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# BEHAVIOR OF RCC STRUCTURE SUBJECTED TO SEISMIC FORCES WITH DIFFERENT SUBSTRUCTURES

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**Abstract:** *Foundation is the first element of any structure that encounters seismic forces. The various types of seismic waves, reaches and affects the foundations first and then the superstructure. Instead, this is the underprivileged component of the structure, when it comes to seismic forces consideration, compared with super structure. Different types of foundations respond differently to seismic forces. The type of soil, its characteristics, and bearing capacity, affects the design and capacity of foundations severely. Average response acceleration coefficient, as specified in IS 1893-2002 (Part 1), which takes into account the type of soil, also plays a vital role in determining the seismic forces on structure. Therefore, in this research work, RCC structure will be analyzed for the seismic behavior for different types of foundations. Various types of foundations like isolated footings, raft foundations, combined footings, pile foundations, etc. will be analyzed. Seismic analysis will be done in STAAD Pro to compare values of nodal displacement, drift, story and base shear, moment development and fundamental time period. Comments will be made considering safety, stability and economical aspects of the structure.*

**Keywords:** *Semisolid, Infant's, Steeping, Kilning, Malt, Alpha-Amylase, Yield.*

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**INTRODUCTION**

As waves from an earthquake by the substructure for they are the link between structure and reach a structure, they produce motions in the structure. These waves are firstly encountered soil strata, on which the structure rests. These depend on the structure's vibrational characteristics, layout of structure and the soil on which it rests. For the structure to react to the motion, it needs to overcome its own inertia force, which results in an interaction between the structure and the soil.

Various types of substructures respond differently to the earthquake waves. Various types of substructures can be provided for various types of structures depending on layout and purpose of structure, loading on structure and soil conditions.

So in this paper behavior of different types of substructures is studied for same structural, loading and soil conditions.

**LITERATURE REVIEW**

**Shamsher Prakash & Vijay K Puri** in their paper *Foundations Under Seismic Loads* concluded that analytical solutions need validation on model, full scale and/or centrifuge tests. Again, The codal provisions permitting 33% increase in static bearing capacity for the seismic case need to be re-examined in view of the test results cited in paper and the settlement and tilt that may be experienced by the footings due to earthquake loading.

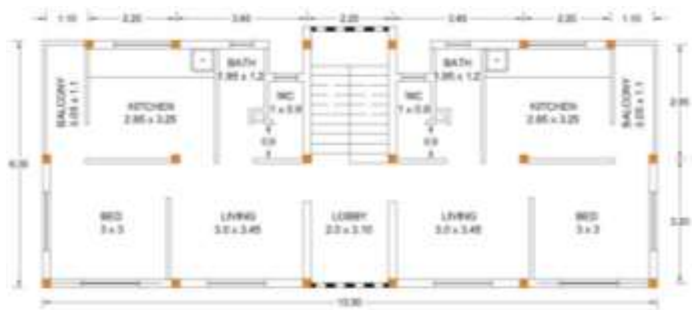
**R. M. Jenifer Priyanka, N. Anand, Dr. S. Justin** in their paper *Studies on Soil Structure Interaction of Multi Storeyed Buildings with Rigid and Flexible Foundation* studied and compared the seismic response of the building frames such as Lateral deflection, Storey drift, Base shear and Moment values building frames with flexible and fixed base. Lateral deflection, Storey drift, Base shear and Moment values increases when the type of soil changes from hard to medium and medium to soft for fixed and flexible base buildings. Lateral deflection, Storey drift, Base shear and Moment values of fixed base building was found to be lower as compared to flexible base building.

**Aslan S. Hokmabadi & Behzad Fatahi** in their paper *Influence of Foundation Type on Seismic Performance of Buildings Considering Soil–Structure Interaction* in their paper describes how a 3D numerical simulation was used to conduct a series of parametric studies on a 15-storey full-scale (prototype) structure with different types of foundations including a fixed base, a shallow foundation, a floating pile foundation, and a pile-raft foundation. Material (soil and superstructure) and geometric (uplifting, gapping and P-Δ effects) nonlinearities have been considered in the 3D numerical simulation. The results of this study indicated that the structure supported by the pile-raft foundation and the floating pile foundation experienced more base shear than the structure ssupported by the shallow foundation and structure supported by the shallow foundation experienced the most severe rocking compared to the floating pile and pile-raft foundations because the pile elements in both foundations reduced the maximum uplift and the rocking experienced by the structure. Moreover, the structure supported by the pile-raft foundation experienced on average 20% less rocking than the structure supported by the floating pile foundation because the compressive stresses generated in one side of the floating pile foundation meant that the piles experienced more settlement here than in the pile raft foundation where the compressive stresses were distributed over a larger area, which in turn, reduced the settlement. So, the types of foundations that experienced a considerable amount of rocking during an earthquake, dissipated much more earthquake energy than other types of foundations and demonstrated that rocking-dissipation directed less shear forces to the superstructure and reduced the structural demand of the superstructure.

**Samridhi Singh, Faizan Ahmad, Bandita Paikaray** in their *paper Effects of Earthquake on Foundations* studied that the effect of earthquake on the foundation of different architectural structures are influenced in a number of ways by the nature and the behavior of the soils in the affected area. The solution to prevent the damage is either the super structure should be tied to the foundation so that the entire structure acts as a single unit or the building can be floated above its foundation which is known as base isolation . Resulting to which, lateral acceleration is decreased and the structure experiences far less deformity and damage. However, the structure still can receive fixed amount of vibrational energy during seismic loading even with base isolation system in place. The building itself can drench this energy to some level, however its capability to do so is proportionate with the ductile nature of the material used during construction

## METHODOLOGY

Multi storeyed building with same superstructure subjected to seismic forces was analyzed for different types of substructures namely isolated footings, strap footings and raft foundation . The structures were analyzed using static method using software STAAD Pro. The floor plan is as shown in *fig.a* for all floors of the analyzed building.




Seismic analysis was carried out by following IS 1893 : 2002 - Part I. Results were found for nodal displacement, drift, story and base shear, moment development and fundamental time period.

**A] Input Data**

Size of the building : 6.35 m X 15.90 m,

Type of structure : RCC Multi storeyed framed,

Seismic zone - IV,

Response reduction factor - 3,

Importance factor -1,

Height of the building - 22 m,

No of storey - 7 (G + 6),

Height of floor - 3 m,

Imposed load - 3 kN/m$^2$,

Materials - M20 (beams & columns), Fe 415,

Depth of the slab - 125mm,

Unit weight of RCC - 25 kN/m$^3$,

Type of soil - Soft,

Static Method - IS 1893 (Part I) 2002,

Damping - 5% ,

Depth of foundation - 1.5m,

Wall thickness - Ext. 200 mm, Int. 100 mm

**B] Description of Structural Models**

Three models of G+6 RCC framed structure were created in STAAD Pro as described above in input data. Isolated footings, Strap footings and Raft foundation are provided to the models respectively.

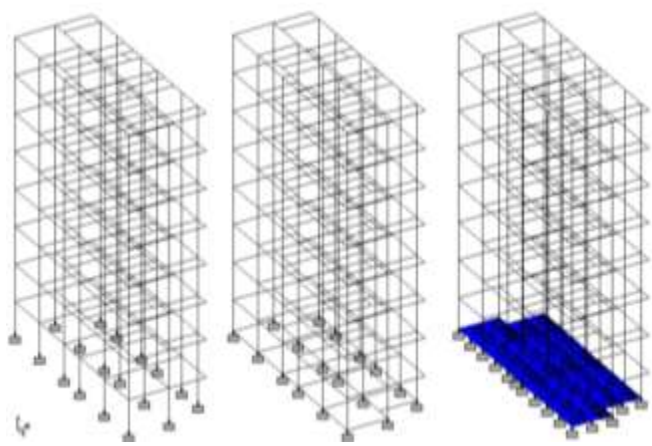


*fig. b* *fig. c* *fig. d*

**Case I - Isolated Footings**

For the first structure *(fig.b)*, isolated footings are provided in the form of fixed supports at the bottom nodes of columns.

**Case II - Strap Footings**

For the second structure *(fig.c)*, strap footings are provided in the form of fixed supports at the bottom nodes of columns which are interconnected by beams. The strap beams carry an overlying load of 8.1 kN/m of the soil above.

**Case III - Raft Foundation**

For the third structure *(fig.d)*, raft foundation is provided in the form of plates connected to column bottom end. Fixed supports are provided at the bottom nodes of columns and the nodes on the plate periphery created because of meshing. The plates are subjected to uplift pressure for the soft soil and corresponding effective area is affected.

**OBSERVATIONS**

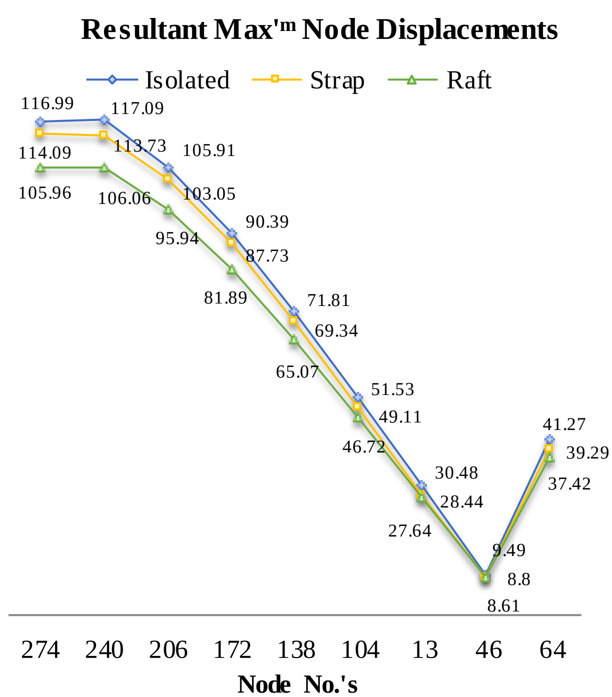
**Resultant Displacements at nodes**

| Node No. | Case I<br>Isolated | Case II<br>Strap | Case III<br>Raft |
|---|---|---|---|
| **Top - 274** | 116.99 | 114.09 | 105.96 |
| **240** | 117.09 | 113.73 | 106.06 |
| **206** | 105.91 | 103.05 | 95.94 |
| **172** | 90.39 | 87.73 | 81.89 |
| **138** | 71.81 | 69.34 | 65.07 |
| **104** | 51.53 | 49.11 | 46.72 |
| **13** | 30.48 | 28.44 | 27.64 |
| **46** | 9.49 | 8.8 | 8.61 |
| **GL - 64** | 41.27 | 39.29 | 37.42 |

**Storey Drift**

| Node No. | Case I<br>Isolated | Case II<br>Strap | Case III<br>Raft |
|---|---|---|---|
| **Top - 274** | - | - | - |
| **240** | -0.1 | 0.36 | -0.1 |
| **206** | 11.18 | 10.68 | 10.12 |

| | | | |
|---|---|---|---|
| 172 | 15.52 | 15.32 | 14.05 |
| 138 | 18.58 | 18.39 | 16.82 |
| 104 | 20.28 | 20.23 | 18.35 |
| 13 | 21.05 | 20.67 | 19.08 |
| 46 | 20.99 | 19.64 | 19.03 |
| GL - 64 | -31.78 | -30.49 | -28.81 |




## CONCLUSION

For the various cases considered under the study subjected to seismic forces, some of the important observations are depicted over here. For the G + 6 RCC structure the modeling and analysis is done for the seismic region which comes under zone IV located on soft soil. The consideration of loading combinations and method of analysis is purely based on IS 1893 : 2002. The effect of various substructures and its behavior when subjected to seismic forces is studied over here.

From the observation table it can seen that in any of the cases maximum displacement is at story just below terrace level, this may be because of absence of live load consideration at terrace. When the comparison is made between various substructure of buildings, it can be seen that maximum base displacement is for isolated footing and minimum for raft foundation. When the comparison is made for edge located nodal displacement, profile indicates its maximum for isolated followed by strap and minimum for raft foundation.

Derived values of storey drift indicates that maximum drift occurs at first storey in any of the cases which may result into sudden breakup of load transfer path. Drift value increases from top to first storey and then it falls up to base level.

Drift values are maximum for isolated followed by strap and minimum for raft. Some more statics related to storey shear, base shear, support moments are required to justify complete suitability of foundation type. However, if economical aspects can be balanced, raft type of foundation is most suitable.

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