Comparative Study on Different Types and Shapes of Footing and Effect of Load on Soil Using Staad Pro

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ABSTRACT

Seismic response is affected by soil-foundation-structure interaction. This proposed procedure reveals the effects of soil-foundation-structure interaction on the seismic response. Soil-foundation-structure interaction provisions of seismic design codes are optional and allow designers to reduce the design base capacity of buildings by considering soil-structure interaction (SSI) as a beneficial effect. The soil-structure system can be replaced with an equivalent fixed-base model with a longer period and usually a larger damping ratio. Spread foundation, mono pile, pile group with cap, and combined foundation are the four types of foundations were analyzed, with frequency-based design. Implicitly (subgrade reaction modulus) and explicitly both are used to model the soil. STAAD Pro program used with finite level model were the first validation using experimental data. Recommendations were given to simplify the soil-foundation structure interaction analysis of seismic loading. Different shaped footing for same loading condition are compared in this proposed work. Also, best suitable and stale type of footing which can transfer load is determined using soil bearing capacity and by using analysis tool Staad pro, cost analysis of all is determined to find the economical section.

Keyword: *Finite element; foundation; pile; seismic; soil bearing capacity; Staad pro*.

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1. INTRODUCTION

The lowest part of a structure which transfers its load to the soil underneath is foundation. It is the component of a structure which associates it to the ground and moves loads from the structure to the ground. These are commonly viewed as either shallow or profound. The strength of a structure for the most part relies upon the performance of foundation. Its plan ought to be done appropriately, thinking about its significance. With the assistance of bearing capacity a ultimate load of soil is recognized. Two parameter which is required for the structure of shallow establishment are Bearing capacity and settlement.

1.1 Types of Foundation

1.1.1 Spread footings and wall footings

A spread footing is a quite rigid element therefore, the applied soil stresses are almost linear and in case of a symmetric (with respect to the pedestal) footing, they are orthogonal.

1.1.2 Mat Foundations

Mat foundations are the types of foundation which are spread across the entire area of the building to support heavy structural loads from columns and walls.

1.1.3 Pile Foundations

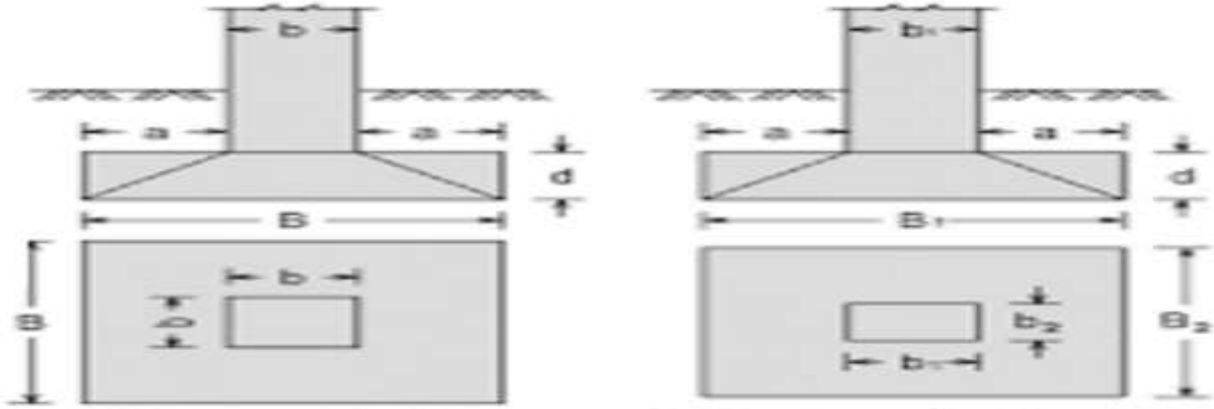
Pile foundation is a type of deep foundation which is used to transfer heavy loads from the structure to a hard rock stratum much deep below the ground level.

1.1.4 Drilled Shafts

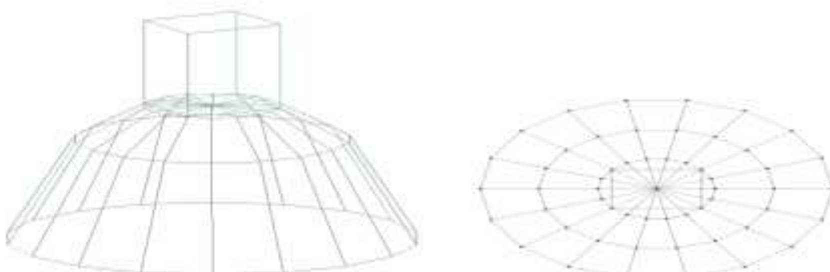
Drilled shafts, also referred to as drilled piers, caissons or bored piles, are deep foundation solutions used to support structures with large axial and lateral loads by excavating cylindrical shafts into the ground and filling them with concrete. Auger is used to construct drilled shaft.

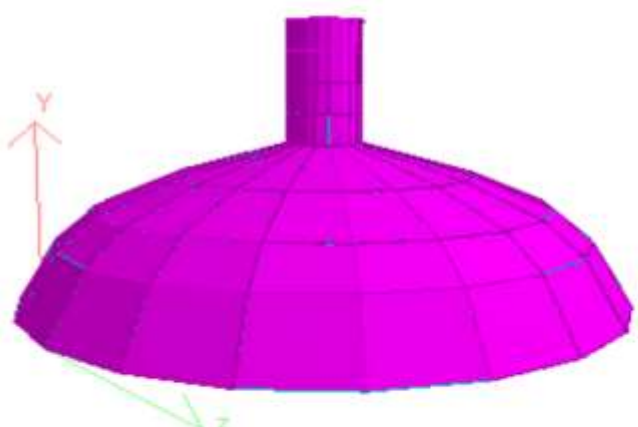
1.2 Bearing capacity of Soil

The safe bearing capacity qc of soil is the permissible soil pressure considering safety factors in the range of 2 to 6 depending on the type of soil, approximations and assumptions and uncertainties. This is applicable under service load condition and, therefore, the partial safety factors λ f for different load combinations are to be taken from those under limit state of serviceability (vide Table 18 of IS 456 or Table 2.1 of Lesson 3). Normally, the acceptable value of qc is supplied by the geotechnical consultant to the structural engineer after proper soil investigations. The safe bearing stress on soil is also related to corresponding permissible displacement / settlement.



(a) Square Footing (b) Rectangnlar Footing





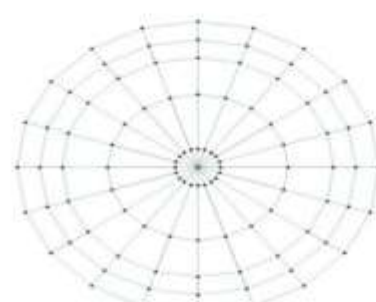


Fig 1 Different shape of footing

This research work has been carried out to study the effect of different types of footing geometries for same building with same loading conditions in unsymmetrical shape (irregular) building considering dynamic analysis using response spectrum method as per 1893-I 2016, modelling of RCC frame building and different footing is analysed using STAAD. Pro and STAAD foundation software.

2. METHODOLOGY

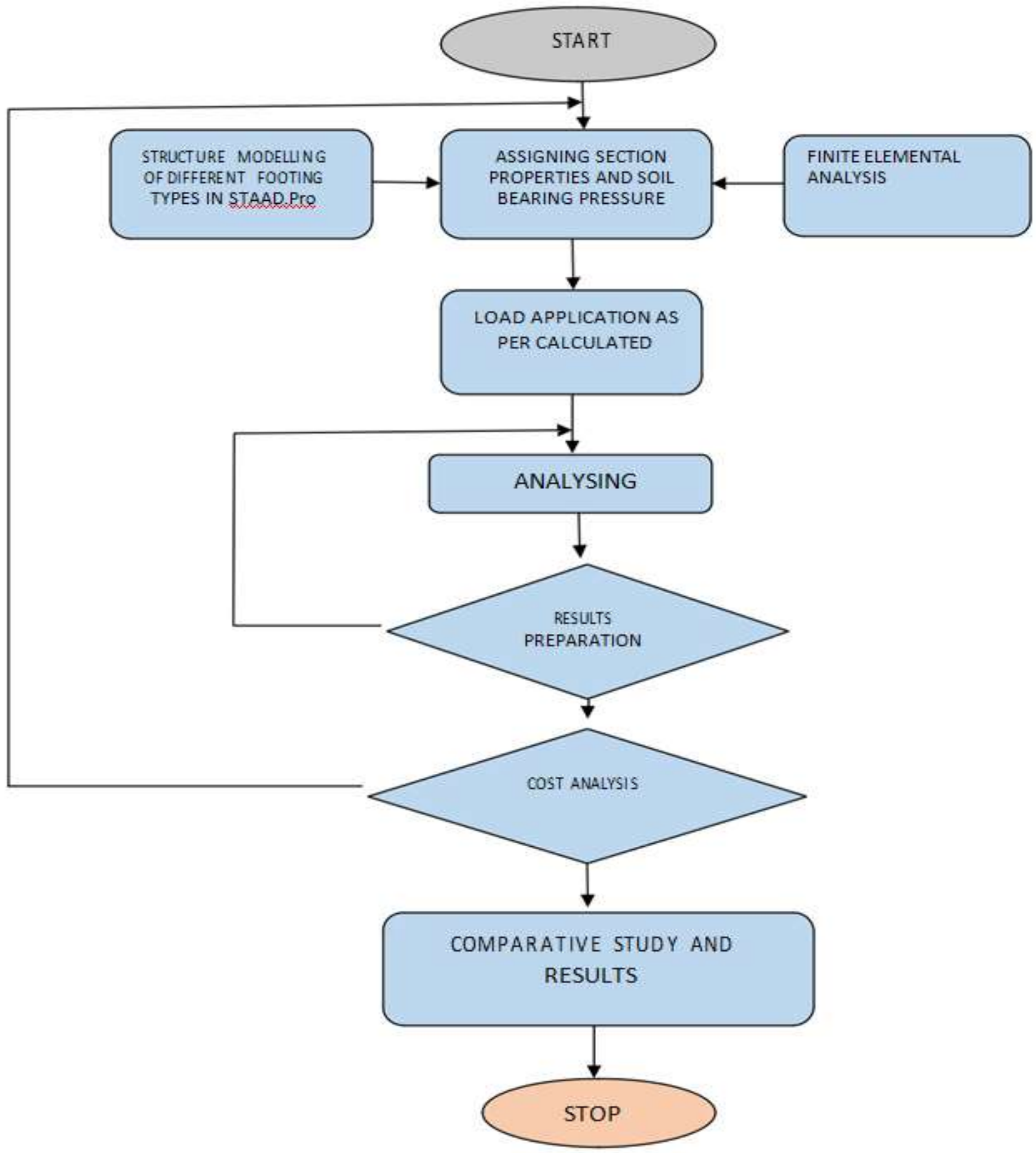


Fig 2 Flow chart showing process of analysis and design of structure

Table 1 Material Specification

S. No.	Material Specification	
1.	Grade of Concrete, M-25	fck = 25 N/mm^2
2.	Grade of Steel, Fe-415	fy = 415 N/mm^2
3.	Density of Concrete	ϒ'c = 25 KN/m^3
4.	Density of Brick wall considered	ϒ'brick = 18 KN/m^3
5.	Live Load	4KN/m^2
6.	Wall Load	12KN/m^2

2.1 Loading conditions

Self weight: It comprises of weight of beams, columns and slabs in the structure.

Dead Load: It is calculated as per IS-875 (Part I): 1987

Masonry wall Load on beams

Wall Load = (Unit weight of brick masonry X Wall thickness X Wall Height)

= 20KN/m^3 X 0.230m X (3-0.45) m

= 11.75KN/m

(Unit weight of concrete X thickness of shear wall X Wall Height)

= 25KN/m^3 X 0.2m X 3m

= 15KN/m

b) Self weight of slab

Floor load = (Density of concrete X Slab thickness)

= 25KN/m^3 X 0.15m

= 3.75KN/ m^2

Floor finishing = 1.25KN/ m^2

Total Weight of slab = 3.75KN/ m^2 + 1.25KN/ m^2

= 5KN/ m^2

Live Load: It is calculated as per IS-875 (Part II): 1987 Live load on floors = 4KN/ m^2

Earthquake Load: It is calculated as per IS-1893 (Part I): 2002

Seismic Definition

Earthquake zone – II (Z=0.1)

Response reduction factor – 5

Importance Factor – 1.5

Damping - .05%

Soil Type: Medium

Natural Time Period (Ta) - $0.075h^{0.75}$ (Ta = 2.145 sec)

h = Height of building, in m. This excludes the basement storeys, where basement walls are connected with the ground floor deck or fitted between the building columns. But it includes the basement storeys, when they are not so connected.

Seismic weight of floor = (Total Applied Dead load + 50% of Imposed load)

=5KN/ m^2 + 2KN/ m^2

=7KN/ m^2

thus, Design seismic base shear Vb = Ah x weight of structure

Vb = 0.345 x 1987 KN

- Response Spectrum Analysis is performed in order to compare seismic response of RCC structure in different footing shapes.
- The main difference between the equivalent static analysis and dynamic analysis lies in the magnitude and distribution of lateral forces over the height of the building.
- In the equivalent lateral force procedure, the magnitude of forces is based on an estimation of the fundamental period and on distribution of forces, as given by simple formula in IS 1893- 2016.
- In the dynamic analysis procedure, the lateral forces are based on the properties of the natural vibration modes of the building, which are determined by the distribution of mass and stiffness over height.
- The maximum sagging and hogging bending moment, shear force, axial force of each footing type is calculated and tabulated below.

3 RESULT AND DISCUSSION

Table 2 Max. Shear force (kN)

Maximum Shear force kN			
Combined	Pad	Oval	Circular
228.13	234.56	230.87	229.45

Table 3 Maximum Axial force (kN)

Maximum Axial force (kN)			
Combined	Pad	Oval	Circular
1032	1123	1040	1036

Fig 3 Graph showing maximum shear force with different foundation

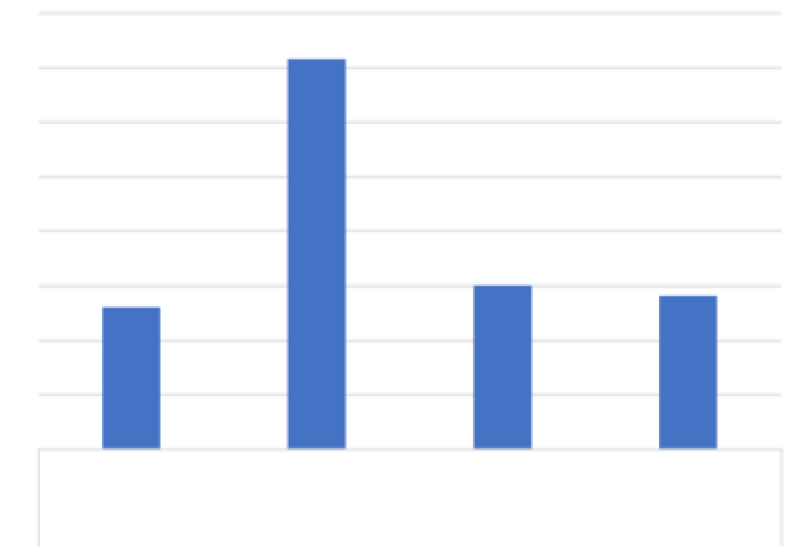


Fig 4 Graph showing maximum Axial force with different foundation

Table 4 Support reaction Y-direction

Support reaction Y-direction			
Combined	Pad	Oval	Circular
10.512	12.45	10.52	11.2

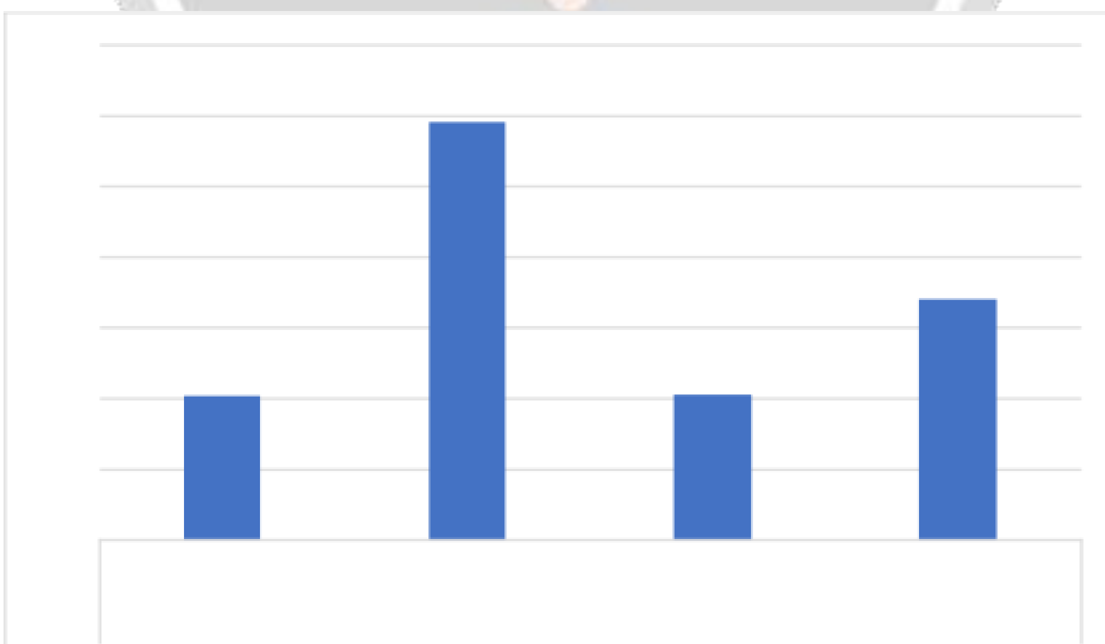


Fig 5 Graph showing Support reaction Y-direction for different foundation

Table 5 Maximum deflection mm

Maximum deflection mm			
Combined	Pad	Oval	Circular
228.13	234.56	230.87	229.45

Fig 6 Graph showing Maximum deflection in mm with different foundation

Table 6 Cost analysis

Sl.N	**Footing**	**Reinforcement (Kg)**	**Rate of Reinforcement (Kg) as per S.O.R.**	**Cost of Reinforcement in INR (Rupees)**	**Remark**
1	**Oval Footing**	**7953.65**	**160 / Kg**	**12,72,584.00**	**Here Result shows that for same loading condition and soil bearing capacity variation in load distribution occurs due to shape of footing**
2	Circular **Footing**	**8021.672**	**160 / Kg**	**12,83,467.52**	
3	Combined **Footing**	**7651.23**	**160 / Kg**	**12,24,196.80**	

4	Pad **Footing**	**7867.43**	**160 / Kg**	**12,58,788.80**	

It is concluded that Combined footing results in economical type of footing for same conditions whereas Circular is costlier in comparison.

CONCLUSION

- Combined footing shows 23% less unbalanced forces comparing to Pad shape footing case which makes rectangular footing.
- It is clearly mentioned in the above chapter that Pad shape footing distributes maximum Axial force comparatively to other conditions whereas Combined footing shows minimum.
- It can be clearly visible that best support reaction is generated in Combined footing comparatively to others. As support reaction shows its intensity to distribute load to the soil hence for this distribution Combined footing is considered best and suitable.
- The value of deflection is observed maximum in Pad whereas in oval shape condition it results in minimum. Thus, it can be said that deflection will occur minimum in this condition and second best will be oval one. In oval shape footing deflection is comparatively 13% low.
- As quantity estimation is done and rate is analyzed as per S.O.R it is concluded that Combined footing results in economical type of footing for same conditions whereas circular is costlier and in comparison, difficult to build.

FUTURE SCOPE

- In this study dynamic seismic analysis is considered, in future wind and temperature effect can be consider.
- In future matt footing and pile can be consider for study.
- In future different soil conditions can be considered.

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