This Field Operations Guide contains specific information on technical rescue procedures.

THIS GUIDE IS NOT ALL INCLUSIVE!

It is intended to be used as a tool for training and for quick field reference. Refer to current training manuals and your department policies for detailed explanations. There is no substitute for regular, quality, hands-on training by a qualified instructor.

The techniques and procedures illustrated in this guide follow NFPA standards and OSHA regulations as much as possible. This guide can be used by rescuers at all skill levels but was specifically developed for fully qualified technical rescue technicians. Special operations are inherently dangerous and serious injury or fatality may result from improper performance of these techniques. The author accepts no responsibility for damage, loss, injury or death resulting from information contained in or omitted from this guide.

Thanks to the Phoenix Fire Department and everyone who helped make this guide possible. Special thanks to my friend Ron Jamison for helping to write this guide, Kathy Darrow for editing and to George Drees, Ken Phillips and Jim Frank for great ideas and input.

This guide is dedicated to all those people who go the extra inch every day to make themselves better rescuers.

This handbook is based on the Phoenix Fire Department and Arizona State Fire Marshall's Office technical rescue programs.

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Structural Collapse Command Checklist A

Phase I: Size up

- ☐ Primary assessment
  - ☐ Secure witness or reporting party (RP)
  - ☐ Determine location, number & condition of victims
  - ☐ Determine location and number of buildings involved
  - ☐ Rescue mode or recovery mode
- ☐ Secondary assessment
  - ☐ Type of occupancy (business, mercantile, assembly)
  - ☐ Building construction type
  - ☐ Assess hazards (secondary collapse, gas, electric)
  - ☐ Assess need for additional personnel (search dogs, Red Cross, structural engineer, surgeon, FEMA)
  - ☐ Assess need for additional equipment (100 ton crane, heavy equipment, lumber in quantity)

Phase II: Pre-rescue operations

- ☐ Make general area safe (i.e., traffic & crowd control)
  - ☐ Establish transportation corridor
- ☐ Make rescue area safe (secure utilities)
  - ☐ Establish perimeter (lobby control)
  - ☐ Assign safety officer
  - ☐ Personal protective equipment
  - ☐ Establish victim staging area (accountability)
  - ☐ Establish treatment area
- ☐ Remove all non-essential personnel from rescue area
- ☐ Establish building triage team
- ☐ Establish action plan for building search team
- ☐ Establish action plan for rescue team
- ☐ Rescue briefing

Phase III: Rescue operations

- ☐ Remove surface victims
- ☐ Implement search and rescue action plan
- ☐ Medical (treatment, transport)

Phase IV: Termination

- ☐ Personnel Accountability Report
- ☐ General debris removal
- ☐ Remove equipment
- ☐ CISD

Task Level Checklist

Assessment

- ☐ Reconnoiter entire site
  - ☐ Determine structure type
  - ☐ Interview neighbors, survivors to determine how many potential victims and points last seen
  - ☐ Obtain building plan or draw crude plan
    - ☐ Probable location of voids
    - ☐ Best access
    - ☐ Basements
- ☐ Search specialists re-assess building to re-identify hazards
- ☐ Prioritize site and make risk management profile
  - ☐ Structural engineer
    - ☐ Determines level of access to structure
    - ☐ Determines appropriate shoring
  - ☐ Plan shoring at accesses, and or use most efficient access
  - ☐ Determine condition of basement
  - ☐ Avoid falling hazards unless they can be removed or shored

Search

- ☐ Initial search
  - ☐ Conduct visual search
  - ☐ Conduct callout/listen search
  - ☐ Search from safe stable areas into unstable areas
  - ☐ Explore horizontal openings with great care
- ☐ Advanced search
  - ☐ Use search dogs with send out as far as possible
    - ☐ Check alerts with second dog
  - ☐ Use listening seismic finders, if available
  - ☐ Use search cam and thermal imager on high probability areas
  - ☐ Explore existing vertical shaft openings
  - ☐ Re-prioritize site vs. location of potential live victims

Access

- ☐ Rescue squad/rescue operations
  - ☐ Establish shoring/extrication plan
  - ☐ Cut team
    - ☐ 5 technicians optimum
    - ☐ Lumber supply
    - ☐ Build cut station
  - ☐ Rescue team
    - ☐ Gather all tools
    - ☐ Use appropriate protective equipment
    - ☐ Measure area to be shored and request material from cut team
  - ☐ Initial shoring for access
  - ☐ Build shores in safe area if possible
- ☐ Selected cutting and removal
  - ☐ Cut vertical openings and re-search, re-check with dogs
  - ☐ Avoid unshored overhead structures
  - ☐ Recheck all shoring after cutting and removal
  - ☐ Stabilize area at victim to give aid

Extricate

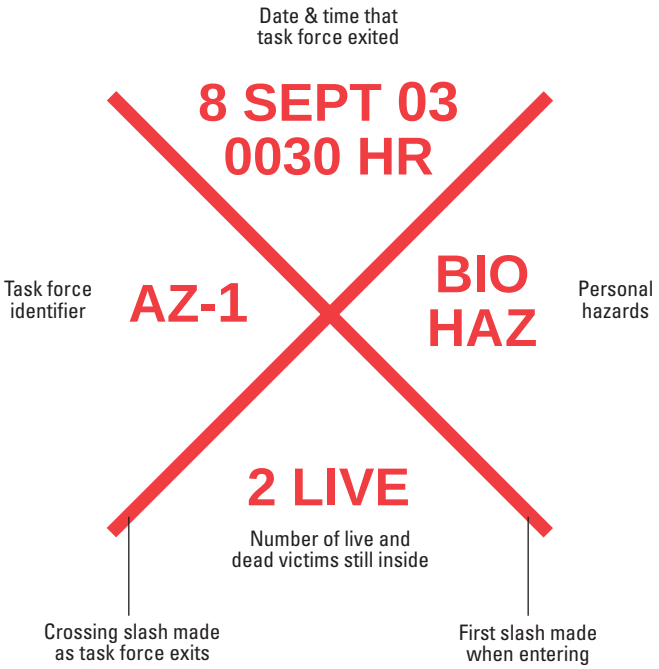
- ☐ Assemble medical specialist at patient location with treatment and extrication gear
  - ☐ Conduct patient assessment and triage
  - ☐ Provide appropriate level of treatment
  - ☐ Package patient for extrication
- ☐ Remove patient to treatment area

All clear on structure

- ☐ Re-assess survivability profile considering:
  - ☐ Elapsed time
  - ☐ Condition of remaining structure
- ☐ Declare all clear on entire structure or as much of structure as possible when appropriate

All shoring systems in this guide are for reference only and are subject to modification and approval by the on-site structural engineer.

FEMA Task Force
Search and Rescue Marking System



FEMA Task Force Building Marking System

Structure and hazard evaluation

Structural specialist makes a 2′ x 2′ box on building adjacent to most accessible entry. This is done after doing hazards assessment and filling out hazards assessment form. Box (illustrated below) is spray painted with international orange paint and marked as follows:

Structure is relatively safe for SAR operations. Damage is such that there is little danger of further collapse (can be pancaked building).

Structure is significantly damaged. Some areas might be relatively safe, but other areas may need shoring, bracing or removal of hazards.

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

Arrow located next to the marking box indicates the direction of safest entry to the structure.

HM

Indicates hazmat condition in or adjacent to structure. SAR operations normally will not be allowed until condition is better defined or eliminated.

Example

Cut Station Setup and Operation

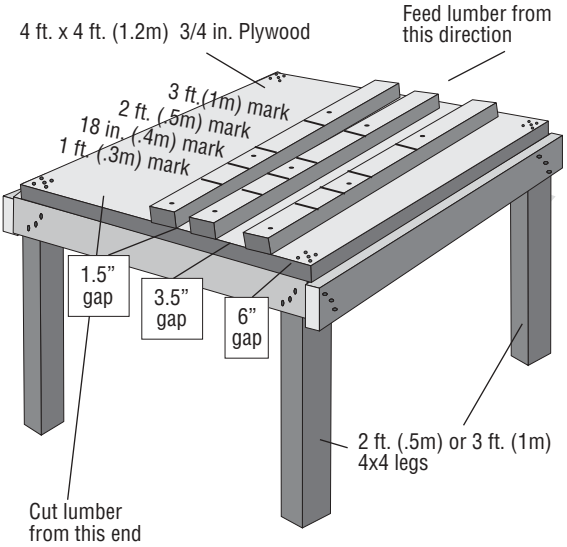
Cut team positions	**Tools**
1 Cutter	2- Carpenter kits
2 Feeders	1- 10 1/4 in. circular saw
1 Runner	1- Chain saw with supplies
1 Layout person	1- K12 saw with supplies
	110 volt power supply, 20A preferred
	200 ft. (60m) Extension cords

1. Cut one: 4 ft. x 4 ft. (1.2x1.2m) sheet 3/4 in. plywood
   Cut four: 4 ft. (1.2m) 2x4 lacing pieces
   Cut four: 2 ft. (.5m) 4x4 legs
2. Nail 2x4 lacing at top of first two 4x4 legs
3. Repeat with second set of legs
4. Set both sets of legs on end and join with 2x4 lacing
5. Flip legs over and add last piece of 2x4 lacing
6. Nail 4 ft. x 4 ft. (1.2x1.2m) sheet of plywood on burying nails
7. Nail 2x4 guides at indicated intervals

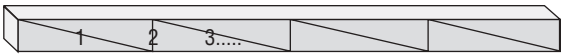
Cut station operation

9. The cut station needs material to function. Request from resource:
   - 4 sheets plywood
   - 12-36 4x4 or 6x6 posts (qty. and length depend on job)
   - 12-36 2x6 (qty. and length depend on job)
   - 12-36 2x4 (qty. and length depend on job)
10. Begin cutting gusset plates and wedges immediately.
    - Cut 64 1 ft. x 1 ft. (.3x.3m) gusset plates
    - Cut 24 sets 18 in. (.4m) 4x4 wedges
    - Cut 24 sets of 12 in. (.3m) 2x4 wedges
11. Cut wedge sets by placing stock in guide on cut table.
12. Layout cut marks on entire piece of stock with marks to match sets.
13. Feeder holds stock while cutter makes first diagonal cut.
14. Cut second half of wedge off and repeat process.
15. Runner takes material to shoring team and gets cut list.

Cut Station



18 in. (.4m) 4x4 Wedge layout cut sequence



12 in. (.3m) 2x4 Wedge layout cut sequence

Material Capacities and Weights

Material Capacities

Post Shores	
Height of post	Capacity
4x4 8 ft. (2.5m)	8000 lbs.
4x4 10 ft. (3m)	5000 lbs.
4x4 12 ft. (3.6m)	3500 lbs.
6x6 8 ft. (2.5m)	20,000 lbs.
6x6 10 ft. (3m)	12,000 lbs.
6x6 12 ft. (3.6m)	7500 lbs.

Wood Cribbing	
Size	Capacity
2-4x4	24,000 lbs.
3-4x4	55,000 lbs.
2-6x6	60,000 lbs.
3-6x6	136,000 lbs.

- Limit height to triple width
- Overlap corners by 4 inches
- Bottom layer should be solid

Box Shores	
Height of post	Capacity
4-4x4 up to 16 ft. (4.8m)	30,000 lbs.
4-6x6 up to 24 ft. (7.3m)	72,000 lbs.

Miscellaneous Strengths	
Material	Capacity
4x4 screw jack	use 4x4 capacity
16d nail	150 lbs. shear

Unit Weights

Common Material	
Type	Weight lbs.
Concrete	150 pcf
Masonry	125 pcf
Wood	35 pcf
Steel	490 pcf
Masonry Rubble	10 psf/inch

Common Construction	
Type	Weight lbs.
Concrete floors	90-150 psf
Steel beam/ concrete deck	50-70 psf
Wood floors	10-25 psf

- Add 10-20 psf for wood or metal stud wall each level
- Add 10 psf for furniture

Calculating weight

Weight of object = length x width x height x unit weight

- Round weight up.
- Err on the heavy side when calculating.

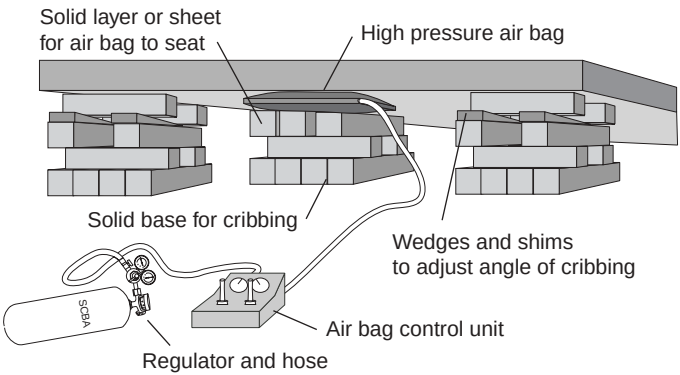
Airbag Operation

Lifting heavy objects

1. Calculate the weight of the object to be lifted.
2. Choose best shoring and cribbing material.
3. Choose best lifting technique; crane, airbags, pry bars.
4. Form a lifting sequence plan.
5. Lift the object in small increments equal to the dimension of the shoring or cribbing material.
6. Add cribbing progressively.
7. Never reach under the object being lifted; use tools to move cribbing.

Airbag operation

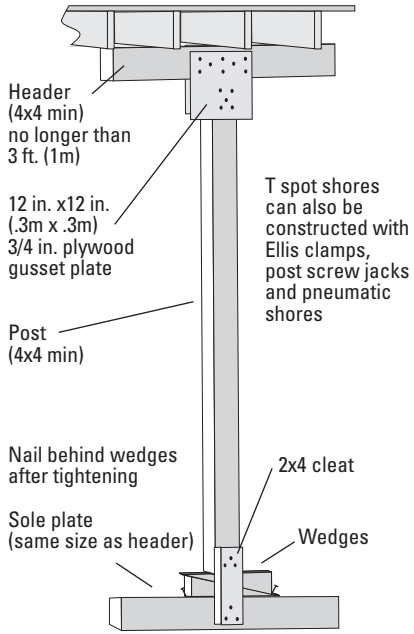
1. Connect air supply and airbags to control unit.
2. Adjust regulator to 120 psi.
3. Place airbag on solid base under object.
4. Protect top of airbag from any sharp points on object.
5. Add air to airbag and lift object slowly and carefully.
6. Watch for instability and re-adjust as needed.
7. Place cribbing under object.
8. Deflate airbag, raise airbag base and lift again.



T Spot Shore

Temporary shore used ONLY until a complete shoring system can be erected.

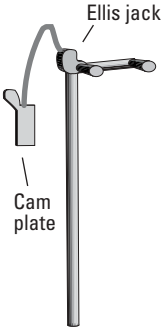
1. Survey area and determine load displacement and structurally unstable elements.
2. Clean area to be shored
3. Measure overall height of space to be shored.
   - Deduct depth of header, sole and wedges
   - Cut post to length
4. Prefabricate T spot shore in safe area.
   - Nail post to header in center of header
   - Nail plywood gusset over joint both sides
5. Place T in position with post centered under load.
   - Slide sole under post and wedge into position
   - Check shore for straightness and tighten wedges
   - Install bottom 2x4 cleat
   - Anchor header and sole to floor and ceiling

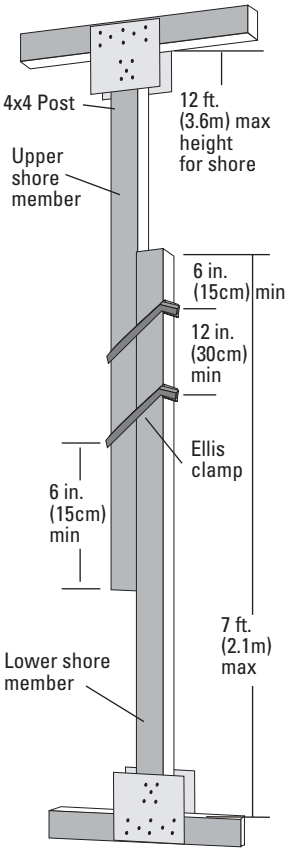


Ellis Clamps

6000 lb. (26kn) capacity each, up to 10 ft. (3m)

1. Measure distance to be shored.
2. Each shore member should be 3/4 of total distance but not more than 7 ft. (2.1m).
3. Place two Ellis clamps on lower shore member and nail into place with 16d nails.
4. Slide upper shore member into Ellis clamps.
5. Apply a header and sole plate with gussets as shown. This configuration is a T spot shore and is very versatile and adjustable.
6. Position shore and hand tighten clamps.
7. Fit Ellis jack onto lower shore member and cam plate between cam and bottom of upper shore.
8. Jack shore to desired tightness.
9. Set clamp plates on upper shore by striking hammer lug.
10. Place a safety nail in each upper shore clamp plate.

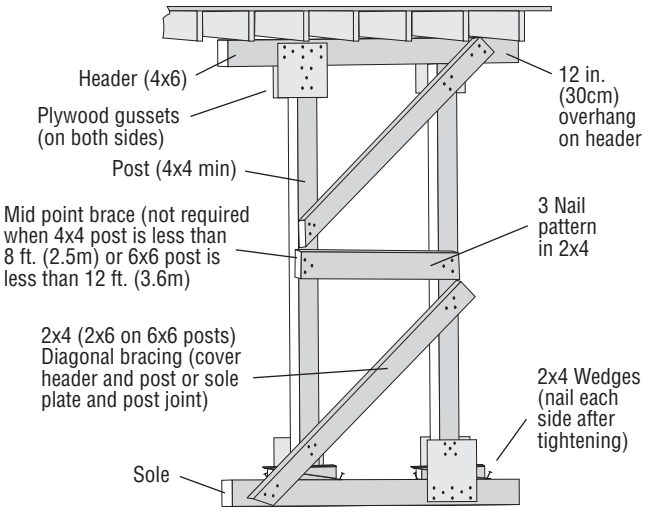




Two Post Vertical Shore

Position header and sole across floor and ceiling joists and position posts directly under joists not greater than 5 ft. (1.5m) on center header may slope 6 in. (15cm) in 10 ft. (3m).

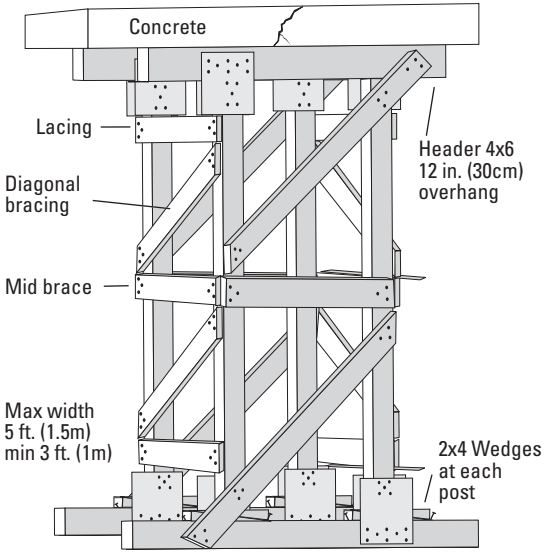
1. Measure distance to be shored in 3 places and use the smallest dimension.
2. Header and sole plate should be same size as post.
3. Subtract dimension of header and sole.
4. Subtract 3 in. (8cm) for 4x4 wedges.
5. Subtract 1.5 in. (4cm) for 2x4 wedges.
6. Give cut list to runner.
7. Construct shore in safe zone if possible.
8. Place posts against header flat on ground and nail gusset plates on both sides as shown (omit one gusset plate to leave space for cross brace).
9. Nail gusset plates to sole plate as shown.
10. Move shore into position and tighten wedges.
11. Add diagonal and mid bracing as shown.
12. Toe nail wedges with one nail.



Laced Post Shore

High capacity four post shore system that can be used to support a damaged concrete floor or a heavily loaded wood floor. Construct a pair of two post shores no more than 5 ft. (1.5 m) apart and lace together.

1. Construct two double post shore units 4 ft. (1.2m) on center from each other.
2. Tighten all wedges.
3. Measure distances for 2x6 lacing and 2x4 diagonal bracing.
4. Give cut list to runner.
5. Connect shore units into safe box as shown.
6. Use air nailer or impulse nailer for all bracing.
7. Re-tighten wedges and toe nail if possible.



Max height = 4x width
but if over 12 ft. (3.6m) high add additional mid brace

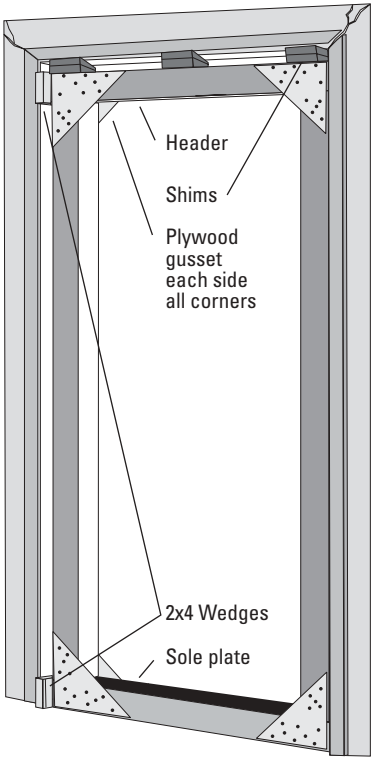
For maximum capacity use 2x6 lacing with 5 nail pattern

✓ Can be used as a refuge.

✓ Shoring concrete and steel is a technician level skill.

Alternate Door/Window Shore
Pre-constructed Door/Window Shore

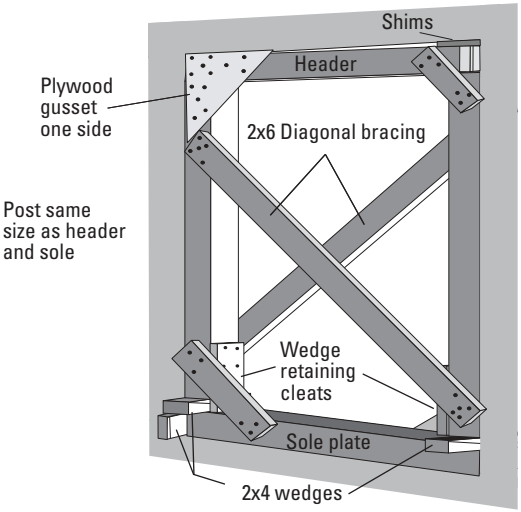
1. Measure the opening in 3 places and use the smallest measurement.
2. Finished shore should be 1.5 in. (4cm) smaller than opening in each direction.
3. Construct shore in safe area as shown.
4. Install shore in opening.
5. Wedge side and shim top.



Standard Door/Window Shore

1. Measure the opening.
2. Subtract 8.5 in. (21cm) for vertical posts.
3. Subtract 1.5 in. (4cm) for header and sole.
4. Use 2x4 wedges.
5. Place sole plate and tighten wedges.
6. Place header and tighten wedges.
7. Install each post and tighten wedges.
8. The header must rest on at least 1/3 of the vertical post.
9. Place 2x4 wedge-retaining cleats.
10. Install gusset plates and/or corner cleats.
11. Place diagonal cross bracing if the door is not needed for access.
12. Re-tighten wedges and secure with single toe nail to each

- Window shore steps are the same as for a doorway
- If possible, let diagonal bracing extend outside window frame to help secure shore



60° and 45° Solid Sole Rakers

To calculate the length of 60° and 45° rakers

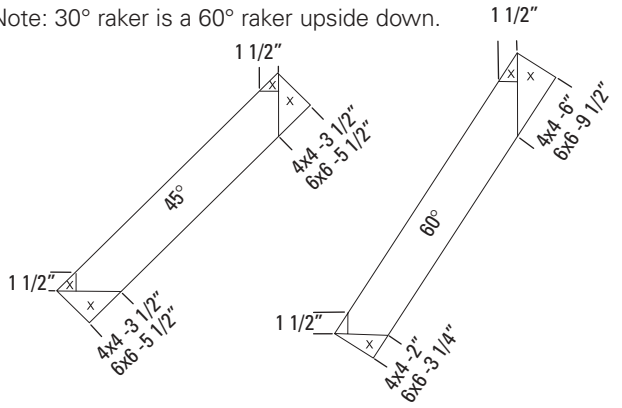
1. Measure from the top of sole plate up to the point where you want the top side of the raker to meet the wall within 1 ft. of floor level.
2. Go to the nearest foot.
3. For 45° Multiply x 17.
4. For 60° Multiply x 14.
5. Convert to inches for the required length.
   - Add 2 in. (5cm) for 45° raker cut length.
   - Add 3 in. (8cm) for 60° raker cut length.

Example
8″ x17= 136″
136′/12= 11.33′
11.33″ = 11′4″
11′4″+2″= 11′6″

To cut the angled ends on rakers

6. For a 45° raker, measure down 3.5 in. on one end.
7. Draw a line from the 3.5 in. (9cm) mark to the corner of the 4x4.
8. Hold a 2x4 on edge next to the line.
9. Slide the 2x4 toward the corner until one corner of 2x4 reaches an edge of the 4x4.
10. Draw a line and mark x's on the section to be removed.
11. Repeat the process on the other end, being careful to reverse the direction of cut.
12. Refer to the illustration for 60° rakers and 6x6 rakers.

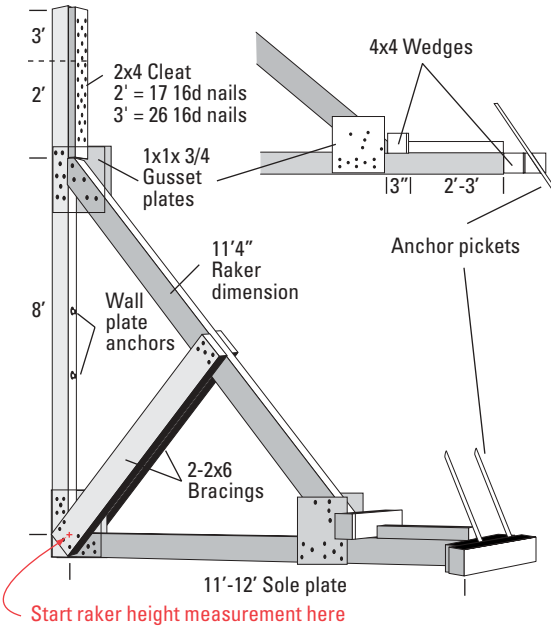
Note: 30° raker is a 60° raker upside down.



60° and 45° Solid Sole Rakers

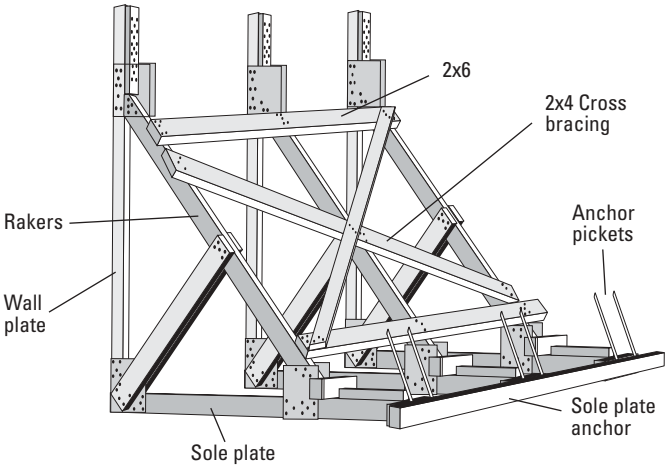
To assemble the solid sole raker shore

13. Nail a cleat onto the wall plate at the level of the raker placement (minimum 2 ft. (60cm) & 17 16d nails).
14. Place the wall plate and raker together on their side and nail the upper gusset plate onto both.
15. Place the sole plate against the wall plate (90°) and nail gusset plate on.
16. Nail the 2x6 diagonal brace from the wall/sole junction to the raker.
17. Nail the front sole gusset plate to the sole plate leaving at least 2 in. (5cm) of the raker foot exposed.
18. Flip the shore over and perform the same steps to the opposite side.
19. Stand the shore up and nail the bottom cleat into position leaving 3-4 in. (8-10cm) for wedges. (continued)



60° and 45° Solid Sole Rakers

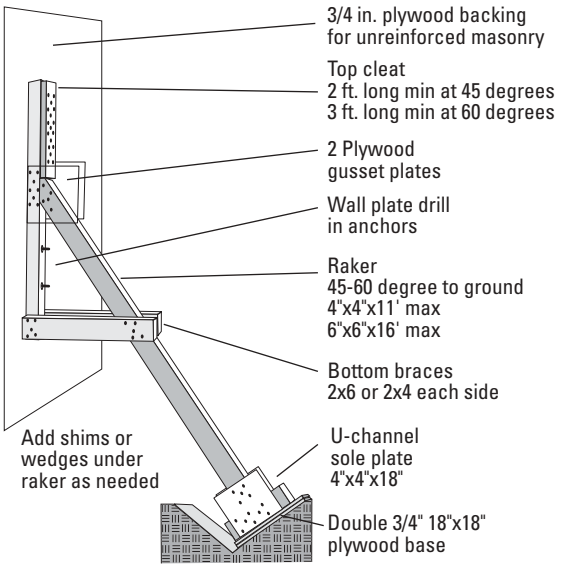
20. Place one nail into the bottom raker/gusset plate contact area.
21. Move the shore into position against the wall and tighten just enough to hold into position.
22. Assemble additional raker shores and move into position (max 8 ft. (2.5m) on center).
23. Place the sole plate anchor in front of the raker set.
24. Drill 2 diagonal anchor holes in front of each raker through the sole plate anchor and into the ground.
25. Place appropriate wedges between sole plate anchor and sole plate.
26. Install the anchor pickets and tighten the anchor plate wedges.
27. Check each raker for plumb and install shims, as needed.
28. Tighten the raker wedges and toenail with one nail.
29. Connect the raker shores with 2x4 diagonal cross bracing.



Flying Raker

The flying raker is considered a temporary spot shore to be used only until permanent shoring can be placed. Use the following steps to pre-construct the flying raker.

1. Determine height to raker insertion point on building (within 1 ft. (.3m) above or below the upper floor level).
2. Layout in safe area.
3. Cut top of raker as shown on page 131.
4. Nail cleat to wall plate and apply raker and gusset plates.
5. Apply bottom braces as shown.
6. Assemble U-channel sole plate as shown.
7. Move raker into position and dig out base for sole plate.
8. Wedge and shim sole plate as needed and anchor wall plate as shown (anchor plywood backing if used).



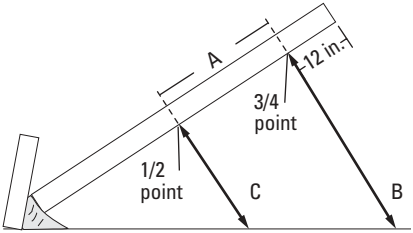
Sloped Floor Shoring

Take off dimensions

1. The rubble or ground must resist the slope force.
2. Provide temporary shoring of sloped area.
3. Measure the total distance to be shored, divide into 1/4's and mark the 1/2 and 3/4 points for the posts.
4. The position of the long post should allow for a minimum 12 ft. overhang of the header.
5. Measure from the point of contact at 90° to the slope and note the distance as B and C for long and short respectively.
6. Measure the distance on the slope between the long and short and note as A.

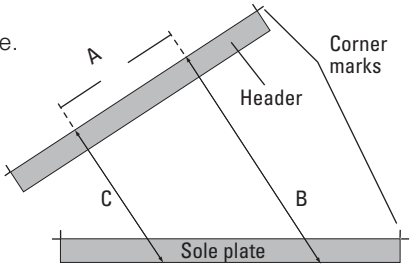
Layout in safe area

If more than one shore will be made, layout all shore components at the same time (3 sole plates etc.).



Step 1

1. Cut the header and sole to length.
2. Lay header down in layout area and mark corners.
3. Mark dimension A on the header (leave equal overhang on each side).
4. Using a square and tape measure, measure and mark distance B and C on the ground.
5. Position sole plate as shown and re-measure.
6. After double-checking measurements and position, mark the B and C point on the sole plate and mark the corners of the sole plate on the layout surface.



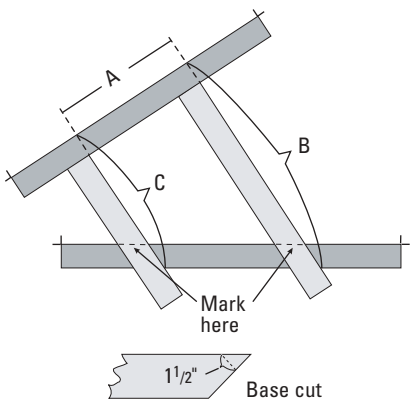
Sloped Floor Shoring

Step 2

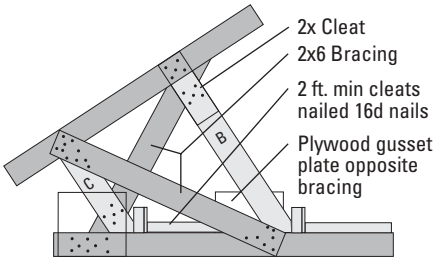
1. Lay posts on sole plate and against header as shown.
2. Both posts must be at 90° to the header.
3. Confirm that header and sole are still in position with corner marks.
4. Mark each shore post as shown and cut.
5. Make 1.5 in. (4cm) cut at base of each post as shown below for cleat.

Step 3 Assembly

1. Place B and C posts into position and re-check corner marks on header and sole.
2. Cut 2x cleat 18 in. (46cm) long and nail B post to header.
3. Nail plywood gusset plate to bottom of C post (leave an inch of room in the inside for wedge adjustment.
4. Cut 2x6 to fit between top of C post and bottom of B post. Nail into place as shown.
5. Turn shore over.
6. Nail gusset plate to bottom of B post and sole plate.
7. Nail 2x cleat to top of C post and header.
8. Nail 2x6 brace between bottom of C post and top of B post.
9. Nail 2x cleat in front of B and C post with min. of 17 x 16d nails (leave 1.5 in. (4cm) room for 2x4 wedges).
10. Stand up shore and install 2x4 wedges and lightly tighten.

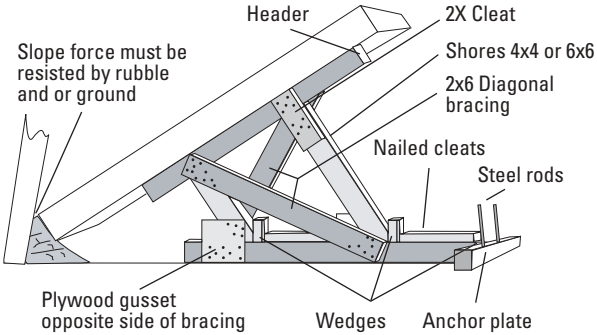


Sloped Floor Shoring

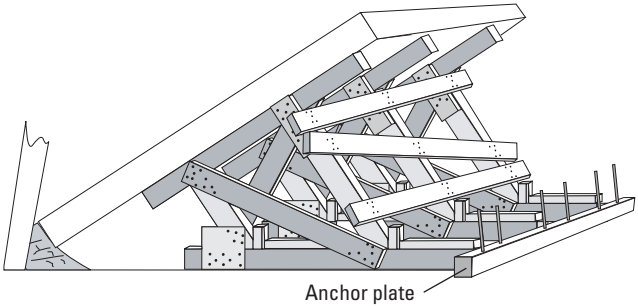


Step 5 Install Shore

1. Move shore(s) into hazard area and place into position.
2. Place 2x4 or 4x4 wedges in front of anchor plate.
3. Place 4x4 or 6x6 anchor plate up against each set of wedges.
4. Drill 2 1/2 in. holes through the anchor plate and into the concrete or pavement in front of each header.
5. Drive rebar or the most appropriate steel through anchor plate to secure slope shores.
6. Tighten shores with anchor plate wedges first and then with post wedges.
7. Add 2x6 bracing to link all shores together.



Slope Shore Set



Optional Vertical Post Slope Shore

If the sloping material is not connected to the structure or resisted by rubble or structural element, vertical posts should be used.

1. Take off dimension for B and C posts at 90 degrees to floor.
2. Layout in safe area if possible and construct as shown.
3. Use 2x4 or 4x4 wedged under posts.
4. Anchor header to slope with drill in rods.
5. Anchor sole plate with anchor plate.