Structural and Foundation Analysis

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INTRODUCTION

Structural engineering is the field of engineering particularly concerned with the design of economical and efficient load-bearing structures. Within the civil engineering, it is largely the implementation of mechanics to the design of the large structures that are fundamental to basic living, such as buildings, bridges, walls, dams, and tunnels. Structural engineers need to design structures that do not collapse or behave in undesirable ways while serving their useful functions.

Structural design is the process of determining location, material, and size of structural elements to resist forces acting in a structure. A structure essentially consists of two parts, namely the super structure which is above the plinth level and the substructure which is below the plinth. Substructure is also known as the foundation and this forms the base for any structure. The soil on which the foundation rests is called the "foundation soil".

A foundation is provided for the following purposes: (a) to distribute the total load coming on the structure on a larger area (b) to support the structures (c) to give enough stability to the structures against various disturbing forces such as wind and rain (d) to prepare a level surface for concreting and masonry work. There are mainly two types of foundations: shallow foundation and deep foundation (Figure 1).

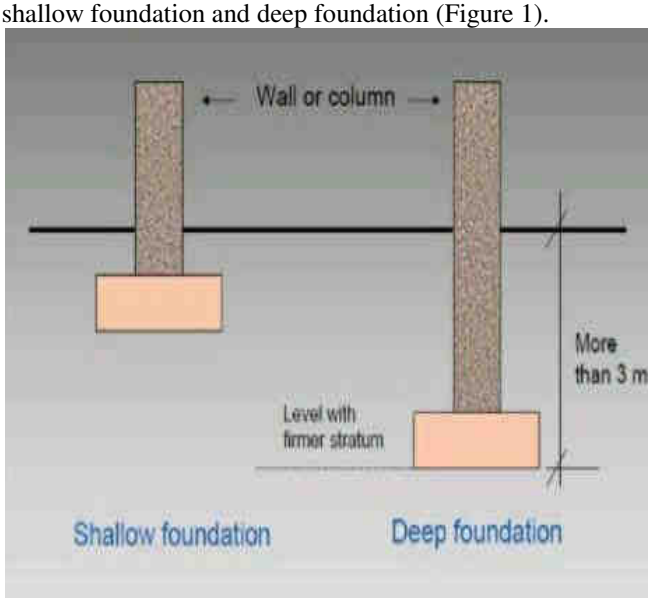

Figure 1

Shallow foundation is also known as a stepped foundation (Figure 2). If the depth of the foundation is less than the width of foundation, it is known as shallow or stepped foundation. It can be used where the bearing capacity of soil on which the structure is to be constructed is maximum.

Figure 2

Types of shallow foundation: Isolated footing and combined footing.

Isolated footing: Isolated footings are provided under each column (Figure 1). These may be square, rectangular or circular in plan. This type of footing is preferred when only single column is appearing in the foundation plan of a particular project.

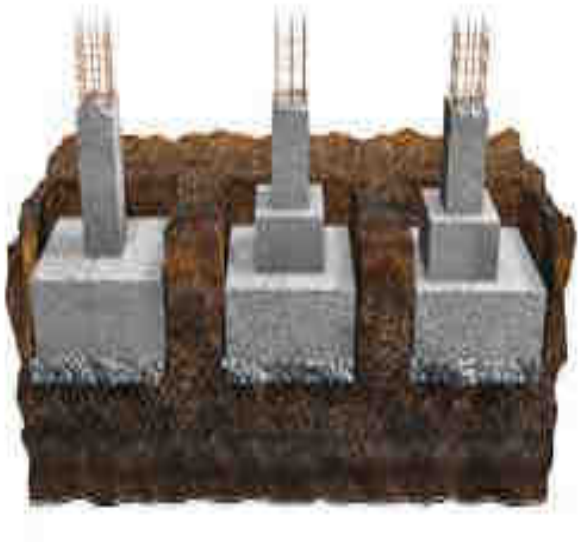

Figure 3

Combined footing: Combined footing supports two or more column loads (Figure 2). The foundation engineer is responsible for assessing these factors and working together with other members of the design and construction team, selecting the most suitable foundation system.

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Figure 4

Most of the shallow foundations are simple concrete footings. A column footing is a square block of concrete, with or without steel reinforcing, that accepts the concentrated load placed on it from above by a building column and spreads this load across an area of soil large enough that the allowable bearing stress of the soil is not exceeded. A wall footing or strip footing is a continuous strip of concrete that serves the same function for a load-bearing wall. To minimize settlement, footings are usually placed on undisturbed soil. Under some circumstances, footings may be constructed over engineered fill, which is earth that has been deposited under the supervision of a soils engineer. The engineer, working from the results of laboratory compaction tests on samples taken from the soil used for filling, makes sure that the soil is deposited in thin layers at a controlled moisture content and compacted in accordance with detailed procedures that ensure a known load-bearing capacity and long-term stability.

Footings appear in many forms in different foundation in different foundation systems. In climates with little or no ground frost, a concrete slab on grade with thickened edges is the least expensive foundation and floor system that one can use and is applicable to one and two storey buildings of any type of construction. In colder regions the edges of a slab on grade may be supported with deeper wall footings that bear on soil below the frost line. The floors which are raised above the ground, either over a crawlspace or a basement, support is provided by concrete or masonry foundation walls supported on concrete strip footings. When we are building on slopes, it is often necessary to step the footings to maintain the required depth of footing at all points around the building.

Column footings on steep slopes may be linked together with reinforced concrete tie beams to avoid possible differential slippage between footings, if soil conditions or earthquake precautions require it. Footings cannot be extended legally beyond a property line, even for a building built tightly against that another building. If the outer toe of the footing were simply cut off at the property line, the footing would not be symmetrically loaded by the column or wall and would tend to rotate and fail combined footings and cantilever. Footings solve these problems by tying the footings for the outside row of columns to those of the next row in such a way that any rotational tendency is neutralized.

In situations where the allowable bearing capacity of the soil is low in relation to the weight of the building, column footings may become large enough that it is more economical to merge them into a single mat or raft foundation that supports the entire building. Mats for every tall buildings may be 6 feet (1.8 m) thick or more and are heavily reinforced. A floating foundation is sometimes used where the bearing capacity of the soil is low and settlement must be carefully controlled. A floating foundation is similar to a mat foundation, but is placed beneath a building at a depth such that the weight of the soil removed from the excavation is equal to the weight of the building above.

Deep Foundation: A deep foundation is a foundation that is installed to significant depth so as to handle a specific load. Defined by its depth to length ratio, the depth will usually have to go beyond 10 feet deep in order for the foundation to truly be a deep foundation. Deep Foundation is used where the bearing capacity of the soil is very low. The load coming from the superstructure is further transmitted vertically to the soil. Deep foundation can be provided at a greater depth, provide lateral support and resist uplift, effective when foundation at shallow depth is not possible, can carry a huge load, etc.

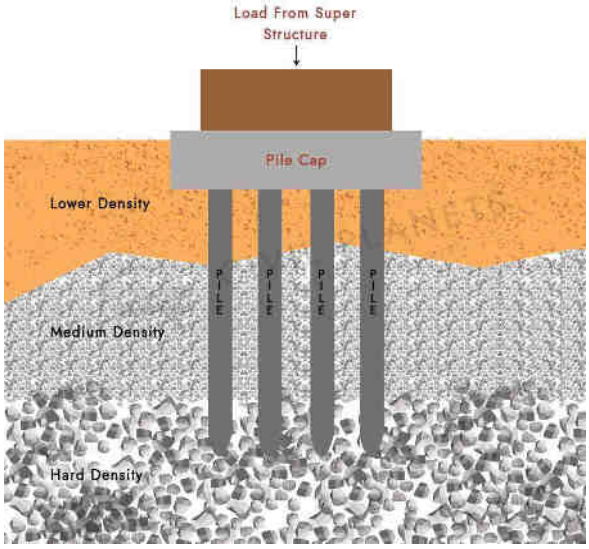

Figure 5

Figure 6

Types of deep foundation: Pile foundation and Pier foundation.

Pile Foundation: A pile foundation is defined as a series of columns constructed or inserted into the ground to transmit loads to a lower level of subsoil (Figure 5).

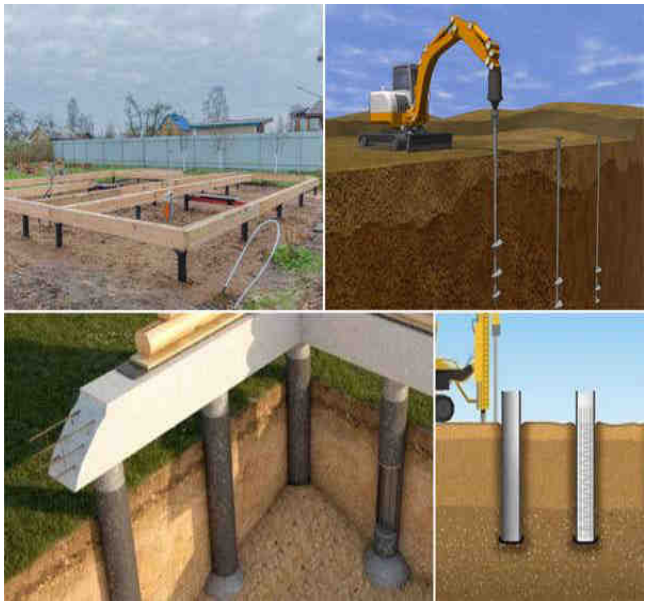

Figure 7

A pile is a long cylinder made up of a strong material, such as concrete. Piles are pushed into the ground to act as a steady support for structures built on top of them. Pile foundation is needed in areas where the structures constructed are large & heavy and the soil underlying is weak. In areas where settlement issues are common due to soil liquefaction or water table issues, pile foundation is a better choice.

Pier Foundation: The foundation which is constructed to bear the heavy load from the superstructure with the help of a pile below the soil and cylindrical columns is known as a pier foundation (Figure 8).

Figure 8

These are of shallow depth. It is used where top strata consist of decomposed rock, stiff clays. The advantages of pier foundations often come to cost, flood protection and flexibility, protection from flooding. Since the house is elevated above the ground, sitting atop posts, it will be protected from flooding.

The pile foundation is similar to shallow foundation but with excessive depth till it reach the hard strata of soil or bedrock to transfer the load without exceeding the safe bearing capacity. There can also be of different shapes, but generally, it is preferred to use a cylindrical pier to neglect the twisting effect.