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Cost Effectiveness of Several Types of Foundation

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***ABSTRACT*—** This project presents a comparative study of cost of several types of foundation for example, Pad footing, Trapezoidal footing, Stepped footing. These foundations are used to estimate the cost of an optimized design of reinforced concrete footing base on structural safety. Foundation is the interface between the superstructure building and the ground. Its task is to transfer safely the building load into the ground and to keep settlement as small as possible. The foundation system must be designed to ensure sufficient external stability of the entire system and maintain the internal load bearing capacity of the building components through appropriate design of the components. The serviceability of the building must be guaranteed for its entire lifecycle. Similarly the costing of the foundation effects the entire costing of the building which should be as economical as possible. The above footing, are worked for design, material cost and optimization. The optimization consists of depth of concrete and area of steel. Optimized footing materials, cost of concrete, reinforcing steel and formwork of designed sections are computed. Total cost factor and other cost factor are developed to generalize and simplify the calculations of footing material cost. Numerical example is presented for estimating the material cost of the footing for a desired axial load.

KEYWORDS – foundation, Pad footing, Trapezoidal footing, stepped footing, axial load.

I. INTRODUCTION

The lowest part of a structure is generally referred to as the foundation.Its function is to transfer the load of the structure to the soil on which it is resting. A properly designed foundation is one that transfers the load throughout the soil without over-stressing the soil. Overstressing the soil can result in either excessive settlement or shear failure of the soil, both of which cause damage to the structure. Thus, geotechnical and structural engineers who design foundations must evaluate the bearing capacity of soils.Depending on the structure and soil encountered, various types of foundations are used. A footing is simply an enlargement of a load-bearing wall or column that makes it possible to spread the load of the structure over a larger area of the soil. In soil with low load-bearing capacity, the size of the footings required is impractically large. In that case, it is more economical to constructs the entire structure over a concrete pad.Pile and drilled shaft foundations are used for heavier structures when great depth is required for supporting the load. Piles are structural members made of timber, concrete, or steel that transmits the load of the superstructure to the lower layers of the soil. According to how they transmit their load into the subsoil, piles can be divided into two categories: friction piles and end-bearing pile, the load carried by the pile is transmitted at its tip to a firm stratum.In the case of drilled shafts, a shaft is drilled into the subsoil and is then filled with concrete. A metal casing may be used while the shaft is being drilled. The casing may be left in place or withdrawn during the placing of concrete. Generally, the diameter of a drilled shaft is much larger than that of a pile. The distinction between piles and drilled shafts becomes hazy at an approximate diameter of 1m, and then the definitions and nomenclature are inaccurate.Spread footings and mat foundations are generally referred to as shallow foundations, and pile and drilled shaft foundations are classified as deep foundations. In a more general sense, shallow foundations are those foundations that have a depth-of-embedment-to-width ratio of approximately less than four. When the depth of embedment-to-width ratio of a foundation is greater than four, it may be classified as a deep foundation.

II. METHODOLOGY

The introduction about the project, the objective of the study and the organization of the project report.*It*deals with the various research papers related to introduce categories of the buildings. It provides an overview of the literature related to the study of cost effectiveness of several types of foundation by using the Pad footing, Trapezoidal footing, Stepped footing. At the end conclusion on the .*These are* the design of foundation.total costing for each type of foundation with comparison of each type of foundation related to the costing and located on the graph for final comparison. the total costing for each type of foundation with comparison of each type of foundation related to the load and located on the graph for final comparison. Finally a summary of the project work Conclusion and the future scope of the work are also presented in this paper.

Footing Classification

The type of footing for particular structure is influenced by many factors that may control type of footing to be used, these main factor are: the strength and compressibility of various soil strata at the site the magnitude of the column bad, the position of water table and the depth of footing of adjacent buildings.

We can classify footing as follows:

a. Shallow footings; its depth is usually $D \leq B$, it contains isolated, combined, strip and raft footing.

b. Deep footings; with depth > [4-5]B, pile footing is one type of deep footing.

c. Special footing.

Selection of Type of Footing

If the layer of soil of footing level which is suitable for bearing the load is located at a relatively shallow depth, the structure may be supported by shallow footing. If the upper strata are too weak or compressible, the load will be transferred to more suitable soil layer at a greater depth by means of deep footing

Foundation Types

Foundation is a supporting portion of a structure located below the structure and it is supported only by soil or rock. It is mainly used to support the structure and then distribute the weight of that structure, so it settles to the ground evenly rather than unevenly. Each individual foundation must be sized so that the maximum soil bearing pressure does not exceed the allowable soil bearing capacity of the under lying soil mass. In addition, footing settlement must not exceed tolerable limits established for differential and total settlement.

There are two main types of foundations:

a. Shallow Foundations.

b. Deep Foundations.

- **Shallow foundations**

To perform satisfactory, shallow foundations must have two main characteristics:

1. They have to be safe against overall shear failure in the soil that supports them.
2. They cannot undergo excessive displacement, or settlement. (the term excessive is relative, because the degree of settlement allowed for a structure depends on several considerations).

The most common structural foundation in today's construction industry is the shallow foundation. Shallow foundation are those founded near to the finished ground surface; generally where the foundation depth (Df) is less than or equal to (3-4) of the foundation depth. These are not strict rules, but merely guide lines; basically, if surface loading or other surface conditions will affect the bearing capacity of a foundation it is then shallow.

Shallow foundation include spread foundation (carrying a single column) combined foundation, continuous foundation and mat (raft) foundation. Shallow foundations are used when surface soils are sufficiently strong and stiff to support the imposed loads.

- **Advantage of using Shallow foundations:**

a. Simple construction procedure.
b. Affordable cost.
c. Available material (mostly concrete).
d. Does not need experts (labors).

- **Disadvantage of using Shallow foundation:**
  1) Settlement.
  2) Foundation is subjected to pull off out, torsion, and moment.
  3) Irregular ground surface (slope).

- **Spread or isolated Foundations**

Isolated footing is a foundation that carries a single column. It distributes the column load to an area of soil around the column. Spread foundation may be circular, square, or rectangular. They usually consist of a block or slab of uniform thickness, but they may be stepped or hunched if they are required to spread the load from a heavy column. Figure 1.2 shows spread foundations

- **Combined Foundations**

Combined foundation combines the loads from two or more columns to the soil. It may be rectangular, trapezoidal or cantilever.

- **Continuous (wall) Foundations**

One dimensional action, cantilever out on each side of the wall. Continuous footings are used to support a line of loads, rather due a load-bearing wall, or if a line of columns need supporting where columns positions are so close that individual foundation inappropriate. Figure 1.4 shows a wall foundation.

- **Mat (Raft) Foundations**

Raft foundation is a combined footing that may cover the entire area under a structure supporting several columns and walls. Mat foundations are sometimes preferred for soils that have low load-bearing capacities but that will have to support high column and/or wall loads. Under some conditions, spread footings would have to cover more than half the building area, and mat foundations might be more economical. Several types of mat foundations are currently used. Some of common types are shown schematically in figure 1.5 and include the following:

a. Flat plate, the mat is of a uniform thickness.
b. Flat plate thickened under columns.
c. Beams and slab, the beams run both ways, and the columns are located at the intersection of the beams.
d. Flat plates with pedestals.
e. Slab with basement walls as a part of the mat, the walls act as stiffeners for the mat.

Mats may be supported by piles. The piles help in reducing the settlement of a structure built over highly compressible soil. Where the water table is high, mats are often placed over piles to control buoyancy

- **Deep Foundations**

Piles are structural members made of steel, concrete, and/or timber. They are used to build pile foundations, which are deep and more costly than shallow foundations. Despite the cost, the use of piles is often necessary to ensure structural safety. Drilled shaft are cast-in-place piles that generally have a diameter greater than 750 mm with or without steel reinforcement and with or

without an enlarged bottom. The first part of this section considered pile foundations, and the second part presents a detailed discussion on drilled shafts.

In general, the purpose of the site investigation was to provide the following:

1. Information to determine the type of foundation required (shallow or deep).
2. Information to allow the geotechnical consultant to make a recommendation on the allowable bearing capacity of the soil.
3. Sufficient data/ laboratory tests to make settlement and swelling predictions.
4. Location of the groundwater level.
5. Information so that the identification and solution of excavation problems can be made.
6. Information regarding permeability and compaction properties of the encountered materials.

Objective of the Project

The objective of the dissertation work is to estimate the cost of the different foundation for ex. Pad footing, Trapezoidal footing, Stepped footing. Optimum cost design of such foundation needs several calculations.

3 In the first stage, suitable plan is selected of G+5 building.
4 In the second stage, the axial load calculated with the help of staad pro.
5 In the third stage Pad footing, Trapezoidal footing, Stepped footing are designed for the max axial load, for different SBC from 100 kN/m^2 to 450 kN/m^2 at an interval of 25 kN/m^2.
6 In the fourth the cost of foundation will be estimated on the same building.

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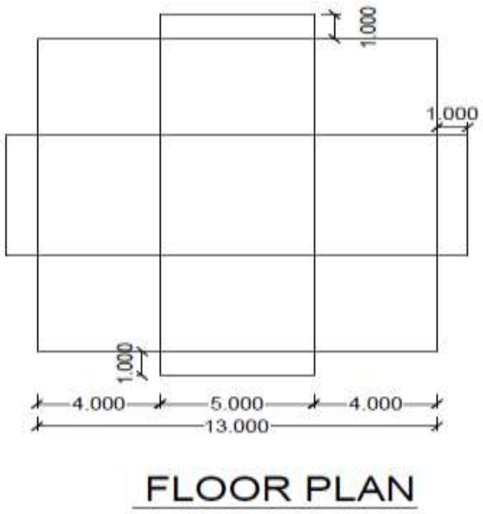

Fig 1. (Floor Plan Of A G+5 Building)

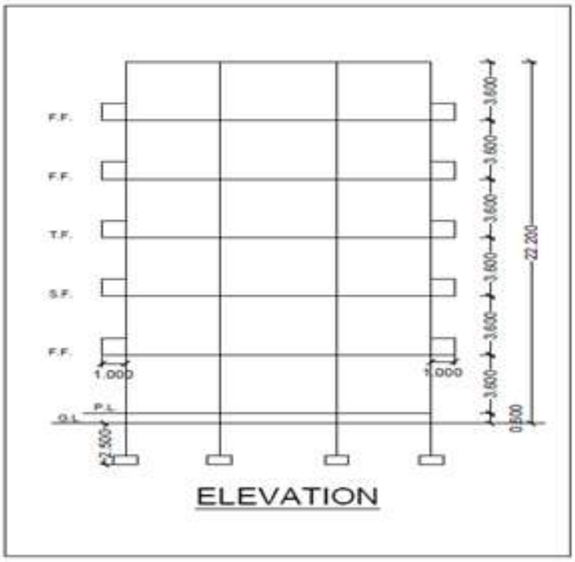

Fig 2. Elevations of A G+5 Building

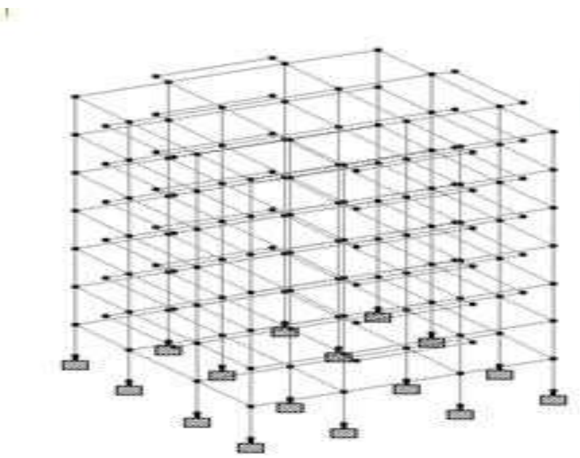

Fig 3. Model of G+5 building by using STAAD- PRO

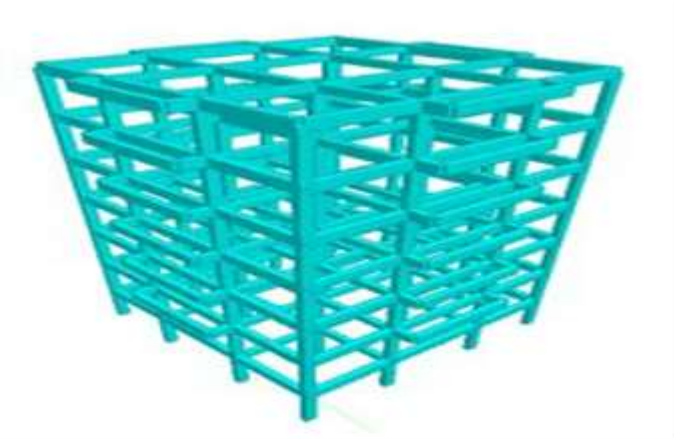

Fig 4. Rendering view of G+5 building

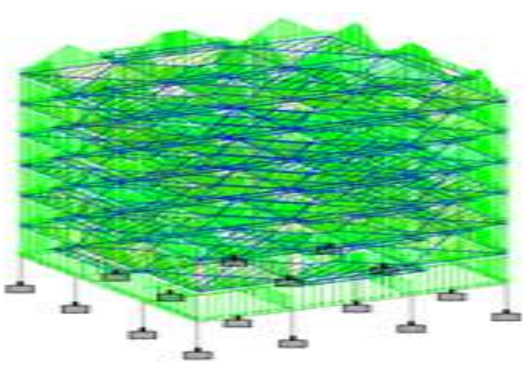

Fig 5. STAAD model showing dead load.

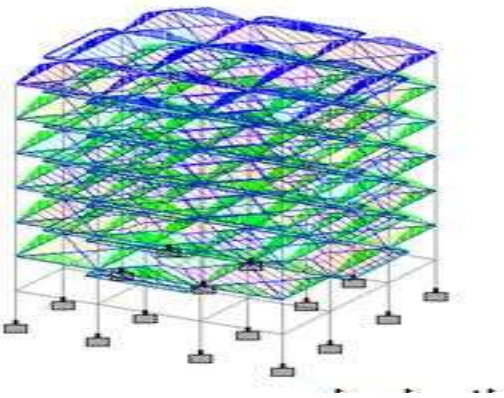

Fig 6. STAAD model showing Live load

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Sr.No	Column	y	Mx	Mz
	No	kN	kNm	kNm
1	1	1048.408	-4.448	-6.358
2	2	1693.060	-3.178	-3.191
3	3	1693.060	-3.178	3.191
4	4	1048.048	-4.448	6.358
5	5	1760.607	-1.957	-3.926
6	6	2021.947	-0.959	-1.280
7	7	2021.947	-0.959	1.280
8	8	1760.607	-1.957	3.926
9	9	1760.607	1.957	-3.926
10	10	2021.947	0.959	-1.280
11	11	2021.947	0.959	1.280
12	12	1760.607	1.957	3.926
13	13	1048.408	4.448	-6.358
14	14	1693.060	3.178	-3.191
15	15	1693.060	3.178	3.191
16	16	1048.408	4.448	6.358

Table 1. Reactions developed at foundation (G+5 Building) From above table Maximum axial force = 2021.947

SBC	EXCAVATION	PCC	REINFORCEMENT	CONCRETING	TOTAL COST
kN/m^2	**Rs**	**Rs**	**Rs**	**Rs**	**Rs**
100	15026	8505	21428	66410	112686
125	12336	6983	17336	53321	89975
150	10516	5952	14432	44576	75476
175	9235	5228	12364	38491	65318
200	8245	4667	10736	33835	57484
225	7430	4206	9592	30039	51267
250	6809	3854	8624	27170	46457
275	6287	3559	7876	24782	42504
300	5857	3315	7216	22827	39215
325	5509	3119	6600	21263	36490
350	5173	2928	6160	19756	34017
375	4911	2780	5764	18593	32048
400	4656	2636	5368	17468	30128
425	4439	2513	5016	16513	28481
450	4227	2393	4752	15588	26959

Table 2. Costing of Pad footing

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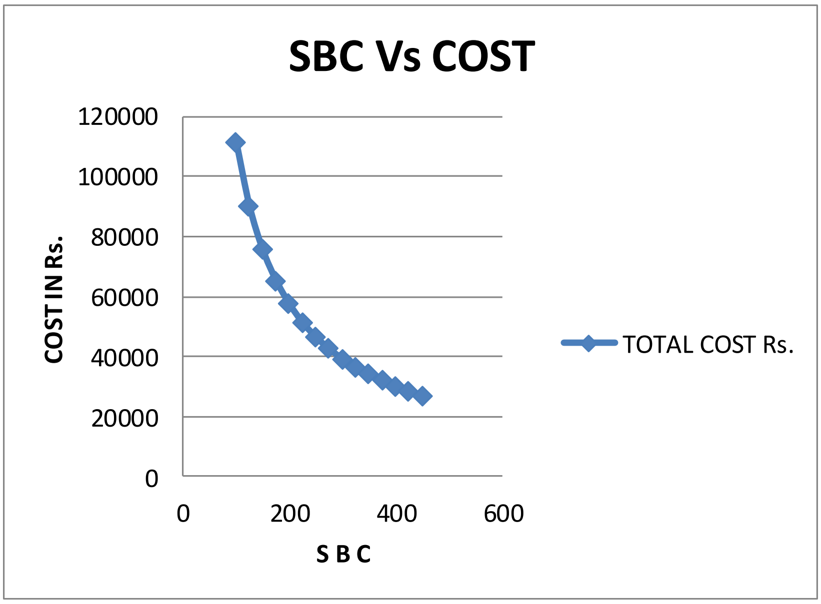

(Trapezoidal Footing)

RATE OF STEEL	44	PER KG
RATEOF CONCRETING	4500	PER M^3

SBC	EXCAVATION	PCC	REINFORCEMENT	CONCRETING SLOPED FOOTING	TOTAL COST
kN/m^2	**Rs.**	**Rs.**	**Rs.**	**Rs.**	**Rs.**
100	15026	8505	21428	43948	88906
125	12336	6983	17336	35389	72043
150	10516	5952	14432	29672	60572
175	9235	5228	12364	25693	52520
200	8245	4667	10736	22649	46297
225	7430	4206	9592	20166	41394
250	6809	3854	8624	18291	37577
275	6287	3559	7876	16730	34451
300	5857	3315	7216	15451	31839
325	5509	3119	6600	14428	29656
350	5173	2928	6160	13443	27704
375	4911	2780	5764	12683	26138
400	4656	2636	5368	11947	24607
425	4439	2513	5016	11323	23291
450	4227	2393	4752	10718	22089

Table 4.3 Costing of Trapezoidal footing

VI. CONCLUSION

The Quantity calculations and costing are estimated for a five storied having same axial load and different SBC for Pad footing, Trapezoidal footing and stepped footing and also changing the axial load from 600 kN/m2 to 2000 kN/m2, Based on the results obtained the following conclusions are made.

1. For rectangular footing cost of foundation is 1, 11,368.00Rs approximately for SBC 100 kN/m2 where as it is 89,906.00 Rs for sloped footing, 70,423.00 for stepped footing. This shows that when SBC of soil is low we should go for stepped footing as it proves to be economical.
2. As SBC of soil increases from 100 to 300 kN/m2 the total cost of footing designed by all three methods, decreases in Parabolic shape.
3. Where SBC of soil is between 300 to 400 kN/m2, it is observed that cost difference between sloped and stepped footing is getting reduced, also rectangular footing proves uneconomical in this range of SBC.

For SBC of soil 400 kN/m2 and above it is observed that footing design by either stepped or sloped footing gives nearly same costing. Which means above SBC 400 kN/m2, we can adopt any of the above footing? But for this SBC also rectangular footing is not recommended as it proves uneconomical.

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