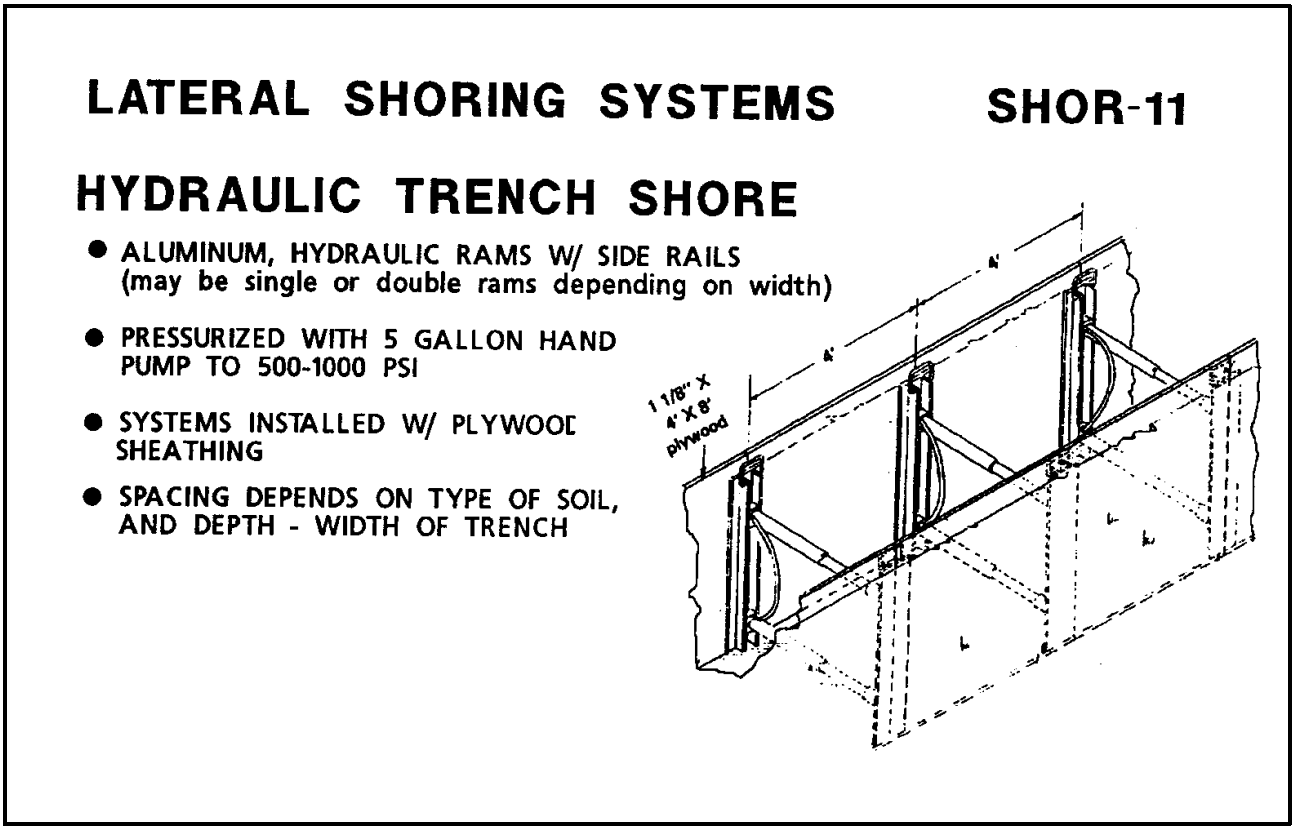
LATERAL SHORING SYSTEMS

Principles of trench shoring may sometimes need to be applied to US&R, where pulverized masonry rubble tend to cave into an otherwise accessible space.

There are several systems used, such as Hydraulic Shores, Pneumatic Shores, Tieback Systems and Drilled-in Solid or Pole Systems. The design of these systems is very competently presented in the CALTRANS, Trenching and Shoring Manual.

Hydraulic Trench Shore

These are frames made from aluminum hydraulic ram(s) with continuous side rails
They are intended to be dropped into open trenches from the top and pressurized with a 5 gallon hand pump to between 500 - 1000 PSI.
Shores can have a single ram with 2' long rails or double rams with rails up to 12' long. Standard double ram frames have rails in 3'-6 , 5'-0 , and 7'-0 lengths
They are intended to be dropped into open trenches from the top, and special, thick, plywood panels are added against the soil to spread the load and confine soils.
The larger shores can be spread as far as 8' which could be useful for vertical support, but are difficult to carry and install in irregular shaped openings. They require the pressure to be maintained in order to support any load (no locking device as for pneumatic shores), and , therefore are **not recommended** for use supporting critical vertical loads.



VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

LATERAL SHORING SYSTEMS (continued)

Other Trench Shores

- # Trench Jack (Screw Jack)
- # Post Screw Jack
- # Pneumatic Shore
- # All have same capabilities as in vertical application.

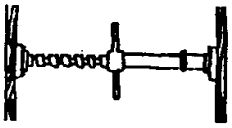
One-Sided Trench Shore

- # This type of shoring is needed when one side of a trench has caved in.
- # These systems have been successfully used to temporarily raise river levees.
- # They must be designed for specific condition of type of load (soil, water) and type of supporting soil.

SHOR 11-A

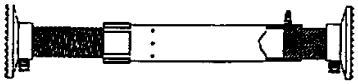
OTHER TRENCH SHORES

- TRENCH JACK - SAME CAPABILITY AS IN VERTICAL POSITION



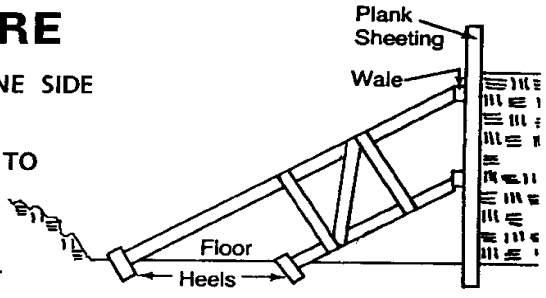
- POST SCREW JACK (by ellis) " " " "

- PNEUMATIC SHORE - SAME CAPABILITY AS IN VERTICAL (these shores originally intended as trench shores)



ONE SIDE LATERAL SHORE

- THIS TYPE OF SHORING IS NEEDED WHEN ONE SIDE OF TRENCH HAS CAVED IN.
- SIMILAR TYPE OF SHORING HAS BEEN USED TO RAISE RIVER LEVEES
- SYSTEM MUST BE DESIGNED FOR SPECIFIC CONDITIONS OF LOAD AND SUPPORTING SOIL



VI. EXTRICATION OPERATIONS
MODULE ONE: A — SHORING

LATERAL SHORING SYSTEMS (continued)

Raker Shores (Used to diagonally brace walls and buildings)

- Useful in bracing URM and other heavy walls that have cracked, (especially at corners) and/or are leaning away from building.

- Need to be configured in system that will account for both vertical and horizontal components of force in diagonal member (SHOR-12)

- The vertical component may be resisted by:
  - Friction, which may be increased in a full triangular configuration, by applying more horizontal load at the base, against the wall. However, friction should not be considered as reliable, especially during aftershocks.
  - By placing drilled-in anchors thru the wall plate into the masonry. (This may be too dangerous in some areas of badly cracked walls)
  - By bearing the wall plate against a projection in the wall surface, or by placing the raker at an opening and nailing a cleat onto the plate so that it will bear on the opening head.
- The required horizontal force may be less than two percent of the wall weight, since URM walls are seldom left standing very far out of plumb. However, since aftershocks are likely to occur, raker systems should be designed for about 10 percent of the weight of the wall and roof that is within the tributary area that they support.

- Raker shores should be placed from 8 ft. on center, depending on wall type and condition. They should be designed by engineers that have experience with these systems.

- Lateral bracing, consisting of continuous horizontal struts (capable of resisting compression and tension) and diagonal bracing (in either V or X configuration) should be installed in all raker systems.

- Rakers should be built away from dangerous area next to wall and then carried/walked into place

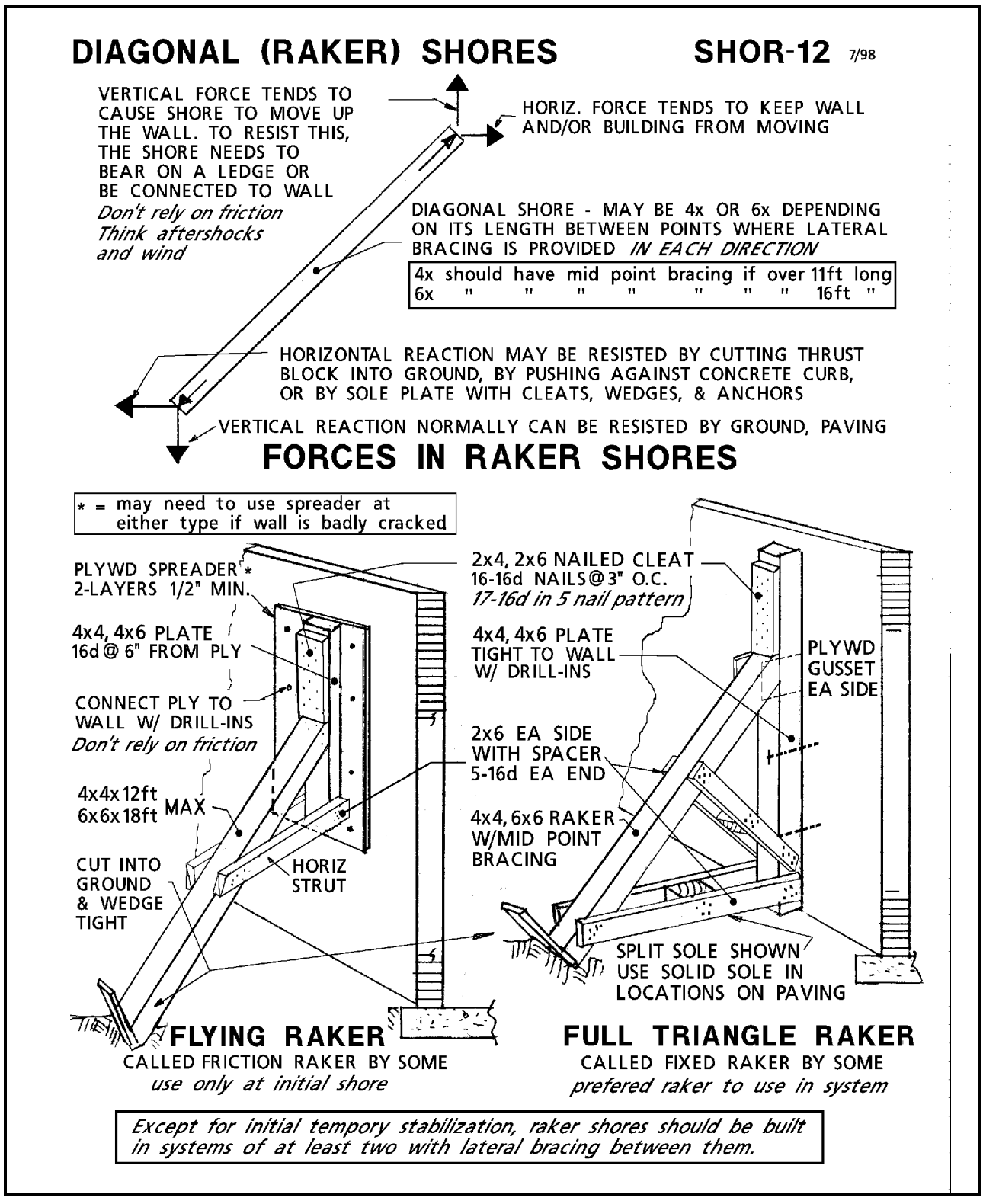
- Rakers may be configured using the Full Triangle method (sometimes called Fixed raker) or as a Flying Raker (Friction Raker) (SHOR-12)

- Either configuration (Full Triangle or Flying) could be used on walls up to about 24 ft. high. Six inch wood members would be required when raker length exceeds 12 ft., unless midpoint lateral bracing is provided. It is difficult to obtain lumber over 20 ft. long, but splices may be made in rakers as long as they are located near where the diagonal and lateral braces connect. (SHOR-14) Use 2x4x3ft min each side of splice, nailed with 8-16d each side each end.

VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

LATERAL SHORING SYSTEMS (continued)



VI. EXTRICATION OPERATIONS

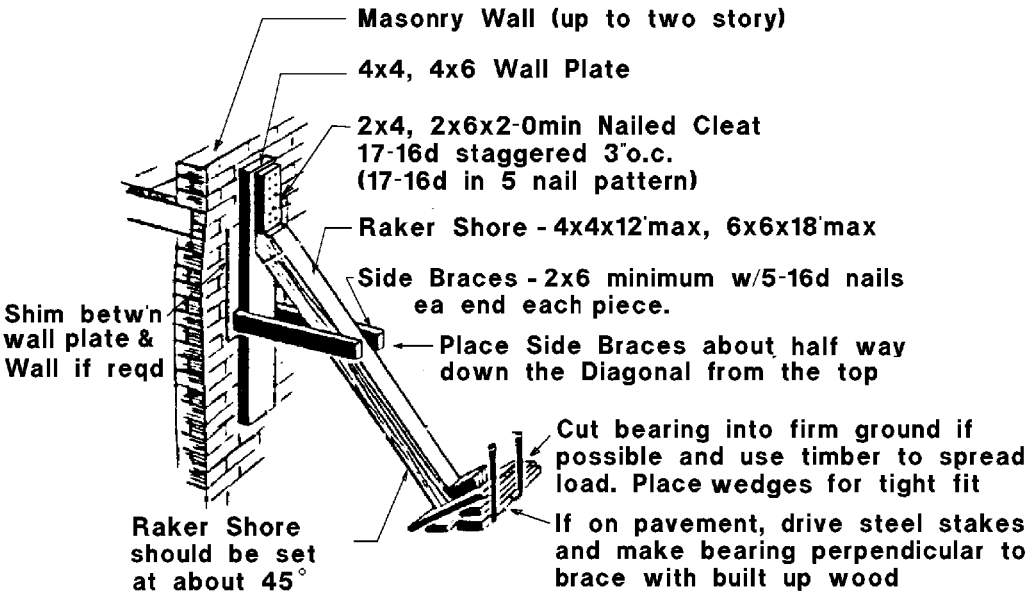
MODULE ONE: A — SHORING

LATERAL SHORING SYSTEMS

Raker Shores (continued)

Flying Rakers take the least amount of material to build but have several disadvantages (SHOR-13) They are recommended for use to initially stabilize a wall and/or building until a system with more reliable bracing can be installed.

FLYING RAKER SHORE **SHOR-13** 7/98



ADVANTAGES:
1. Uses least amount of material when compared to full height, triangle
2. Is easier to prefabricate, carry to wall, and adjust in place.

DISADVANTAGES:
1. Unless wall spreader is drill-anchored to wall or engages a ledge, the vertical force must be resisted by friction.
2. If ground is covered by concrete slab of paving, holes must be cut in to receive diagonal brace at base.
3. The diagonal brace is stressed in bending and will tend to kick-out at its base.
4. It is more difficult to install adequate lateral bracing between a group of this type of rakers.

FINAL COMMENT:
One strategy would be to first install a few of this type of Rakers to stabilize a leaning wall, etc. , and then follow with a group of well braced full height Rakers that would better resist aftershocks.

VI. EXTRICATION OPERATIONS

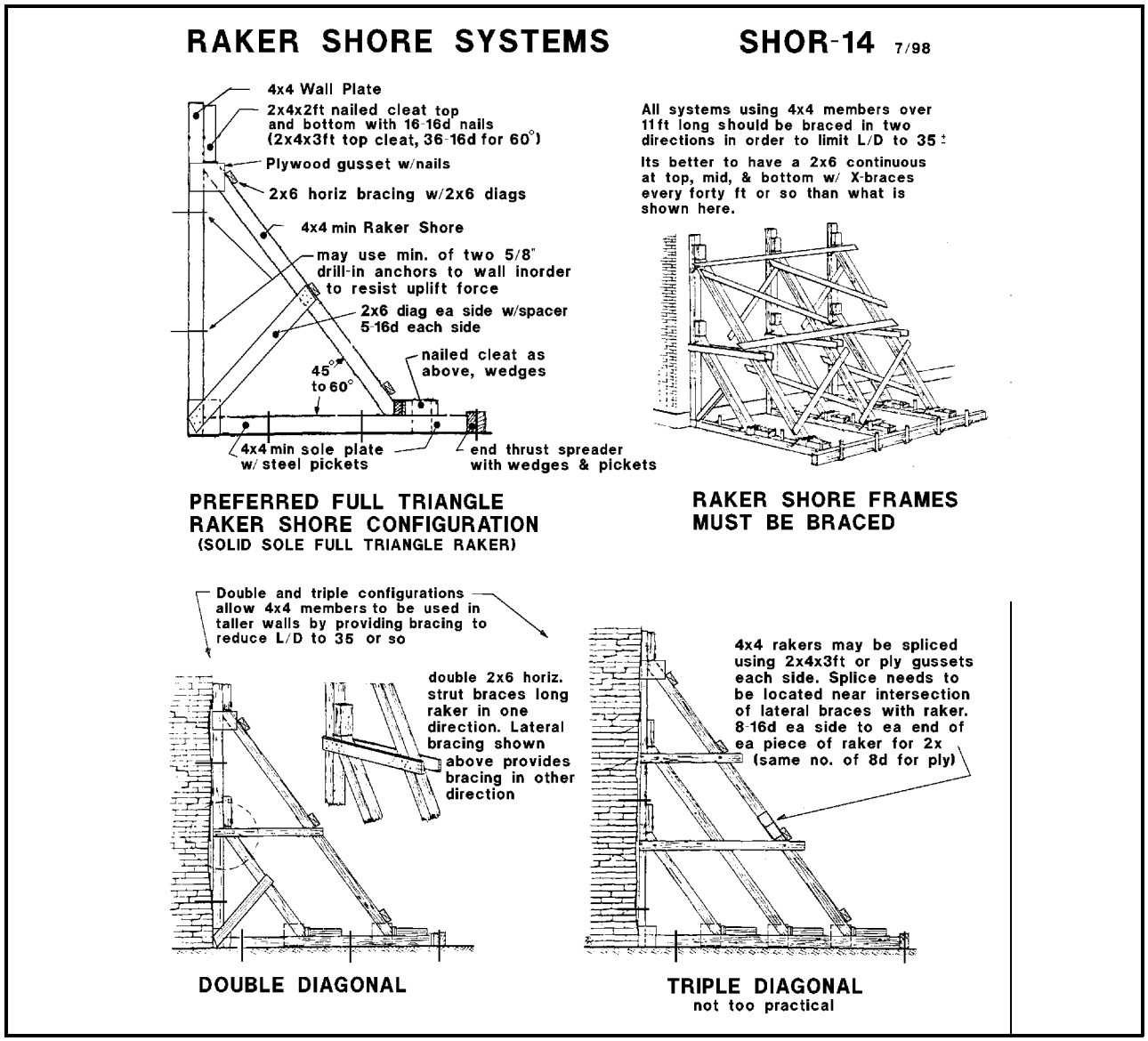
MODULE ONE: A — SHORING

LATERAL SHORING SYSTEMS

Raker Shores (continued)

Full Height Rakers will weigh more, use more material, but are easier to walk along the ground for installation and can be more adequately braced.

- ! They can be built into tall, multi-raker configurations using 4x4 members with lateral bracing to bring the L/D ratio to between 35 and 40. (SHOR-14)
- ! Multi-raker are fairly complicated, but show how the smaller timbers can be used in a system to stabilize a two story wall. Note that the bracing needs to be placed in two mutually perpendicular directions.



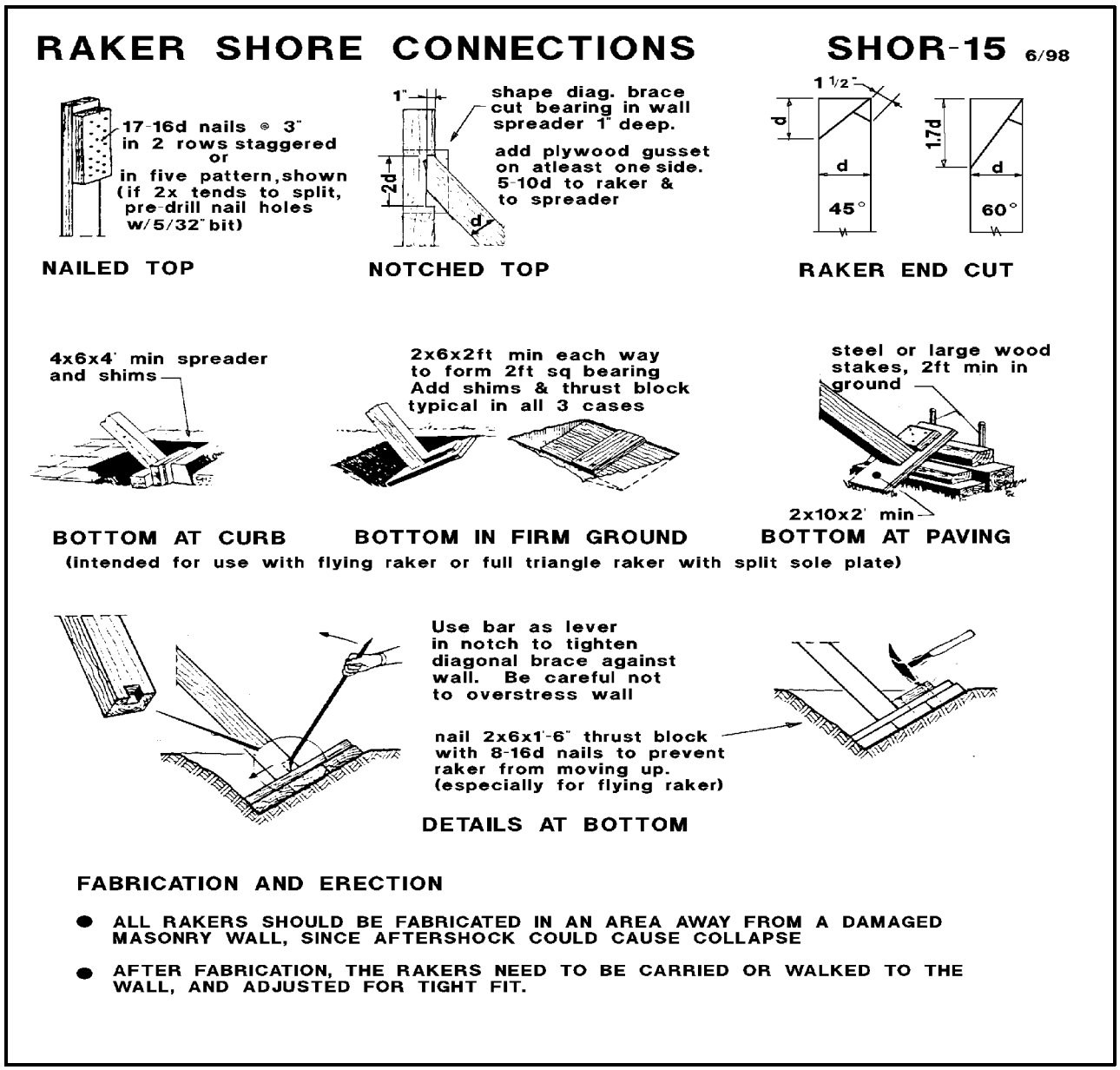
VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

LATERAL SHORING SYSTEMS

Raker Shores (continued)

Connection at top of raker should bear on thrust block or notch in wall plate plus thrust block (SHOR-15). Bearing cut at top is difficult to make a tight fit, but if Raker angle is set at 45 degrees or 60 degrees, the cut should be relatively easy to repeat. Plywood scab/gussets should be used to hold this connection together. Connections of Raker to ground are also shown.



VI. EXTRICATION OPERATIONS

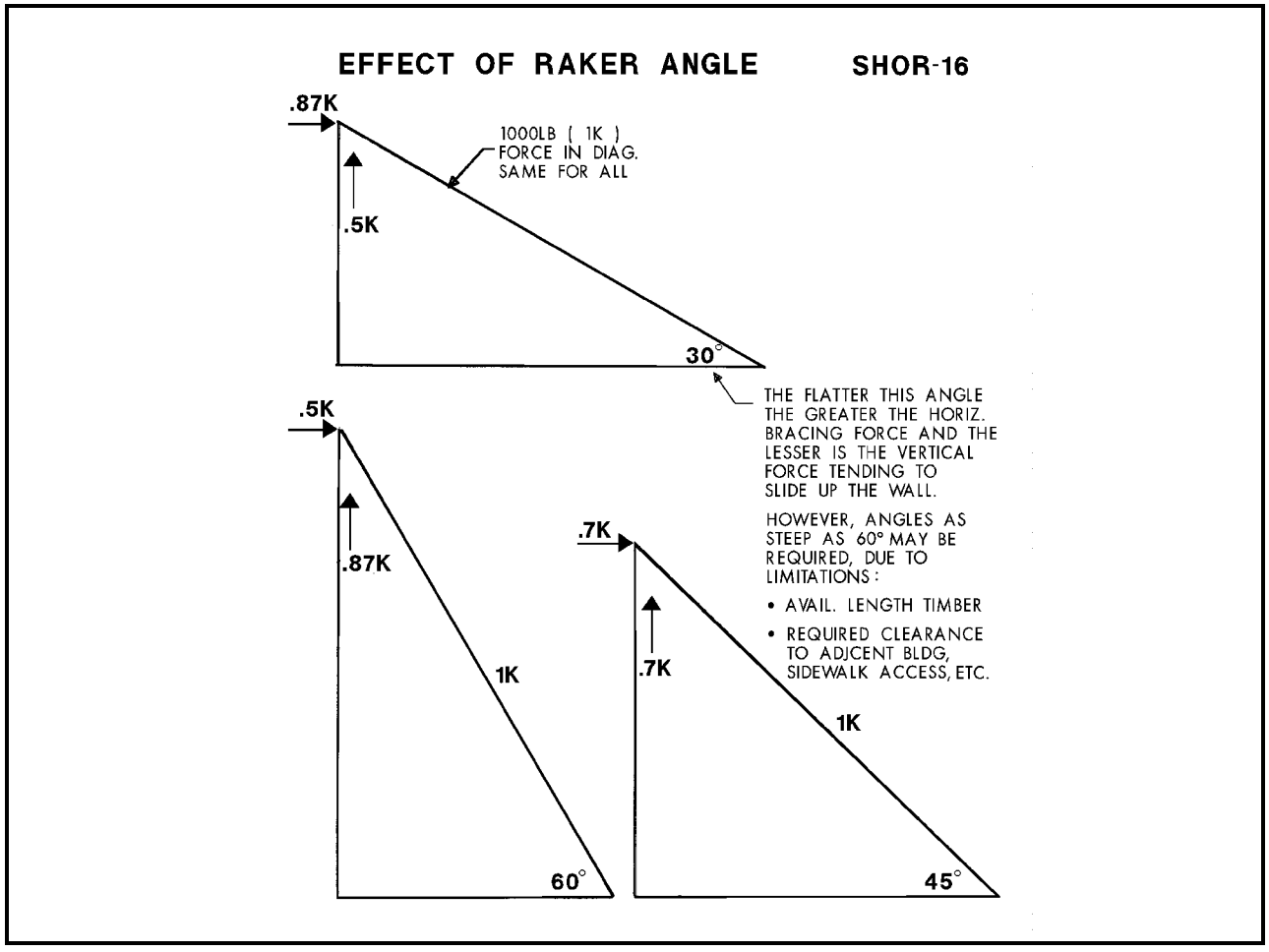
MODULE ONE: A — SHORING

LATERAL SHORING SYSTEMS (continued)

Raker Shores

Raker Angle (see SHOR-16) - the angle between the ground and a diagonal (Raker) brace member should be as small as practicable.

- **!** When the angle is as small as 30 degrees, the horizontal force applied to the wall is 87% of the force in the diagonal, and the upward force that needs to be resisted at the wall face is only 50% of the diagonal force.
- **!** When the angle increases to 60° the horiz. is 50%, and the vertical is 87%.
- **!** At 45 degrees the two are equal at 71% of diagonal force.
- **!** The disaster "field" conditions such as need for access, available timber length, or clearance, may require that the less efficient 60 degree system is the only practical way to do the bracing.
- **!** One must find the best compromise between structural efficiency and practical considerations. The simplest to deal with may be 45 degrees (1 to 1) and 60 degrees (1.7 to 1)



VI. EXTRICATION OPERATIONS
MODULE ONE: A — SHORING

LATERAL SHORING SYSTEMS (continued)

Raker Shores

The capacity of individual, single Rakers is in the range of 2400 lbs. (2.4k). This is normally sufficient to brace most masonry or low rise concrete walls up to about 20 ft high.

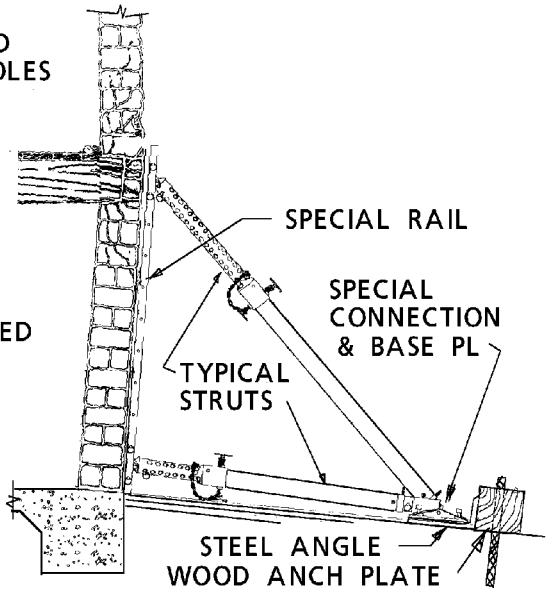
The full Triangle Rakers can be configured with a split sole plate (SHOR-17), which is most useful for bearing on ground. This example shows how a 4 x 4 lumber x 20 ft. long can be used to brace a 20 ft. wall.
- ! Lateral bracing is required at mid-height of the 4 x 4 in each direction.
- ! Overall lateral bracing is required to stabilize the system of Rakers, especially during aftershocks.

A second configuration of full Triangle Raker is shown with solid sole plate (SHOR-18). This is most useful where paving is found next to the wall. It has the same L/D and overall bracing requirements as the split sole type.

A quick, temporary raker can be constructed using pneumatic shores. (SHOR-16a)
- ! They can be used as individual units, or be configured in a system of two or more that are interconnected with 2x6 wood bracing.
- ! Special rails and connections are available for the shore manufacturers, as well as base plate and bracing connections.

PNEUMATIC STRUTS USED AS RAKERS **SHOR-16a**
7/98

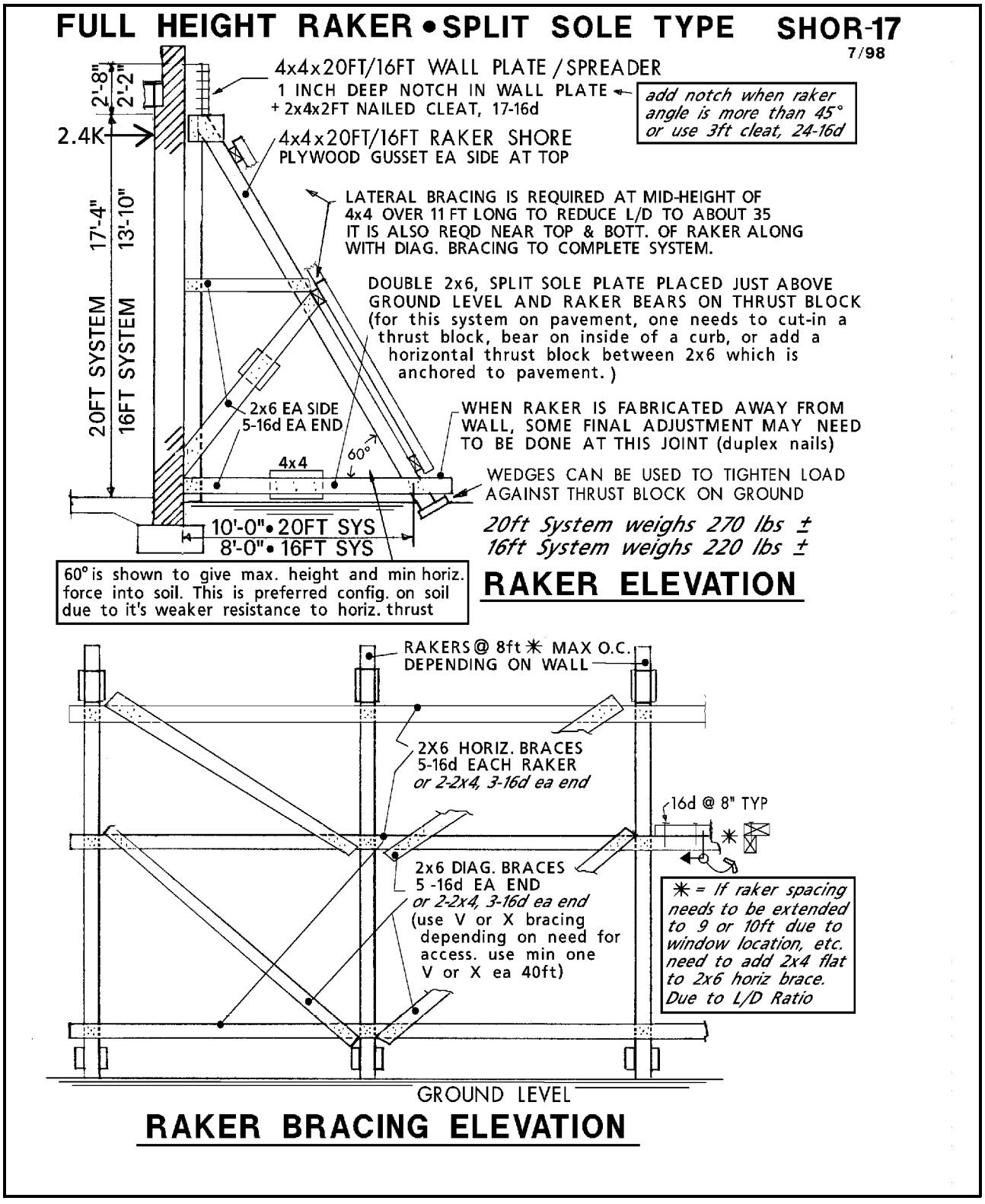
- INDIVDUAL RAKERS CAN BE CONFIGURED FROM TWO STRUTS (UP TO 16FT LONG) AND A SPECIAL RAIL THAT HAS CONNECTION HOLES
- MANUFACTURED BASE PLATE CAN BE CONNECTED TO PAVING THRU EXISTING HOLES USING STEEL BARS/DRILL-INS. STEEL ANGLE CAN BE ADDED UNDER BASE PLATE TO PROVIDE SURFACE TO BEAR ON TYPICAL WOOD SOLE PLATE ANCHOR
- THESE CAN BE MADE INTO SYSTEM USING TWO OR MORE INDIVIDUALS, INTERCONNECTED WITH HORIZONTAL + DIAGONAL 2x6 WOOD BRACING CONNECTED TO MANUFACTURED CLIPS (THAT HAVE WOOD NAILERS)
- RAKER RAILS NEED TO BE PINNED TO WALL AS W/TYP RAKERS. THESE CAN PROVIDE A QUICKLY PLACED, INITIAL SYSTEM TO BE FOLLOWED W/TYP WOOD SYSTEM



VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

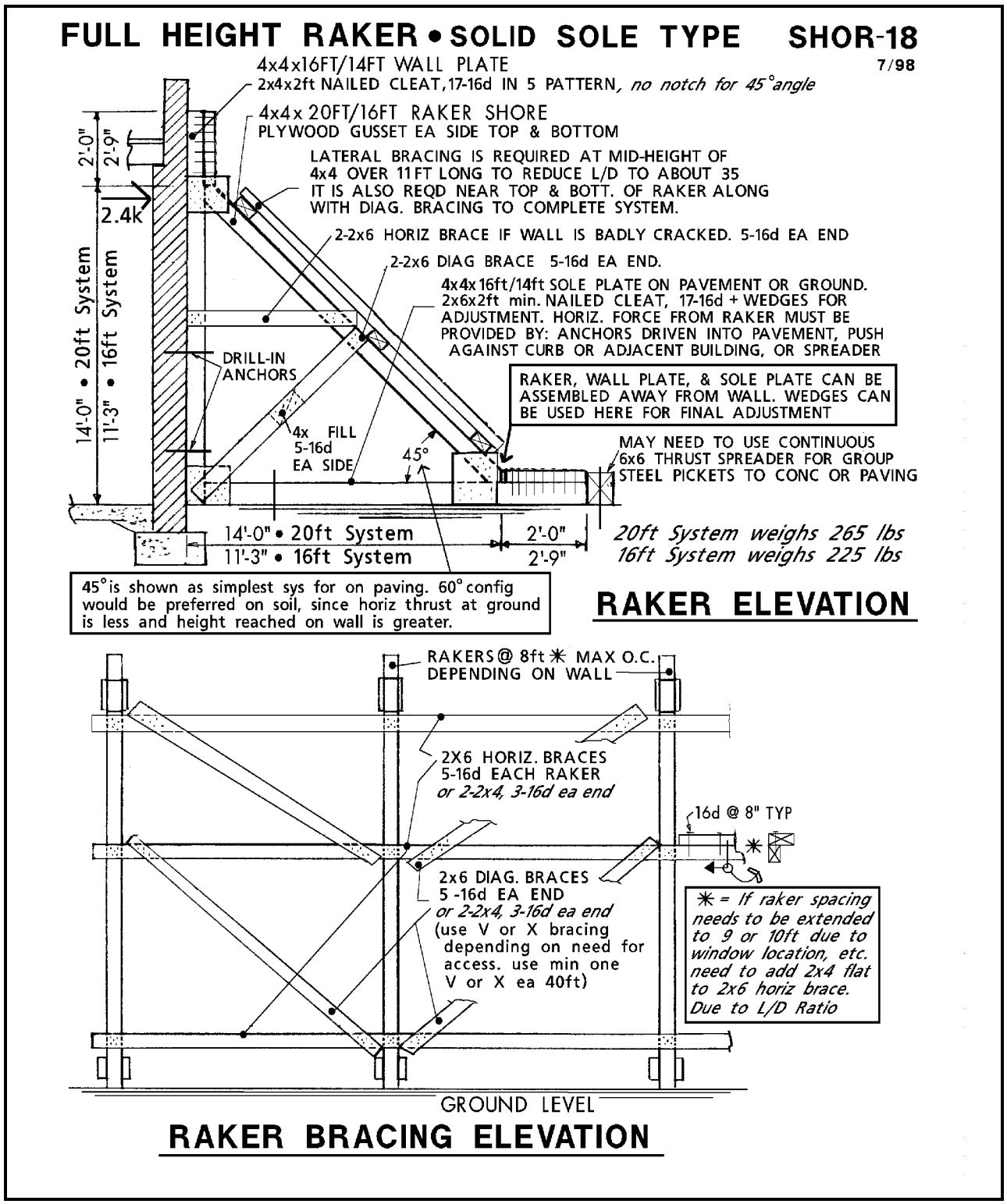
LATERAL SHORING SYSTEMS (continued)



VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

LATERAL SHORING SYSTEMS (continued)



VI. EXTRICATION OPERATIONS
MODULE ONE: A — SHORING

LATERAL SHORING SYSTEMS (continued)

Tilt-up wall braces (SHOR-19)

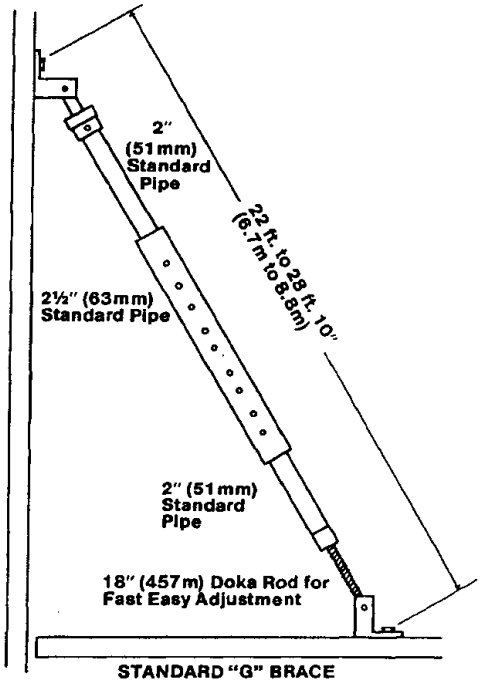
Can be used to brace concrete tilt-up walls and other reinforced masonry walls.

The walls would need to be pretty well intact and only in need of bracing, due to connection failure. (spreading of the load would induce bending moments in the wall).

Connection of braces to the wall could be by drill-in-anchors and anchorage at the base could be to a wood curb/pad or slab on grade with a drill-in.

These braces could also act in tension.

LATERAL WALL BRACING **SHOR-19**



STANDARD "G" TILT-UP BRACE

Standard "G" Brace is designed for use with large tilt-up panels. Major adjustments within 12 inches (305mm) of the insert are quickly made with sliding "L" pins. Fine adjustments then can be made utilizing the heavy-duty screw rod. Panels up to 30 ft. (9.1m) high are normally braced without knee braces or cross lacing.

Brace Weight: 155 lbs. (70kg)

BIG "G" TILT-UP BRACE

The Big "G" Brace is a Standard "G" Brace with a longer center pipe section. It is intended for use with panels over 30 ft. (9.1m) high. The Big "G" adjusts from 24 ft. to 39 ft. (7.3m to 11.8m). On very tall panels, knee braces and cross lacing can be used to increase brace spacing.

Brace Weight: 214 lbs. (97kg)

LITTLE "G" TILT-UP BRACE

The Little "G" Brace is a Standard "G" Brace with a shorter top inner pipe section. It is intended for use with panels up to 28 ft. (8.5m) high. The Little "G" adjusts from 14 ft. to 20 ft. (4.2m to 6.1m).

Brace Weight: 122 lbs. (55kg)

STANDARD BRACES • TILT-UP WALL CONSTRUCTION

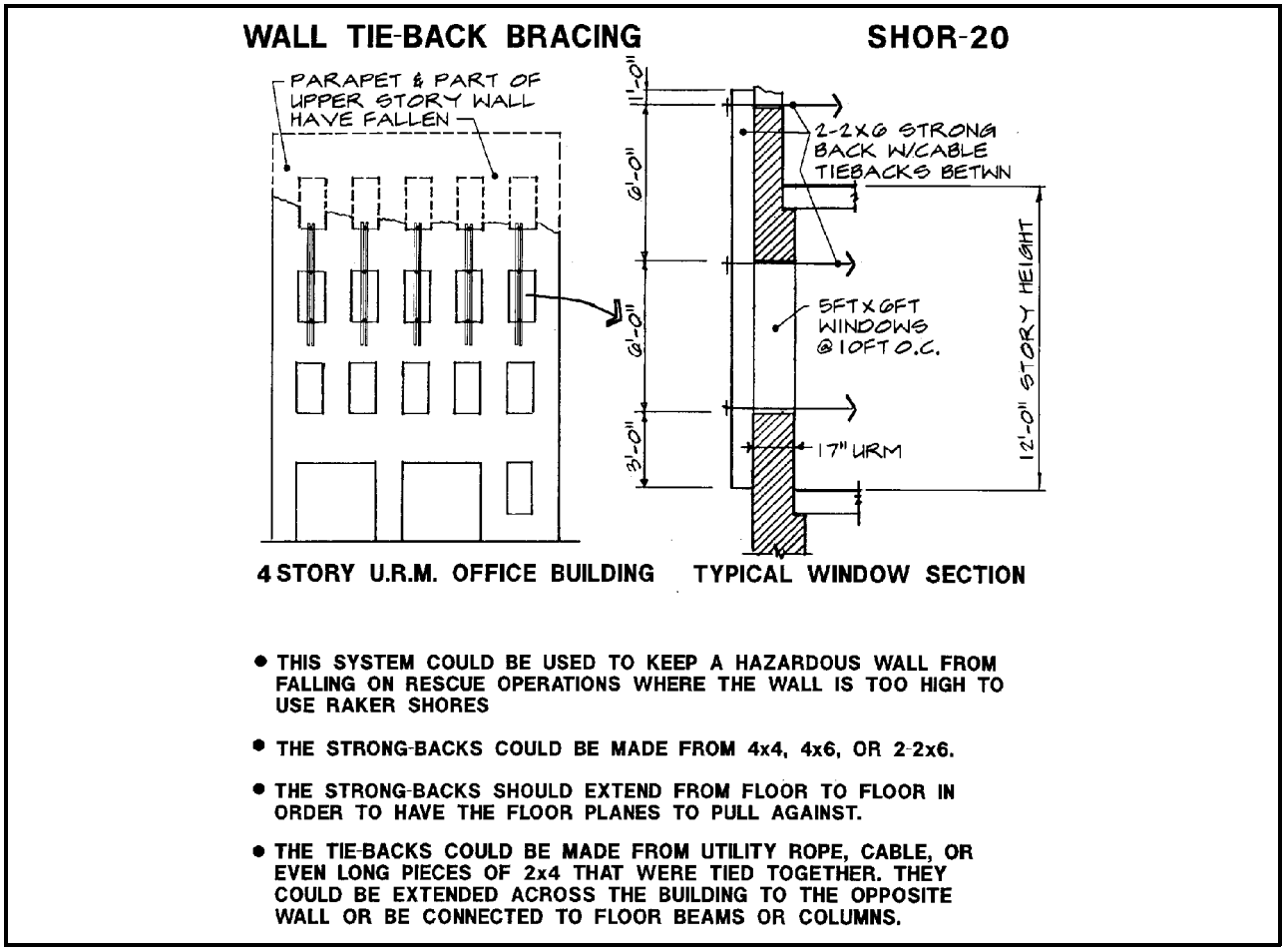
VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

LATERAL SHORING SYSTEMS (continued)

 # Tiebacks (SHOR-20)

- **!** When URM walls are over thirty feet tall it is probably impractical to attempt to brace them with raker shores.
- **!** Vertical, or horizontal and vertical 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.
- **!** 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)



VI. EXTRICATION OPERATIONS
MODULE ONE: A — SHORING

SHORING SYSTEMS USED IN US&R

The Special Medical Response Team, a group of medical first responders organized to aid mine collapse victims, has a plan to use a combination of pneumatic shores and cribbing to assure vertical support in order to provide medical care within the collapse. They first set the pneumatic shores and then follow with the cribbing.

The House Moving Contractor, R. Trost, provided emergency shoring after the 1989 Loma Prieta Quake for twenty five buildings in the San Francisco Marina District. The 3 & 4 story wood buildings were out of plumb in the first story as much as 2 feet. As shown in SHOR-21 & 22, they provided lateral stability by placing 6x8 diagonal shores from the inside of the street curb to the second floor, and added 6x6 diagonals in doorways. They later placed story high cribbing and large steel beams to provide better vertical support, and allow for later straightening of the buildings.

! One must carefully consider where this type of bracing is connected to the structure in order for it to effectively obtain a vertical reaction while it is providing the horizontal resistance.

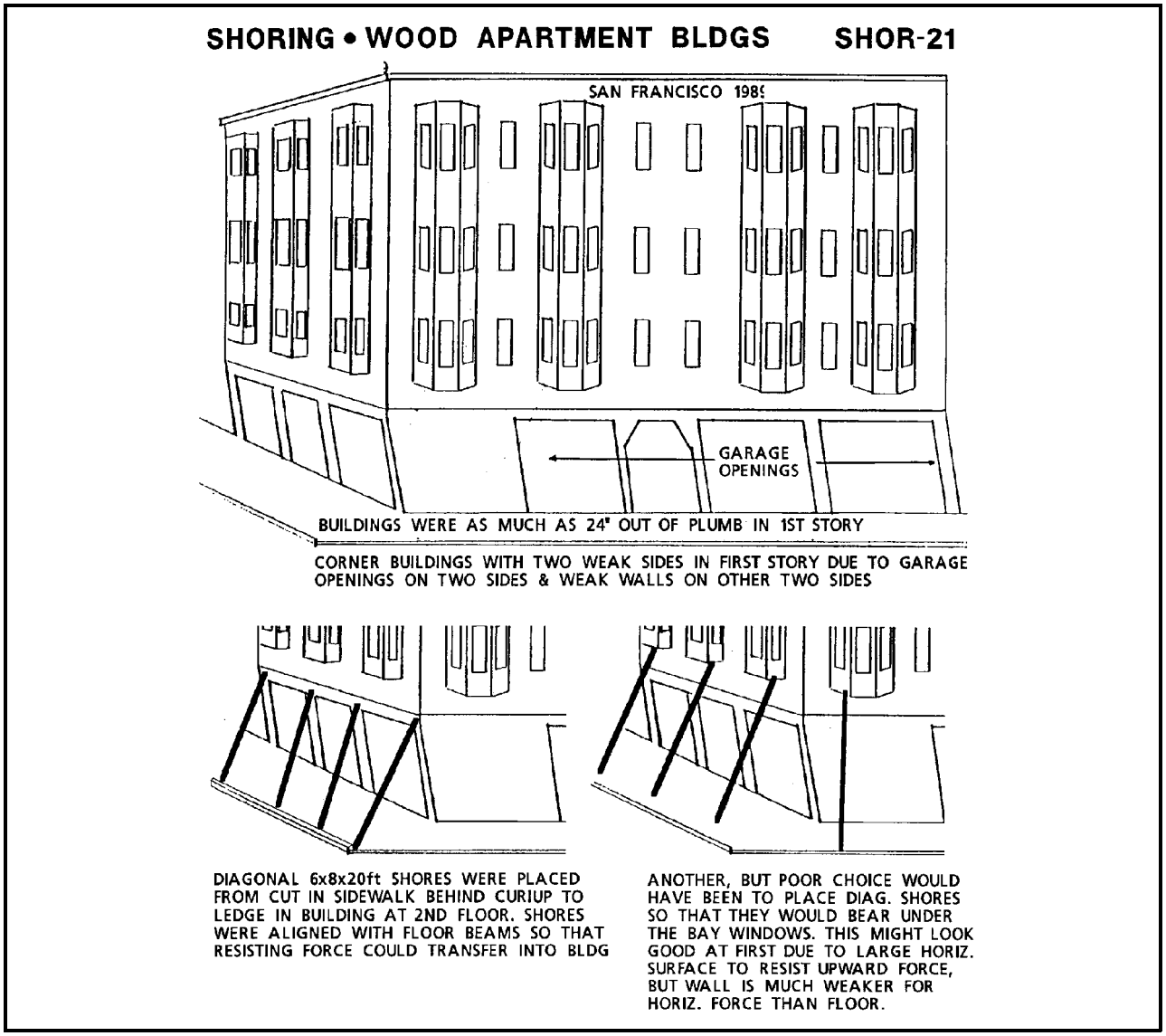
VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

SHORING SYSTEMS USED IN US&R

At the Highway 880 collapse, Loma Prieta Earthquake, shoring contractors used 12x12 vertical posts to support the concrete frames in the first story that were damaged by the collapse of the second story. The 20 ft. height was too great for cribbing, and a spreader system was used to interconnect the posts at the ground level. Diagonal bracing was added to same locations of those rows of posts, but it was very light for the potential load.

Large back-hoe/excavator or bucket-loader vehicles have been used to provide lateral (raker) support to leaning walls and buildings at several disaster sites. Very good idea for an emergency condition.

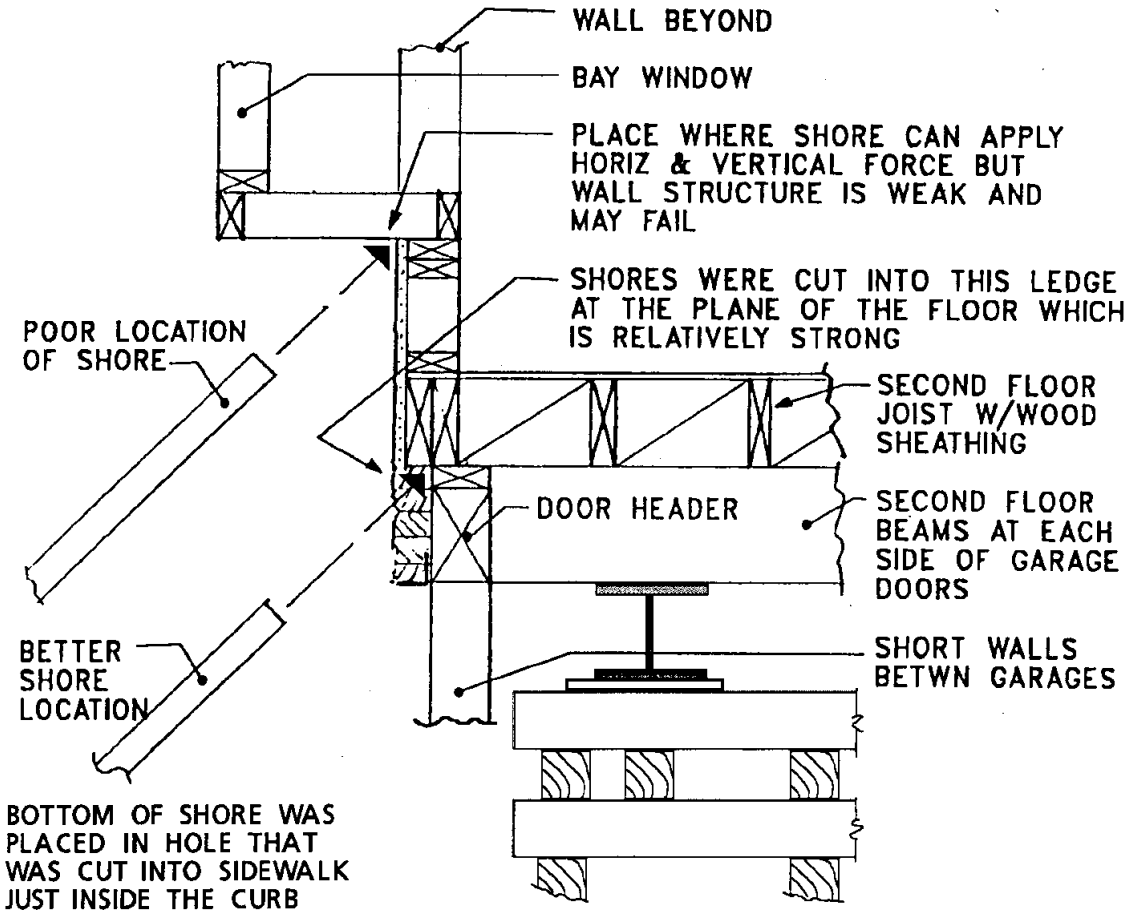


VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

SHORING SYSTEMS USED IN US&R

SHORING USED IN COMBINATION SHOR-22



- SOME BUILDINGS WERE AS MUCH AS 24" OUT OF PLUMB IN FIRST STORY
- DIAGONAL 6x8x20ft SHORES WERE QUICKLY PLACED TO STABILIZE BUILDINGS AND DIAGONAL 6x BRACES WERE ADDED IN THE PLANE OF THE GARAGE DOOR OPENINGS.
- LATER CRIBBING WAS PLACED TO ADD VERTICAL SUPPORT. LONG STEEL BEAMS WERE PLACED ON TOP OF JACKS THAT WERE SITTING ON SOLID CRIB LAYERS THEN RAMS WERE USED TO PUSH THE STEEL BEAMS AND BUILDING BACK TO THEIR ORIGINAL POSITION

VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

SHORING FOR SPECIFIC BUILDING TYPES

Shoring considerations for light frame, multi-story buildings

- **!** Multi-story frame with leaning first story need lateral/diagonal shoring that acts against the floor plane
- **!** Wood building with crawl space that have moved off foundation have normally come to rest, but roof and upper story floors may also be offset/cracked and need vertical shoring
- **!** Brick veneer on wood frame walls often are falling hazards in aftershocks, and may need to be shored or protective tunneling type structure may be required to protect access.

Shoring considerations related to URM buildings (Heavy Wall)

- **!** URM walls may be cracked (especially at corners) or peeled and need diagonal/raker shores.
- **!** Cracked URM walls may also require shoring of openings.
- **!** When URM exterior walls have fallen the remaining wood floors may require vertical shoring.

VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

SHORING FOR SPECIFIC BUILDING TYPES

Shoring considerations related to URM buildings **(continued)**

! Floors often collapse into the following patterns:

- LEAN-TO - shoring is usually required under the suspended floor and possibly on the outside wall, opposite where the floor is still connected. Victims might be found under the suspended floor and on top of this floor at the lowest end

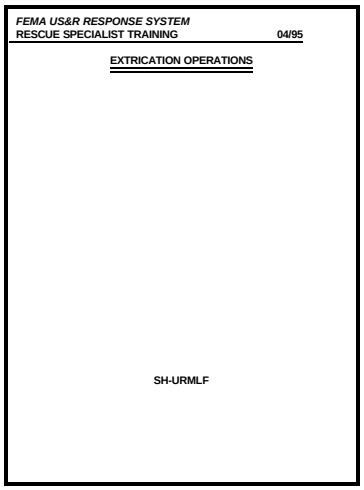
- V-SHAPE - shoring is usually required under the two suspended floor pieces and possibly on the outside walls, opposite where the floors are still connected. Victims might be found under the two suspended floor pieces and on top of the floor in the middle of the V .

- PANCAKE - shoring is usually required under the floors. Victims might be found under the floors. Voids are formed by building contents and debris wedged between floors

- CANTILEVER - this type is similar to the pancake pattern with the added problem of some of the floor planes extending, unsupported from the debris pile. Shoring is usually required under and above the floors starting at the lowest level. Victims might be found under the floors as in the pancake condition.

! Must consider that rubble will flow into any victim access trench or tunnel, and close-in vertical and lateral shores may be required

! May need support system with sheathing, spreader beams, & shores in both vertical & horizontal directions.



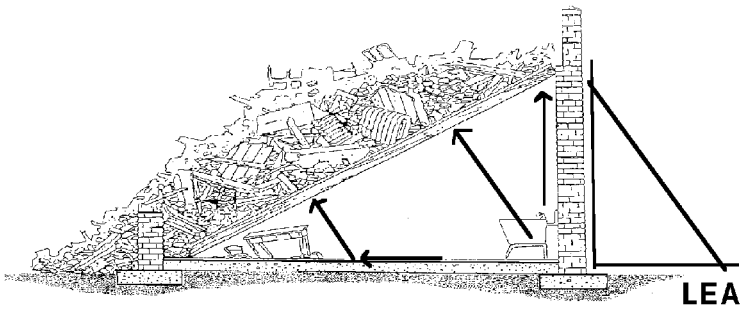
VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

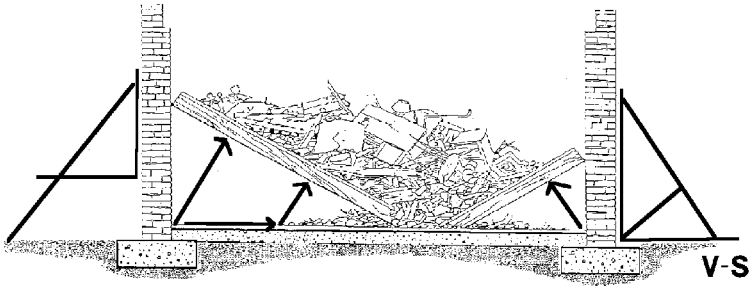
SHORING FOR SPECIFIC BUILDING TYPES (continued)

URM WALL / WOOD FLOOR COLLAPSE PATTERNS

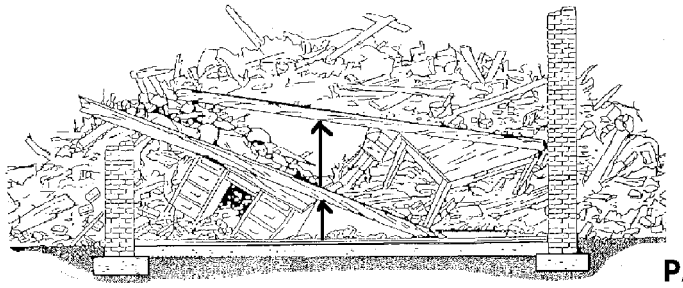
SHOWING POSSIBLE SHORING LOCATIONS **URM-SHOR**



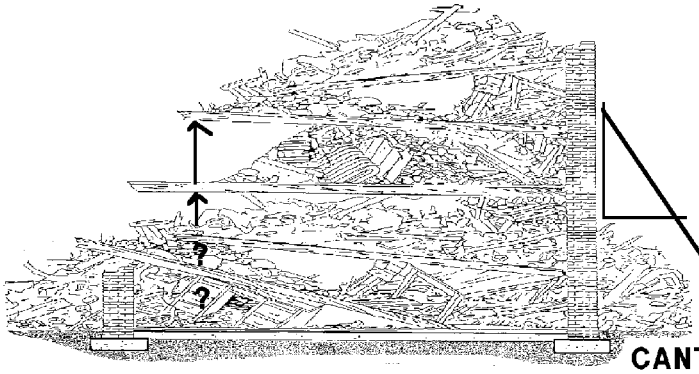
LEAN-TO FLOOR COLLAPSE



V-SHAPE FLOOR COLLAPSE



PANCAKE FLOOR COLLAPSE



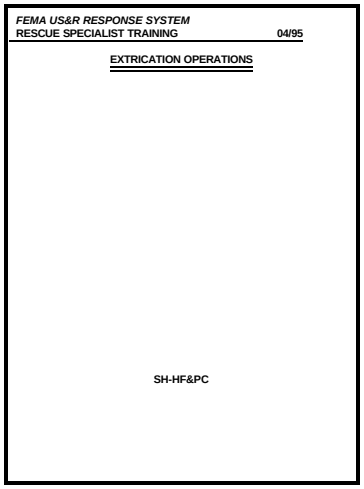
CANTILEVER FLOOR COLLAPSE
(pancake with extended floor)

VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

SHORING FOR SPECIFIC BUILDING TYPES (continued)

Shoring considerations related to Reinforced Concrete Buildings (Heavy Floor)
- **!** Will often have fairly unbroken planes that can be easily shored w/ vertical shores.
- **!** When floors have beams & girders intersecting at the columns, diagonal tension, shear cracks will give indication of potential failure.
- **!** In flat slab (beamless) floors that are heavily loaded with debris, a punching shear (rapid) failure is possible. Since the cracking that indicates this type of overload usually is best seen from the top of the slab (covered by debris), it is very difficult to assess.
- **!** If concrete floor plane is badly broken, a system with sheathing, spreaders, and safe haven areas may be needed.
- **!** Lean-to, V-shape, and Pancake collapse patterns may be found in heavy floor buildings. (especially pancake)
- **!** In floors where post-tensioned, cable reinforcing is present, a double hazard may be present. If the cables are loose, then the collapse will contain a mass of closely spaced, unreinforced pieces that are difficult to shore. If the cables are still tensioned, then they can become lethal missiles.



Shoring considerations related to Precast Concrete Structures
- **!** Collapses of this type will normally contain large pieces of lightweight concrete. Shapes like single and double tees are difficult to shore.
- **!** Lean-to, V-shape, and Pancake collapse patterns may be found in precast concrete buildings. (especially lean-to)
- **!** Shoring of sloped surfaces will probably be required. Large pieces may be lightly interconnected and there will be the potential of their shifting.
- **!** Using cranes to remove critical pieces may be the best strategy to access voids

VI. EXTRICATION OPERATIONS

MODULE ONE: A — SHORING

SUMMARY FOR EMERGENCY SHORING OF STRUCTURES

- Shores need to be strong, light, portable, adjustable, and reliably support the structure as gently as possible.

- Systems should be used that are positively interconnected, laterally braced, and have slow, predictable failure mode

- One of the best systems is cribbing since they are :
  - Made from light pieces that are adjustable & can be built into sloped surface
  - Relatively wide and stable. will spread the load.

- Have slow failure mode that will give warning

- Systems need to be tested in order to determine best methods to resist:
  - Loads on sloped surfaces above and below
  - Loads during large aftershocks

- In a disaster we need to consider 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 co-operation between all members of the Task Force is essential.

VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

MITIGATION OF STRUCTURE COLLAPSE HAZARDS

Three basic methods
  - ! Avoid It — barrier tape around a hazardous area preventing access.
  - ! Remove It — pulling down a cracked and leaning brick chimney.
  - ! Shore It — Constructing shoring systems.

SHORING SIZE-UP

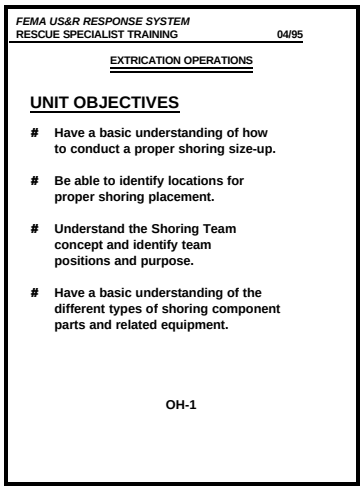
The Shoring Size-Up provides a survey of structural damage and potential victim locations in buildings identified during the initial building triage and Structure/Hazards Evaluation process.
  - ! Identify structural hazards, damage and potential victim locations.
  - ! Determine best method to mitigate the structural hazards and damage. Avoid, remove or shore.
  - ! Determine the type and placement of shoring systems in relation to structural hazards, damage and potential victim location.

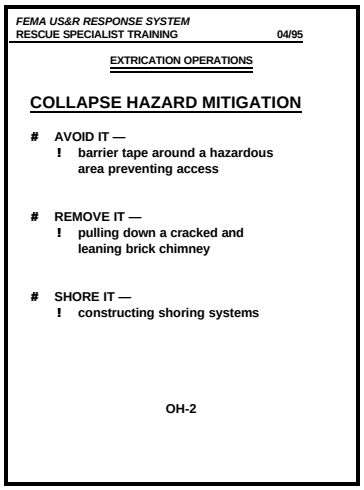
The shoring size-up should be performed by at least a Structural Specialist, Rescue Team Manager and/or Rescue Squad Officer.

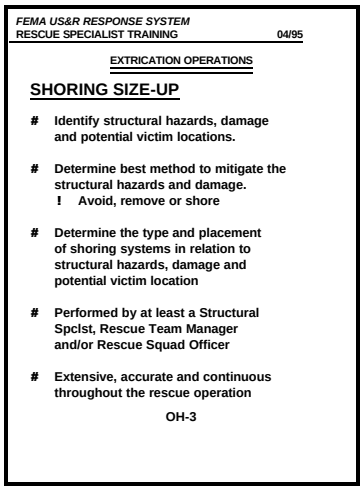
The shoring size-up must be extensive, accurate and continue throughout the rescue operation.

SHORING SIZE-UP CONSIDERATIONS

Victims
  - ! How many victims are trapped and where are they located?
  - ! Is the information coming from reliable sources and can it be confirmed?







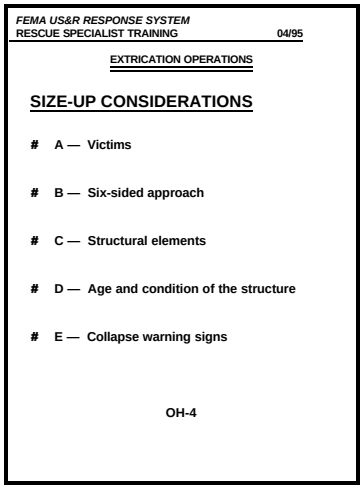
VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

SHORING SIZE-UP CONSIDERATIONS (continued)

Six-sided Approach
- **!** Survey all four sides, the top and the bottom of the entire structure paying particular attention to the collapse area.
- **!** The top survey is extremely important because loose or hanging debris, structural elements and other overhead hazards must be identified and addressed.
- **!** Gravity being constant, will continually try to pull the remains of the structure and its contents to the ground.
- **!** Surveying the bottom is equally important because shifted loads created by the collapse must be transferred to other stable structural members or back to stable ground.

Structural Elements
- **!** Walls out of plumb determine building stability immediately on arrival.
- **!** Bearing walls are the most important structural elements in an unframed building and failure of any part of these walls can cause extensive damage and further collapse.
- **!** Identification and assessment of all beams, columns, arches, joists and other structural supporting elements under the main debris pile or the victim's location should be among the top priorities of the shoring size-up.
  - All severely stressed, broken, missing, bowed or cracked supporting elements which could affect the rescue operation must be shored up before any personnel are committed to work in the area.
  - The building elements they supported must also be examined and resupported.



VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

SHORING SIZE-UP CONSIDERATIONS (continued)

- # Age and Condition of the Structure
  - ! The shrinkage of structural elements over time results in a loss of strength and the loosening of important hangers and connecting supports which may require more shoring.
  - ! Supporting elements of a well-maintained building may be utilized to help support and transfer the collapse load throughout the structure. However, if the building's condition was in a state of disrepair or suspect prior to the collapse, do not assume any structural support exists without a thorough inspection.

- # Collapse Warning Signs
  - ! Continual surveillance of the structure from several vantage points must be maintained from the time of arrival to the time the last rescue personnel have terminated their operation and exited the building.
  - ! Surveyor transits and theodolites are excellent tools for detecting any wall and floor movement.
  - ! Pay particular attention to signs of a possible imminent secondary collapse which can include shifting debris, airborne dust, sliding plaster and unnatural sounds such as creaking, moaning and groaning coming from the structure.

SHORING PLACEMENT

- # Two Main Objectives
  - ! 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.

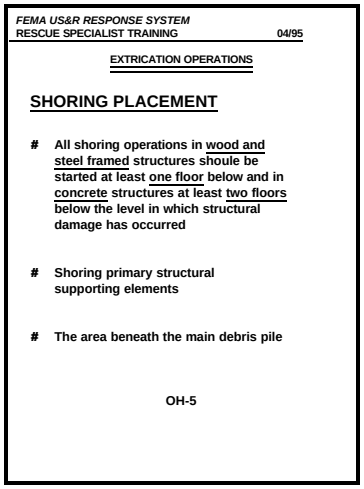
VI. EXTRICATION OPERATIONS

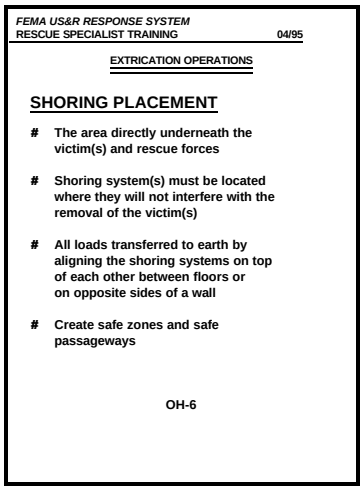
MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

SHORING PLACEMENT (continued)

Shoring Placement Considerations

- **!** All shoring operations in wood and steel framed structures should be started at least one floor below the level in which structural damage has occurred, including stressed beams, or at the lowest level if a full-scale collapse has transpired.
- **!** All shoring operations in concrete structures should be started at least two floors below the level in which structural damage has occurred.
- **!** Shoring primary structural supporting elements such as bearing walls, girders, columns and arches will more effectively utilize shoring materials and existing construction features of the building.
- **!** The area beneath the main debris pile must be examined and shored as needed to provide additional support to the existing structural elements currently sustaining the load before any personnel can be committed to rescue operations in or on top of the debris pile.
- **!** The area directly underneath the victim(s) and rescue forces must be shored up before significant debris removal operations are attempted. Shores may need to be retightened continually as debris is removed.
- **!** Shoring system(s) must be located where they will not interfere with the removal of the victim(s).
- **!** All loads transferred to earth or other suitable structural element capable of handling the additional load require the shoring systems(s) to be located where they will bear on each other. This is sometimes accomplished by aligning the shoring systems on top of each other between floors or on opposite sides of a wall.
- **!** Access into the building may require shoring to be started from the point of entry to where the victim is located in the structure. Several sections of shoring may have to be constructed to create safe zones and safe passageways.





VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

THE SHORING TEAMS

To conduct shoring operations safely and efficiently two separate teams are formed.

The Shore Assembly Team

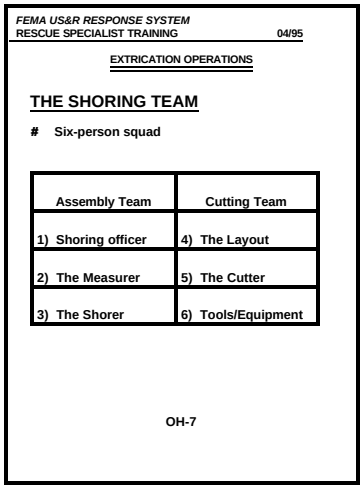
- **!** Performs the actual shoring size-up and construction of the shores.

The Cutting Team

- **!** Establishes the equipment area and cuts the shoring lumber.

The Shore Assembly Team

- **!** The **Shoring Officer** (Rescue Squad Officer) — in charge of the operation and works with the structural specialist to determine where to place and erect the shores.
- **!** The **Measurer** — performs all the measuring required in the erection of the shoring and relays all measurements and lumber sizes to the “layout” of the cutting team.
- **!** **Shorer** — clears away debris and obstructions that could interfere with constructing the shore, assists the “measure” as needed and erects the shores.



VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

THE SHORING TEAMS (continued)

The Cutting Team

The initial responsibility of the cutting team is to secure an area as close as possible to the collapse operation so as to minimize the number of personnel needed to relay the materials to the shore assembly team. The assistance of several other personnel may be required to help expedite the movement of lumber and tools to the collapse area.

! The **Layout** — in charge of setting up the cutting station and readying the materials to be cut.

- Performs all measuring and layout of angles and should be in direct contact with the shore assembly team "measure" via portable radio to eliminate problems in miscommunicating measurements of lengths to be cut.

! The **Cutter** — cuts the shoring material.

! **Tools and Equipment** — directs the movement of tools and equipment to be placed where they are requested, anticipates logistical needs of the shoring team and keeps an inventory checklist/log sheet for easier retrieval of tools and equipment at the conclusion of rescue operations.

A single Rescue Squad can normally fill the six individual shoring team positions during most shoring operations.

Larger or more complex shoring operations may require two complete Rescue Squads, with one squad assigned to the Shore Assembly Team and the other assigned to the Cutting Team.

VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

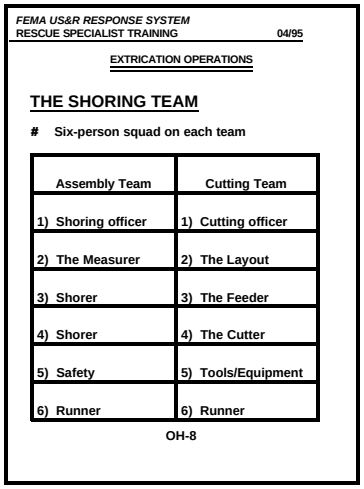
THE SHORING TEAMS (continued)

Shore Assembly Team with a complete six person Rescue Squad:

- **!** The Shoring Officer (Rescue Squad Officer)
- **!** The Measurer
- **!** Shorer [these two work together assembling
- **!** Shorer and erecting shores in place]
- **!** Safety
- **!** Runner — ensures tools, equipment and shoring materials are moved from the shoring operation primary access point to the shoring site and assists in the erection of shores as needed.

Cutting Team with a complete six person Rescue Squad:

- **!** The Cutting Team Officer (Rescue Squad Officer)
- **!** The Layout
- **!** The Feeder — moves and feeds measured and marked shoring material from the Layout to the Cutter and helps secure it when being cut.
- **!** The Cutter
- **!** Tool and Equipment
- **!** Runner — ensures tools, equipment and shoring materials are moved from the cutting area to the shoring operation primary access point.


FEMA US&R RESPONSE SYSTEM
RESCUE SPECIALIST TRAINING 04/95

EXTRICATION OPERATIONS

THE SHORING TEAM

Six-person squad on each team

Assembly Team	Cutting Team
1) Shoring officer	1) Cutting officer
2) The Measurer	2) The Layout
3) Shorer	3) The Feeder
4) Shorer	4) The Cutter
5) Safety	5) Tools/Equipment
6) Runner	6) Runner

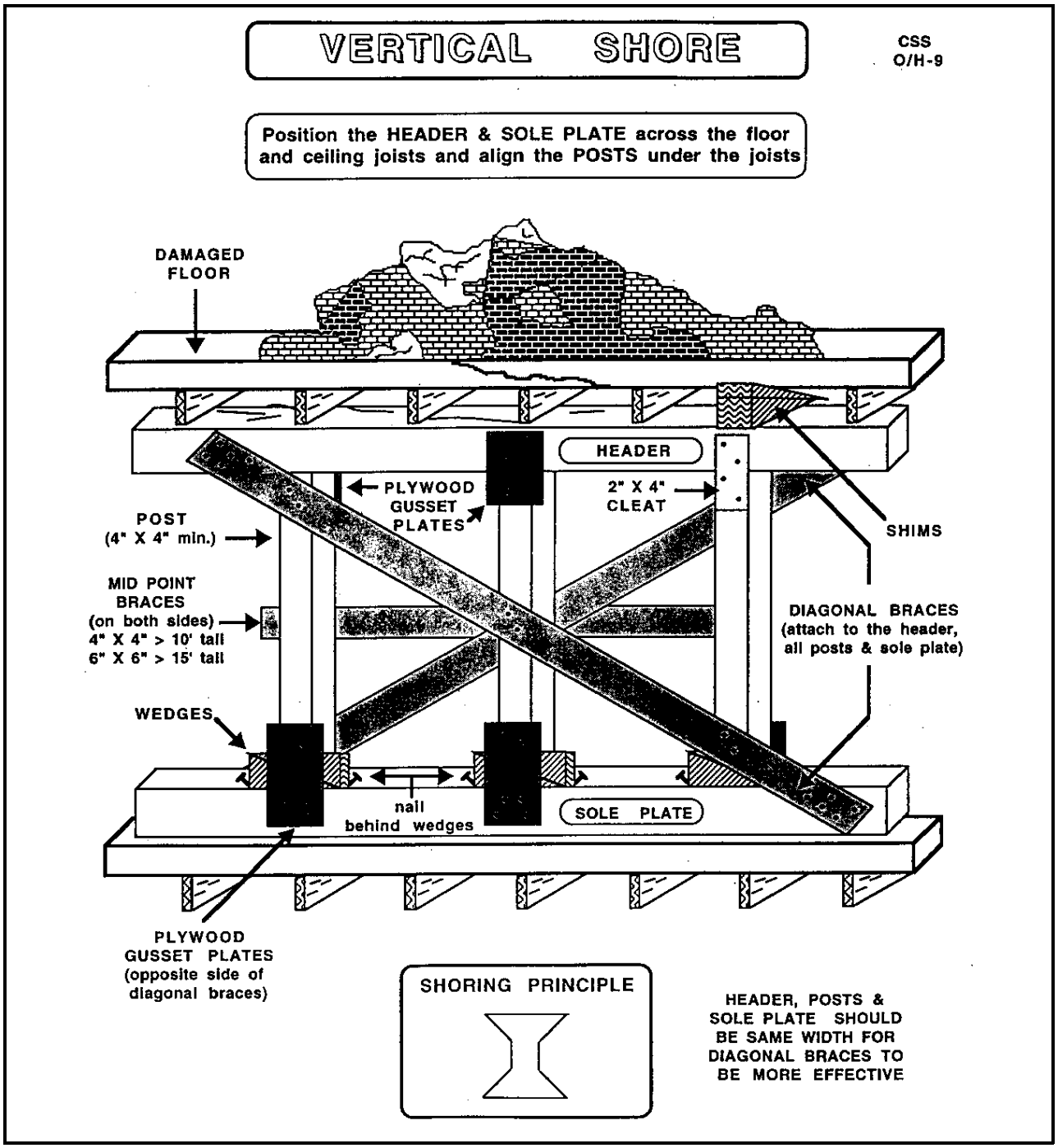
OH-8

VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

THE VERTICAL SHORE

The main purpose of the vertical shore is to stabilize damaged floors, ceilings or roofs. It can also be used to replace missing or unstable bearing walls or columns.



VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

THE VERTICAL SHORE (continued)

The two sizes of lumber most commonly used in vertical shoring are 4" X 4" and "6 X 6" douglas fir. The estimated weight of the floor and its contents will help to determine the size of shoring materials and their spacing.

Businesses and commercial occupancies with heavier structural elements and greater floor height and/or loading may require 8" X 8" or even 12" X 12" lumber. The Structures Specialist should be used to help determine the correct size and placement of shoring materials.

Structural Components of the Vertical Shore

! The **Sole Plate** — provides a foundation for the shoring system by supporting the weight being transferred from above/distributes it over a wider area.

! The **Header** — collects the weight from above and spreads it throughout the shoring system.

! The **Posts** — supports the weight being collected by the header or spreader beam and transfers it to the sole plate where it is distributed.

! The sole plate, header and posts should be the same width for a more secure attachment.

! **Cleats** or **Gusset Plates** — short pieces of 2" X 4" (Cleat) or small pieces of 3/4" plywood (Gusset Plate) nailed to the top/bottom of posts to ease shore placement and secure the posts to header and sole plate.

! **Wedges** — two wooden incline planes "married" together and placed under the bottom of the post. Simultaneously tapped together until the shoring system is under compression and takes the weight of the structural materials above.

! **Diagonal Braces** — the last items to be installed on the vertical shore should be long enough to span its entire length and be attached to the header, each post and the sole plate to lock the entire shore together as one unit and support against possible eccentric loads applied to it.

- a 2" X 4" or 2" X 6" nailed on both sides of the shore in opposite directions of each other to resist lateral deflection from either side.

VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

THE VERTICAL SHORE (continued)

- **Mid-Point Braces** — are needed when 4" X 4" posts are greater than 10' long or 6" X 6" posts greater than 15' long.
  - a 1" X 6" or length of 3/4" plywood at least six inches wide nailed to the mid point of the posts on both sides takes deflection out of the post.
  - to increase the posts bearing capabilities, mid point bracing must be in both directions with diagonal braces long enough to connect the header to the sole plate or two shorter diagonal braces, one connecting the header to the mid point braces and the other connecting the mid point braces to the sole plate.

How to Construct the Vertical Shore

Determine where to erect the vertical shore.
- After initial temporary shoring has been installed as needed, clear the area of debris, down to the floor, removing thick carpeting if necessary. A clearance of three to four feet wide is usually adequate.
- If the vertical shore is to bear directly on soil, examine the ground for stability. If the earth is soft, additional supports should be installed under the sole plate to transfer the load over a wider area.

Lay the sole plate on the floor or ground directly under and in line where the header will be installed.
- The sole plate should be as level as possible.

Measure and cut the posts to the proper height.
- Place the header on top of the sole plate.
- With the end of the tape measure on top of the header where the posts are to be installed, slide the tape up to the bottom of the structural element to be shored and measure in at least three places deducting the width of the wedges to be used.

VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

THE VERTICAL SHORE (continued)

If possible, anchor the header to the area that is to be shored, square and in line with the sole plate.

- ! Secure it at the lowest point and shim the structural elements down to the header trying to keep it as level as possible.

Install the posts between the header and sole plate under each structural element to be supported.

- ! The first two posts are installed at opposite ends at least 12” in from each end of the sole plate.
- ! Keep the posts in line and plumb with the header and sole plate.

Install a set of wedges under the bottom of each post and tap them together simultaneously until the posts are under compression and tight.

- ! Nail behind the wedges to secure them in place.

Attach cleats or gusset plates to at least one side of the header and posts and nail in place if not done previously.

Attach cleats or gusset plates to at least one side of the sole plate and posts and nail in place.

- ! Nails may need to be Duplex for future adjustment of the wedges.

Attach the diagonal braces to each side of the vertical shore.

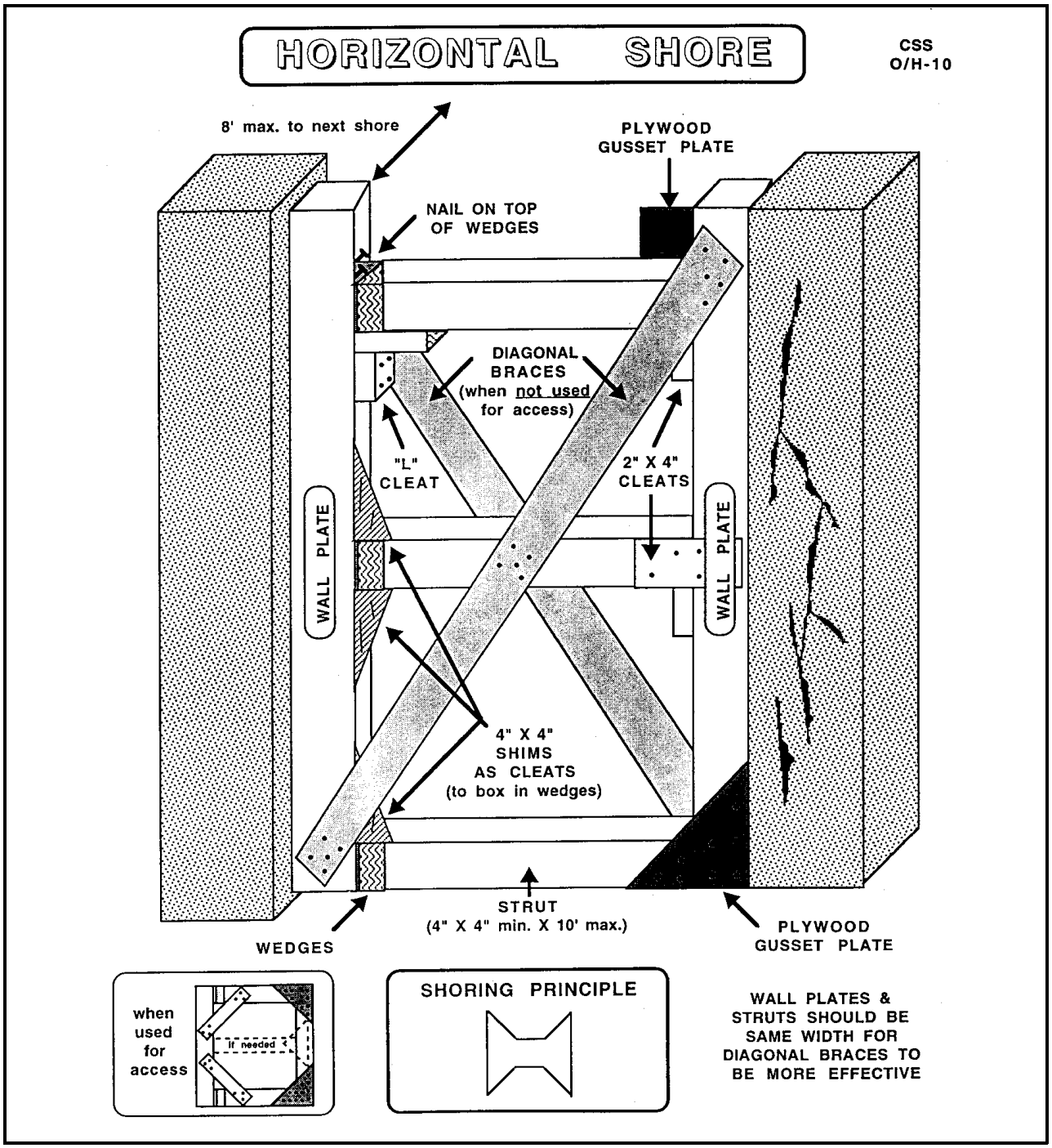
- ! Mid-point braces, when needed, should be installed prior the diagonal braces.
- ! The diagonal braces should be long enough to span its entire length and be attached to the sole plate and header and each post.
- ! If possible, diagonal braces should be installed in a “X” pattern on opposite sides of the system.
- ! Vertical shoring systems which span a long area may require several sets of diagonal braces to connect multiple posts.

VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

THE HORIZONTAL SHORE

The main purpose of the horizontal shore is to stabilize a damaged wall against an undamaged wall in hallways, corridors or between buildings.



VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

THE HORIZONTAL SHORE (continued)

Structural Components of the Horizontal Shore

The **Wall Plates** — provide a foundation for the shoring system by collecting the weight being transferred laterally and spreads it throughout the shoring system.

The **Struts** — supports the weight being collected by one wall plate and transfers it to the other wall plate.
- ! The wall plates and struts should be the same width for a more secure attachment.

Cleats or **Gusset Plates** —
- ! Cleats: short pieces of (2" X 4") nailed under the struts to ease in their placement and prevent the struts from being dislodged.
- ! Gusset Plates: small pieces of 3/4" plywood nailed on at lest one side of the wall plates and struts to prevent struts from being dislodged.

Wedges — two wooden incline planes "married" together and placed under one end of the strut.
- ! Simultaneously tapped together until the shoring system is under compression and takes the weight of the structural materials.

Diagonal Braces — the last items to be installed on the horizontal shore when the hallway or corridor is **not used** for access or egress.
- ! Should be long enough to contact both the top and bottom of the wall plates and all the struts to lock the entire shore together as one unit and support against possible eccentric loads applied to it.
- ! A 2" X 4" or 2" X 6" nailed on both sides of the wall plates in opposite directions of each other to resist lateral deflection from either side.

VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

THE HORIZONTAL SHORE (continued)

How to Construct the Horizontal Shore

Determine where to erect the horizontal shore

- ! After initial temporary shoring has been installed as needed, clear the area of debris.
- ! A clearance of three to four feet wide is usually adequate.

Measure and cut the wall plates to the proper length.

Measure and cut the struts to the proper length.

- ! Place both wall plates against the walls.
- ! Measure between the wall plates where the struts are to be installed, deducting the width of the wedges to be used.

Place both wall plates next to each other and attach cleats to the wall plates just below where the struts will be installed.

Place the wall plates in the area that is to be shored, square and in line with each other and as plumb as possible by shiming any void spaces behind the wall plates.

Install the struts between the wall plates. Keep the struts in line and plumb with the wall plates.

VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

THE HORIZONTAL SHORE (continued)

Install a set of wedges under one end of each strut and tap them together simultaneously until the struts are under compression and tight.

  ! Secure the wedges in by placing the back of a shim on top of the wedges and nail it to the wall plate or toe nail the wedges to the wall plate.

  ! Nails may need to be Duplex for future adjustment of the wedges.

Attach cleats or gusset plates to at least one side of the wall plates and struts.

If possible, attach the wall plates to the walls.

Attach the diagonal braces to each side of the horizontal shore when **not used** for access or egress.

  ! The diagonal braces should be long enough to span its entire length and be attached to both wall plates and each strut.

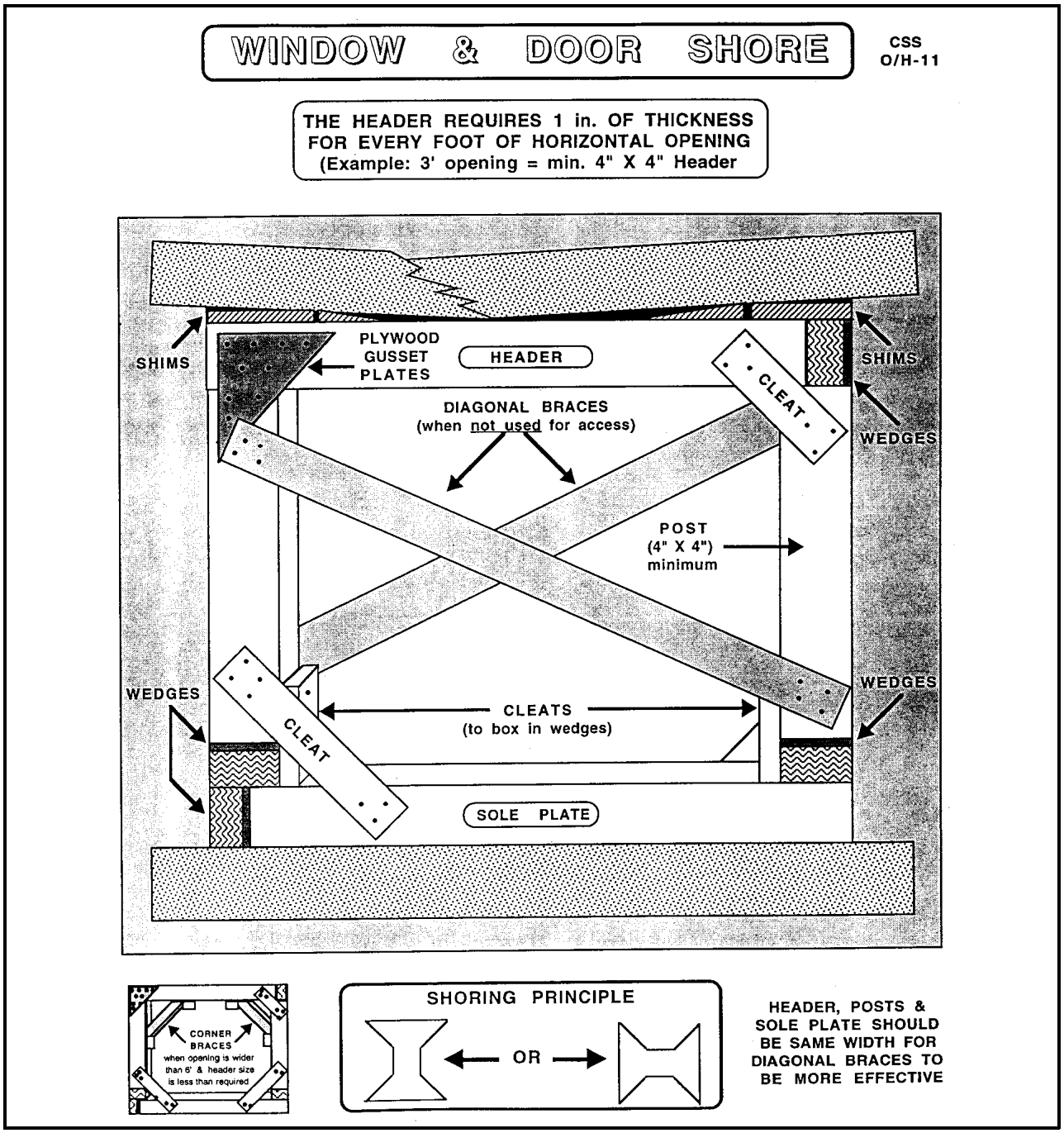
  ! When used, diagonal braces should be installed in a “X” pattern on opposite sides of the system.

VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

WINDOW AND DOOR SHORE

The main purpose of the window and door shore is to stabilize a window, doorway or other access way. An extensive collapse can generate a tremendous amount of debris blocking the primary entrances into a building and sometimes require a window entry.



VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

WINDOW AND DOOR SHORE (continued)

The window and door shore is usually installed in entry points intended for use by rescue personnel to hold up or stabilize loose headers or lintels that have lost their integrity.

Additional load stress is usually exerted from above and therefore, constructed similar to the vertical shore.
  ! If additional load stress is exerted from the side, the window and door shore is constructed similar to the horizontal shore.

Structural Components of the Window and Door Shore

The **Sole Plate** — provides a foundation for the shoring system by supporting the weight being transferred from above and distributing it over a wider area.

The **Header** — collects the weight from above and spreads it throughout the shoring system.

The **Posts** — supports the weight being collected by the header and transfers it to the sole plate where it is distributed.
  ! The sole plate, header and posts should be the same width for a more secure attachment.
  ! Buildings with large structural elements or openings greater than four feet usually require lumber larger than 4” X 4” for the sole plate, header and posts.

Cleats or **Gusset Plates** — short pieces of 2” X 4” (Cleat) or small pieces of 3/4” plywood (Gusset Plate) nailed to both ends of the posts and struts to ease in the placement and securing the posts to the header and sole plate.

Wedges — two wooden incline planes “married” together and placed under the bottom of the posts or struts.
  ! Simultaneously tapped together until the shoring system is under compression and takes the weight of the structural materials.

VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

WINDOW AND DOOR SHORE (continued)

Diagonal Braces — the last items to be installed on the window and door shore when the opening is **not used** for access or egress.
  - **!** The diagonal braces should be long enough to contact the top of the posts on one side and the bottom of the posts on the other to lock the entire shore together as one unit and support against possible eccentric loads applied to it.
  - **!** A 2" X 4" or 2" X 6" nailed on both sides of the shore in opposite directions of each other to resist lateral deflection from either side.

Corner Braces — used when additional support is needed or if the opening is more than six feet wide.
  - **!** Two 45-degree angle braces with 1 1/2" return cuts on both ends for full contact with the installed cleats. Cleats should be a minimum of 2 ft. in length with sixteen 16p nails.

How to Construct the Window and Door Shore

Determine where to erect the window and door shore
  - **!** After initial temporary shoring has been installed clear the area of debris or remaining framing material.

Measure and cut the sole plate to the proper length deducting the width of the wedges to be used.

Measure and cut the header to the proper length deducting the width of the wedges to be used.

Measure and cut the posts to the proper height.
  - **!** Place the header on top of the sole plate.
  - **!** With the end of the tape measure on top of the header where the posts are to be installed, slide the tape up to the bottom of the structural element to be shored on both sides deducting the width of the wedges to be used.
  - **!** Use the shorter of the two measurements.

VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

WINDOW AND DOOR SHORE (continued)

Install the sole plate with a set of wedges at one end and tap them together simultaneously until the sole plate is under compression and tight.
  - ! The sole plate should be as level as possible, use shims as necessary under the sole plate.

Install the header with a set of wedges at the opposite end of the sole plate and tap them together simultaneously until the header is under compression and tight.
  - ! The header should be as level as possible, use shims as necessary above the header.

Install the posts between the header and sole plate and against the sides of the opening.
  - ! Install the first post under the wedge side of the header to prevent accidental movement if the header wedges loosen up.
  - ! Keep the posts in line and plumb with the header and sole plate.
  - ! A set of wedges is installed under each post, on top of the sole plate. The wedges are then tightened to lock the shore in place.

Attach cleats or gusset plates to at least one side of the header and posts and nail in place.

Secure the wedges by placing the back of a shim against the sides of the wedges and nail it in place or toe nail the wedges.
  - ! Nails may need to be Duplex for future adjustment of the wedges.

Install corner braces when additional support is needed or if the opening is more than six feet wide.

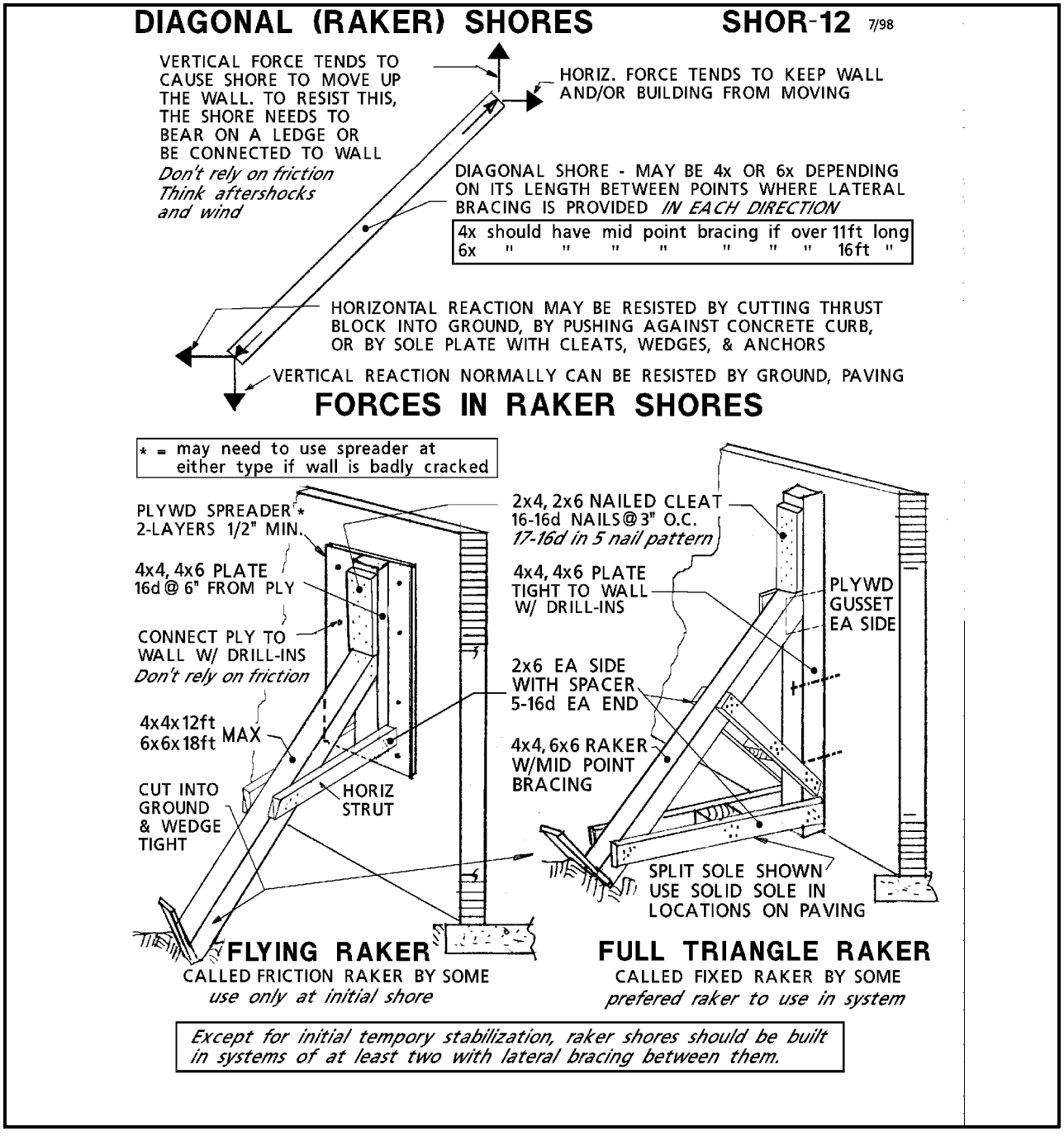
Install diagonal braces on the window and door shore when the opening is **not used** for access or egress.

VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

THE RAKER SHORE

The main purpose of the raker shore is to support leaning or unstable walls and columns by transferring additional weight down the raker, to the ground or other structural supporting members, and away from the wall or column.



VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

THE RAKER SHORE (continued)

Raker shores must always be installed in series, at least two must be erected in any given situation and braced together with a recommended separation of 8 feet.

Two general styles of raker shores are the (Flying) Friction Raker Shore and the (Full Triangle) Fixed Raker Shore.

The (Flying) **Friction Raker Shore**
- ! May be considered for initial temporary shoring due to its ease of construction and fewer shoring materials when followed with a group of well braced (Full Triangle) Fixed Raker Shores.
- ! Stability is increased by attaching the wall plate directly to the wall to reduce or eliminate slippage/shifting.

(Full Triangle) **Fixed Raker Shore**
- ! All of the structural elements are tied together, making the shore one integral unit and provides the best method of anchoring and bracing, but requires the most shoring material.
- ! The shore itself is stable and because of its ability to stay together this style of shoring is most often recommended for rescue situations.

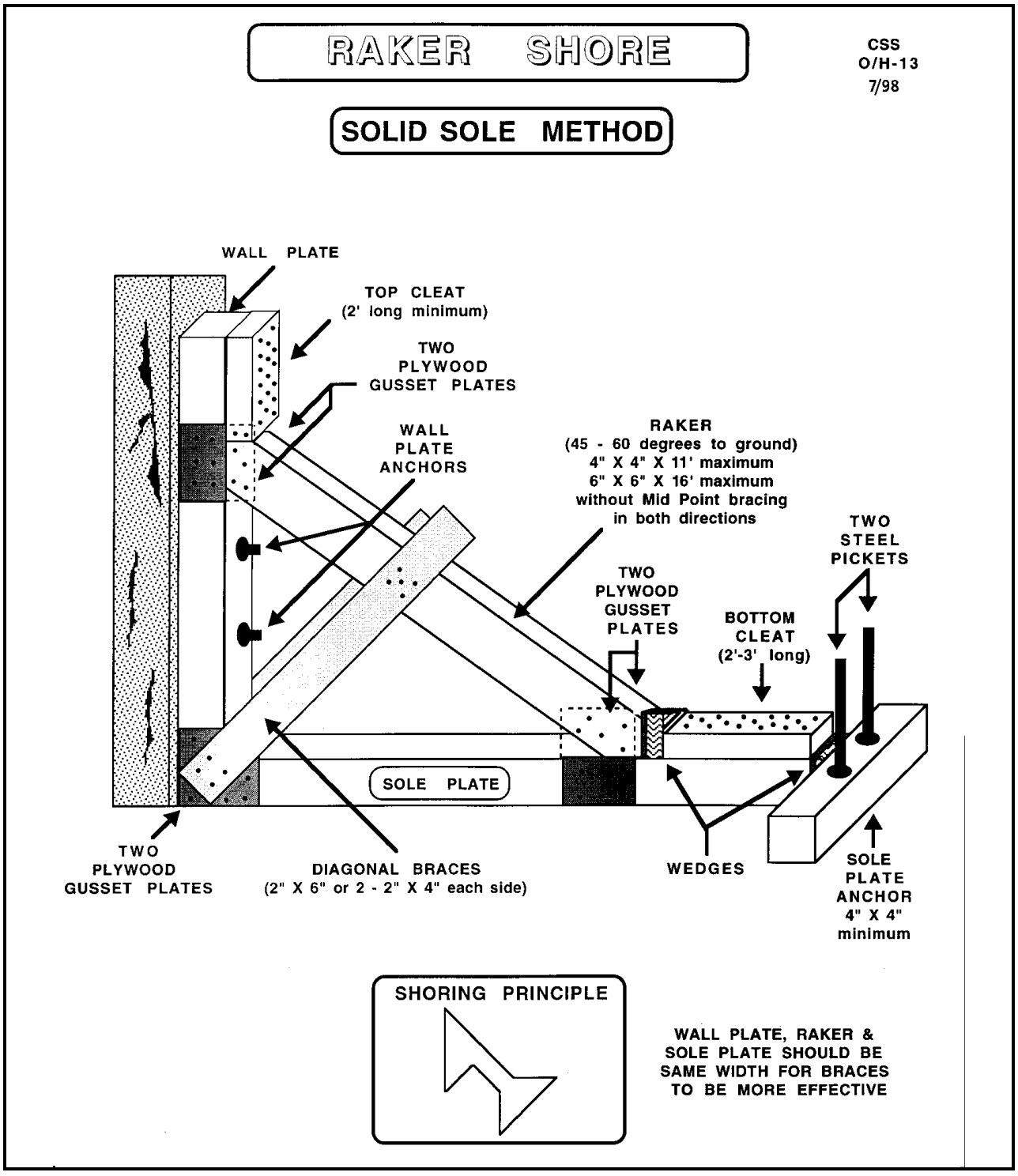
The two types of (Full Triangle) Fixed Raker Shores are the solid sole plate and the split sole plate.
- ! The Solid Sole Plate (Full Triangle) Fixed Raker Shore **(CSS O/H-13)** — utilized more in urban environments where concrete/asphalt commonly cover the ground.
- ! The Split Sole Plate (Full Triangle) Fixed Raker Shore **(CSS O/H-14)** — utilized more in suburban environments where open ground is available.

Raker Shore Support Point
- ! The support point at which the raker shore should intercept the buildings load is within one foot below the center of the floor or roof joist.
- ! Rounding off the height of the raker shore support point to the nearest foot will make the raker easier to measure and cut.

VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

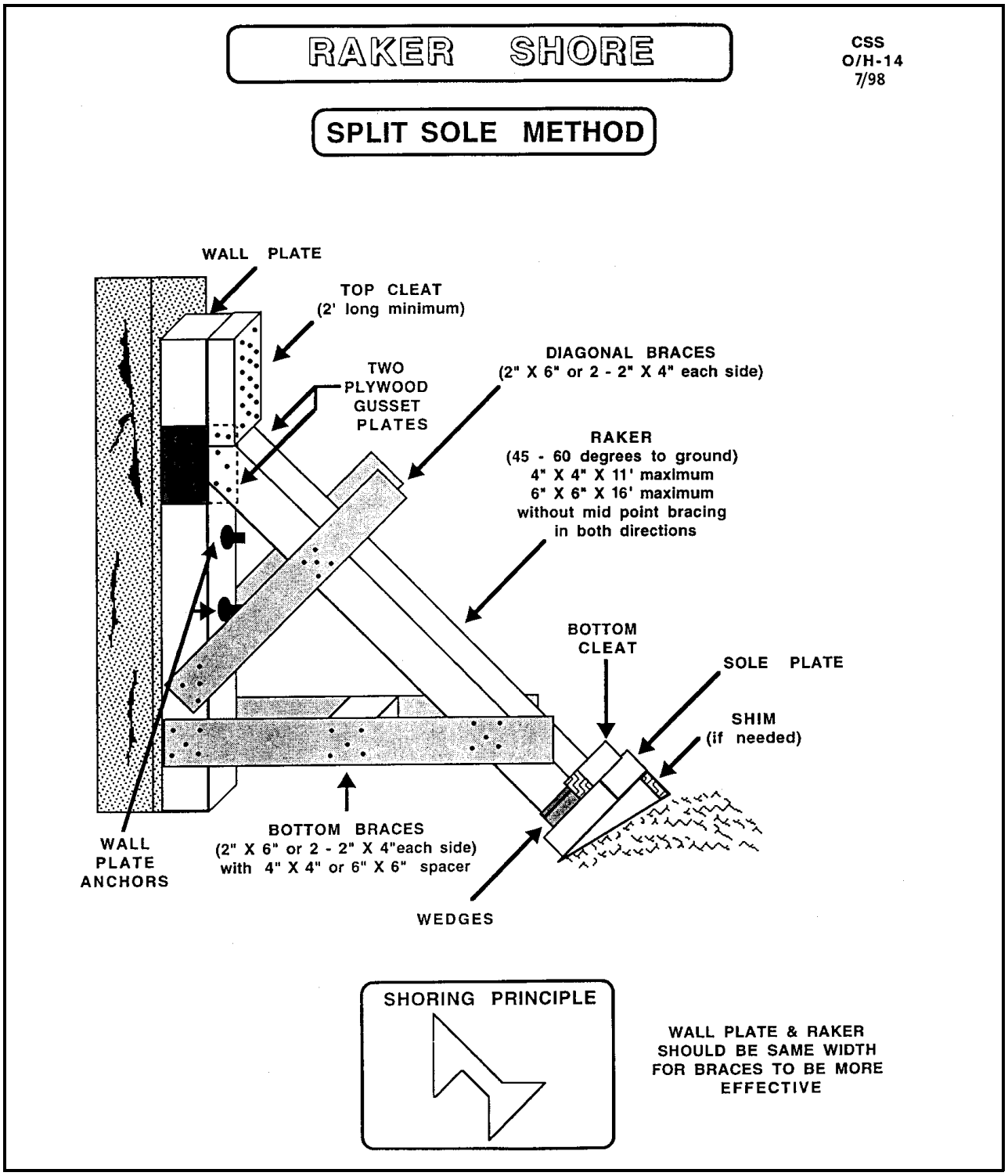
THE RAKER SHORE



VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

THE RAKER SHORE



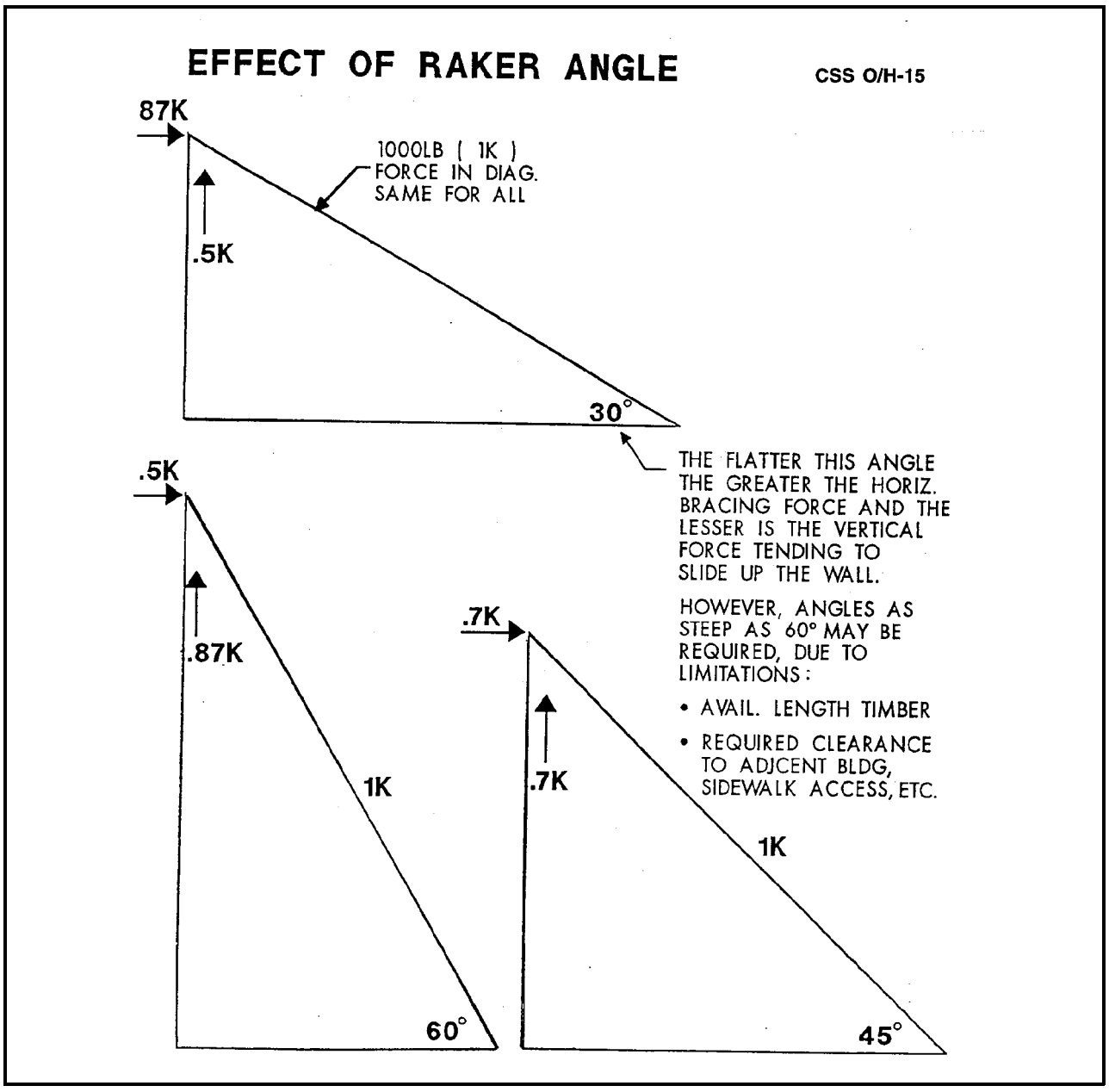
VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

THE RAKER SHORE

Determining the Raker Shore Angle and Length

Any angle between 30 and 60 degrees will work effectively.
- **!** The lower the angle, the more efficient the raker will be.
- **!** Above the 45° angle, the vertical force becomes larger than the horizontal force.



VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

THE RAKER SHORE

The two most common angles used are 45 and 60 degrees.

- **!** A 60 degree angle is the maximum recommended angle used to safely erect a raker shore.

Determining the height at which the raker shore needs to intersect the wall will identify the angle to work best with the available lengths of lumber.

- **!** A 45 degree angle raker shore requires longer lumber than a 60 degree raker shore.

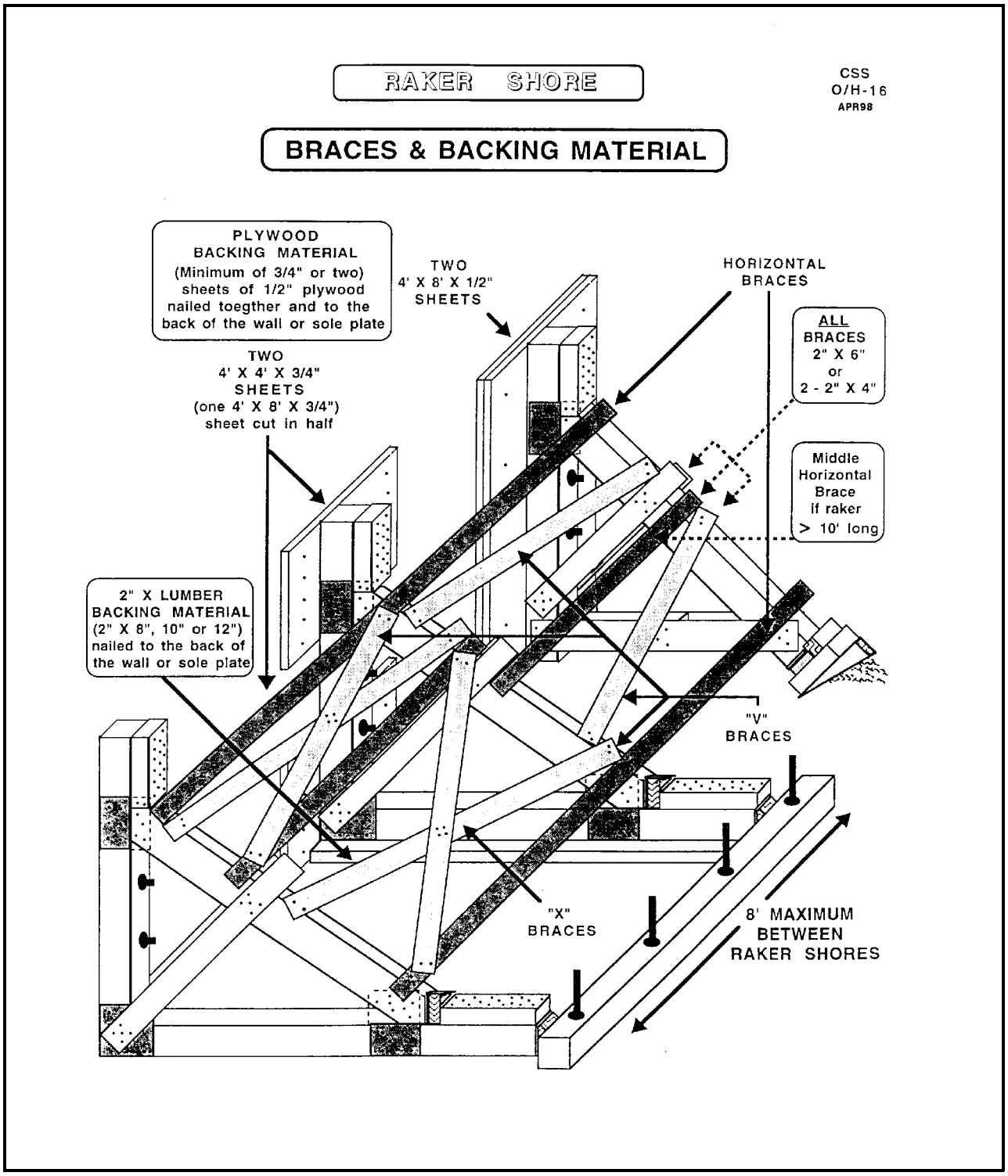
The length of a 45-degree angle raker shore: Height of the raker shore support point in feet multiplied by 17 will give the length of the raker, tip to tip, in inches. (8’ x 17 = 136” or 11’ 4”).

The length of a 60-degree angle raker shore: Height of the raker shore support point in feet multiplied by 14 will give the length of the raker, tip to tip, in inches. (8’ x 14 = 112” or 9’ 4”).

VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

STRUCTURAL COMPONENTS OF THE RAKER SHORE



VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

COMPONENTS OF THE RAKER SHORE (continued)

The **Wall Plate** — provides a foundation for the shoring system by collecting the weight being transferred laterally and spreads it throughout the shoring system.

The **Sole Plate** — collects the weight being transferred laterally and distributes it to the ground or other structural supporting member.

The **Raker** — supports the weight being collected by the wall plate and transfers it to the sole plate.

- **!** The wall plate, sole plate and raker should be the same width for a more secure attachment.
- **!** Buildings with heavy structural elements or support points taller than 12 feet usually require lumber larger than 4” X 4” for the wall plate, sole plate and raker.

The **Top Cleat** — short two foot piece of 2”X lumber nailed to the top of the wall plate to keep the raker from riding up the wall plate.

The **Bottom Cleat** — short two to three foot piece of 2”X lumber nailed to the top of the sole plate to keep the raker from riding back on the sole plate.

- **!** If possible and practical, the bottom cleat on the solid sole plate raker shore can be long enough to return back to a solid object, such as an adjoining wall.

Wedges — two wooden incline planes “married” together and placed against the bottom end of the raker and the bottom cleat.

- **!** Simultaneously tapped together until the shoring system is under compression and takes the weight of the structural materials.

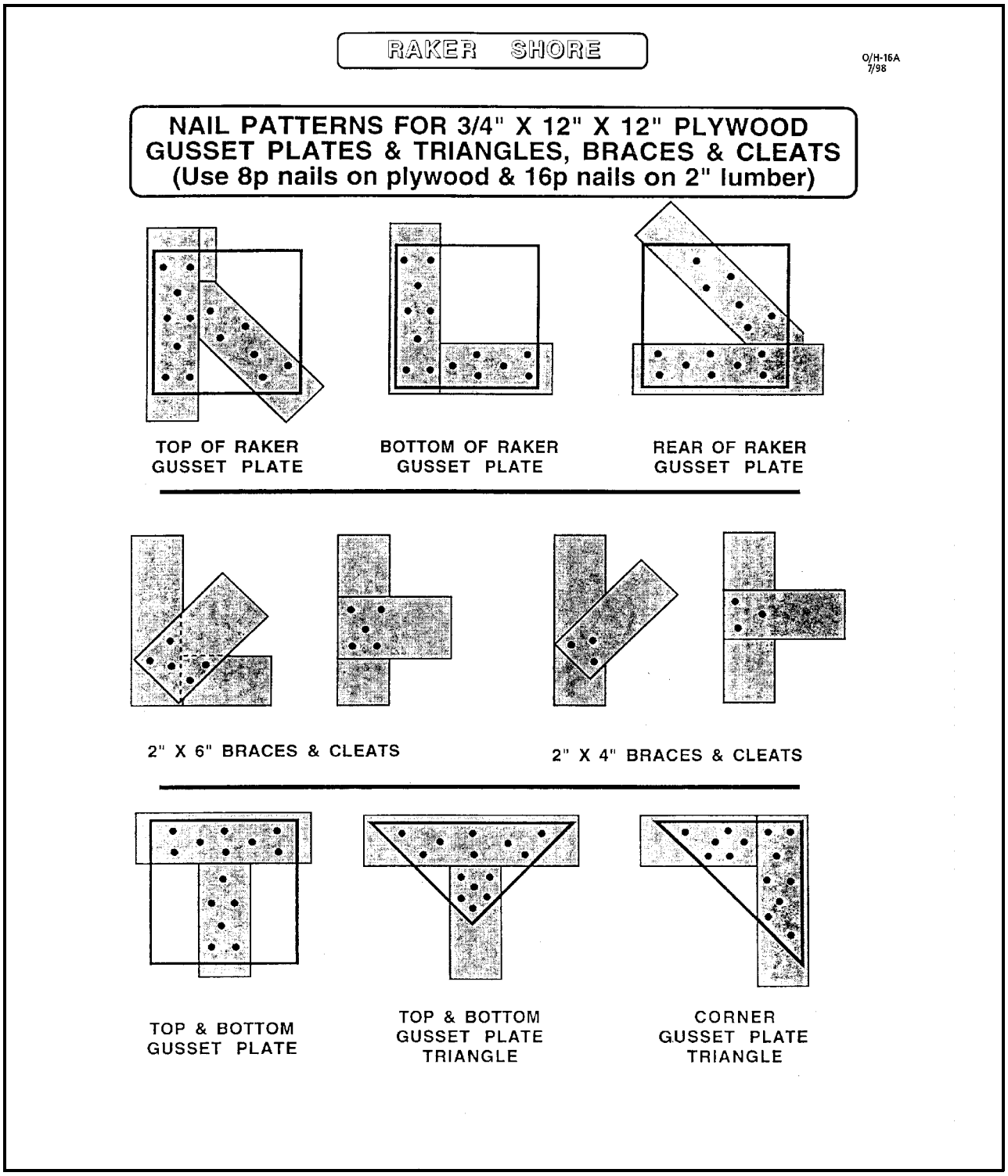
Gusset Plates — 12" X 12"pieces of 3/4” plywood nailed on both sides of the wall plate and sole plate connection and the top and bottom of the raker to prevent the them from being dislodged.

- **!** Split sole raker shores require gusset plates on both sides of the wall plate at the top of the raker only.

VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

NAIL PATTERNS FOR RAKER AND OTHER SHORES



VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

COMPONENTS OF THE RAKER SHORE (continued)

Diagonal Braces —diagonal braces increase the strength of the raker by reducing the L/D ratio.
- **!** The diagonal braces should be long enough to reach from the wall plate and sole plate connection to near the mid point of the raker.
- **!** On the solid sole raker shore, a 2” X 6” or two 2” X 4” are nailed to both sides of the wall plate and sole plate connection and mid point on the raker.
- **!** On the split sole raker shore, a 2” X 6” or two 2” X 4” are nailed to both sides of the wall plate and just above the bottom braces connection and mid point on the raker.

Bottom Braces — on split sole raker shores, a 2” X 6” or two 2” X 4” are nailed just above the ground and attached as close to the bottom of the raker as possible and the bottom of the wall plate with a fill block near the middle for additional stability.
- **!** Placed at the bottom of the wall plate and along the raker above the ground on the (Flying) Friction Raker Shore.

Horizontal Braces — horizontally connects the raker shores together near the top and bottom of the raker to provide additional stability to the raker shore system.
- **!** Horizontal braces attached to the mid point of the raker increase the strength of the raker by reducing the L/D ratio.

“**X**” and “**V**” **Braces** — connects the raker shores in a “X” or “V” pattern near the bottom and middle of the raker depending on access needs and available lumber.
- **!** Provides additional stability to the raker shore system and decreases the lateral movement when at least a pair are used at the beginning and end of the raker shore system.

VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

COMPONENTS OF THE RAKER SHORE (continued)

 # Backing Material —

- **!** Plywood (Full and Half Sheets) require a minimum of 3/4" or two 1/2" sheets of plywood nailed together.
- **!** 2" X Lumber (2" X 8, 10" & 12")
- **!** Nailed to the back of the wall plate can help distribute the weight of the wall over a wider area and prevent the wall plate from pushing through an unstable wall.
- **!** Very useful on unreinforced masonry (URM)
- **!** Nailed to the back of the sole plate can help distribute the weight of the wall over a wider area and prevent the sole plate from pushing into soft or muddy soil.
- **!** Backing material must contact the wall at the raker support point and at the bottom of the wall plate.
- **!** Shims may be needed to fill void spaces.
- **!** Backing material can be used to attach the wall plate to the wall or sole plate to the ground.

How to Construct the Raker Shore

Determine where to erect the raker shores and the height of its support points.

- **!** After initial temporary shoring has been installed as needed, clear the area of debris.
- **!** Three to four feet wide and at least the height of the support point out from the wall or column.

Measure and cut the wall plate to the proper length, if needed.

Measure, cut the top cleat and attach it to the top of the wall plate with at least 16-16d nails.

- **!** The top cleat is usually 2" X lumber two feet long for rakers at 45 degree angles or less.
- **!** The top cleat is usually 2" X lumber three feet long with 24 to 36-16d nails for rakers at 60 degree angles.
- **!** Another method for 60 degree angle rakers is to use the two foot cleat with 16-16d nails and cut a 1" deep notch just below the location for the bottom of the cleat. Length of the notch will be two times the width of the raker (8" for 4" X 4" and 12" for 6" X 6").

VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

COMPONENTS OF THE RAKER SHORE (continued)

- **!** The longer cleat with more nails or the notch below the two foot cleat are required because of the greater vertical forces applied to rakers at 60 degree. angles.

Measure and cut the raker to the proper length and angle to reach the support point.
- **!** Solid sole raker shores need both ends of the raker to be angle cut with 1 1/2" return cuts for full contact with the wall plate, top cleat, sole plate and wedges.
- **!** Split sole raker shores only one end need one end of the raker to be angle cut with a 11/2" return cut for full contact with the wall plate and top cleat.
- **!** The other end of the raker will contact the short sole plate dug into the ground at a 30 to 45 degree angle.

Measure and cut the sole plate to the proper length, if needed.
- **!** The solid sole raker shore sole plate must extend from the wall plate several feet past the point at which the raker intersects at the floor.
- **!** The split sole raker sole plate is approx. two ft long.

Place the wall plate against the area to be shored and plumb up in both directions.
- **!** If the area is bulged or cracked due to the strain exerted by the collapse debris, the wall plate may need to be shimmed.
- **!** Full contact must be maintained between the base of the wall plate and the area being shored.
- **!** Full contact must also be maintained between the wall plate and the support point of the raker.

Attach the sole plate to the bottom of the wall plate with gusset plates and nails on both sides on solid sole raker shores.
- **!** The wall plate and sole plate should be as level, plumb and at right angles to each other.
- **!** Attach the sole plate to the floor if possible and use shims as necessary to keep it level.
- **!** Split sole raker shores require a shallow hole dug at a 30 to 45 degree angle for the sole plate and raker to push against.

VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

COMPONENTS OF THE RAKER SHORE (continued)

Install the raker by gently lowering it onto the wall plate and sliding it up into position under the top cleat.

- **!** The ends of the raker should be flush and in full contact with the wall plate, top cleat and sole plate.
- **!** Attach the top of the raker to the wall plate with gusset plates and nails on both sides.

On the solid sole raker shore, attach the bottom cleat to the sole plate just behind the base of the raker with room left to apply wedges.

- **!** On the split sole raker shore, the bottom cleat is attached to the short sole plate on top of the bottom end of the raker after the raker shore is tightened with wedges.

On the solid sole raker shore, install wedges between the bottom cleat and the base of the raker and tighten them slightly.

- **!** After adjusting the shims or spacers between the wall plate and the object being shored to ensure full contact with the support point and the raker and the bottom of the wall plate, finish tightening the wedges.

Secure all wedges by placing a cleat against the sides of the wedges and nail it in place or toe nail the wedges.

- **!** Nails may need to be Duplex for future adjustment of the wedges.

Attach Bottom Braces on Split Sole Raker Shores

- **!** A 2” X 6” or two 2” X 4” are nailed just above the ground and attached as close to the bottom of the raker as possible and the bottom of the wall plate with a fill block near the middle for additional stability.

VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

COMPONENTS OF THE RAKER SHORE (continued)

Attach Diagonal Braces

- **!** On the solid sole raker shore, a 2” X 6” or two 2” X 4” are nailed to both sides of the wall plate and sole plate connection and mid point on the raker.
- **!** On the split sole raker shore, a 2” X 6” or two 2” X 4” are nailed to both sides of the wall plate and just above the bottom braces connection and mid point on the raker.

Attach Horizontal Braces

- **!** Connect the raker shores together near the top and bottom of the raker with at least 2” X 6” size material, or two 2" X 4".

Attach“X” or “V” Braces

- **!** All raker shore systems must be connected with either “X” or “V” bracing near the top and bottom of the raker between at least two raker shores with at least 2” X 4” size material.
- **!** Attach the **first brace to the rakers** near the top and bottom between the upper and lower horizontal braces.
- **!** Attach the **second brace to the upper and lower horizontal braces** near the rakers.

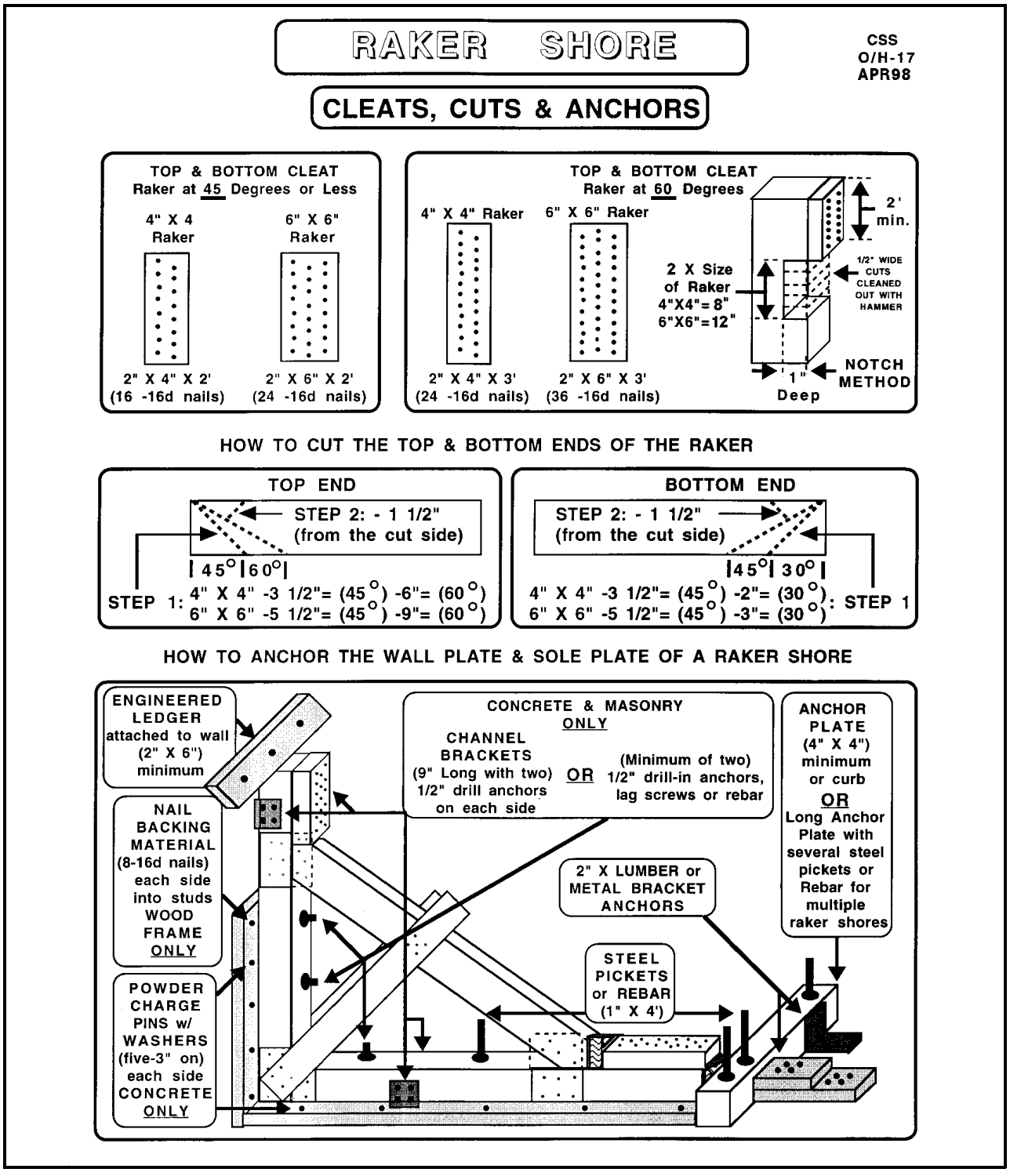
After the raker shore is assembled, prevent the raker shore from sliding up the wall. **(CSS O/H-17)**

- **!** To attach the wall plate directly to a concrete and masonry wall.
  - a minimum of two 1/2” drill-in anchors, lag screws or rebar should be placed through the wall plate or four 1/2” drill-in anchors through two 9” long channel brackets attached with two on each side of the wall plate near the top.
  - on concrete walls only, when backing material is attached to the wall plate, the use of at least five 3” powder charge pins with washers through the backing material on each side of the raker is acceptable.

VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

COMPONENTS OF THE RAKER SHORE (continued)



VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

COMPONENTS OF THE RAKER SHORE (continued)

- **!** To attach the wall plate directly to a wood framed wall.
  - a minimum of two 1/2" lag screws should be placed through the wall plate directly into the wall studs.
  - when plywood backing material is attached to the wall plate, the use of at least 8-16d nails through the backing material directly into the wall studs on each side of the raker is acceptable.
- **!** Another method is to attach a engineered ledger (2" x 6" minimum) to the wall above the wall plate.

After the solid sole raker shore is assembled, prevent the sole plate from sliding back away from the wall.

- **!** To attach the sole plate directly to concrete, asphalt or dirt. Drill a minimum of two 1" holes through the sole plate, concrete or asphalt and pound 1" steel pickets or rebar directly into the ground.
- **!** To attach the sole plate to concrete and masonry.
  - a minimum of two 1/2" drill-in anchors, lag screws or rebar should be placed through the sole plate or four 1/2" drill-in anchors through two 9" long channel brackets attached with two on each side of the sole plate.
  - on concrete only, when backing material is attached to the sole plate, the use of at least five 3" powder charge pins with washers through the backing material on each side of the sole plate is acceptable.
- **!** An anchor can be secured to the ground or floor behind the sole plate to prevent the sole plate from backing away from the wall.
  - timber anchors should be as least 4" X 4" size lumber.
  - steel anchors or channel brackets should be at least 1/4" thick.
  - concrete curbs, walls and other nearby secure structures may also be used.

VI. EXTRICATION OPERATIONS

MODULE ONE: B — CONSTRUCTING SHORING SYSTEMS

COMPONENTS OF THE RAKER SHORE (continued)

How to Pre-Construct the Raker Shore

The areas to be supported by raker shores should be considered extremely dangerous most of the time. Temporary (Flying) Friction raker shores may need to be erected prior to building more permanent (Full Triangle) Fixed raker shores.

One way to reduce the amount of time spent in front of unstable structural elements receiving a raker shore is to pre-construct the majority of the shore in a safe location near the shoring site.

! When possible, pre-construction of raker shores should be your first choice.

The Split Sole Raker Shore can be pre-constructed with the wall plate, raker and bottom braces pre-attached.

! After placing the raker shore in position, final adjustments are made with wedges at the sole plate in the ground and the bottom braces and raker connection.

The Solid Sole Raker Shore can be pre-constructed with the wall plate, raker and sole plate pre-attached.

! After placing the raker shore in position, final adjustments are made with wedges at the bottom cleat on the sole plate.

VI. EXTRICATION OPERATIONS

MODULE ONE: C — VERTICAL AND LATERAL SHORING

WORK STATION SET UP & OPERATION

The Vertical and Lateral Shore Work Station is one of three work stations for Emergency Shoring. The other two work stations are:
  - ! The Raker Shore Work Station
  - ! The Equipment and Cutting Work Station

Vertical and Lateral Shoring Systems will be pre-constructed as described in the "Constructing Shoring Systems" curriculum prior to students arriving at the work station.
  - ! The vertical and lateral shoring systems will be used to further explain proper terminology, shoring material placement and construction techniques.

After conducting a thorough explanation of each vertical and lateral shoring system the students will be divided into two half squads.
  - ! Half the shoring systems will be assigned to each half squad to dismantle and reconstruct.
  - ! When both half squads have finished, they will switch shoring sites to dismantle and reconstruct the other half of the shoring systems just reconstructed by the other squad.
  - ! When both half squads have finished with the other half of the shoring systems, a final walk through with the instructor will be conducted to answer any questions and critique the shoring.
  - ! Make any corrections to the shoring systems prior to the start of the next squad rotation.

PRE-CONSTRUCTED VERTICAL AND LATERAL SHORING SYSTEMS

The Vertical and Lateral Shoring Systems to pre-construct are:

Vertical Shore with lumber and a minimum of three posts, diagonal braces and gusset plates or cleats connecting the header to the posts.

VI. EXTRICATION OPERATIONS

MODULE ONE: C — VERTICAL AND LATERAL SHORING

PRE-CONSTRUCTED VERTICAL AND LATERAL SHORING SYSTEMS (continued)

Ellis Shores with a minimum of two posts with gusset plates or cleats connecting the header and sole plate to the posts.

- **!** Ellis Clamp positions on posts:
  - top clamp is attached 2” below top of the lower post with two nails.
  - bottom clamp is attached 12” below top clamp on the lower post with two nails.
- **!** Slide the upper post under the clamps and manually raise to proper height and pull down on the top clamp.
- **!** Attach the shore-jack to the lower post under the upper post and lift on the handle.
- **!** While pressure is being applied to the shore-jack, tap downward on the unsecured end plate of the top clamp and then tap downward on the unsecured end plate of the bottom clamp with a hammer to lock the clamps in place.
- **!** For training purposes, <u>do not</u> nail the clamps to the upper post. This will aid in a quicker dismantle and reconstruction, but nailing the upper post is stressed during the instruction of the Ellis Clamp system.
- **!** Gusset plates or cleats connecting the header and sole plate to the posts can be done before or after the shores are in place.
- **!** Diagonal braces are mentioned but not attached.

Post Screw Jack (when available) with a minimum of two posts with gusset plates or cleats connecting the header to the posts.

- **!** Diagonal braces are mentioned but not attached.

Hi-Lift Jacks with Extension Tubes (when available), using two jacks to support the header and 3 X 3 Crosstie Crib Beds for additional height as needed.

Pipe Shores (when available) with a minimum of two shores and 3 X 3 Crosstie Crib Beds for additional height as needed. When available, a combination of 1 pipe shore and pneumatic shore supporting the header is preferred for training purposes.

VI. EXTRICATION OPERATIONS

MODULE ONE: C — VERTICAL AND LATERAL SHORING

PRE-CONSTRUCTED VERTICAL AND LATERAL SHORING SYSTEMS (continued)

Pneumatic Shore (when available) with a minimum of two shores and 3 X 3 Crosstie Crib Beds for additional height as needed. When available, a combination of one pneumatic shore and one pipe shore supporting the header is preferred for training purposes.

Window and/or Door Shore with lumber.
- **!** Diagonal braces are mentioned but not attached.

Horizontal Shore with two struts, using at least one lumber strut with gusset plates or cleats connecting the strut to the wall plates and one pipe screw jack.
- **!** Cleats should be attached to the wall plates under the struts where appropriate.
- **!** Diagonal braces are mentioned but not attached.

Laced Post System with a minimum of four 4" X 4" posts and 4" X 4" headers and sole plates. (Build as a static display and dismantle and rebuild during class **ONLY** if time permits.)
- **!** Four posts 3' - 4' apart each way.
- **!** Built in two half sections then laced together in a square pattern.
- **!** Lacing material is 2" X 4" lumber, nailed with two or three Duplex 16p nails at each end.

Explain and demonstrate how to measure shoring materials while deducting for wedges, the proper use of wedges and maximum thickness while maintaining full contact with perpendicular shoring materials.

When possible, round off shoring material measurements to the nearest inch to ease in marking and cutting.

When using 4" X 4" X 18" wedges deduct the width of the wedge from the length of the shoring material being measured.

VI. EXTRICATION OPERATIONS

MODULE ONE: C — VERTICAL AND LATERAL SHORING

PRE-CONSTRUCTED VERTICAL AND LATERAL SHORING SYSTEMS (continued)

When using 2" X 4" X 12" wedges deduct the width of the wedge from the length of the shoring material being measured.

4" X 4" X 18" wedges can be moved together to a thickness of 6" while still maintaining full contact with a perpendicular 4" X 4".

2" X 4" X 12" wedges can be moved together to a thickness of 2 1/4" while still maintaining full contact with a perpendicular 4" X 4".

SUPPLIES AND EQUIPMENT

The use of same dimension lumber for the headers, wall plates, sole plates, posts and struts will ease in the construction of the shoring systems and make the braces more effective.

The use of Duplex 16p and 8p nails will assist in the dismantling of the shoring systems and reduce the amount of destroyed shoring materials during the dismantling process.
  - ! Use Duplex 8p nails with plywood gusset plates.

Two dozen cleats and plywood gusset plates should be at the shoring site due to the high probability of being destroyed during the dismantling process.
  - ! Cleats should be 2" X 4" X 12"
  - ! Plywood gusset plates should be 12" X 12" X 3/4" thick.
  - ! Smaller square gusset plates can easily be formed by cutting the larger square gusset plates in half in both directions making four 6" X 6" gusset plates.
  - ! Triangle gusset plates (12" X 12" X 17") can easily be formed by cutting the larger square gusset plates in half from one corner to the opposite diagonal corner.

VI. EXTRICATION OPERATIONS

MODULE ONE: C — VERTICAL AND LATERAL SHORING

SUPPLIES AND EQUIPMENT (continued)

The following list of hardware should be at the vertical and lateral shoring site:

!	4	Framing hammers
!	4	Single jack hammers, 3-lb.
!	4	Crow bars
!	2	Levels (1 @ 6” and 1 @ 3’ - 4’)
!	2	Carpenter belts w/ pencils/lumber crayons
!	2	Tape measures, 25’
!	2	Framing Square
!	1	A-Frame Ladder, 6’ minimum
!	1	Chalk Lines
!	1	Utility Razor Knife
!	25-lb.	Duplex 16p nails
!	25-lb.	Duplex 8p nails
!	1	Container for pulled nails, box, can, etc.
!	12	Ellis Clamps
!	2	Ellis Jacks
!	4	Ellis Post Screw Jacks
!	5	Pipe Screw Jacks, 2”
!	20’	Pipe, 2”, Schedule 40
!	2 each	High Lift Jack with Ext. Tubes
!	1	SCBA Bottle, full
!	2 each	Pneumatic Shore, 2’ - 6’ (when available)
!	1	Pneumatic Shore regulator & hose
!	1 set	Pneumatic Shore ends & extensions

The following list of lumber should be at the vertical and lateral shoring site:

!	24	12” x 12” x 3/4” gusset plates
!	48	2” x 4” x 12” cleats
!	42	4” x 4” x 18” cribbing
!	24	2” x 4” x 18” cribbing
!	22	2” x 4” x 12” wedge pairs
!	24	4” x 4” x 18” wedge pairs
!	12	4” x 4” x 12’
!	36	4” x 4” x 8’
!	12	2” x 4” x 12’
!	18	2” x 4” x 8’

VI. EXTRICATION OPERATIONS
MODULE ONE: D — RAKER SHORING

Work Station Set Up and Operations

Raker shore systems will be properly preconstructed as described in the Constructing Shoring Systems curriculum prior to students arriving at the work station.

The raker shore systems will be used to further explain proper terminology, shoring material placement and construction techniques.
- **!** Proper methods to determine raker length using the suppport point on the wall in feet, times 17 for 45^{o}, and times 14 for 60^{o}, and the steel framing square will be further explained.

After conducting a thorough explanation of each raker shore system, the students will be assigned to:
- **!** Dismantle and reconstruct a solid sole raker shore and reattach the braces.
- **!** If time permits, dismantle and reconstruct a split sole raker shore and reattach the braces.
- **!** Measure and cut a raker to 45^{o} and 60^{o}.
- **!** Make any corrections to the shoring systems prior to the start of the next squad rotation.

Pre-constructed Raker Shore Systems

The raker shore systems to preconstruct are:
- **!** Friction (flying) raker shore.
- **!** Fixed (full triangle) raker shore using a split sole plate.
- **!** Fixed (full triangle) raker shore using a solid sole plate.
- **!** Fixed (full triangle) raker shore with plywood backing material attached to the wall plate, using two rakers to a (simulated) second floor, with a notch and cleat at the top support point and the solid or split sole plate method.
- **!** Connect all raker shore systems together with horizontal braces.
- **!** Two raker shores will be connected with "X" braces and the other two raker shores will be connected to the X-braced pair with "V" braces.

VI. EXTRICATION OPERATIONS
MODULE ONE: D — RAKER SHORING

Supplies and Equipment

The use of same dimension lumber for the wall plates, rakers and sole plates will ease in the construction of the shoring systems and make the braces more effective.

The use of Duplex 16p and 8p nails will assist in the dismantling of the shoring systems and reduce the amount of destroyed shoring materials during the dismantling process.

Two dozen cleats and plywood gusset plates should be at the shoring site due to the high probability of being destroyed during the dismantling process.

- **!** Cleats should be 2"X4" X 12".
- **!** Plywood gussets should be 12" X 2" X ¾" thick.
- **!** Smaller square gusset plates can easily be formed by cutting the larger square gusset plates in half in both directions making four 6" X 6" plates.
- **!** Triangle gusset plates (12" X 12" X 17") can easily be formed by cutting the larger square gusset plates in half from one corner to the opposite diagonal corner.
- **!** Using Duplex 8p nails with plywood gusset plates.

VI. EXTRICATION OPERATIONS
MODULE ONE: D — RAKER SHORING

Supplies and Equipment (continued)

The following list of hardware should be at the Raker Shore Work Station:

!	4	framing hammers
!	4	single jack hammers, 3 lb.
!	4	crow bars
!	2	levels (1 @ 6" and 1 @ 3 - 4 ft.)
!	2	carpenter belts w/ pencils/lumber crayons
!	2	tape measures, 25 ft.
!	2	steel framing squares
!	1	speed square
!	2	round point shovels
!	1	utility razor knife
!	2	cats paw nail pullers
!	1	container for pulled nails (can/box/etc.)
!	1	A-frame ladder (6 ft. min.)
!	25 lb.	Duplex 16p nails
!	25 lb.	Duplex 8p nails
!	1	chain saw, gasoline
!	1	rotary hammer
!	1	rotary hammer masonry bit (1" X 18")
!	200 ft. extension cords	
!	20	rebar or steel pickets, 1"
!	2	4 X 8 sheets ¾" plywood
!	100	12" X 12" X ¾" gusset plates
!	36	2" X 4" X 12" wedge pairs
!	4	4" X 4" X 12" wedge pairs
!	4	6" X 6" X 16 ft. lumber
!	24	4" X 4" X 16 ft. lumber
!	30	4" X 4" X 12 ft. lumber
!	26	2" X 6" X 16 ft. lumber
!	48	2" X 4" X 12 ft. lumber

VI. EXTRICATION OPERATIONS
MODULE ONE: D — RAKER SHORING

The Steel Framing Square & Determining the Length of Raker Shores

- The tongue:
  - Shorter, narrower part is usually 16" long and 1½ wide.
- The body (blade):
  - Usually 24" long and 2" wide.
- The Heel:
  - The point where the tongue and the body meet on the outside edge.
- The Face:
  - The side with the manufacturer's stamp.
  - The side that is visible when the body is held in the left hand and the tongue in the right hand.
- The Back:
  - Opposite of the face.

The Scales and Tables

- There are seven different scales and tables on the steel framing square:
  - Four of the seven scales and tables commonly used for rescue shoring.
- The Rafter Table:
  - Found on the face of the square, on the body, starting on the left.
  - Used to determine the lengths of common, hip, valley and jack rafters and the angles at which they must be cut to properly fit ridge board/top plates for roof framing.
  - Can be used to determine the length of the raker.
- The Brace Table:
  - Found along the center of the back of the tongue, giving lengths from 24" to 60" forming 45^{o} angles.
  - Determine the length of short rakers/corner bracing.

VI. EXTRICATION OPERATIONS
MODULE ONE: D — RAKER SHORING

The Scales and Tables (continued)

The Hundredths Scale:
- ! Found on the back of the tongue, near the heel.
- ! Consists of one inch divided into one hundred parts.
- ! Useful to convert lengths given in hundredths.

The Inch Scale:
- ! Found on both the body and the tongue along the inside and outside edges of the square.
- ! Used for measuring inches and different graduations of an inch.

Using the Steel Framing Square to Determine the Length of A Raker

Three Methods to determine the length of a raker with the steel framing square:
- ! The Diagonal Method
- ! The Step-Off Method
- ! The Length-Per-Foot Run Method

The Diagonal Method **(Figure: 1 on Page 83)**
- ! The least accurate of the three methods.
- ! Use the tongue to simulate the wall and the body to simulate the floor.
- ! Use the inch markings on the outside edges as “foot measurements”.
- ! Place the tape measure tip on the outside inch mark simulating the support point on the wall and lay it across the square until it intersects the outside inch mark on the body simulating the contact point on the floor.
- ! The length of the tape measure when it is intersecting the outside tongue and body inch marks will be the length of the raker from tip to tip.
- ! Example: 9’ high support point on the wall, 12’ back from the wall will be a 15’ long raker.

VI. EXTRICATION OPERATIONS
MODULE ONE: D — RAKER SHORING

Using the Steel Framing Square to Determine the Length of A Raker (continued)

The Step-Off Method **(Figure: 2 on Page 83)**

- **!** Place the square on the raker with heel pointing up and the body on the left side and the tongue on the right.
- **!** Use the tongue to simulate the wall and the body to simulate the floor.
- **!** Use the inch markings on the outside edges as “foot measurements”.
- **!** Align the tongue outside edge inch mark representing the height in feet of the support point on the wall with the bottom edge of the raker.
- **!** Align the outside edge inch mark on the body representing the length in feet away from the wall the contact point on the floor with the bottom edge of the raker.
- **!** Scribe a line, which will be the top cut of the raker along the outer edge of the tongue.
- **!** Mark the point where the outer edge inch mark of the body contacts the bottom edge of the raker.
- **!** Hold the square with the outer edge inch marks remaining constant and “step” over the pencil mark to the left and place outer edge inch mark of the tongue next to it.
- **!** Realign the same outer edge inch marks as before and mark the point where the outer edge inch mark of the body contacts the bottom edge of the raker.
- **!** Repeat this “step” as may times as there are feet in the length away from the wall.
- **!** On the last “step”, scribe a line along the outer edge of body for the bottom cut of the raker.
- **!** Example: 9’ high support point on the wall, 12’ back from the wall will be a 15’ long raker.
  - 9” mark on the outer edge of the tongue and the 12” mark on the outer edge of the body is “stepped” over these marks twelve times.
  - Measuring the distance covered after twelve “steps” is 15’ tip to tip.

VI. EXTRICATION OPERATIONS
MODULE ONE: D — RAKER SHORING

Using the Steel Framing Square to Determine the Length of A Raker (continued)

The Length-Per-Foot Run Method **(Figure: 3 on Page 83)**

- **!** The most accurate of the three methods.
- **!** Using the rafter table, located on the body, on the face.
- **!** The first line under the inch graduations, the table if broken down into inches and hundredths of an inch.
- **!** Use the number 12 as the horizontal constant.
- **!** When the height of the support point on the wall is eight feet, then the pitch will be 8/12.
  - When the height of the support point on the wall is nine feet, then the pitch will be 9/12, etc., etc.
- **!** The length-per-run table on the square, under the inch number which corresponds to the height of the support point on the wall in feet, will be the length of the raker in inches and hundredths of an inch, which will stand for the raker in feet.
- **!** Example: 9’ high support point on the wall.
  - Under the number 9 on the first line on the length-per-foot run table is the number 15, which represents 15” and stands for 15’ for the raker from tip to tip.

VI. EXTRICATION OPERATIONS

MODULE ONE: D — RAKER SHORING

Using the Steel Framing Square to Determine the Length of A Raker (continued)

USING THE STEEL FRAMING SQUARE TO DETERMINE THE LENGTH OF A RAKE

Figure:1

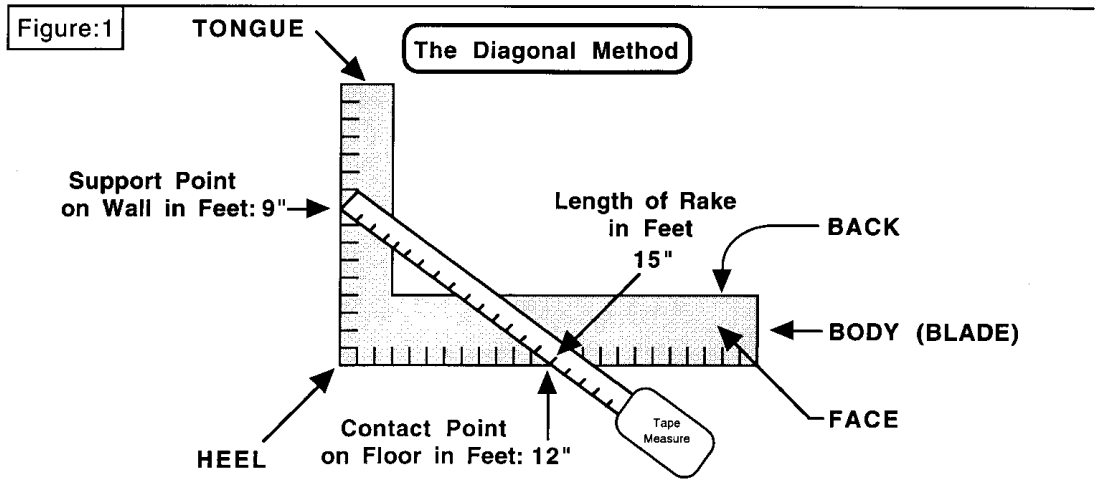


Figure:2

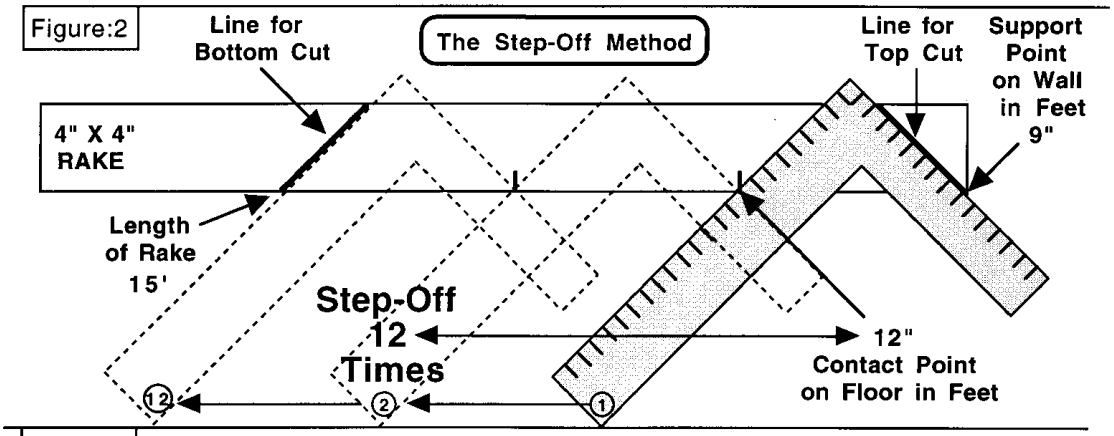
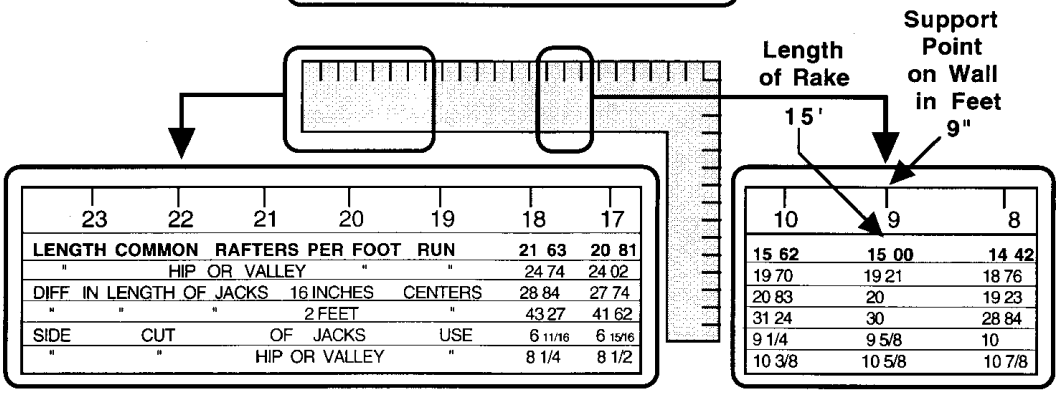


Figure:3

The Length-Per-Foot Run Method



23	22	21	20	19	18	17
LENGTH COMMON RAFTERS PER FOOT RUN					21 63	20 81
" HIP OR VALLEY " "					24 74	24 02
DIFF IN LENGTH OF JACKS 16 INCHES CENTERS					28 84	27 74
" " " 2 FEET "					43 27	41 62
SIDE CUT OF JACKS USE					6 11/16	6 15/16
" " HIP OR VALLEY "					8 1/4	8 1/2

10	9	8
15 62	15 00	14 42
19 70	19 21	18 76
20 83	20	19 23
31 24	30	28 84
9 1/4	9 5/8	10
10 3/8	10 5/8	10 7/8

VI. EXTRICATION OPERATIONS

MODULE ONE: E — EQUIPMENT & CUTTING STATION

WORK STATION SET UP & OPERATION

The Equipment and Cutting Work Station is one of three work stations for Emergency Shoring. The other two work stations are:
  - ! The Vertical & Lateral Shore Work Station
  - ! The Raker Shore Work Station

The Equipment and Cutting Work Station will be properly set up prior to students arriving.

After conducting a thorough explanation and demonstration, the squad will be provided opportunities to practice with the tools and equipment commonly used to cut and create shoring materials.

EQUIPMENT AND CUTTING ASSIGNMENTS

Thoroughly explain and demonstrate the proper use and safety of the following tools:
  - ! Chain Saw (Gas and Electric)
  - ! Rotary Saw
  - ! Circular Saw (7 1/4”)
  - ! Pipe Cutter
  - ! Nail Gun, Pneumatic & Gas Fired (when available)
  - ! Hilti Kwik Bolt System
  - ! Powder charge ram sets with pins and washers
  - ! Tape measure and Tri-Square

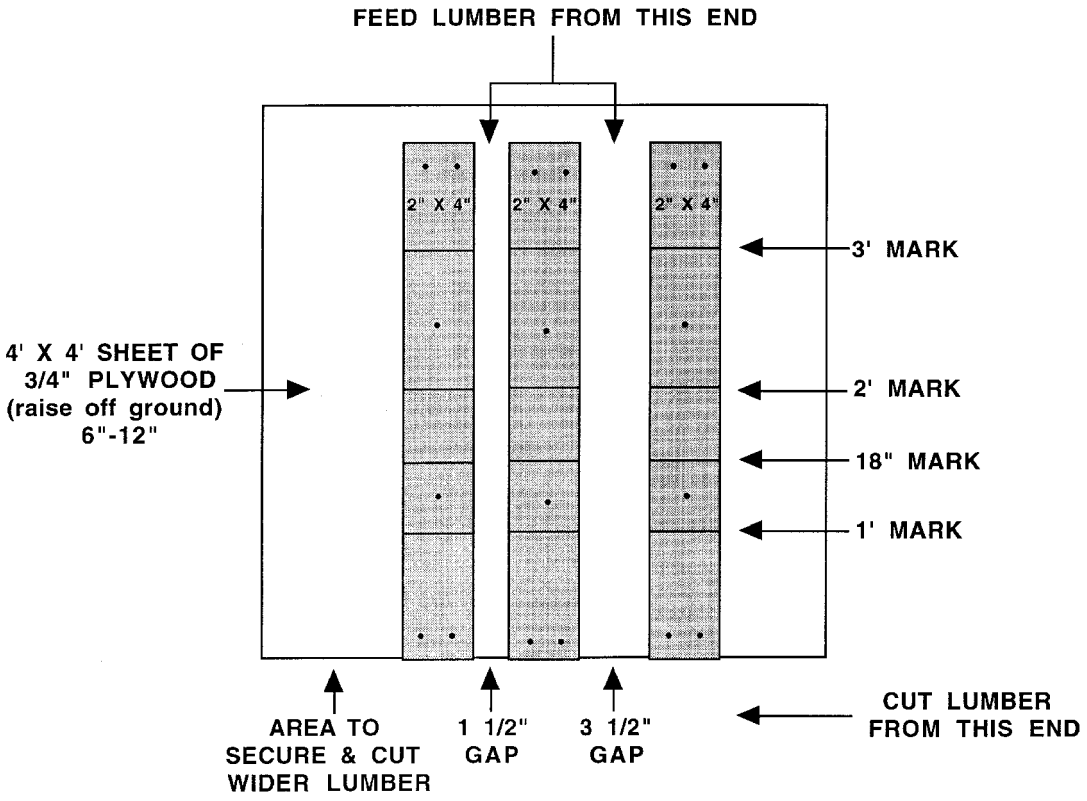
Construct a cutting table and jig to secure 4” X 4”, 2” X lumber on edge and larger dimension materials while being cut. (See next page.)

VI. EXTRICATION OPERATIONS

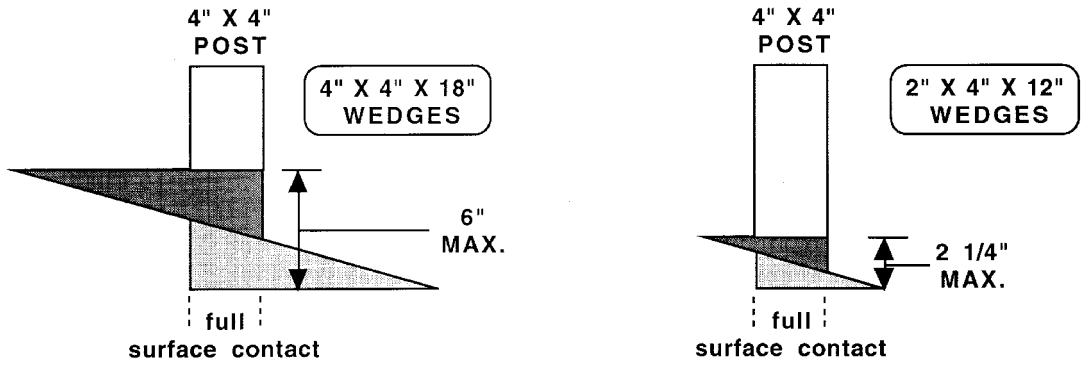
MODULE ONE: E — EQUIPMENT & CUTTING STATION

EQUIPMENT AND CUTTING ASSIGNMENTS (continued)

CUTTING TABLE & JIG APPENDIX - A



Maximum Spread for Wedges with Full Surface Contact (Wedges must be connected cut side to cut side)



VI. EXTRICATION OPERATIONS

MODULE ONE: E — EQUIPMENT & CUTTING STATION

EQUIPMENT AND CUTTING ASSIGNMENTS (continued)

Explain and demonstrate how to cut wedges.

- # Cutting 4" X 4" X 18" wedges.
  - ! Mark a full length 4" X 4" X 8' every 18".
  - ! This will make five pair of wedges with a 6" piece left to secure the last pair while being cut.
  - ! Mark a diagonal line from the top edge of one 18" line to the bottom edge of the opposite 18" line every 18".

- # Cutting Wedges with a Rotary Saw
  - ! Score the line with the blade 1/2" deep.
  - ! Second pass cut half way through.
  - ! Third pass cut all the way through.
  - ! Cut the other half of the wedge off of the remaining 4" X 4" at the 18" line.

- # Cutting Wedges with a Chain Saw
  - ! Align the blade with the diagonal line on the 4" X 4" with the tip of the saw pointing towards the cutting table.
  - ! Start cutting with the tip of the saw bar approximately 2" past the edge of the 4" X 4".
  - ! Once the tip of the saw bar is through the full thickness of the 4" X 4" start to drag the saw towards the opposite end of the diagonal line.
  - ! Once the heel of the saw is past the end of the 4" X 4", flatten the saw and cut the remaining part of the 4" X 4" with the full bar.
  - ! Cut the other half of the wedge off of the remaining 4" X 4" at the 18" line.

- # Cutting Wedges with a Circular Saw
  - ! Difficult to do unless the saw has at least a 10 1/4" blade.
  - ! Circular saws with blades 10 1/4" or larger need only one pass from corner to corner along the diagonal line.
  - ! Circular saw with blades less than 10 1/4" require marking and cutting on both sides and do not always align correctly.

VI. EXTRICATION OPERATIONS

MODULE ONE: E — EQUIPMENT & CUTTING STATION

EQUIPMENT AND CUTTING ASSIGNMENTS (continued)

- **#** Cutting 2" X 4" X 12" wedges
  - **!** Mark a full length 2" X 4" X 8' on edge, every 12".
  - **!** This will make seven pair of wedges with a 12" piece left to secure the last pair while being cut.
  - **!** Mark a diagonal line from the top edge of one 12" line to the bottom edge of the opposite 12" line every 12".

- **#** Cutting Wedges with a Rotary Saw and Chain Saw
  - **!** Start the cut a little past the mark away from the corner to prevent making the wedge too thin.

Explain and demonstrate the personnel positions at the cutting station as described in the "Constructing Shoring Systems" curriculum.

- **#** Explain how the Shore Assembly Team "Measure" will relay the size and length of material to cut and that number will already account for the thickness of the header, sole plate and wedges. The "Cutter" simply cuts what is requested.

- **#** Always mark the length of cut lumber on the lumber, for quicker identification and installation of the correct piece of shoring material.

- **#** The cutting team will mark and cut two pair of field wedges.
  - **!** Cut one pair with a Rotary Saw
  - **!** Cut the other pair with a Chain Saw

- **#** Explain the importance of a square cut and the strength loss when shoring materials do not have good surface contact or are out of plumb.
  - **!** Five degrees out of plumb can equal a 50% loss of surface contact and strength.

VI. EXTRICATION OPERATIONS

MODULE ONE: E — EQUIPMENT & CUTTING STATION

EQUIPMENT AND CUTTING ASSIGNMENTS (continued)

Explain the most common sizes of cleats and plywood gusset plates.

- **!** Cleats are usually 2” X 4” X 12”.
- **!** Plywood gusset plates are usually 12” X 12” X 3/4” thick.
- **!** Smaller square gusset plates can easily be formed by cutting the larger square gusset plates in half in both directions making four 6” X 6” gusset plates.
- **!** Triangle gusset plates (12” X 12” X 17”) can easily be formed by cutting the larger square gusset plates in half from one corner to the opposite diagonal corner.

Explain and demonstrate how to cut the end of the rake at 45 and 60 degrees.

- **!** Mark the end of the rake to be cut
- **!** 4” X 4” = 3 1/2” from the end for 45 degrees
- **!** 4” X 4” = 6” from the end for 60 degrees
- **!** 6” X 6” = 5 1/2” from the end for 45 degrees
- **!** 6” X 6” = 9” from the end for 60 degrees
- **!** Mark a diagonal line from the upper end of the lumber to the mark on the lower edge of the lumber and cut the end off at this angle.
- **!** Measure 1 1/2” wide on the tapered end and mark a line on the cut side for the relief cut to make full contact with the end of a cleat.
- **!** Cut this line from the cut side with a circular saw.

The cutting team will mark and cut the end of a rake at 45 degrees and after cutting the angle end cut off the rake, they will cut the end of the rake at 60 degrees.

VI. EXTRICATION OPERATIONS

MODULE ONE: E — EQUIPMENT & CUTTING STATION

EQUIPMENT AND CUTTING ASSIGNMENTS (continued)

Explain and demonstrate how to notch lumber for added stability of a crib bed or a raker shore wall plate support point.

Notched Cribbing

- **!** Mark 2" from the end of the cribbing to prevent the end piece from splitting off.
- **!** From the 2" mark, make a second mark the true thickness of the lumber being used for cribbing.
  - 4" X 4" = 3½ "
  - 6" X 6" = 5 ½"
- **!** Adjust a circular saw to the depth of 1" and cut the two lines and then between the two lines every 1/2" inch.
- **!** Ensure saw is unplugged while adjusting blade depth.
- **!** Hit the sliced pieces of lumber with a hammer towards the remaining cribbing to break off the pieces.
- **!** Clean out the notch with the claw end of the hammer until smooth.
- **!** Have one of the squad members repeat this process on the opposite end of the cribbing.
- **!** Notches should only be made on one side of the cribbing to maintain the thickness/strength of lumber.

Notched Raker Shore Wall Plate Support Point

- **!** Used in conjunction with a top and bottom cleat when using a 60 degree raker.
- **!** Mark 2' down from the top of the raker shore wall plate.
- **!** From the 2' mark, make a second mark two times the size what the raker lumber is called.
  - 4" X 4" = 8"
  - 6" X 6" = 12"
- **!** Adjust a circular saw to the depth of 1" and cut the two lines and then between the two lines every 1/2" inch.
- **!** Ensure saw is unplugged while adjusting blade depth.
- **!** Hit the sliced pieces of lumber with a hammer towards the remaining wall plate to break off the pieces.
- **!** Clean out the notch with the claw end of the hammer until smooth.
- **!** Attach a 2' cleat above the notch and flush with the top of the notch.
- **!** Demonstrate how the angle end cut of a rake will connect in the wall plate notch.

VI. EXTRICATION OPERATIONS

MODULE ONE: E — EQUIPMENT & CUTTING STATION

SUPPLIES AND EQUIPMENT

The following tools should be available at the Equipment and Cutting Work Station:

2	Framing Hammer
2	Crow Bars
2	Carpenter Belt w/ lumber pencil
2	Tape Measure - 25'
2	Tri-Square
1	Speed Square
1	Chalk Lines
1	Utility Razor Knife
1	Container for pulled nails- can, box, etc.
1	Pipe Screw Jacks, 2"
1	Pipe, 2", Schedule 40, 1 foot section
1	Pipe Cutter, 2" capabililty
25 lbs.	Nails,16 p Duplex
25 lbs.	Nails, 8 p Duplex
1	Chain Saw, Gasoline
1	Chain Adjustment Tool
1	Spare Chain
1	Spare Bar (at the Base of Ops)
1	Spare Spark Plug (at the Base of Ops)
1	Rotary Saw, Gasoline w/ Carbide Tip
1	Belt Adjustment Tool
1	Spare Blade, Carbide Tip (at the Base of Ops)
1	Spare Belt (at the Base of Ops)
1	Spare Spark Plug (at the Base of Ops)
1	Gas Can, 5 gal. w/ pre-mix for saws
1	Chain Saw, Electric
1	Spare Chain
1	Chain Adjustment Tool
1	Bar oil
1	7¼" Circular Saw, Electric
1	Spare Blade, Carbide Tip, 7¼"
1	Wrench to replace blade
2	Spare Blade, carbide tip, 7¼"(at the Base of Ops)
1	110 Volt Power Supply (min. 15A, 20A preferred)
200'	Extension Cords
1	Hilti Kwik Bolt
1	Hilti Ramset Tool w/ kit
10	Hilti Ramset Powder Charge strips

VI. EXTRICATION OPERATIONS

MODULE ONE: E — EQUIPMENT & CUTTING STATION

SUPPLIES AND EQUIPMENT (continued)

1 Box	Hilti Ramset Pins, 3” w/ washers
1	Paslode Nail Gun (when available)
2	Paslode Nail Gun, gas canisters
1 case	Paslode Nail Gun, 16p nails
1 case	Paslode Nail Gun, 8p nails
1	Pneumatic Nail Gun
1 each	Pneumatic Nail Gun hose & regulator
2	SCBA Bottle, full
1	SCBA Back Pack
1 case	Pneumatic Nail Gun Nails, 16 p
1 case	Pneumatic Nail Gun Nails, 8 p
1	Pneumatic Nail Gun Oil
1 case	Pneumatic Nail Gun Nails, Duplex 16 p (Duofast, Model CN 350 SP)
1 case	Pneumatic Nail Gun Nails, Duplex 8 p (Duofast, Model CN 350 SP)

The following lumber should be available at the Equipment and Cutting Work Station:

2	Cleats, 2” X 4” X 12”
2	Plywood gusset plates,12” X 12” X 3/4” thick
4	Plywood gusset plates, 6” X 6” X 3/4” thick
2	Triangle gusset plates, 12” X 12” X 17”
2	Wedges, 4” X 4” X 18”
2	Wedges, 2” X 4” X 12”
6	Cribbing, 4” X 4” X 18”
2	Plywood Sheets, 4’ X 8’ X 3/4” thick
6	2” X 4” X 8’
6	4” X 4” X 8’
6	Wooden Pallets

VI. EXTRICATION OPERATIONS

MODULE ONE: F — EMERGENCY SHORING SCENARIOS

Shoring Scenarios Set Up & Operation

The Shoring Scenarios are structured somewhat similar to the Emergency Shoring Work Stations to duplicate familiar situations and increase student retention of the subject matter.

During the drill scenarios, instructors shall remain in-charge of the same shoring work stations they taught.

The three shoring scenarios are:
- **!** Equipment and Cutting Station
- **!** Raker Shore Systems
- **!** Vertical & Lateral Shoring Systems

The shoring scenarios are allotted 3 hours which is divided into three individual squad assignments and one group activity with all three squads.

!	Scenario #1 Assignment	45 minutes
	Break and Rotate	5 minutes
!	Scenario #2 Assignment	45 minutes
	Break and Rotate	5 minutes
!	Scenario #3 Assignment	45 minutes
	Break and Rotate	5 minutes
!	Review & Critique	30 minutes

Each squad will individually complete all three shoring scenarios.

- **!** The Vertical & Lateral Shoring System scenarios will be completed in three different locations on the Emergency Shoring site.
- **!** The Equipment and Cutting Station and Raker Shore System scenarios will be completed at the same location by all three squads.

VI. EXTRICATION OPERATIONS

MODULE ONE: F — EMERGENCY SHORING SCENARIOS

Shoring Scenarios Set Up & Operation (continued)

The three squads will rotate through all three scenarios in the following order:

- **!** A — Equipment and Cutting Station
- **!** B — Raker Shore Systems
- **!** C — Vertical & Lateral Shoring Systems

SQUAD	HOUR 1	HOUR 2	HOUR 3
1	A	B	C
2	C	A	B
3	B	C	A

The Shoring Scenarios will be properly set up prior to students arriving.

- **!** All required tools, equipment and supplies will be at the Emergency Shoring scenario site.
- **!** A location will be pre-identified for each of the three scenario assignments.

After conducting a thorough explanation of squad rotation, scenario assignments and issuing the Rescue Squad Officers a radio (when available), the squads will complete the scenario assignments.

VI. EXTRICATION OPERATIONS

MODULE ONE: F — EMERGENCY SHORING SCENARIOS

Shoring Scenario Assignments

Equipment and Cutting Station

- **!** The instructor shall thoroughly describe to the Rescue Squad Officer that the squad is responsible for providing any and all tools, shoring materials and cutting for both Shore Assembly Teams.

- **!** The Rescue Squad Officer assigns squad members to Cutting Team positions.

  - The Cutting Team will set up the equipment and cutting station.

  - The Cutting Team will build a cutting table and jig.

  - The Cutting Team will cut shoring materials for both Shore Assembly Teams conducting shoring operations utilizing any of the tools, equipment and techniques demonstrated during the Emergency Shoring class.

  - The Cutting Team will deliver requested tools, equipment and shoring materials to both Shore Assembly Teams.

VI. EXTRICATION OPERATIONS

MODULE ONE: F — EMERGENCY SHORING SCENARIOS

Shoring Scenario Assignments (continued)

Raker Shore Systems

- **!** The instructor shall thoroughly describe to the Rescue Squad Officer the type of shores to be constructed and indicate the exact location where the shores are to be erected.
  - One solid sole raker shore will be pre-constructed and in the proper location for the start of the raker shore system as described in Section V, Supplies and Equipment.
  - All raker shores constructed by the squads will be connected to this original shore by braces.
- **!** The Rescue Squad Officer assigns squad members to Shore Assembly Team positions.
- **!** The squad will construct the following by utilizing any of the tools, equipment and techniques demonstrated during the Emergency Shoring class:
  - A minimum of one solid sole raker and attach it to the pre-constructed raker shore
  - The squad may construct as many raker shores as time permits.
  - All raker shores will be connected by horizontal braces at the top and bottom of the raker shore.
  - All raker shores will be laterally supported by either “X” or “V” braces.

Vertical & Lateral Shoring Systems

- **!** The instructor shall thoroughly describe to the Rescue Squad Officer the type of shores to be constructed and indicate the exact location where the shores are to be erected.
- **!** The Rescue Squad Officer assigns squad members to Shore Assembly Team positions.
- **!** The squad will complete the following vertical and lateral shoring systems utilizing any of the tools, equipment and techniques demonstrated during the Emergency Shoring class:
  - One window or door shore
  - One vertical shore with three posts
  - One horizontal shore
  - If time permits, one laced post with four posts

VI. EXTRICATION OPERATIONS

MODULE ONE: F — EMERGENCY SHORING SCENARIOS

Shoring Scenario Review and Critique

- The shoring scenario review and critique will be conducted by all three instructors and all three squads at the same time.
- Each shoring scenario assignment will be reviewed, discussed and lessons learned identified.
- The four shoring sites will be reviewed first and the equipment and cutting station will be reviewed last.
- Each Rescue Squad Officer will be encouraged to describe any problems encountered and how the squad overcame them and provide any helpful hints for the entire group.
- The three instructors shall describe any positive observations and identify corrective measures needed to improve any improperly constructed shoring systems.

Supplies and Equipment

- All shoring equipment and materials at the Emergency Shoring Work Station shall be brought to a central location near the Equipment and Cutting Work Station.
- One solid sole raker shall be brought from the Raker shore Work Station and assembled at the location where the raker shore system will start.
  - ! The remaining raker shores will be left pre-constructed and in tact at the Raker Shore Work Station.
- All vertical and Lateral shoring systems will be disassembled and brought to the Equipment and Cutting Station.
- All pre-constructed Lateral and Vertical shoring systems will be reassembled during the Secure Work Sites and Prep for the next day time allotment.
- The pre-constructed solid sole raker shore will be returned to the Raker Shore Work Station and reattached to the braces during the Secure Work Sites for the next day time allotment.

VI. EXTRICATION OPERATIONS

MODULE ONE: G — EMERGENCY SHORING LOGISTICS LIST

Item:		Minimum number of:
Lumber	6" X 6" X 16'	4 each
	4" X 4" X 16'	24
	4" X 4" X 12'	42
	4" X 4" X 8'	42
	2" X 6" X 16'	36
	2" X 4" X 12'	60
	2" X 4" X 8'	24
Cribbing	4" X 4" X 18"	48
	2" X 4" X 18"	24
Cleats	2" X 4" X 12"	48
Plywood Gussets	12" X 12" X 3/4"	128
Plywood Sheets	4' X 8' X 3/4"	4
Wedges	4" X 4" X 18"	30 pair
	2" X 4" X 12"	60 pair
Wooden Pallets		6 each
Radios		9
Water Jug, 5 gal.		1
Cups		200
Dust Masks		1 Case
Single Jack Hammer, 3 lb.		8 each
Sledge Hammer, 10 lb.		1
Framing Hammer		10
Crow Bars		10
Carpenter Belt w/ lumber pencil		6
Level, 3' - 4'		2
Level, 6"		2
Tape Measure - 25'		6

VI. EXTRICATION OPERATIONS

MODULE ONE: G — EMERGENCY SHORING LOGISTICS LIST

Item:	Minimum number of:
Tri-Square	2
Speed Square	2
Steel Framing Square	4
Chalk Lines	2
Utility Razor Knife	3
Cats Paw Nail Puller	2
Container for pulled nails- can, box, ?	3
Ellis Clamps	12
Ellis Jacks	2
Ellis Post Screw Jacks	4
Shovel, Round Point	2
Pipe Screw Jacks, 2"	6
Pipe, 2", Schedule 40, 10 foot section	2
Pipe Cutter, 2" capabililty	1
High Lift Jack with Ext. Tubes	2 each
Nails,16 p Duplex	75 lbs.
Nails, 8 p Duplex	75 lbs.
Rotary Hammer	1 each
Rotary Hammer Masonry Bit, 1" X 18"	1
Rebar or Steel Pickets, 1"	20
Chain Saw, Gasoline	2
Chain Adjustment Tool	1
Spare Chain	1
Spare Bar	1 (at the Base of Ops)
Spare Spark Plug	1 (at the Base of Ops)
Rotary Saw, Gasoline w/ Carbide Tip	1
Belt Adjustment Tool	1
Spare Blade, Carbide Tip	1 (at the Base of Ops)
Spare Belt	1 (at the Base of Ops)
Spare Spark Plug	1 (at the Base of Ops)
Gas Can, 5 gal. w/ pre-mix for saws	1

VI. EXTRICATION OPERATIONS

MODULE ONE: G — EMERGENCY SHORING LOGISTICS LIST

Item:	Minimum number of:
Chain Saw, Electric	1
Spare Chain	1
Chain Adjustment Tool	1
Bar oil	1
7 1/4" Circular Saw, Electric	1
Spare Blade, Carbide Tip, 7 1/4"	1
Wrench to replace blade	1
Spare Blade, Carbide Tip, 7 1/4"	2 (at the Base of Ops)
110 Volt Power Supply	1 (tower outlets OK)
Extension Cords	400'
Hilti Kwik Bolt	1
Hilti Ramset Tool w/ kit	1
Hilti Ramset Powder Charges	10 strips
Hilti Ramset Pins, 3" w/ washers	1 Box
Paslode Nail Gun	1 (when available)
Paslode Nail Gun, gas canisters	2
Paslode Nail Gun, 16p nails	1 case
Paslode Nail Gun, 8p nails	1 case
Pneumatic Nail Gun	1
Pneumatic Nail Gun hose & regulator	1 each
SCBA Bottle, full	3
SCBA Back Pack	1
Pneumatic Nail Gun Nails, 16 p	1 case
Pneumatic Nail Gun Nails, 8 p	1 case
Pneumatic Nail Gun Oil	1
Pneumatic Nail Gun Nails, Duplex 16 p	1 case (Duofast M#CN350 SP)
Pneumatic Nail Gun Nails, Duplex 8 p	1 case (Duofast M#CN350 SP)
Pneumatic Shore, 2' - 6'	2 each (when available)
Pneumatic Shore regulator & hose	1
Pneumatic Shore ends & extensions,	1 set
A-Frame Ladder, 6' minimum	2 each