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Seismic Behavior of RCC Frame Structure Considering Soil Structure Interaction

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Abstract - *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 behavior of soil and structure affecting the total response of the structure is called as soil structure interaction.*

In the present work, to study the effects of soil-structure interaction on the seismic response of framed structures, frames with 3, 7 and 15 storey have been considered with base supported as fixed with and without considering the soil structure interaction. Buildings are modeled using STAAD-PRO software. Three types of soil i.e. hard, medium hard, and soft soil are used to SSI study.

Key words: Dynamics of soil, Natural Time Period, Soil Structure Interaction, Stiffness, Staad-Pro.

I. INTRODUCTION

Since the past 4 decades, there has been a many studies done for understanding the nature of earthquakes and their impact on structures. Considering few earthquakes in recent years, it is observed that the soil-structure interaction (SSI) effects play an important role in determining the behaviour of building structures. The response of a structure at the time of an earthquake mainly depends on the ground characteristics, the surrounding soil medium, its properties and the structure itself. The movements of soil under foundation will interact with the deformations of the structure itself. Soil dynamics involves the estimation of dynamic soil properties and the study of the behaviour of various types of soils under dynamic loads. Seismic waves are transmitted through soil from the origin and the wave motion of the soil excites the structure. The extent of damage caused by earthquakes depends essentially on the dynamic response of soil deposits, which is governed by the cyclic non-linear and strength characteristics of the soil.

The foundation and the superstructure are typically designed as two independent systems, and the superstructure is fixed at the bottom. The calculated seismic response of the building is generally dependent on the structure above ground level i.e., superstructure. This method is generally simple and convenient, but the energetic characteristics and earthquake response of buildings will be different than those of actual buildings, if we do not consider the flexible property of soil at the foundation as well as the surrounding soil, which may lead to an unsafe design, specially in case of the earthquake design and for the performance analysis of major and valuable structures, such as huge sky scrapers. The foundation designer must consider the behavior of both structure and soil and their interaction with each other. The interaction between the soil and the foundation is very much important for various civil engineering cases and it covers a wide spectrum of problems. These include the study of shallow and deep foundation, floating structure, retaining wall-soil system, tunnel lining, earth structure etc.

The purpose of this study is to describe and investigate different approaches by considering the analysis of soil structure interaction with respect to the response in the superstructure. For the study of soil structure interaction three types of soil are consider soft, medium and hard. The study is focused on SSI analysis of frame of 3,7 and 15 storey resting on isolated foundation with fixed and flexible base. Dynamic analysis is carried out using IS: 1893-2000.These models are developed by using STAAD-PRO software.

A.) Soil Structure Interaction –
The phrase soil structure interaction is defines as the influence of soil with structure and influence of structure with soil.

B.) Dynamic Behavior of Soil –
Soil Behavior under dynamic loading depends on the strain magnitude, the strain rate and the number of loading cycles. The strength of certain soils increases under rapid cyclic loading, while saturated sand may lose strength with vibration.

II. OBJECTIVES OF PROJECT

- To study the literature available regarding soil-structure interaction (SSI) and understanding the effects of both on structural performance.
- To study the structure without considering soil-structure interaction.
- To study the structure considering soil-structure interaction.

III. METHODOLOGY

The steps involved in the design and analysis can be summarized as:-

1. First to study the literatures existing by different researchers.
2. Selection of type of framed structure and plan of building and taking different heights of building.
3. Three different types of soil are considered i.e., hard, medium and soft soil on which the RC structures are to be rested.
4. The properties of soil are taken according to IS 1893:2002.
5. For the interaction analysis, two different approaches are used –

A.) Winkler Approach :-
Winkler assumed that the surface displacement of the soil medium is proportional directly to the stress applied to it at that point and completely independent of stresses or displacement at other, even immediately neighboring point of the soil-foundation interface.

B.) Elastic Continuum Approach :-
In the case of in-situ surface deflections will occur certainly under and around the loaded region. A Winkler Model is generally limited for such soil media that has cohesion or transmissibility of applied forces.

The analysis is carried out in following manner:-

1. Various storeyed RC frame structures are designed using STAAD-PRO. i.e., 3, 7 and 15 storey.
2. These structures are analyzed for fixed base without considering soil structure interaction.
3. These structures are analyzed for flexible base with considering soil structure interaction.
4. These structures are going to be analyzed for various earthquake zones i.e., II, III, IV, V.
5. The effect of SSI on various structural parameters i.e., Natural Time Period, Base Shear, are studied.

The design and analysis of 3, 7 and 15 storey buildings, using STAAD-Pro is shown below:-

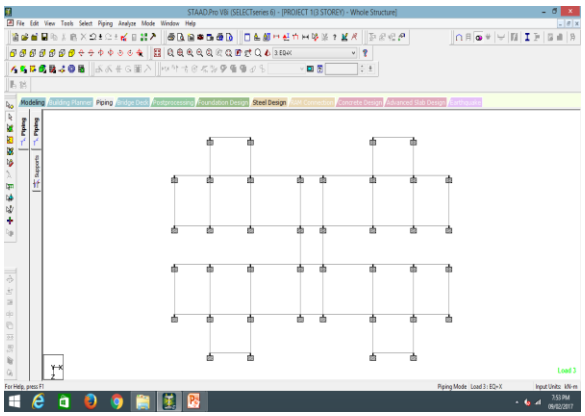

Fig-1: Plan of Building

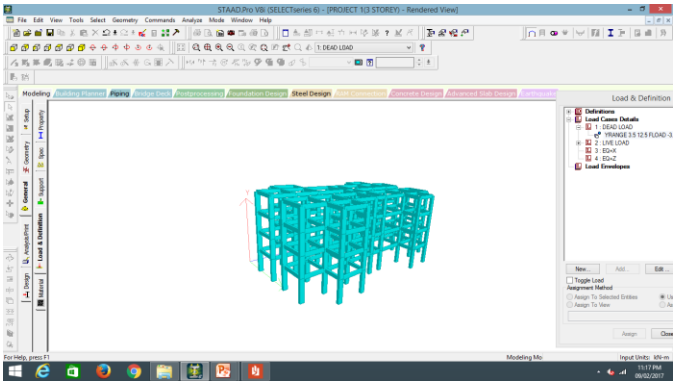

Fig – 2: Elevation for 3 storey building

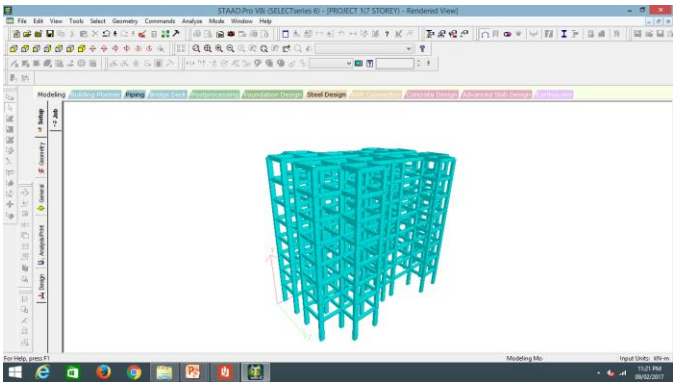

Fig – 3: Elevation for 7 storey building

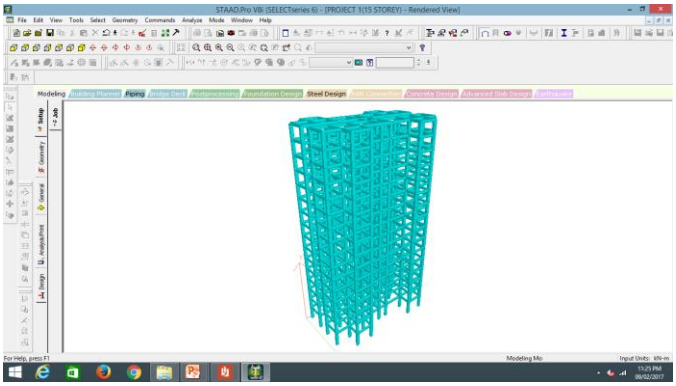

Fig – 4: Elevation for 15 storey building

IV. CONCLUSION SO FAR

Analytical investigations have been carried out to study the behavior of isolated structure founded on different types of soil considering the soil structure interaction. Based on this work following conclusions can be drawn.

1. The natural time period of structure increases when soil structure interaction is considered on base isolated structure.
2. The performance quantities like displacements, acceleration and base shear are affected due to soil structure interaction.
3. The responses of base isolated structure are increased when soil behavior is taken into account in the analysis.
4. The deformation in soil at isolation level is significantly affected, so soil structure interaction should be considered for base isolated structures, essentially when founded on soft soils.
5. Effect of soil structure interaction is predominant for soils with soft and medium strata.
6. As the number of storey increases in the building the base shear and displacement are increases.
7. In case of soft soil, soil structure interaction has been recommended as the height of building increases.

V. FUTURE SCOPE

The use of soil structure interaction while designing and analyzing a structure is very much important and is necessarily useful in case of a structure to be constructed in soft and medium soil conditions, especially present in earthquake zones.

The SSI application is to be applied to the structure increasing with height for its safety working condition.

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