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ANALYSIS AND DESIGN OF MAT FOUNDATION USING SAFE

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Abstract-The use of Mat Foundation has become more popular in recent years, as the mostly suitable and economical for high raised structures and for low bearing soils. In mat foundation the loads coming from the superstructure is uniformly distributed to the soil. The mat foundation proves more effective on such low bearing soils. It carries the heavy vertical loads and are used to bring the settlement, uneven settlement and overturning of the structure with in the permissible limits. This study is carried out for analysis and design of mat foundation of uniform thickness without considering the beam or pedestals for G+5 framed Residential Structure and low bearing capacity of soil. The main objective of this project is based on behaviour of mat foundation due to loads transferred on column and uplift soil pressure and further designed for Static and Dynamic load paten. In study two software programs are used for the Analysis and Design are SAP-2000 and SAFE-2014.

Keywords - Mat Foundation, Static Load, Dynamic Load, Soil Pressure, and Moment.

I. Introduction

From the resent past few decades there have been rapid urbanization and lack of space for horizontal expansion of the structures the cities have been growing vertically. That is high raised buildings are increasing rapidly. For such high rise buildings and also when available soil in site is of low bearing capacity normally mat/ raft foundation, pile foundations are used. The analysis and design of the structures is one of the most difficult technical features of civil engineering practices, as it deals with working out the structural and geotechnical analysis. There for generally simplified approach of conventional design is adopted in most of the cases.

A mat foundation is a monolithic footing which covers the total floor area under of a structure and supports loads from all the walls and columns. Raft or mat foundation generally consists of thick reinforced concrete structure over the entire area at the bottom of the structure like a slab. The slab is reinforced with bars running at right angles to each with one layer at the top and other at the bottom in the form of mesh. Sometimes it is provided with inverted beams on both sides of mat called as main beams and secondary beams cast monolithically with mat footing.

The foundation is the most important element in the structure which carries out any type of superstructure and transmits the loads including its self-weight to the underlying soil strata. Foundation does the work of spreading the load from the superstructure to the soil so that the load or pressure transmitted to the underlying soil without causing excessive shear in the ground to fail or settlement that leads to the distortion and failure of the structure. This report will deal with the Analysis of Mat Foundation for the G+5 residential building of 27x24m^2 (analysed using SAP2000 for the Static load and Dynamic load on the building and to get the loads coming from each column on to the foundation.) and designed for Response Spectrum method of IS 1893-2000 using SAFE2014 software. This report shows the moments, soil pressure and deformed shapes of the Mat foundation when subjected to Static load to that of Dynamic load. It also shows ductile detailing of mat foundation in both the load cases.

II. Literature Review

The analysis and design of mat foundation hat captured the attention of engineers and researchers for a long time. This is because mat foundations are mostly incorporated with heavy and multi-storeyed structures founded on different soils. Mat foundation is one type shallow foundation and mostly used all over the world. This study is focused on design of mat foundation for low grade soil and some of reviews on mat foundation are as fallows.

Ball Et Al

He analysed a raft foundation founded on the Winkler medium using FEM with the help of a computer program. He made the some assumptions such as: (i) the raft acts as isotropic homogeneous elastic solid, (ii) the soil reaction as vertical vectors and are directly proportional to the displacement of the node points and (iii) the soil reaction is equal to the spring constant at a node point multiplied by the displacement of that node. He concluded the response of the superstructure in the analysis of the mat foundation and calculated the settlement and the interaction pressure below the mat foundation.

Witt

He has conceded a square plate founded on a soil having its properties same in a particular direction at any

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point and analysed then he compared it with a non-homogeneous soil by using FEM. The uncertainty of the foundation caused by the vertical loads has been considered when forming the equations of equilibrium and for different thickness of the foundation by nearly resembling it by Heirs functions. The results obtained for the different type of soil condition were compared with those obtained for the homogenous condition. And it was noticed that the displacement of the foundation and the square plate considered were differing under extreme condition up to 10% with the discrepancy of the bending moment up to 60%.

Srinivasaraghavan

He carried out his studies to the interaction among superstructure, foundation and the soil in contact and introduced the term „relative rigidity index" (RRI) such that the combined response of the rigidity of the superstructure, foundation and the subgrade can be known. He analyzed two by two bays on mat foundation and 2 bay 4 bay structures on mat foundation and a structure on isolated footings

Smith

In 1991 in his paper explained about dynamic analysis based on considerable amount of research conducted on the structural behaviour of the structure subjected to base movements. These methods generally determine the shear action due to an earthquake as equivalent static base shear. It depends on the weight of the structure, the dynamic characteristic of the building as expressed in the form of natural period or natural frequency, the seismic risk zone, the type of structure, and the geology of the site and importance of the building.

Chopra

In 1995 in his paper wrote about the Dynamic Time History analysis, which can be classified as either elastic or inelastic. The linear elastic modelling and analysis of Steel and Reinforced Concrete structure is a well-established technique. Several commercial packages for the 3D elastic analysis of structures are available and are in widespread use (e.g. SAP2000, SAFE, ETABS etc.)

III. Methodology

Methodology is a procedure to analysis and design the structure under differ types of loads, different types of boundary conditions, various types of material properties.The result thus obtained by analysis is checked to their respective limitations. The analysis may be carried Linear Response, Non-linear behaviour. Generally three methods are used for the analysis, Strength of Material method, Elastic Theory method and Finite Element Method.In the present study Finite Element Method is used for analysis. Finite Element Method is a numerical technique for finding at most accurate solutions. However the Finite Element Method depends mostly on the programming power of computers and is mostly applicable for complex structures.

This study consist of mainly two parts, first part includes the Analysis of Assumed G+5 structure having an area of 27x24 m^2 and parameters by using Flexible Method by employing commercial Finite Element Method based on structural analysis program SAP-2000. The second part consists of design of mat foundation for column load and lateral load using SAFE.

IV. Analysis and Design

Analysis of G+5 Residential Building

In this part the structure in analysed for assumed area and parameters of the G+5 Model and the geometrical parameters and loads and the model has been run and analysed using the Sap2000.The resultants are Mode shapes, Axial, Shear Forces. The span of first and second bay X-Direction is 9m; third and fourth spans are of 4.5m. In Y-Direction each bay is of 8m. The height of each story is 3m.

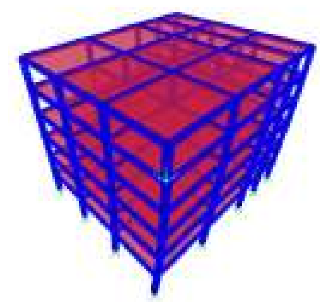


Figure-4.4.1 Analyzed Model

Design of Mat Foundation

The mat foundation is modelled in SAFE software for the loads analysed. All analysis and design are based on the IS 456-2000 for the following parameters and some of the views are shown below.

Table5.2.1 Material Properties of Mat

Parameters	Values
Mat Thickness	600 mm
Grade of Concrete	M_{25}
Grade of Steel	Fe415
Bearing Capacity of Soil	100 KN/m^2

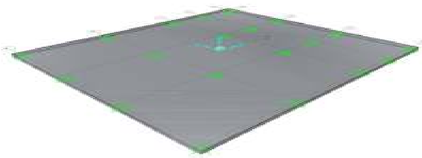


Figure-5.2.3 Mat Foundation

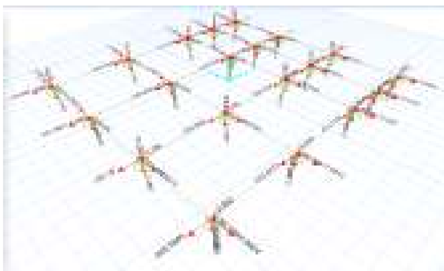


Figure-5.2 Axial Load reactions

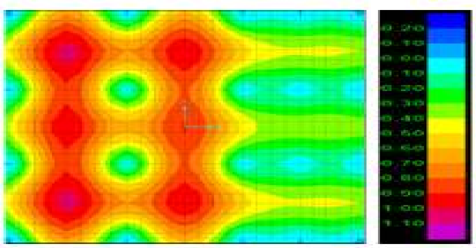


Figure5.2.4 Displaced shape due to dead load

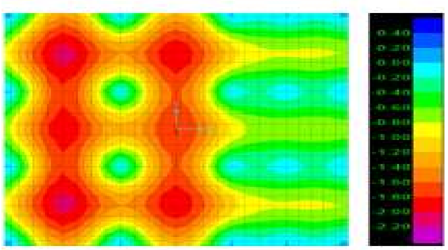
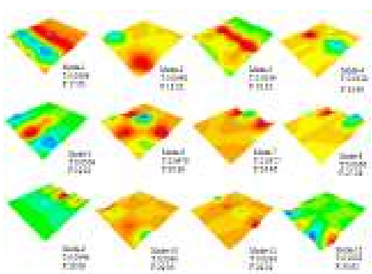


Figure-5.2.5 Deformed shape due to Soil Pressure

Mode Shapes Of Mat Foundation



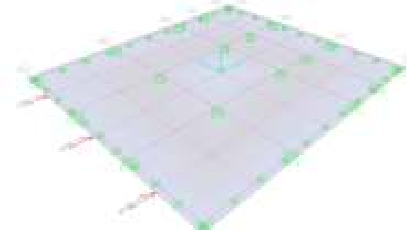


Figure-5.3.1 Mat with Lateral Load

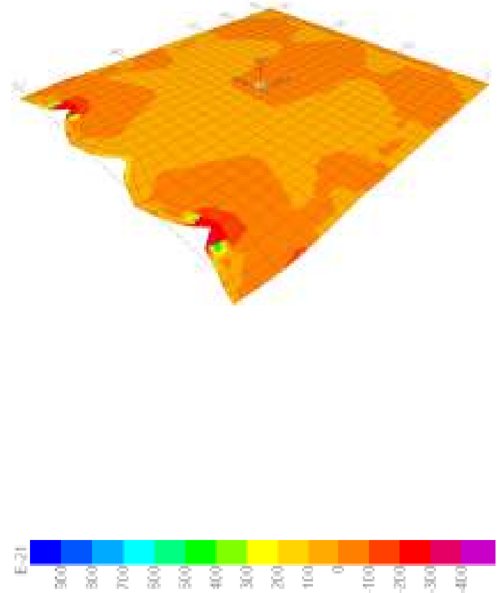


Figure5.3.2 Displacement (mm) Due to Lateral Load

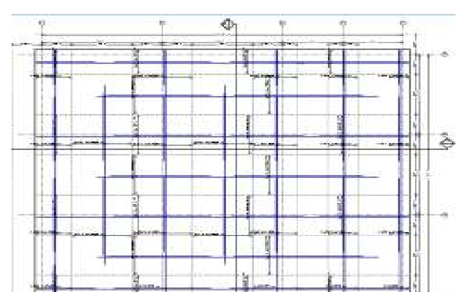


Figure-5.4.1 Rebar details of mat foundation

V. Results and Discussion

The mat foundation is analysis and designed for G+5 Residential building resting on soil having bearing capacity of soil as 100 KN/ m^2 using SAFE software. When the mat foundation is subjected to axial and lateral loads, soil pressure is excreted on the mat at the interaction of soil and mat in upward direction. There for causing the displacement in the mat. The resultant displacements are as follows.

Displacement (mm)	Due to Dead Load	Due To Live Load
Corner Panel	-0.993	-3.37×10^{-20}
Edge Panel	-0.933	-4.52×10^{-20}
Middle Panel	-0.792	0.00

The resultant displacements due lateral loads as compared to axial loads is negligible i.e.. -4.52×10^{-20} mm

The mat has been designed as per IS 456-2000 using SAFE software and the ductile detailing along section-A and B is as shown below.

Load Case	Rebar Details At Sec-A	Rebar Details At Sec-B
Static Load	16 dia- 22, 16 dia- 23	16 dai- 07, 16 dia- 22
Dynamic Load	12 dia- 23, 12 dia- 24	10 dai- 43, 10 dai- 44

The area of steel required for Dynamic loading is 37.6% more than the area of steel required for Static loading of the mat foundation.

VI. Conclusion

In concurrence with the objectives of the project the analysis and design of mat foundation for the G+5 Residential building is presented. It can be concluded that there is a difference between mat foundation designed for Static loads and Dynamic loads (by non-linear analysis). The mat foundation has been modelled and analysed to the loads and considering the effect of lateral load by using SAFE software and the results obtained are within the limits and safe.

It is observed that the displacement in the mat foundation for the applied lateral load is very small. And the area of steel required for Dynamic load is 37.6% more than the steel required for Static loading.

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