C7

Importance of Site and Soil conditions

No. of Slides: 37
Time: 45 min

National Disaster Management Authority

IIT-Gandhinagar

People in Centre

Gujarat Institute of Disaster Management

Expected Outcomes

1. Participants know the importance of better locations of houses, through desirable site features.

2. They learn to modify site conditions, where possible, to make it better.

3. They understand soil types and its impact on foundation - stability of houses.

UNDERSTANDING THE SOIL

Site and Soil Conditions should be identified before starting construction

1. **Location:** Proximity to certain geographical conditions (ridge, cliff edge, sand dunes, mangroves, forests, tree cover, water bodies-river, ocean, ponds)

2. **Slope:** What is the angle of repose of the soil and what is the angle of the slope?

3. **Drainage:** How well drained is the slope? Or how does the site and its surroundings drain itself when it rains.

4. **Soil Type:** What kind of soil is on your site (clayey soil, sandy soil, silty soil, loamy soil)? Are the conditions of soil varying or are they the same on the site and the surroundings? Is there organic matter in the soil?

5. **Water Table:** How much below the surface is the groundwater level?

Ideal site and soil conditions:

1. **Location:** Proximity to certain geographical conditions (ridge, cliff edge, sand dunes, mangroves, forests, tree cover, water bodies-river, ocean, ponds)

   a) Must not be on a natural water path and floodplains,

   b) Natural cover,

   c) Ideally, not too close to water bodies, and

   d) Ideally, not too close to cliff edge or on an unstable slope.

2. **Slope**: Gentle

3. **Drainage**: Well drained soil and surroundings. Not coming in the natural flow of water.

4. **Soil Type:** Well graded soil, compact, non-expansive

5. **Water Table:** Best, if water is far below the foundation; it does not cause problems for the stability of the building.

Why is the type of soil important?

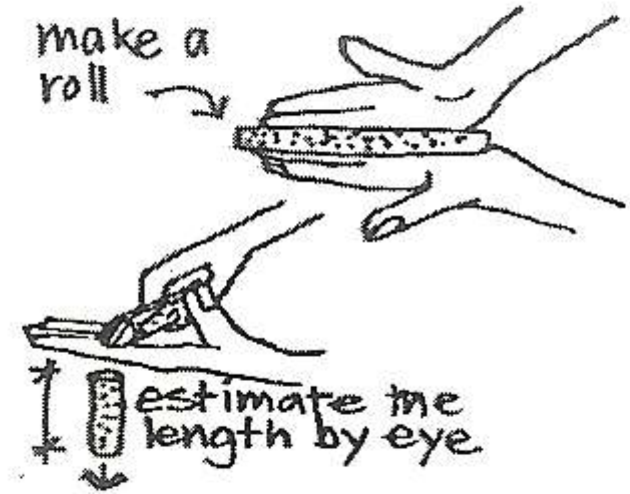
1. **Bearing Capacity** is the capacity of soil to support the loads applied to the ground.
2. **Soil with high bearing capacity is suitable for construction.**
3. A soft soil, which is not fully compacted, will have low bearing capacity. To capture the kind of soil and to know whether it is properly compacted, the bearing capacity of the soil should be determined through field tests.

Why should a house be built on hard soil?

1. **Gravity load is being taken by the soil. Soft soil has low bearing capacity, whereas hard soil has high load bearing capacity.**
2. During hazards, sometimes, soil loses its capacity, especially when there is sand and water. Hence the building tends to sink.
3. Sandy soil with water (in times of heavy rainfall, flood or dam breaks during earthquakes) may lose its bearing capacity.

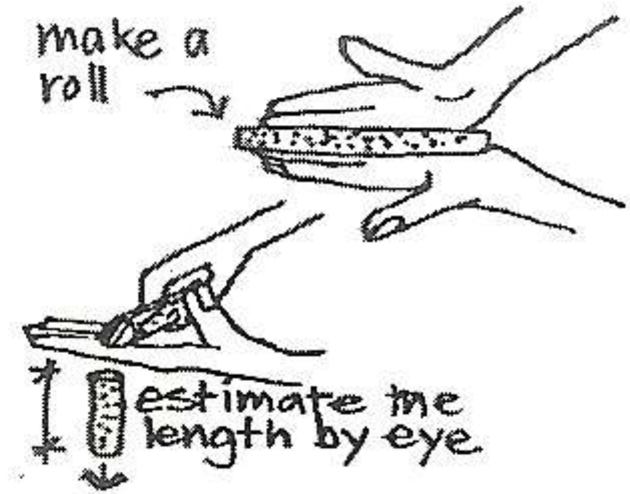
Test to identify Soil Type: Ribbon Test

- Take a handful of soil and moisten it to the point where it will form a ball. Wrap your fingers around the ball, and try to squeeze out a sausage between the thumb and forefinger. Let the sausage bend as you form it, whilst watching to see how far it can be bent before breaking.
- If you cannot form a ball, you have very sandy soil.
- If you can feel larger gritty particles in the ball, you have course sand.
- If you can form a ball but a sausage cannot be formed without breaking, you have sandy soil with some clay.



Test to identify Soil Type: Ribbon Test

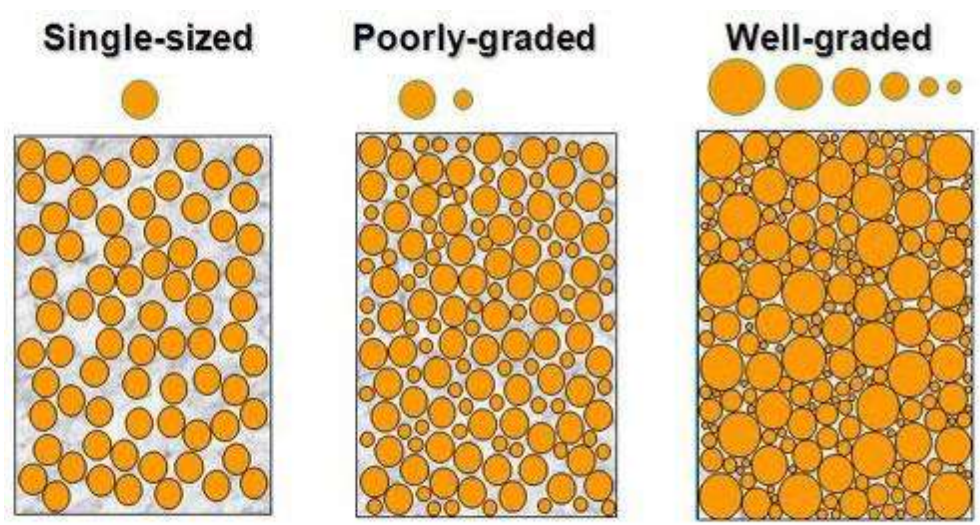
- If the sausage bends a little, you have a sandy loam.
- If the sausage bends half way around the forefinger, you have loam or silty-loam.
- If the sausage bends more than halfway around your finger, you have clay-loam or sandy-clay.
- If you can form a longer sausage with cracks, you have a clay soil.
- If you can form a longer sausage without cracks, you have fine (or heavy) clay.



Soil tests

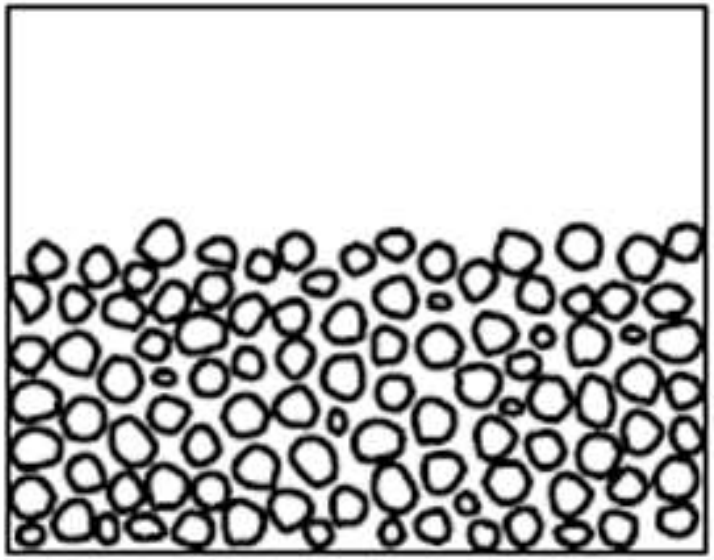
Ideal soil type is well graded, compact and non-expansive without any organic matter.

To check whether a soil is well graded, one must spread out the soil to check whether there are a large variety of sizes of particles in the soil. A mix of different sizes of particles in the soil is preferred.

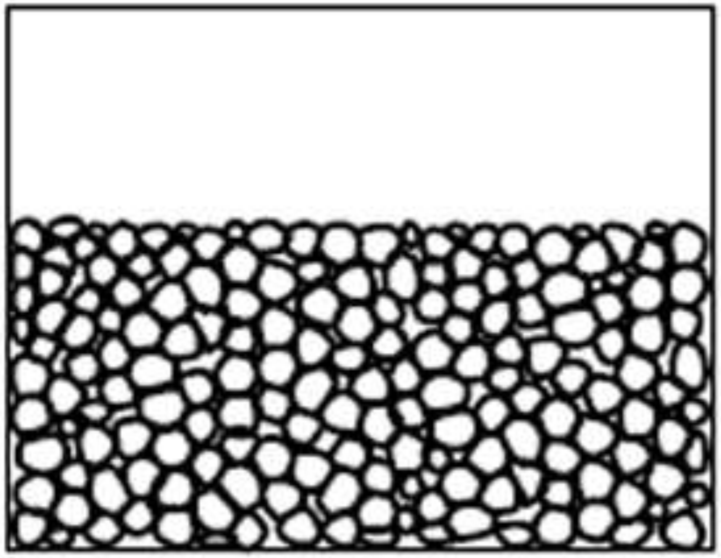


Soil tests

Soils that are compacted naturally, usually have their voids properly filled up. Such sites are good for house construction as they have compacted slowly over centuries.



Loose soil(Poor load support)



Compacted soil(Good load support)

Identifying Soft and Hard Grounds

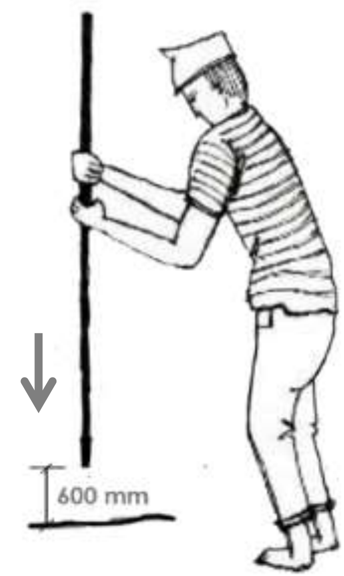
1. Remove top 150mm of soil, and all the filled in soil so that natural soil is exposed.

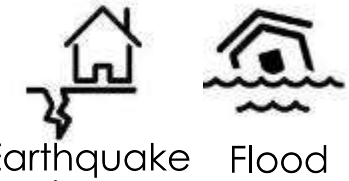
2. Take a crowbar of approximately 1.5m length and about 4.5 kg weight.

3. Hold it vertically with its sharp point towards the ground, about 600 mm above the ground, and drop the bar.

4. Ensure the bar falls vertically on the ground.

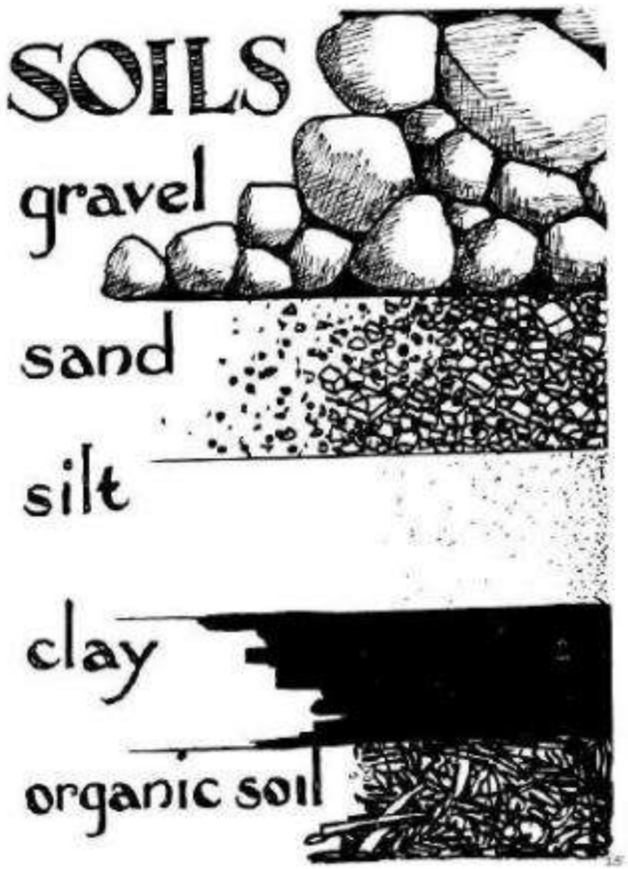
5. Based on the penetration of the bottom end, determine if soil is hard or soft.





Components of Soil

The soil is made up the following particles in different proportions.



Credits: Lauri Baker

Components of Soil

Soils have 3 basic ingredients.

Sand

It is dry and gritty to the touch and does not hold moisture because of the large openings, but drains easily. When compacted and moist, it holds together fairly well.

Clay

It is made up of tiny particles, so it stores water well, but because of its tight grasp on water, it expands greatly when moist and shrinks significantly when dry.

Silt

Silt can be smooth to the touch and retains water longer because of its smaller particles. But, it is cold and drains poorly.

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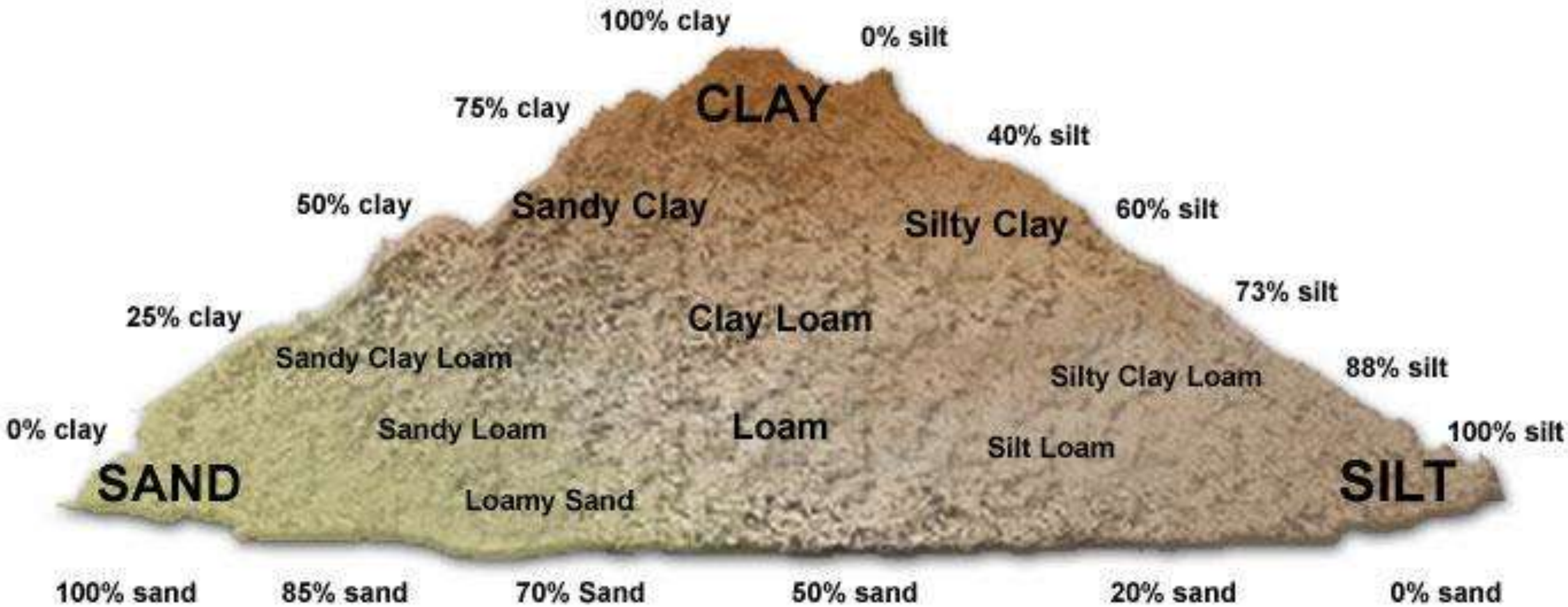
Components of Soil

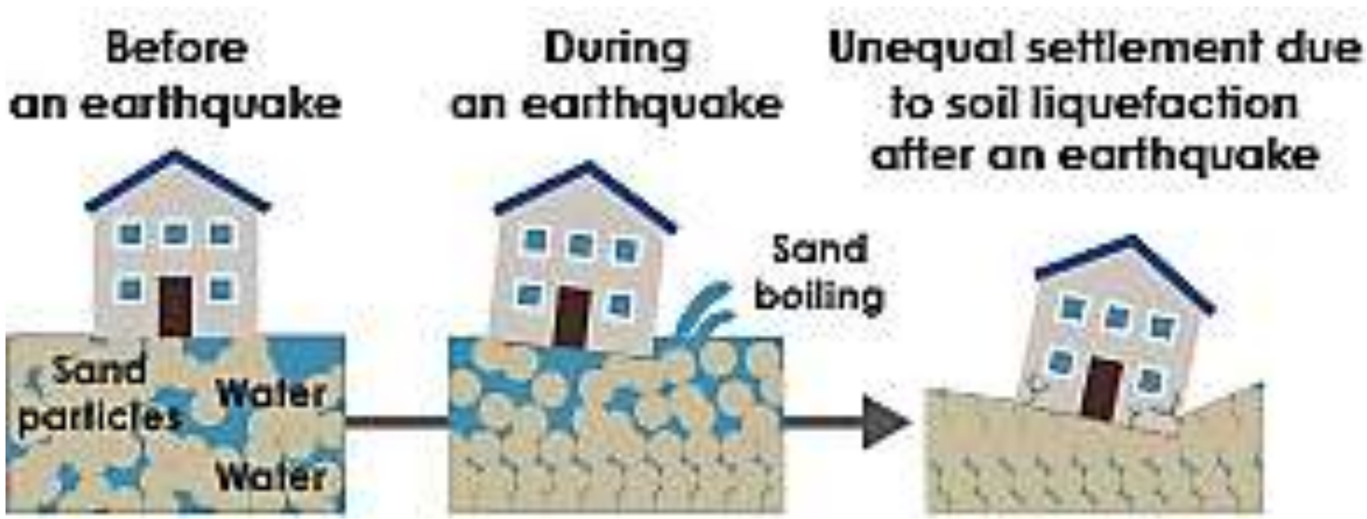
Soils normally found in nature have different proportions of sand, silt and clay



Earthquake Flood

LIQUEFACTION & SINKING during Earthquakes and Floods

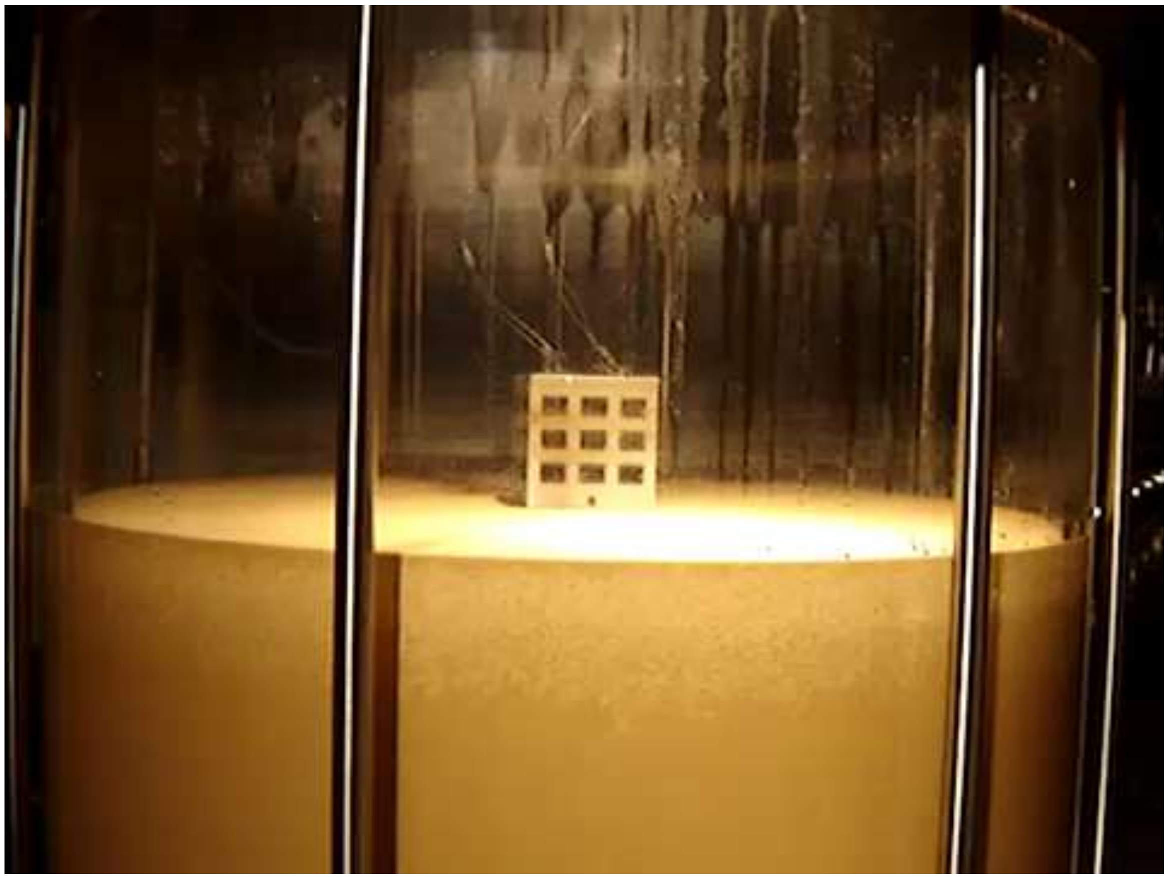
Liquefaction is a phenomenon in which the strength and stiffness of a soil is reduced by earthquake shaking or other rapid loading.



LIQUEFACTION

Earthquake Flood

The sand-water mixture looses capacity to hold the weight of the building above it, and hence the house sinks.




Earthquake Flood

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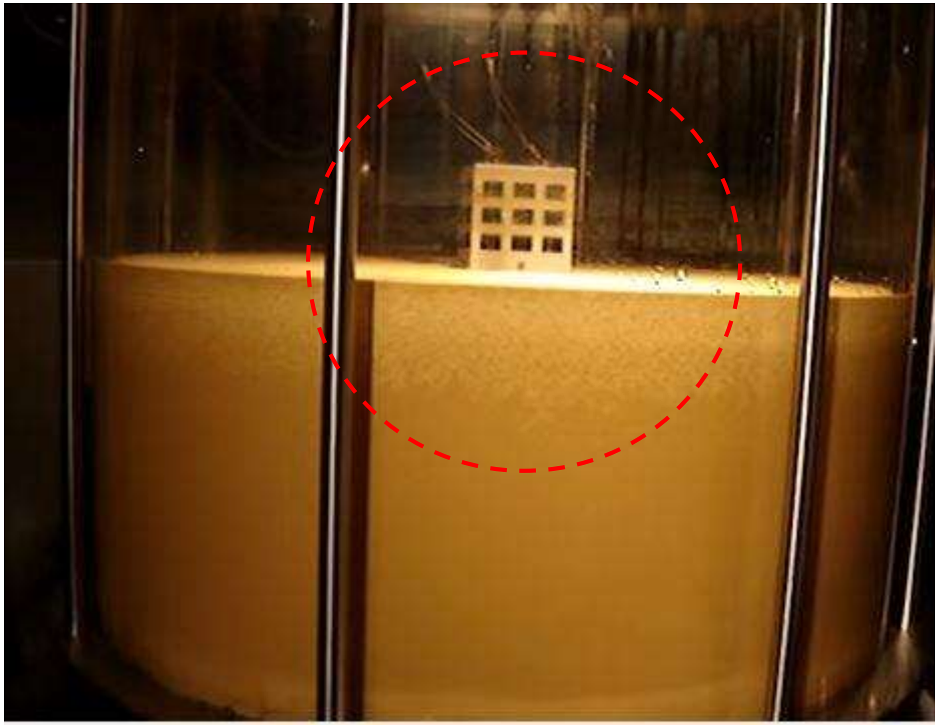

Before shaking


After shaking

What to do, if there is a risk of liquefaction?


Earthquake


Flood

1. Learn about the geological and earthquake history of the area

   a) Has liquefaction occurred before?
   b) How far below is the ground water table?
   c) Are there existing water bodies close by?

2. In case these questions report danger of loose soil or historical examples of liquefaction having occurred in the area of the site of the house, a special foundation will have to be made.

An appropriate pile foundation or a raft foundation will have to be designed by an engineer. This can become expensive, In such cases, the site is unsuitable for housing.

Flood Tsunami

What happens when the soil around the foundation gets washed out because of a flood or tsunami?

The foundation is exposed and weakened which may cause the house to collapse and fall into the pit created due to the scouring of the foundation. We need to ensure the foundations are built on strong ground, so that even if the top layer of soil is washed out, the house continues to stand.


Earthquake


Flood

DO NOT BUILD in saline soil

Salt degrades all materials and so they lose their strength overtime. One can check for salt in the soil by tasting it.

Source:
http://www.fao.org/docrep/006/x8234e/x8234e00.htm#Contents


Earthquake


Landslide

Building on a site with hard ground

1. If the soil is a mix of rocks and earth, the loose rocks need to be removed, and foundation can be made only on the virgin soil.
2. In case the entire ground is stone, it is possible to anchor the house directly on the rock. It must be ensured that the rock is completely stable.
3. Foundation depth can be minimum 6” in case of rock.

HOW TO BUILD ACCORDING TO SITE

To keep in mind while planning your house

1. Will a hazard affect all the areas in the village equally?

This will help to start thinking about the different conditions of sites in your village, related to geographical and other conditions. It will help to identify the particularly vulnerable parts of your village and ensure that your site does not fall in those areas.

2. Is the house you are building coming in the way of natural flow of drainage of water?

How does the rainwater in the surroundings of your site drain out? If the house is in the way of the natural flow it will cause problems for the house. The best way to deal with this is to allow for a path for the water to pass through your site, and thereby not affecting the house.

To keep in mind while planning your house

3. Is there a presence of natural barriers on your site against cyclone or floods?

4. What is the soil type on your site? Type of soil present on site will affect the foundation type. Salt content of the soil must be checked.

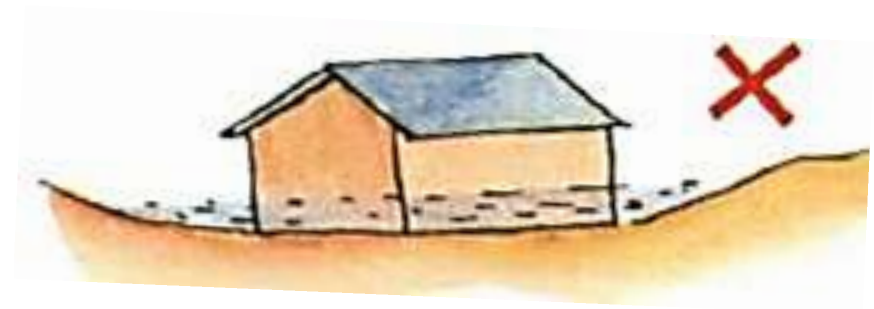
5. What is the terrain of your site? Low lying areas become catchments during monsoons and must be avoided.


Cyclone

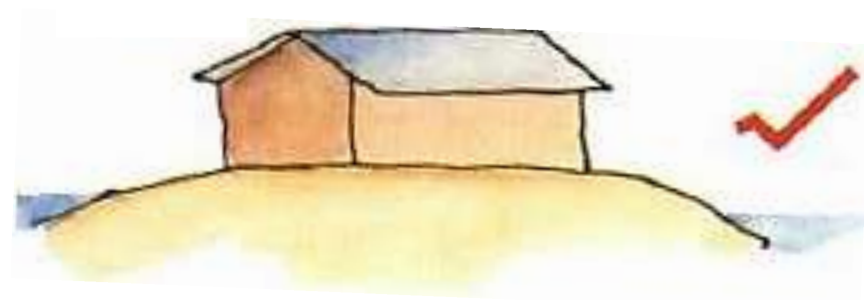

Flood

A. Location of Site

1. Considering the highest flood level in 50 years and the low lying areas of your region, decide on a site which is preferably on high ground.



2. Choose site behind wind breakers, or away from localised effects of excessive winds.



3. Choose sites away from steep slopes.

B. Add Wind Breakers around the site

1. A house built on the leeward side of Trees and/or an earthen mound is protected from excessive winds as the trees or earthen mound acts as a wind breaker.
2. High, strong boundary walls act as barriers to wind movement.

Landslide

C. Angle of Repose and Angle of Soil Slope

If a slope is steeper than the angle of repose of the soil, there is a concern on its stablity against a landslide.

Soil Type	Dry	Moist	Wet
Top Soil; Loose	35 - 40		45
Loam; Loose	40 - 45		20 - 25
Peat; Loose	15	45	
Clay/Silt; Solid		40 - 50	
Clay/Silt; Firm		17-19	
Clay/Silt; Loose		20 - 25	
Puddle Clay			15-19
Silt		19	
Sandy Clay		15	
Sand; Compact		35 - 40	
Sand; Loose	30 - 35		25
Sandy Gravel; Compact		40 - 45	
Sandy Gravel; Loose		35 - 45	
Sandy Gravel; Natural		25 - 30	
Gravel; Medium Coarse	25 - 30		25 - 30
Shingle; Loose		40	
Shale; Hard		19 - 22	
Broken Rock	35		45

D. Identify Unstable Slopes around the Site

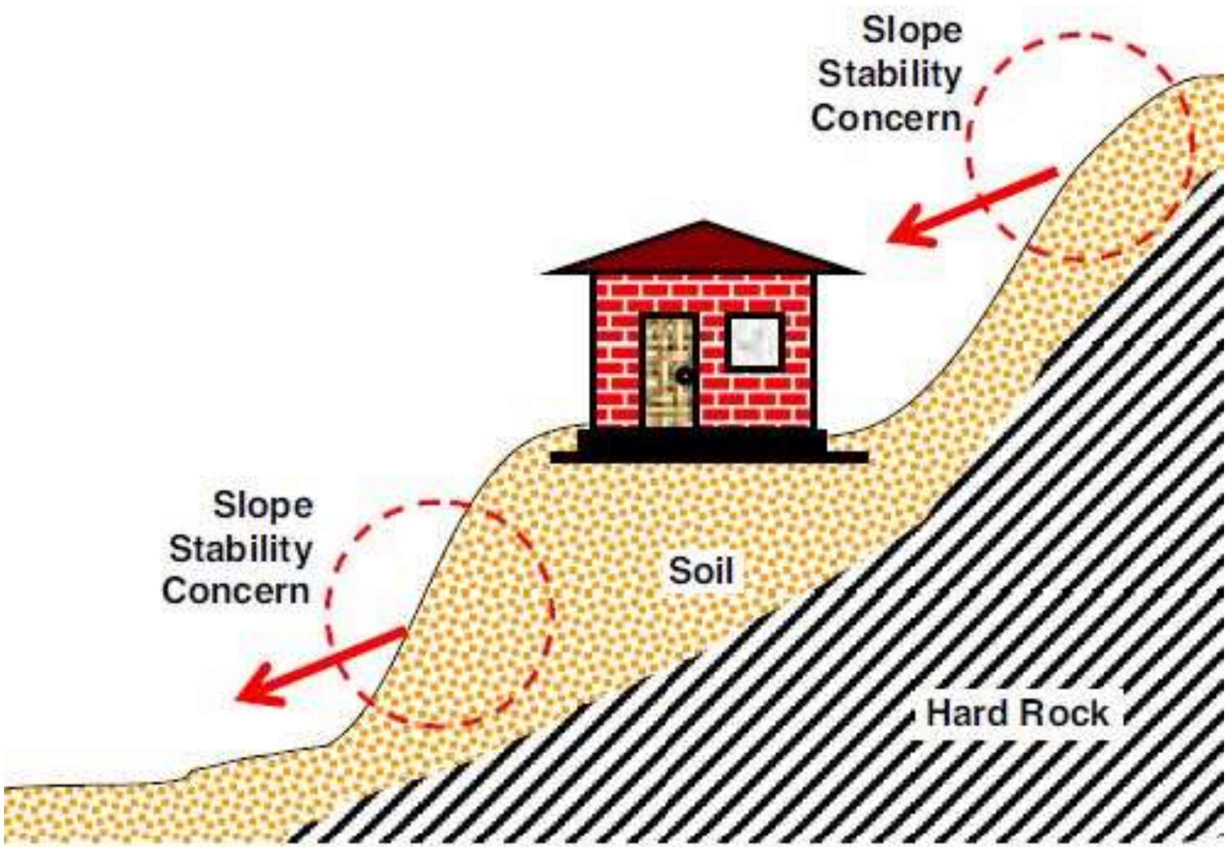
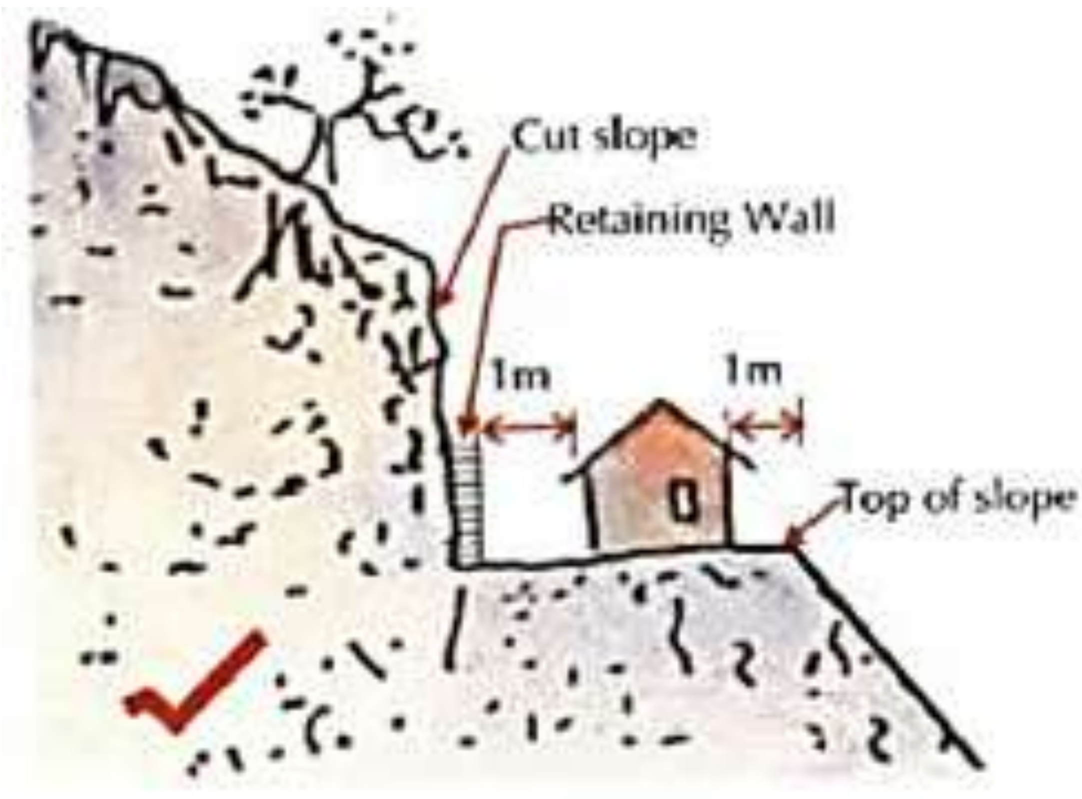


Figure 2: Unstable hill slopes – *landslides are major concerns in hilly areas*

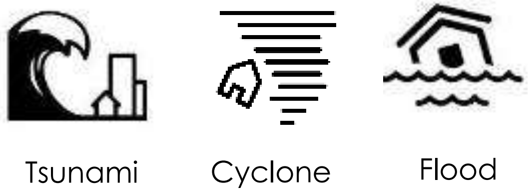
E. Build Retaining Walls when cutting Slopes

Landslide

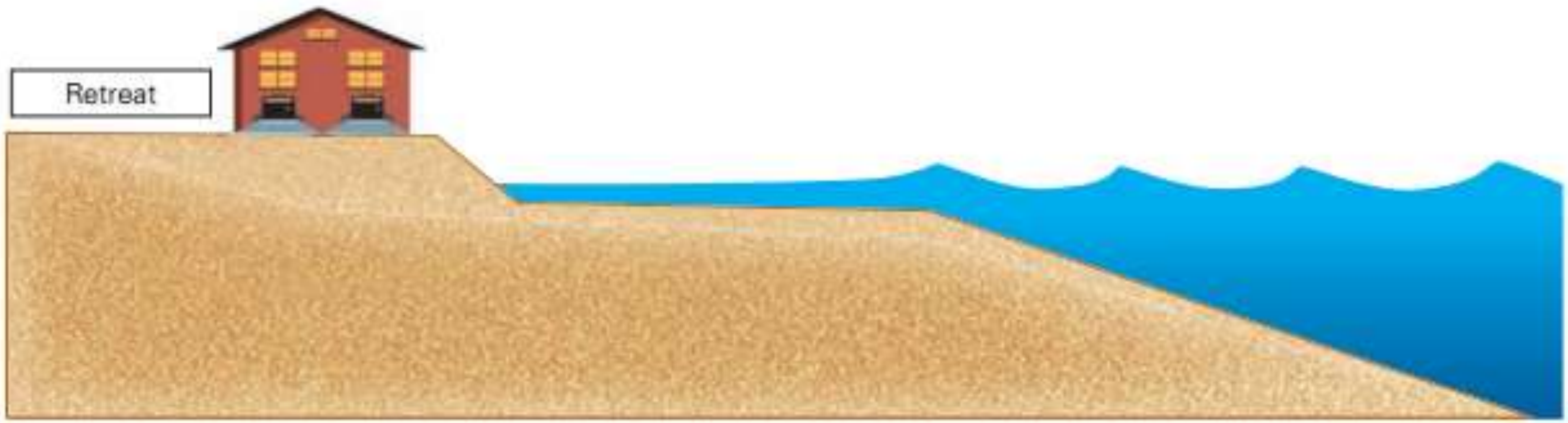
Construct building at least 1m away from top of slope and 1m away from the cut. Also, construct retaining wall to support very steep cut slope, before building the house.



F. Building near water-body

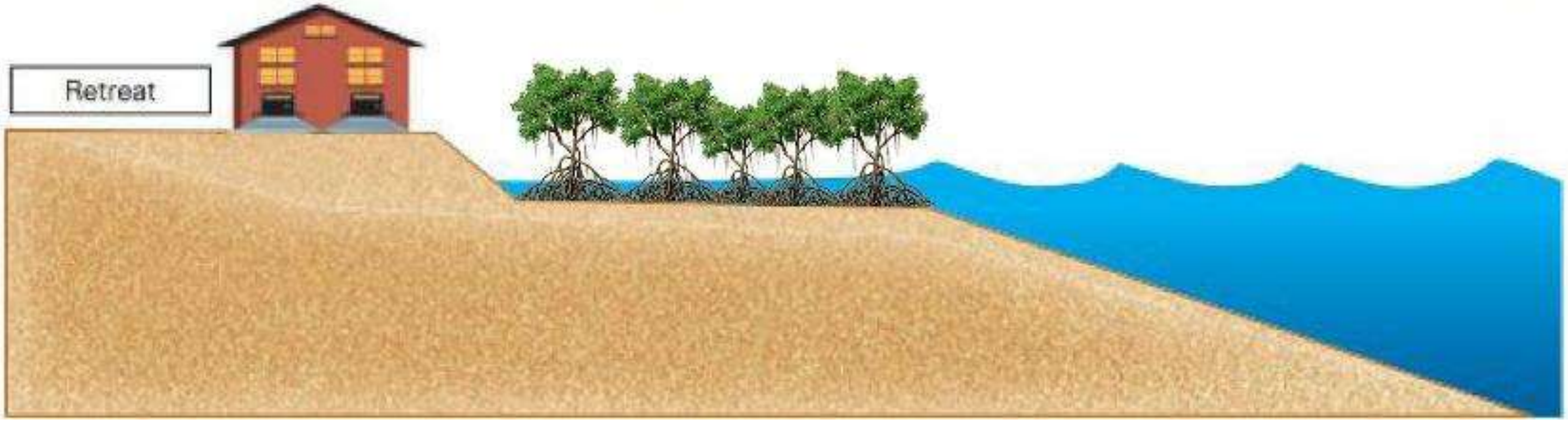


1. Build far away from the inundation lines of the water body.
2. Build higher than the 50 year-high flood level of the region.



F. Building near water-body

For added protection, mangroves can be planted to absorb the impact of the waves and water between the house and the waters.



What can be done, if site is less than ideal?

Let's make a list of possible solutions

Measures when Soil and Site conditions are difficult

1. **Low Bearing Capacity**: Soil with a low bearing capacity is unfit for house construction. But, if such construction cannot be avoided, the following techniques (though expensive) can be used with the concurrence of a competent Civil Engineer:

a) Pile foundation,

b) Wider footing,

c) Digging deep to get stable ground for the foundation, and

d) Build a lighter house to reduce load.

2. High Water Table: Excessive water renders the area unfit for house construction. But, if such construction cannot be avoided, the following techniques can be used:

a) Raft foundation (with consultation of an engineer)
b) Pile foundation

3. Expansive and Clayey Soil: It is best to avoid construction on such soil; it expands and contracts depending on moisture in the soil, and renders the foundation unstable, e.g., Black cotton soil. But, if construction cannot be avoided, the following techniques can be used in consultation with an engineer:

- Raft foundation,
- Pile foundation,
- Digging deep to get stable ground for the foundation, and
- Strip foundations with reinforcement.

4. Foundation Depths

How deep are the foundations in your region?

Thumb rules:

a) For light weight single storey house, 600mm is the minimum depth required
b) Rocky ground needs at least 150mm deep foundations
c) Special soil conditions may need 600-700 mm deep foundations

Summary

We discussed the importance of siting the house in the best possible way with respect to resilience against all hazards.

1. For resilience against the effects of an **earthquake**, the mason should check the type of soil, it's hardness, its evenness in composition, possibilities of liquefaction, its expansive nature and whether there are chances of settlement. This will help choose a site with ideal soil type or get help of an expert to design an appropriate foundation for a site, which is not ideal.

2. For resilience against a **landslide**, the slope of the site should be checked against the angle of repose of the site to check whether there is a chance of it being unstable. Also, the slope must be well drained to ensure that the water doesn't create problems to the stability of the slope.

3. For resilience against a **tsunami**, siting the building at a high place such that the water does not reach becomes critical.
4. For resilience against a **cyclone**, the house may be built on the leeward side of trees, hill/earthen mound or other barrier to protect against excessive winds.
5. For resilience against **floods**, the plinth must be made at least 15 cm higher than the expected high flood level, which is something that must be decided based on frequency and intensity of floods in the region, and 50-year high flood level, and make a choice based on the number of days of high floods and the cost of construction.