C8

Hazard Resistant Features Foundation and Plinth

No. of Slides: 41
Time: 45 min

National Disaster Management Authority

Hunnarshala Foundation

People in Centre

Gujarat Institute of Disaster Management

Expected Outcomes

1. Participants understand importance of foundations in hazard resistant construction.
2. They are able to select appropriate foundation for local conditions.

How is the foundation made in your region?

Q1. What are the different materials and types of foundations that are used in houses?

Q2. How deep and wide is the foundation built:

a) For a single storey house?
b) For a double storey house?

Q3. Is the decision about depth and width of foundation dependent on soil type, budget, number of storeys and type of roof?

Q4. Considering the hazard this region is prone to and the soil types commonly present, what may happen to the foundation, if hazard strikes?

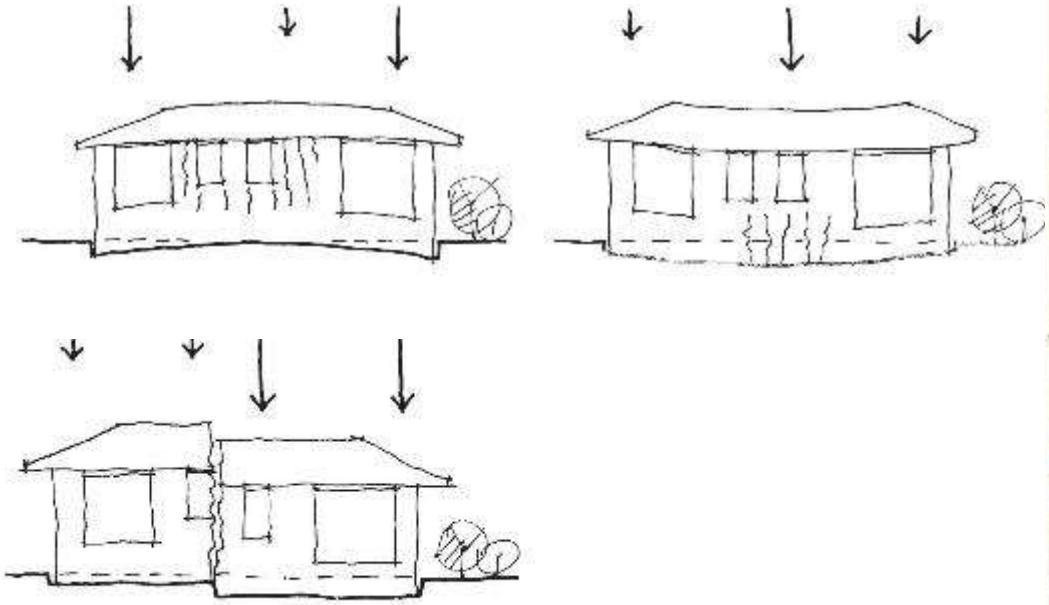
Q5. What is the risk involved, when upgradations, modifications or additions are done? For example, when the CGI sheet is replaced with RCC, a single storey house becomes a double storey house.

Damages to Foundation and Plinth

Earthquake Flood

1. Uneven Settlement of Soil and Impact on Foundation

If the foundation of the house is built on non-compacted soil or if it is clayey soil which is partially saturated, it may lead to uneven settlement of the building.



Earthquake Flood

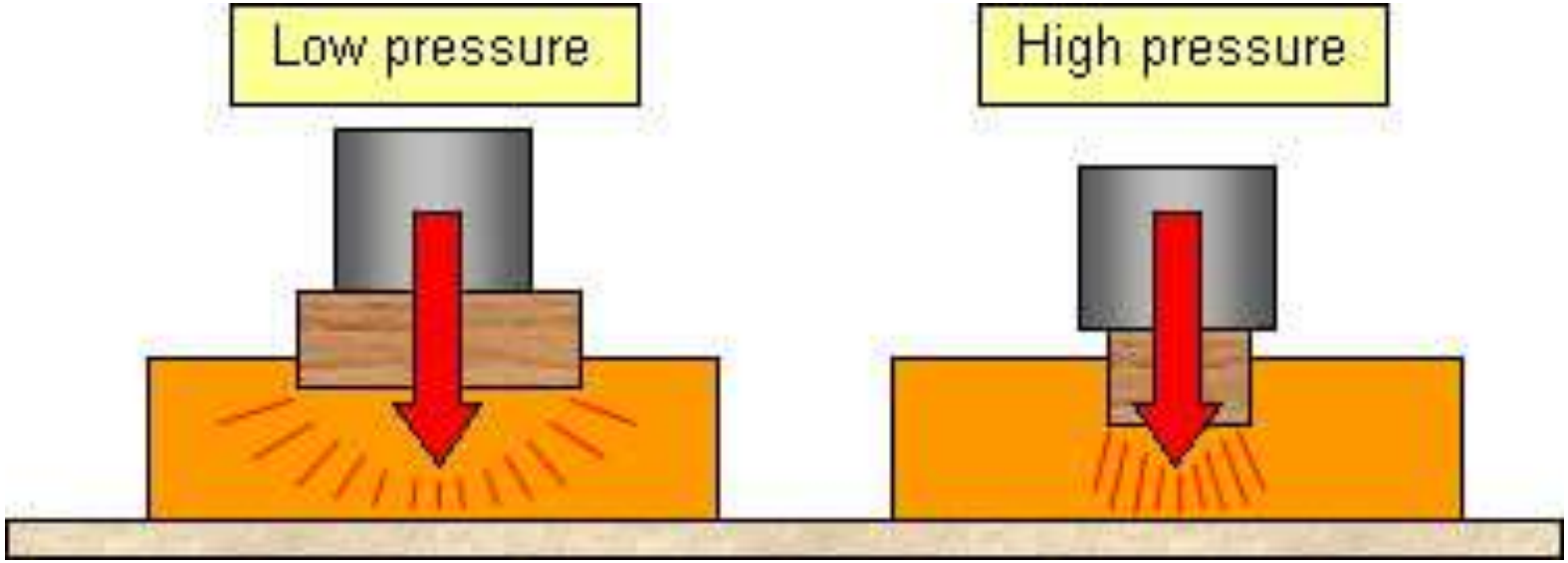
2. Scouring of Foundation and Wall Base

Fast moving water erodes the soil underneath the foundation. This weakens the structure resulting into large holes or cracks or collapse of walls.

Types of Foundations

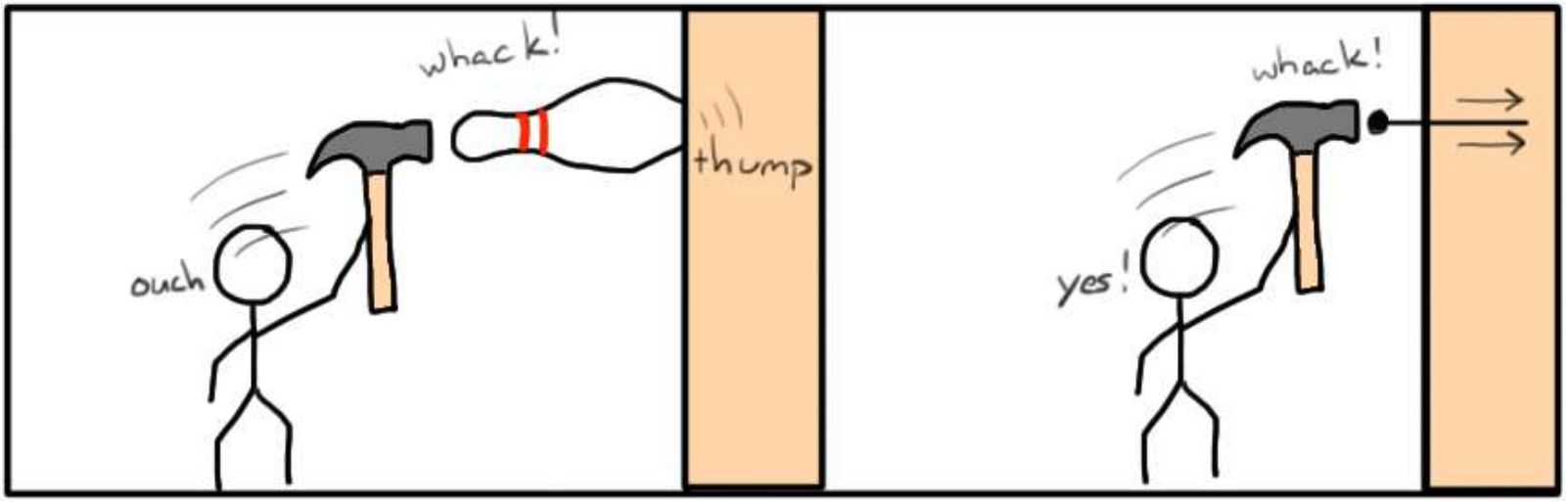
1. Strip Foundation

Load bearing walls are supported by continuous foundations that spread out at the base to ensure a wider surface area for the load to transfer to the ground. This type of foundation is called a Strip Foundation. The spreading out of the base ensures stability.



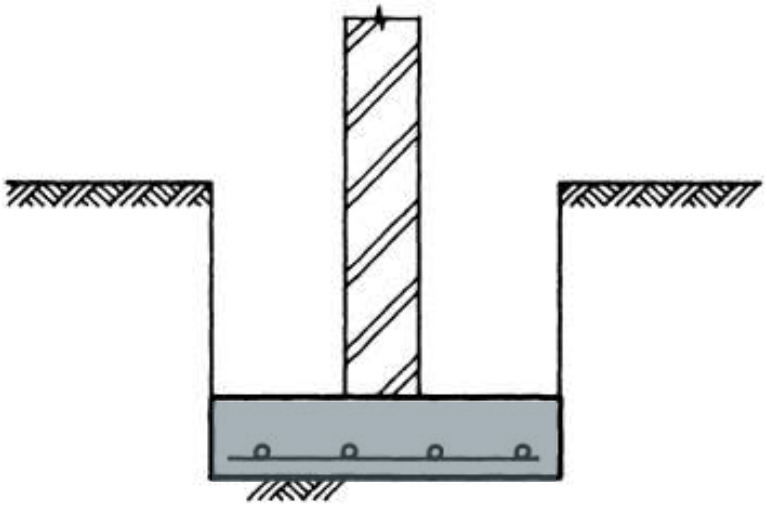
Strip Foundation

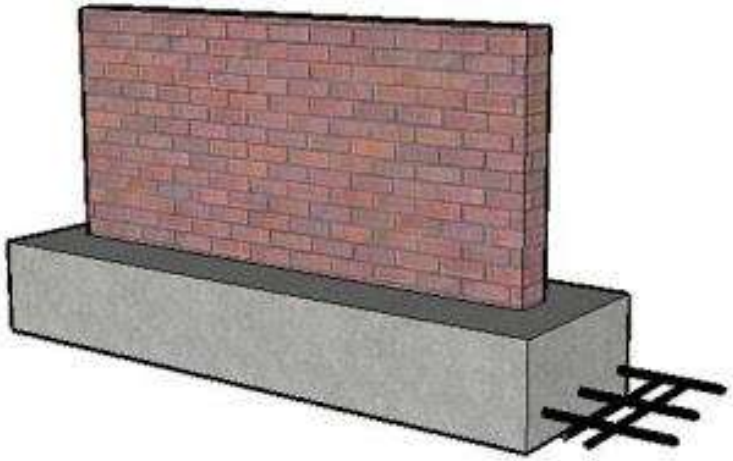
Imagine piercing a narrow object into the wall versus piercing one with a large base. What happens in the two situations?



Strip Foundation

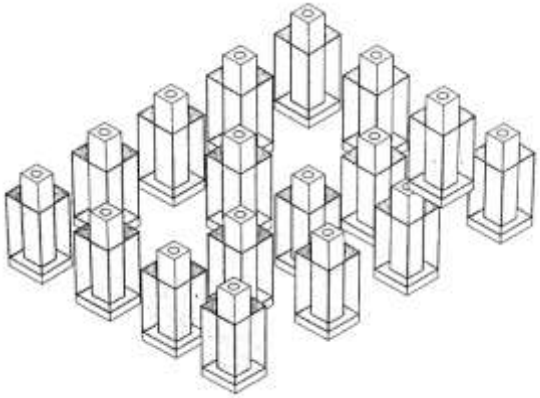
The base of the strip foundation is always wider at the bottom. If the soil, where you are building, has lower bearing capacity, the foundation should have an even wider base at the bottom.



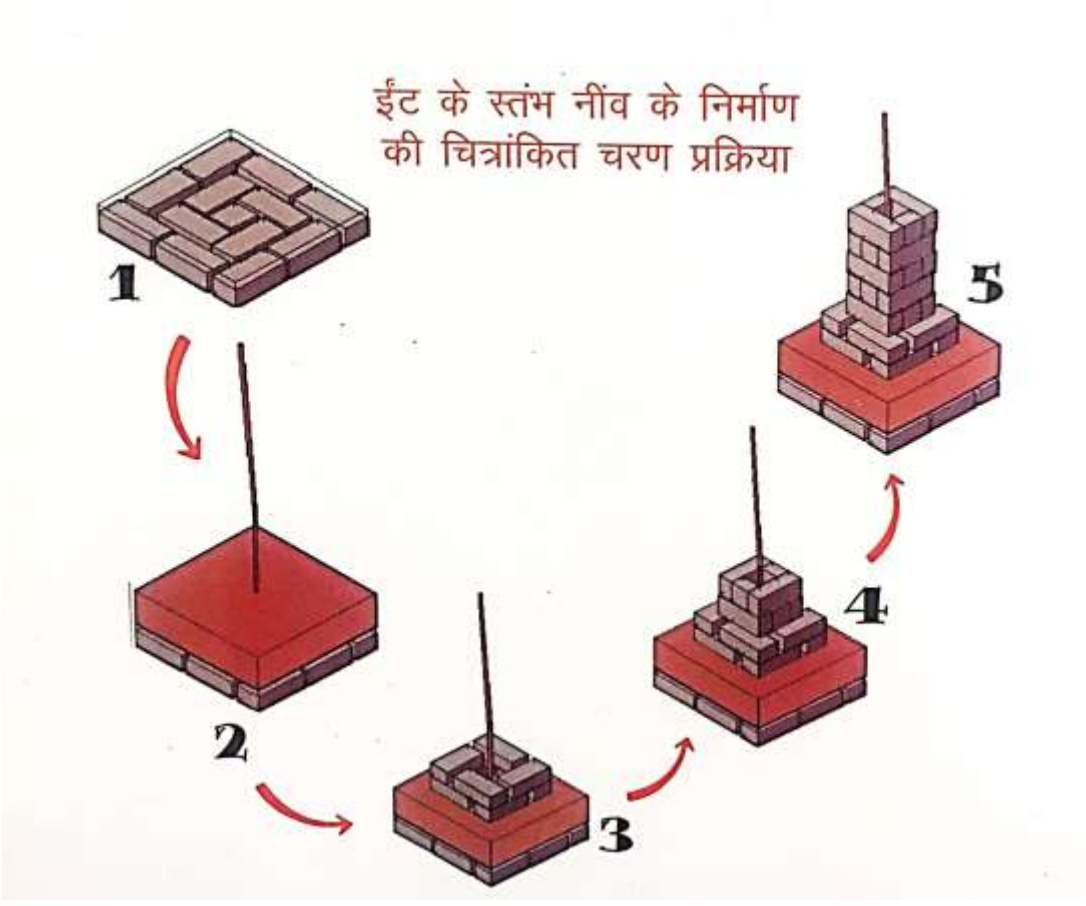


2. Stub Foundation

In the stub foundation too, the base is wider and it becomes narrower as it comes up. The stubs need to be provided at all junctions and tied with beam.



The stub foundation has a concrete padding and is made of brick. On top, it is the size of the column itself.

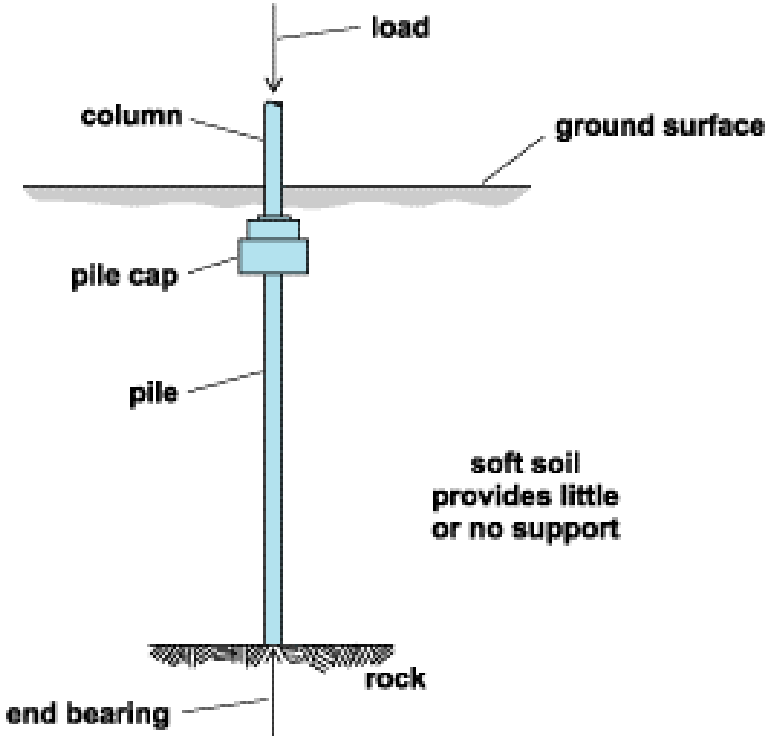


Pile Foundation, Raft Foundation and Individual Footing

Special Foundations when the soil type is less than ideal (loose soil, too much clayey and expansive, or with possibility of settlement or liquefaction). **All these foundations need to be designed by an engineer.**

3. Pile Foundation

When the soil is loose and the foundation needs to take a heavy building's load, the foundation is taken down to the bedrock.



4. Raft Foundation

Raft foundation consists of RC slabs of uniform thickness, that cover the entire fooprint of the building and support a number of walls and columns.

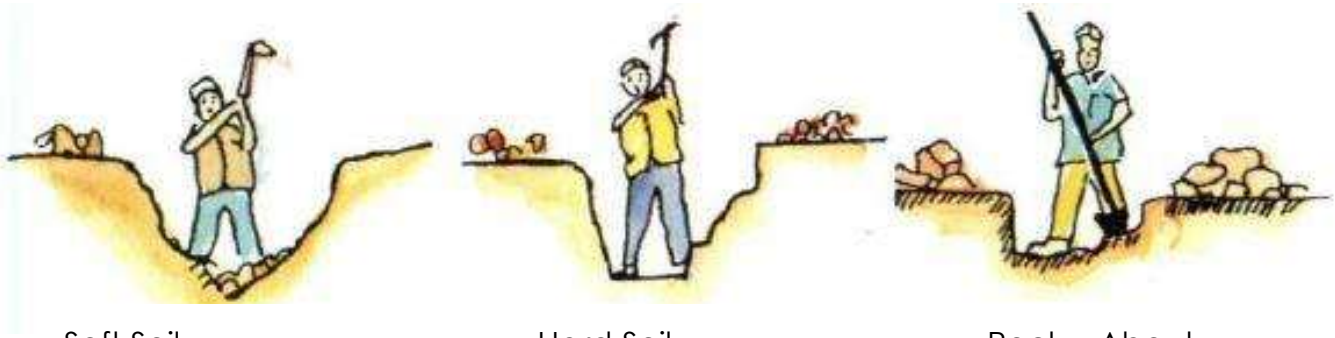
5. Individual Footing

When the soil is relatively hard and the RC column needs to take a heavy load, the foundation of the RC column is made as an Individual Footing.

Foundation Details

1. Founding Depths

How deep are the foundations in your region?



Soft Soil - Minimum 900 mm

Hard Soil - Minimum 600 mm

Rock – About 150 mm

Thumb rules:

1. For light weight single storey structures, 600mm is the minimum depth.
2. Rocky structures allow 150mm deep foundations
3. Special soil conditions as discussed above allow 600-900mm depth.

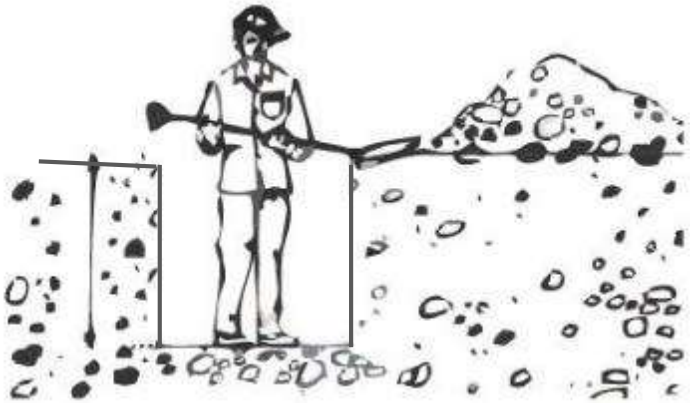
2. Shape of Trench

1. Where there is hard soil and the foundation is not deeper than 900 mm, a trench with vertical walls can be dug.

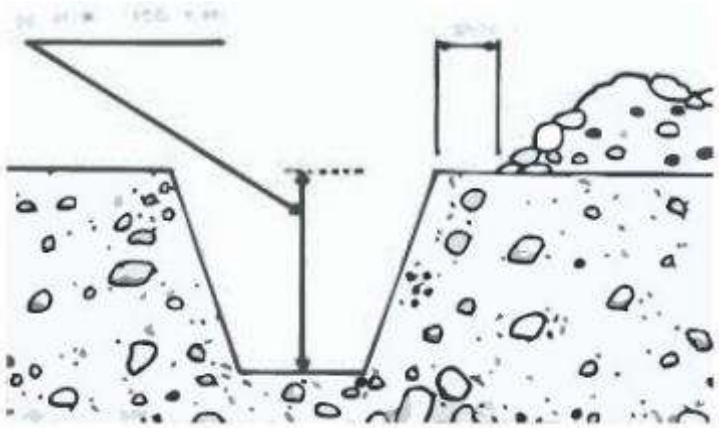
2. In any other situation, a trench with a slope will be dug which cannot have a slope more than 2:1.

3. The material dug out of the trench must be kept at least 600 mm away from the trench line.

4. The line out of the centre lines with string must exist until the plinth is complete.



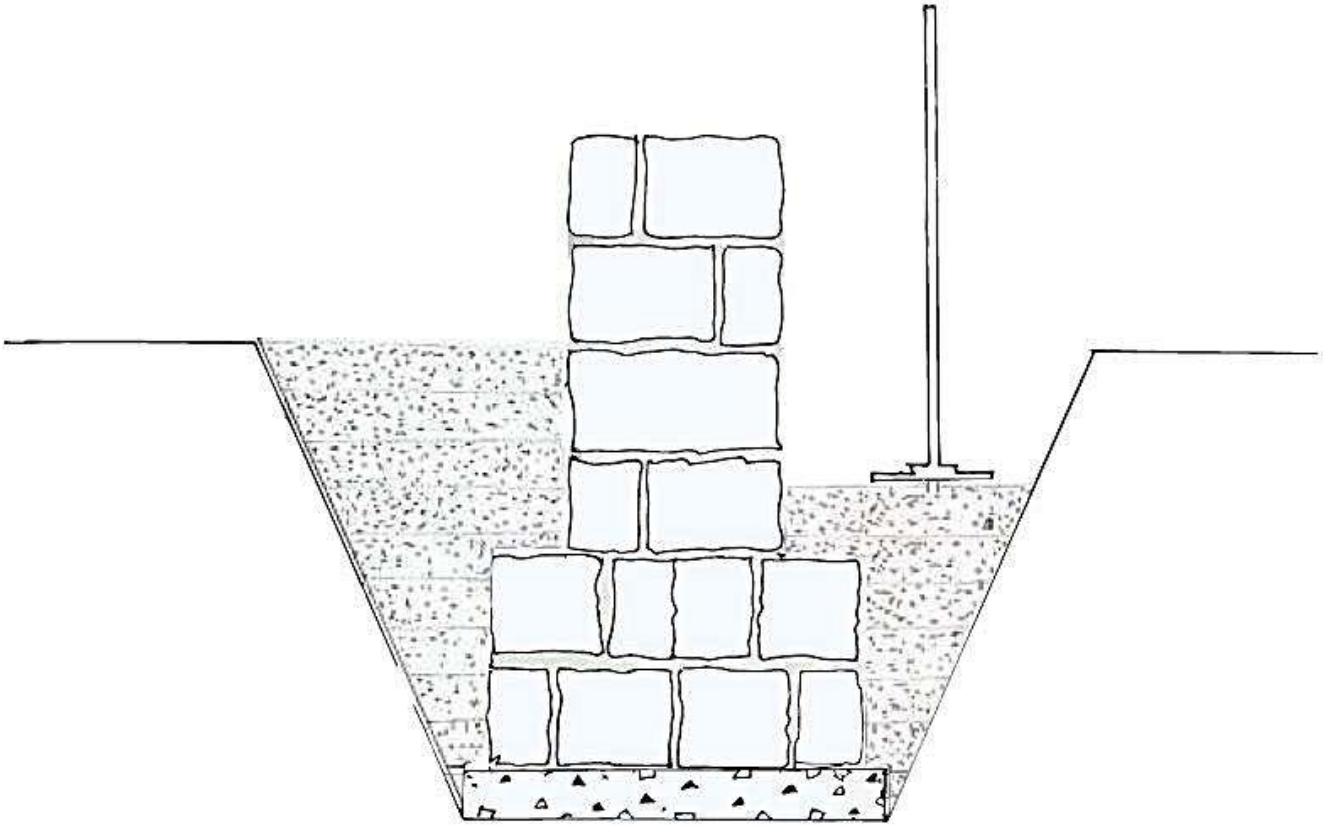
Hard soil



Soft soil

3. Backfilling of Trench

The backfilling of the soil must be done carefully, layer-wise and rammed in with every layer so that the soil is properly compacted.



4. Rules for Stone Foundation

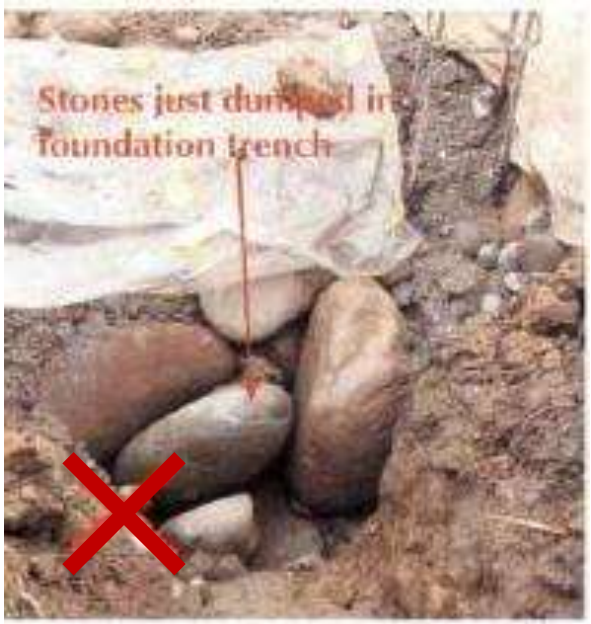
Rules for stone masonry must be followed in the foundation.

1. Trench must be dug in a way that the sides of the trench must be as straight as possible.
2. Corner stones must be placed in each course.
3. No voids must be left in masonry.
4. Longer stones/ Through stones should be used.
5. Each course must be levelled well
6. Provide at least one "through stone" at every 1,200mm horizontal distance in the masonry course and at every 600mm height in a staggered manner.

Place each stone flat on its broadest face.

Place long stones at corner in each course with length of stone placed parallel to the length of the wall.

7. Rounded stones cannot be used anywhere, including in the foundation.
8. Each course must be properly laid and compacted with sand, following which the trench must be backfilled completely as required with layer-wise compacting.



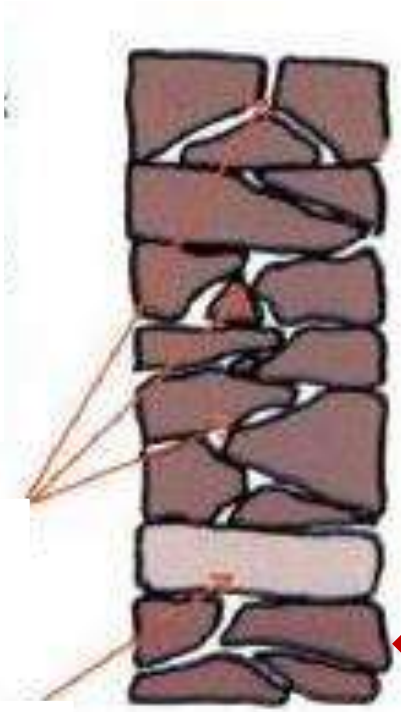
In the portion of foundation below ground stones must be placed as per rules of masonry.

In the portion of foundation below ground do not use round stones, and do not just dump stones.

5. Through Stones in Foundation

Through stones in foundations must be staggered and used every few courses to bind the wall well.

Both faces must interlock with each other to form one wall. The vertical join must be broken.



Broken vertical joint

Through Stone

Use RC blocks as through stones, when through stones of the right length are not available.

6. Vertical Reinforcement in Stone Masonry Walls

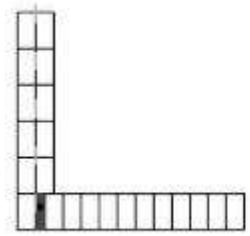
Vertical reinforcement in the walls must be anchored right from the foundation. The steel bar can be kept in place using a PVC pipe till 3-4 layers of stone masonry is done; then the pipe is removed and the void is filled with concrete, providing cover to the steel.

L-junction in English Bond (Foundation)

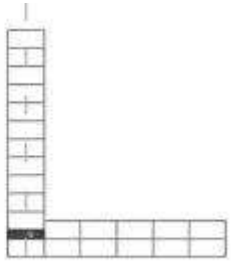
Vertical Reinforcement in L-Junctions in English bond, where at the base of the Brick Foundation,

the wall is 2 brick thick.

1 brick thick

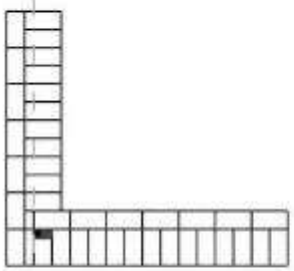


Single brick wall- Course 1

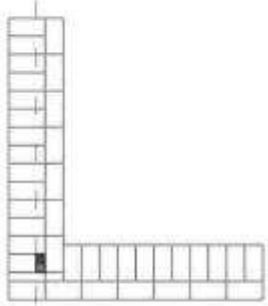


Single brick wall- Course 2

1 ½ brick thick

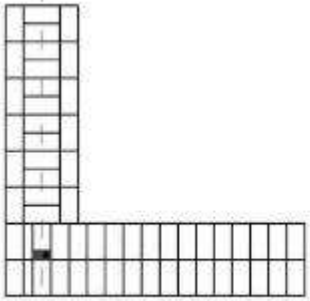


One and half brick wall- Course 1

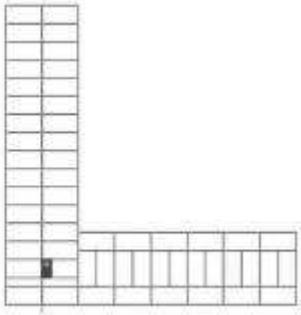


One and half brick wall- Course 2

2 brick thick



Double brick wall- Course 1

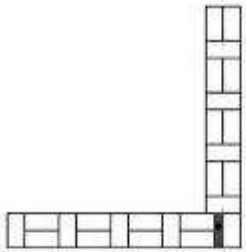


Double brick wall- Course 2

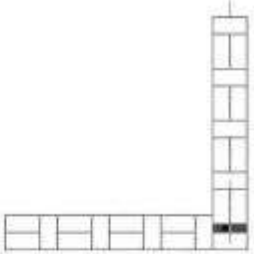
L-junction in Flemish Bond (Foundation)

Vertical Reinforcement in L-Junctions in Flemish bond, where at the base of the Brick Foundation, the wall is 2 brick thick.

1 brick thick

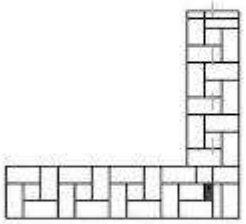


Single brick wall- Course 1

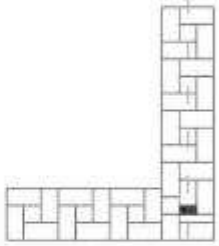


Single brick wall- Course 2

1 ½ brick thick

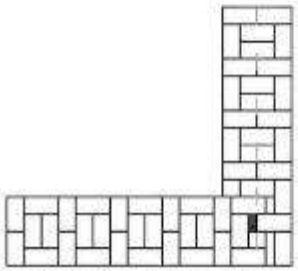


One and half brick wall- Course 1

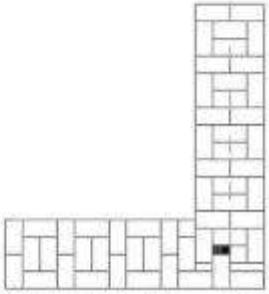


One and half brick wall- Course 2

2 brick thick



Double brick wall- Course 1

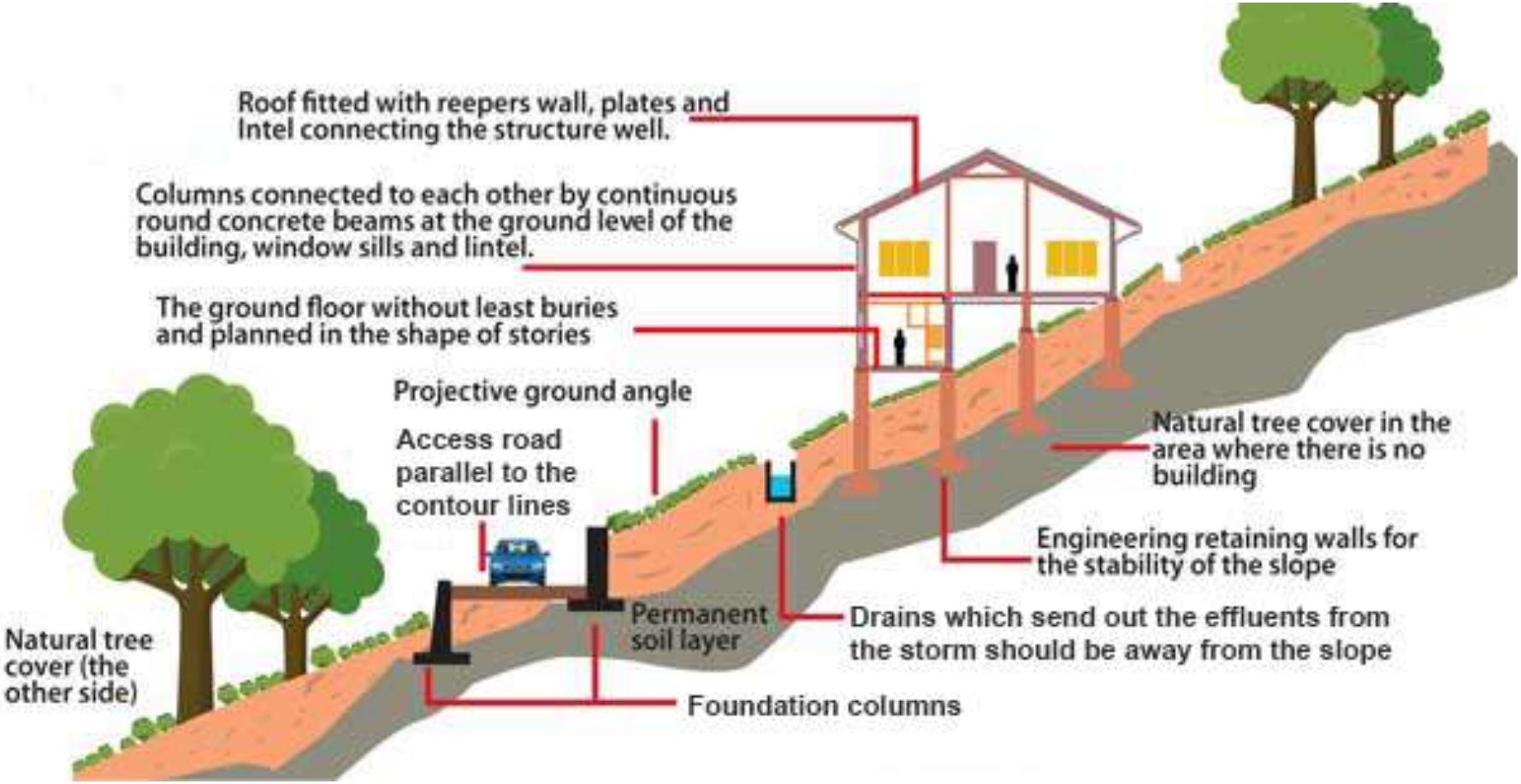


Double brick wall- Course 2

7. Filling Mortar in Joints

All joints must be completely packed using mortar.

8. Foundations in Landslide Prone Areas



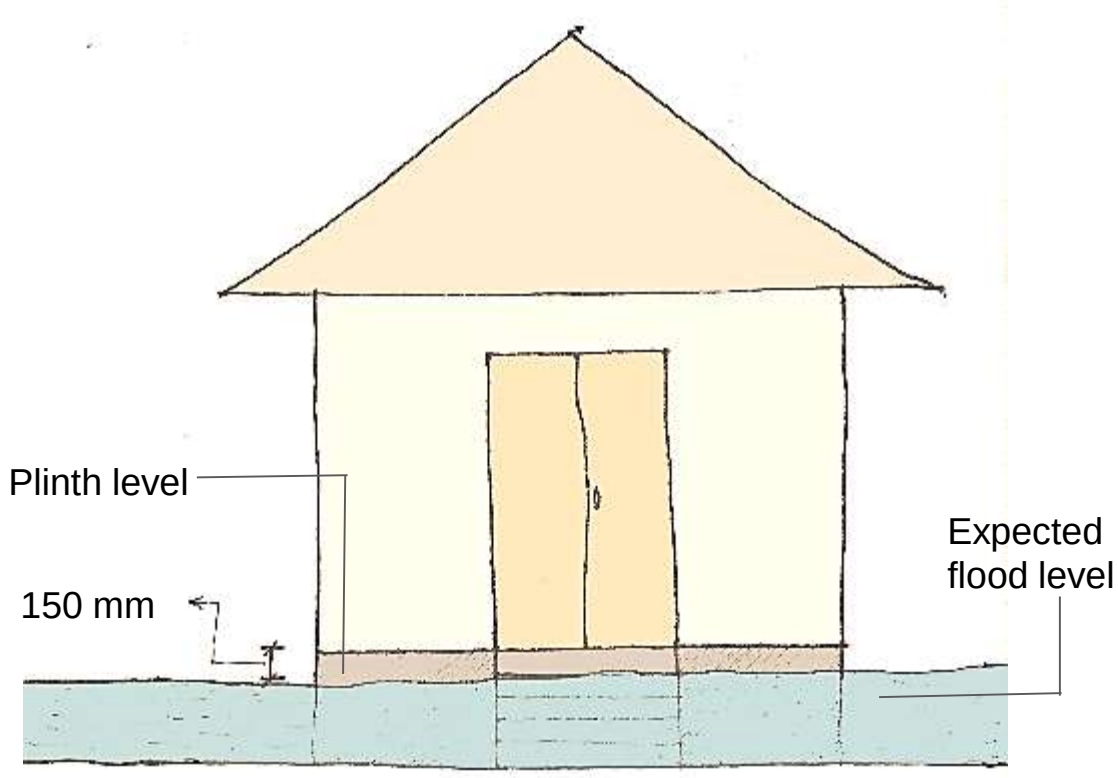
Plinth

A plinth serves many purposes. It not only protects the base of the house and raises it above the flood levels, but also becomes a social space for people to come together, relax and chat.

Plinth height must be at least 150 mm higher that the highest annual flood level of the last 50 years.

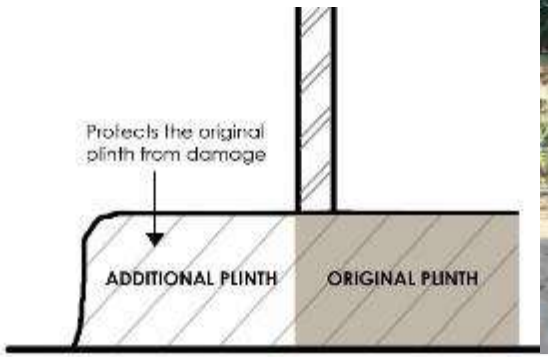
If the threat perception at any location is more, plinth height should be increased.

Materials that degenerate or lose their strength due to presence of water, should not be used for the plinth.

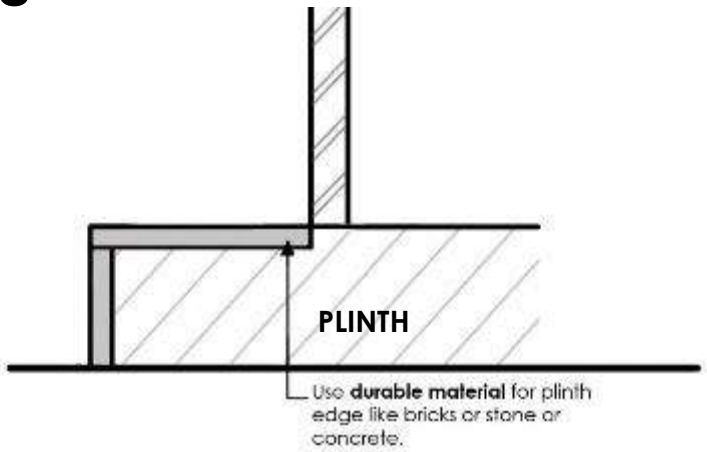


Plinth Protection (recollection)

Extended Plinth



Plinth Edge



Plinth Protection

Plinth should be made with ‘cement’ or ‘mud mortar with cement plaster’. If cement plaster cannot be done, cement pointing is necessary for the protection of the plinth.

Plinth Details

1. Damp Proof Protection

Damp proofing is done to protect the walls of the house from becoming moist/damp due to capillary action of water. As discussed previously, such action in walls can lead to loss of strength of materials used for wall.
The Damp Proofing Course should be provided at the junction of the plinth and the wall such that water from plinth does not rise into to walls.

Options for Damp Proof Course

1. Make RC band at plinth level with proper rodding to minimize percolations.

2. Use sheet of polyethylene, plastic or bitumen coated woven polypropylene sacks just at the base of the wall.

2. Grade Beam and Plinth Band

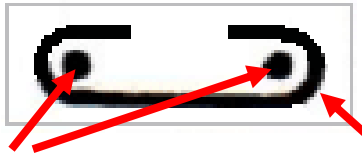
The grade beam acts as the damp proof course and avoids water from going up the walls.

Steps to make a concrete DPC

Step 1:
At the desired height,
2 longitudinal bars are placed 25 mm inside from the wall faces, with cross links in between them at 150mm distance.

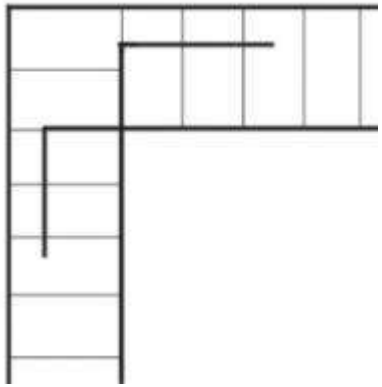
Step 2:

The longitudinal bars should be at mid height of the required band. This can be done by placing stone pieces under the bars.



Step 3.
The longitudinal bars must be lapped at the L-junction to make a proper joint at the corner. This is the critical joint, which transfers the loads.

Connect bars at wall junction with minimum 450 mm lap length.

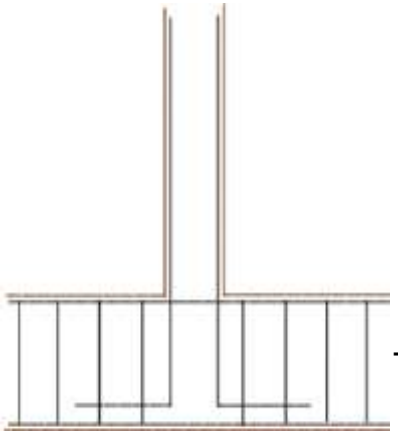


L-Junction Bar arrangement

Step 4

Arrangement of longitudinal bars at T-junction. Here too, the bars need to overlap properly to ensure transfer of loads.

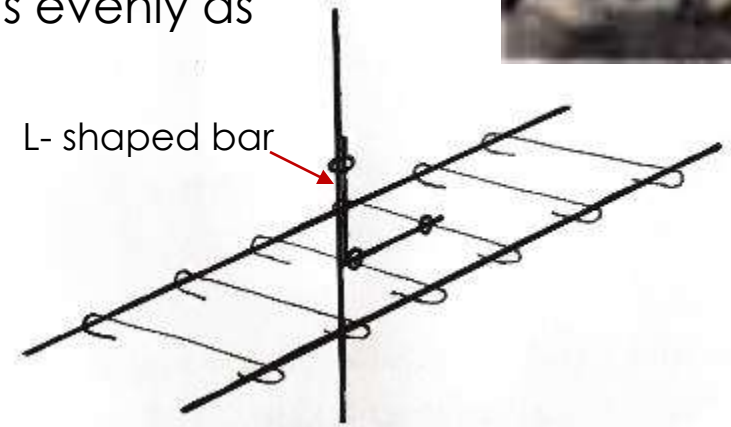
Connect bars at wall junction with minimum 450 mm overlaps.



T-Junction Bar arrangement

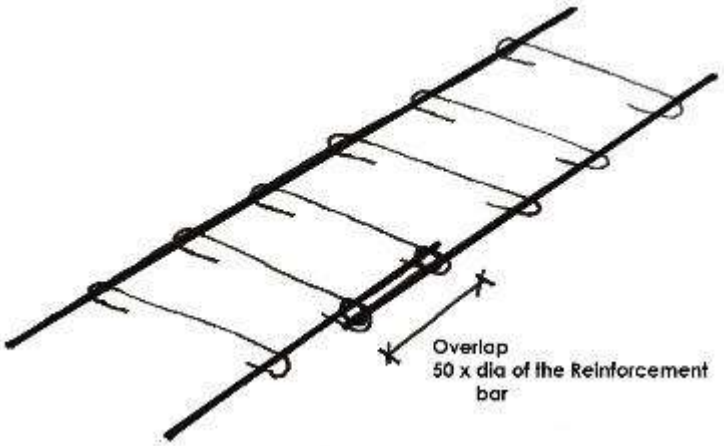
Step 5.

An L shaped bar with each leg 450mm long is to be tied to the main rebar of the band and the vertical bar together to ensure the entire house is well connected and box-action occurs to transfer the loads to the ground as evenly as possible.



Step 6.

Bar to bar connection must be done with overlap joint of 400 mm for 8mm diameter and 500mm for 10mm diameter.



Step 7.
Pour concrete 1:1.5:3 proportion with rodding and cure for 15 days.

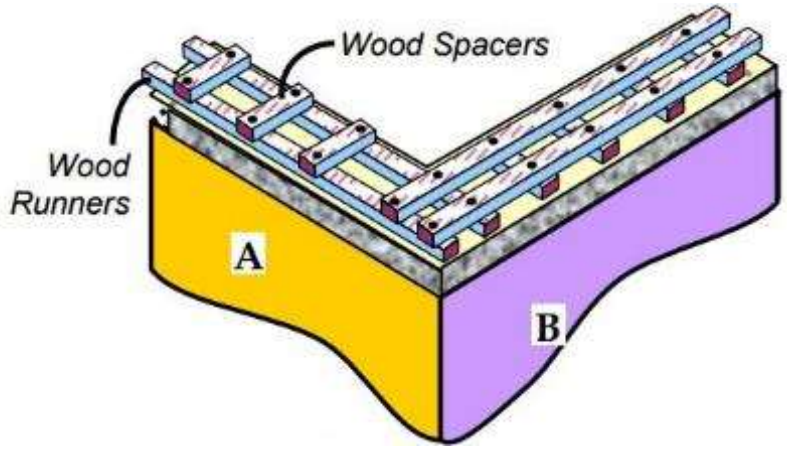
Pour concrete of 1:1.5:3 proportion with rodding. Cure band for fifteen days.

3. Alternative Materials to make Plinth Band

Weld mesh encased in 25 mm thick layer of mud mortar.

3. Alternative Materials to make Plinth Band

Timber/Bamboo ladder with proper overlapping at junctions in the wood. Corner joints secured with screws or wooden pegs to ensure proper transfer of loads.



4. Cement Pointing to protect Plinth

Repointing is the process of renewing the **pointing**, which is the external part of mortar joints in masonry construction. Over time, weathering and decay cause voids in the joints between masonry units, usually in bricks, allowing the undesirable entrance of water. This is especially of concern in masonry walls with mud mortar. Repointing the walls is essential periodically over time.

Summary

1. Typical damages to plinths and foundations occur due to uneven settlement of soil, liquefaction, and scouring. When the foundation is damaged, it may be unable to take the load of the house, making the house vulnerable.

2. Depending on the soil type, one can choose between Strip Foundation, Stub Foundation or an Isolated Footing. If the soil is not ideal, i.e. loose, expansive, prone to settlement or liquefaction, pile foundation or raft foundation may be considered and designed with the help of an engineer.

3. We discussed about increasing hazard resistance in foundation and plinth including: (i) Appropriate depth, width and shape of foundation for different conditions, (ii) importance of backfilling and compacting it, (iii) providing vertical reinforcement from the foundations, (iv) following proper stone/brick masonry, (v) Foundations in landslide prone areas, (vi) Plinth protection, (vii) DPC and grade beam and plinth band, and (viii) cement plastering or cement pointing of plinth.