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# Seismic Analysis of R.C. Structures with Fixed and Hinged Base for Different Soil Conditions – A Review

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**ABSTRACT**

Earthquakes have the potential to cause the utmost damages, among the other natural hazards. Earthquakes are maybe the most flighty and highly critical of all the natural disasters. Structures are subjected to different earthquake loading, behaves differently with diversification in hard, medium and soft soil. Soil properties get affected significantly as seismic waves pass through a soil layer. When a structure is subjected to an earthquake excitation, it interacts with the foundation and soil, and thus changes the motion of the ground. It means that the movement of the whole ground structure system is influenced by type of soil as well as by the type of structure. In this paper, we study about the previous researches made on the effect of such soil structure interaction which will gives an idea about the behaviour of the structure in such condition.

***Keywords****: Soil Structure Interaction, Seismic Performance, Fixed Base, Hinged Base, StoreyDrift, Storey Displacement, RC Structure .*

## 1.1 Introduction -

Most of the time earthquakes are caused by the slippage along a fault in the earth's crust. When the fault ruptures in the earth's crust, the seismic waves will travel away from the source known as focus, in all direction to the ground surface. As they travel through different geological materials, the waves are reflected and refracted. Throughout the whole journey from the bedrock to the ground surface, the waves may experience amplification. Seismic wave amplification may cause large acceleration to be transferred to the structures, especially when the resulting seismic wave frequencies match with the structure resonant frequencies. This phenomenon may result in catastrophic damages and losses. Thus, with respect to the possible risk of earthquake hazard, it is essential to estimate the peak ground acceleration at the ground surface in order to produce appropriate response spectra for the purpose of structural design and structural safety evaluation. An earthquake is a ground vibration due to the rapid release of energy. The vibration produced causing the ground to be in motion where such ground motion generates complicated transient vibrations in structures. The response of a structure under earthquake loading is directly associated with the response of soil to ground shaking. Thus, the extent and degree of damage during an earthquake is mainly influenced by the response of soil to ground vibrations. Therefore, it is vital to evaluate the response of soil due to ground vibration.

Though the structures are supported on soil, most of the designers do not consider the soil structure interaction and its subsequent effect on structure during an earthquake. Different soil properties can affect seismic waves as they pass through a soil layer. When a structure is subjected to an earthquake excitation, it interact the foundation and soil, and thus changes the motion of the ground. It means that the movement of the whole ground structure system is influenced by type of soil as well as by the type of structure. Tall buildings are supposed to be of engineered construction in sense that they might have been analyzed and designed to meet the provision of relevant codes of practice and building bye-laws. IS 1893: 2016 "Criteria for Earthquake Resistant Design of Structures" gives response spectrum for different types of soil such as hard, medium and soft soil.

**Soil Structure Interaction**

The soil-structure interaction refers to effects of the flexibility of supporting soil-foundation system on the response of RC frame structure. When earthquake force acts on these structural elements, neither the displacement of the structure nor the ground motion, are independent of each other. The phenomenon in which the response of both soil and structure caused due to earthquake are interdependent on each other is termed as Soil-Structure Interaction (SSI) or Soil-Foundation Structure Interaction (SFSI). Soil-structure interaction may not be considered in seismic analysis of structure supported on rock or rock like material at shallow depth. The response of a structure is affected by interactions between three linked systems under to earthquake load: the foundation, the structure, and the soil surrounding and underlying the foundation. Soil-structure interaction analysis evaluates response of these systems collectively to a specified ground motion.

**Factors Affecting Soil Structure Interaction**

The major factors which are responsible in influencing the behaviour of framed structure foundation- soil interaction are

- Types of soil available surrounding and below the foundation at various depths.

- Stiffness between footing and soil, and also between super-structure and footing.
- Size, shape and types of footing/foundation.
- Stress-stain relationship and soil nonlinearity of foundation soil.

## 2. LITERATURE REVIEW

This study focuses on behaviour of buildings in different types of soils i.e. hard, medium, and soft with different base condition. The amount to which the response of building changes the characteristics of seismic motions observed at level of foundation is depends on the relative mass and stiffness property of soil and substructures. So behaviour of building in different types of soil is an important factor that should be considered at the time of design of buildings. Previous researches have been done to analyze buildings in different types of soil with different base conditions in buildings and corresponding base shear, story drift, and lateral displacement is determined compared.

By referring journals it was clear that effect of SSI in the response of a structure plays a vital role. To understand the exact concept of soil structure effect different methods are adopted by different researchers. Some choose the experimental method and some of them choose numerical methods. In experimental analysis the structure was scaled down and supported by pile foundation which was inserted in to a laminar container containing soil mass, series of shake table tests were conducted to study the behaviour of super- structure. In analysis, software like ETABS, SAP-2000, ANSYS and Abacus were most commonly used by researchers to do perform the simulation of SSI continuum models and to obtain the response under different conditions. From all literature it is clear that foundation type, soil condition and soil properties were the key factors which affect the behaviour of the structure.

1. Hidalgo.P.A et al (2002) proposed and implemented a model to include the shear failure mode for walls in available computer programs. The model developed by them is a macro-model validated with the experimental results of cyclic tests of shear walls. Though this model may still be refined, it may be used to predict the inelastic seismic behaviour of reinforced concrete, building structures as long as they have nominally symmetric structural plans, thus providing a useful tool to estimate seismic demands on this type of buildings.
2. Ashraf. M et al (2008) studied the effect of location on shear wall on axial and shear forces along with bending and twisting moments of beams and columns. It was reported that placing shear wall away from centre of gravity resulted in increase in most of the members forces. For minimizing the forces in the members, the shear wall should be placed such that centre of gravity and centroid of the building coincide with each other.
3. Verma s. K. And Maru s. et al, study about a number of reports about the characteristics, behaviour, stabilization and effects on structures of expansive soil have been published over the years but no comprehensive review has been published specially during the last decade. Thus the aim of this paper is to present a review on characteristics, behaviour, stabilization of expansive soil and its effects on the structures. Up to certain extant its nature and mechanics is understood and tried to stabilized by different techniques. Mainly this soil is stabilized with lime and fly ash and with the addition of certain chemicals gives very good performance even in the adverse conditions. But very little work has been done on its effects and remedial measures on the structures. The study will give technical overview and useful information to the engineers and researchers who will work for the betterment of research activities in this field in future."
4. Ketan Bajaj and Jitesh T Chavda et al studied that the Buildings are subjected to different earthquake loading and behaves differently with diversification in the types of soil condition, such as dense soil, medium and soft soil. Different soil properties can affect seismic waves as they pass through a soil layer. When a structure is subjected to an earthquake excitation, it interacts with the foundation and soil, and thus changes the motion of the ground. It means that the movement of the whole ground structure system is influenced by type of soil as well as by the type of structure. As the seismic waves transfer from the ground which consists of alteration in soil properties and performs differently according to soil's respective properties."
5. Jenifer Priyanka studied the effect of lateral force on tall buildings with different type of irregularities. It was found that building with soft soil gives more deflection as compared to medium and hard soil for all types of building. Building with stiffness irregularity gives more deflection as compared to other type of buildings with different irregularity.
6. Er. Raman Kumar Sidhu et al states that the seismic behaviour of buildings is strongly affected by the arrangement of shear walls, the rigidity of floors and the connections of floors to the walls. Shear walls are normally arranged in such a way that they resist lateral loads most effectively. Therefore, in the present study the structural behaviour of the buildings with shear walls at different locations has been investigated and compared in terms of storey drift, average displacement and member forces induced in the various members of the buildings. Two reinforced concrete framed regular buildings with different locations of shear walls situated in seismic zone v have been analyzed in this study. Ten-storied and fifteen-storied buildings were taken with four different locations of shear-walls i.e. at central frame, external frame, internal frame, and combined external and internal frames."
7. Anand studied the seismic behaviour of RCC buildings with and without shear wall under different soil conditions. One to fifteen storied space frames with and without shear wall were analyzed using ETABS software for different soil conditions (hard, medium, soft). The values of base shear, axial force and lateral displacement were compared between two frames. Lateral displacement, base shear, axial force and moment in the column value increases when the type of soil changes from hard to medium and medium to soft for all the building frames. It was concluded that the soil structure interaction must be suitably considered while designing frames for seismic forces.
8. Rahul Sawant and Dr. M. N. Bajad et al focuses on a review of the influence of soil conditions on the seismic forces in RC buildings. The aim of this study is to gain understanding the effect of the local site conditions on the seismic forces in building. The study helps in creating awareness about the importance of the local site conditions, such as proximity to the source of earthquakes (faults) and the local geological and topographical features in the earthquake resistant design of buildings. The current Indian code of practice for seismic analysis IS 1893:2002, specifies seismic zones to consider different levels of intensity of ground shaking, There are also maps of the principal tectonic features and litho logical formations. This paper shows the soil condition effects studied by the various researchers."

9. U.G.Fulzele, V.R. Ghane et al, states that with the rapid development in Soil improvement, construction technique and social need various constructions of structure are taking place. The possibility of good construction sites to build structures on Black Cotton Soils is difficult due to their poor strength and deformation characteristics. This study discussed Black Cotton Soil problems their remedies, precaution taken and covers the guidelines to construct the structure in Black Cotton Soil."
10. Prashant Patil,Abhishek Chaskar, and Pradeep Landage et al studied that, there is a common design practice for dynamic loading, in which it is assumed that the building is fixed at it bases, but in reality the soil medium allows movement to some extent due to its property to deform. Therefore, this may decrease the stiffness of the structure and hence may increase the natural periods of the system. Thus, this behaviour of soil and structure affecting the total response of the structure is called as soil structure interaction."
11. Landage et al, states that generally, there is a common design practice for dynamic loading, in which it is assumed that the building is fixed at it bases, but in reality the soil medium allows movement to some extent due to its property to deform. Therefore, this may decrease the stiffness of the structure and hence may increase the natural periods of the system. Thus, this behaviour of soil and structure affecting the total response of the structure is called as soil structure interaction'.
12. Sameer Kumar K1, Ashwini G2, Lokesha N3, Mohan B4 states in this study, the seismic response of the super-structure and sub-structure is investigated for the fixed base and flexible base models in SAP-2000 for 6 storey and 8 storey RC framed structure with 2 bays in both X and Y directions. For the both framed structure two types of end conditions, they are a) Column base is fixed (ideally) b) flexible base in which SSI is considered Storey displacement for time history analysis in structure resting on pile foundation is less when compared to the structure resting on isolated footing.

Structural rigidity is a useful parameter which is responsible to co-relate the seismic elastic response of structures. When the structural system is excited into the inelastic range, yielding of the resisting elements complicates the behaviour. Therefore there is a need to study this parameter that captures the inelastic response of the structure. As a part of civil engineering work or as being a civil engineer it's our duty to design such a structure which will sustain in severe earthquakes in various earthquake prone zones and which will lead to reduce the harm of catastrophic as well as economic losses.

## 3. CONCLUSION

The purpose of this hypothetical study is to evaluate the seismic properties and & characteristics for regular structures with different base support conditions for different types of soil. The main aspect of this analysis is to obtain the sustainability of the building regarding the performance of the buildings by using the aid of capacity and the demand of the structure for a designed strong motion earthquake characteristics using the dynamic method of analysis.

With requirement of high infrastructure increasing day by day, more amounts of high rise structures have been designed and analyzed. The research works were undertaken with various issues related to seismic analysis of such structures in severe seismic zones. Regarding to such studies, following conclusions have been drawn in this study to overcome the problem -

- To study the response of buildings subjected to seismic forces with Rigid and Flexible foundations.
- Multi storied buildings with fixed and flexible support subjected to seismic forces were analyzed under different soil conditions like hard, medium and soft strata.
- To compare seismic performance like drift, displacement, storey shear etc with Fixed and Flexible base foundations in different seismic zones.
- To identify the resistance of RC structural member against seismic loads under either fixed or flexible base

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