

Unit 3

Foundation – Introduction, Necessity of Foundation, Causes of failure of Foundations and Remedial Measures.

Soil stabilization techniques & Underpinning methods for foundation repair

Types of Structure – Load Bearing Structures and Framed Structures.

Foundation

Introduction

Every structure consists of the following two parts:

- (i) Foundations; and
- (ii) Superstructures.

The lowest artificially prepared parts of the structures which are in direct contact with the ground and which transmit the loads of the structures to the ground are known as the **foundations** or **substructures**. The solid ground on which the foundations rest is called the foundation bed or foundation soil and it ultimately bears the load and interacts with the foundations of buildings. The lowermost portion of the foundation which is in direct contact with the sub-soil is called the footing.

Objects/ Necessity of foundations

The foundations are provided for the following purposes:

- i. To distribute the total load coming on the structure on a larger area so as to bring down the intensity of load at its base below the safe bearing capacity of sub-soil;
- ii. To support the structures;
- iii. To give enough lateral stability to the structures against various disturbing horizontal forces such as wind, rain, earthquake, etc.;
- iv. To prepare a level and hard surface for concreting and masonry work;
- v. To transmit the super-imposed loads through side friction and end bearing in case of deep foundations;
- vi. To distribute the non-uniform load of the superstructure evenly to the sub-soil;
- vii. To provide the structural safety against undermining or scouring due to animals, flood water, etc.;
- viii. To prevent or minimize cracks due to movement of moisture in case of weak or poor soils; etc.

Essential requirements of a good foundation

Following are the **three basic requirements** to be fulfilled by a foundation to be satisfactory:

(1) Location: The foundation structure should be so located that it is able to resist any unexpected future influence which may adversely affect its performance. This aspect requires careful engineering judgement.

(2) Stability: The foundation structure should be stable or safe against any possible failure. The foundation base should be rigid enough to bring down the differential settlements to a minimum extent, especially when the superimposed loads are unevenly distributed.

(3) Settlement: The foundation structure should not settle or deflect to such an extent so as to impair its usefulness or the stability of the building or the adjoining structures. It is however difficult to define the objectionable amount of settlement or deflection.

The above **three requirements** are independent of each other and for the foundation structure to be satisfactory, all the three conditions should be simultaneously satisfied.

Types of Foundation

- A. Shallow Foundations
- B. Deep Foundations

A. Shallow Foundations

The terms Shallow and Deep Foundation refer to the depth of the soil at which it is placed. Generally, if the width of the foundation is greater than the depth, it is labeled as the “Shallow Foundation.”

As the shallow foundation depth is low and it is economical, it is the most popular type of foundation for lightweight structures.

Types of Shallow Foundation

1. Isolated Spred Footing
2. Wall Footing or Strip footing
3. Combined Footing
4. Cantilever or strap footing
5. Raft or Mat Foundation

1. Isolated Spred Footing

This is the most widely recognized and most straightforward shallow foundation type, as this is the most economical type. They are typically utilized for shallow establishments to convey and spread concentrated burdens caused, for instance, by pillars or columns. They are generally used for ordinary buildings (Typically up to five stories).

Isolated footing comprises a foundation directly at the base of the segment. Generally, every section has its footing. They straightforwardly transfer the loads from the column to the soil. It might be rectangular, square, or roundabout. It can comprise both reinforced and non-reinforced material. For the non-reinforced footing, however, the stature of the footing has to be more prominent to give the vital spreading of the load. They should possibly be utilized when it is sure beyond a shadow of a doubt that no differing settlements will happen under the whole structure. Spread footings are inadmissible for the orientation of large loads. It is given to lessen the twisting minutes and shearing powers in their primary areas.

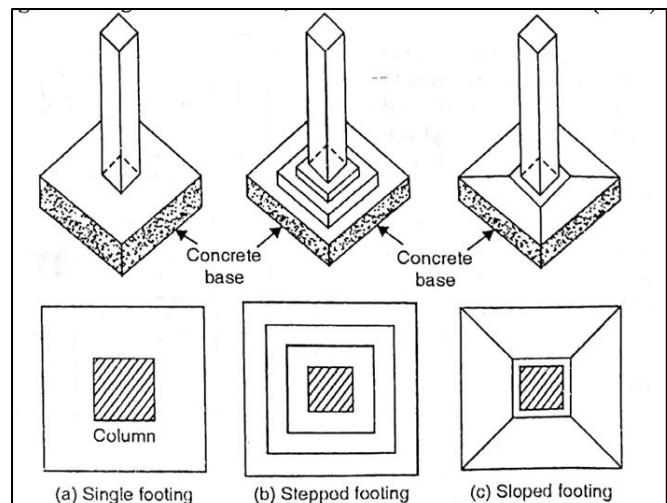
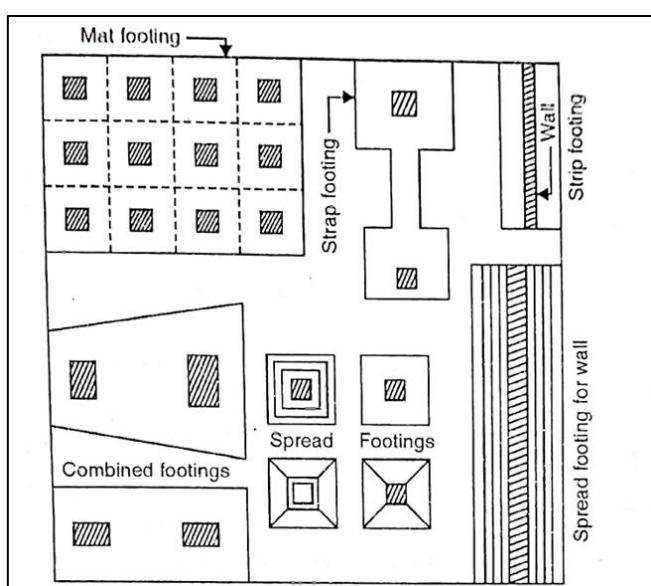


Fig. Various Types of Shallow Foundations

2. Wall Footing or Strip footing

Wall footing is also known as continuous footing. This type is used to distribute loads of structural or non-structural load-bearing walls to the ground in such a way that the load-bearing limit of the soil isn't outperformed. It runs along the direction of the wall. The width of the wall foundation is usually 2-3 times the width of the wall.

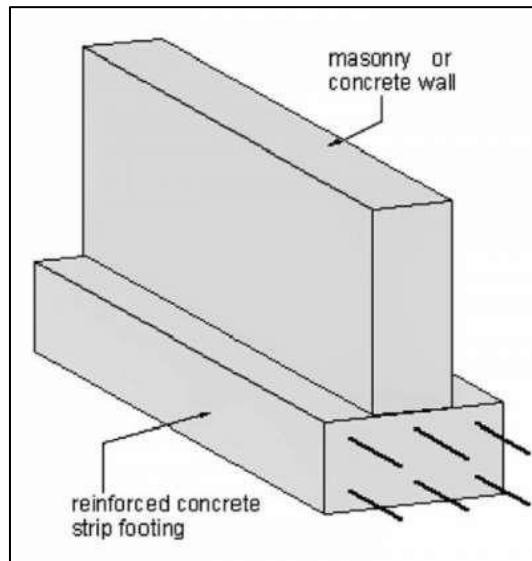


Fig. Wall Footing or Strip footing

3. Combined Footing

The combined footing is very similar to the isolated footing. A spread footing which supports two or more columns is termed as combined footing. The combined footings may be of the following kinds:

- (i) Rectangular combined footing Fig. (a)
- (ii) Trapezoidal combined footing Fig. (b)
- (iii) Combined column-wall footings Fig.(c) (d)

Combined footings are invariably constructed of reinforced concrete.

The combined footing for columns will be rectangular in shape if they carry equal loads. The design of rigid rectangular combined footing should be done in such a way that centre of gravity of column loads coincide with the centroid of the footing area. If the columns carry unequal loads, the footing is of trapezoidal shape, as shown in Fig. (b).

Sometimes, it may be required to provide a combined footing for columns and a wall. Such combined footings are shown in Fig. (c) [when the columns carry equal loads] and in Fig. (d) [when the columns carry unequal loads].

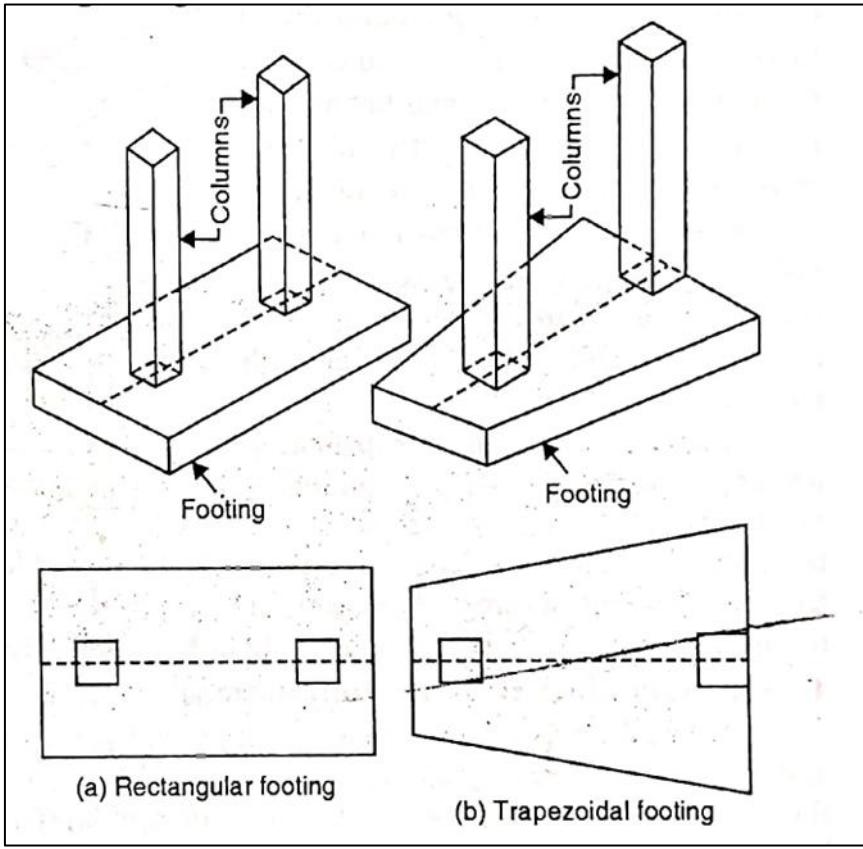


Fig. (a) Rectangular footing

Fig. (b) Trapezoidal footing

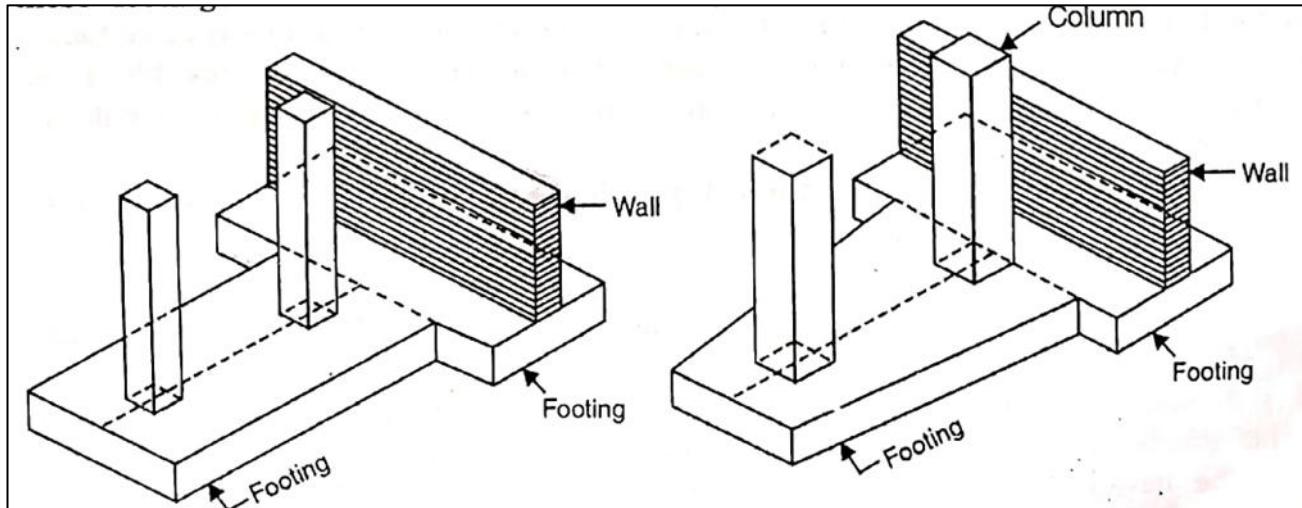


Fig. (c) Rectangular

Fig. (d) Trapezoidal

4. Cantilever or strap footing

Strap footings are similar to combined footings. If the independent footings of two columns are connected by a beam, it is called a strap footing. A strap footing may be used where the distance between the columns is so great that a combined trapezoidal footing becomes quite narrow, with high bending moments. In that case, each column is provided with its independent footings and a beam is used to connect the two footings.

The strap beam does not remain in contact with soil, and thus does not transfer any pressure to the soil. The strap, assumed to be infinitely stiff, serves to transfer the column loads on to the soil with equal and uniform soil pressure under both footings.

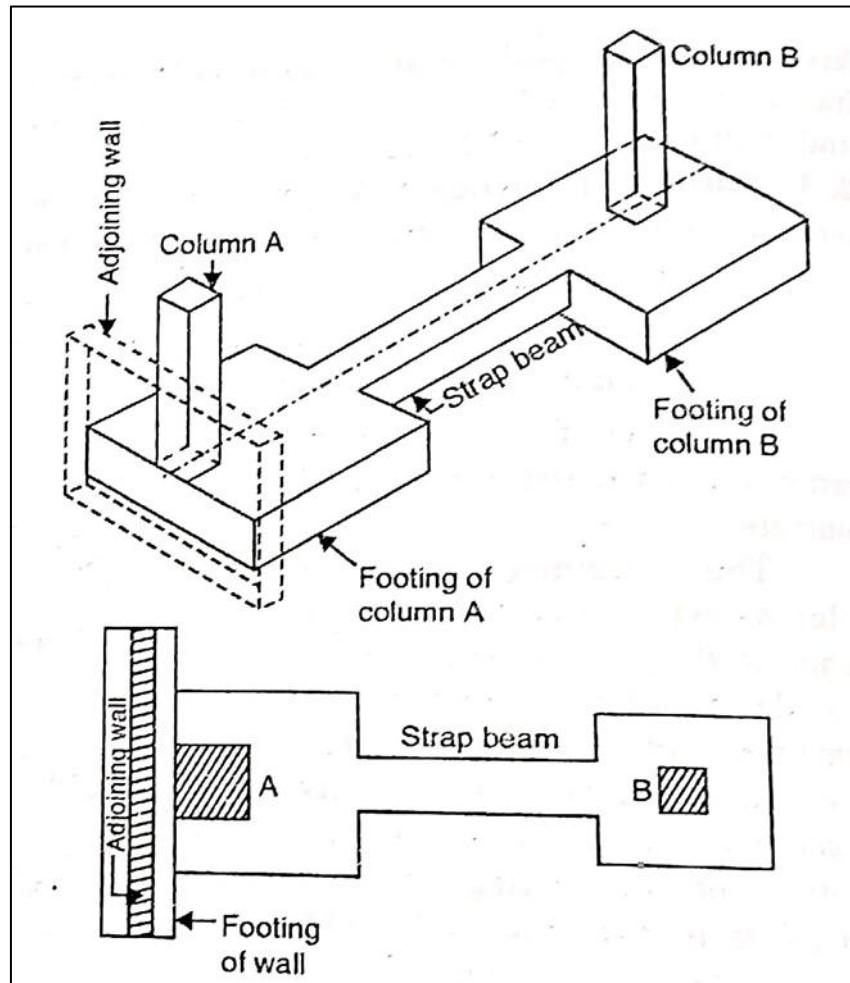
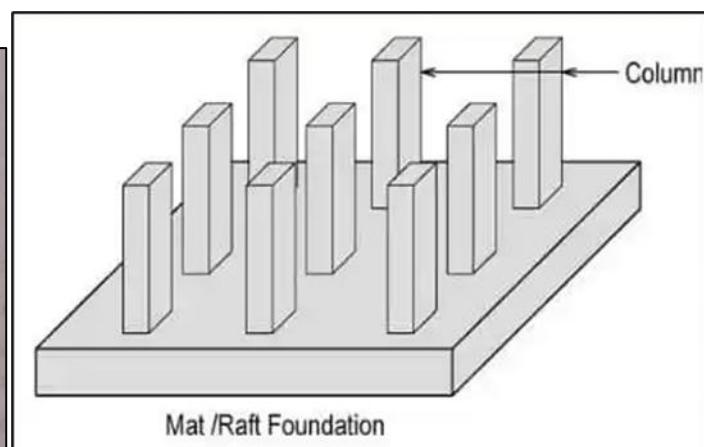
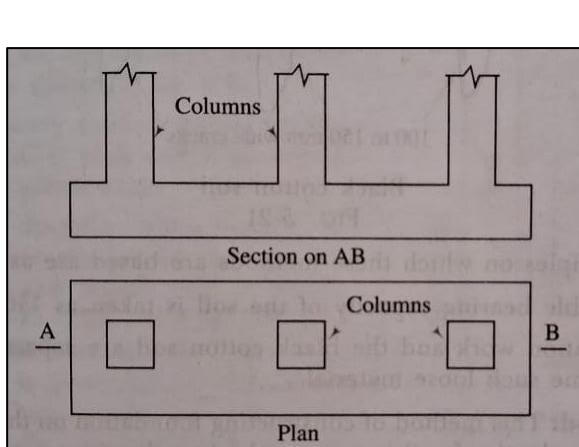


Fig. Cantilever or strap footing

5. Raft or Mat Foundation

Raft or Mat foundations are used where other shallow or pile foundations are not suitable. It is also recommended in situations where the bearing capacity of the soil is inadequate, the load of the structure is to be distributed over a large area, or the structure is subjected continuously to shocks or jerks.

A raft foundation consists of a reinforced concrete slab or T-beam slab placed over the entire area of the structure. In this type, the whole basement floor slab acts as the foundation. The total load of the structure is spread evenly over the entire area of the structure. This is called a raft because, in this case, the building seems like a vessel that floats on a sea of soil.



B. Deep Foundations

If the width is smaller than the depth of the foundation it is called a Deep Foundation.

Types of Deep Foundation

1. Deep strip, rectangular or square footings
2. Pile foundation
3. Pier foundation or drilled caisson foundation
4. Well foundation or caissons

1. Deep strip, rectangular or square footings

Pile foundation is that type of deep foundation in which the loads are taken to a low level by means of vertical members which may be of timber, concrete or steel. Pile foundation may be adopted (i) instead of a raft foundation where no firm bearing strata exists at any reasonable depth and the loading is uneven, (ii) when a firm bearing strata does exist but at a depth such as to make strip or spread footing uneconomical, and (iii) when pumping of sub-soil water would be too costly or timbering to excavations too difficult to permit the construction of normal foundations.

Piles used for building foundation may be four types

End bearing piles [Fig. (a)] are used to transfer load through water or soft soil to a suitable bearing stratum. Such piles are used to carry heavy loads safely to hard strata. Multi-storeyed buildings are invariably founded on end bearing piles, so that the settlements are minimised.

Friction piles [Fig. (b)] are used to transfer loads to a depth of a friction-load-carrying material by means of skin friction along the length of the pile used in granular soil where the depth of hard stratum is very great.

Combined End bearing pile and Friction pile [Fig. (c)] shows a pile which transfers the super-imposed load both through side friction as well as end bearing. Such piles are more common, specially when the end bearing piles pass through granular soils.

Compaction piles [Fig. (d)] are used to compact loose granular soils, thus increasing their bearing capacity. The compaction piles themselves do not carry a load. Hence they may be of weaker material (such as timber, bamboo sticks etc.) — sometimes of sand only. The pile tube, driven to compact the soil, is gradually taken out and sand is filled in its place thus forming a ‘sand pile’.

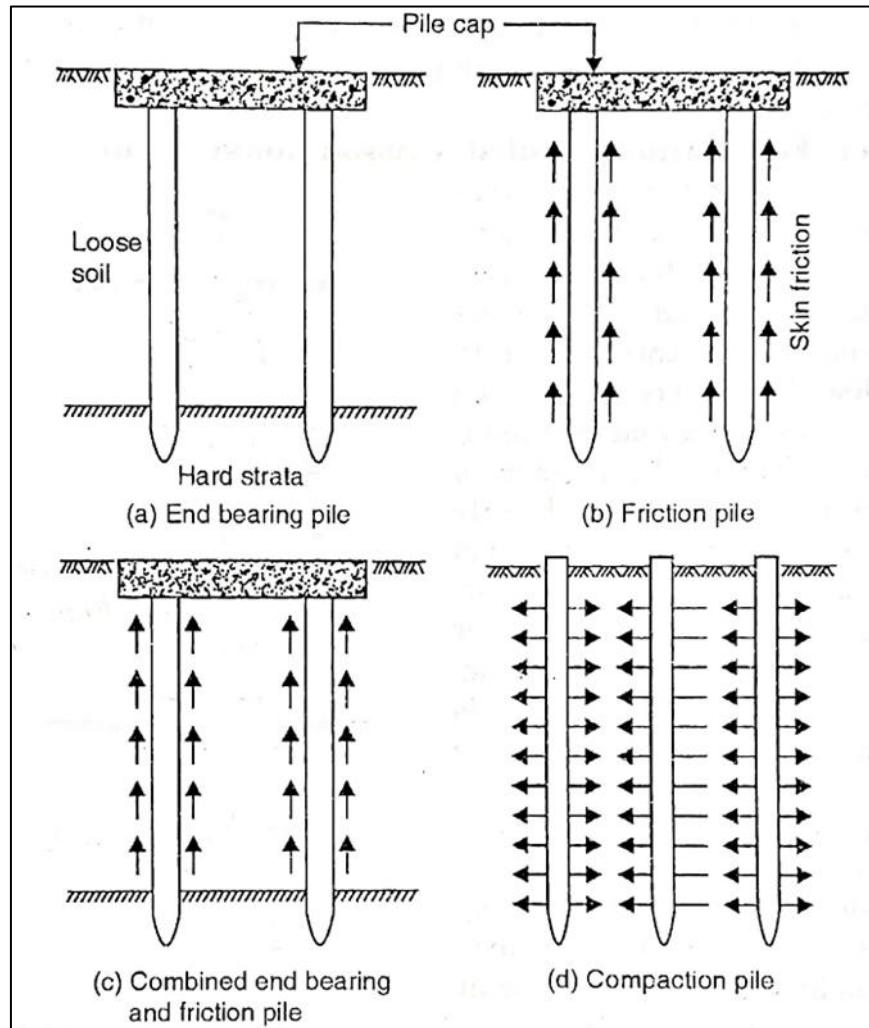


Fig. Pile Foundation

3. Pier foundation or drilled caisson foundation

A Pier foundation consists of a cylindrical column of large diameter to support and transfer large superimposed loads to the firm strata below. The difference between pile foundation and pier foundation lies in the method of construction. Though pile foundations transfer the load through friction and/or bearing, pier foundations transfer the load only through bearing. Generally, pier foundation is shallower in depth than the pile foundation. Pier foundation is preferred in a location where the top strata consists of decomposed rock overlying a strata of sound rock. In such a condition, it becomes difficult to drive the bearing piles through decomposed rock. In the case of stiff clays, which offer large resistance to the driving of a bearing pile, pier foundation can be conveniently constructed.

Pier foundations may be of the following types:

- Masonry or concrete pier
- Drilled caissons.

When a good bearing stratum exists upto 5 m below ground level, brick, masonry or concrete foundation piers in excavated pits may be used [Fig. (a)]. The size and spacing of the piers depends upon the depth of hard bed, nature of overlying soil and super-imposed loads.

The terms drilled caissons, foundation pier or sub-pier are interchangeably used by engineers to denote a cylindrical foundation. A drilled caisson is largely a compressed member subjected to an axial load at the top and reaction at the bottom. Drilled caissons are generally drilled with the mechanical means.

Drilled caissons may be of three types:

- (i) concrete caisson with enlarged bottom Fig. (b),
- (ii) caisson of steel pipe with concrete filled in the pipe Fig. (c) and
- (iii) caisson with concrete and steel core in steel pipe Fig. 2.9 (d).

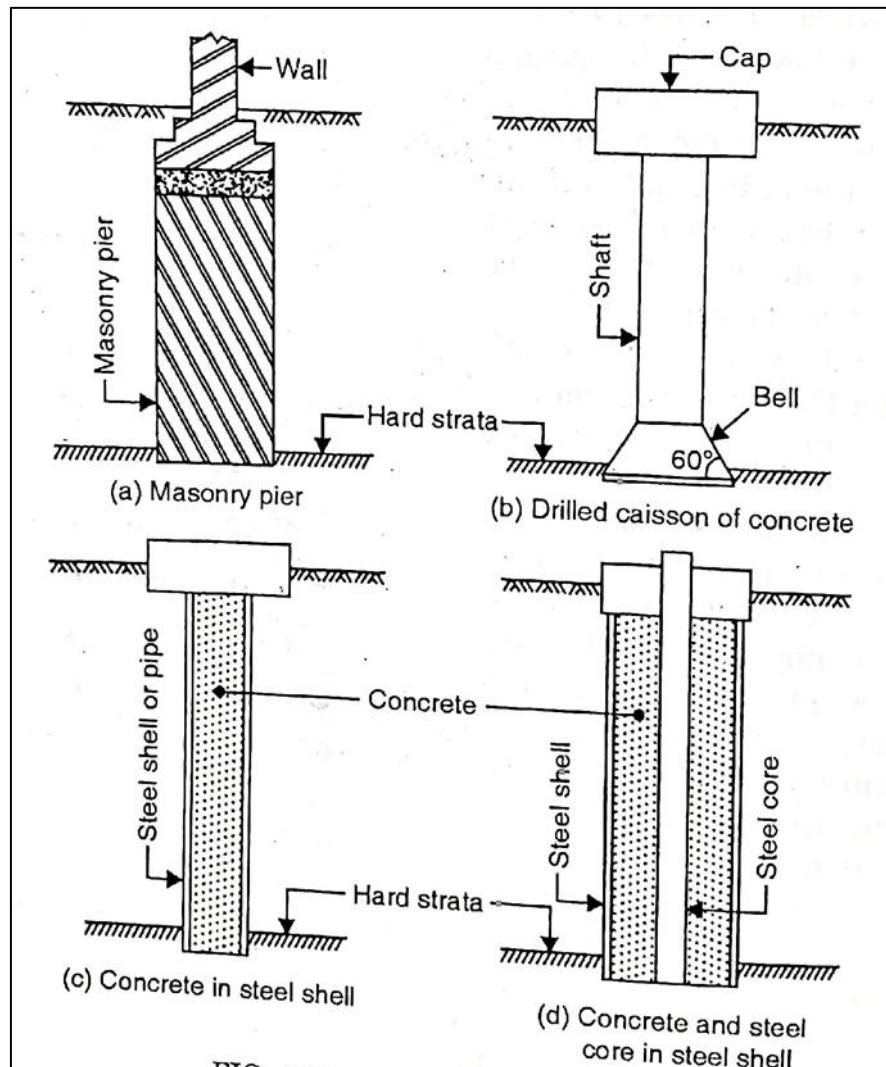


Fig. Pier foundation or drilled caisson foundation

4. Well foundation or caissons

Well foundations or caissons are box like structure - circular or rectangular - which are sunk from the surface of either land or water to the desired depth. They are much large in diameter than the pier foundations or drilled caissons. Caisson foundations are used for major foundation works, such as for:

- (i) Bridge piers and abutments in rivers, lakes etc.
- (ii) Wharves, quay walls, docks.
- (iii) Break waters and other structures for shore protections.
- (iv) Large water front structures such as pump houses, subjected to heavy vertical and horizontal loads.

Well foundations or caissons are hollow from inside, which may be filled with sand, and are plugged at the bottom. The load is transferred through the perimeter wall, called steining.

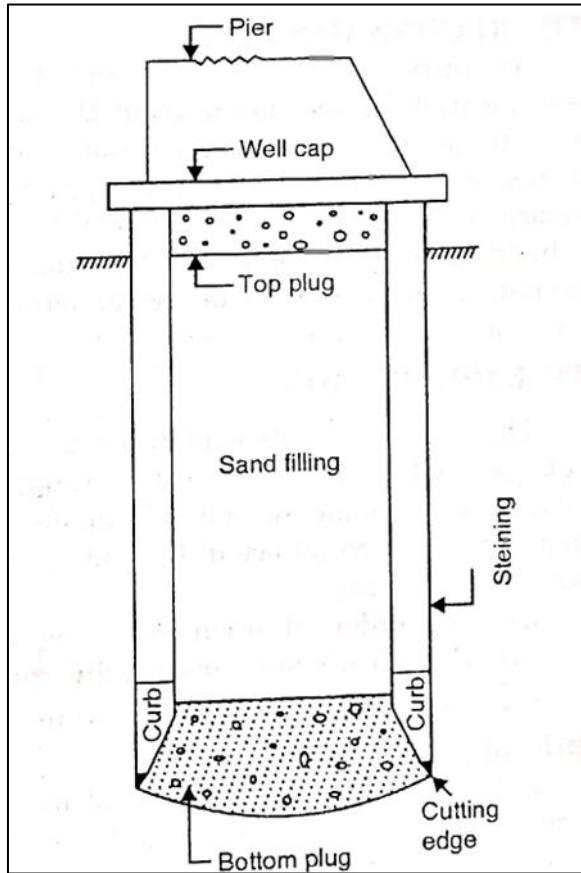


Fig. Well Foundation

Causes of failure of Foundations and Remedial Measures.

The main causes of failure of foundations are as follows:

- (1) Unequal settlement of the sub-soil
- (2) Unequal settlement of the masonry
- (3) Withdrawal of moisture from the sub-soil
- (4) Lateral pressure on the superstructure
- (5) Horizontal movement of the earth
- (6) Transpiration of trees and shrubs
- (7) Atmospheric action.

Each one in detail together with the measures to be taken to prevent such failures.

(1) Unequal settlement of the sub-soil: This occurs due to various reasons such as unequal distribution of load on the foundations, varying bearing power of the sub-soil, eccentricity of the load, etc. Due to unequal settlement of the sub-soil, the cracks are formed in the buildings, which in future, leads to serious defects. Following are the measures to be adopted to prevent such failure:

- (i) The foundations should rest on the rock or hard moorum.
- (ii) The design of foundations should be appropriate to the nature of sub-soil.
- (iii) It should be seen that the allowable bearing pressure on the soil is not exceeded, even under the worst conditions.
- (iv) The proper attention should be given to the eccentricity of the load on the foundations and design should be accordingly modified.

(2) Unequal settlement of the masonry: The mortar used as the binding material in the masonry construction shrinks and gets compressed when loaded excessively before it has fully set. This may lead to the unequal settlement of the masonry and the measures to avoid such situation are as follows:

- (i) The mortar to be used in the masonry should be stiff and in line with the workability desired.
- (ii) The masonry work should be raised evenly.
- (iii) The height of wall to be raised per day should be limited to one metre, if lime mortar is used and to 1.50 metres, if cement mortar is used.
- (iv) The proper watering or curing for a period of at least 10 days should be done to the masonry work to ensure the development of adequate strength of the mortar joints.

(3) Withdrawal of moisture from the sub-soil: This occurs at places where there is considerable variation in the height of water table. When water table falls, the soil particles lose cohesion and hence, there is shrinkage of soil, resulting in the crack to the buildings. The precaution to be taken to avoid such failure would be to drive piles upto the hard rock.

(4) Lateral pressure on the superstructure: The thrust of a pitched roof or arch action or wind action on the superstructure causes wall to overturn. The remedial measures to prevent this failure would be to provide a sufficient wide base and to design the foundations for the worst conditions.

(5) Horizontal movement of the earth: Very soft soil is liable to give way under the action of load, especially at places such as sloping ground, river banks, etc. Hence, in such cases, it is desirable to construct the retaining walls or to drive sheet piles to prevent the escape of the earth.

(6) Transpiration of trees and shrubs: The roots of trees planted near a building may extend upto the foundation level and may absorb the moisture. This effect is seen in the form of a depression on the ground and it may lead to cracks in the building. The remedial measures are as follows:

- (i) The foundations should be taken sufficiently deep. A minimum depth of one metre is required for this purpose.
- (ii) The fast growing and water-seeking trees should not be planted near the building with a minimum distance of 8 metres.

(7) Atmospheric action: The rain and sun are the main atmospheric agents to seriously affect the foundations of a building. The heavy rains or considerable variation in temperature or frost action may damage the foundations. The rain water may create pockets near the walls and while descending, it may carry certain chemicals and salts obtained from sewage, animal dung, etc. These chemicals and salts may react with the materials used for the foundation work and turn them into powder. The remedial measures to be taken are as follows:

- (i) The foundations should be taken beyond the depth upto which rain water can reach.
- (ii) Suitable underground drains should be provided to maintain the water table at a definite level.
- (iii) After the masonry work is completed, the sides of the trenches should be carefully filled with earth and well-consolidated. A gentle slope should be provided so as to keep rain water away from the wall.

Soil stabilization techniques & Underpinning methods for foundation repair

Soil stabilization techniques methods for foundation repair

The process of improving the engineering properties of the soil by using different admixtures is called soil stabilization. To summarise, the engineering properties of soil are modified to achieve more stable soil. The stabilized soil may form the subgrade or wear a layer of the road.

Soil stabilization is adding and mixing other materials into the soil to change its properties. Soil stabilization is a way to improve the soil's shear strength parameters, which increases the soil's ability to support the weight. It is usually needed when the soil under a building's foundation is not strong enough to hold up the structure. Soil stabilization is a way to stop structures from sinking into the ground. It does this by making the soil less porous and easy to pack down. It also makes the soil more resistant to shear.

Importance of Soil Stabilization:

A solid base is essential for the longevity and integrity of any structure. In the end, the soil is where the foundation must rest, shifting all the weight to the ground. Differential settlement occurs if a weak soil base is chosen for construction, as the soil gradually becomes more compacted and consolidated over time. Also, it might cause the structure to crack, which can have disastrous results. Soil stabilization is an option worth considering to prevent these issues in the future on fragile ground.

Objectives Of Soil Stabilization

There are different objectives for this, which include:

- Substituting poor-quality soils with aggregates with better engineering properties.
- Strengthening of the soil, and its bearing capacity.
- Waterproofing is used to preserve natural or man-made buildings.
- To encourage the use of waste geomaterials in building construction.
- To improve permeability characteristics.
- To enhance unfavorable soil properties such as excessive swelling or shrinkage, high plasticity, and so on.
- To make use of inferior quality local materials.

Types of Soil stabilization

There are several types, each suitable for different soil types and engineering needs. Let us have a detailed look at the four types.

1. Mechanical stabilization

Mechanical stabilization involves physical alteration of the soil structure to increase density and improve load-bearing capacity. It is used in granular soils, such as sandy or gravelly, which respond well to mechanical methods. It is used in road construction, where a firm, even surface is needed for vehicle traffic. Mechanical stabilization methods include:

- Compaction: Compacting soil using rollers or other machinery to reduce void spaces and increase density.
- Blending with aggregates: Mix soil with aggregates like sand, gravel, or crushed stone to create a more stable, load-bearing material.

2. Chemical stabilization of Soil

Chemical stabilization of soil involves adding chemical compounds to the soil to improve its properties. This method is effective for fine-grained soils, such as clay, which have high plasticity and poor stability. Common chemicals used are:

Lime: Lime stabilization is highly effective in clayey soils, reducing plasticity and shrink-swell potential by initiating a pozzolanic reaction, which binds soil particles together.

Cement: Soil cement stabilization uses Portland cement, which chemically bonds with soil particles to create a rigid structure. This method significantly increases the soil's strength and reduces permeability, making it ideal for roads and foundations.

Fly Ash: Often combined with lime or cement, fly ash is a byproduct of coal combustion. It helps to stabilise soil by reducing its plasticity and increasing strength, especially in high-plasticity soils.

Bitumen: Bituminous stabilization includes adding bitumen to the soil to make it water-resistant and reduce susceptibility to erosion. This technique is commonly applied in pavement and road construction to maintain stable layers beneath asphalt.

3. Biological stabilization

Biological stabilization uses vegetation and plant roots to stabilise soil. Roots of plants bind soil particles together, reducing erosion and preventing landslides. This method works well for slope protection and erosion control. Vegetation also has environmental benefits, supporting biodiversity and improving soil health. Biological stabilization often combines with other soil improvement techniques to provide natural, sustainable reinforcement.

4. Geotextile stabilization

Geotextile stabilization uses geosynthetic materials to reinforce and separate soil layers. Geotextiles are synthetic fabrics placed within soil layers to improve drainage, control erosion, and prevent soil movement. Geotextile stabilization is widely used in projects where additional soil strength and durability are needed, such as highways, slopes, and retaining walls. Types of geotextiles are:

Methods of Soil stabilization

1. Mechanical Stabilization:

It changes the soil's gradation by packing it with mechanical energy to make it more stable. For this method, equipment like rollers, vibrators, and earth rammers are often used. The trapped air and pores are released when the soil compacts and becomes less porous. When you mix two kinds of soil to make composite soil, you can sometimes get the properties you want. Filling and backfilling the soil and reinforcing the soil are two other ways to make sloped areas more stable.

2. Chemical Stabilization:

Chemical stabilization of soil is a way to change the physical structure around and inside clay particles so that the soil needs less water to compensate for the static imbalance. Calcium chloride is usually hygroscopic and deliquescent. It is a water-retaining ingredient in soil bases and surfaces that have been mechanically stabilized. This process lowers the vapor pressure, raises the surface tension, and slows the rate at which water evaporates.

It also reduces the temperature at which water freezes, which helps stop frost heave. It lowers the electric double layer and reduces the amount of water that fine-grained soils can absorb. Calcium chloride usually makes the soil stick together and easier to pack down. When calcium chloride is used often, chemicals may

be lost through leaching. If you want to use salt effectively, the relative humidity of the air should be above 30%. Calcium chloride can also be used to do this, but sodium chloride can also be used for the same purpose.

3. Cement Stabilization Method:

The process of stabilizing cement can be done by mixing. Mixing portland cement and pulverized soil with water and then packing the mixture together makes a strong material. The material is made by mixing soil and cement, known as “soil-cement.” As the cement dries out and gets stronger, the material gets hard and can be used to build strong structures.

4. Lime Stabilization:

Lime soil is commonly used as a binding agent or to improve the texture of clay soil. As the plasticity index drops and the soil becomes more brittle and easy to pulverize, its attraction to water decreases, making it ideal for use in construction. The binding properties of lime are also contributed. Lime’s pozzolanic action strengthens fine-grained soil. For stabilizing purposes, all of these adjustments are for the best.

As a sub-base course, soil lime works well for light traffic and high-type pavements. However, this technique cannot be utilized as a finishing coat due to its low resistance to wear and damage. It works great in the tropics but freezes too quickly for optimal use elsewhere.

5. Fly Ash Stabilization:

These days, more and more people are opting to use fly ash stabilization because it is so readily available. Stabilization with fly ash is quick, easy, and doesn’t cost very much. As an engineering material with a long and reliable history in geotechnical applications, fly ash has been widely used for decades.

Those who use coal to generate electricity produce fly ash as a by-product. When compared to lime and cement, fly ash has very limited cementation characteristics. Because these binders don’t have enough power, we refer to them as “secondary.” However, when combined with primary binders, it can undergo a chemical reaction to form a cementation compound that helps increase the strength of soft soil.

6. Rice Husk Ash Stabilization:

Rice husk ash is a suitable material that, at first glance, appears to be an inert substance, with the silica in the crystalline form suggested by the structure of the particles; yet, it may react with lime to generate calcium silicates. Like fly ash, which is more finely divided, rice husk has a high reactive potential. If you want to stabilize your soil, try using rice husk ash.

Factors Affecting the Strength of Stabilized Soil:

i) Organic Matter:

When there is a lot of organic matter, it reacts with the water and lowers the pH value. It will slow down the soil’s ability to absorb water and make it less stable.

ii) Compaction:

Soil carrying capacity can be increased with proper compaction, and compaction is also crucial in cement and lime stabilization.

iii) Occurrence of Sulfates and Sulphide:

It takes longer to stabilize the soil when Sulphates and Sulphides are in the soil.

iv) Moisture Content:

For the hydration process and effective compaction, the moisture content is crucial. The environment's moisture contributes to 20% of the weight of hydrated cement and 32% of the weight of quick lime.

v) Temperature:

When the temperature changes, the pozzolanic reaction slow down or speeds up. Weak stabilized soil results from the sluggish pozzolanic reaction caused by low temperatures.

Underpinning methods for foundation repair

Underpinning is a method for repairing and strengthening of building foundations. Underpinning methods, procedures, and their applications in strengthening of different types of foundations are discussed in this course. There are situations where a failure in foundation or footing happens unexpectedly after the completion of the whole structure (both sub and superstructure). Under such emergency situations, a remedial method has to be suggested to regain structural stability. Underpinning method helps to strengthen the foundation of an existing building or any other infrastructure. It involves the installation of permanent or temporary support to an existing foundation so that additional depth and bearing capacity is achieved.

Selection of Underpinning Methods

Underpinning methods are chosen based on the age of the building and the kinds of work it has. Depending on how old a building is, it is classified as:

- i) Ancient Structures are older than 150 years.
- ii) Recent Structures: Ages between 50 and 150 years.
- iii) Modern Structures: Ages under 50 years.

Types of works for selection of underpinning methods

Conversion Works

The structure has to be converted to another function, which requires stronger foundation compared to existing.

Protection Works

The following problems of a building has to undergo protection works:

- The existing foundation is not strong or stable
- Nearby excavation would affect the soil that supports existing footing
- Stabilization of the foundation soil to resist against natural calamities
- Requirement of basement below an already existing structure

Remedial Works

- Mistakes in initial foundation design caused subsidence of the structure
- Work on present structure than building a new one

Structural Conditions Which Requires Underpinning

There are many reasons that make an engineer to suggest underpinning method for stabilization of the substructure such as:

- The degradation of timber piles used as a foundation for normal buildings would
- cause settlement. This degradation of structures is due to water table fluctuations.

- Rise and lowering of the water table can cause a decrease of bearing capacity of
- Soil making the structure to settle.
- Structures that are built over soil with a bearing capacity not suitable for the
- structure would cause settlement.

Purpose of Underpinning

Underpinning is done for the following purposes:

- a) For the purpose of leading an old shallow foundation to the deeper depth when the adjoining building is constructed with a deep foundation.
- b) Underpinning is done for building a basement in the existing building.
- c) Underpinning is done to deepen the existing foundation (resting on poor strata) and make it rest on deeper soil strata of higher bearing capacity.
- d) To strengthen a settled foundation that may be caused by cracks in the wall.

Need for Underpinning

The decision of underpinning requirement can be made based on observations. When an already existing structure starts to show certain change through settlement or any kind of distress, it is necessary to establish vertical level readings as well as at the offset level, on a timely basis. The time period depends upon how severe the settlement is. Now, before the excavation for a new project, professionals have to closely examine and determine the soil capability to resist the structure that is coming over it. Based on that report, the need for underpinning is decided. Sometimes such test would avoid underpinning to be done after the whole structure is constructed.

Necessity of Underpinning Foundation

Underpinning foundation is a necessity:

- a) When an original or existing foundation is not stable at that time underpinning is required.
- b) When the purpose of the structure is changed
- c) When the supporting or strengthening soil property of the foundation is changed
- d) When mischaracterized during the design of the foundation
- e) When the existing foundation soil structure is disturbing during the construction of nearby structure

Methods of Underpinning

Underpinning can be carried but by the following methods:

- 1) Pit method
- 2) Pile methods
- 3) Underpinning to walls
- 4) Jack pile underpinning
- 5) Needle and pile underpinning
- 6) ‘Pynford’ Stool method of underpinning
- 7) Root pile or angle Piling Underpinning columns

Advantages of Underpinning

1. Underpinning is good because it strengthens the foundation and protects it from all kinds of disasters.

- With underpinning, you can get more light into your building. You add new rooms or offices to your building and add more windows and doors so that natural light can get in.
- By underpinning your basement, you can get to your home's plumbing, insulation, and wiring to see if they need to be fixed.
- One great thing about underpinning is that it raises the value of your home. If you want to sell your home in the future, it will be worth more and give you a good return if it is well-built and has finished underpinning.
- Underpinning is a great way to add more space to a structure in a way that costs less and causes less trouble. Buying a new house could be expensive if you want more space, but underpinning can save you that money. Also, you won't have to pay for expensive repairs down the road.

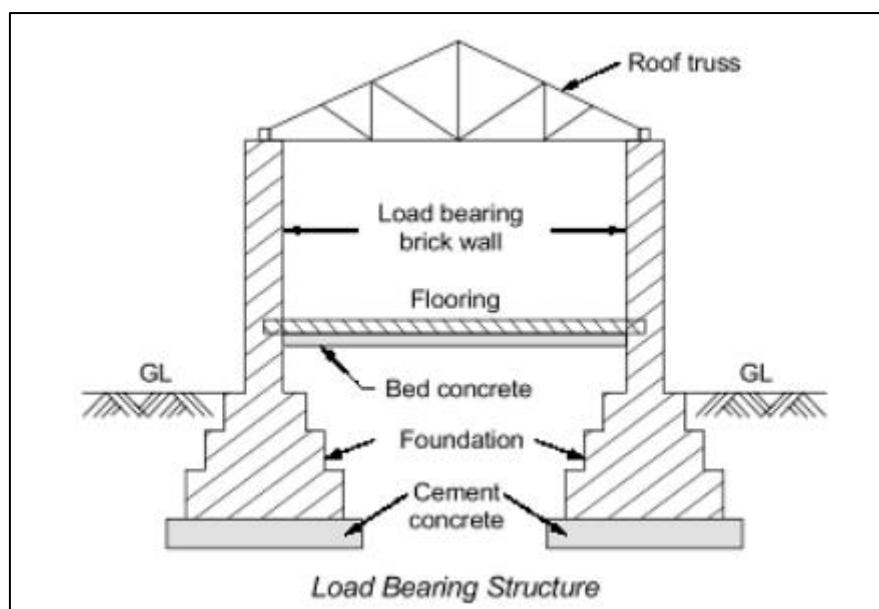
Disadvantages of Underpinning

- The nature of the underlying foundation method is expansive.
- When unstable and flooded ground, it is exceedingly challenging to underpin buildings.
- On the working site, a significant volume of excavated material is dumped during excavation.

Types of Structure – Load Bearing Structures and Framed Structures.

1. Load Bearing Structures

A Load-Bearing Structure relies on walls to support the building's weight, including the floors, roof, and any live loads (people, furniture, etc.). These walls transfer the load directly to the foundation. This method has been used for centuries and is common in traditional, low-rise, or rural buildings.



Key Characteristics:

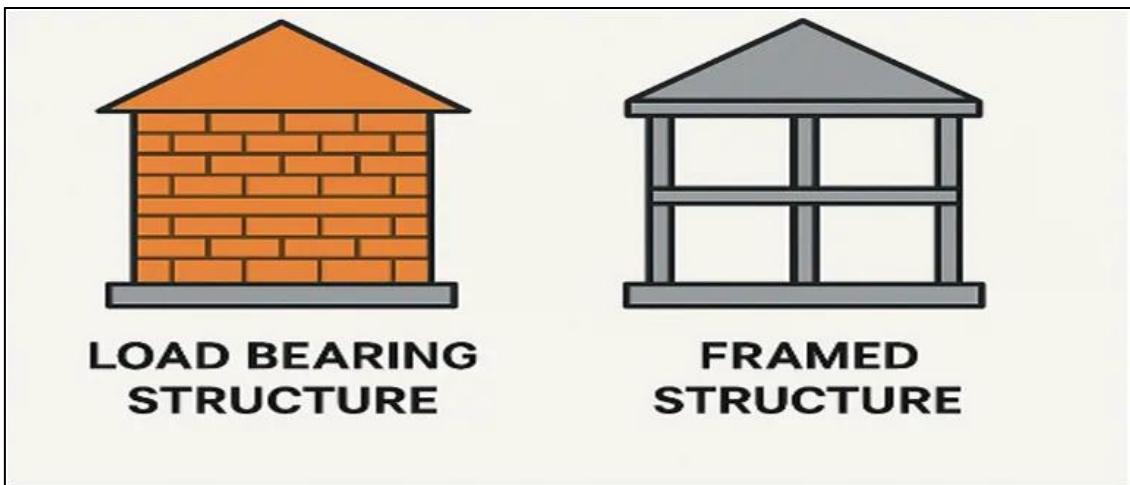
- Constructed using masonry materials such as bricks, stones, or concrete blocks
- Walls are thick and solid to handle vertical loads
- No skeletal frame (no columns or beams)
- Suitable for 1–2 storey buildings
- Common in residential houses, heritage buildings, and village homes

Advantages of Load Bearing Structure:

- Simpler construction; often doesn't require advanced machinery
- Lower cost for small structures
- Better thermal and acoustic insulation due to thick masonry
- Uses locally available materials

Limitations of Load Bearing Structure:

- Rigid design; hard to modify or extend rooms
- Not feasible for multi-storey buildings
- Longer construction time in some cases
- Reduces the floor area due to thick walls

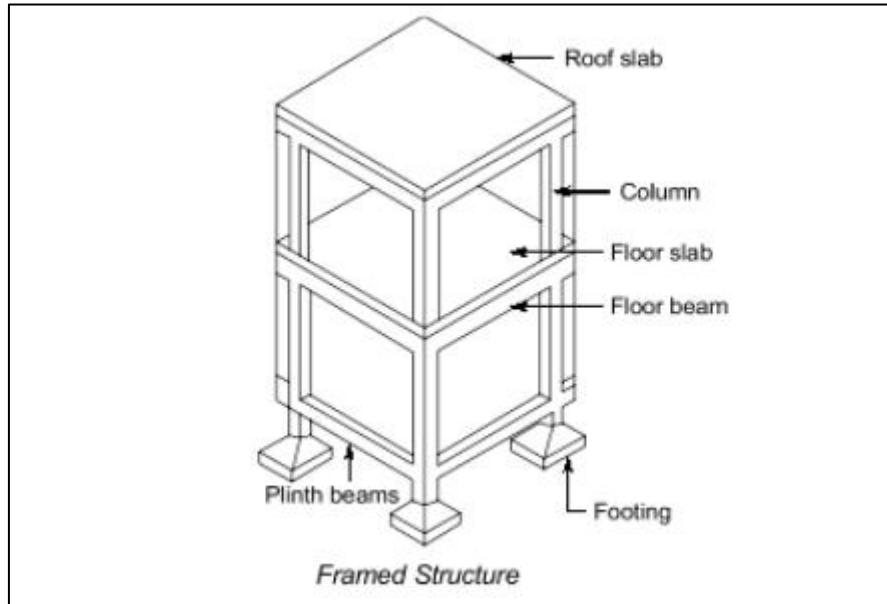


2. Framed structures

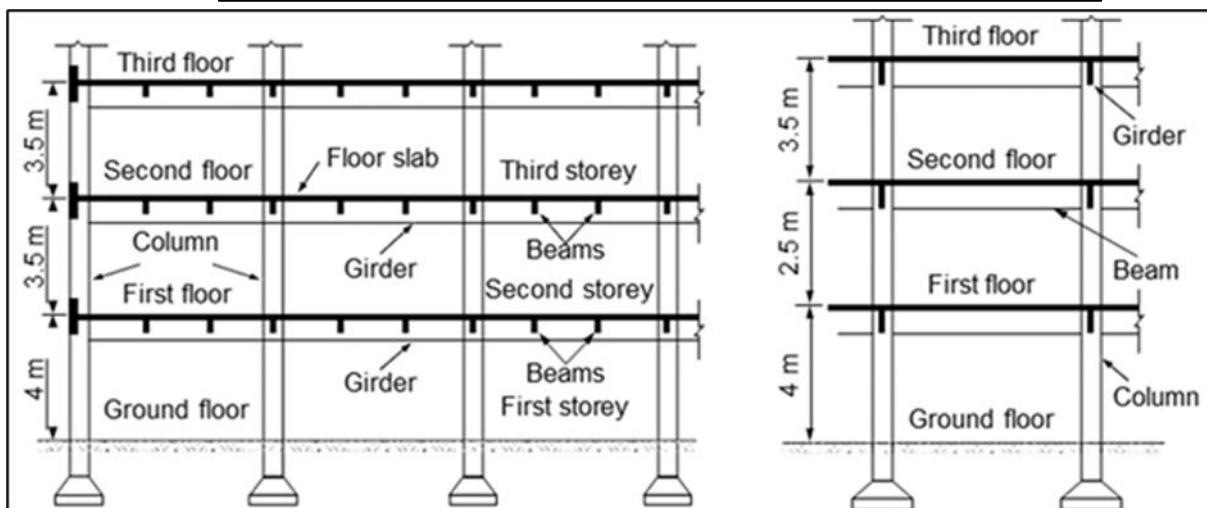
A framed structure consists of a series of frames, formed of columns or pillars or stanchions which are connected by means of beams at floor and roof levels. The walls are constructed within these frames. These walls are known as the panel walls or infillings. Thus the loads of the floors, roofs and panel walls are supported by the beams which, in turn, transmit the loads to the columns and these, in turn, carry the whole weight of the structure of the foundations.

The materials used for the construction of framed structures are: wood, steel and R.C.C.. The wood is used for light-framed structures. For multi-storey buildings, the frames of mild steel or R.C.C. are formed.

In case of light-framed structures, the panel walls can be replaced by cladding panels. The cladding is a term which is used to denote comparatively thin sheets required to enclose the framework. This cladding may be of asbestos cement sheet, corrugated galvanized iron sheets, copper sheets, thin concrete slabs, panels of glass or wood, tiles, etc.



Framed Structure



Key Characteristics:

- Uses steel or reinforced concrete (RCC)
- Walls are lightweight and non-structural
- Loads are transferred to the foundation through the beam-column framework
- Common in commercial complexes, high-rise apartments, shopping malls, airports, etc.
- Allows open floor plans and larger spans

Advantages Framed structures:

- Flexible layout; rooms can be changed or extended easily
- Perfect for vertical expansion (adding more floors)
- Faster construction with prefabricated or modular techniques
- Can resist earthquakes and wind loads better (when properly designed)

Limitations Framed structures:

- Requires structural expertise and proper engineering
- Higher initial cost (materials and skilled labor)
- Might need regular maintenance in high-rise buildings

Advantages of framed structures:

Following are the advantages of framed structures:

(1) Thin panels: It can be easily seen that in case of a framed structure, a beam has to support a wall between the adjacent columns and the beam immediately above it, irrespective of the height of the building. The maximum height of wall that a beam has to support would be that of storey height. This results in thin panels which incidentally increases the floor area. The external walls should only be sufficiently thick to withstand weather conditions and to have required heat and sound insulation. The internal walls should be only sufficiently thick to have heat and sound insulation.

(2) Speed in construction: It is possible to achieve speed in construction in case of a framed structure. The construction of framework of the upper floors and finishing of the lower floors can be carried out simultaneously. Thus it is possible to execute several building trades in a building at the same time.

(3) Freedom in planning: A framed structure permits greater freedom in the planning. The large open spaces can be easily provided within the building and the provisions of panel walls can be suitably changed to meet the requirements at any time.

(4) Use of proper materials: A framed structure divides the members of building into two groups:

(i) load-bearing and

(ii) non-load-bearing: The materials of inferior quality can be used for the latter members where strength is not the main consideration.

(5) Better resistant to vibrations: It is found that the framed structures can resist vibrations effectively. Hence the framed structures are useful for factory buildings and also for places subjected to the earthquakes.

(6) Unreliable soils: For made up and unreliable soils and for pile foundations, the framed structures are found to be more suitable and less expensive than ordinary walled structures.

(7) Economy in construction: The advantages of the framed structures, mentioned above, lead to overall economy in the construction of a structure. Hence the present day tendency is to adopt the framed structures as far as possible.

The Difference Between Load Bearing and Framed Structure

Load Bearing Structure	Framed Structure
Walls carry the structural load.	Columns and beams carry the structural load.
Load is transferred from slab to wall and then to the foundation.	Load is transferred from slab to beam, then to column and finally to the foundation.
Walls are very thick to support the load.	Thin partition walls are used since they do not carry load.
It is generally limited to 1–3 storeys.	It is suitable for multi-storey and high-rise buildings.
Design flexibility is low.	Design flexibility is high.
Modification and alteration are difficult.	Modification and alteration are easy.
Earthquake resistance is poor.	Earthquake resistance is good.
Brick or stone masonry is mainly used.	RCC (concrete and steel) is mainly used.

A larger foundation size is required.	A comparatively smaller foundation size is required.
Carpet area obtained is less due to thick walls.	More carpet area is obtained due to thin walls.
Initial construction cost is low.	Initial construction cost is high.
Long-term cost is higher.	Long-term cost is lower.
Construction is faster for small buildings.	Construction is faster for large buildings.
It is economical for small houses.	It is economical for large buildings.
Durability is moderate.	Durability is high.
Maintenance requirement is low.	Maintenance requirement is moderate.
Future expansion is difficult.	Future expansion is easy.