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A Review of comparative study of unsymmetric structure under different seismic zone supported on Conventional Strip and Strip with Projection

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***Abstract** This review paper examines the soil structure interaction (SSI) caused by dynamic and eccentric loads on several foundation types, including conventional raft, piled raft, angle-shaped, and Tee-shaped footings. The development of skyscrapers and asymmetrical structures over the past few decades has necessitated the creation of an affordable and more durable base. According to recent studies, SSI impacts could negatively affect a structure's seismic response, and SSI neglect could result in an unconservative design. This general review study discusses the designing, load distribution, numerical analysis, angle form, Tee-shape footings, seismic analysis of asymmetrical structures, and effects on foundation bearing capacity and peak structural responses.*

***Key Words:** Eccentric loading, Peak storey response, Seismic design, Soil-structure interaction, Unsymmetrical structure.*

I. INTRODUCTION

Every engineered structure resting on the ground needs to be supported by a foundation, which is a type of interacting component. Numerous foundation types have been developed to civil engineering over the last few decades. Typically, there are two subcategories of foundation: shallow foundation and deep foundation.

To combat eccentric and dynamic loading brought on by earthquake and wind forces in asymmetrical structures, numerous nontraditional foundations have recently been established in geotechnical engineering. Therefore, seismic analyses are carried out to determine how unsymmetrical buildings would respond to earthquakes. Because earthquakes are uncontrollable natural disasters that cannot be avoided, ignoring their consequences in Soil Structure Interaction may result in unconservative design. In this study, a number of contemporary footings that are regularly used have been covered.

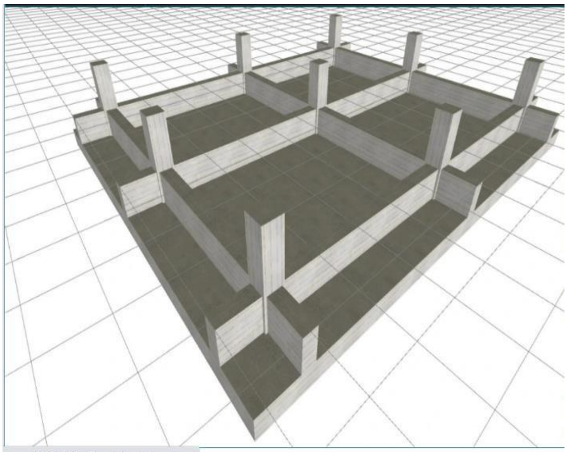
1.1 Tee Shape Footing

Tee-shaped footings are made up of two parts: a horizontal leg that is the footing itself, and a vertical leg that protrudes from the center and is inserted into the soil. It provides significant resistance to tilting, differential settlement, and footing sliding. A tee-shaped footing is used to improve the load-bearing capacity of a foundation against eccentric and lateral loading caused by seismic and wind forces. However, in the case of a conventional foundation, in addition to vertical settlement, eccentrically loaded footings may be affected by both horizontal displacement (sliding) and/or rotation (overturning), which can reduce the ultimate bearing capacity and increase settlement. However, in the case of a tee- shaped footing, the vertical insertion of the proposed rigid t-shaped footing into the soil provides significantresistance against both sliding and slipping[1].

1.2Raft Foundation

A raft foundation is a substructure that supports a rowof columns or walls while transmitting loads to the soil via a continuous slab with or without depressions or openings. These foundations are useful in areas where the soil has a low bearing capacity.

A raft foundation is usually provided when building loads are so heavy or the allowable pressure on soil isso low that individual footings would cover more than the floor area. When the soil contains compressive lenses or is sufficiently erratic, it is difficult to define and assess the extent of each of the weak pockets or cavities and, thus, estimate the overall and differentialsettlement.



2. LITERATURE REVIEW

H.K. Mahiyar, (2000) Footing is frequently subjected to eccentric loading as a result of lateral seismic and wind forces, resulting in footing tilting and pressure below the footing not remaining uniform. This study uses the idea of lateral confinement of soil by introducing angle shape footing to eliminate it. The horizontal leg of an angle shape footing is the footing itself, while the vertical leg is the projection. A square plate of mild steel is used to create an angle shape footing, with both plates at a right angle. Load is applied at the nearer end of vertical projection at various eccentricities and depths of projection, but the problem at hand is quite complex and cannot be solved manually. As a result, the analysis is performed using ANSYS software, and the nonlinear behavior of soil is incorporated using the Drucker and Pragar model. It was concluded that by giving the footing an angle shape, a footing subjected to uniaxial eccentric loads can be designed for negligible tilt [1].

J. Hamada (2014) describes the seismic performance of a piled raft foundation subjected to asymmetrical earth pressure based on seismic observation records. A seven-story, three-basement residential building supported on a raft foundation can be seen in Tokyo, Japan. 140 kPa is the unconfined compressive strength of the earth beneath the foundation. A few LVDT-type strain gauges were used to measure the piles' axial forces and bending moments. Triaxial servo accelerometers were used to record the acceleration of the building's third basement floor. The sampling rate is set to 100 Hz, with a triggering acceleration of 0.004 m/s2. At the end of construction, the piles' load as a percentage of the whole load was 40%; five years later,it was 47% [2].

P. D. Pawarl and P. B. Murnal (2008) present the effect of seismic pounding on adjacent blocks of unsymmetrical buildings while taking soil-structure interaction into account. For this purpose, the G+7 L shape configuration model is used, with a seismic gap of 160 mm between two building blocks as per IS 4326:1993. The bay direction plan is 4 by 4, and the storey height is 3 meters. To study the pounding effect of earthquakes, two time-history records, Northridge and Loma Prieta, were used. SSI has both beneficial and detrimental effects on building response. The response of buildings to earthquake pounding is amplified in terms of base shear, accelerations, and impact force. According to this study, taking soil-structure interaction into account lengthens the time a structure is in place, increases displacement, and decreases base shear, kinetic energy, and impact forces. Neglecting SSI may lead to an inaccurate conclusion regarding the potential for pounding because SSE may occasionally be responsible for pounding because of an increase in displacement [3].

Shehata E. Abdel Raheem Mohamed M. Ahmed Tarek M. A. Alazrak (2015) Structures' susceptibility to earthquake damage is heavily influenced by the soil. Soil-structure interaction studies are urgently needed for safe structure design as the effects of soil flexibilityare typically ignored in the seismic design of buildings by assuming the foundation of the building to be a fixed base, neglecting SSI, which results in severe damage to buildings during earthquakes. The study ofthe mechanism of energy transfer from soils to buildings during earthquakes is crucial for the seismic planning of multi-story buildings and In this study, a 6- and 12-story MRF building on a raft foundation with various soil conditions—a fixed rigid base and stiff, medium, and soft conditions—is taken into consideration. Here, three analytical techniques— equivalent static load, response spectrum analysis, and time history analysis—are employed. The peak storeyresponse of the building, which includes storey drift, storey shear, lateral displacement, and base shear, is assessed under various soil conditions, including stiff, medium, and soft soils, and the results are contrasted with regard to a fixed base system foundation. It may be inferred from this research that time increases with decreasing soil stiffness and that peak storey response,storey shear, base shear, story drift ratio, and lateral displacement also increase with decreasing soil stiffness [4].

Pancham Kumar (2015) reported that the study of foundations under dynamic loading is carried out to assess the behaviors of angle-shaped footing under variable experimental parameters. Extensive experimental studies on angle-shaped footings revealed that they displace less in the directions parallel and perpendicular to the direction of shaking but tilt more than normal footings [5].

Nitin Nandwani (2015) presents a study that includes a parametric study of piled raft foundations, with the variables being raft thickness, pile diameter, number of piles, pile length, and pile spacing. The software packages Etabs and Safe are used for finite element analysis. The combined action of the raft and piles can increase soil bearing capacity, reduce settlement, and the piles can be arranged to reduce differential deflection in the raft. This study is useful in determining the various parameters required in the design of a combined pile-raft foundation and recommending the best combination of pile-raft foundations [6].

Effect of Pile Diameter = As pile diameter increases, settlement decreases.

Effect Of Pile Spacing = As spacing increases, Settlement increases [6].

Sunil Kumawat (2015) presents an experimental study on tee-shaped footings subjected to eccentric vertical loading caused by earthquake and wind forces. Mahiyar and Patel [12] proposed the angle-shaped footing with the idea of lateral confinement of soil in which the tilt due to eccentric load was reduced to zero by providing a vertical downward projection nearer to the eccentric loading end of the footing, which remains embedded in soil. Because an angle-shaped footing is asymmetrical, this concept is extended to a tee-shaped footing. In this study, experimental studies on tee-shaped footing are carried out in the S.G.S.I.T.S. laboratory. The parameters studied were the dimensions of the tee-shaped footing (250*250, 200*200, and 150*150), the load eccentricity e/B 0,0.1,0.2,0.3, and the footing projection D/B 0.2,0.4,0.6. For the experimental setup, a workshop employee fabricates a steel tank with dimensions of 1.2m by 1.2 m and 1.2 m in height. Sand is then put withinthe tank using the rainfall technique, and four dial gauges are mounted at each corner of the footing to monitor settlement and load. General shear failure wasthe type of failure that was seen, and a graph is shownbetween the maximum load intensity and the D/B ratiofor eccentricities of 0, 0.1, and 0.2 when the load is applied both parallel to and along the depth of the projection [7].

Jayrajan Puttatt. (2015) reports that Combined Pile Raft Foundation (CPRF) increases bearing capacity, total settlement, and differential settlement by addinga small number of well-placed piles under the raft. This study evaluates the combined pile-raft foundation by examining interactions between piles, soil, and piles. The design engineer continues to use STAAD.pro and Etabs SAP2000, two pieces of structure-assisted software that do not take into account the interaction between piles, soil, and rafts and produce inaccurate findings for differential settlement, raft bending, and pile loads. The software packages PLAXIS-3D and FLAC-3D, which use finite elements and take interactions between pile, raft, and foundation elements into account, are used for extensive analysis. Using the Poulos Davis-Randolph (PDR) approach, a load of 28800 KN is applied to the CPRF in order to arrive at various pile counts and a satisfactory arrangement of those piles. CPRF is thoroughly examined using the finite element geotechnical software PLAXIS-3D, and the outcomes of the two analyses are contrasted. Four CPRF configurations— 16 piles, 12 piles, 8 piles, and 4 piles with rafts—at various pile spacings and positions are taken into consideration when using the PDR approach for a streamlined analysis. The comparison of simplifiedand detailed analysis results is plotted in graphs showing load and settlement, settlement and number ofpiles, and percentage load on piles and settlement. It can also be concluded that the number of piles reducessettlement and increases load bearing capacity, up to apoint where very little additional benefit for settlementand bearing capacity for a piled raft is obtained [8].

Pratik Agrawal (2019) uses a ready-made software package to perform a finite element analysis of a tee-shaped footing with varying projection depth and e/B eccentricity. ANSYS. Tee-shaped footing is an extension of angle-shaped footing; in angle-shaped footing, the projection was at one side of the footing to counteract eccentric loading, whereas in tee-shaped footing, the projection was given at the center position. It is a parametric study that aims to evaluate the effects of eccentricity, inclination of load, and eccentric-inclined load on the performance of a tee-shaped footing with a projection of depth D under the soil to reduce tilt and lateral movement of the footing. Ex/B is maintained at = 0.00, 0.05, 0.1, and 0.15, while the depth of the vertical projection of the footing is adjusted as D/B = 0, 0.25, 0.5, 0.75, and 1. The range of the vertical footing projection from the center, C/B, is 0.05 to 0.4. When the location of the footing projection C = 325, or when C/B = 0.325, the value of tilt becomes zero for an eccentricity width ratio (Ex/B) = 0.15 and a D/B ratio of 1 [9].

Felipe Vicencio and Nicholas A. Alexander (2019) In this study, the effect of coupled torsional and rocking seismic motion between two buildings—one with an asymmetrical plan and the other with a symmetrical plan—is examined. SSSI is a phenomenon that results in the seismic coupling of nearby buildings via the subsurface soil. Using finite element analysis using MIDAS, a reduced-order parametric 2D model of this system is suggested. 15 strong ground motion records are used as a database. According to the study's findings, SSSI has a considerable impact on the displacement andacceleration behavior of asymmetric planar structures.An amplified impact of the building's twisting buildingresponses for a larger set of factors where SSSI effectsare important. Additionally, SSSI can have a negative impact in specific parametric scenarios when a higher building with uneven torsion is near a smaller building[10].

Yogesh Ramesh Vanshe and Nagendra M. V. (2020) present the seismic design of unsymmetrical structures and their comparison with symmetric structures. Structures can be classified as irregular if they have irregular distributions of mass stiffness and strength or because of irregular geometrical configurations. The unsymmetrical structure plans considered are E, L, T, Y, and R (rectangular plan) in seismic zone 3, medium soil conditions, and an area of 652 sq. The analysis is performed in STAAD.pro software, and the results are evaluated and compared to a symmetric rectangular shape. The behaviour of any building structure is determined by the arrangement of structural elements within it. Response spectrum analysis is used to compare fundamental parameters such as shape factor, modal analysis, modal analysis, deflection, and storey drift[11].

3. CONCLUSION

Based on the available literature on different types of foundation, soil-structure interaction, and seismic study of unsymmetrical structures, considerable research has been done individually either experimentally or by using finite element geotechnical software. Footing with vertical projection is provided to counteract eccentric loads on column nearby property line, in which vertical leg protrudes from the horizontal leg is inserted in soil. This increases the soilbearing capacity by 25% and skin friction of foundation.

Combined Piled raft foundation significantly increases the load carrying capacity in soft soil condition. If conventional raft foundation were used, then excessive settlement is observed and if only conventional pile foundation is used the piles will carry excessive load. Therefore, combined piled foundation give satisfactorily results in settlement and load bearing capacity. The lateral inertial force of building was closely related to shear force and bending moment of the piles as well as frictional resistance beneath the raft

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