ALL HANDS VOLUNTEERS

SMALL STUCTURE DEMOLITION MANUAL

PROJECT NEPAL

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Prepared in Conjunction with Engineers Without Borders

ENGINEERS WITHOUT BORDERS USA

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1 Introduction

All Hands Volunteers, Project Nepal (AHV) is assisting the affected populations of the April 25, 2015 Nepal Earthquake and its significant aftershocks. Their program largely consists of three projects:

1. Safe demolition of structurally unsound buildings
2. Clearance of debris and salvage of reusable building materials
3. Construction of Temporary Learning Centers and temporary housing.

To assist with the safe demolition of structurally unsound buildings, AHV has teamed up with Engineers Without Borders (EWB) to develop this Program Manual to be used as a reference to guide program development and execution. The intent of this Manual is not to be the sole resource for demolition activities, but one of many, and it is always recommended that an engineer or demolition expert is consulted in more complex demolitions.

1.1 Background

The April 25, 2015, 7.8 Richter earthquake in Nepal followed by the multiple aftershocks including the 7.3 aftershock on May 12th was a major disaster. It left 489,000 houses totally destroyed and 267,000 damaged. There is also widespread critical damage and destruction to schools, community and government buildings. A large number of these structures that have failed are currently a safety hazard to the public and are in need of being fully demolished. Partially collapsed buildings are in need of being brought down and cleared in order for rebuilding to commence. It is essential during the clearing process that reusable building materials are salvaged so homeowners can have the maximum amount of materials needed to begin reconstruction.

The All Hands Volunteers teams, Nepal Engineers' Association and other NGO's have been conducting assessments for demolition in the Kathmandu and Sindhupalchowk districts. In Kathmandu, the AHV team noted that there are a high number of precariously positioned buildings which pose significant risk to the local population. A number of these buildings (5+ stories) are considered complex demolition and are currently not within AHV scope of capabilities; others are smaller and within scope of AHV's capabilities. However, current commitments from the government to provide homeowners with cash grants for their destroyed homes are causing homeowners to be left in the position of refusing debris assistance until government officials inspect and confirm the damage.

An AHV assessment team visited Sindhupalchowk from 12th- 15th May. The reports of 95% total damages from government sources were clearly verified upon visual inspection. The majority of households are composed of rock/stone walls, mud mortar and wooden beams. The assessment team visited a total of nine Village Development Committees (VDCs) from Sindhupalchowk capital VDC – Choutara to mountainous terrain VDC – Ichok.

The Nepalese Army has been tasked by the government with the job of handling the demolition needs in the affected areas. Discussions between AHV and the Nepalese army have found that the Army is without the necessary resources/equipment needed for effective demolition. They are requesting partnership assistance in tools and demolition expertise. A large number of organizations are focusing on the need for immediate humanitarian relief and the early recovery activities are very much in the planning stages. The situation is coming under critical pressure due to the incoming monsoon season. Due to limited suitable land space in the mountainous terrains of Sindhupalchowk, it is imperative that destroyed homes are cleared and spaces provided for rebuilding or shelter assistance.

AHV and EWB volunteers returned to Sindhupalchowk the weeks of June 6-17th to assess buildings and perform practice demolitions. The VDC and the Army asked that AHV focus on school buildings for demolition and debris removal, and the Team looked at several schools in the Melamchi area. The army also said that they did not have any heavy equipment to assist with demolitions, so the types of demolitions undertaken were limited to smaller/simpler construction. A single story stacked stone with mud mortar and metal roof school was selected for the first demolition site. This is a very common type of construction for the area and easily falls within the scope of AHV's demolition expertise and can be

performed with hand tools. In order to get practice with different types of building construction, a two story, stone and mud mortar school with a wood trussed roof was demo'ed, followed by private residence consisting of a two story stone with mud mortar building with a concrete slab roof over one section and a wood trussed roof over the remaining structure. Detailed approaches to these types of buildings are provided in Section 6.

Prior to providing general and specific demolition procedures, this manual first outlies safety procedures to be followed, describes the common type of building construction found in Nepal, outlines assessment techniques, and provides shoring and bracing recommendations.

1.2 The History of the AHV Demolition Program

The All Hands Volunteers demolition program began after the Pedang earthquake of 2009 in Indonesia. The AHV assessment team of Sungai Geringging district found that the earthquake had caused a large number of homes to partially collapse and/or become structurally unsound, posing a safety threat unless they were further demolished and taken down. In consultation with community members it was found that families did not have the knowledge or resources to bring down the houses safely without risk to personal injury.

AHV, with the use of engineers, was able to look at ways in which homes could be brought down in a safe manner without the use of heavy machinery. Machinery was largely not available and the locations of households were inaccessible to such machines. Volunteer team leaders were trained up over time from the guidelines set by the in-house engineer. This information and training was then passed from team leader to team leader throughout the project.

Following the Haiti earthquake and 250,000 houses destroyed, AHV again initiated the debris management program. This bought forward a different type of building with heavy concrete roofs and more complex construction/demolition. The demolition work ran for a total of 18 months and was deemed a success, bringing down 117 unsafe structures, complimented by the debris clearance work which provided the clear foundations for 259 spaces to start rebuilding their homes. Over the years, concerns of safety lapses have come from both volunteers and staff in regards to the demolition program.

The last major demolition program was established in the Philippines following the Bohol earthquake in 2013. The Nepal project team discussed at length the activities of the program, including its successes and areas needing improvement.

As with Indonesia and Haiti, the demolition program is always initiated and led by a qualified engineer who sets the tone of the program in regards to process, guidelines and safety. This is then passed from volunteer team leader to team leader as volunteers can only stay for a limited amount of time. It was noted that this adherence to safety and guidelines was diluted with the passing of responsibilities from team leader to team leader. In addition, tools were compromised on numerous occasions, largely due to teams using tools for purposes other than their original design or lack of post use care and maintenance. This lack of effective tool management was costly and caused losses in efficiency, relying on numerous purchase trips or external personnel bringing in more tools. Overall coordination to the program was lacking as there never was an appointed program person responsible to ensure best practices were kept.

1.3 Demolition program in the Nepal context

Over 700,000 houses have been destroyed or severely damaged in Nepal. Community members are requiring assistance in safely demolishing their homes as they currently lack the resources or knowledge to do so. This request for assistance has also come from the army, facing a similar lack of qualified resources, but the added responsibility of being tasked by the government for overall demolition.

The Government of Nepal, Ministry of Urban Development has issued a Draft "Guidelines for the Demolition of Risky Structures due to Earthquake 2015". A copy of these Guidelines is provided in Appendix C. These are the Draft Guidelines and changes may and likely will occur. The Guidelines outline the procedures for identifying those buildings that require demolition and the responsibility of various agencies for providing or obtaining approval for demolition. It is recommended that these guidelines be referenced and approvals be obtained prior to demolition of specific structures. Given that these guidelines are in the Draft stage, this Manual does not address the process or procedures for

obtaining authorization for demolition, and leaves it to the reader to ensure that the appropriate approvals are obtained.

The buildings differ in Nepal by location. Kathmandu structures tend to be built with a reinforced concrete column and beam lattice structure, with the connecting walls built with unreinforced red fired brick with cement mortar. Buildings in the city are high with numerous 6 story buildings which are now dangerously situated and if not brought down, can fail and collapse completely with following aftershocks. Sindhupalchowk structures utilize natural building materials of mountainous rocks and mud mortar, approximately 95% of these buildings in the district were unable to withstand the 7.8 quake.

The early recovery cluster is a working group found within OCHA that aims to coordinate efforts that include demolition and the effective management of debris. Analysis from the AHV team has shown that there are not a large number of agencies working within demolition. A handful of teams are in planning phases, but are yet to roll out any activities. Agencies within the cluster are developing plans that include key messages to be delivered to communities that can teach homeowners how to demolish structures themselves. The army appears to be the only group at present actively demolishing structures.

Given this current need, but thinking of long-term replicability, the AHV demolition program should undergo a re-design, bringing forward a more process driven approach that has safety and professionalism at its forefront. For that reason, AHV sought out the support of EWB and their experienced civil and structural engineers to assist in the program development. The goals of this will be three fold:

1) Assist the people of Nepal in the most effective manner for them to be able to start the recovery process and have access to shelter.
2) Provide AHV personnel a safe environment to work, which actively strides towards minimizing risk at the work site.
3) Create the most effective international demolition program that can be deployed to assist communities in the wake of a disaster.

The Manual seeks to provide information to assist in the implementation of all three of these goals.

2 Safety

2.1 Introduction

Safety is of primary importance on all projects. Demolition is inherently risky as you are attempting to bring down already compromised structures, and they can move in unexpected and dangerous ways. The first and foremost thought in any demolition plan should be; “can this be done safely and in a way that protects and ensures no damage to volunteers, the public, and/or the surrounding property?” That should be the goal of all demolition plans, and the plan should not be executed until the answer to that question is an unequivocal yes. It may be hard to walk away from a structure that cannot be brought down safely within the scope of AHV’s existing equipment and expertise, but that unfortunately must be the response.

2.2 Safety Concerns

There are multiple safety concerns associated with the assessment and demolition of earthquake damaged buildings and all these concerns should be assessed and addressed prior to beginning any work.

- Teams should have access to a first aid kit and cell phones or other means of communication for use during an emergency. The cell phone should never be on the person who is performing work within the structure.
- All assessment and demolition work should be performed with a minimum of teams of two at all time. One person should be watching from a safe distance while the other person is working within or next to the structure.

- All personnel shall have proper Personal Protective Equipment including hardhats and hard soled boots/shoes at a minimum. Gloves, dust masks, safety glasses should also be worn as the work warrants.
- Start each day with a safety briefing to all members of the team. Make sure they are all aware of the days plan, the hazards identified, the Key Safety Words and their meanings, and make sure there are no questions or concerns. An example Safety Talk is provided in the next section.
- The damaged building should initially be assessed from a safe distance and walked around to identify areas of concern. Any portions of the building that look as if collapse is eminent or if they would quickly collapse in the case of an aftershock should be avoided.
- Never assume that conditions are the same from one place in the structure to the next or from one instant in time to the next. Always check support, braces and ropes as the building changes and throughout the day.
- Identify any utility lines including downed power lines. Attempt to confirm from owner that utilities have been disconnected and confirm for yourself. It is always safest if you can hold the disconnected end of the power line in your hand to confirm it has been disconnected.
- Identify safe exit routes from all parts of the building. Make sure that they are free from debris, tripping hazards, broken glass, nails in boards, exposed rebar, edges of tin sheets, exposed metal, holes, pits, etc., and/or clear them of such. Look for overhead debris that may come loose and block the escape routes. Clear debris as the work progresses to ensure continually clear exit routes. Every time you go into a new room, immediately re-evaluate and determine your new exit route.
- Shoring should be done carefully and completely. Make sure all shoring materials are free from defects that may cause premature or catastrophic failure if subjected to loads, e.g. knot holes, cracks, bolt holes, etc. Shoring should error on the side of being overly conservative. Make sure that you have analyzed for progressive failures, i.e. if the load shifts and this piece of shoring gives way, what will pick up the load and will it be able to handle it.
- Attempt to block access by the public to the building, especially after shoring is complete as they may now assume the building is safe to enter. Use danger or caution tape across openings.
- After shoring is completed, all other personnel affects or other salvage material should be removed from the building to preserve the materials and clear the area prior to demolition. During this process, a person should be identified to regularly assess the shoring and building structure to make sure it has not shifted or moved. This should be done at regular intervals throughout the day and every day prior to the start of work.
- Plan for the demo, go over the plan, and go over the plan again. Make sure that everyone understands it. Make sure that all load bearing members are identified, and make sure the load paths are thoroughly understood, including the changing of the load paths as portions of the building are brought down. If there is any disagreement as to what may occur, assume the worst case and plan for that.
- Make sure that people stay out of the collapse zone (1.5 times the height of the building) unless they are actively working on something within that zone.
- Locals and the home owner will likely want to help. Make sure they adhere to the same safety protocol as AHV. Make sure they understand what is happened and do not demo'ing or going into areas that are not yet stabilized. Provide them with extra PPE if available.
- Make sure the correct tools are used for the job and that they are all in good condition. Check the ropes or cables to make sure they are not frayed or compromised in any way.
- Prior to the drop, make sure everyone again understands what is going to happen and what their role is. Make sure that everyone understands that they can call "Stop" at any time if they have any concerns.
- Make sure you always have spotters placed at strategic locations to keep the public or animals, etc. out and who are watching for movement in the building. Make sure that they do not have multiple tasks that will cause distraction.
- Make sure everyone has identified a safe escape route and that it is clear from debris and other hazards. When working in groups, make sure everyone had their own escape route and that they tell each other what they are. Do not stand directly behind a person or between them and their escape route.

- If possible, reduce noise and other distractions to make sure all members can hear one another.
- Alert nearby homeowners or neighbors prior to beginning the demo.
- Do a last safety check prior to beginning to make sure the area is clear of people, animals, and tools.
- Make sure that any shoring that needs to be removed can be done safely from a distance.
- Metal and physical fatigue should continually be assessed throughout the day. Make sure people take breaks and rehydrate at regular intervals. Stop work if it is too hot/cold. Don't keep working just because there is day light left. It is the Team Leader's responsibility to watch for fatigue and to stop work BEFORE people are too tired to work safely.

2.3 Safety Talk

A MANDATORY safety talk will be made on site by the team leader at the start of every workday, prior to the commencement of work, and stressing the following things:

- The key safety words and their meanings.
- Wearing a hard hat and other PPE at all times when inside or in close proximity to the structure.
- Identify site hazards.
- Always know your escape to safety and ensure it is clear. Ensure that each team member has their own exclusive escape route.
- Consider how different areas of the building are affecting each other. Evaluate and determine the potential consequences of every action onsite.
- Do not begin a task unless it has been approved by the team leader.
- Do not use tools/equipment unless trained.
- Ladder safety, ALWAYS have it tied or footed by someone.
- Be aware where the phone and medical kit are, the phone should never be on a team member who is performing hazardous activity.
- Any team member leaving/arriving on site must notify team leader.

Key Safety Words:

These words are essential and should always be yelled loudly.

"STOP"	Means stop. Everyone stops working immediately until the reason for the call has been assessed and remedied.
"CLEAR" or "OUT"	Exit the building or move to a safe area immediately. Spoken when any Team member sees a situation that is unsafe and could lead to the structure collapsing.
"EYES ON?"	Request to a spotter to observe the structure while you are preforming a potentially dangerous activity.
"WATCHING"	A confirmation from the Team member that they have heard you and are watching for dangers while you are working.

3 Common Structures in Nepal

As shown in the following figures by Dr. Gokarna Bdr. Motra, 44% of buildings in Nepal are mud bonded brick or stone, 25% are wooden pillar, 18% are cement bonded brick or stone, and 10% are reinforced concrete frames. 90% and 93% of the mud bonded brick/stone and the wooden pillar construction respectively are found in the rural areas. The RCC framed structures are located in both the urban and rural areas, as are the cement bonded brick/stone. The stacked stone building generally have a tin roof supported by wood or metal trusses. The RCC structures generally have concrete slabs for the floor and roof and brick infill for the walls.

FIGURE 1 - Total Building Stock in Nepal

Area	Total	Type of foundation of house					Not stated
		Mud bonded bricks/ stone	Cement bonded bricks/ stone	RCC with pillar	Wooden pillar	Others	
Nepal	**5,423,297**	**2,397,441**	**952,702**	**539,004**	**1,350,151**	**126,281**	**57,718**
Urban/Rural							
Urban	1,045,575	229,733	399,479	297,117	89,343	10,852	19,051
Rural	4,377,722	2,167,708	553,223	241,887	1,260,808	115,429	38,667
Ecological Belt							
Mountain	363,698	337,421	7,893	2,954	11,562	1,206	2,662
Hill	2,532,041	1,641,237	343,461	324,881	187,836	7,493	27,133
Terai	2,527,558	418,783	601,348	211,169	1,150,753	117,582	27,923

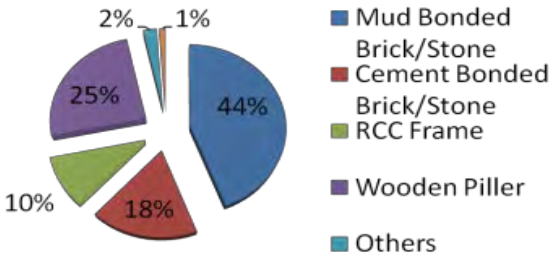
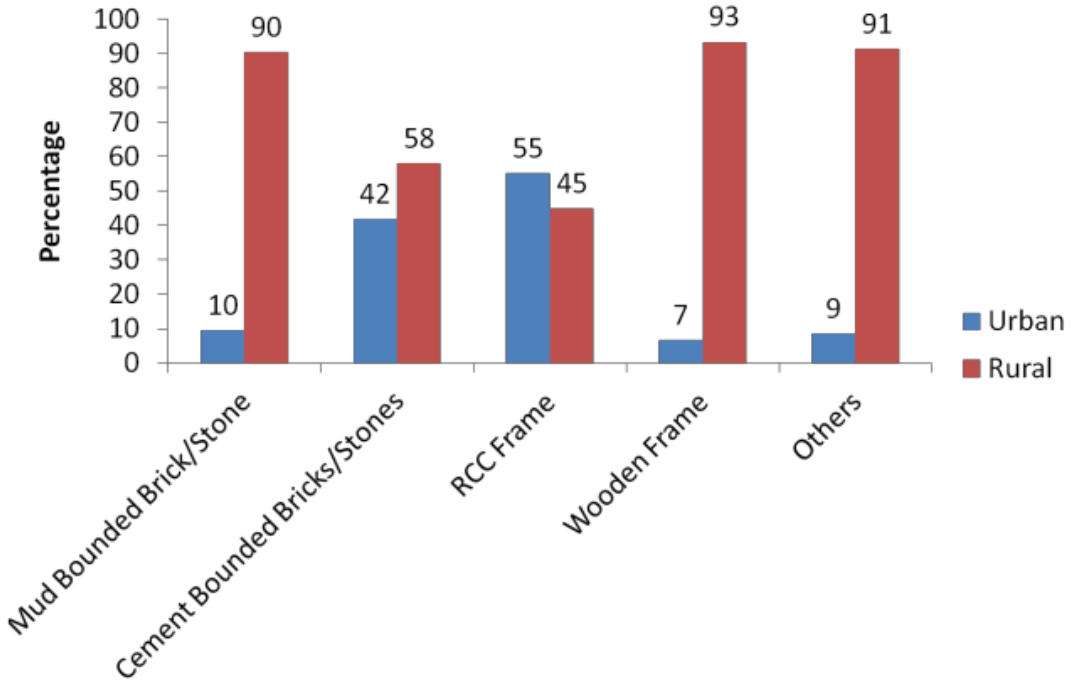


FIGURE 2 - Household Types in Urban vs. Rural Areas



Vertical construction is very common in Nepal, with two and three or more stories very common, even with stacked stone structures. Plan and vertical irregularities are also extremely common, with uniform floor plans very much the exception. These irregularities frequently are the cause of non-uniform movement and failure at the points of contact. Structures also typically have water tanks on the roof. They are frequently fairly well restrained, although there are some that are placed on very poorly constructed platforms that subsequently failed. Construction methods in all types can vary widely in technique and quality. Reinforcement bars are often undersized and lack stirrups and are not placed with sufficient penetration or hooks at joints to prevent pull-out. Reinforcement also tend to be at the bottom of any structure where it was installed.

Rebar exposed at the bottom of a beam due to lack of support in forms during construction

Column pulled out of beam due to lack of hooks

3.1 Stacked Stone

This is a very common building type in rural areas. Natural stones are either dry stacked with dirt mortar or with cement grout. Frequently the majority of the structure is built with mud mortar, with concrete used at the anchors for the doors and windows and/or for concrete lintels above or below doors or windows. Walls are usually two layers of stone thick, and the two layers frequently act as separate structures. The foundations are also placed stone or concrete slab or perimeter footings. Second or third story floors are frequently wood beams and floor joists covered with mud plaster. A wooden lintel is placed across the top of the stones at or near the roof line, with a layer of rock placed on top of the lintel.

Roof trusses are wood or metal. Metal trusses may have rebar placed into the walls and the rocks stacked around it to anchor it, or are nailed via a metal plate to the wooden lintel and tack welded to the truss as an anchor. Wood trusses may be nailed to the lintel or may simply be placed on it and stone stacked around them to anchor them.

Doors and windows typically have a metal hook on the inside of the frame (top and bottom of both sides) that is placed into the wall and rock placed over or a blob of concrete poured around it to anchor it to the walls. These door and wall anchors typically are very effective at tying the walls together and should be

removed prior to demolition. The anchor can be pried off the door/window frame, or the wall deconstructed around the anchor to release it.

Walls maybe covered with plaster, which helps to bind the wall together and prevent the mortar from being washed out. The plaster also is very effective at holding the wall together and needs to be removed or cracked to release the wall at the point where you want it to fail. Interior walls are stacked stone as well and may or may not have stones that extend into the exterior wall.

There were also several schools in Sindhupalchowk that were constructed by a Japanese aid organization. They have a metal frame structure that holds the metal framed roof on and is anchored onto metal columns that extend to the ground and a concrete footing. These round columns are enclosed within stacked stone columns and interior and exterior stacked stone walls. The stacked stone walls of these buildings generally have even less tying them together, so frequently failed, however the roof column system was not damaged and can be reused, with the walls again constructed around them.

Three story stacked stone structure. Note that windows do not have anchor hooks, which likely contributed wall failure.

Stacked stone structure with wooden lintels on top of wall which steel roof trusses are anchored to.

Note metal anchor from window frame set into (and separated from) concrete anchor

School built by Japanese consisting of metal framed structure. Note that the stacked stone end and divider walls have failed, but the metal columns and roof trusses are sound and are anchored to concrete footings.

3.2 Reinforced Concrete Frame with Brick Infill

This is the most common type of construction in Kathmandu and for the larger buildings in the rural areas. Reinforced concrete columns form the vertical support of the building, and reinforced concrete beams form the horizontal support. The floor and roofs are constructed of reinforced concrete slabs. The Concrete beams and columns form the frame work and the internal and external walls are infilled with brick and are generally not tied to the columns. These walls are very weak and frequently failed. The strength and stability of the building depends largely on the quality of the construction including the quality

and size of the rebar and the quality of the concrete. The quality of construction varies widely from building to building, with some being very well constructed, and others very poorly constructed.

Foundations – Generally the concrete columns are sitting on a concrete footing that varies in footprint size and thickness. The floor is a concrete slab, approximately 4 to 6-inches thick and may or may not have reinforcement.

Columns & Beams – Typically 10-inches (25 cm) square with 4-rebar,usually #4 rebar, arranged in a square. The rebar usually has stirrups holding it together, but their presence depends on the quality of construction. The columns and beams are generally tied into each other and the slab rebar in the roof or floor slabs, usually by simply extending the rebar into the beam or slab a few inches, they frequently do not have hooks on the end of them. The columns and beams are the primary support for the roof or upper floors.

Walls are unreinforced brick joined with mortar. They offer very little structural support and frequently failed. If the beams and columns are structurally sound, the walls can simply be rebuilt. When given the opportunity, it should be suggested that the new walls be constructed with a midline lintel beam that is of reinforced concrete, doweled into the existing columns to offer structural support to the wall.

Roof & Floors - The second, third, etc. floors and the roof are reinforced concrete slabs. The rebar is typically #4 and is spaced at approximately 12-inches on center each way.

Reinforce concrete structure.

(Note racking of center storey)

4 Assessment

4.1 Introduction

It is assumed that since you are planning on demolishing a building, it has already been assessed and found to be unsafe, or that it is obviously unsafe. However, a review of the ATC-20 definition of an unsafe structure is warranted and the list of failures that make a building “unsafe” is also a good review of items to be looking for in planning a demolition.

The ATC-20 criteria for the placement of an “UNSAFE” or red placard is that one of the following conditions exists:

- There is an extreme hazard and the building may collapse.
- There is an imminent hazard of collapse from an aftershock.
- There has been a significant decrease in vertical load and/or lateral force resistance capacity.

When assessing a building for demolition, first survey the building exterior. While one member of the team waits outside the collapse zone (1.5 times the height of the building) as a safety watch, the others walk completely around the building, examining it from the foundation to the roof line. As you walk by windows, note if there are any conditions inside that speak to the safety of the building.

Examine the site for geotechnical hazards, particularly for landslide threat. Look for evidence of slope movement, either at the top or bottom of the slope, which could be a potential threat.

If access is possible, identify a safe exit route and enter with caution. Always be aware of your safe exit route as you move through the building. Look at the structure in areas where it is exposed, and if necessary, remove plaster to assess the condition. Look for failed columns or framing connections, or where the supporting members are pulling away from the framing. Look for overhead hazards such as loose stones at the top of walls or separated roof rafters/purlins.

Examine lateral load systems. Examine every floor of the building, from the basement to the roof. Move systematically through the building.

Inspect for nonstructural hazards. Watch for damage to parapets, stairs, water tank or other equipment supports, as well as large debris hanging overhead or loose roofing sheets.

Inspect for other hazards including downed power or other utility lines.

Make sure you look up to identify overhead hazards

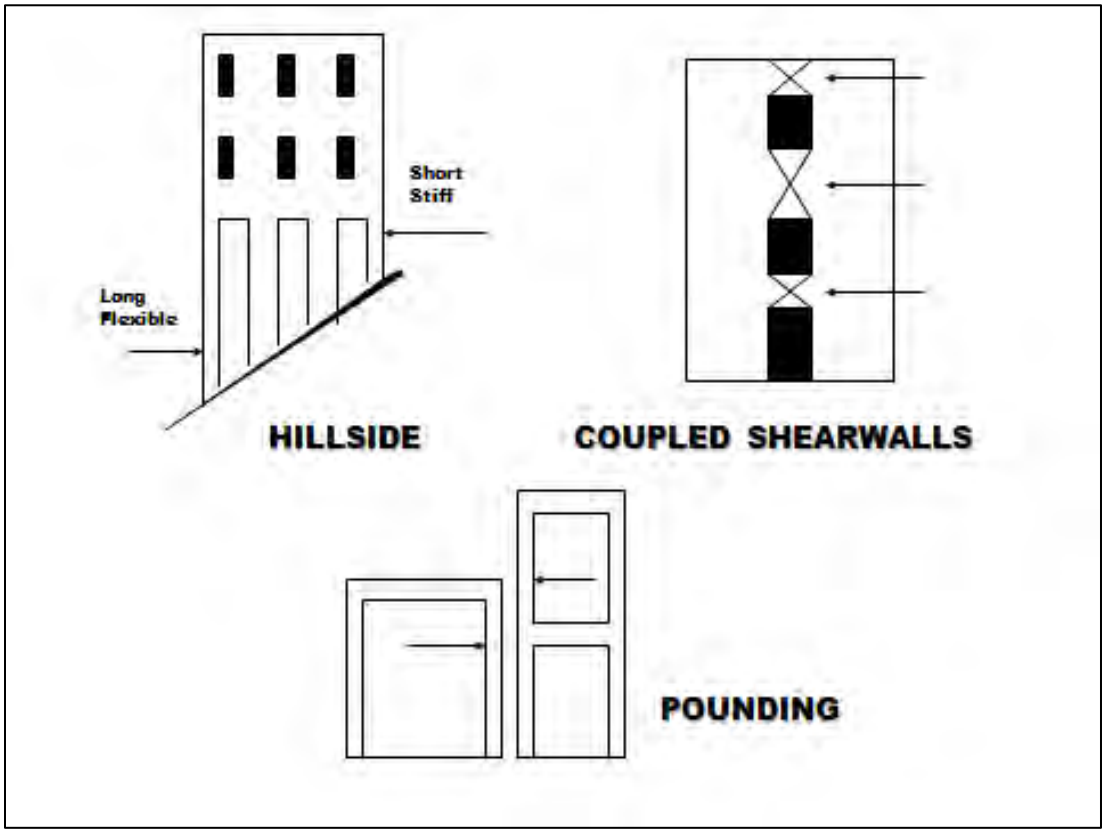
And clear the site of nails and other potential puncture/slip/trip/fall hazards

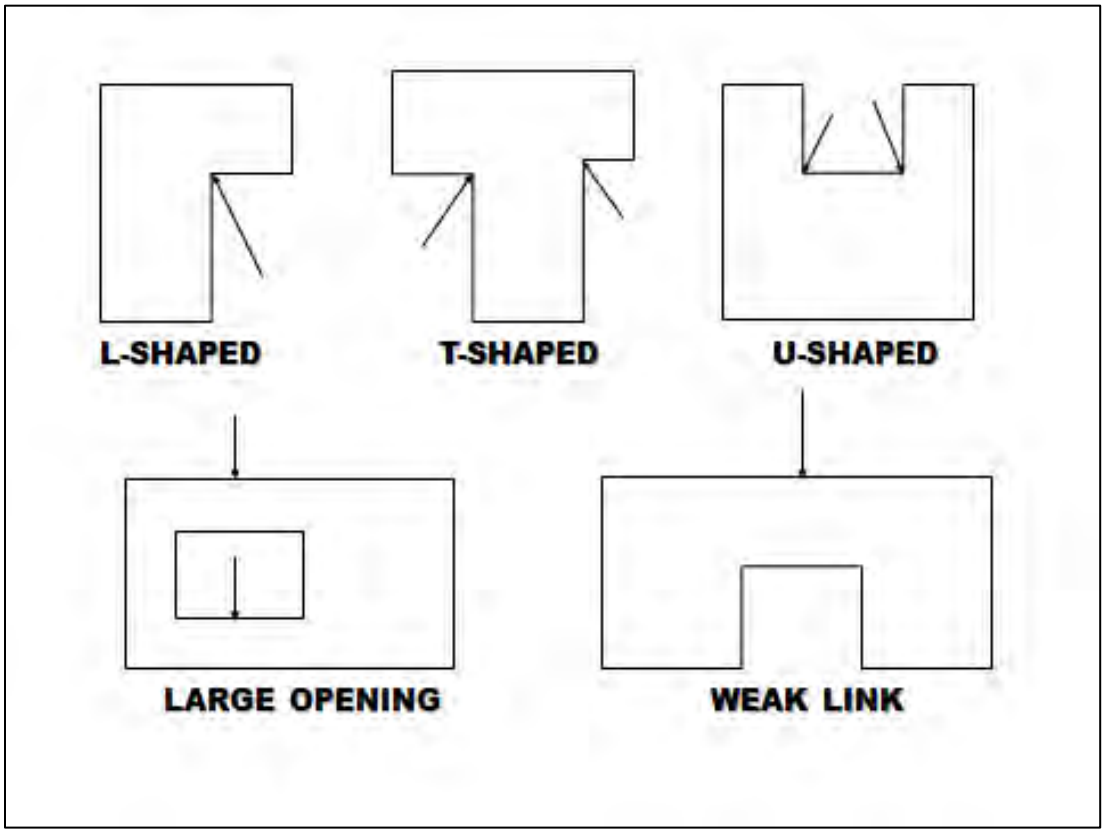
4.2 Places to look for damage

The following figures show the most common forms of vertical damages. The arrows indicate the likely location of damage.

For hillside buildings, damage will most likely occur in the short, stiff columns and beam connections rather than the long, more flexible columns. The longer columns must also be reviewed, though, as they may have damage mid-height due to excessive deflection.

Pounding occurs when buildings of different earthquake responses are too close together. Check the top point where a shorter building pounds into a taller building.





4.3 Assessment

ATC-20 recommends the following criteria to assist evaluators and help them to post structures properly. The following are what you should be looking for during your safety assessment and areas to look at to plan for your demolition. Generally speaking, these conditions constitute an UNSAFE condition, which does not necessarily mean that the building needs to be demolished, but that it is unsafe for occupation. The removal of some of these conditions, such as a damaged parapet hanging over a door, can remove the hazard and make the building safe for occupancy.

Vertical Load System

- Columns noticeably out of plumb - UNSAFE
- Buckled or failed columns - UNSAFE
- Roof or floor framing separation from walls or other vertical supports - UNSAFE
- Bearing wall, pilaster, or corbel cracking jeopardizing vertical support - UNSAFE
- Other failure of vertical load carrying elements - UNSAFE

Lateral Force System

- Buckled, torn, or displaced diaphragms or horizontal bracing - UNSAFE
- Broken, leaning, or seriously degraded moment frames (look for cracks at welds or across the center field of the moment frame connection) - UNSAFE
- Severely cracked shear walls (ATC-20 identifies this as 1/8” or greater) - UNSAFE
- Other failure of lateral load-carrying elements or connections - UNSAFE

Degradation of Structural System

- Cracking, spalling, or local crushing of concrete or masonry - UNSAFE

Falling Hazard

- No safe entry to building due to a falling hazard, such as a dangerous parapet, or if a collapse hazard from a nearby structure exists - UNSAFE

Slope or Foundation Distress

- Base of building pulled apart differentially, severe settlement, fractured foundations, walls, floors, or roof - UNSAFE
- Building in zone of fault or rupture - UNSAFE
- Suspected major slope movement - UNSAFE
- Building in danger of being impacted by slide or falling landslide debris from upslope- UNSAFE

5 Shoring, Bracing and Temporary Supports

Vertical supports, “shoring”, shall be installed under any seriously unstable or failed sections of roof or floor and/or diagonal supports and “bracing” at any unstable or failed sections of walls, if there is possibility that shifting may trigger collapse of the structure, especially under an unstable area that you plan to work on, under or around.

Vertical supports, “shoring”, shall also be used to raise and re-support a section of roof or floor to clear roof or floor from a section of wall that needs to be removed and pulled down.

When sourcing material for supports and installing supports, consider the following:

- Survey collapse zone for any potential members that can be used for shoring or bracing. Source and gather vertical supports, “shoring”, in lengths equal to the height from the supporting ground to the bottom of roof member to be supported, ‘H’, see shoring and bracing table below for type and size of shoring. Source and gather diagonal supports, “bracing”, in lengths equal to 0.7’H’, see shoring and bracing table below for type and size of bracing. Provide quantities of shoring and bracing to be used in the working zone and stabilization of the entire structure. Provide additional shoring and bracing members for each section of wall to be removed. The members can be re-used from section to section assuming the overall integrity of the building can be maintained.
- Select a stable location, preferable not directly under or in front of a section and area being removed. If the shoring and bracing needs to be located under or in front of a section and area being removed because of the demolition task at hand, leave it in place until just prior to wall removal or pull. Make sure you attach a rope to it to allow it to be pulled from a safe distance, or you have a pole of sufficient length to knock the shoring or bracing out from a safe distance
- There should be a minimum of one brace at a 45 degree angle and half way up each wall section to be removed. The top end of each brace should be located either at a door or window jamb, a crack or wedge into the wall or against a flat vertical board tight to the wall where there are long

runs of walls without any openings or cracks. The bottom of each brace should be wedged into the ground with a stake securing the end.

- A set of tapered wedges can be used together below the brace or shoring with a rope tied through a wedge to enable the brace or shoring to be removed.
- Always plan for the protection and retrieval of shoring and braces just prior to section of wall to be removed and the area they support or control.

Shoring Table for One-Story Roof and Two-Story Floor

Recommended minimum shoring sizes

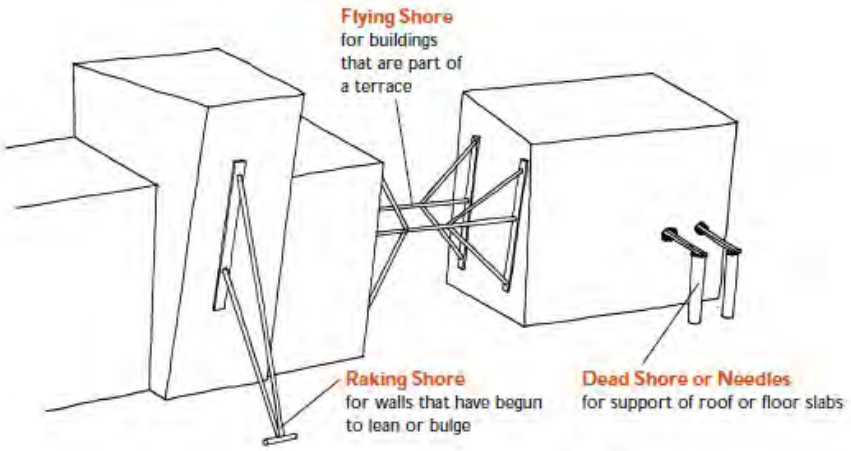
Height 'H'	Vertical Roof Wood Shoring	Vertical Roof Bamboo Shoring	Vertical 2nd Floor Wood Shoring	Vertical 2nd Floor Bamboo Shoring
8 ft(2.4 m)	4x4 in (10x10 cm)	2 in (5 cm) dia	8x8 in (20x20 cm)	3 in (7.5 cm) dia
12 ft(3.6 m)	6x6 in (15x15 cm)	2-1/2 in (6.5 cm) dia	10x10 in (25x25 cm)	3-1/2 in (9 cm) dia
16 ft(4.8 m)	8x8 in (20x20 cm)	3 in (7.5 cm) dia	----------	----------
20 ft(6.1 m)	10x10 in (25x25 cm)	3-1/2 in (9 cm) dia	----------	----------

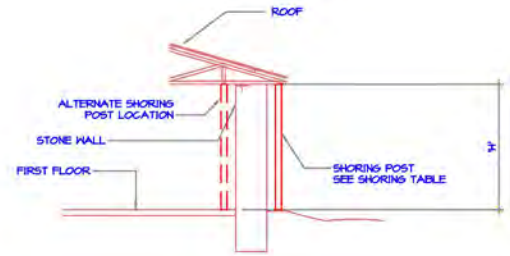
Wall Bracing Table for One-Story Roof and Two Story Floor

Recommended minimum shoring sizes

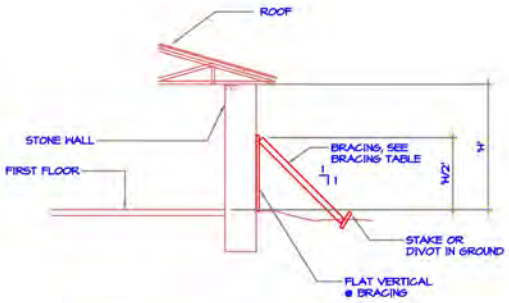
Height 'H'	Diagonal 1-story Wood Bracing	Diagonal 1-story Bamboo Bracing	Diagonal 2-story Wood Bracing	Diagonal 2-story Bamboo Bracing
8 ft(2.4 m)	3x3 in (7.5x7.5 cm)	1-1/2 in (4 cm) dia	6x6 in (15x15 cm)	2-1/2 in (6.5 cm) dia
12 ft(3.6 m)	4x4 in (10x10 cm)	2 in (5 cm) dia	8x8 in (20x20 cm)	3 in (7.5 cm) dia
16 ft(4.8 m)	6x6 in (15x15 cm)	2-1/2 in (6.5 cm) dia	----------	----------
20 ft(6.1 m)	8x8 in (20x20 cm)	3 in (7.5 cm) dia	----------	----------

The following figures are from a presentation by Jitendra Bothara and provide examples for various shoring and bracing configurations, although simple vertical and diagonal braces can also be very effective. The complete presentation by Mr. Bothara can be found in Appendix A.

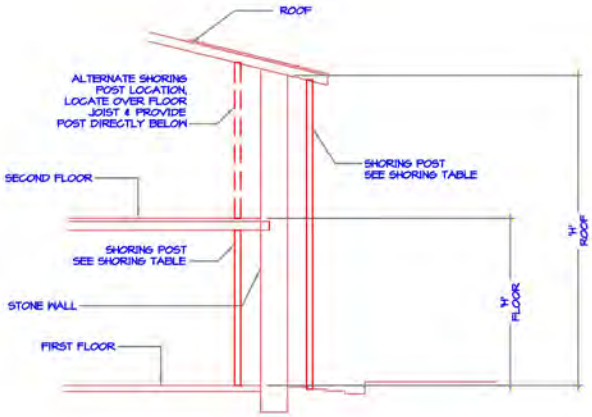




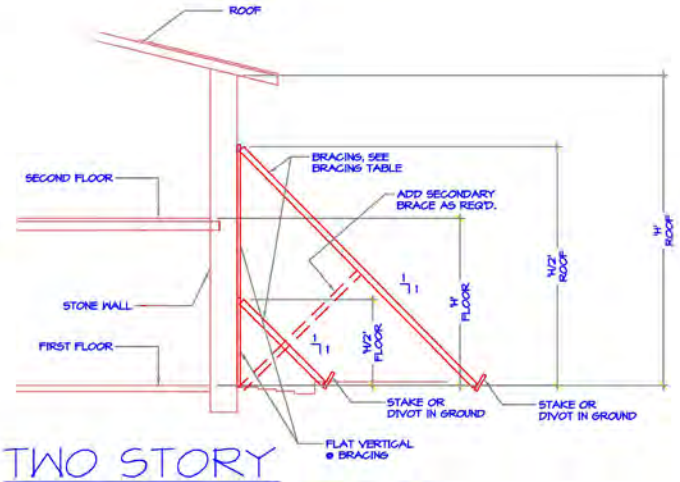
ONE STORY SHORING DIAGRAM



ONE STORY BRACING DIAGRAM



TWO STORY SHORING DIAGRAM



TWO STORY BRACING DIAGRAM

6 Demolition

6.1 General Demolition Planning

6.1.1 Demolition Team roles:

Team Leader - Responsible for planning and safe execution of the demolition. Specific Task include:

Before starting demo:

- Find out existing information about the site from the person who assessed it.
- Find out who the home owner or person in responsible charge is.
- Find out what exactly needs to be done and if there are any special conditions, e.g. things to be left alone, specific materials to be reclaimed, etc.
- Review the assessment form and any photos available.
- Come up with list of specific tools needs, gather tools, check tool condition and check rope/chain/cable condition.

- Gather med kit, cell phone, water, lunch or food.
- Arrange transportation.
- Gather and brief Team.

At the site:

- Introduce yourself to the home owner/principal. Make them feel comfortable. Don't promise them anything other than what you are there to do. Verify what they want saved/reclaimed. Verify where they want it stored/placed.
- Verify that the water and power have been shut down, and have them show you.
- Perform the safety talk with the team. Discuss safety gear, hazard zones, pinch points, escape routes. Review safety words. Discuss and stress the importance of spotters and make sure everyone is comfortable with and knows they can and should stop work if they see anything unsafe.
- Lead a walk around of the site prior to work and encouraging open discussion and idea sharing.
- Make sure team members are aware of potential hazards.
- Verify the assessment recheck all the load bearing members and potential failure modes. Assess shoring and bracing requirements and/or recheck shoring.
- Teach other members of the team how to use tools they aren't familiar with.
- Formulate an action plan and assign jobs to team members.

Do solicit comments and feedback on the demolition plan and other aspects of the work, but ultimately it is the Team Leader who makes the final decision and is to ensure that the work is done in a Safe Manner.

Team Members

Team members should follow the action plan laid out by the team leader. Team members are responsible to point out hazards and offer suggestions and ideas for the specific building areas under demolition. It is very important to ask questions if there are any aspects of the plan not clearly understood.

- Be aware of your surroundings.
- Never use a tool in a manner you are not comfortable with or skilled in using unless under direct instruction.

- Safety is everyone's responsibility and the highest priority on every job site. If you are ever concerned about whether a task can be performed safely, VOICE YOUR CONCERN!

6.2 General Demolition Procedures

The number one priority on any site is safety, of both the team and residents in the area. Materials may be salvaged when possible providing that doing so does not compromise people's safety. Demolition should never be undertaken if it cannot be done safely.

Arriving on Site:

Team leader to assess the site with one or two selected team members. Give the site safety talk and explain the plan. Show the team the job and the key structural points but ensure at least one team member stays in a safe place. Discuss the plan with the team, team input is important but remember the team leader is ultimately responsible for making decisions.

Assessment

- Decide where the house or sections of the house will eventually fail or fall. This is important when considering where to place braces and static lines to prevent the building moving in an unwanted direction.
- Eliminate immediate hazards so that work can begin safely. In particular look for overhead rocks or slab hazards or failing beam/column connections.

Clearing Escape Routes

- Remove necessary rubble to create safe exit paths from any areas on which you plan to work. Clear good paths for efficiency and to eliminate slips, trips, and falls. Identify and eliminate other hazards such as nails in boards or rebar or metal roofing edges sticking out into work area.

Shoring

- Begin shoring. Work in teams of at least two. Support weakened or seriously compromised sections first. Have only one team working on these sections and the rest of the team provide spotting. Take measures to control the fall of anything that might suddenly fail.
- Identify specific areas/walls/roofing to be shorn or supported. Significant removal of rubble may be required to install shoring. Always be overly conservative with shoring. Always plan for removal of shoring.

Salvage

- Enter and remove any materials to be salvaged from the interior. Always have spotters on the outside observing for any movement. Make sure that safe routes of exit are identified and if possible identify secondary routes if the first one gets blocked for any reason. Be sensitive with personal items. Discuss with the owner on where to put the items. Cover them if possible, and make sure they are well removed and protected from the drop zone. When in doubt, save it. If it can't be removed safely, leave it.

Planning

- Formulate the demo plan and sequencing. Discuss with the Team and adjust as necessary to address new ideas or concerns. Welcome and solicit feedback from all team members, particularly in areas of safety. Understand the structure.
- Assess the location, condition and current function of columns, beams, walls, doorways and windows. Follow the load paths down to the ground and understand what happens when you remove one or more elements.
- Separate the building into elements and focus on removing the non-structural elements first.
- Start with the inside and work your way out. Make sure the sequencing is well thought out and that safe routes of escape will always be available.

Rigging

- Install rigging ropes or come-along cables/chains.
- Make sure that they have been inspected and are not compromised. Make sure that you inspect them after every pull to ensure they have not been compromised. Make sure that they are the right size/capacity for the work to be done and will not break in the middle of a pull.
- Make sure that correct knots are used for correct applications (the bowline is a good default for the pull). Try to locate knots in areas that will not become covered in debris. Plan for the retrieval of ropes and lines.
- Locate the lines high on the wall for added leverage. Connect to wood or other pieces of the building that are strong and will be able to resist the pull. Sudden failures can result in injuries.
- Connect lines or chains to structurally sound points on the building. Connect the end of come-along cables to solid anchor points such as trees.

- Statics are used to control the direction the structure falls. For them to work effectively the lines must be in tension.

Weakening

- Fault the walls and supports as necessary. The idea is to weaken the supporting members in the direction that you want the wall to fall.
- Separate the roof supports from the columns as necessary.
- Crack the plaster with a sledge hammer in lines where you want it to fail, vertically and horizontally.
- Break the concrete around and expose the rebar in the beams where they are to be separated.
- Fault the columns as necessary. Break concrete and expose the rebar in reinforced structures, or cut partially through wooden columns.
- Cut the rebar in the beams.

The Pull

- Get ready to pull down the building section.
- Double check to make sure the area is clear of tools, people and animals.
- Warn the neighbors or bystanders and warn them to keep clear.
- Position spotters to make sure no-one wanders into the area.
- Get everyone on the rope ready to pull and make sure they understand when to pull (e.g. pull on the count of 3) and when/how to pull in rhythm.
- Remove supports either by pulling them out on a rope or knocking them over with a long pole.
- Pull.
- If section fails to drop, reinstall support as necessary and further weaken structural members. This should be done by one person with multiple spotters making sure that nothing is moving.
- Refrain from cheering when the building falls. This is someone's home and they probably are not excited to be losing their home.

Leaving the Site

- Plan ahead! Do not begin a task that may leave the house in an unsafe state unless you are certain that there is time to complete the task. Stay late if necessary. It is important to remember that people may enter the building before you return.
- Ensure that potential hazards have been dealt with wherever possible, and check that braces and supports are in place if necessary and are set up correctly.
- As many team members as possible should be knowledgeable of the supports, load bearing points and structural failures (cracks) so any changes can be noted.

Returning to Site

- Repeat the above section when returning to the site. Examine the building for any structural changes. For example wider wall cracks or columns that have shifted.
- Check all supports, braces and load bearing points to ensure that the distribution of forces has not changed while away.
- When the walk around is complete, either continue with the original plan or discuss any structural changes and adapt the plan accordingly.

6.3 Equipment

The required equipment will vary depending on what type of structure is to be demolished. Stacked rock structures can generally be demolished using hand tools, however multi-story reinforced concrete structures will likely require power tools or heavy equipment. Separate equipment lists are given below for the various types of demolition.

6.3.1 Safety Equipment

- Hard Hats
- Hard Soled Shoes
- Gloves
- Safety Goggles
- Ear protection if using power tools
- Dust masks
- Phone
- Medical Kit
- Water
- “Caution” or “Danger” Tape

6.3.2 Equipment List for Hand Demo of Stacked Rock Structures

Minimum List

- Crowbar
- Sledgehammers
- Wood Saw
- Tape Measure
- Ropes: Nylon, minimum ½” braided, 100-feet minimum

Expanded List

- Screwdriver, Phillips and regular head
- Claw hammer
- Shovels
- Pick Axe
- Rebar Cutters
- Wreaking bar
- Bolt Cutters
- Hacksaw
- Wire Snips
- Ladder
- Cold Chisel
- Come-along winches minimum 5 ton
- Chains: 3/4” or greater links, minimum 30’ length
- “Caution” or “Danger” Tape
- Notebook and pens/pencils
- Permanent markers
- Spray Paint
- Hatchet
- Wheelbarrows
- Plumb bob
- Laser level
- Metal Adjustable Supports with wood for base and wedges
  15’ length of 2” x 4” wood timber

Wish List

- Saws-All
- Concrete Saw
- Chain Saw
- Hammer drill
- Backhoe
- Excavator

6.4 Demolition Pointers for Various Structures

The following sections are suggestions for various types of structures, based on their actual demolition. It is important to remember that these are only suggestions and varying site conditions will require that these procedures be adjusted. Every site is unique.

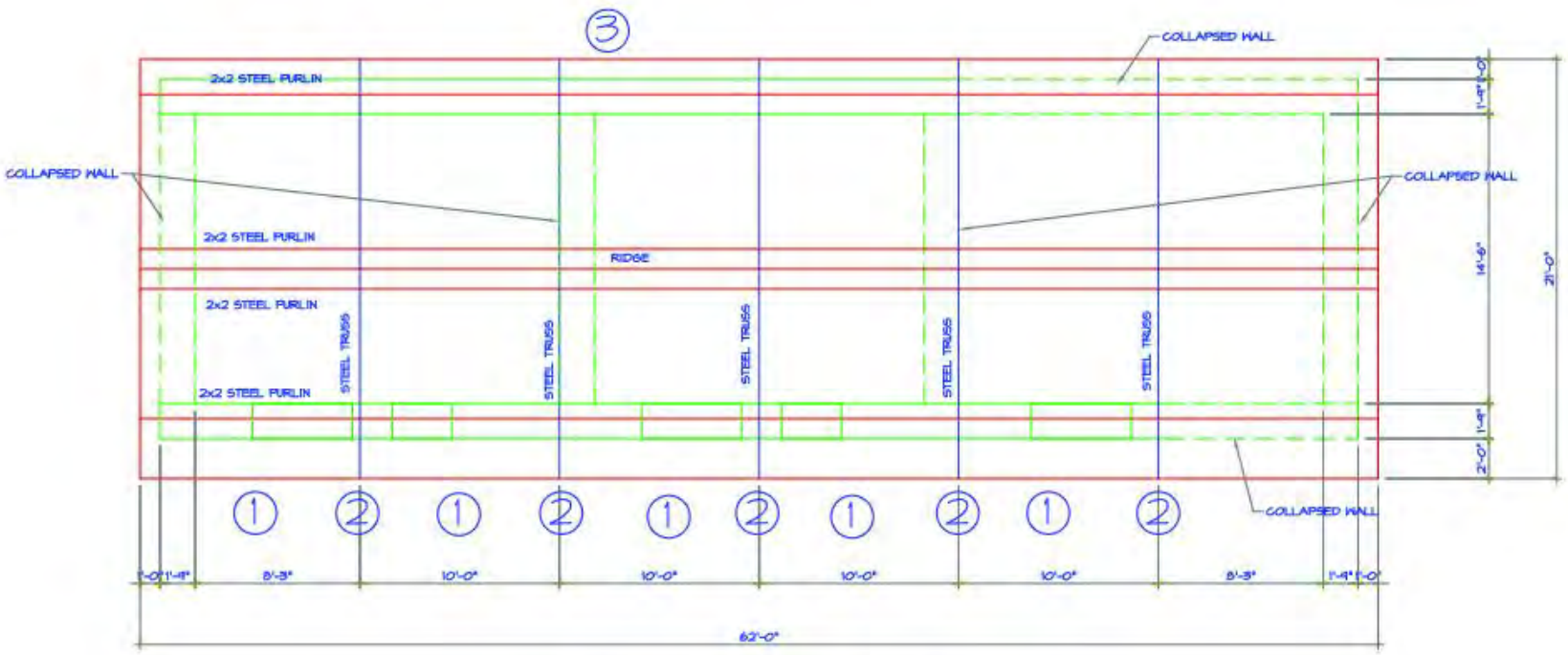
6.4.1 Stacked Stone Structures

Demolition Procedure

<u>One-Story school building stone & mud mortar load bearing wall, wood lintels and top stone course, steel trusses, steel purlins & metal roof deck</u>

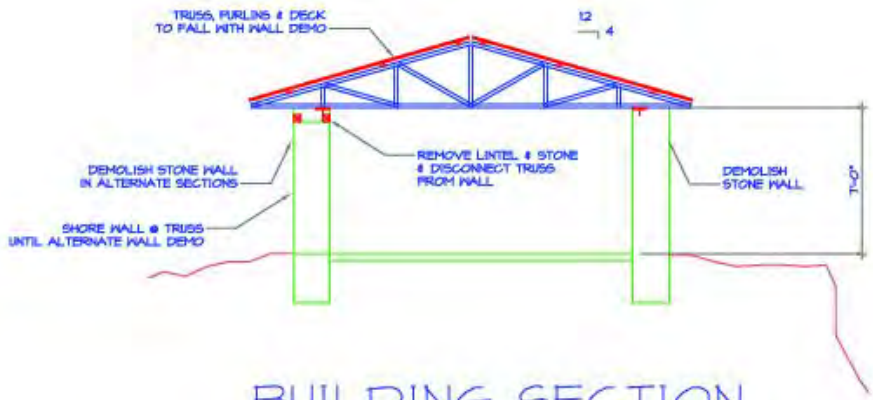
1. Brace all unstable walls and brace walls with one brace located at each truss or main wall supporting member at a minimum.
2. Shore all unstable roof trusses and sections, also shore under truss if roof is sagging so wall will clear roof structure.
3. Make sure no temporary braces supporting the roof are located where they can be struck by falling debris from the wall.
4. Clear exit paths of debris.
5. Hand remove loose sections of walls that could pose danger, e.g. overhanging rocks, etc.
6. Remove salvageable doors, windows, and other materials from the interior of the structure.
7. Divide each wall into sections for demolition, locate and mark the joints
    a. Maintain a section of wall under truss to maintain support
    b. Locate the breaks for the remaining section between truss sections

8. Break the plaster with vertical cracks at the edge of windows or top of door marking the edge of the section to be removed.
9. Remove door and window frames from stone walls (locate and breakaway door and window frame anchors from stone wall as required)
10. Tie rope onto section of wall to be removed.
11. Remove wood lintels and top stone course as required so wall will clear roof structure, or cut lintels at section joint.
12. Weaken section to be removed by breaking any surface plaster with a sledge hammer on the inside face-of-wall, opposite existing external horizontal crack. If there are no cracks in the plaster on the inside or outside, break both walls in a line near the bottom of the wall or at a point in between the top and the bottom at observed point of weakness (i.e. bulge, lateral offsets, etc.).
13. Positions spotters and people on rope.
14. Remove temporary supports.
15. Pull.
16. If section does not fall, reinstall supports, and either divide wall into a smaller section or weaken the wall further by hand removing rocks or if this cannot be done safely, knock them out with long poles.
17. Repeat pull.
18. Remove alternate sections of wall between the trusses to support roof as long as possible.
19. After the non-support sections of the walls have been removed, cut or break loose truss main member from the wall connection.
20. Remove alternating remaining wall sections at trusses down to two or three main roof support sections, or alternately start at one end of the building and remove support sections from one end to the other to allow the roof to slope down to the ground.
21. Dismantle the roof after it is on the ground, or cut into sections to allow for reuse.



ROOF FRAMING PLAN

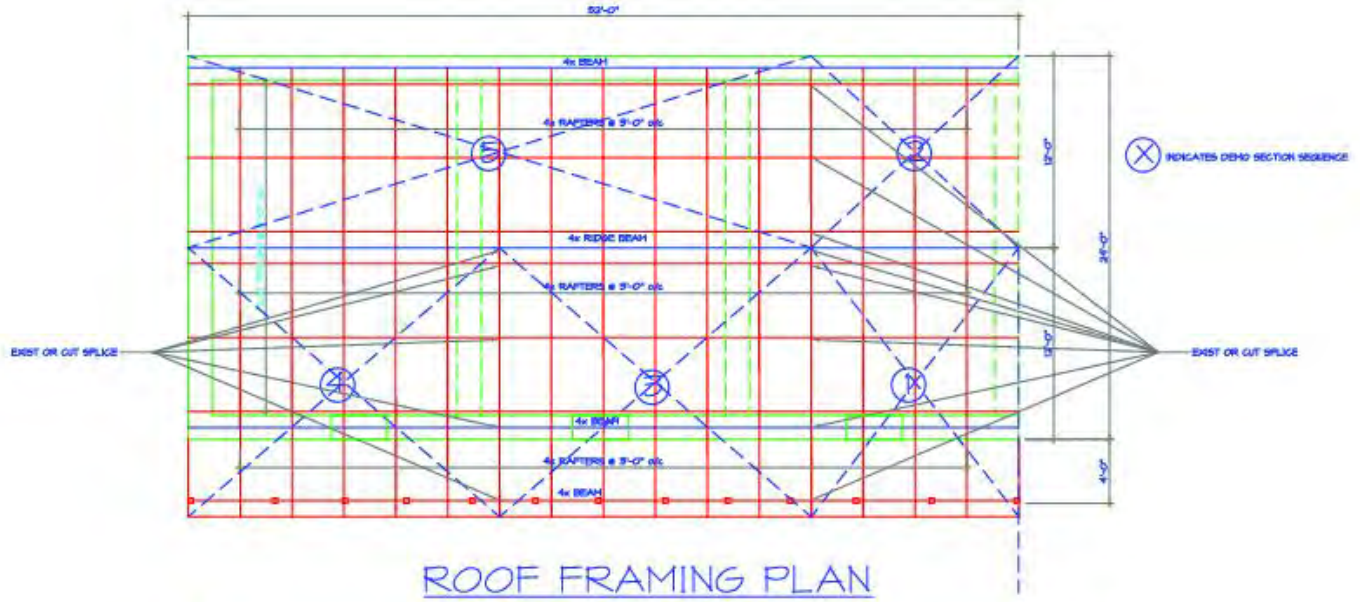
(X) INDICATES DEMO SECTION SEQUENCE



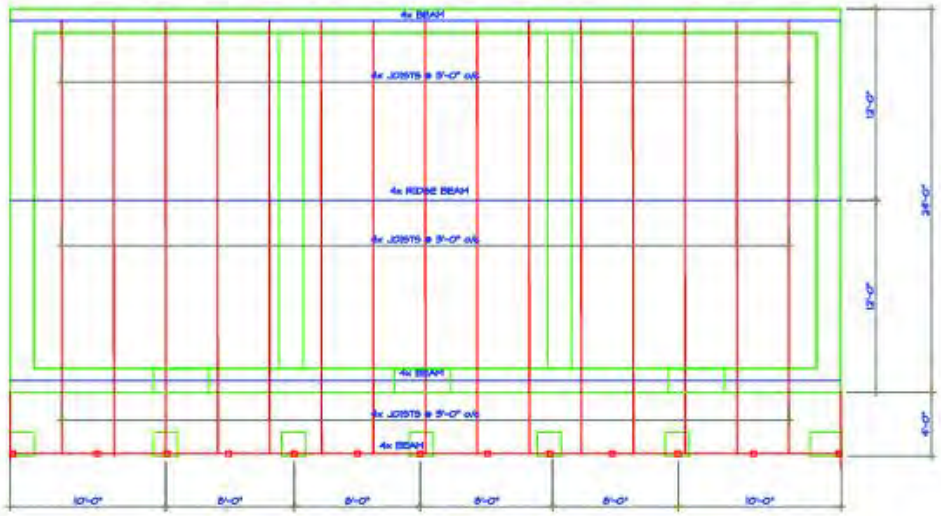
BUILDING SECTION

Two-Story school building, stone & mud mortar load bearing wall, wood lintels and top stone course, wood roof rafters, ridge beam & metal roofing and wood floor joists, beam and posts

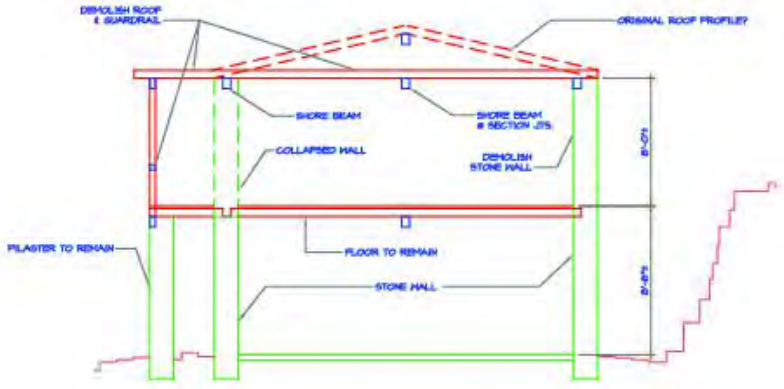
1. Brace unstable load-bearing walls, with one brace minimum.
2. Shore unstable roof and second floor beams and at failed or unstable load-bearing walls.
3. Clear exit routes of debris.
4. Hand dismantle walls as deemed necessary for safety considerations (i.e. removing loose rocks that are hanging overhead or potentially blocking exit routes, or can damage neighbouring structures, etc.)
5. Remove salvageable materials and doors and window shutters from the interior of the structure.
6. Remove top stone course from walls as required so they will not fall while working on roof structure and/or will allow the roof to come free.
7. Divide roof into sections for demolition. Generally fairly large sections of roof can be removed (i.e. section roof into four quarters). Test first roof section and adjust sections as required.
    a. Locate section joints at existing center beam joints.
    b. Shore beams each side of new joint.
    c. Connect rope to section of roof to be removed.
    d. Sawcut rafters or purlins in line with existing beam joint to be removed.
    e. Disconnect metal roof panels between each other and the rafters/purlins at or near section joints.
8. Position spotters.
9. Position other people on rope.
10. Position one person to remove nails between rafters and center beam while they are physically positioned under the section to remain. Once nails are removed and person is down, pull on the section roof to bring it down.
11. Repeat procedures for each remaining sections of roof.
12. Dismantle the roof after it is on the ground, and/or cut into sections to allow for reuse.
13. Once roof is off, break the plaster in walls with vertical cracks at the edge of windows or top of door marking the edge of the section to be removed.
14. Remove windows and doors as they have anchors into the walls (either with rocks set on them or a chunk of concrete) and they tend to tie the walls together.
15. Weaken sections of wall to be removed by breaking any surface plaster with a sledge hammer on the inside face-of-wall, opposite existing external horizontal crack. If there are no cracks in the plaster on the inside or outside, break both walls in a line near the bottom of the wall or at a point in between the top and the bottom at observed point of weakness (i.e. bulge, lateral offsets, etc.)
16. Pull down most unstable sections of wall first, or if equally damaged, start at one end of the building and remove wall sections from one end to the other.



ROOF FRAMING PLAN



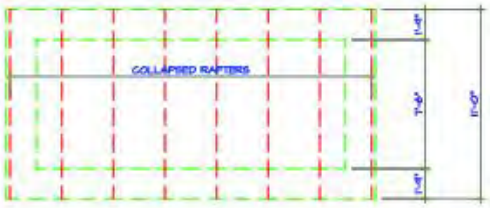
FLOOR FRAMING PLAN



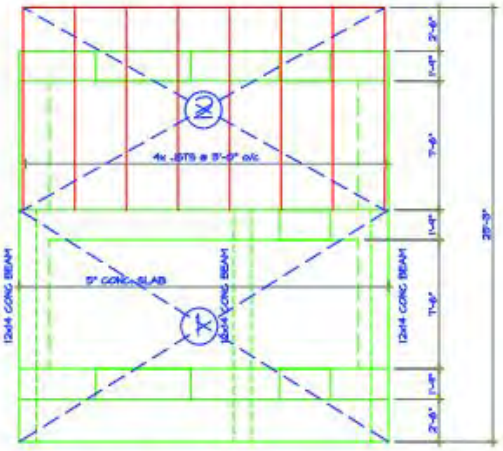
BUILDING SECTION

Three-story home, stone & mud mortar load bearing wall, wood lintels and top stone course, wood roof rafters & metal roofing (collapsed), second and first floor wood decking and joists, second floor roof-concrete slab and beam terrace

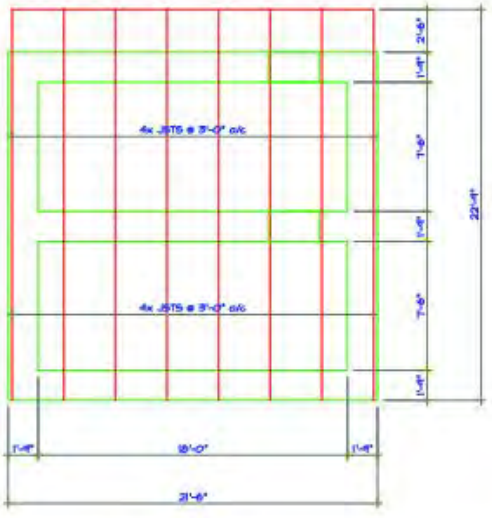
1. Brace unstable load-bearing walls, with one brace minimum. Locate interior bracing over floor joist or add additional shoring or support blocking directly below to first floor if necessary (do not support brace off of floor deck only)
2. Shore unstable concrete roof, first and second floor beams and at failed or unstable load-bearing walls. Locate interior shoring over floor joist or add additional shoring or support blocking, directly below to first floor if necessary (do not support shoring off of floor deck only). Position shoring vertically or if angled against the direction of pull, attach rope or make sure you are able to knock the shoring loose with a long pole from a safe distance. Carefully consider which shoring should or needs to be removed prior to pulling, and make sure that can be done safely.
3. Clear exit routes.
4. Remove walls as deemed necessary for safety considerations (i.e. remove overhanging rocks, rocks that may block exit routes or fall on neighbouring structures, etc.)
5. Remove salvage materials including doors, window shutters, etc.
6. Remove all excess load from top of roof slab including debris, mud, dirt, short divider walls, etc.
7. Divide concrete and wood floors into separate sections for demolition.
8. Connect rope to section of wall to be removed.
9. Tie rope on other sections of wall that may be inaccessible or unsafe to access after first section of building is demo'ed.
10. At remaining walls, break the plaster with vertical cracks at the edge of windows and doors marking the edge of the section to be removed.
11. Remove windows and doors as they have anchors into the walls (either with rocks set on them or a chunk of concrete) and they tend to tie the walls together. Start at the interior doors and work your way outward (or from the longest exit routes to the shortest).
12. Weaken sections of wall to be removed by breaking any surface plaster with a sledge hammer on the inside face-of-wall, opposite existing external horizontal crack. If there are no cracks in the plaster on the inside or outside, break both walls in a line near the bottom of the wall or at a point in between the top and the bottom at observed point of weakness (i.e. bulge, lateral offsets, etc.)
13. Make sure to break away stone/plaster between wood floor joists to allow separation of wood floor joists from common wall.
14. Again, start at the interior and work your way outward while weakening walls (or from the longest escape route to the shortest.)
15. Weaken the walls as much as possible, including knocking down rock sections with a long pole.
16. Positions people on rope and as spotters.
17. Remove bracing.
18. Pull.
19. If wall section and/or concrete roof fails to fall. Reinstall supports, weaken walls by removing more stones by knocking them out with a long pole, and repeat pull procedures.
20. Once the concrete slab roof is removed, remove the wood truss section of the roof, by dismantling enough of the wall to remove wood rafters, tying rope to each rafter, and pulling them out. This should hopefully weaken the remaining walls.
21. Position people on rope attached to remaining walls (again make sure this rope in prepositioned if the wall to be removed is no longer safe to access).
22. Positions Spotters.
23. Pull.
24. If wall fails to collapse, reinstall supports, weaken the wall further by knocking loose stones with long poles, and repeat process.



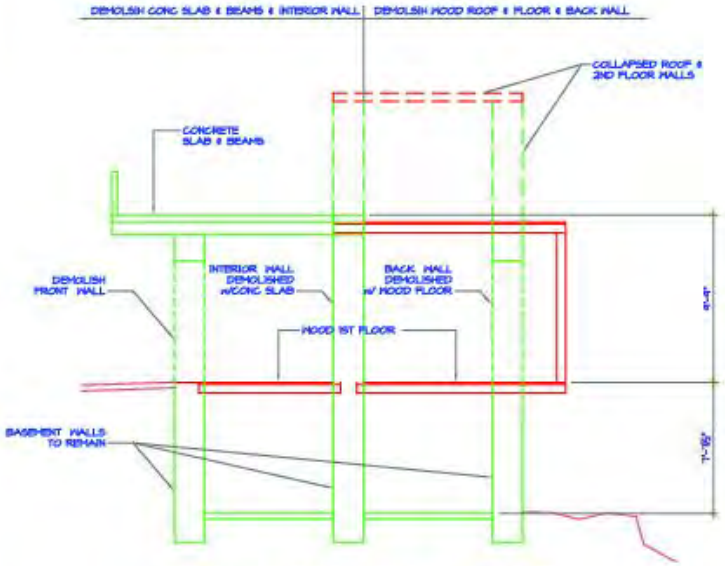
ROOF FRAMING PLAN



2ND FLOOR FRAMING PLAN



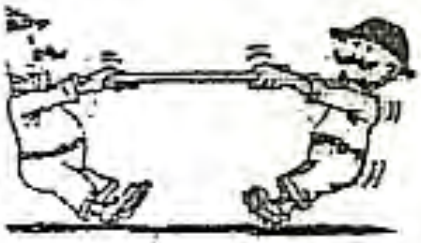
1ST FLOOR FRAMING PLAN



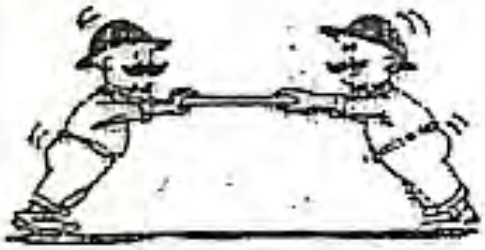
BUILDING SECTION

INDICATES DEMO SECTION SEQUENCE

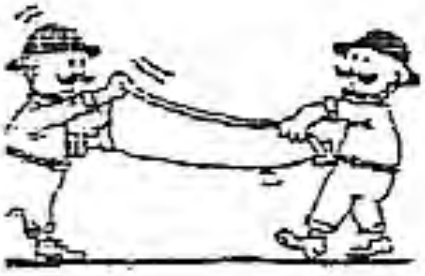
Appendix A – Glossary of Building & Structural Terms



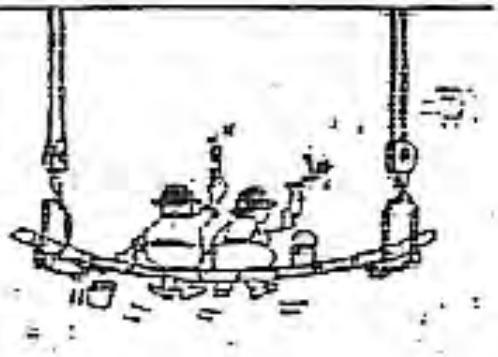
Tension (stretch)



Compression (squeeze)

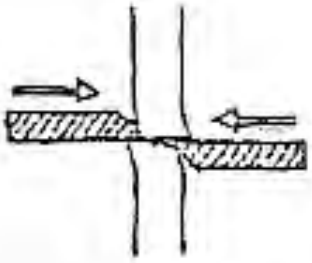


Torsion (twist)



Deflection (bend)

Shear (sideways slip)



Shearing Action
(similar to pair of scissors)

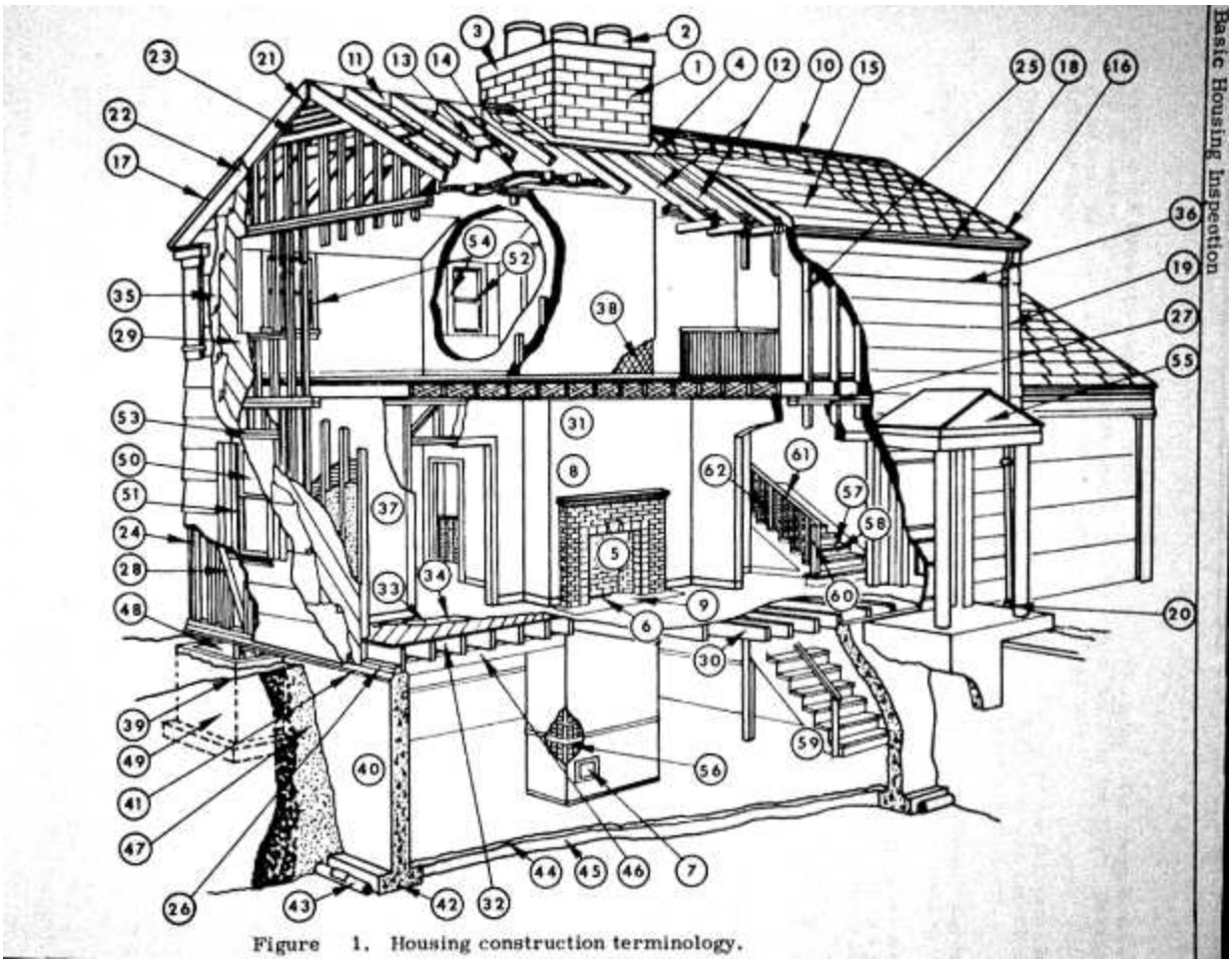
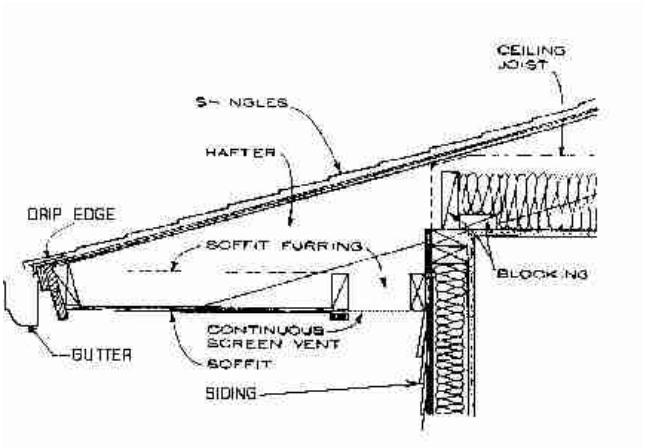
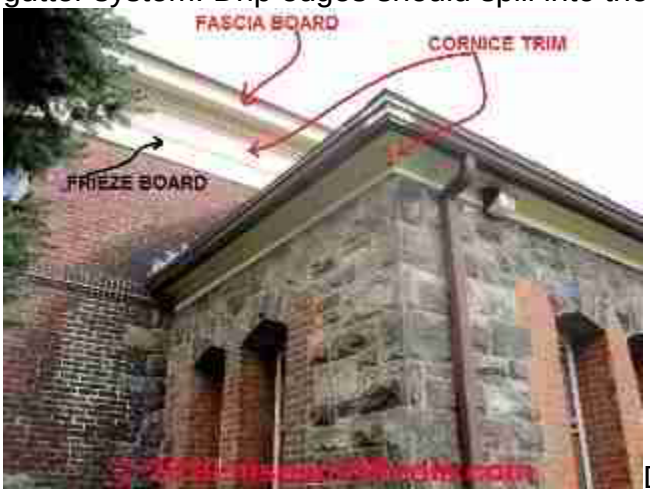


Figure 1. Housing construction terminology.



10. **Ridge cap** or ridge vent (if present)
11. **Ridge board**
12. **Cripple rafters or Jack rafters** (between chimney and house eaves - rafters that do not extend the full distance between house eaves and the roof ridge board)
13. **Rafter blocking** or cross bridging, also found on floor joists and in some wall framing

14. **Soffit** or lookout or house eaves. The soffit is the enclosed portion of the roof that overhangs the house walls at the roof lower edges. The construction of a typical roof overhang, eave or soffit is shown in our sketch at left.
15. **Roof sheathing** or roof decking.
16. **Roof shingles** (asphalt shingles, clay tiles, slates, wood shingles, or shakes, similar materials) -
17. **Drip edge** (shown on gable end, used at lower roof edges or eaves). The drip edge is special metal flashing intended to divert water off of the roof lower edges into the roof gutter system. Drip edges should spill into the gutter, not behind it.



Definition of **Cornice molding** or cornice trim: The horizontal board running at the top of a building exterior wall is a cornice molding or cornice trim board; some buildings have a decorative cornice while more common on simple residential structures is a plain horizontal trim board.
The cornice is also described in some dictionaries as the uppermost part of an entablature. Cornice molding also is used indoors in some buildings and appears as a trim board mounted at the juncture of wall top and ceiling.

Definition of **frieze board**: a frieze board is a horizontal decorative board at the top of a wall or between the cornice and the wall covering; a frieze board may appear on the building exterior or on an interior wall as well. A frieze board may appear alone, without cornice molding. Thus some architects and builders may refer to the horizontal board at the top of the wall, below the soffit as simply the frieze board, omitting any discussion of (the more complex) cornice or cornice trim.

Definition of **Facia board** or fascia trim: The horizontal board running along the outer edge of a soffit, typically covered or mostly covered by a gutter on modern homes, is the fascia board. Dont' confuse fascia board with cornice molding which is below the soffit and in the plane of the wall itself. On some buildings the water table trim is a bit more complex, using at least two pieces of horizontal trim: a narrow board, perhaps 1-3" in width is placed on an angle sloping away from the wall to form a drip cap atop a 6-10" wide horizontal trim board placed flat against the building.

21. **Gable end** and gable-end attic vent. The gable end the house wall on a conventional simple gable roof such as shown in our sketch is the triangular end wall

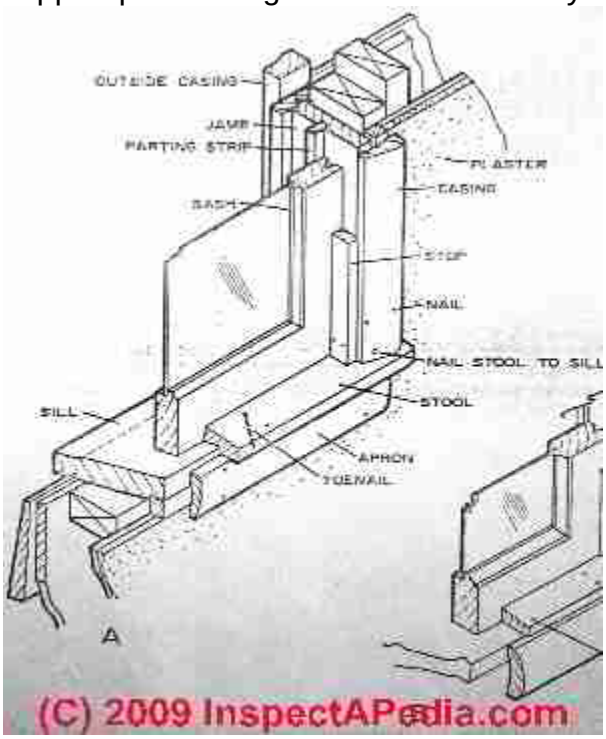
(arrows 17, 22, 23, and 31)

Definition of The **rake area of the roof** or ends of the roof itself may overhang the gable end wall. The rake is the edge of the gable roof that runs parallel to the sloping roof edge and extends from the ridge or "peak" to the lower roof edges at the gable end walls of the home. Don't confuse "rake" or "gable end" (arrows 17, 22, 23, and 31) with "soffit" or "eaves" of a roof. The eaves are the lower edges of the roof that run parallel to the house walls under the lowest roof edges (arrows 18 and 36 in the sketch).

22. **Gable end fascia**. See notes at 21 above. The gable end fascia is the trim board attached to the roof edges, extending from ridge to lower roof edge, and where a rake overhang is present, covering the outermost rake rafter or barge rafter.
24. **Wall corner studs** or post;
25. **Wall Stud** basic framing unit of wood frame construction building walls
26. **Sill plate** (rests atop foundation wall, nailed to rim joist and joists)
27. **Wall top plate**
28. **Diagonal wall bracing** (not present on all buildings, modern wood frame construction uses plywood or OSB sheathing to provide wall stiffness and protect against "racking" or diagonal movement in the wood framed structure)
29. **Wall sheathing** - showing diagonal tongue and groove boards, typically 3/4" thick; modern wall sheathing in wood frame construction uses 1/2" thick plywood or OSB sheathing products. Also see INSULATION INSPECTION & IMPROVEMENT.
30. **Floor joist** resting on sill plate atop foundation wall.
31. **Interior partition wall** over fireplace mantel; may be plaster over solid masonry or other construction;
32. **Floor joist resting on basement beam or center girder**.
33. **Flooring underlayment** (in 1955 this was red rosin paper or 15# roofing felt). Modern floor underlayment uses at least one thickness of tongue-and groove 3/4" plywood. Where carpeting is to be installed builders may use solid-core plywood to avoid accidental punctures of the flooring through the carpeting (stiletto heeled shoes).

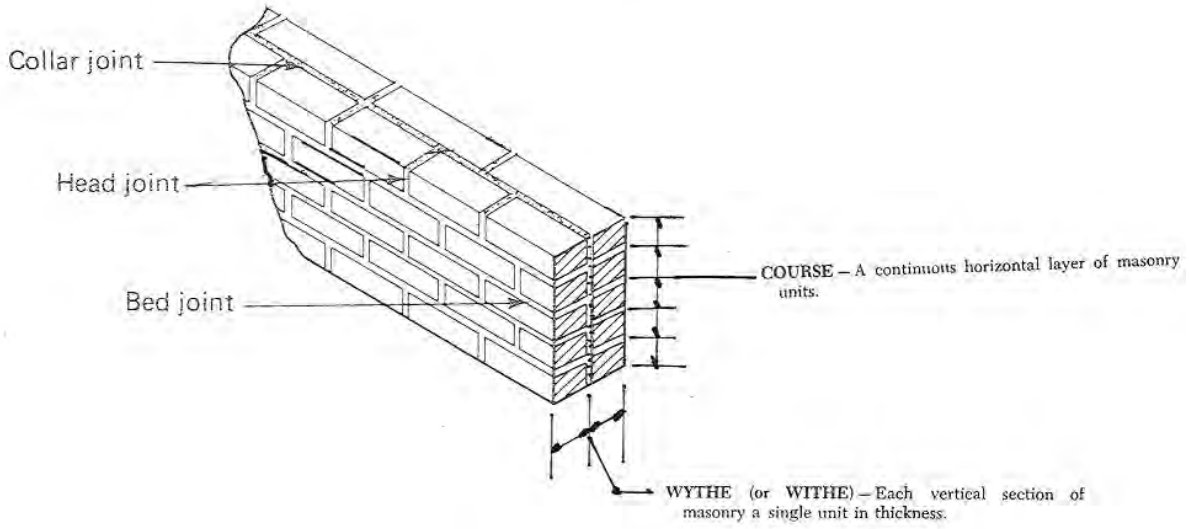
34. **Subflooring** (shown, diagonal tongue and groove boards) - see #33 above. Additional layers of subflooring over the base underlayment may be installed where tile is to be installed;
35. **Housewrap or moisture barrier** (in 1955 this was red rosin paper or 15# roofing felt).
37. **Interior partition wall** or center wall partition (may be load bearing, supporting 2nd floor joists)
38. **Interior wall covering**: Plaster wall scratch coat or masonry for chimney (if present)
39. **Grade level** (top of soil around building).
40. **Foundation wall**, along with wall footings (42) supports the structure and holds back earth where a basement or crawl space is included.
41. **Sill sealer** (between sill plate and foundation wall top)
42. **Footing**, supports the foundation wall.
43. **Footing drain** or foundation drain (perforated pipe + gravel, should extend to daylight to drain by gravity).

44. **Poured concrete basement floor slab** (floating slab atop compacted fill inside foundation wall)
45. **Compacted fill** (or gravel atop fill or poly on gravel on fill) below basement floor slab
46. **Main girder** resting on supporting posts or pockets in foundation walls (not shown but you can see a post to the right of (30). The main girder carries part of the floor joist load, typically through the center of the home.
47. Backfill around foundation wall.
48. **Rim joist or pier cap** (rests on pier top where a continuous foundation wall is not present)
49. **Pier**, alternative to a continuous foundation wall, piers may support posts that in turn support perimeter girders or beams carrying the building wall loads.



50. **Window sash**.
51. **Window jamb** or window frame
52. **Window sash frame**
53. **Window header**
57. **Stair tread**.
58. **Stair riser**
59. **Stair stringer** (structural support for stair treads and risers)
60. **Newell post** at stair bottom (handrail ends at this post)
61. **Stair rail** or handrail; on landings or balconies: guardrail.
62. **Stair baluster**. Balusters are the vertical supports enclosing the space between the underside of the stair railing and the stair tread upper surface. Typically spaced 4" o.c. to avoid child hazards

FIGURE 2-19. Basic terms applied to mortar joints.



Appendix B

Shoring and Stabilization by Jetendra Bothara

Government of Nepal
Department of Urban Development and Building Construction
and
Nepal Engineers' Association

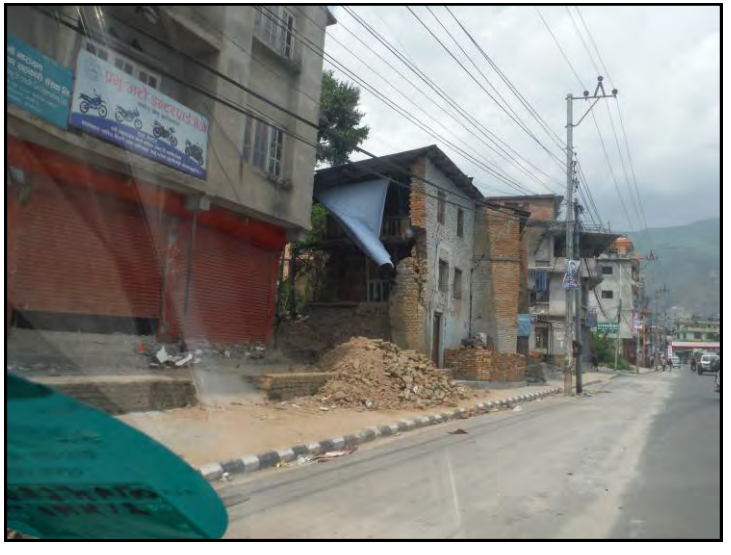
TRAINING WORKSHOP
POST DAMAGE ASSESSMENT, REPAIR & STRENGTHENING
OF
MASONRY AND REINFORCED CONCRETE STRUCTURES

May 20, 2015 to May 22, 2015
Engineer Bhawan, Pulchowk

Technical Support
IOE, NSET & CORD

Supporting Institutions
SCAEF, SONA, RUPSON, SEANep, SERDEN, NGS, ngs, NELS, NSC/DMG & AITAAN

Shoring and Stabilisation of Earthquake-damaged Buildings




ctopus Fashion
Contact: 9841546963

Objective

To stabilize the damaged building so

- Any further damage/ destruction of the building could be prevented,
- Provide gravity load capacity
- Provide some lateral capacity for future shaking
- Building could be safely demolished,

Temporary Protection

- Immediate temporary support is needed for buildings which are severely damaged but did not collapse after an earthquake.
- Temporary support can relieve damaged elements of their loads by means of additional temporary support and thereby protecting the structure or its components from collapsing in future aftershock or effects of gravity loads

Temporary Protection

- Temporary protection measures provide safety of people in the buildings, streets and yards adjacent to the damaged buildings.
- It also provides safety to workers making repair and strengthening works.

Hazards

Check:

- **Falling debris or objects from overhead.**
- **Leaning walls,**
- **Leaning columns**
- **Over all instability of buildings**

Monitoring of building

- **Global building movement.**
- **Element or component movement.**
- **Debris field movement.**
- **Localised area deformations.**

Tools for Monitoring of building

- **Plumb bob**
- **Tale tale signs**
- **Wireless sensors for monitoring dangerous areas.**

Designing a shoring

- Adjustability.
- Positive Connections.
- Lateral Bracing.
- Ductility.
- Warning of Overload

Understanding a Building

Before approaching a damaged building, the following observations should be noted:

- Building construction type and materials.
- Racked openings.
- Walls out of plumb.
- Damaged bearing walls.
- Damaged beams, columns, arches, joists and other
- structural supporting elements.
- Damaged connections between structural elements (walls and roofs, beams and columns, etc).
- General age and condition of the structure.

Shoring

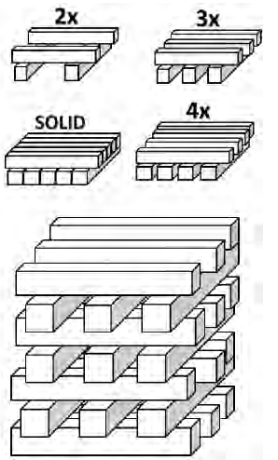
•Shoring is the provision of temporary support to buildings that are not safe or need to be supported while work is carried out.

•Before repair and retrofit of earthquake damaged building, it is very important to support the building using shoring for the safety of workers

•Shoring may be done using timber or steel props

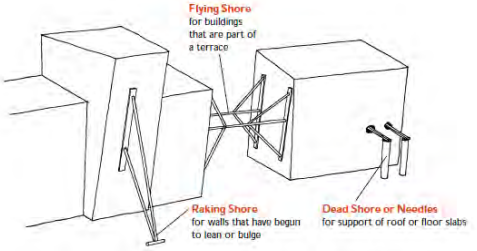
A Few methods

Cribbing



Shoring types

- Raking shore
- Flying shore
- Dead shore

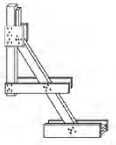


Racking

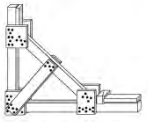
Raker with X-Brace

Raker with Dbl X-Brace

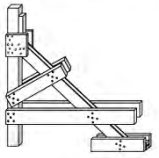
Racking



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



Raker: Solid Sole (Full Triangle)
Most desirable rakers, are normally built in groups of 2 or more as Class 3 Systems with lateral bracing.



Raker: 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. Should be built as Class 3 Systems.

Shoring

Raking shore

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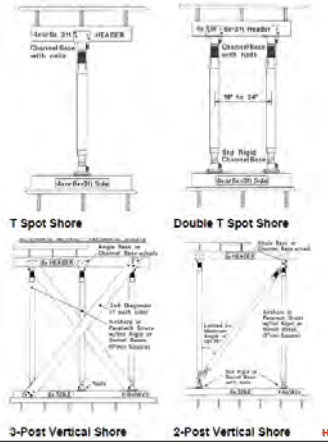
Shores



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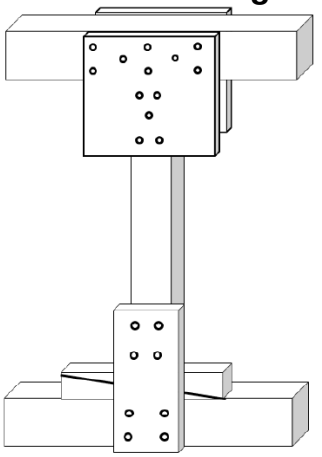
Shoring



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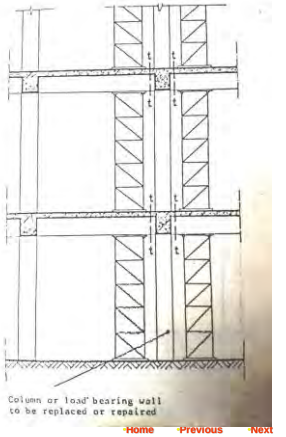
Vertical Support

- Providing vertical support for failed or severely damaged columns or bearing walls is the first consideration for temporary support



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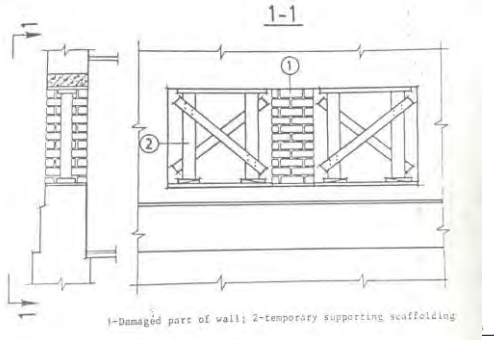
Vertical Support

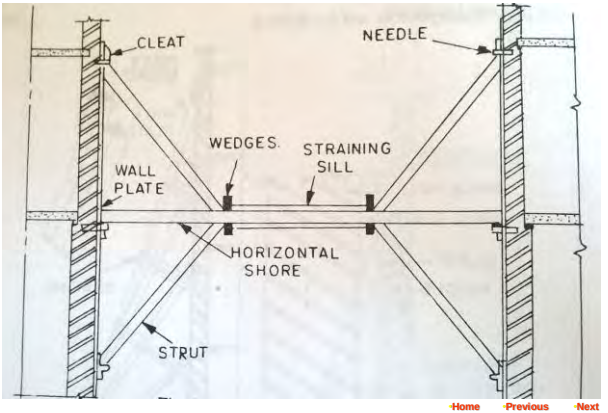
- When wall piers between openings are cracked or questionable stability, scaffolding should be used



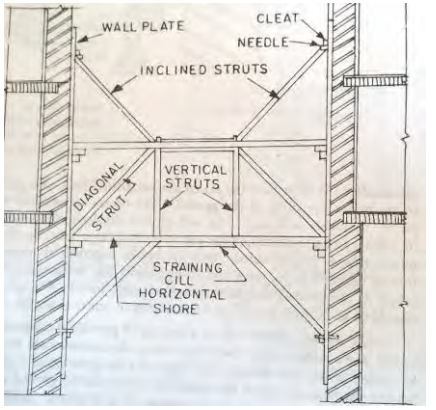
Vertical Props

- In case of very light loads, independent vertical props can be used, or
- Use steel sections

Flying shore



Flying shore



Flying shore

Flying shore

- Flying shores are used to provide temporary support to two parallel walls where one or both show signs of failure or being pulled down and rebuilt
- For distances between walls of up to 9m or less, a single shore may be used
- For distances up to 15m, a compound or double flying shore is needed.
- A single flying shore consists of a horizontal strut set between the walls in need of support.
- The ends rest on needles set into the wall and are stiffened by inclined struts above and below at either end.

THANK YOU!!

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Appendix C

DRAFT "Guideline for the Demolition of Risky Structures due to Earthquake-2015", Gov. of Nepal, Ministry of Urban Development

Government of Nepal

Ministry of Urban Development

Guideline for the Demolition of Risky Structures due to Earthquake-2015

2015

1. Preamble

This Guideline is issued as per the authority provided by clause 4 (l) of Natural Calamity (Relief) Act 1982 where the buildings that are in danger in the aftermath of the devastating Earthquake on April 25 2015 with epicenter in Barkpak of Gorkha district have posed serious threat due to continuous aftershocks. In this regard, the buildings that cannot be renovated or retrofitted should be demolished, in coordination with various agencies, in safe manner and reduce the risk that comes along.

2. Short title and commencement

(2.1) This Guideline may be called "Guideline for the Demolition of Risky Structures due to Earthquake-2072" (2015).

(2.2) This Guideline will implemented from the date of approval by the Government of Nepal

(2.3) This Guideline will be implemented across the country.

3. Identifying buildings for demolition

(3.1) The house owner should file an application along with details of damages sustained by the building in respective ward office (in case of municipality) and village development committee. The owner, if possible, should also bring along a copy each of land certificate, citizenship certificate and picture of the damaged house.

(3.2) If damaged building posses visible threat to the safer ones but house owner is reluctant to submit application or is not available, the neighourbs and other house owners can file joint application.

(3.3) The secretary of ward office/village development committee should submit the applications lodged at the ward offices/ village development committees of respective municipality to municipality/ village development committees.

(3.4) A local level technical committee to recommend the need of demolition shall be formed which will assess the threat based on field inspections of the dilapidated houses that have blocked public commuting and posed risk to nearby houses.

(a) For Kathmandu Metropolis, head of the department of physical infrastructure development department, for other municipalities engineer of respective municipality and in case of municipality with no engineers, the engineer deployed by District Technical Office ….. **Coordinator**

(b) Engineer assigned by Department of Urban Development and Building Construction/ Division Office….. **Member**

(c) Ward secretary of respective Metropolitan/ Sub-metropolitan/Municipality /village development secretary ….. **Member**

(3.5) The technical committee during its field inspection should abide by following process.

a. Fill up the Rapid Evaluation in Annex 2.

b. Take pictures from all four corners of the house.

c. Prepare deed of enquiry (muchulka) in presence of, if possible, the house owner in accordance with Annex 1.

d. Prepare report for or against the need of demolition of the building.

(3.6) The technical committee based on the field inspection should submit the report whether to or not to demolish the building to Metropolitan/Sub-metropolitan/municipality/village development committee.

(3.7) Based on the threat of the building as submitted by the report of the technical committee, the municipality/village development committee will prioritise the urgency before presenting it to the district disaster relief committee which will again report to the "Recommendation Committee to demolish buildings dilapidated by the earthquake" as mentioned below:

a. Joint Secretary, Ministry of Urban Development **Coordinator**

b. Joint-Secretary, Ministry of Home Affairs **Member**

c. Joint-Secretary, Ministry of Federal Affairs and Local Development **Member**

d. Joint-Secretary, Ministry of Physcial Infrastructure and Transportation **Member**

e. Colonel, Nepal Army **Member**

f. Deputy Inspector General of Police, Nepal Police **Member**

g. Deputy Inspector General of Police, Armed Police Force **Member**

h. Chief of the respective Metropolitan/Sub-Metropolitan/Municipality **Member**

(3.8) If the technical committee based on the field inspection cannot decide whether to or not to demolish the building then for further evaluation it will be submitted along with recommendation to central technical body formed by the central body "Recommendation Committee to demolish buildings dilapidated by the earthquake"

a. Senior Divisional Engineer designated by Department of Urban Development and Building Construction **Coordinator**

b. Major (Structural Engineer) from technical department of Nepal Army **Member**

c. Deputy Superintendent of Police (Engineer), Armed Police Force, **Member**

d. Deputy Superintendent of Police (Engineer), Nepal Police, **Member**

(3.8.1) The central technical team will conduct field inspection before preparing the report whether to or not to demolish building as presented by the field inspection of the local team.

(3.8.2) In case of apartments and other complex buildings Department of Urban Development and Building Construction, Division Office, Kathmandu will look into the detail assessment prepared by the technical team of the builders and based on its study further actions shall be recommended.

(3.8.2) Big Buildings built for commercial or public purpose including Shopping complex, educational institute, health institute buildings will first need to be detail assessed by the builders and based on its study further actions shall be recommended.

4. Central Disaster Relief Committee may issue Directives:

The buildings that need to be demolished as submitted by District Disaster Relief Committee by local technical team of municipality/village development committee in accordance to Clause 3.4 or submitted by the central level technical committee in accordance to Clause 3.5 to Central Disaster Relief Committee which can or shall direct a squad led by Nepal Army as mentioned below.

a. Nepal Army
b. Nepal Police
c. Armed Police Force
d. Representative of respective Metropolitan/Sub-Metropolitan/Municipality or Village Development Committee

(4.1) The squad assigned for demolition shall begin pulling down the buildings as prioritized by the local technical team.

(4.2) The demolition squad should list the houses to be pulled down, thereby going systematically, a day before going out for action.

(4.3) The demolition squad should keep the record in a safe manner of the house before demolition and after demolition.

(4.4) The demolition squad shall present its daily work progress and tomorrow's work plan to the district disaster relief committee and Ministry of Urban Development.

5. House owner's decision to demolish building

(5.1) Simple buildings that are deemed unsafe by technical committee and has been recommended for demolition shall be done by house owner itself. The technical should clearly mention the details in its report.

(5.2) For houses partially damaged that is almost ready to collapse and where house owners cannot demolish by themselves, the demolition will begin once the local technical team along submits its technical report.

(5.3) The house owners should consider details of Annex 3 before demolishing house by themselves.

(5.4) The house owner should bear all the cost of demolishing buildings including private hospitals, private schools and commercial buildings that are deemed unsafe. If it is not demolished, the demolition squad shall pull down the building as per Clause 4 after fulfilling criteria of Clause 8.5 and the cost should be reimbursed by the house owner to the government.

6. Precautions while demolishing building

(6.1) Demolition squad in accordance with Clause 4 or house owners demolishing by themselves in accordance to Clause 5 should consider and abide by the precautions as listed in Annex 3.

7. Role of Chief District Officer: The Chief District Officer is responsible to manage and coordinate the demolition of building in each district.

8. Miscellaneous

(8.1) The debris collected in the course of demolition should not impact the public transportation and commutation.

(8.2) For unsafe buildings that cannot be pulled down by house owners, the municipality should make arrangements of necessary equipments and helmets, gloves and other security materials.

(8.3) The concerned authority of the unsafe government and public buildings should coordinate with village development committee/ municipality and demolish the building within legal jurisdiction wherein the cost shall be borne by the authority itself.

(8.4) Should there be any hurdle while implementing this Guideline, the district disaster relief committee should clear the hurdles accordingly without creating any trouble to the Guideline.

(8.5) In absence of house owner where there is need to demolish unsafe buildings, a three day notice shall be issued by municipality/ward/village development committee as per the recommendation of technical committee before pulling down the building. The cost of demolition shall be reimbursed from the owner.

(8.6) The safe portion of the house shall be left once the unsafe portion is pulled down.

(8.7) The demolition of the houses will be prioritised according to the earthquake victims socio-economic status where people are too much affected by earthquake but have nowhere to go for temporary shelter…

(8.8) The recommendation committee for demolition shall recommend for changes in the Guideline without tampering its main theme.

ANNEX 1

(Related to Clause 3.5)

In written, in our presence, appeal that living in ……municipality/VDC ward no…. former ……VDC ward no…… Mr ……. I and my family have been living in a property owned by myself or jointly with……. registered in Land Revenue Office….. validated by ….. VDC/ward no. ….. seat no. …… plot no……area……. with …..storey house/temporary home or wall has sustained severe damages in the devastating earthquake on April 25 2015 and continuous aftershocks posing serious risk and hurdle for public commutation and with possible impact to neighboring houses. Therefore we lodge complaint in …. VDC

…….incomplete

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All the aforementioned details are true. The facts and figure are correct. Hereby, if anything is tampered, shall be liable to actions as per the existing law. Those involved in identification (sanakhat):

1. Mr/Mrs …… from …… municipality/VDC ward ...

2. Mr/Mrs ……. from ……. municipality/VDC ward ...
3. Mr/Mrs ……. from ……. municipality/VDC ward ...
4. Mr/Mrs ……. from ……. municipality/VDC ward ...
5. Mr/Mrs ……. from ……. municipality/VDC ward ...
6. Mr/Mrs ……. from ……. municipality/VDC ward ...

Witness

Coordinator of Ward Citizens forum/ Member	Mr/Mrs……
Political representative	Mr/Mrs……
Member of Nepal Police	Mr/Mrs…….
Owner of the house	Mr/Mrs…….

Officials of the Technical Team

1. Coordinator: …….. Engineer (……. Municipality)
2. Member:…… Engineer (…..Department of Urban Development and Building Construction)
3. Member:…… Ward Secretary (Ward Office ……..)

Miscellaneous

- Date of construction of the house……..
- Type of house cemented and non-cemented (Pakki and Kachchhi). If cemented Could be Frame Structured, Load Bearing or Composite
- Length ……., Breadth……,height ……., floor …… of the house
- Type of destruction :
- Remarks :

ANNEX 2

(Related to clause 3.5)

Preliminary Evaluation Form

Inspection

Inspection ID:…….. Inspection Date : ……..

Inspection Time: …….

Area inspected: ☐ External Only ☐ Exterior and Interior

Building Description

Building Owner's Name : …….

Address:

Ward /Tole : ……. Municipality/VDC: ……

District :…… Contact Number: ……

Approx. Building Footprint area (Sq. ft): …… No. of Stories: ……

Construction year: …… B.S. (……..AD)

Type of Construction

☐ Adobe ☐ Stone in Mud ☐ Brick in Mud

☐ Brick in Cement ☐ Stone in cement ☐ RC Frame

☐ Wood Frame ☐ Bamboo ☐ Other

Type of Floor ☐ Flexible ☐ Rigid

Type of Roof ☐ Flexible ☐ Rigid

Primary occupancy:

☐ Residential ☐ Educational ☐ Commercial

☐ Hospital ☐ Industry ☐ Club

☐ Government Office ☐ Office ☐ Hotel/ Restaurant

☐ Police Station ☐ Institute ☐ Mix

☐ Others

Land Slope ☐ Plain ☐ Gentle Slope ☐ Steep Slope

Adjacent Building ☐ Free Standing ☐ Building in 1 side

☐ Building in 2 sides ☐ Building in 3 sides

Road Access: Rode width

Current Status: ☐ Accessible ☐ Not accessible due to debris / road damage

Evaluation

Observed Condition	Minor	Moderate	Severe
Collapsed, Partially Collapsed, Or Moved off its foundation	☐	☐	☐
Ground in the vicinity of building moved irregularly in vertical direction with cracking or fissures	☐	☐	☐
Gap between ground and building foundation wall (i.e. wall of building that is normally underground) since large gap may lead to overturning	☐	☐	☐
Building or any story is out of plumb	☐	☐	☐
Damage to primary structural members, cracking of walls, or other signs of distress present	☐	☐	☐
Large fissures in ground, massive ground movement, or slope displacement present	☐	☐	☐
Other hazard 9 Specify) e. g tree, Power line, gas leakage	☐	☐	☐
Have the wall moved visibly (% degree)	☐	☐	☐

Possibility of Trapped / Dead persons: ☐ N☐

Tentative Number of Victims: ……..

Posting based on Evaluation

☐ Restricted ☐ Unsafe

Comments:

……
……
……
……
……
……

ANNEX 3

(Related to clause 6)

Things to be taken into consideration while demolishing the houses/buildings:

- Get fully abided by all the legal provisions required for the demolition
- Inform to the nearest ward office before starting demolition
- If possible carry out demolition only after the consent from the house owner
- Get signature of the owner in the form ensuring that s/he is responsible if there is damage or destruction of facilities. If s/he does not agree for it, act as per the suggestion of the recommendation committee
- Ban heavy vehicles in the area where houses are in dilapidated condition
- Fence the area of demolition using ropes to ensure safety
- Work in coordination with Electricity Authority to make sure that power is cutoff during demolition
- Keep in mind the possibility of fire or other disaster keep fire fighter standby
- Station ambulance with doctor and medics in the demolition area
- First of all manage the materials that are likely to fall down
- Start the demolition only after ensuring that everyone has helmet, gloves, masks, boots, clothes with full sleeves, whistle among others
- Working in pair increases safety level
- Also, keep in mind the safety of onlookers and other people before initiating the work
- Remain alert for aftershocks
- Never work in rainfall
- Start demolition from the top floor
- Remove unstable things first
- Stay alert for the outcome invited while removing the remains of the houses
- Stay safe from the structures that are likely to fall at any time
- Start demolition only after putting support to the dilapidated walls
- Pay special attention while using equipments
- Make sure that the house being demolished makes no loss to nearby buildings or facilities

- Prioritise in making debris wet or covering while ferrying it to the designated site dumping site
- Ban mobility in the roads during demolition
- Ask others who are not involved in the demolition to stay in the safe place

ANNEX 4

Related Laws (Act)

1. Natural Calamity (Relief) Act 1982
2. Interim Constitution of Nepal 2007
3. Town Development Act 1998
4. Public Roads Act 1974
5. Kathmandu Valley Development Authority Act 1998
6. Ownership of Joint Housing Act 1997
7. Building Act 1998
8. Construction Business Act 1999
9. The Private Financing in Build and Operation of Infrastructures Act 2006
10. Environment Protection Act 1997
11. Local Administration Act 1971
12. Police Act 1955
13. Army Act 2006
14. Civil Rights Act 1955
15. Armed Police Act 2001
16. Local Self Governance Act 1999

Executive Summary

Subject	Process	Remarks
Application	Related house owners/ Neighbour	
Application Collection	Ward Office/ VDC Offices	
Technical assessment and	Team at the local level	

recommendation		
Re-assessment and recommendation	Team at the Central Level	In case the local team cannot take clear decision
The final decision for demolition	The committee formed to recommend the demolition of earthquake hit buildings	
Deed of inquiry	Ward Office/VDC Office	
Decision of demolition and prioritisation	Municipality/ VDC	
Make available the list of the buildings to be demolished	District Administration Office	
Execute demolition	District Administration/ Designated Team	
Deed of Inquiry before and after demolition	Designated Demolition Team	
Clear the hurdle	Chief District Officer	