ISISE

Institute for Sustainability and Innovation in Structural Engineering

Emergency Forms and Stabilization

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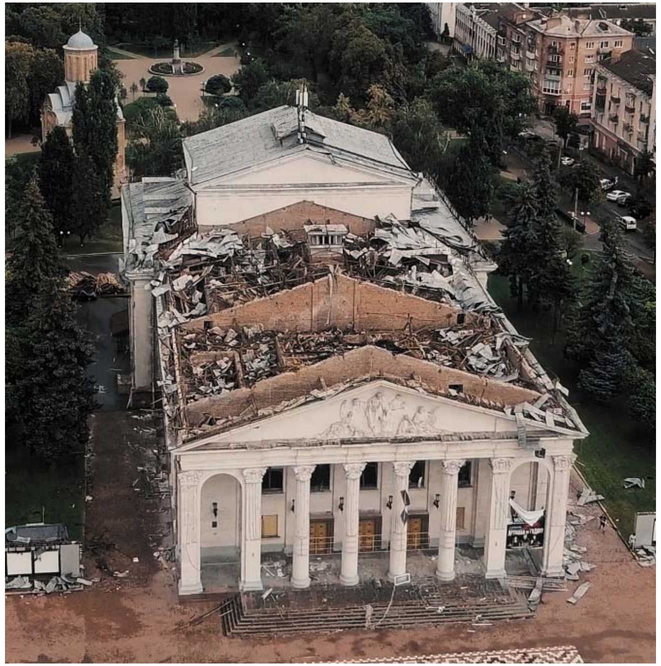
Outline

- Cultural heritage first aid
  - Basic concepts
  - First aid steps
  - Security and stabilisation
- Vertical shoring
  - Basic concepts
  - Shoring schemes and details
- Horizontal shoring
  - Basic concepts
  - Shoring schemes and details
- Emergency forms
  - General buildings
  - Heritage structures

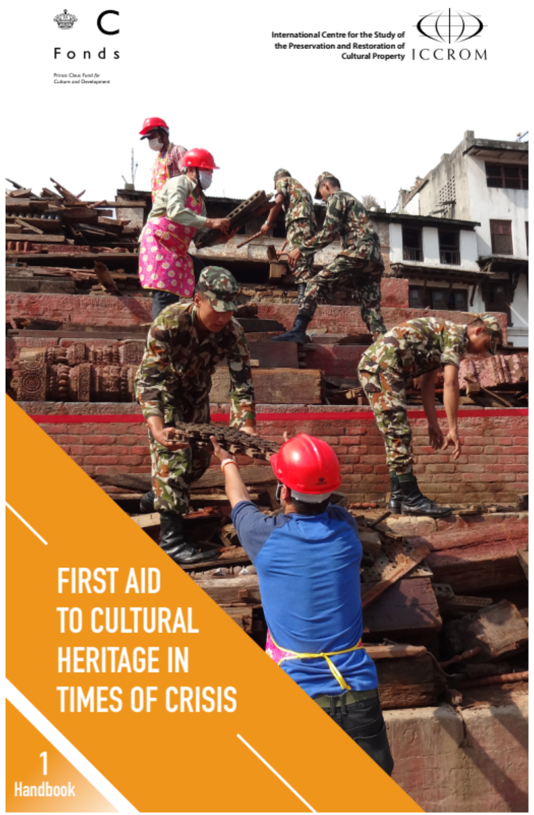
Dubliany (Ukraine, 2024)

Chernihiv (Ukraine, 2023)



Cultural Heritage First Aid

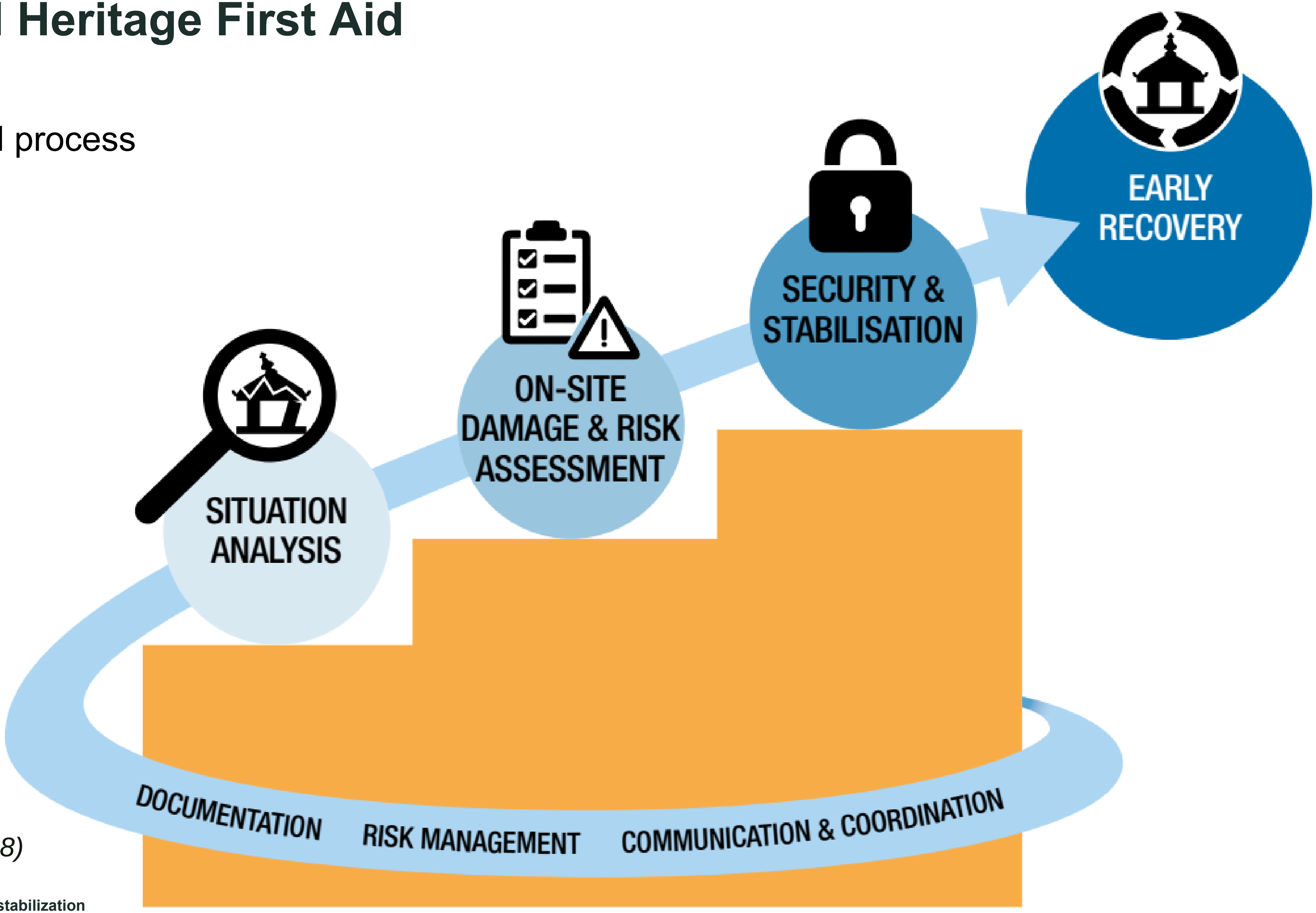
- The immediate and interdependent actions taken to stabilize and reduce **risks** to endangered **cultural heritage** during and after an **emergency**.
- The immediate cause of such an emergency may be a **natural** or **man-made** hazard, or a combination of both.
- First aid includes:
  - **analysis** of an emergency situation and its likely effects on cultural heritage;
  - **on-site damage and risk assessment**; and
  - **security and stabilization**



ICCROM & Prince Claus Fund for Culture and Development, "First Aid to Cultural Heritage in Times of Crisis", (2018).

Cultural Heritage First Aid

- First aid process



ICCROM (2018)

Guiding Principles for Cultural Heritage First Aid

- **People-centered first aid**. Prioritize people’s needs and enhance their ability to secure and recover their own heritage.
- **Inclusive attitude and respect for diversity**. Recognition of elements that constitute the cultural heritage of the disaster-affected area.
- **Context-specific response**. Understanding the wider emergency context is crucial for providing effective actions.
- **Interlock culture with humanitarian assistance**. First aid to cultural heritage should be provided in conjunction with humanitarian relief and recovery.
- **Do no harm**. First aid actions should prevent further damage and promote recovery.

Step 1: Situation Analysis

Collect information

Analyze the information

Plan for on-site first aid actions

ICCROM (2018)

Step 2: Post-Event On-Site Damage and Risk Assessment

ICCROM (2018)

Step 3: Security and Stabilization

- Actions that **stabilize** the condition of the affected heritage **and prevent further damage** and loss through risk reduction.

- These actions are **temporary** in nature and are intended to provide adequate support to damaged heritage during an emergency **until** it is possible for **full conservation treatments** to take place.

- Security and stabilization actions are **context-dependent** and do not always follow a particular sequence.

- Nonetheless, for an intervention to be successful, it is crucial that there is careful **documentation** of the heritage asset and of the actions taken to stabilize and secure it.

Step 3: Security and Stabilization Actions

- Security and stabilization actions include:
  - Erecting a fence around the affected site.
  - Providing temporary cover for exposed built elements.
  - Post-event evacuation of cultural heritage objects to another safer, temporary location.
  - Salvage of damaged cultural heritage collections, building fragments and decorations. This action includes sorting, stabilization through surface cleaning, and/or drying objects.
  - Providing safe and secure temporary storage for evacuated and salvaged cultural heritage materials.
  - Drying a building or structure in the aftermath of a flood.
  - **Shoring** a wall or other load-bearing structural element in order to provide a temporary support.

Emergency Stabilization of Historical Structures

If a structure is damaged and left unattended, the risk of further damage or collapse increases, which may endanger lives.

After a hazard event, a structure may fail, or become unsafe if:

- its **structural continuity** is affected, and **loads** (whether usual or exceptional) cannot be safely transferred to the ground anymore;
- the partial collapse of the structure induces localized **overloads**;
- internal structural elements are no longer protected from the outside **environment**, for example, when the internal elements of a wall are exposed due to damage to the wall surface.

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Shoring

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Shoring Structures in Emergency Situations

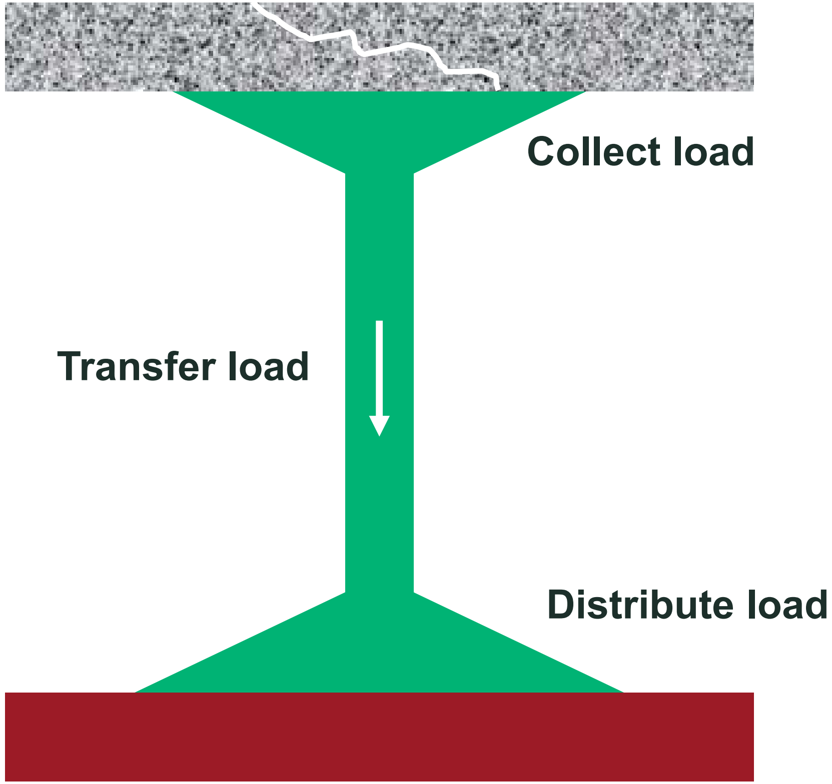
Shoring is the technique of using shores (or props) to **temporarily support** a structure when it is **at risk of collapse** or while undergoing repairs or modifications.

In emergency contexts, shoring is needed to **ensure safety** and maintain ongoing operations (e.g., rescue) until permanent repairs are implemented.

They work based on the premise of their ability to **collect** load, **transfer** it through the temporary structure **and redistribute** it elsewhere.

Shoring is a set of actions that provides support and prevents collapse of the whole or part of a building, ensuring temporary stability and safety for workers. It can be used when there was "poor construction, material's degradation, earthquakes, storms, explosions and fires".

Double-funnel scheme



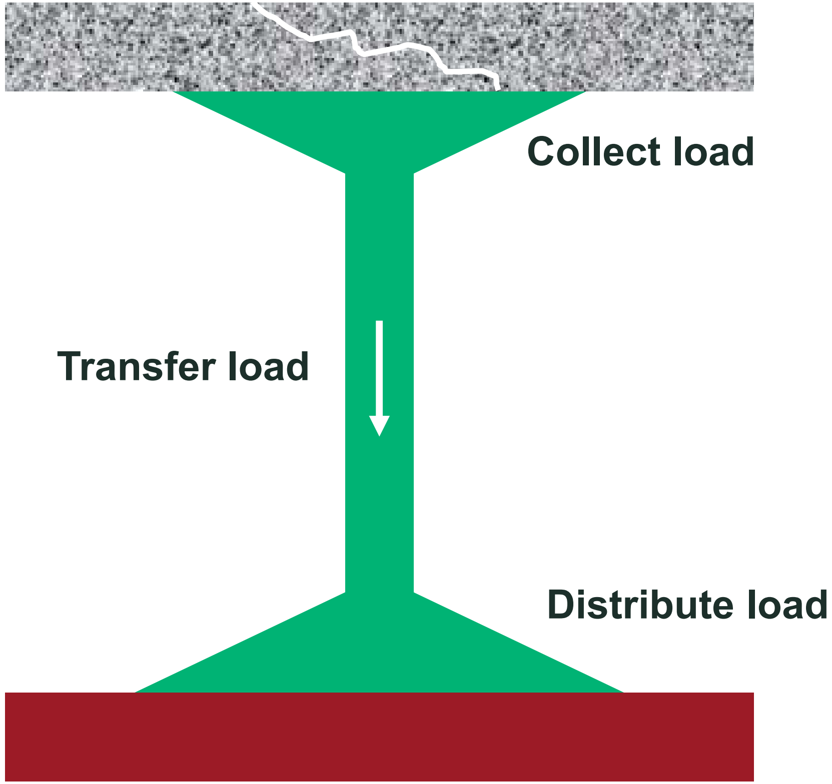
Shoring Structures in Emergency Situations

There are two main types of shoring systems:

- **Vertical Shore**. A type of shoring designed to support vertical loads, typically used to brace beams, floors, or ceilings that are at risk of collapse.
- **Lateral (Horizontal) Shore**. A type of shoring that provides horizontal support to walls and other vertical elements, preventing them from buckling or tilting due to lateral forces.

The **type of shoring** is chosen depending on the type and extent of damage, load requirements, and available materials.

Double-funnel scheme



Shoring Structures in Emergency Situations

In emergencies, not all damaged structures can or need to be shored, shoring is employed to:

- stabilize partially collapsed structures and **prevent further damage** until permanent repairs can be made;
- protect adjoining structures from further collapse on neighbouring ones, and **ensure containment**;
- secure specific portion of structures to enable their use for **essential operations**;
- provide access and safety for **rescue or inspection teams** (Urban Search and Rescue (USAR), Damage Assessment Coordination (DAC)).

Emergency / Urgency does not imply "in a rush"

Most of the literature available on shoring is focused on USAR and **post-seismic damage intervention** and was produced in countries with long history in emergency response (USA, Italy, Portugal, Australia, Brazil, Spain). Most of the design principles and rules used in these references can be used in other emergency situations, for example in case of damage due to explosion or high energy impact.

Shoring Structures References

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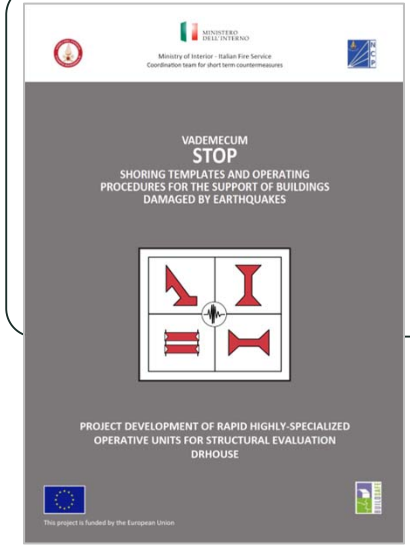
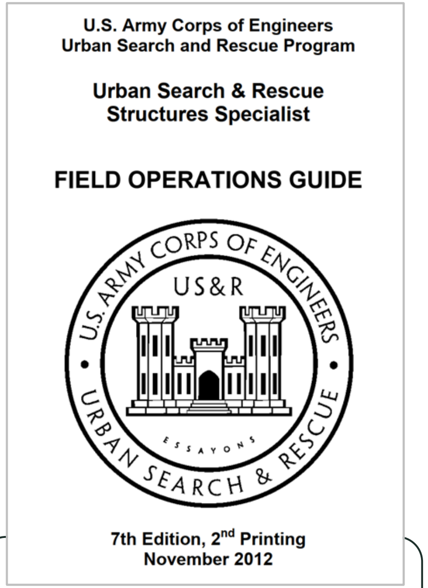
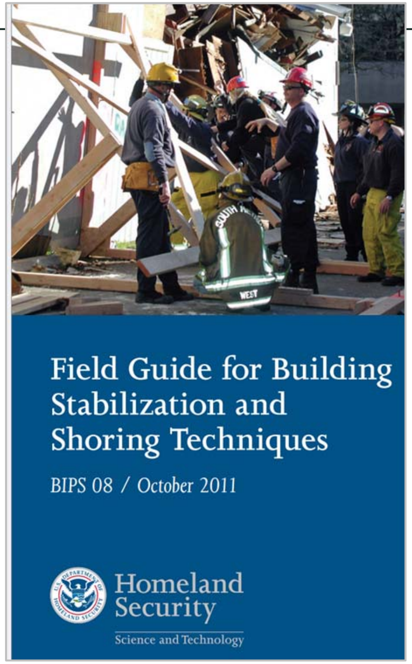


Italian Ministry of the Interior "Vademecum STOP (Shoring Templates and Operating Procedures) for the support of buildings damaged by Earthquakes", (2010).

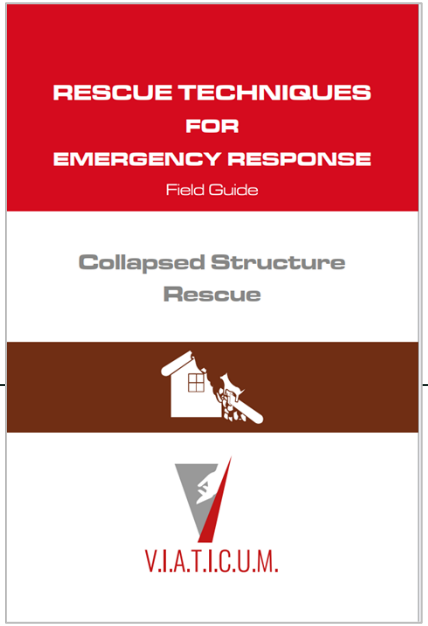


U.S. Army Corps of Engineers. "Field Operation Guide (FOG)", USA (2012)

Department of Homeland Securing, "Field Guide for Building Stabilization and Shoring Techniques" (2011)



Calafato T., European Association of Civil Protection, "Collapsed structure Rescue (2022)



USA Federal Emergency Management Agency (FEMA), "Structural Collapse Technician Training Manual" (2012)

Diapositivo 15

RR1 Among the emergency situations that advise or require shoring, the ones resulting from intense seismic actions are the worldwide most commonly met and the most studied ones.

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Design Concepts

In unreinforced masonry (URM) or reinforced concrete (RC) buildings damage to the structural elements due to poor construction, material degradation, earthquakes, storms, explosions and fires, occurs with significant material rupture of the partition walls, façades and load-bearing walls. These damages can cause collapse and serious diagonal cracking on the walls, leading to excessive deformation of doors or windows, among other.

Shoring could be used to support walls, openings, slabs, balconies, vaults or arches. Regardless of the application, the following design guidelines always apply:

- **Load transfer and stability**
- **Safety factor**
- **Minimizing risk**
- **Redundancy**
- **Modularity and adaptability**
- **Efficient load distribution**

Design Concepts

- **Load Transfer and Stability:** Ensure that shoring systems are designed to collect and transfer loads safely to stable ground or structural elements. This involves aligning shores vertically to avoid eccentric loads that could cause buckling.

- **Safety Factor:** Apply a sufficient safety factor to account for uncertainties in load calculations, material strengths, and structural conditions. Typically, a higher safety factor is used in emergency situations due to unpredictable conditions.

- **Minimizing Risk:** Focus on minimizing exposure to danger by stabilizing hazardous elements quickly. This may include using rapid-deployment shoring systems or temporary supports to prevent further collapse.

- **Redundancy:** Incorporate redundancy into shoring systems to ensure that even if one component fails, the structure remains supported. This is especially important in unstable environments like post-disaster sites.

Design Concepts

- **Modularity and Adaptability:** Design shoring systems to be modular and adaptable so they can be quickly assembled, adjusted, and/or dismantled based on the specific site conditions.

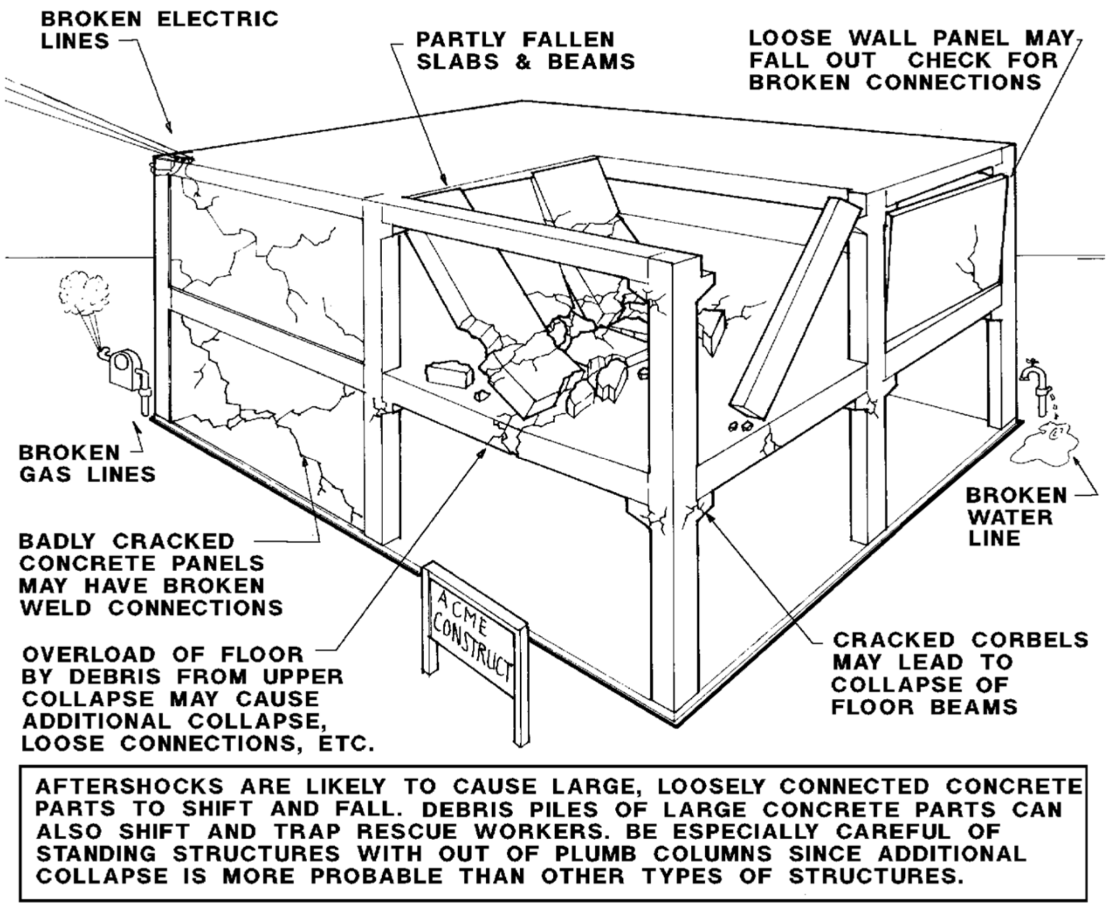
- **Avoiding Damage to Existing Structures:** When shoring inside partially damaged buildings, ensure that the added elements do not further weaken existing structural elements. Use connections through soft elements where necessary.

- **Efficient Load Distribution:** Distribute loads evenly across shoring elements to prevent overloading any single component. For instance, use cribbing or multiple shores to spread the load over a larger area.

Hazard Assessment

Before any shoring design, a **preliminary hazard assessment** needs to be conducted, tailored on the building typology, damage mechanism and the nature of the emergency.

For example, in framed structures such as reinforced concrete, typical failure modes are found in the **interconnections** between parts leading to partial or total collapse, depending on the designed **redundancy**. In the occurrence of specific disastrous events, such as explosions, these structures will perform according to the presence of weak-link connections. In case of high energy impact, damage is likely to be localized if connections are enough ductile.

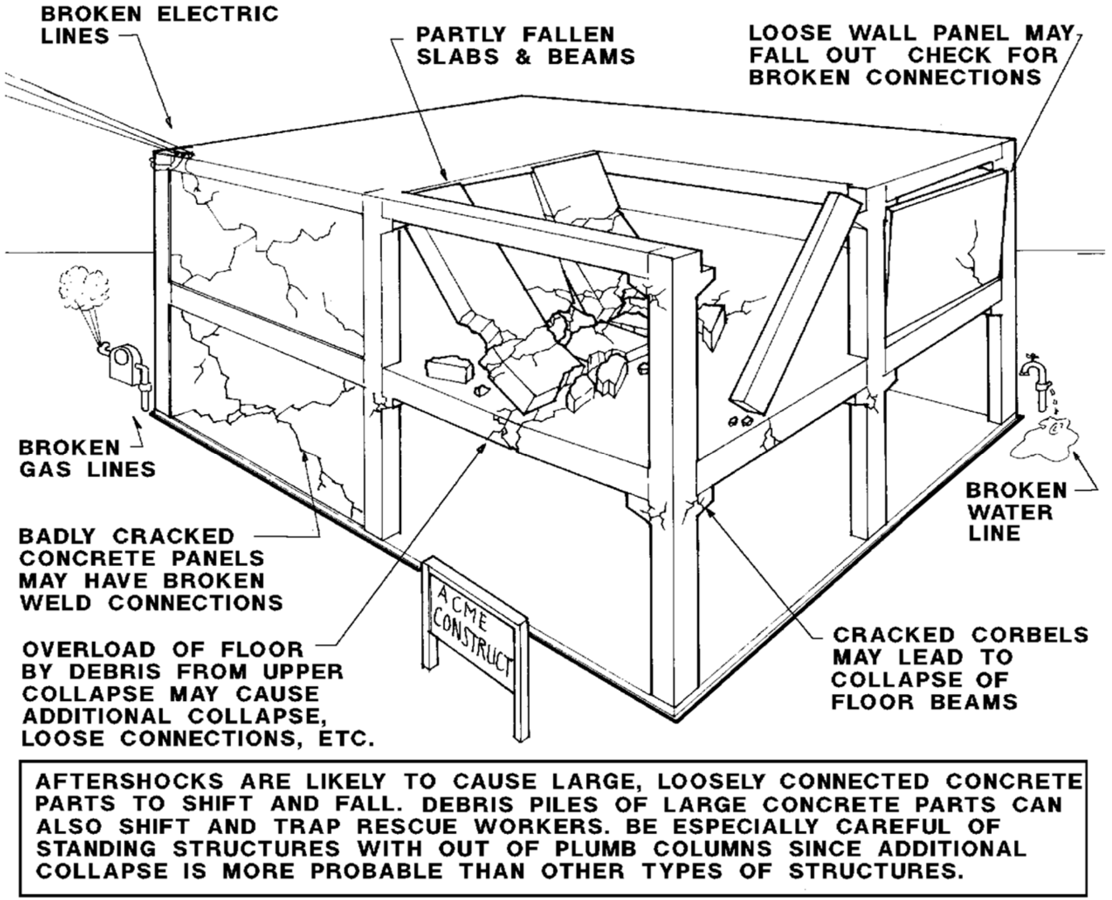


US USAR FOG (2012)

Hazard Assessment

A possible set of **actions to reduce the hazard** for the immediate use or containment of damage could include:

- Remove leaning/hanging concrete elements.
- Shore damaged roof/floor beams, especially next to bad-condition columns.
- Remove/shore unstable wall and floor elements.
- Monitor changes in racked/leaning structures.

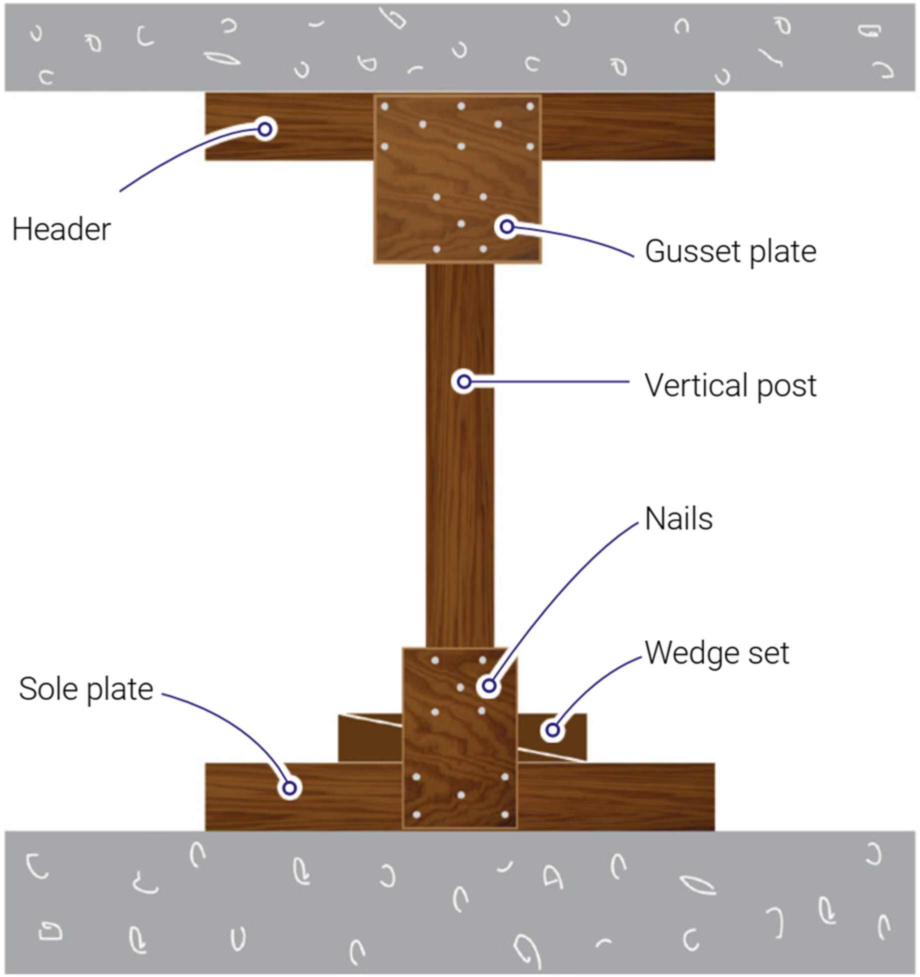


US USAR FOG (2012)

Structural Components of Standard Built-in-Place Shoring

Wood shoring is usually built in place and includes the following components:

- **Header beam**. Wall plate that collects the weight from above and spreads it throughout the shoring system.
- **Post**. It supports the weight being collected by the header or spreader beam and transfers it to the sole plate where it is distributed. It is an adjustable element and has positive end connections.
- **Sole plate**. Bearing plate element to spread the load into the ground or other structure below.

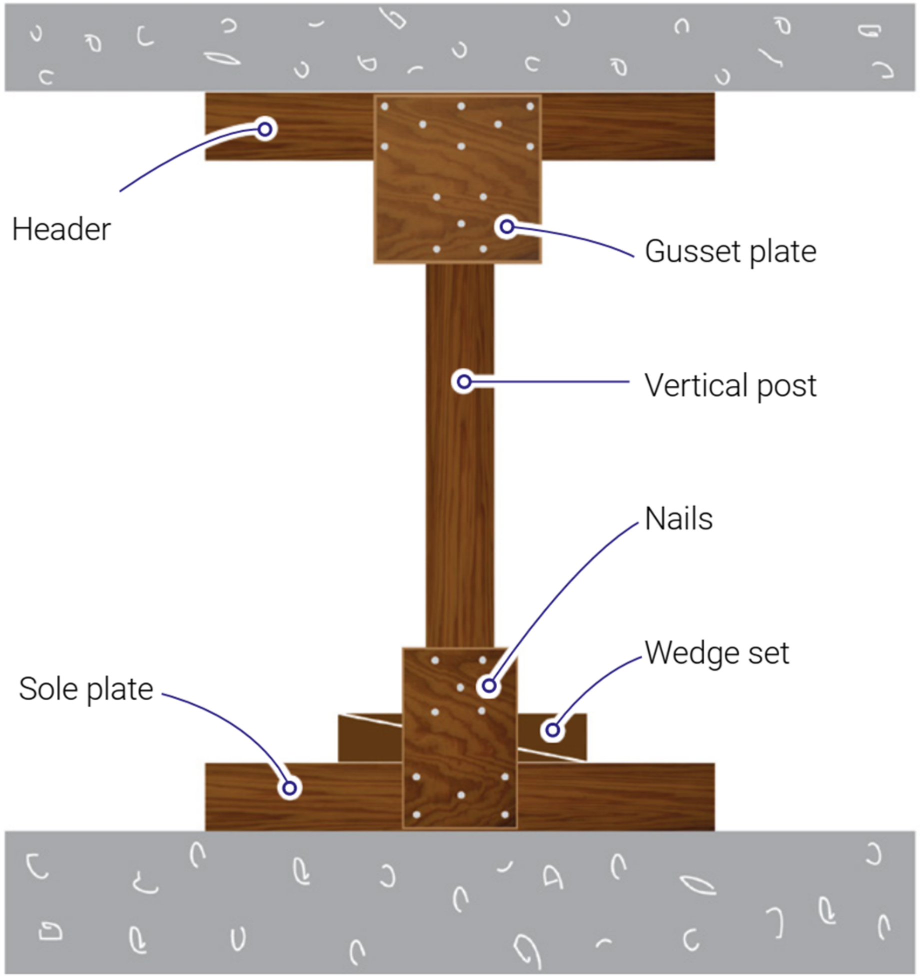


Calafato (2022)

Structural Components of Standard Built-in-Place Shoring

Wood shoring is usually built in place and includes the following components:

- **Cleats or Gusset Plates**. Short pieces of 2 x 4 (Cleat) or small pieces of ¾" plywood (Gusset Plate) nailed to the top/bottom of posts to facilitate shore placement and secure the posts to the header and sole plate.
- **Wedges**. Two wooden incline planes placed under the bottom of the post. They are simultaneously tapped together until the shoring system is under compression and takes the weight of the structural materials above.
- **Connections**. All elements are connected with the use of nails placed on site.



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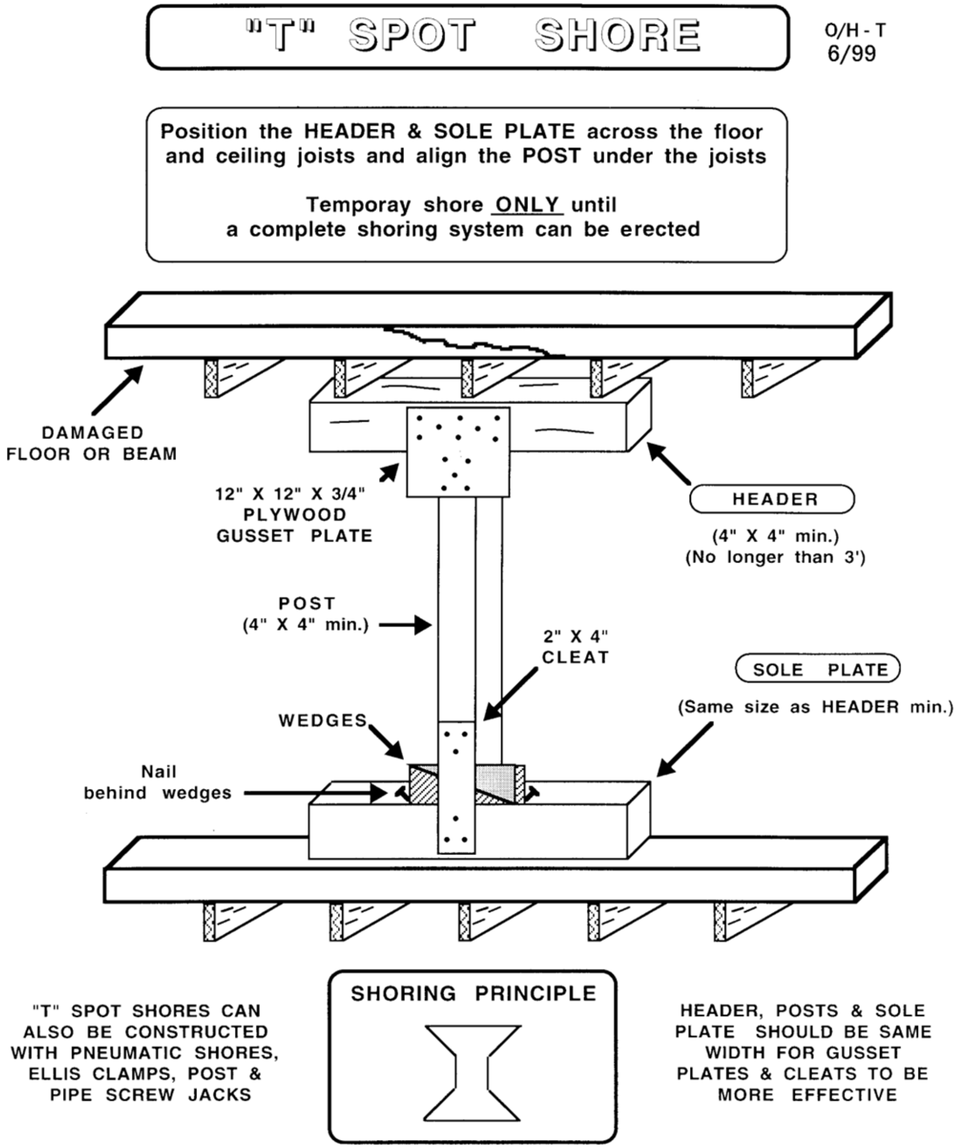
Vertical Shoring

Vertical shoring: Used to support vertical loads, particularly for damaged floors, beams, or walls.

- **T-Shore**: A quick, single-post shore for light-duty applications.
- **Double T-Shore**: A reinforced version of the T-shore, adding stability and load distribution.
- **2-Post Vertical Shore**: A dual-post system that offers better stability for larger or more damaged areas.
- **Cribbing**: Stacked timber or other materials used to support or raise a structure, especially useful under uneven loads.



FEMA (2012)

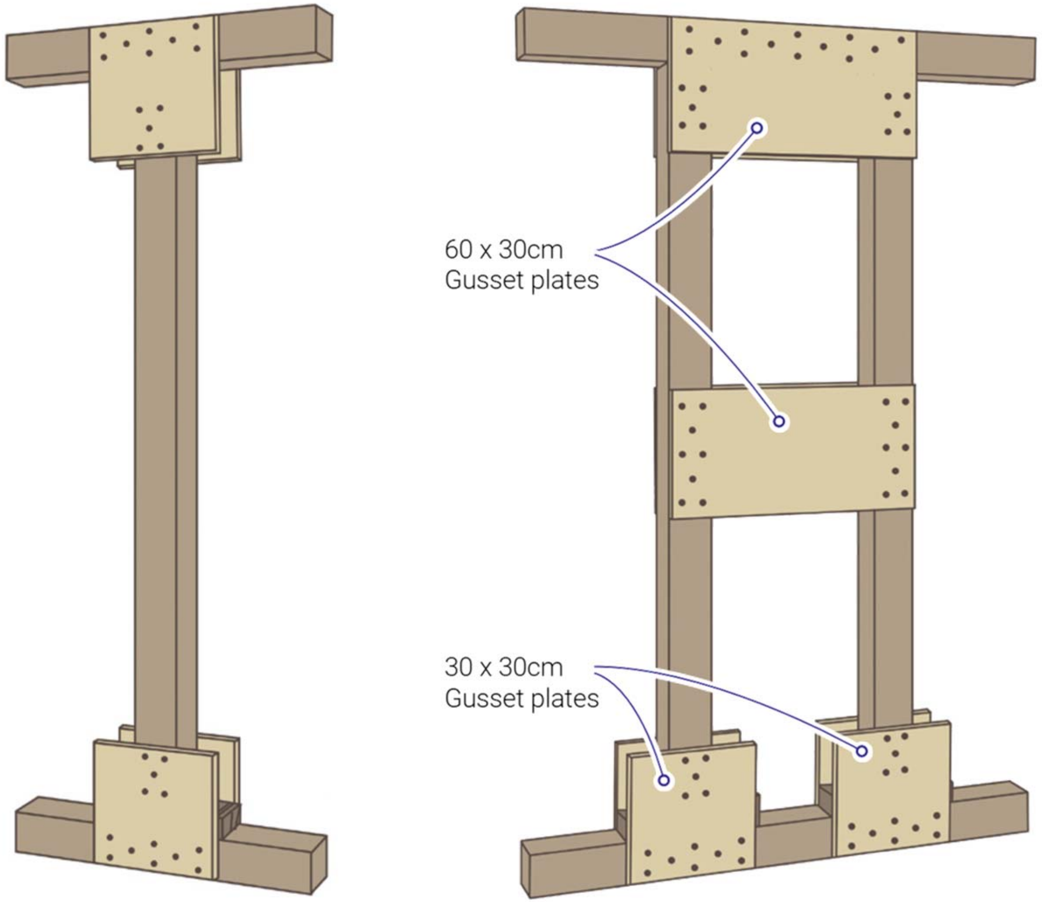
Vertical Spot T-Shore and Double T-Shore

Spot T-shore is a rapidly assembled and installed temporary shore that is intended to be used only until a complete shoring system can be installed. It can become **unstable** if it is not centred under the load.

Maximum Load Capacity: 2500 kg
Maximum Height: 3.6 m

The **Double T-Shore** is a most stable spot shore, much preferred to the marginally stable, T-Shore.

Maximum Load Capacity: 5000 kg
Maximum Height (same): 3.6 m



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Timber Elements for Shoring

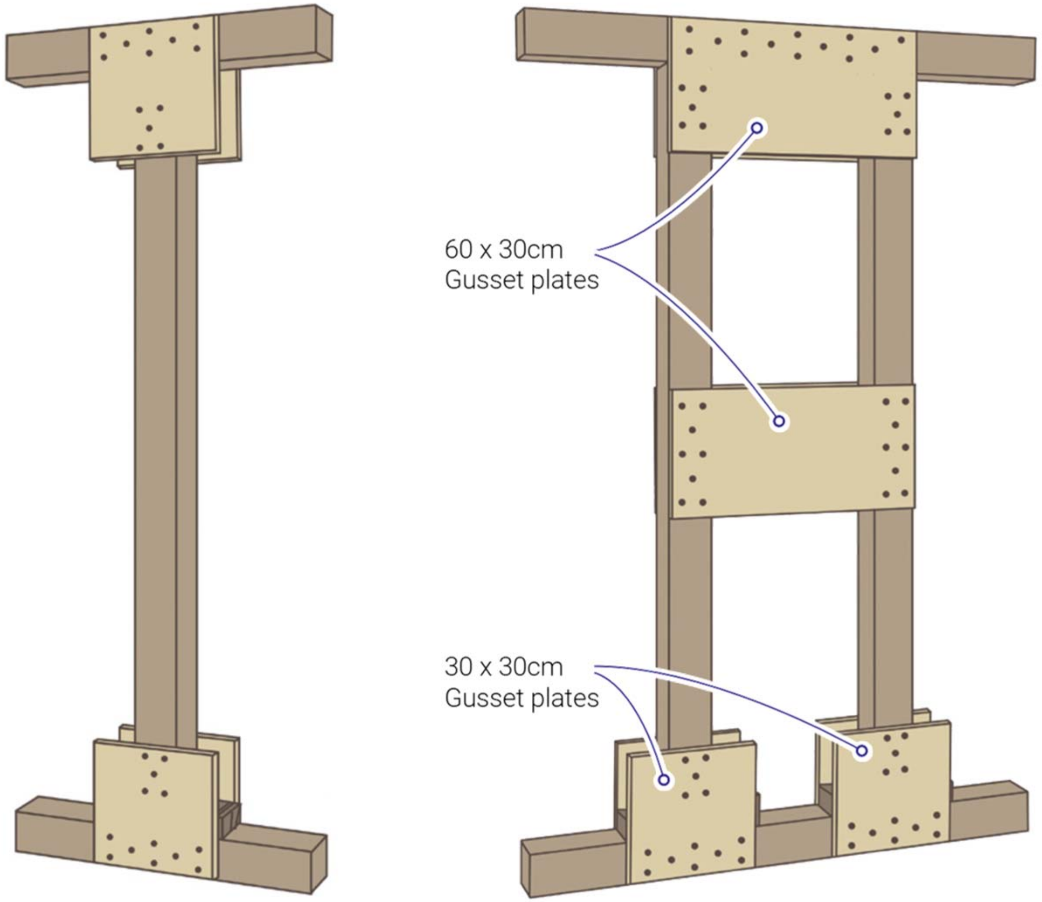
Wood as shoring material:

- Local availability
- Adaptability
- Wood can give **warning of overload!**

Post's strength depends on buckling and varies relative to its length and the modulus of elasticity.

The capacity of header beam and sole plate is determined by bending and/or horizontal shear strength.

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



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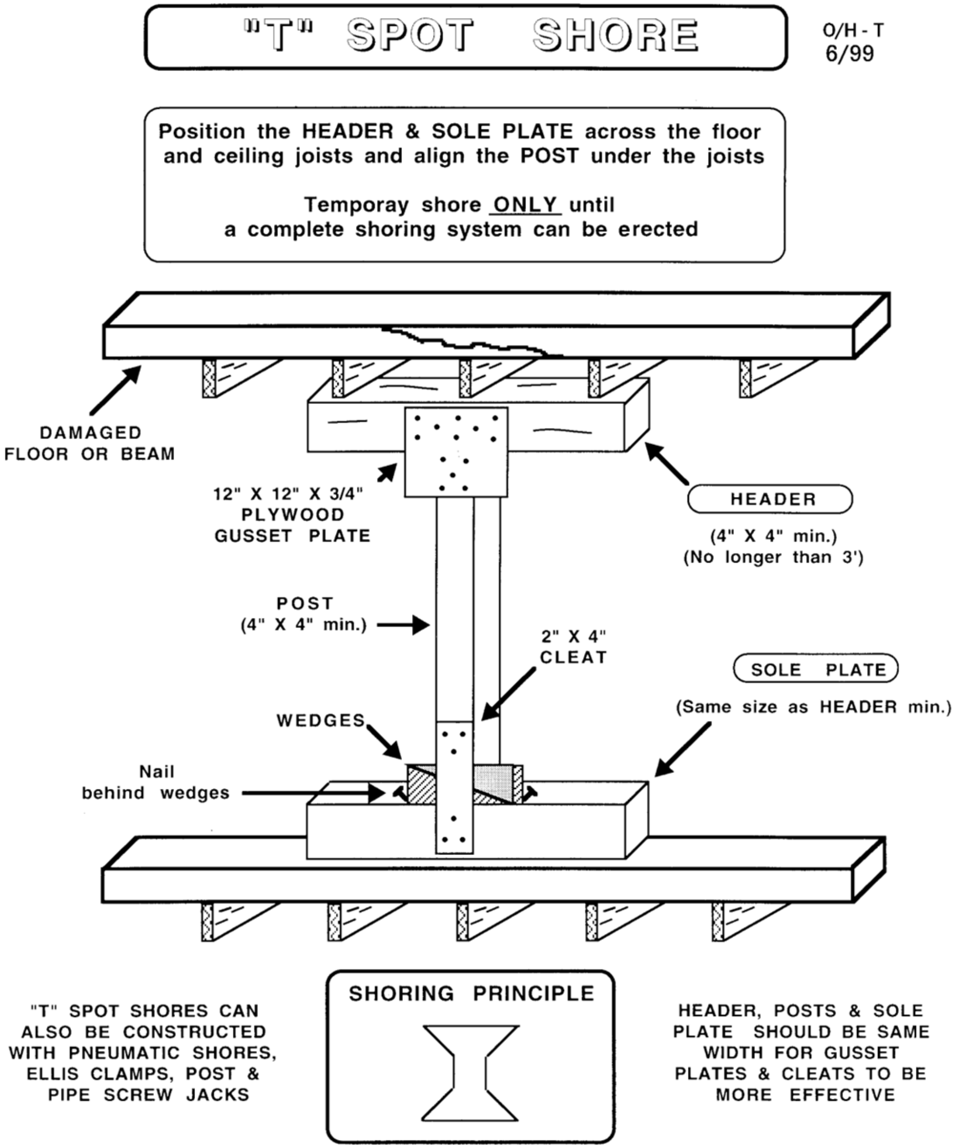
How to Construct the T-Shore (I)

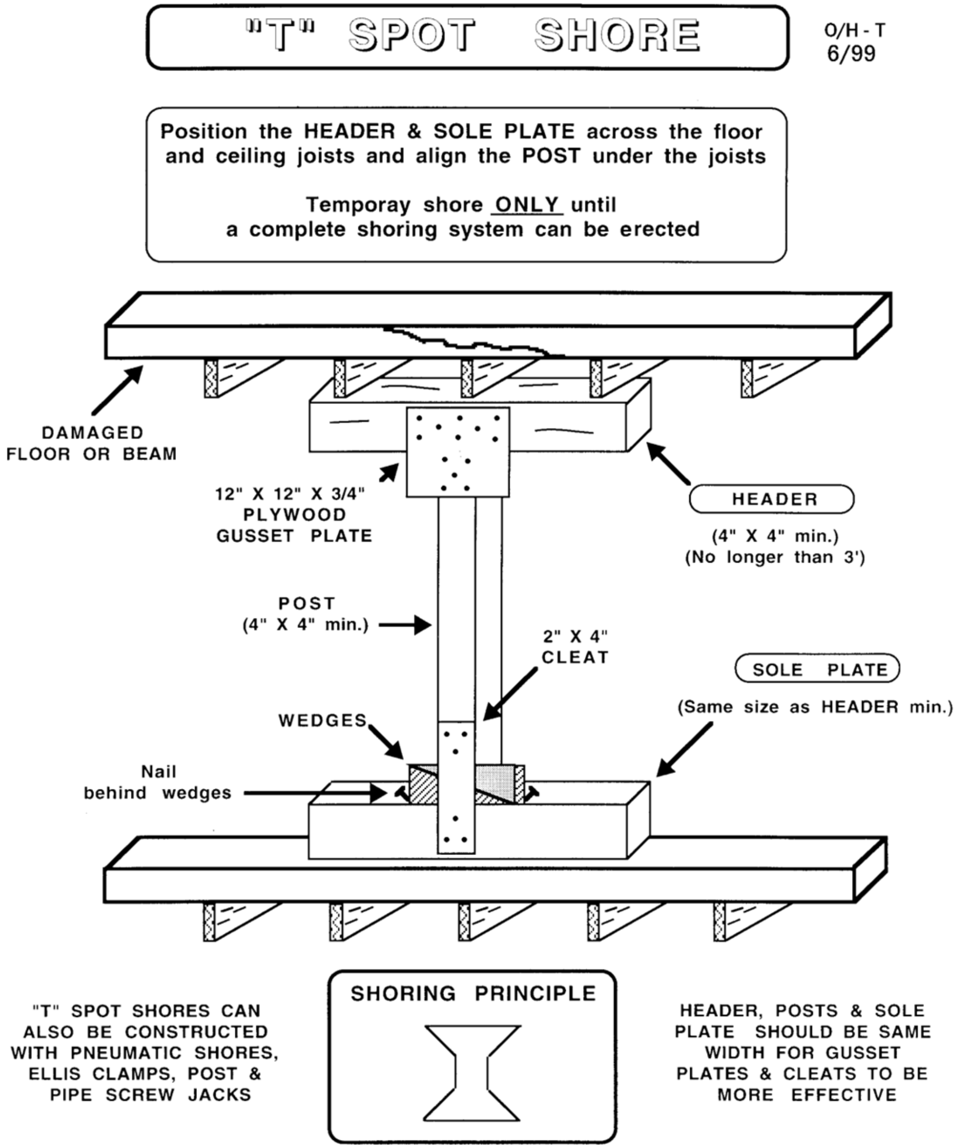
- Survey the area and determine loads, displacement, and structurally unstable elements.
- Clean area to be shored.
- Measure for proper lengths of shoring items.
- Measure the overall height of the space to be shored.
  - Deduct the depth of the header, sole plate, and the wedges, and cut the post to that length.
- Prefabricate T-shore.
- Nail post to header, in center of header.
  - Place plywood gusset plate over joint and nail into position.
- Flip over and nail other gusset in position, utilize the proper 5 nail pattern.



FEMA (2012)

How to Construct the T-Shore (II)

- Place “T” in position with the shore centered under the load.
- Slide sole plate under “T” and wedge in position.
- Check shore for straightness and stability and tighten wedges.
- Install bottom cleat and nail properly.
- Anchor the shore to the floor beams above and nail sole plate into the floor below.



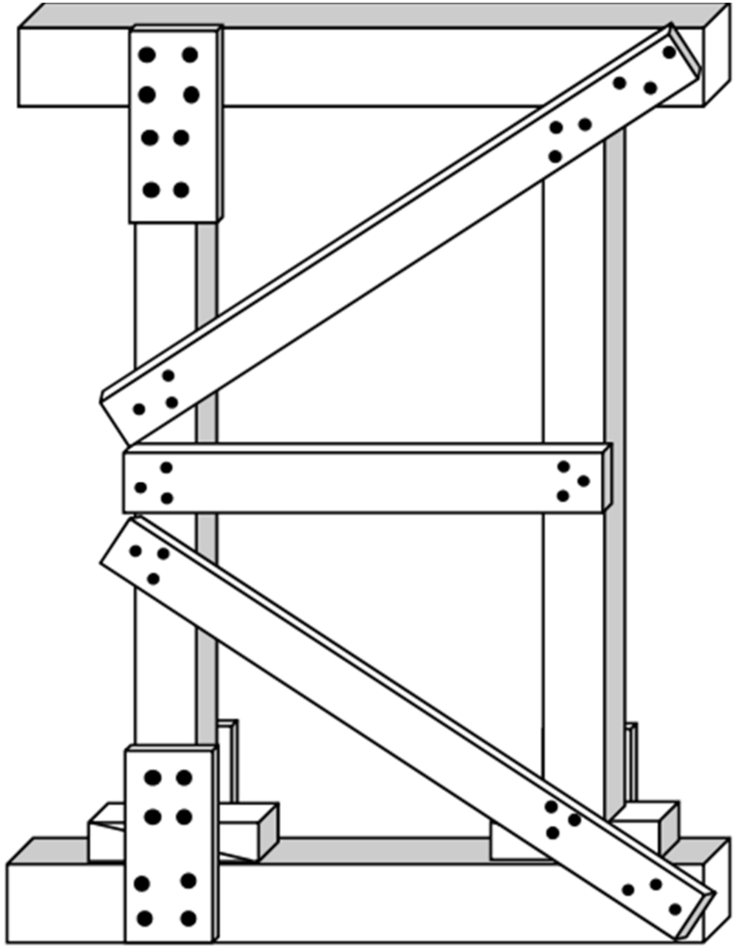
FEMA (2012)

2-Post Vertical Shore

The **2-post vertical shore** includes diagonals and lateral bracing to provide more stability. This shore is the same as one side of the laced post shore.

Maximum Load Capacity: 5000 kg
Maximum Height: 3.6 m

Vertical shoring systems are mainly intended to provide vertical support but should always have some lateral bracing for stability (2% minimum, 10% reasonable).

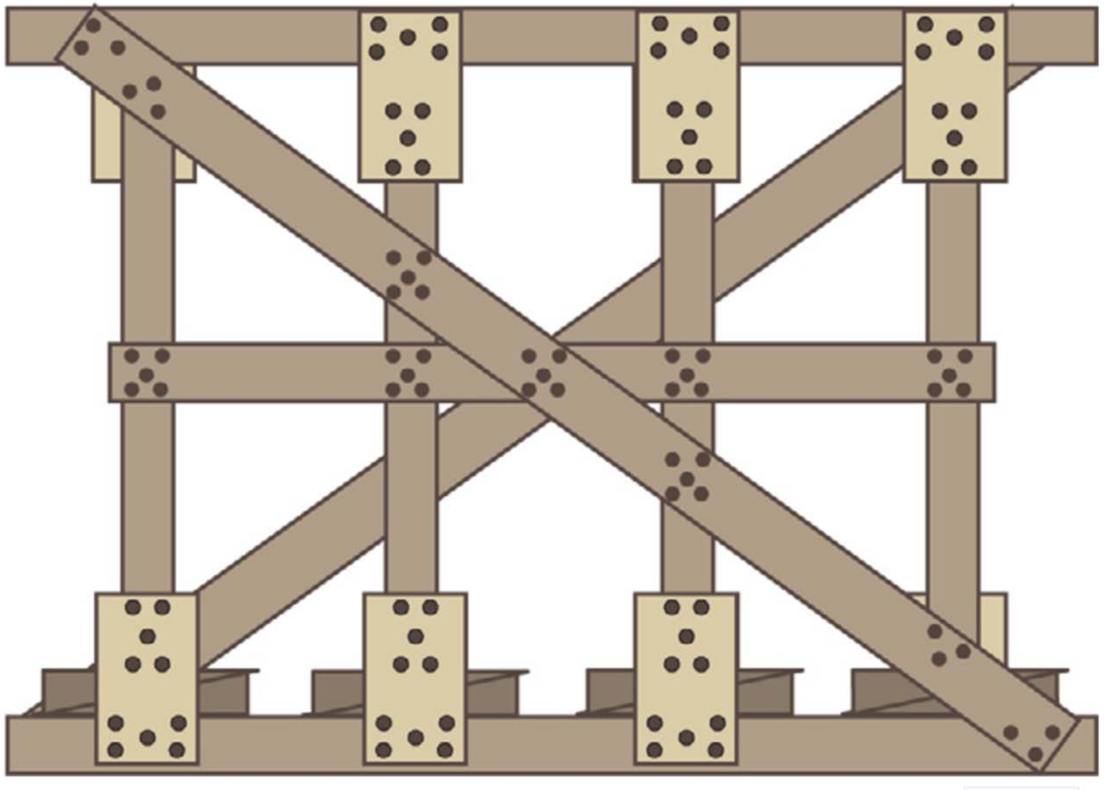


US DHS (2011)

Vertical Multi-Post Shore

The **vertical multi-post shore** is usually built in-place in the danger zone. To reduce risk, spot shores should precede the erection of this vertical shore, As an alternate to the vertical multi-post shore, one may use several double-T post, 2-post, or laced post shores, as they can be partly prefabricated, and more quickly erected in the danger zone.

Maximum Load Capacity: 2500 kg per post
Maximum Height: 3.6 m
Post to be placed 1.0-1.2 m apart



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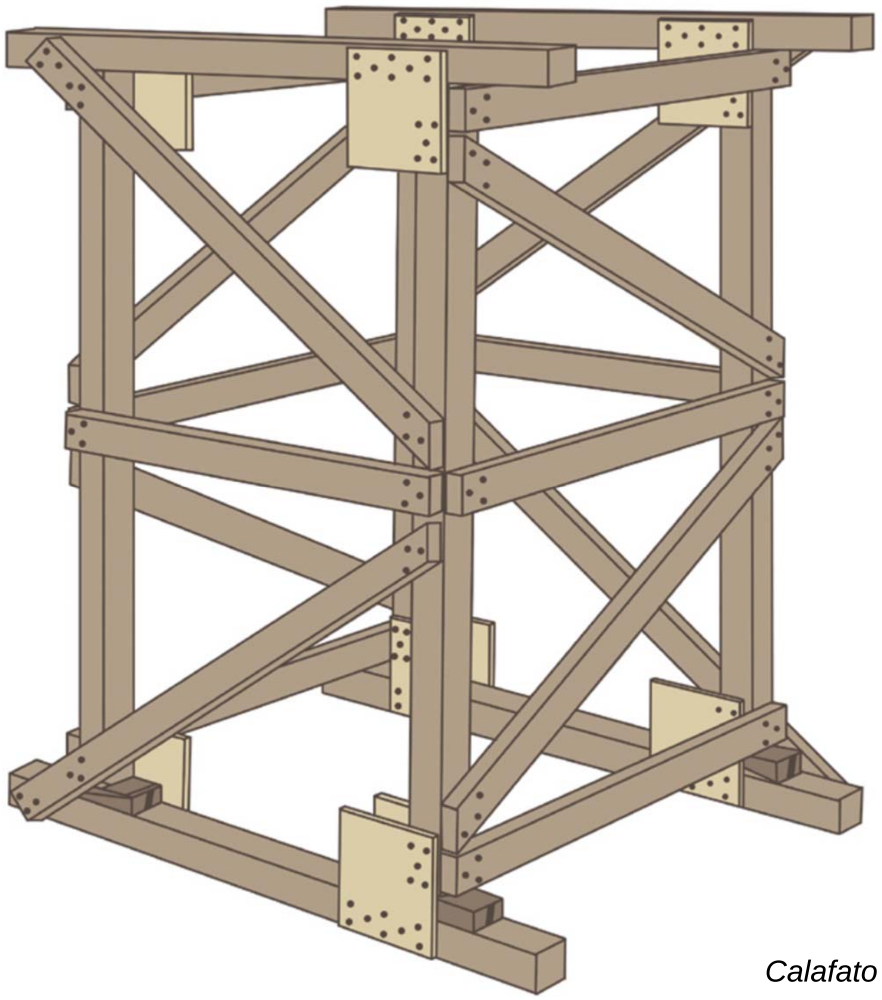
Laced Post Shore or Column Shore

High capacity four-post system. The **laced post shore** is constructed as a pair of 2-post vertical shores, but laced together in a three-dimensional configuration.

Maximum Load Capacity: 2500 kg per post (10000 kg per column)
Maximum Height: 4 x width
Post to be placed: 1.0-1.2 m apart



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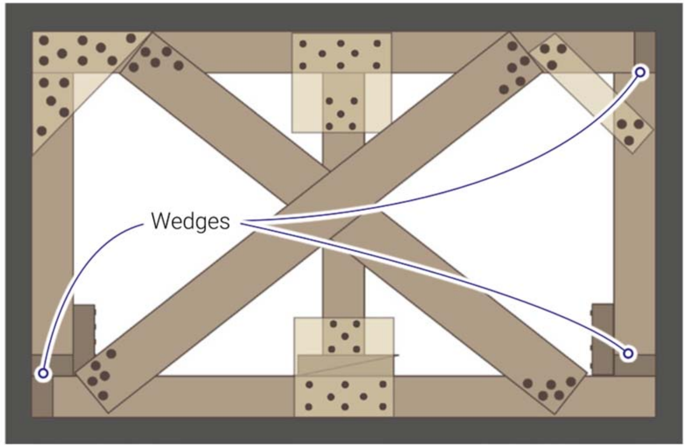
Opening Shore Built-In-Place or Preconstructed

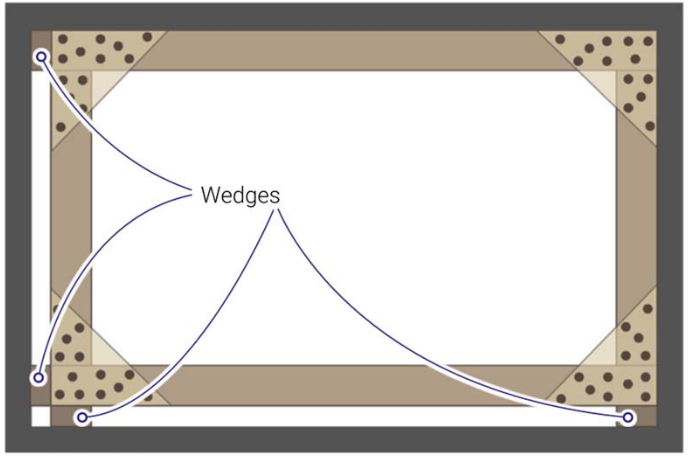
The **built-in-place** shore is used in URM buildings to support loose masonry over openings. It may be used in other building types where door or window headers have been damaged.

Maximum load capacity: 2500 kg per post
X-braces may be removed if access is required
Maximum height: 2.5 m

The **preconstructed** shore allows preparation a safe distance from the dangerous wall or collapse zone. This shore can be reused.

Preconstructed box frame (4 cm less than the opening)
Maximum load capacity: 5000 kg
Maximum height: 2.5 m





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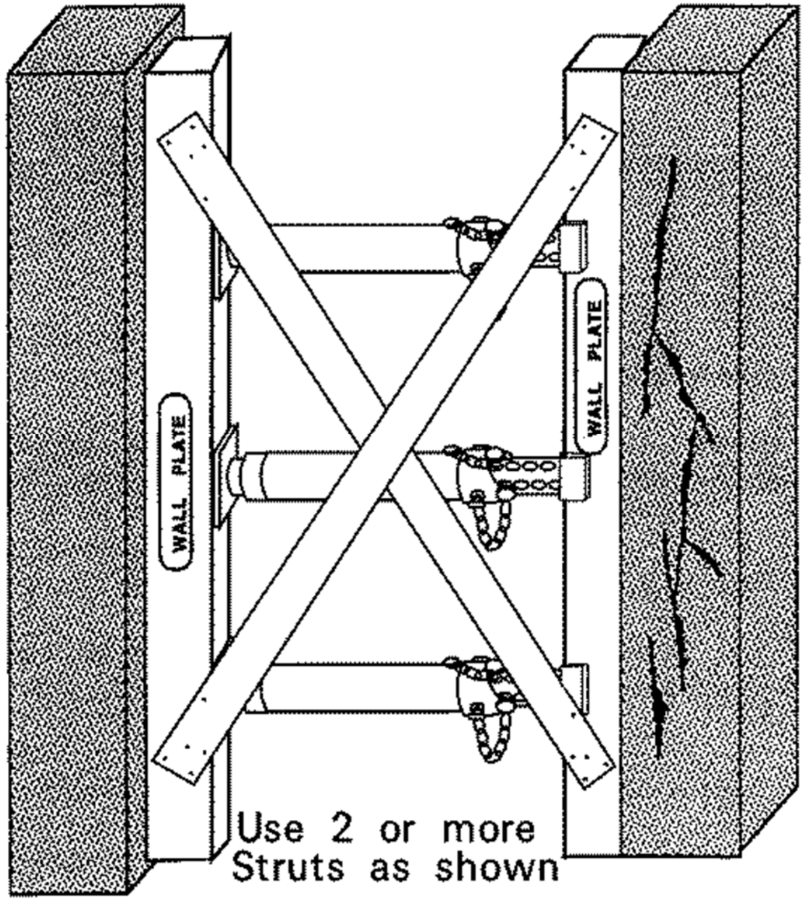
Horizontal or Raker Shoring

Horizontal shoring: Used to stabilize and support walls, arches, or other vertical elements at risk of lateral collapse.

- **Horizontal Shore:** basic horizontal brace placed between two walls to prevent them from leaning or collapsing inward.
- **Flying Raker Shore**: braces walls without touching the ground directly beneath. Useful when lower ground access is restricted.
- **Solid Sole Raker:** reinforced horizontal shore with an anchored sole plate, providing stronger lateral support for heavily compromised walls.
- **Strut and Wedge System:** adjustable horizontal struts used to create outward pressure against opposing walls, stabilized by wedges to maintain a tight fit.
- **Cross-Braced Shores:** combination of horizontal shores with diagonal bracing to enhance lateral stability, especially in large openings or weakened wall sections.



FEMA (2012)

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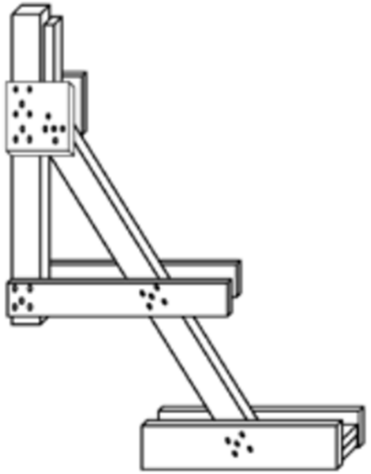
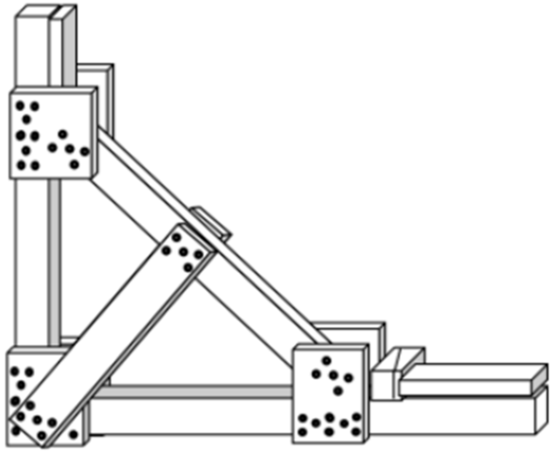
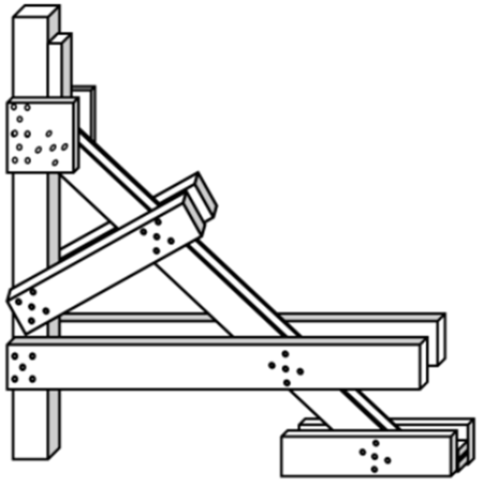
Raker Shore



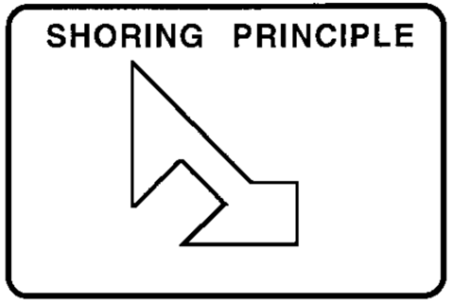
Flying (Friction)
temporary, spot rakers when debris are piled next to the base of the wall.

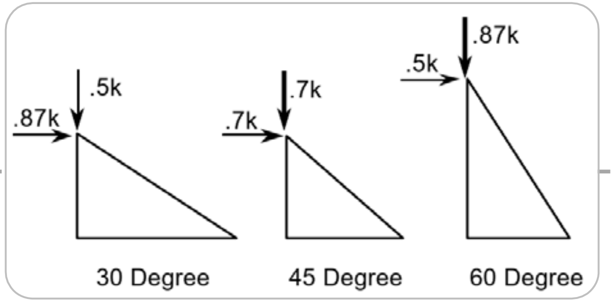


Solid-Sole (Full Triangle)
Most desirable rakers, are normally built in groups of 2 or more with lateral bracing.



Split-Sole
Intended to be used when there is soil adjacent to the wall, and/or there is a limited amount of debris next to the wall.





Either configuration can be used on walls up to about 7 m high

US DHS (2011)

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1) Header (vertical element)
2) Sole plate
3) Raker (just placement into position)
4) Gusset header/sole
5) Cleave blocks (top and bottom)
6a) Gusset nailed only on header
6b) Gusset nailed only on sole
7) Wedges (only on the bottom; raker moves and gets compressed)
8) Gusset nailed on raker
9) Diagonal

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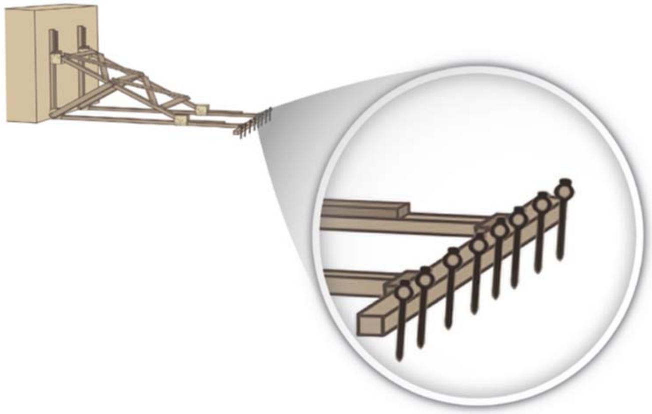
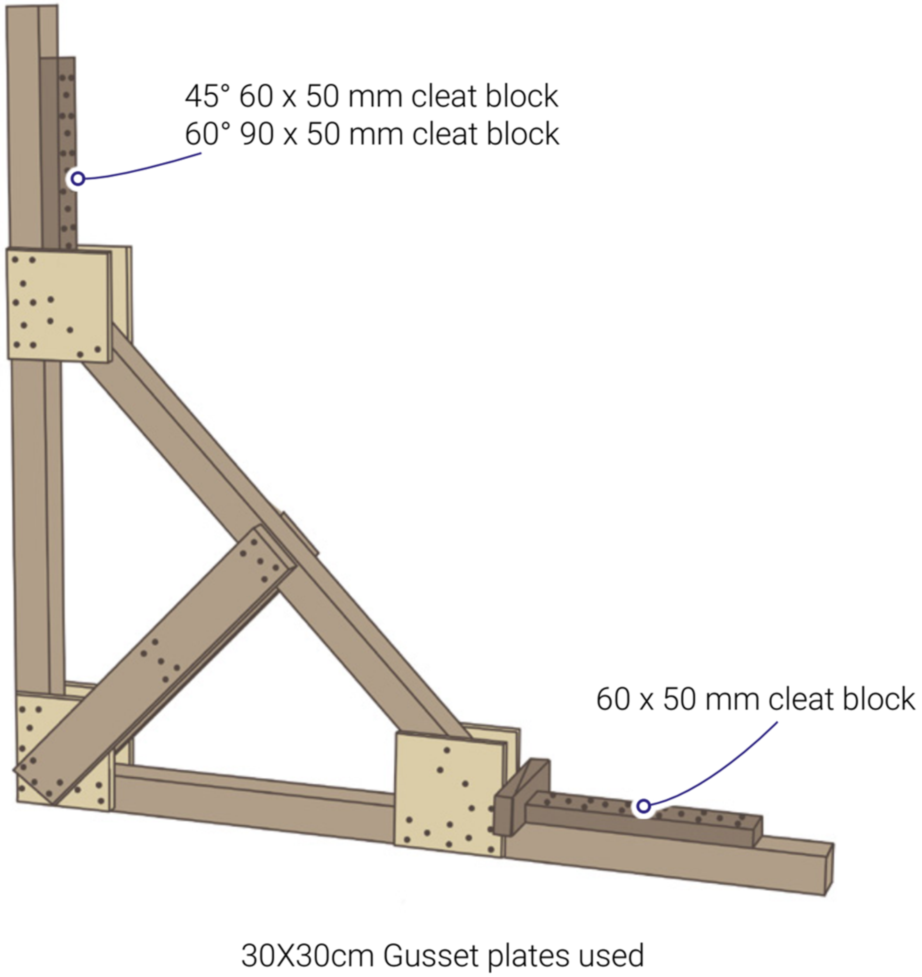
Solid-Sole Raker Shore

Used to support single floor slab on flat, hard ground with no obstructions.

Maximum Horizontal Load Capacity: 1000 kg per raker
Minimum of 2 rakers per shore
To be wedged against a kerb beam
Avoid using 60° raker shores except where space is limited
Remember: 30° shores take a lot of space to construct



To tie in raker sole beams, use a kerb of at least 10x10 cm timber and insert wedges between the kerb and the sole beam.



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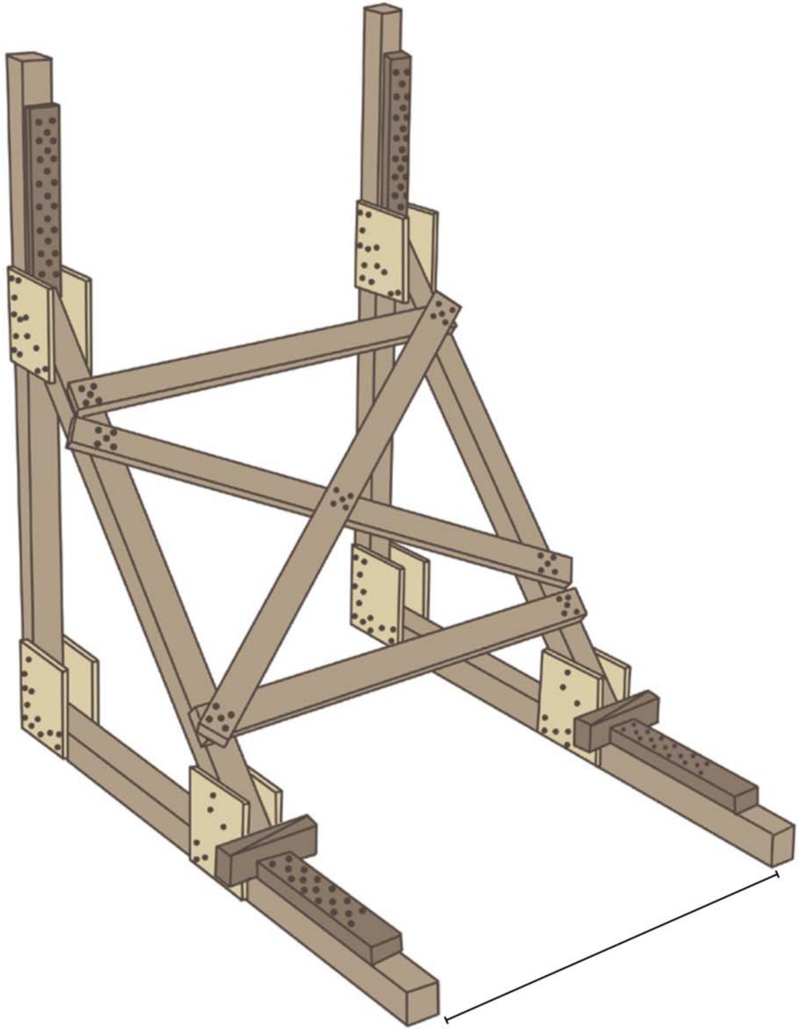
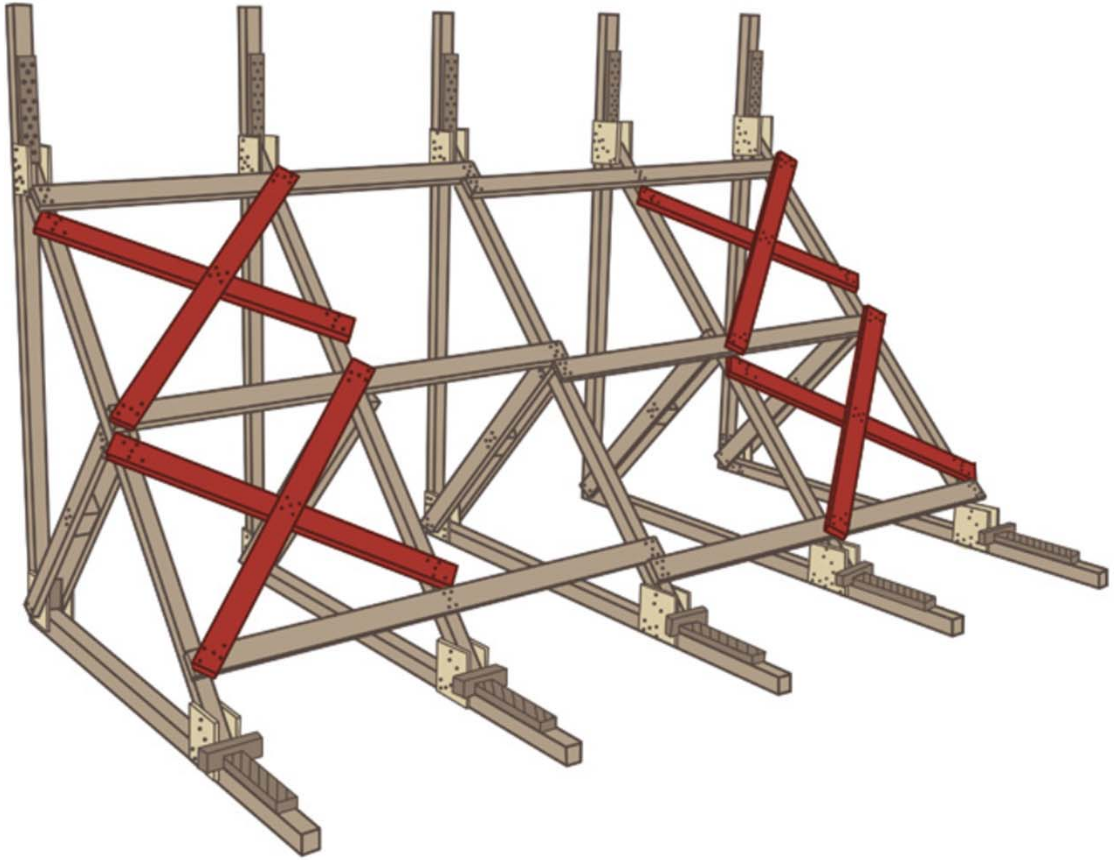
Raker Shore Assembly



Maximimum distance of 2.4m



Each 4th bay must be X-braced

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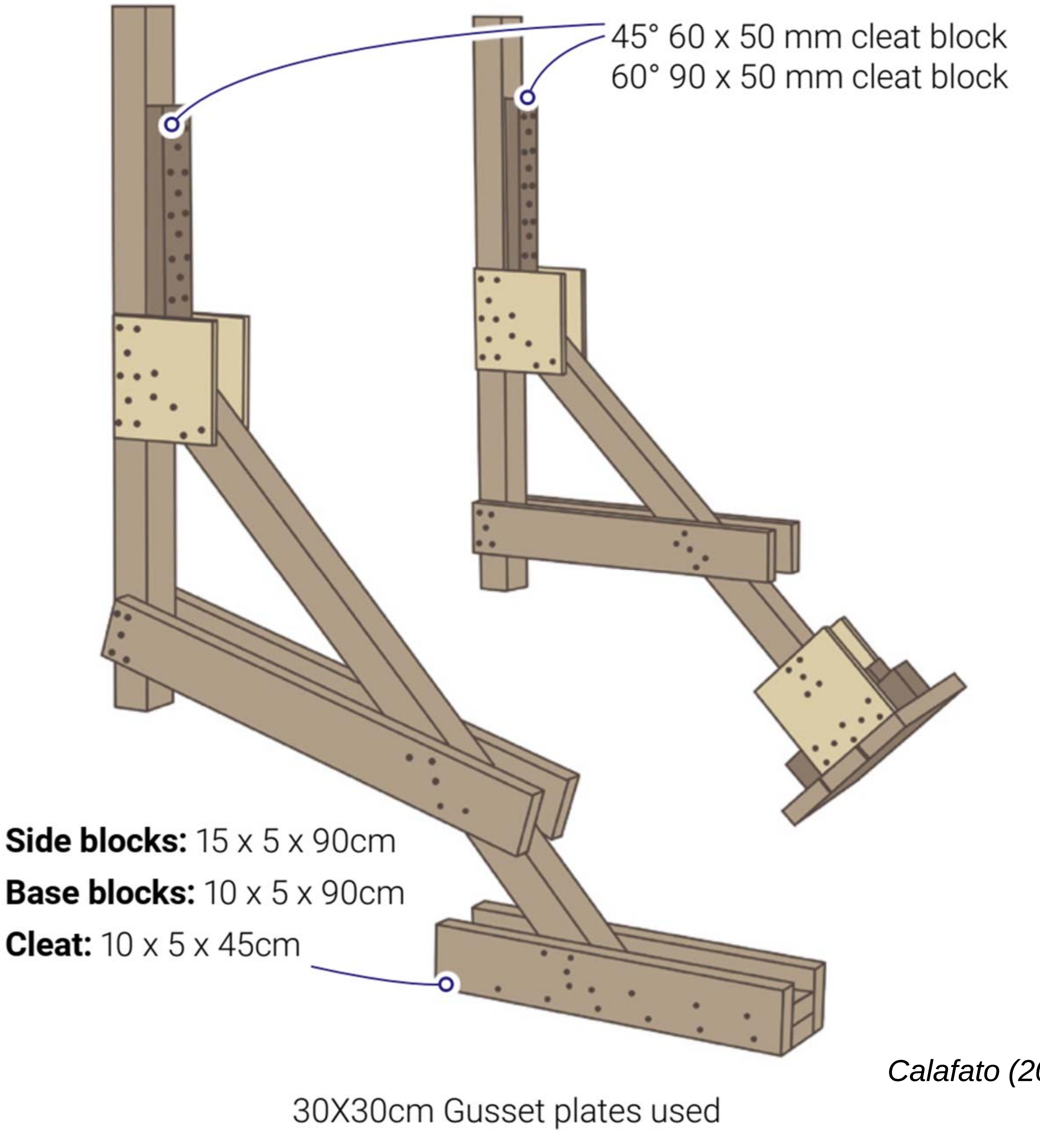
Flying Raker Shore

Maximum Horizontal Load Capacity: 500 kg per raker
Minimum of 2 rakers per shore
Avoid using 60° raker shores except where space is limited
Base type to be used depending on ground condition

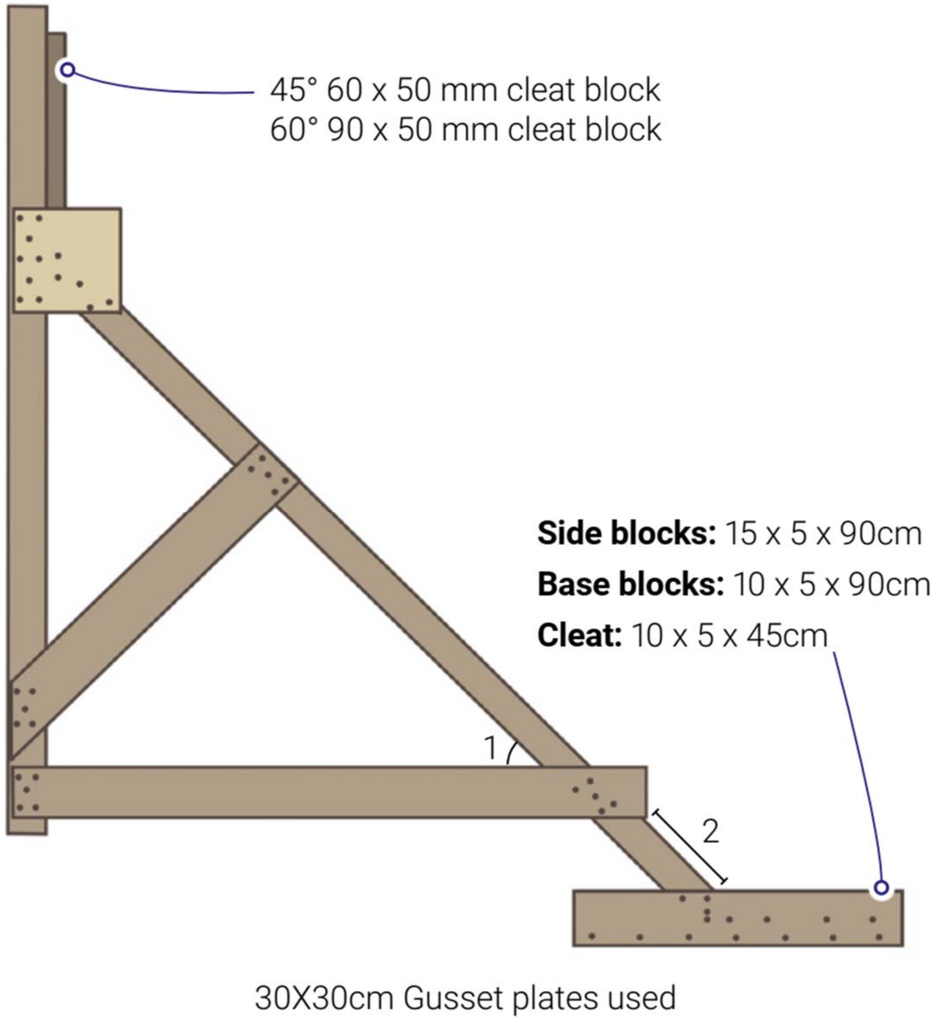


Calafato (2022)

Split-Sole Raker Shore

Used to support a single floor slab on flat, hard ground where there may be obstructions close to the wall.

Maximum Horizontal Load Capacity:
1000 kg per raker
Keep angle 1 above 30°
Keep sole as low as possible to the ground (distance 2 as low as possible)
To be wedged against a kerb beam

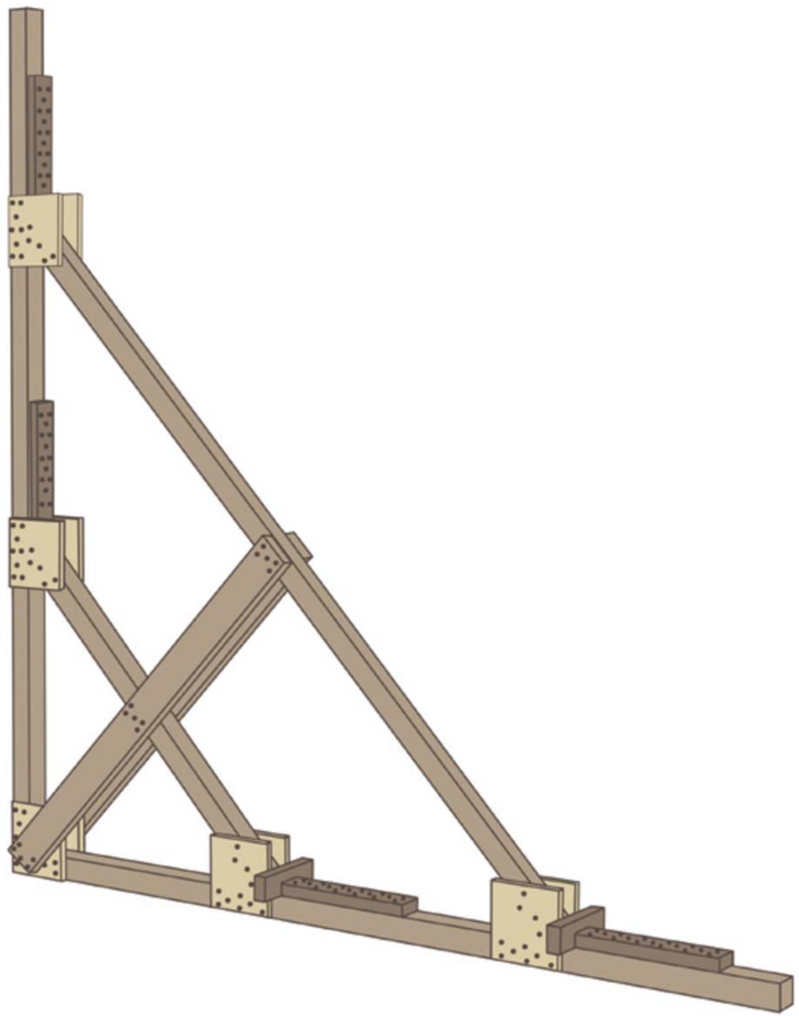


Calafato (2022)

Multi-Insertion Point Raker Shore

The same build as the Solid-Sole with an added raker to support slabs on different floor levels, or where there is a high buckle risk.

Maximum Horizontal Load Capacity: 1000 kg per raker
Minimum of 2 rakers per shore
Keep both rakers at the same angle
To be wedged against a kerb beam

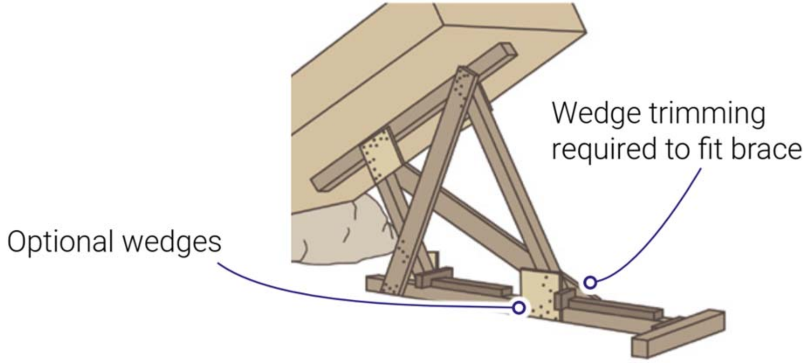


30X30cm Gusset plates used

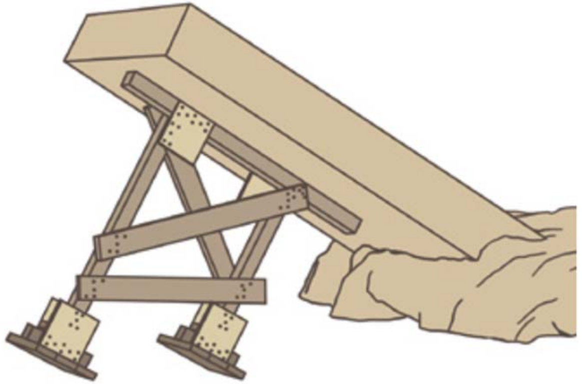
Calafato (2022)

Other Types of Shoring: Inclined or Sloped Floor Shore

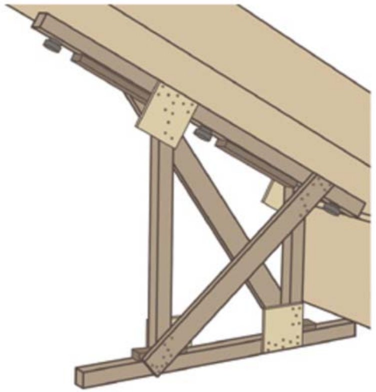
Built in pairs similar to a laced post shore. Used to support damaged and sloped, concrete floors that are still connected to remaining structure. (hinging slabs)



To be used where there is no possibility of the slab to slide



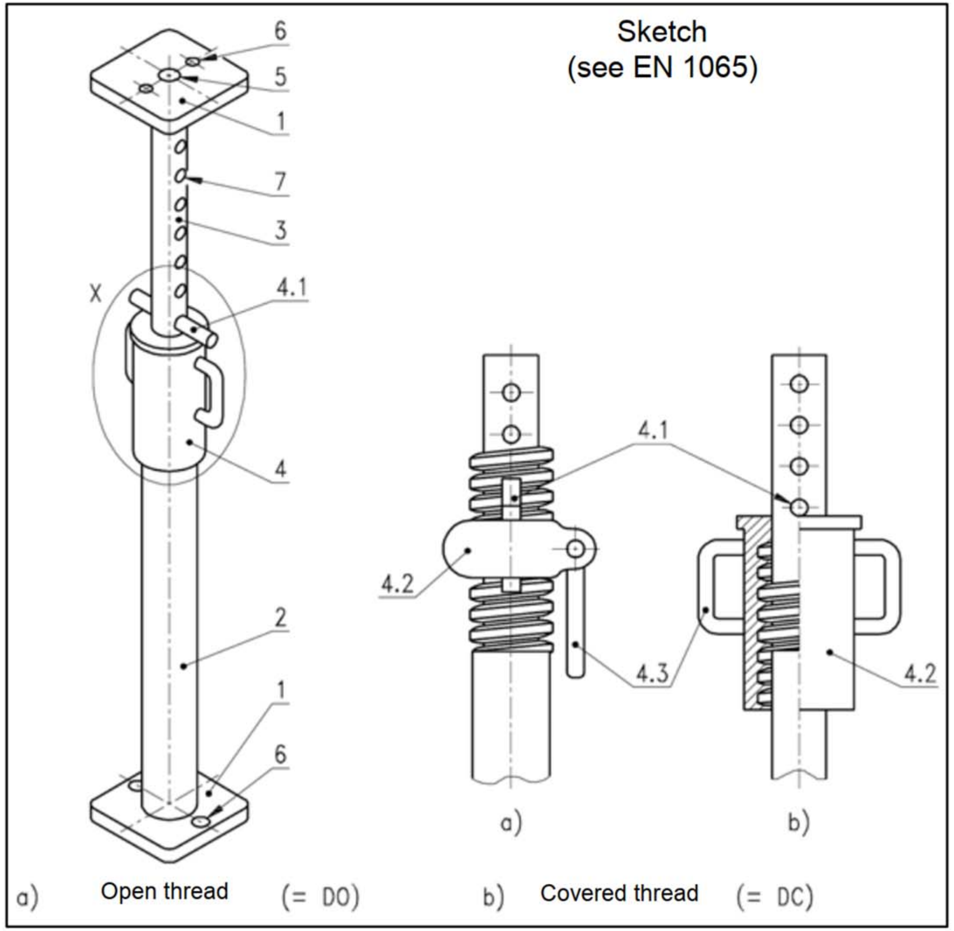
To be used on soft ground
To be used where there is no possibility of the slab to slide



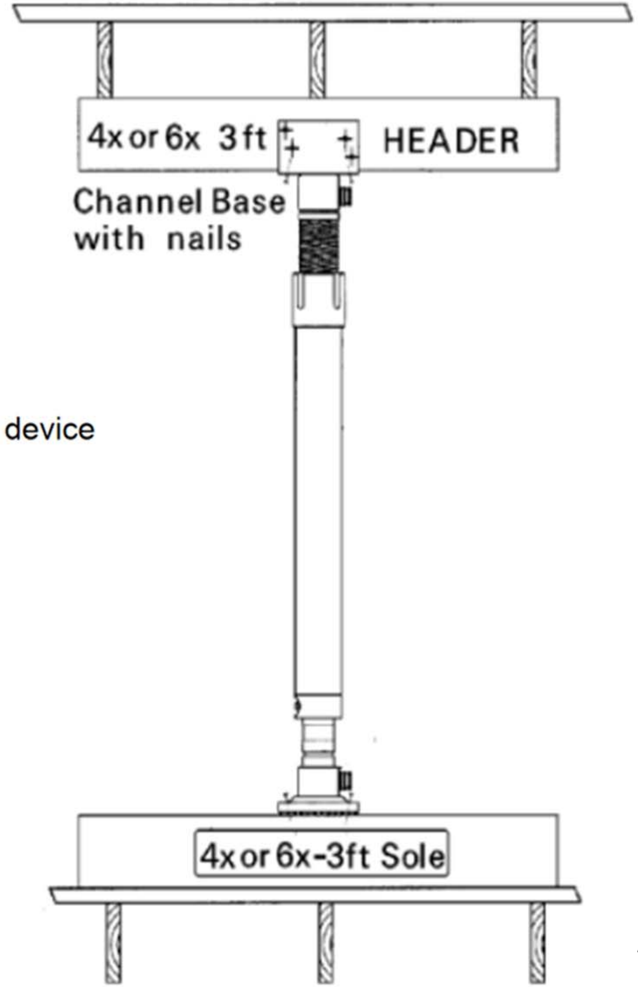
To be used where the slab may slide (Header must be strongly fixed to the slab to prevent movement)

Maximum Vertical Load Capacity: 2500 kg per post
Minimum of 2 posts per shore
Maximum Length 3.5 m
Post to be placed maximum 1.2 m apart
To be wedged against a kerb beam

Other Types of Shoring: Prefabricated Steel Shoring

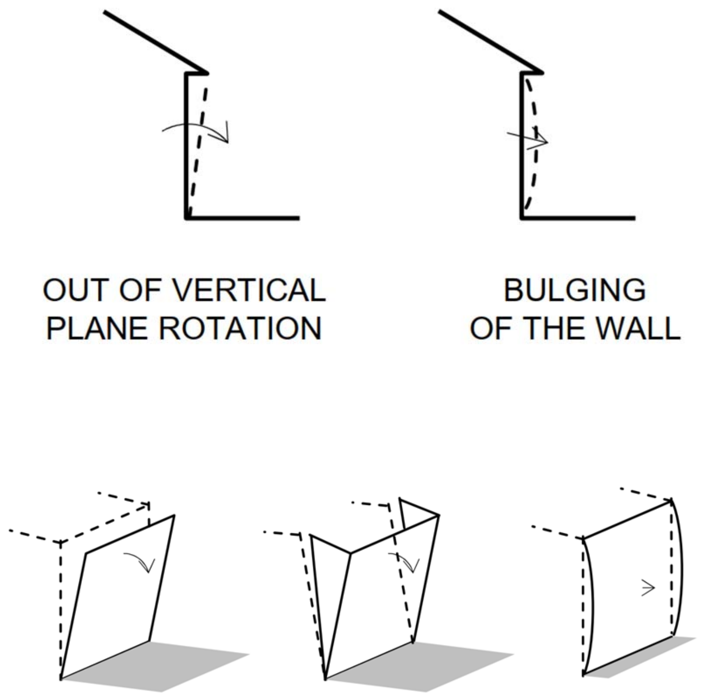


Key
1. Endplate
2. Outer tube
3. Inner tube
4. Length adjustment device
4.1 Attached pin
4.2 Outer ring
4.3 Handle
5. Central hole
6. Connection hole
7. Pin hole

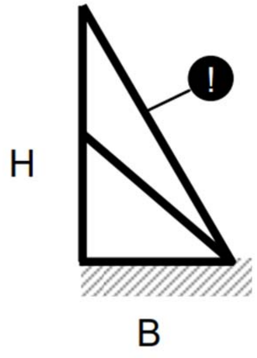


FEMA (2012)

Design Concepts – Solid-Sole Rakers

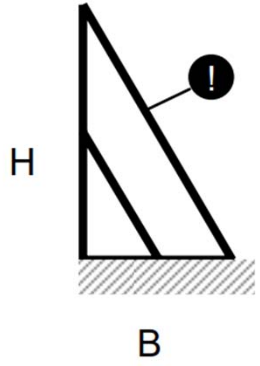


Vademecum STOP (2010)



Critical element: the main raker

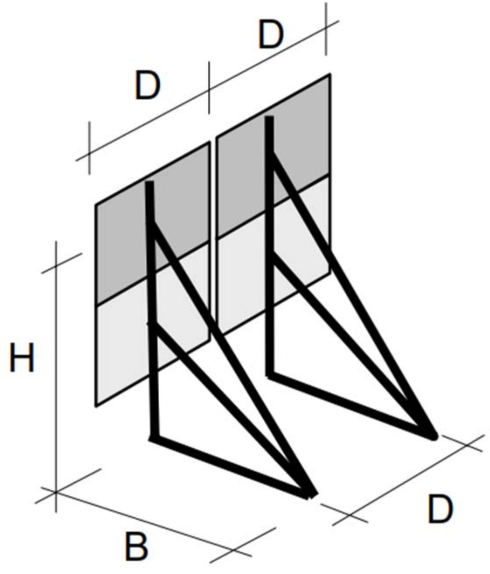
multiple insertion, converging, solid sole, rakers



Critical element: the main raker

multiple insertion, parallel, solid sole, rakers

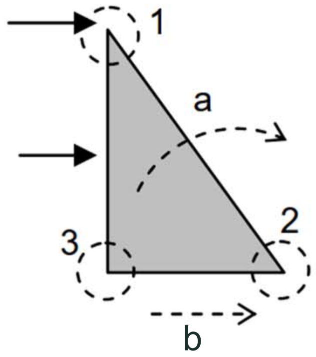
Shored wall area and supporting areas for each raker



H main raker insertion point
D span between shores
B sole length

Design Concepts – Solid-Sole Rakers

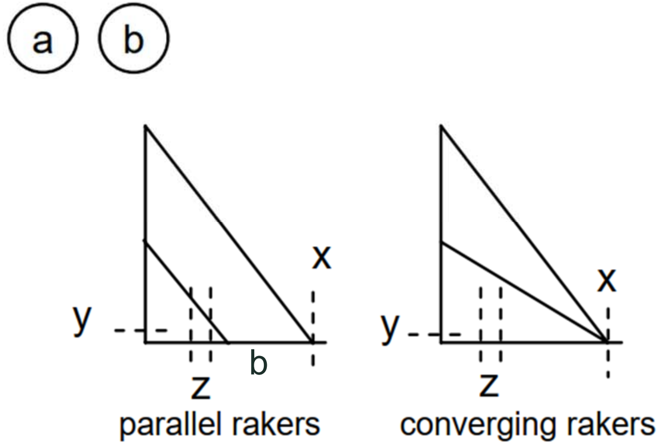
Critical considerations



Global considerations
a – global rotation
b – base sliding

Local considerations
1 – breaking of the top node
2 – breaking of the lower external node
3 – breaking of the lower internal node

Global solutions



x – installing a restraining system to avoid the base sliding outward

y – embedding the sole into the wall or
anchoring the wall plate to the wall

or, instead of y:

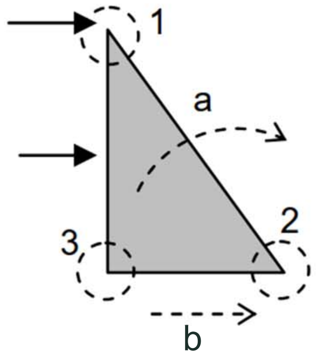
z – pinning the sole to the ground using solution A on page 7/15.
Nailing length shall be half the sole length and start from the wall end.

WARNING: the z solution shall be employed ONLY IF it is not possible to embed the sole into the wall. In this case the wall plate to wall interface shall guarantee enough friction as to prevent the upward sliding of the shore.

Vademecum STOP (2010)

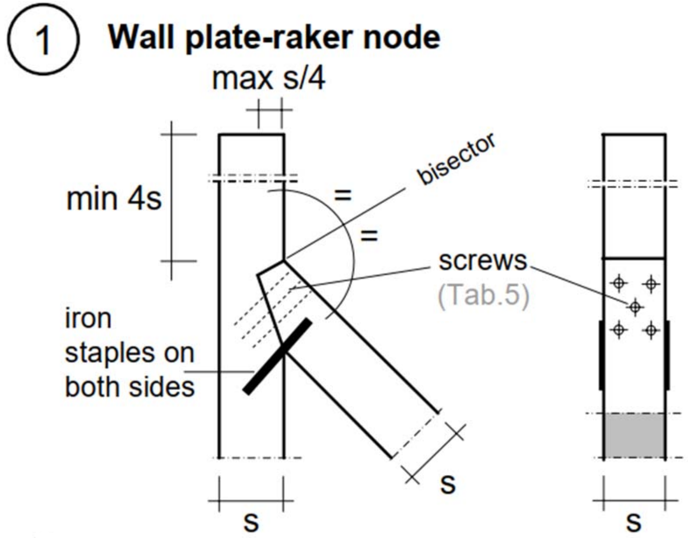
Design Concepts – Solid-Sole Rakers

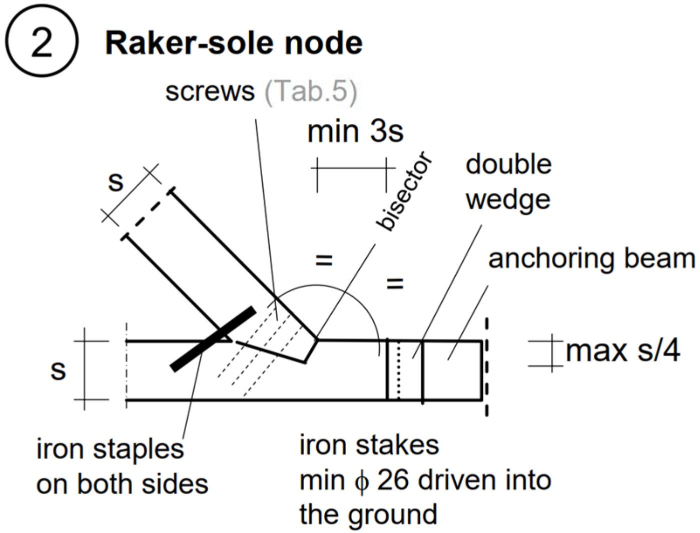
Critical considerations

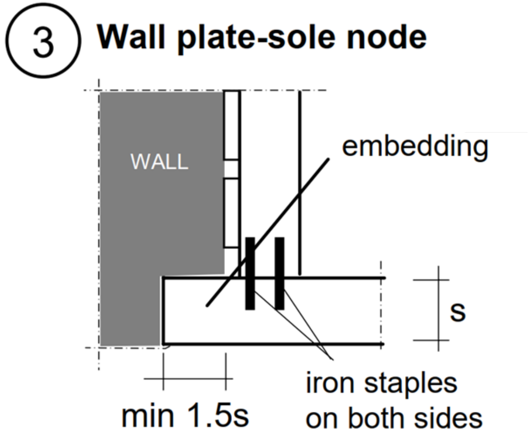


Global considerations
a – global rotation
b – base sliding

Local considerations
1 – breaking of the top node
2 – breaking of the lower external node
3 – breaking of the lower internal node

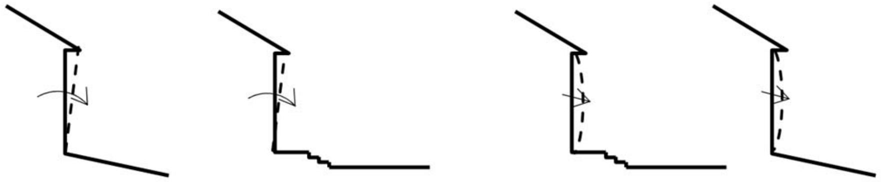






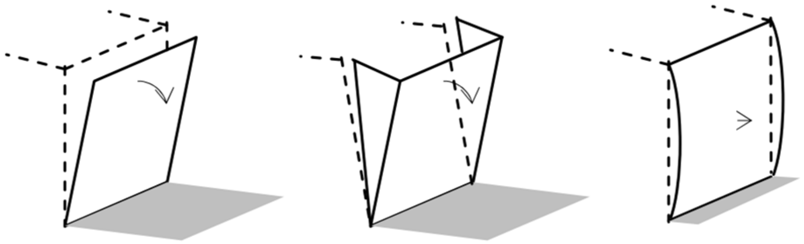
Vademecum STOP (2010)

Design Concepts – Flying Rakers



OUT OF VERTICAL PLANE ROTATION

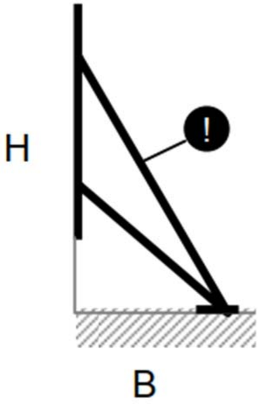
BULGING OF THE WALL



rotation

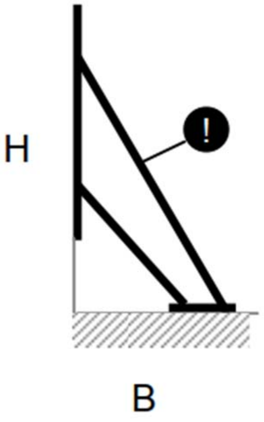
bulging

Vademecum STOP (2010)



Critical element: the main raker

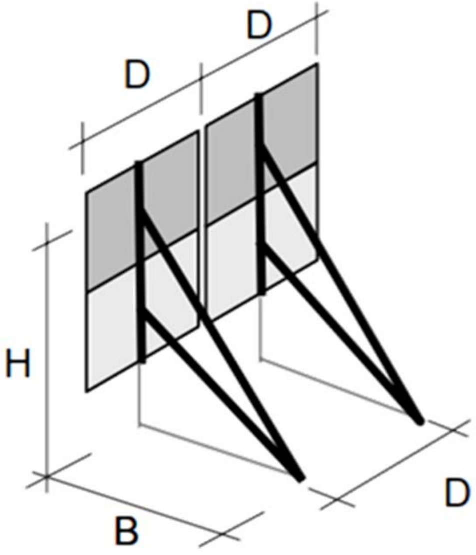
multiple insertion, converging, flying raker, on a single point base



Critical element: the main raker

multiple insertion, flying raker, on a short solid sole

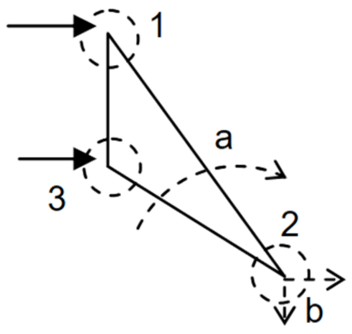
Shored wall area and supporting areas for each raker



H main raker insertion point
D span between shores
B sole length

Design Concepts – Flying Rakers

Critical considerations

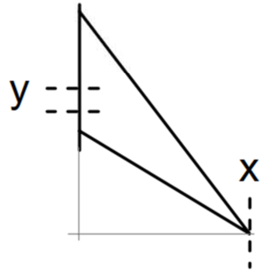


Global considerations
a – global rotation
b – base sliding/sinking

Local considerations
1 – breaking of the top node
2 – breaking of the lower external node
3 – breaking of the lower internal node

Global solutions

a b



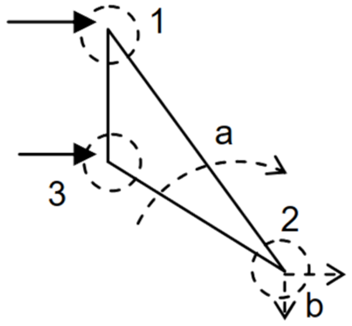
x – installing a restraining system to avoid the base sliding outward

y – anchoring the wall plate to the wall

WARNING: if the y solution is not possible, the wall plate to wall interface shall guarantee enough friction as to prevent the upward sliding of the shore.

Design Concepts – Flying Rakers

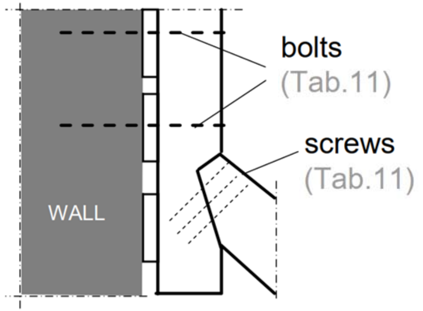
Critical considerations



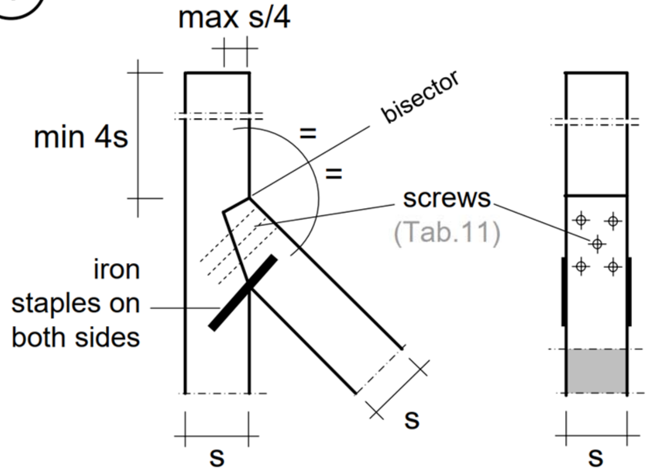
<u>Global considerations</u>
a – global rotation
b – base sliding/sinking

<u>Local considerations</u>
1 – breaking of the top node
2 – breaking of the lower external node
3 – breaking of the lower internal node

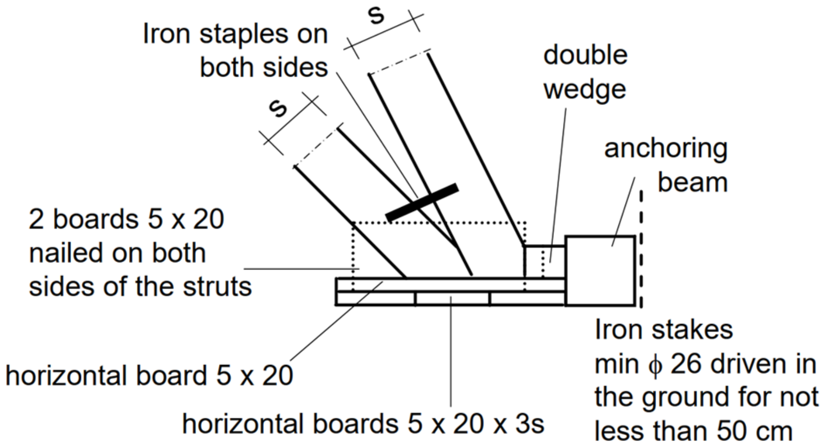
3 Wall plate-lower raker node



1 Wall plate-main raker node



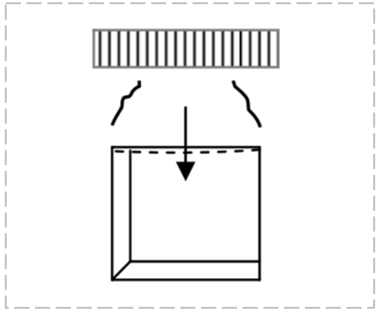
2 Lower node

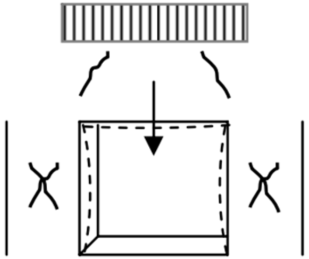


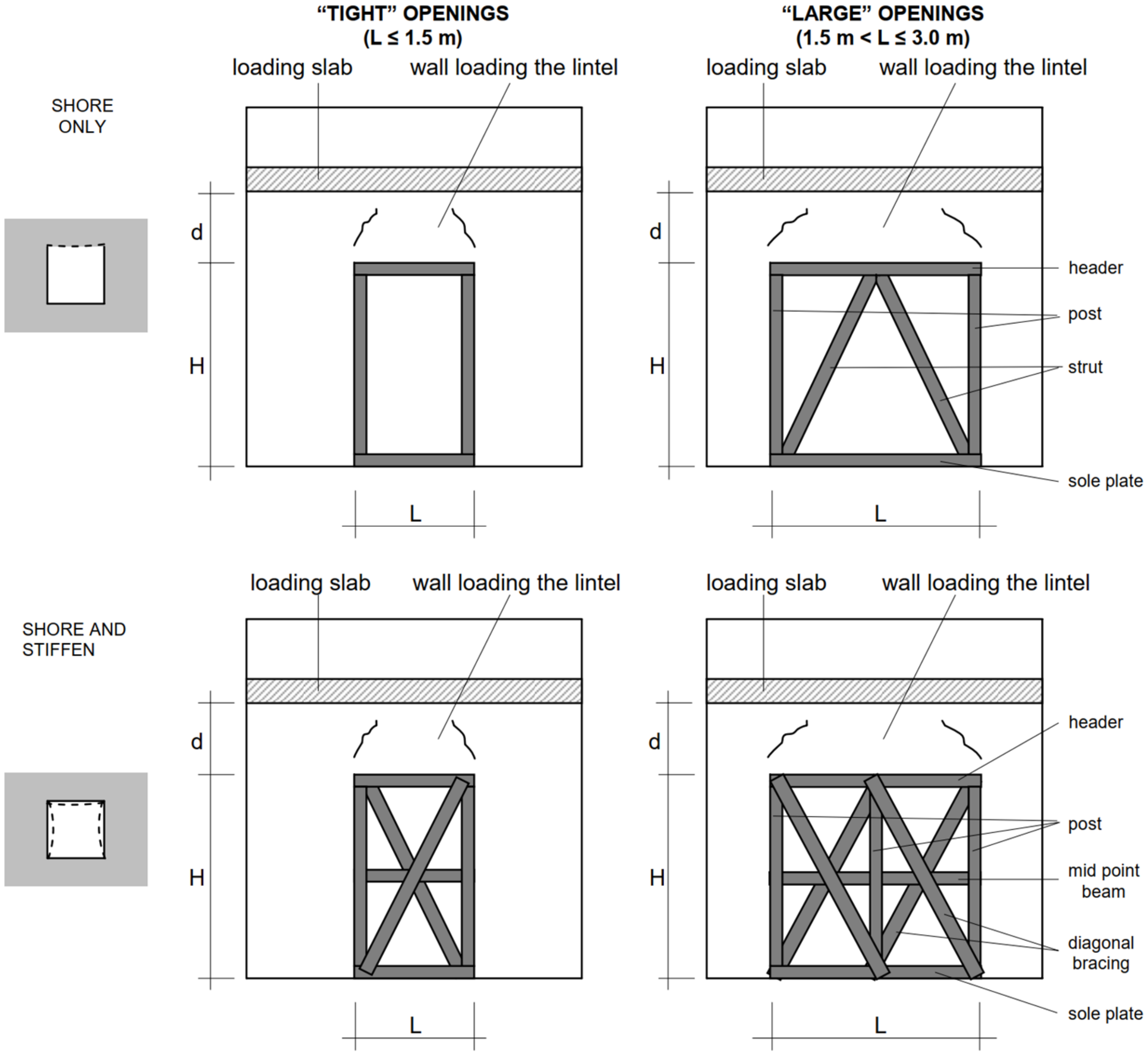
Vademecum STOP (2010)

Opening Shore

Movement to constrain:
breaking of a lintel and
lateral distortion (if present)



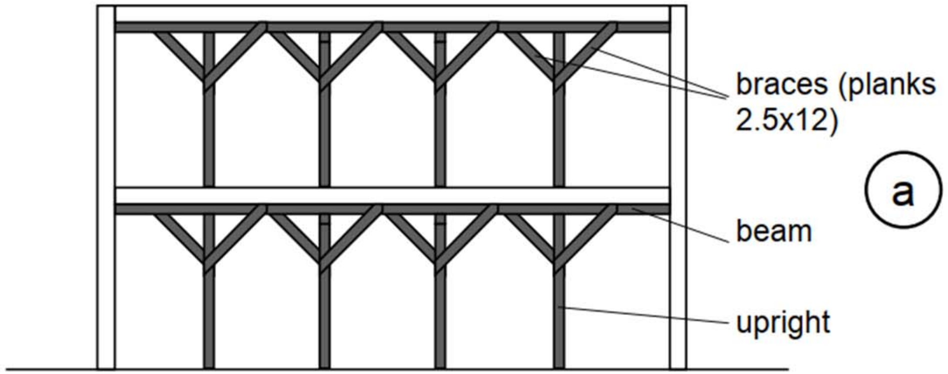




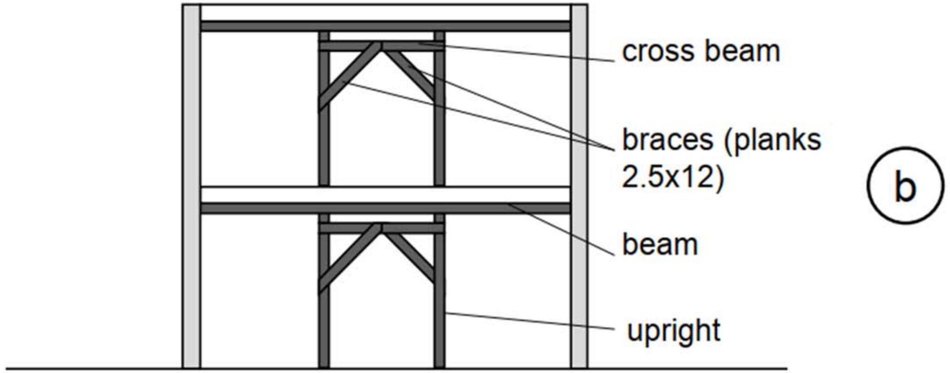
Vademecum STOP (2010)

Slabs and Balconies

SHORES FOR SLABS

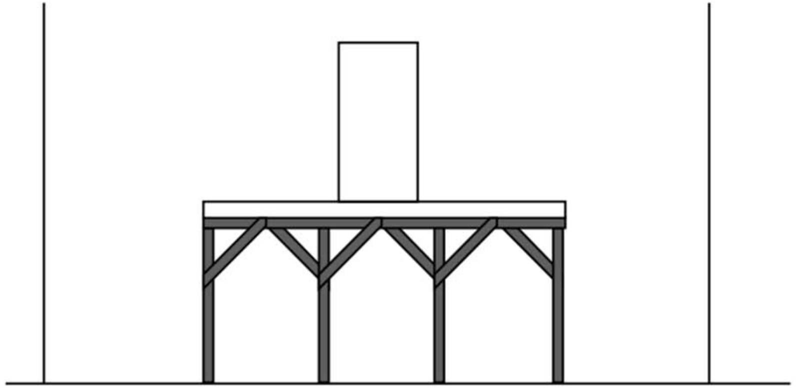


Longitudinal section

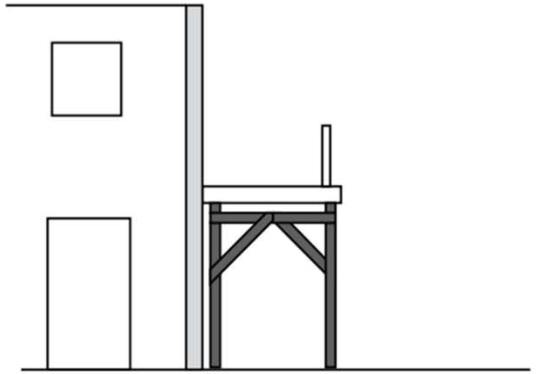


Transverse section

SHORES FOR BALCONIES



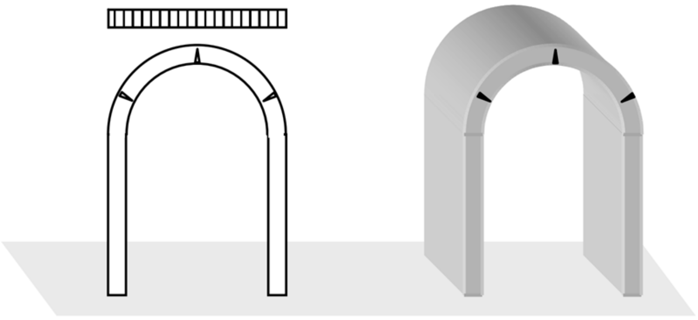
Longitudinal view

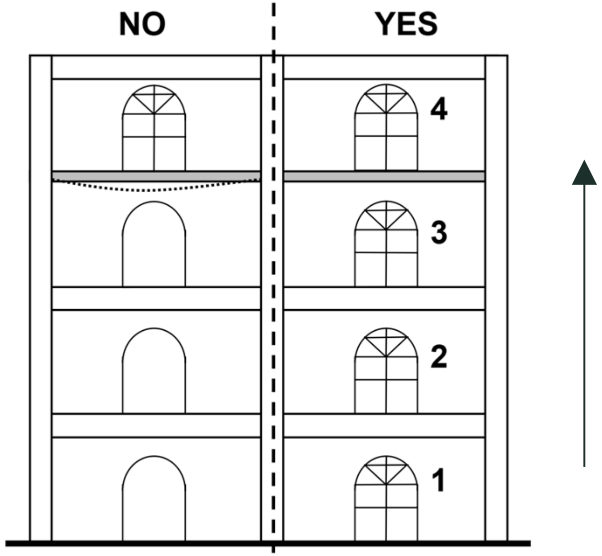


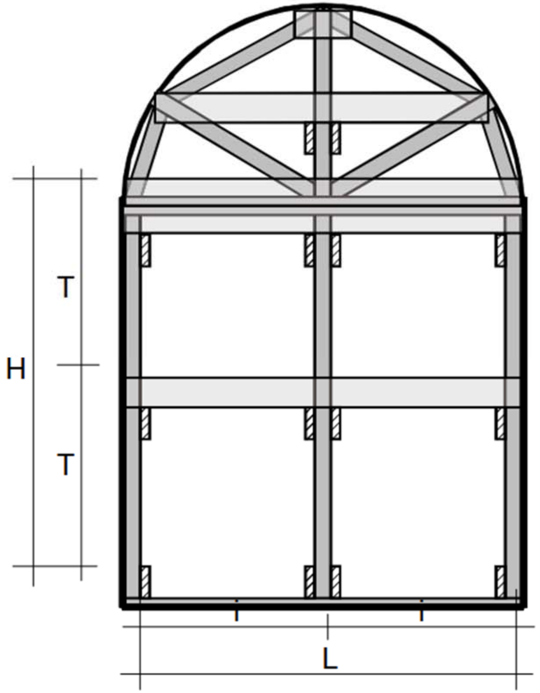
Lateral view

Vademecum STOP (2010)

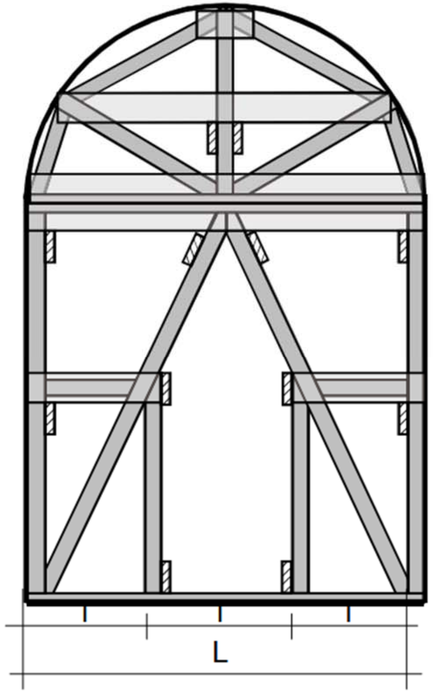
Arches and Vaults







Closed passage



Allowed passage

Vademecum STOP (2010)

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.
  - A typical shoring scenario would begin with the placement of Spot Shores to initially stabilize, followed by
  - Individual multi post shore systems with in-plane bracing, followed by
  - Pairs (or greater numbers) of multi-post shores that are X-braced together as two-dimensional systems.
- 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.

Shoring for URM Buildings

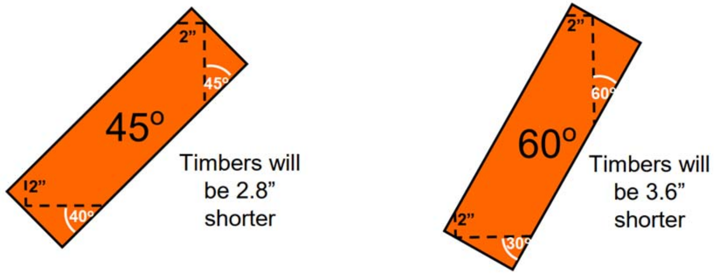
- Heavy walls.
- URM walls may be cracked (especially at corners) and need diagonal/raker shores.
- Cracked URM walls may also require shoring of openings.
- When URM exterior walls have collapsed, the remaining timber floors may require vertical shoring.
- When floors have collapsed, exterior walls may require shoring.

Shoring Sequence

Conduct a thorough **site assessment** to evaluate the structural damage and identify potential hazards.
Perform a detailed survey using a **six-sided approach** (all sides, top, and bottom) to determine the areas requiring support.
Develop a shoring plan that includes load calculations, shoring types, placement locations, and safety measures.

Gather all necessary **materials** (e.g., timber, steel, connectors, bracing) and verify their quality.
Set up a designated cutting and preparation area for measuring and cutting shoring components to the required dimensions.
Ensure all safety equipment is available, including PPE, monitoring devices, and evacuation tools.

Clear **debris and obstacles** from the area where shoring is to be installed to create a safe working environment.
Establish clear access routes for personnel, ensuring they remain free from obstructions and potential collapse zones.
Mark off hazardous areas with barrier tape or signs to restrict unauthorized access.



US DHS (2011)

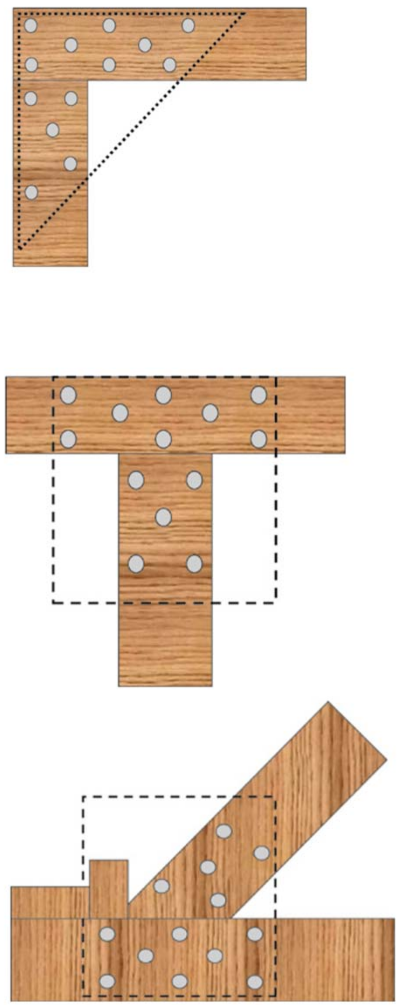
Universidade do Minho

Shoring Sequence

Mark the precise locations where shores are to be placed based on the structural assessment and shoring plan.
Ensure **alignment** with load-bearing elements (beams, columns, or walls) to optimize load transfer.
Use chalk lines or laser levels to achieve accurate measurements and placements.

Pre-**assemble** key components, such as headers, posts, and braces, to minimize installation time on-site.
Position sole plates on stable ground to distribute the load evenly and prevent settlement.
Begin installing vertical posts, ensuring they are plumb (vertically aligned) using levels.

Secure the shores using cleats, wedges, or fasteners to prevent movement.
Add diagonal bracing to increase the stability of the shoring system, especially if the structure is prone to lateral forces.
Tighten and adjust connections to ensure a proper fit and effective load distribution.



Calafato (2022)

Shoring Sequence

Apply initial pressure gradually to **test** the stability of the shoring system.
Observe for any signs of instability or shifting.
Make any necessary adjustments, such as tightening wedges or adding additional supports, to ensure safety.

Continuously **monitor** the shoring system throughout its use, particularly after significant loads are applied or removed.
Inspect all connections, braces, and supports regularly to identify any potential weaknesses or signs of failure.
Retighten or replace components as needed to maintain the integrity of the system.

Once the structure is stabilized or repairs are completed, carefully **dismantle** the shoring system **in the reverse order of assembly**.
Remove all materials and clear the site, ensuring it is safe for continued operations or access.
Conduct a final inspection to confirm that all shoring components have been removed and that no hazards remain.

Dimensions

Rapid assessment of material sizes and load capacities is crucial in emergencies to speed up shoring installation. Quick calculations help determine the dimensions of shores, headers, and sole plates needed to safely stabilize structures. Tables with average weight values are normally available in national norms or guidebooks, as well as in the selected references.

General Guidelines

For concrete slabs:

- A 12" (30.5 cm) concrete slab weighs approximately 732 kg/m².
- For thinner slabs, adjust proportionally: an 8" (20.3 cm) slab is about 488 kg/m².

For steel plates:

- A 1" (2.54 cm) steel plate has a load of around 195 kg/m², decreasing as thickness reduces.

For wooden floors or joists:

- Typical loads range between 50-122 kg/m², depending on the type and spacing.

Placement Considerations

Start shoring **from stable areas** and **progress towards more unstable sections** of the structure. In wood and steel-framed buildings, **begin shoring at least one floor below the damaged area**; for concrete structures, start at least two floors below.

Align shores directly under load-bearing elements (e.g., beams, columns) to ensure effective load transfer. Avoid placing shores where they may interfere with debris removal or rescue operations.

Ensure **adequate spacing** between shores to provide consistent support and prevent overloading individual supports. Use **diagonal bracing** to enhance the stability of shoring systems, especially in tall or heavily loaded applications.

Maintain **clear access routes** for rescue teams and equipment. Shoring should not block entry or exit points. Ensure shores do not obstruct critical pathways needed for safe evacuation of personnel.

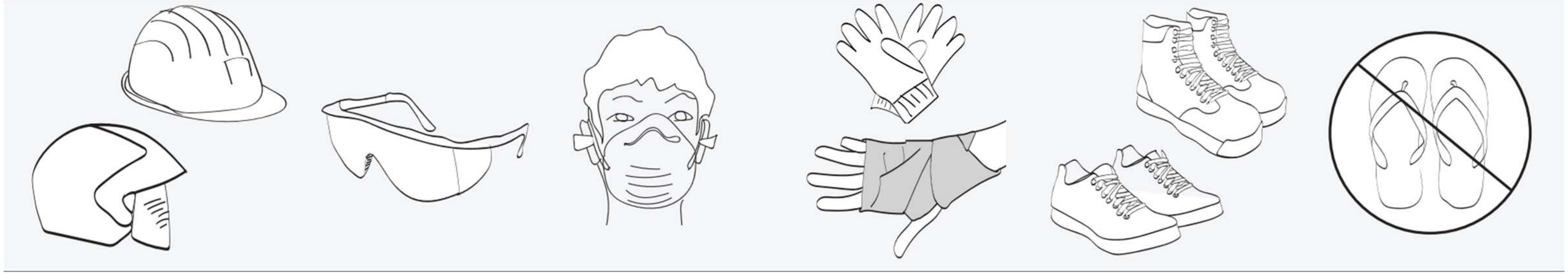
Key Monitoring and Safety Practices

Continuous Monitoring: regularly inspect shores for signs of stress or instability, especially after heavy loads or environmental changes (e.g., aftershocks, strong winds).

Safety Protocols: minimize personnel exposure in high-risk areas; restrict access to essential workers only. Set up clear emergency signals (e.g., air horns) to alert teams of structural movement or imminent danger.

Load Reassessment: Continuously evaluate load distribution as debris is removed or new loads are applied. Retighten or adjust shores as needed to accommodate shifting loads during the stabilization process.

Use of **Personal Protective Equipment** (PPE): Ensure all personnel wear helmets, safety boots, gloves, and other necessary PPE. Enforce the use of fall protection gear when working at heights or on unstable surfaces.



ISISE

Institute for Sustainability and Innovation in Structural Engineering

Emergency Forms

WWW.ISISE.NET

Universidade do Minho

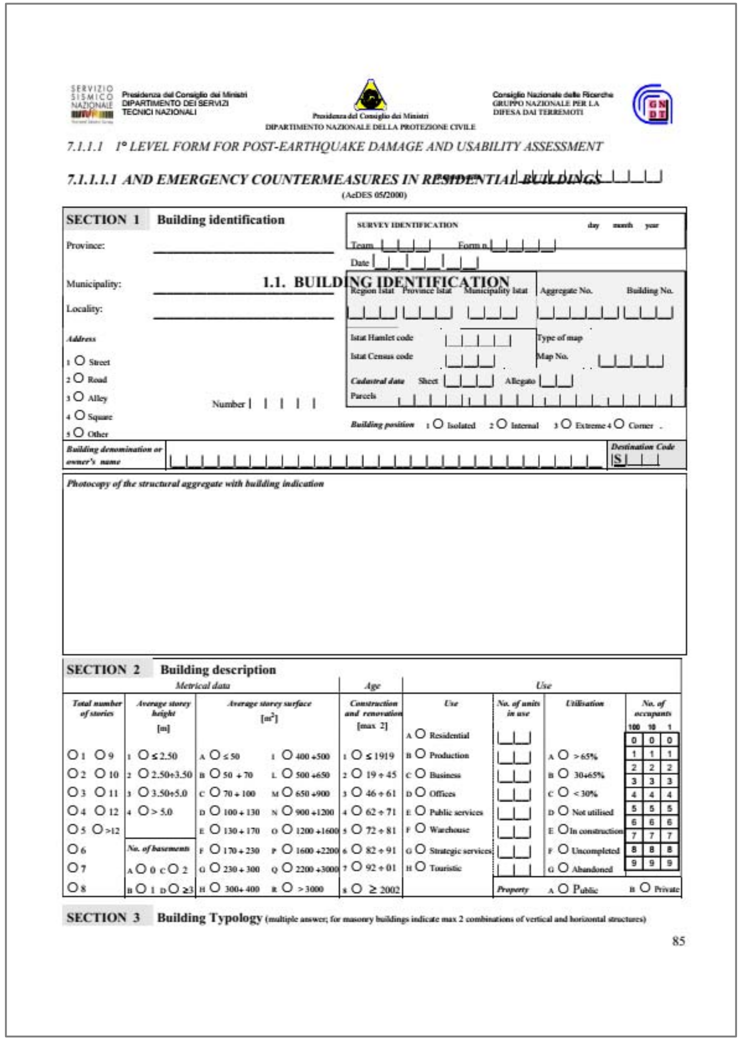
Emergency Forms – Survey Levels

- **Level 0.** Rapid post-event inspection.
  - ◇ Immediate operations by civil protection.
  - ◇ Macroeconomic evaluation of after-effects.
- **Level 1.** Complete post-event inspection.
  - ◇ Evaluation of event intensity / damage caused.
  - ◇ Assessment of economic damage.
  - ◇ Habitability judgment.
- **Level 2.** Rapid vulnerability analysis.
  - ◇ Definition of structural vulnerability.
  - ◇ Prediction of structural behavior.
- **Level 3.** Detailed vulnerability analysis.
  - ◇ Survey of the masonry system to enable the application of simplified structural analyses based on the identification of in-plane and out-of-plane failure mechanisms.
  - ◇ Selection of intervention measures

Emergency Forms – Level 1

- **Damage Assessment – Phase 1**
  - ◇ Within 1 week after the event.

- **Example: AeDES**
  - ◇ Applicable to general and residential buildings.
  - ◇ Divided into 9 sections.
    - Building identification.
    - Building description.
    - Building typology.
    - Damage to structural elements.
    - Damage to non-structural elements.
    - External risk induced by other constructions.
    - Soil and foundation.
    - Usability assessment.
    - Notes.

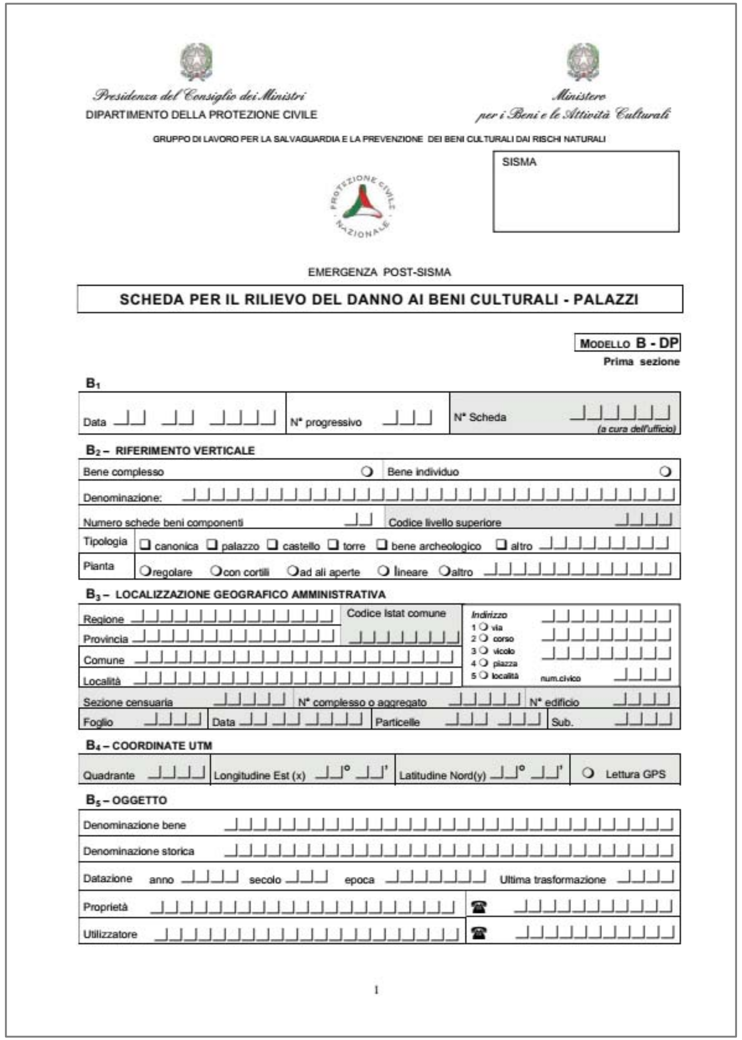


Field Manual for post-earthquake damage and safety assessment and short-term countermeasures (AeDES)

Emergency Forms – Level 2

- **Damage Assessment – Phase 2**
  - ◇ Within 2 weeks after the event.

- **Example: DPCM 23.02.2006 (in Italian)**
  - ◇ Damage assessment on churches and palaces.
  - ◇ Divided into 32 sections.
    - ▪ Deeper level of information and knowledge.
    - ▪ Higher technical requirements.
  - ◇ Catalogue of collapse mechanisms of churches
  - ◇ Catalogue of collapse mechanisms of palaces.



Presidenza del Consiglio dei Ministri
DIPARTIMENTO DELLA PROTEZIONE CIVILE

Ministero per i Beni e le Attività Culturali

GRUPPO DI LAVORO PER LA SALVAGUARDIA E LA PREVENZIONE DEI BENI CULTURALI DAI RISCHI NATURALI

SISMA

EMERGENZA POST-SISMA

SCHEDA PER IL RILIEVO DEL DANNO AI BENI CULTURALI - PALAZZI

MODELLO B - DP
Prima sezione

B_1
Data | N° progressivo | N° Scheda (a cura dell'ufficio)

B_2 – RIFERIMENTO VERTICALE
Bene complesso | Bene individuo
Denominazione:
Numero schede beni componenti | Codice livello superiore
Tipologia: canonica, palazzo, castello, torre, bene archeologico, altro
Pianta: regolare, con cortili, ad ali aperte, lineare, altro

B_3 – LOCALIZZAZIONE GEOGRAFICO AMMINISTRATIVA
Regione | Codice Istat comune | Indirizzo: 1 via, 2 corso, 3 vicolo, 4 piazza, 5 località
Provincia
Comune
Località | num.civico
Sezione censuaria | N° complesso o aggregato | N° edificio
Foglio | Data | Particelle | Sub.

B_4 – COORDINATE UTM
Quadrante | Longitudine Est (x) | Latitudine Nord(y) | Lettura GPS

B_5 – OGGETTO
Denominazione bene
Denominazione storica
Datazione: anno, secolo, epoca | Ultima trasformazione
Proprietà | ☎
Utilizzatore | ☎

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Ministerial Forms for the Survey of Damage to Cultural Heritage (DPCM)

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Emergency Forms and Stabilization

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