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Study and Analysis of Types of Foundation and Design Construction

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Abstract – *Lower base of a structure is a very supreme part as it links the main body superstructure to the earth. That lower base is known as Foundation. In this paper we are going to discuss about the types of foundations used in construction industry, there design and also which alternative materials we can utilize as foundation material which can make it more firm, durable and ecofriendly. When it comes to built a structure it is very crucial to construct a firm base which holds the superstructure in all climatic conditions without collapsing or decaying. It is very important to know which type of foundation is essential to use in a particular superstructure, which materials are more suitable, which designs should be used. If any inappropriate material is used for foundation of structure then high risk is involved of collapsing of the structure. Different types of foundation base are utilized in different types of structures, each one of them has a unique design and specific configuration which makes a particular structure more durable and firm. A different foundation type is used in bungalows and in high rise buildings. In short this study presents the foundation types, which type is used for which superstructure, which design is suitable and more precisely we will be discussing about how we can make the foundation base ecofriendly, cost efficient and more durable and strong to withstand the natural calamities.*

Key Words: **foundation, superstructure, design, durable, ecofriendly, base, collapsing.**

1. INTRODUCTION

Construction is a very oldest human activity. Knowledge of deep founding was possessed more than 12000 years ago in Switzerland by Neolithic inhabitants. They constructed their home on a long wooden piles, high above dangerous animals and hostile neighbors driven into the soft bottoms of shallow lakes. Many years later, the Babylonians which are found on the deep alluvium settled themselves under the weight of the construction. Biggest development in foundation engineering took place in ancient Rome, where certain rules were imposed and pozzolanic concrete was used. In later years many buildings collapsed because of wars earthquakes and natural calamities and those which survived suffer from cracks and other problems. From that period it became very important to have strong foundation.

Construction of any structure starts with the built up of foundation base which holds the weight of all beams, columns, walls, slab, and other household materials. Hence having a strong and solid base is must. Foundation is basically classified into two major category which is further sub divided into number of categories based on the type of structure to be implemented. For low rise houses and bungalows shallow foundation is used and for high rise building and houses deep foundation is used. The classification diagram is shown below for better understanding of the types of foundation. Every foundation has different type of footing. Not only on ground but underground foundation is also exists which has a total different type of construction methodology. Each foundation type has a unique equation which helps us to design the foundation on field. For some foundation the underground depth is 3m while for some the underground depth is 10m and more as it depends upon the height of the structure. Also a thorough understanding of ground and soil condition is must for construction of foundation as it plays a major role in understanding the behavior of the structure, which materials should be used and also will the structure stand firm for longer time or not. So before constructing any foundation it is very important to study the soil type of the ground and also to check if the area is an earthquake prone zone or not.

2. TYPES OF FOUNDATION

Foundation is basically classified into two major types such as:

2.1 SHALLOW FOUNDATION

It is a type of foundation which transfers the structural load to the earth surface which is very close to the earth. The depth of the ground in shallow foundation varies from 1.5m to 3m. Shallow foundation is later divided into three major types such as:

2.1.1 SPREAD FOOTING FOUNDATION

Spread footing is generally used in residential building, has a wider bottom portion as compared to the load bearing foundation walls it supports. This wider bottom portion spreads the weight of the structure over more area to achieve more stability. The layout and design of the spread footing foundation is controlled by some factors, such as the weight of the superstructure it must support, penetration of soft near surface layers and

penetration through near surface layers which are likely to change volume due to shrink swell or frost heave.

This type of footing is basically used to construct basements in residential buildings. Spread footing behaves like an inverted cantilever with load applied in the upward direction. Builders and civil engineers prefer spread footing as it beneficial, as it helps transfer the load to the ground surface making it an excellent solution for stabilizing weak soil. Benefits of spread footing are it reduces the cracking caused by settlement, cost efficient in design, construction and quality control, and stabilize the soil around the structural base, less complicated procedure. Spread footing is further divided into two sub categories such as

2.1.1.1 PAD FOUNDATION

Pad foundation is a sub category of shallow foundation which settles and spreads over the soil safely. If the soil at the site has sufficient strength and is not too deep them Pad foundation is preferred. Thickness of pad foundation is generally uniform. Pad foundation spreads safely over the concentrated load to the bearing stratum. Hence the design of the foundation should be stiff so that uniform spreading of load to the soil takes place without making the foundation pressure exceed the permissible bearing stress. This is achieved by making the pad deep or by reinforcing the pad as both the techniques helps to spread the force in a predefined angle.

The angle of spreading is calculated by the bearing capacity of the underlying soil and concrete strength. Size of the pad should be design such that the tension inside the concrete should be prevented; as a result no cracking will take place which will result in failure. The arrangement of pad foundation mainly depends on load bearing capacity of the soil, available space, imposed loads and the structure to be supported. Materials that can be used in pad foundation are reinforcement and cast in – situ concrete (OPC or SRPC).

ADVANTAGES OF PAD FOUNDATION

- Can be designed to accommodate tight sites
- Reinforcement for tension and shear can be added.
- Economic due to control of foundation size.
- Shallow form of foundation needs little excavation.

DISADVANTAGES OF PAD FOUNDATION

- Foundation size can be a very large to cope with high point loads.
- Limited foundation suitability to point loads of framed buildings.
- Separate foundations make this design weak against differential settlement that may affect the building.
- Deep excavations for foundations would require support to prevent caving in.
- Weak against uplift forces, wind forces and earthquake forces.

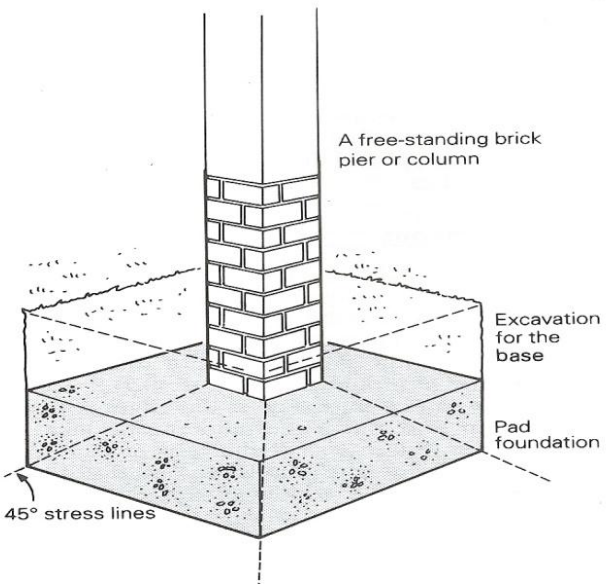

Fig 1: Pad foundation

2.1.1.2 STRIP FOUNDATION

Strip foundation which is also called as strip footing which is sub category of shallow foundation are use to provide continuous level or stepped strip of support to a linear structure for example walls or closely spaced rows or columns built in centre above them. Strip foundations can be done in mostly all sub soils, but a soil of good bearing capacity is suitable. This type of foundation is generally used for the construction of medium or low rise domestic buildings.

The underside of strip footing should be deep so that frost action does not take place. The position and size of strip foundation depends upon the overall width of the wall. The old or traditional strip foundation is basically equal or greater than overall wall width and also the foundation width is three times the width of the supported wall.

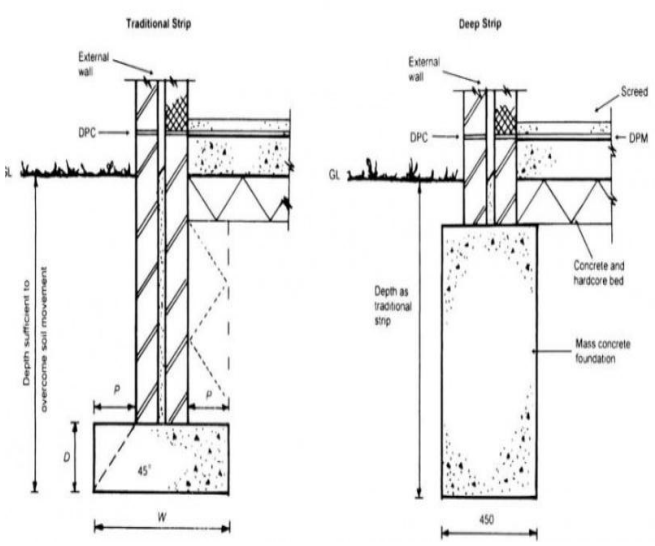

Fig 2: strip foundation

ADVANTAGES OF STRIP FOUNDATIONS:

- Ability to withstand great loads.
- They have subtypes from which you can choose the one you need for particular purposes.
- The price is much lower than that of cast-in-situ structures, although strip foundations are not inferior to them in strength.
- Easy to build, no special training requirements for personnel.
- Very long service life.
- You can insulate the floors much better if you use a strip foundation.

DISADVANTAGES OF STRIP FOUNDATIONS:

- Not suitable for every soil type.
- You have to do the filling on a single go and the amount of material to prepare for filling is a problem.
- It is only suitable in low rise buildings.

2.1.2 COMBINED FOUNDATION

When two or more columns are close to each other and if there foundation are overlapping then combined foundation is constructed. Generally it is carried out on fields which have low soil bearing capacity. It is very economical when isolated footing columns are constructed over it. Combined foundation is again sub divided into three categories such as:

2.1.2.1 RECTANGULAR FOUNDATION

Rectangular footing is constructed when one of the projections of footing is restricted or width of the footing is restricted. In longitudinal direction, it acts as an upward loaded beam spanning between columns and cantilevering beyond.

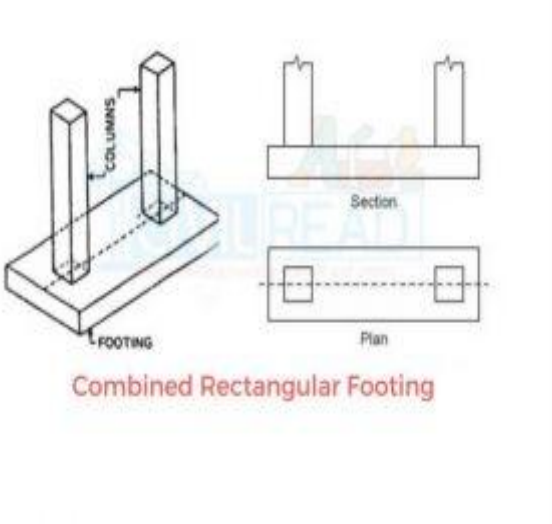

Fig 3: Rectangular foundation

2.1.2.2 TRAPEZOIDAL FOUNDATION

In trapezoidal footing two columns carry unequal load and the distance outside the column of the heaviest load is limited. In such scenario using any other footing method may result in resultant of load does not fall at the middle length of footing. The solution to this problem is using trapezoidal footing in such a way that the centre of gravity of the footing lies under the resultant of the loads. Trapezoidal footing is more economical than other foundation types as it saves concrete. While designing the foundation, the bending moments are critical at the face of the column and the depth requirement reduces as we go further away from it. As a result we should use slope or else we will end up using more unnecessary concrete. In colder regions where water freezes on footing results in additional pressure crack formation in the foundation(freezing and thawing effect), in such area it is very necessary to give slope to the footing so that water will slide over it causing no damage to the foundation.

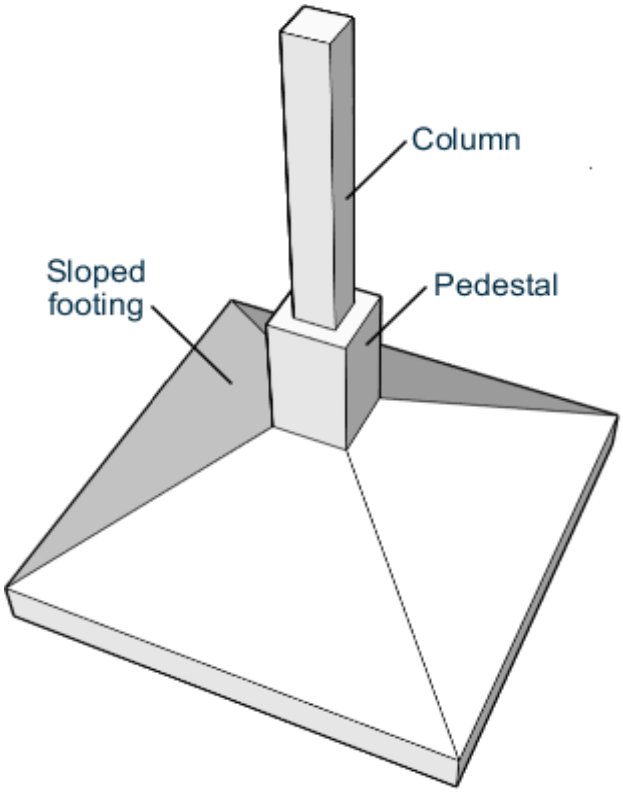

Fig 4: Trapezoidal foundation

2.1.2.3 STRAP FOUNDATION

Strap footing is also known as cantilever footing. When two columns having independent footing base, connected by a beam is called as strap foundation. Strap footing consists two or more columns footing connected by concrete beam. Such type of footing distributes the load of heavy or eccentrically loaded column footing to adjacent footing. Strap footing works as a conjunction with columns which are located along builder's property line or lot line. Main benefit of using strap footing is it gives extra stability to the footing by sharing of loads. Strap footing can also be used in soft soil as it avoids the sinking of an individual footing. In strap footing the strap is attached to the footing and column by the use of dowels in such a way that the footing and the strap act as unit. The footing is subjected to one way end.

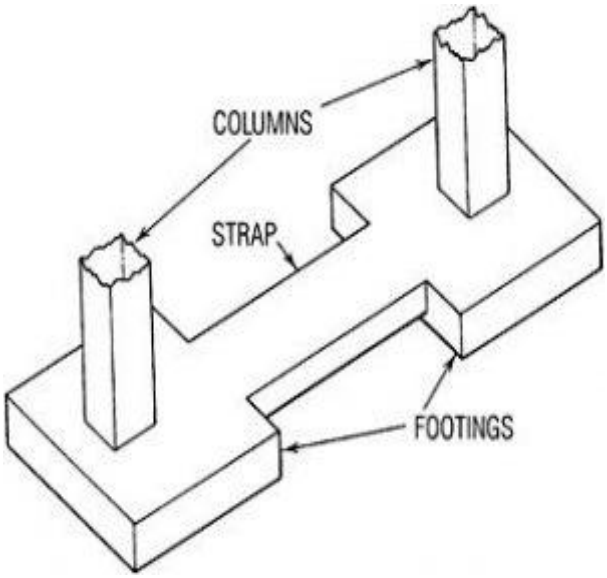

Fig 5: Strap foundation

2.1.3 MAT OR RAFT FOUNDATION

Mat or raft foundation is a continuous slap resting on the soil that extends over an entire footprint of the building, thus supporting the building the building and transferring its weight to the ground. Mat or raft footing is basically a thick concrete slab reinforced with steel that covers the entire contact area of the structure like a thick floor. They are large concrete slabs which supports a number of walls and columns. In this the foundations are constructed by excavating soil in order to compact, strong, undisturbed natural soil which is at least a few feet's below the ground level. This soil is stronger as compared to the loose soil at the surface hence it is very good for basements. Raft or mat foundation is required in areas where soil has to support heavy structural loads and has low bearing capacity.

Fig 6: Mat or Raft foundation

ADVANTAGES OF MAT OR RAFT FOUNDATION

- It can be constructed in poor soil condition.
- It resists differential settlement.
- It distributes load over a larger area.
- It requires less earth excavation.

DISADVANTAGES OF MAT OR RAFT FOUNDATION

- It is prone to edge erosion.
- When subjected to concentrated load it requires special measurements.

2.2 DEEP FOUNDATION

A deep foundation is a type of foundation that transfers building loads to the earth. The depth of the ground in deep foundation is above 3m. This is because; to construct high rise buildings it is necessary to go deep into the ground to provide necessary support to the superstructure and protects it from collapsing. Deep foundations are further classified into four sub categories such as:

2.2.1 PILE FOUNDATION

Pile foundation is type of foundation in which columns of small cylindrical diameter are driven or cast into the ground. It is made up of concrete, timber or steel. This type of foundation is basically used for bridge type of construction. Pile foundation is done in the areas where the upper layer of soil is compressible or weak. Pile foundation is basically used when the soil below the foundation does not have sufficient bearing capacity to carry the weight of the structure into deep soil up to hard strata.

Fig 7: Pile foundation

ADVANTAGES OF PILE FOUNDATION

- Initial cost is low.
- Easy to handle and construct.
- Best suitable for friction pipes.

DISADVANTAGES OF PILE FOUNDATION

- Vulnerable to damage.
- Vulnerable to decay.
- Its durability decreases if subject to wetting and drying.

2.2.2 PIER FOUNDATION

It is also known as post foundation. Pier foundation is basically a collection of large cylindrical diameter to up hold the structure and transfer large super imposed load to the firm strata below. It is placed few feet's below the ground. This is very convenient method as the materials are easily available and the method is easy and requires fewer amounts of materials and labors. It is also very cost efficient. It is preferred in locations where the top strata consist of decomposed rock overlying strata of sound rock.

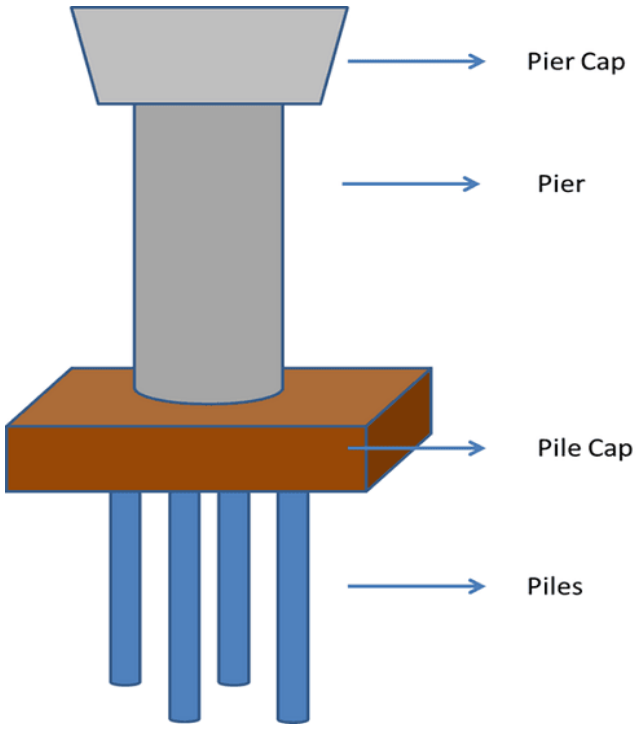

Fig 8: Pier foundation

ADVANTAGES OF PIER FOUNDATION

- Wide range of varieties in terms of design.
- Its bearing capacity can be increased ny under reaming the bottom.
- It is cost efficient and time efficient as it does not needs extensive excavation.

DISADVANTAGES OF PIER FOUNDATION

- Moisture problems and rain accumulation.
- Creaking sagging and bouncy floors.
- Poor ventilation.

2.2.3 COMPENSATED FOUNDATION

Compensated foundation works on the principle that if the load of the excavated material is equal to the weight of the building added then no additional stresses is applied on the soil. It is also called as floating foundation. Compensated foundation consists of deep basements which are used to support high rise buildings and swimming pools, in which large amount of material is excavated. It is a very convenient method of construction as it has minimal impact on adjacent structure.

Fig 9: compensated foundation

ADVANTAGES OF COMPENSATED FOUNDATION

- Simple to construct with minimal impact and disturbance to neighbors.
- Consolidation settlement is eliminated or controlled.
- It provides protection to rising damp, drainage, and thermal insulation.

DISADVANTAGES OF COMPENSATED FOUNDATION

- Comparatively primitive technology.
- Lesser options for design.
- No underground access for utility lines.

2.2.4 CAISSON FOUNDATION

The origin of word caisson is from a Latin word caspa which means case or box. Caissons are basically water tight structures build in connection with the excavation for the foundation of piers, bridges, foreshore protection, abutments in river and lakes dock structure, etc. it can be made of reinforcement concrete, wood, steel etc. It is used to construct foundation when the depth of the water level in the river and sea is high. It is build in the areas where the soil contains large boulders, which obstruct the penetration of piles.

Fig 10: Caisson foundation

ADVANTAGES OF CAISSON FOUNDATION

- Economic and environment friendly.
- Less sound pollution and reduced vibration.
- Suitable for variable underwater soil condition.
- Less handling equipments required.

DISADVANTAGES OF CAISSON FOUNDATION

- Extremely sensitive and problematic.
- Not a good option for polluted sites.
- Only skilled labors required.

3. CONCLUSION

All the different types of foundation and footing types have a specific use in a specific area for a particular weather condition. It is very important to know the foundation work to carry out construction activities. This is the very first and foremost step carried out to build any superstructure. The main objective of this article is to provide detailed and collective information about the types of foundation, there advantages and disadvantages, suitable conditions, design construction. All the major types of foundation are covered in this article to give an overview about various types of foundation.

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