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Analysis of G+8 Building Using ETABS

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***Abstract* - During seismic activity, the response of structures is influenced by Soil Structure Interaction (SSI) which is the process where the response of soil particles to earthquake ground motion affects the motion of structure and the response of structure affects the motion of soil mass. In design offices the base of multi-storey buildings are taken as fixed and analysed for earthquake response using provisions of IS 1893-2016 with the aid of response spectrum given for soft, medium and hard soils in foundation. But in reality, the type of soil present in and around the foundation structure also participates in the seismic response and the assumption of fixed base becomes conservative. Soil structure interaction usually carried out for soft, medium and hard soil. The plan dimension of the building is 16.84 m by 24.15 m and the height of the building is 28.95 m from the ground level. The height of all stories is 3.04 m.**

Keywords: Soil Structure Interaction (SSI), earthquake ground motion affects, response of structure affects the motion of soil mass, provisions of IS 1893-2016.

I. INTRODUCTION

RCC Structure

RCC is a concrete that contains embedded steel bars, plates or fibres that strengthen the material. The capability to carry loads by these materials is magnified; because of these RCC is used extensively in all construction. In fact, it has become the most commonly utilised construction material construction project. The main quality of reinforced concrete is the similarity of its coefficient of thermal expansion with that of steel, due to which the internal stresses initiated due to variation in thermal expansion or contraction are eliminated.

Seismic Zones in India

An earthquake is caused by a sudden slip on a fault. Stresses in the earth's outer layer push the sides of the fault together. Stress builds up and the rocks slip suddenly, releasing energy in waves that travel through the earth's crust and cause the shaking. An Earthquake occurs when plates grind and scrape against each other.

Bureau of Indian Standards, based on the past seismic history, grouped the country into four seismic zones, viz. Zone-II, III, IV and V. Of these, Zone V is the most seismically active region, while zone II is the least. The Modified Mercalli (MM) intensity, which measures the impact of the earthquakes on the surface of the earth, broadly associated with various zones.

Table 1: Seismic Zones

Seismic Zone	Intensity on MMI scale	% of total area
II(Low intensity zone)	VI (or less)	43 %
III(Moderate intensity zone)	VII	27%
IV(Severe intensity zone)	VIII	18 %
V(Very severe intensity zone)	IX (and above)	12 %

Aim

The aim of the project is to analyse the building for soft and medium soil and finding the effect of soil and seismic response of the building. The response of the building varies as the soil type changes and also this dynamic response, depends upon the state of one type of soil at a particular instant. The response values of the building subjected to seismic analysis, under the effect of soil structure interaction are greater than the response values obtained from seismic analysis of building, with fixed base. Therefore it very important to consider the effect of soil structure interaction, to get more appropriate values of response of the building subjected to seismic forces. Soil structure interaction is defined as a process, in which the response of soil for seismic force affects the motion of the structure and the motion of the structure, in turn affects the response of the soil.

Objectives

On the basis of finding the effect of soil structure interaction on seismic response of the building the objectives of our project are:

1) To check the stability of structure with seismic load in different seismic zone.
2) To understand the effect of soil structure interaction.
3) To find the effect of SSI on building.
4) To establish guidelines to prevent the effect of soil structure interaction.

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Effect of Seismic Forces on Structure

Earthquake causes shaking of the ground. So, a building resting on it will experience motion at it base. From Newton's First Law of Motion, even though the base of the building moves with the ground, the roof has a tendency to stay in its original position. But since the walls and columns are connected to it, they drag the roof along with them.

This is much like the situation that you are faced with when the bus you are standing in suddenly starts; your feet move with the bus, but your upper body tends to stay back making you fall backwards!! This tendency to continue to remain in the previous position is known as inertia. In the building, since the walls or columns are flexible, the motion of the roof is different from that of the ground.

Consider a building whose roof is supported on columns. Coming back to the analogy of yourself on the bus: when the bus suddenly starts, you are thrown backwards as if someone has applied a force on the upper body. Similarly, when the ground moves, even the building is thrown backwards, and the roof experiences a force, called inertia force. If the roof has a mass M and experiences an acceleration a, then from Newton's Second Law of Motion, the inertia force FI is mass M times acceleration a, and its direction is opposite to that of the acceleration. Clearly, more mass means higher inertia force. Therefore, lighter buildings sustain the earthquake shaking better.

ETABS: SAP 2000

ETABS stands for Extended Three Dimensional Analysis of Building System, ETABS is an engineering software product that caters to multi storey building analysis and design. Modelling tools and templets, code based load prescription, analysis method and solution techniques, all coordinates with the grid-like geometry unique to this class of structure. Basic or advanced system under static or dynamic conditions may be evaluated using ETABS. Fundamental to ETABS modelling is the generalisation that multi storey typically consist of identical or similar floor plans that repeat in the vertical direction once modelling is complete, ETABS automatically generates and assigns code based loading conditions for gravity, seismic, wind and thermal forces.

II. LITERATURE REVIEW

Chaitanya Patel, Etc. (2016) [1] studied the seismic behavior of reinforced concrete buildings with multiple underground stories. While the current research is primarily aimed at understanding the effects of changes in soil subgrade coefficients, the ultimate goal of this study is to make good recommendations for including underground stories in models for seismic analysis is to find out. To achieve this objective, the methodology involves the computer modelling by two alternate approaches, namely, building frame with fixed supports, building frame with supports accounting for soil-flexibility using Etabs. A comparison of the displacements of the frame and time period of the whole structure is done. They concluded that FEMA spring model gives higher time period compared to Fixed based model and Winkler model when soil subgrade modulus is 2750 kN/m^3 and then winkler model gives higher value when soil subgrade modulus is 4500 kN/m3 and 6250 kN/m^3. Winkler model gives higher value of maximum nodal displacement compared to other to models. Also says that with increasing number of storey variation in soil subgrade modulus effects is reduce. Soil subgrade modulus effects is more on softer soil and plays a significant role in increasing the storey shear and moment demand for relatively low rise building. Soil subgrade modulus effect depends on the stiffness of the foundation and the number of underground storey.

M Roopa etc. (2015) [2] mainly concentrated on in situ clayey soil conditions. The RC building measured to analyze SSI is a G+12-story apartment with an elevation of 40.15m and a plan shape of 28.2mX16.1m, proposed in Manbachham , South Chennai ,Tamil Nadu, India .The study has used the finite element tools ETABS 9.7.4 for modeling and SAP2000 ver17 for SSI analysis. They concluded that Variation of storey drift in both the cases is parabolic with middle storey's showing maximum drift. Considering the SSI, the floor drift increases in the middle floor. Base shear for maximum flexible base conditions compared to fixed base conditions. Considering the effect of SSI, we can see that it has almost doubled from 1845.74 KN to 3475.90 KN. Natural time when building with a fixed base on soft soil in the first mode is 2.551 seconds, and when using a flexible base on clay soil increases by 37.39% to 3.505 seconds. A similar amount of increase in natural duration is understood in all 10 modes. The response of the tall building founded on clayey soil has shown significant increase compared to conventional approach of assuming fixed base and founded on soft soil. Significant increase in response of tall building when SSI is considered is because of flexibility induced to the base by the softness of clayey soil.

Aslan S. Etc. al. (2015) [3] intended to study the effects of the seismic soil-pile- structure interaction (SSPSI) on the dynamic response of buildings with various heights by conducting a series of shaking table tests on 5-, 10-story, and 15-story model structures. Two types of foundations for each case are investigated, including (1) a fixed-base structure, representing the situation excluding the soil-structure interaction; and (2) a structure supported by an end- bearing pile foundation in soft soil. An advanced laminar soil

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container has been designed that uses three dimensional numerical modeling to minimize the boundary effects and to simulate free-field motion during the shaking table tests.

Shehata E. etc. al. (2014) [4] studied that the effects of Soil Structure Interaction (SSI) may be detrimental to the seismic response of structure and neglecting SSI in analysis may lead to un-conservative design. Despite this, normal design procedures usually assume that the foundation is fixed on the foundation, ignoring the flexibility of the foundation, compressibility of the soil mass, and consequently the demands of bending moment and shear force. Includes the effects of subsidence of the foundation on further redistribution. The impact of SSI is analyzed on a typical skyscraper on a raft foundation.

Jui-Liang Lin etc. al. (2014) [5] the proposed approximate method transfers the frequency independent equation of motion for the SSI system into a set of MDOF modal equations of motion. There are four advantages to this method at the expense of increasing degrees of freedom for each vibration mode. The first two advantages are similar to those of conventional modal response history analysis, whereby there is a significant decrease of the degrees of freedom required in the analytical work and the use of only the first few vibration modes to achieve satisfactory analytical results. On the other hand, another advantage is the preservation of the characteristics of non-proportional damping in the MDOF modal equations of motion.

Mohd Ahmed, Etc. (2014) [6] Analysis of building structures in contact with soil includes the stress-strain interaction processes that occur within the structure and soil fields. The response of the Piled-Raft Foundation system to structures is extremely difficult due to the significant interactions between building structure components and soil fields. In this paper, the soil- structure interaction of a building founded by the Piled-Raft Foundation was evaluated by 3D nonlinear finite element analysis using the PLAXIS3D FOUNDATION code.

Jonathan P.etc. al. (2013) [7] described analysis procedures and system identification techniques for evaluating inertial SSI effects on seismic structural response. The analytical procedure is similar to the provisions of some building codes, but more reasonably incorporates the effects of site conditions and the embedding, flexibility, and shape of the foundation on the impedance of the foundation. The implementation of analytical procedures and system identification techniques is shown using buildings shaken during the 1994 Northridge earthquake. The analytical procedure accurately predicts the observed SSI effect. The confidant paper functional these analyze to empirically assess SSI affects by means of strong motion data accessible from a wide range of sites, and then widespread the SSI effects on seismic structure excitation and response. Draw conclusions. Two sets of analyses are described in this paper: (1) Simplified design procedures that can be used to predict period lengthening ratios and foundation damping factors for structures with surface (MV) or embedded (MV or MB) foundations; and (2) system identification procedures for evaluating fixed- and flexible-base modal vibration parameters from earthquake strong motion data.

M. E. Boostani Darmian, Etc. [8] In order to understand the structural behaviour, it is useful to study the effects of soil-structure interaction. However, studies of soil-structure interactions are usually done on the assumption that the foundation is fixed to the soil. During strong ground motion, some uplift of the foundation can occur depending on the type of soil in which the structure is located. This paper investigates the nonlinear behavior of various steel braced structures placed on different types of soil with varying hardness. This can help in better understanding of the actual behavior of structure during an earthquake. The results showed that the softer the soil, the greater the change in seismic response for structures that tolerate foundation uplift. Comparison of rate of uplift for various structures showed that maximum uplift occurred in the part of foundation located on side axis of the structure. This part of foundation carries the brace’s load too. It is also noted that with an increase in the height of structure the foundation uplift increases.

III. METHODOLOGY

Methods of Seismic Analysis

1) Finite Element Modelling

Finite element modelling of the soil-structure problem is tackled here using conventional modelling capabilities normally available in most of the standard finite element programs. In this study the computer program SAP2000 (CSI, 2000) is used for the soil structure interaction modelling. The soil is assumed to be a single layer of 80 meter deep. This is more than 2.5 times the base width of the considered structures. The soil is modelled using two dimensional plane strain elastic elements. Two alternatives of soil modeling are used: one which includes the mass of the soil and other which ignores the mass (massless). The damping is assumed as 4% of the critical damping using Rayleigh damping definition. The members in the frame structures are modelled using beam elements. The construction of the soil-structure model is completed using nonlinear GAP connector elements between the reinforced concrete foundation of the structure and the soil.

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2) Response of reinforced concrete (R/C) structures

Soft and weak storey mechanism: In some R/C buildings, especially at the ground floor, walls may not be continuous along to height of building for architectural, functional, and commercial reasons. While ground floor generally encloses with glass window instead of brick infill walls, partition walls are constructed above from this storey for separating rooms for the residential usage. This situation causes brittle failures at the end of the columns. In mid-rise reinforced concrete buildings, the most common failure mode is soft-storey mechanism, particularly at the first storey. Failures can be concentrated at any story called as weak storey in which the lateral strength changes suddenly between adjacent stories due to lack of or removing of partition walls or decreasing of cross section of columns. Thus, during an earthquake, partial and total collapses occur in these storeys Inadequate transverse reinforcement in columns and beams Shear forces increase during an earthquake especially at columns and beam–column joints.

Model Description

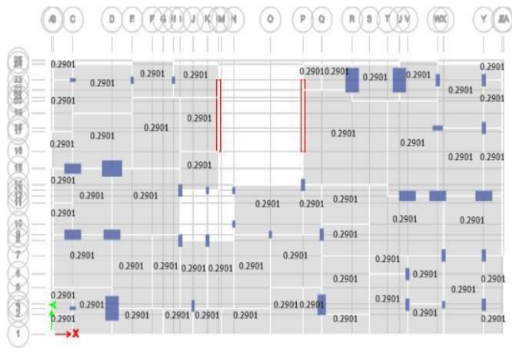
1) The detailed analysis of the processes followed for the modeling of the buildings needed for the present research is indicated.
2) 3D models of two different forms of structural systems are being modeled in the present research in seismic zone III and compare the performance with shear wall and without shear wall structures subjected to Earthquake structural forces.
3) Form of building support is a fixed assist.
4) All versions have dimensions of the same structural plan.
5) The concrete grade for the shear wall, pillars, columns and slabs considered for M25.
6) The planned structure for this plan is a 8-floor high-rise building which is used for residential construction.

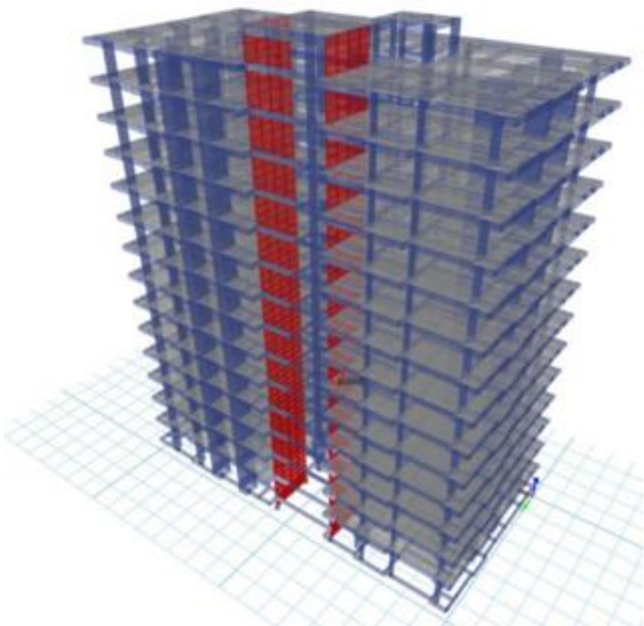
Seismic Load

It is linear dynamic analysis. It determines the response in each mode of vibration and overlay the responses in several modes to attain the total response. Response may be in the appearance of deformation, acceleration etc. A graph between maximum response and natural period is called response spectrum.

Analysis of G+8 Building

1) The structure used in the ETABS model is a high rise residential structure G+8.
2) The built up area of per floor is about 6339.36 sq ft.
3) Per floor consist of four apartments with built up area of 1200sq ft. each.
4) We have assumed that the building is in high risk seismic.





Loading Pattern

Apart from the self-weight, the building is subjected to various type of loading. The major loads acting on the building are:

1) Dead Load (DL): The dead load, include self-weight of the structure itself, and immovable fixtures. Dead loads are also known as permanent loads. The dead load of the beams and columns are automatically considered by the model. The loads from the slabs are distributed as triangular or trapezoidal line loads on the supporting beam as per IS 456:2000.

2) Live Load (LL) or Imposed Load (IL): Live loads, or imposed loads are temporary, of short duration or moving. These dynamic loads involve considerations such as impact, momentum, vibration, fatigue, etc. Apart from the self-weight, the building is subjected to live loads. The load distribution pattern of the live load from the slabs to the supporting beams is similar as that in case of the DL.

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3) Seismic Loading: Seismic loading is one of the basic concepts of earthquake engineering which means application of an earthquake-generated agitation to the structure. It happens at contact surfaces of a structure either with the ground, or with adjacent structures, or with gravity waves from tsunami. The seismic load is calculated as per the provisions given in IS: 1893 (Part l)-2016.

IV. CONCLUSIONS

1) Difference of storey drift in both the cases is parabolic with middle storeys showing maximum drift. When SSI is considered there is an increase of storey drift in the middle storeys.
2) Variation of lateral displacement in both the cases is maximum at top stories showing maximum displacement. The displacement value increases when SSI is taken into consideration.
3) Time period also increase by smaller value in the case of SSI as compared to without SSI.
4) Story stiffness reduces in the case of with SSI as compared to without case, but this change is not significant.
5) Overturning moment reduces in the case of with SSI as compared to without SSI case, it shows that there is some positive effect of SSI as well negative effect on the behavior of the building.

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