iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** V **Month of publication:** May 2022

DOI: https://doi.org/10.22214/ijraset.2022.42921

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue V May 2022- Available at www.ijraset.com

Review on Analysis of Multi-Storey Framed Structure Using ETABS in various zones considering Soil Structure Interaction

Mr. Ayush Jain[1], Prof. Vishal Sepate[2]
[1]PG Student, Department of Engineering & Technology, G.H. Raisoni University, Amravati, Maharashtra, India
[2]Professor, Department of Engineering & Technology, G. H. Raisoni University, Amravati, Maharashtra, India

Abstract: The objective of the paper is to present a review on analysis of Multi – Storey Framed Structure and to create a comparative study in effect of Soil Structure Interaction (SSI) for various zones. The RCC Framed Structure is subjected to various loading and the structure is then analysed using ETAB2016.
Keywords: Soil Structure Interaction, Time History Analysis, Response Spectrum Analysis, Dynamic Analysis

1. INTRODUCTION

Soil Structure Interaction (SSI) is defined as the interaction between soil and the structure built upon it. It is an exchange of mutual stresses as the ground structure system is influenced by both the type of ground and the type of structure.

Soil Structure Interaction (SSI) can be defined as the response of structures resulted from the flexibility of soil under the foundation as well as the response of soils caused by the presence of structures. Soil – foundation structure system consists of frame in superstructure, its foundation and the soil on which it rests.

Soil Structure Interaction (SSI) analysis is a method of evaluating the collective response of three linked systems i.e. the structure, the foundation and the soil underlying and surrounding the foundation. Considering Soil Structure Interaction (SSI) makes a structure more flexible and thus increasing the natural period of the structure compared to corresponding rigidity supported structures.

A. AIM

To analyze and design the mutli – storey Framed Structure using ETABS in various zones considering soil structure interaction.

B. Objective

1) To design G+15 building by using ETABS
2) To understand the effect of Soil Structure Interaction (SSI)
3) To design the analyse and design the structure
4) To find the effect of Soil Structure Interaction (SSI) on structure
5) To study various types of zones
6) To study the effects considering various zones
7) To compare the effect of soil on structure with and without soil structure interaction

II. LITERATURE SURVEY

The Soil Structure Interaction is one of the most flourishing areas of research in structural engineering at present. It can be defined as the coupling between a structure and its supporting medium (bedrock or soil bed) during an earthquake.

Soil Structure Interaction majorly covers a vast area of Civil Engineering field. As it affects the structure and the soil conditions, thus it becomes the important parameter to be focused for the researchers. The literature survey given below explores some of the fields and the Soil Structure Effects in them.

A. Literature Survey

Rahul Raghunath Kharade and M V Nagendra (2020) studied Soil Structure Interaction on Framed Structure using ETABS. Seismic analysis is carried out for reinforced concrete moment resisting building frame G+12 Storey, is considered for the present study to investigate SSI effects on tall buildings. When SSI is considered there is a magnification of storey drift in the middle storeys. 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. The base shear for with soil structure interaction case is almost same as compared to fixed base case as there is no increase in seismic weight of the building. The natural time period in case of building with soil structure interaction is increased a little as compared to fixed base case. The response of the tall building founded on soft soil has shown significant increase compared to hard soil for both fixed base and SSI case.

Anand Jain and Dr. S.R. Parekar (2020) studied effects of Soil Structure Interaction on RC Frame Building and effects on base reaction with and without SSI considering different base condition. After performing response spectrum analysis it is observed that the maximum base reaction occurs when the soil structure interaction effects are taken into consideration. The software response spectrum analysis shows results approximately 10% more of the actual base reaction calculated analytically for the fixed base condition. The base reaction is maximum when SSI effect is considered. Base reaction for SSI effect is more for soft >>medium>>hard>>fixed base. Both the base reaction and lateral story displacement increases with the increase in the flexibility of the soil. Thus one should estimate the importance of SSI and decide whether it should be considered at all. It is recommended that the effect of soil structure interaction to be taken into consideration for the seismic analysis and design of any structure in the region were soft and medium soils are present.

Shreya Thusoo et. Al. (2015) studied the effects of Soil Structure Interaction on a building by varying the soil types beneath. They carried out modal analysis for buildings of various heights with and without the consideration of underlying soil effects. They evidently concluded that SSI lengthens the time period of structure and hence modifies its dynamic behaviour and consequently the design forces.

Since seismic events are a time dependent phenomenon, therefore, evaluation of responses with respect to frequency and intensity of earthquake has been done by using Time History Analysis method. Investigations done shows that sandy soils amplify seismic waves on the soil-structure interface because of the soil - structure interaction effect. The analysis of SSI system was carried out by applying base excitations to the surrounding soil.

These excitations are carried to the foundation and then transferred to structure. They also analyzed it using ANSYS software for validation. In this paper they concluded that the deflection in cases, where the soil is hard or medium, is significantly less as compared to the buildings on soft soils. For moderately stiff soil, as the size of the building increases, deflection response also increases significantly.

The spectral acceleration response pattern changes drastically as stiffness of base soil decreases. The difference in response pattern of the building for both conditions gets can be easily observed and compared from the analysis results. Time period of all the responses increases while considering Soil-Structure Interaction effects. The difference in time period of the building for both conditions gets increased as the stiffness of the soil increases from soft to hard.

Mr. Rahul Sawant and Dr. M. N. Bajad (2017) studied Effect of Soil-Structure Interaction on High Rise RC Building. The system geometry consists of G+42 Storeys located in Mumbai with plan dimension of 42.2m X 16m. The building will be used for residence. The lateral and vertical load resisting systems are reinforced concrete frames. The frames are composed of columns, shear walls, primary beams and secondary beams. The site condition consists of Yellowish stiff Clay for 3m and Greyish Moderately Weathered Rock beneath. It was found that SSI effects are frequency-dependent. Most of effects are valid in a certain frequency range. Out of this range they may lead to the opposite changes. Wave nature of SSI effects requires special attention when FEM is used: element size for the soil and time step must be compared with frequency ranges of interest.

Nimisha Ann Sunny and Dr. Alice Mathai (2017) analysed Soil Structure Interaction Analysis of Multi Storey Building in which analysis of building structure in response of Piled-Raft Foundation system to the structure is studied. Soil - structure interaction of buildings founded on Piled-Raft Foundation is evaluated through Finite Element Analysis using ANSYS v17.0. The building settlement and equivalent stress is computed. The study has been conducted by modelling building with soil and without soil. It is seen that total deformation (vertical) of building is more in flexible base model than in fixed base model, which means that in actual case settlement occurs and it depends on type of soil beneath. In the model where soil is considered stress distribution pattern has varied. Average stress developed in model with soil is greater than other model .This study indicates that building should be modelled along with the soil in which it is resting considering all properties of soil for the analysis and design purpose.

Mr. A. A. Matale (2017) studied Soil - Structure Interaction of Multi-storey R.C.C. Frames in which effect of soil structure interaction on the dynamic characteristics of structure has been studied , it is found that consideration of different parameter such as soil structure interaction, and location of walls influences time period, displacement and base shear of building frame considerably. Hence it is important to consider to all these parameters in the analysis of structures. Also shear walls located in the central part of the multi-storeyed building gives lesser displacement and more base shear compared to other locations.

Mohd Ahmed, Mahmoud H. Mohamed, Javed Mallick and Mohd Abul Hasan (2014) studied 3D-Analysis of Soil-Foundation-Structure Interaction in Layered Soil. It is found that the analysis of combined piled-raft foundation of multi-storey building is very challenging because of complexities involved in the interaction between the components of building structure and soil field. The analysis of the tall building structure with complex foundation system in non-uniform (layered soil) soil field should include the interaction of structure-foundation-soil. In this study, the finite element 3D interaction analysis of building structure having piled-raft foundation in two layered non-cohesive soil field is carried out using PLAXIS 3D foundation code. The foundation structure and soil field response is significantly affected by different building structure shape and soil failure models. The foundation soil settlement and raft differential settlement is highest using Mohr coulomb (MC) failure criteria of soil field among the HS, MC and MCI failure criteria. The soil field response in layered soil is also affected by presence of lesser stiff layer below the raft. The soil behaviour in piled-raft foundation is not much affected by lesser stiff layer having thickness more than the pile length. A clear foundation structure interaction effect is observed on the building superstructure components behaviour with application of construction loading sequentially. The wide variability of deflection and moments of the floor slab is also observed due to loading of super structure applied in sequential manner which is not observed when super structure loading is applied as a single phase.

Vaishali M. Tormal, Dr. K. B. Ladhane and Prof. V. R. Rathi (2014) studied Effect of Soil Structure Interaction on Response of Multistorey Building. A five storied (G+5) space frame resting on a pile foundation is considered for the parametric study. The elements of the superstructure (beam, column and slab) and that of the substructure (pile and soil) are modelled using simplified modelling approach. The slab in the frame is idealized as the two- dimensional plate element and beams and columns of the frame along with the pile are idealized as one dimensional beam element. In case of building with SSI is more conservative. It develops more displacement, amplitude, stresses and strain than the case of building without soil. The case of building with mass soil is more conservative than the case of building without the soil. The SSI is highly nonlinear. The increase in superstructure or pile stiffness does not necessarily reduce the seismic response of SSI system. SSI effect increases displacement in each storey of frame. It is concluded that in seismic response analysis of SSI system, it is important to take into account of material non-linearity of the soil and geometrical nonlinearity at the interface of the structure and the soil. Considering the overall soil behaviour it is seen the soil beneath the structure and near the fixed boundaries is comparatively stable.

B. Summary Of Literature

1) The SSI effect is generally ignored from design consideration till date.
2) Different structures with various properties were chosen for analysis.
3) The structures were analyzed over different soil conditions i.e. hard, medium and soft soil.
4) Response Spectrum and Time History Analysis of the superstructure has been used to obtain the natural periods.
5) Various software were used for the analysis which included ETABS, ABAQUS, ANSYS, STAAD Pro.

II. TERMINOLOGY

1) *Flexibility* – It is the ease with which the
   system can respond to uncertainty in a manner to sustain or increase its value delivery. It can be characterized by the ability to bend or compress easily without cracking under normal conditions.
2) *Ductility* – Ductility of a structure or its members is the capacity to undergo large inelastic deformations without significant loss of strength or stiffness.
3) *Damping* – The effect of internal friction, imperfect elasticity of material, slipping, sliding etc. in reducing the amplitude of vibration and is expressed as a percentage of critical damping.
4) *Critical Damping* – The damping beyond which the free vibration motion will not be oscillatory.
5) *Importance Factor (I)* - It is a factor used to obtain the design seismic force depending on the functional use of the structure characterised by hazardous consequences of its failure, its post earthquake functional need, historic value or economic importance.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue V May 2022- Available at www.ijraset.com

Sr. No.	Structure	Importance Factor (I)
1	Important service and community buildings such as hospitals, schools, monumental structures, emergency buildings like telephone exchange, television stations, radio stations, railway stations, fire station buildings, large community halls and subway stations, power stations	1.5
2	All other Building	1.0

Note – As per IS 1893 (Part 1) : 2002 , Table 6, Pg. No. 18

6) *Natural Period (T)* – Natural period of structure is its time period of undamped free vibration.
7) *Zone Factor (Z)* – It is a factor to obtain the design spectrum depending on the perceived maximum seismic risk characterized by Maximum Considered Earthquake (MCE) in the zone in which the structure is located. The basic zone factors included in this standard are reasonable estimate of effective peak ground acceleration.

Seismic Zone	II	III	IV	V
Seismic Intensity	Low	Moderate	Severe	Very Severe
Z	0.10	0.16	0.24	0.36

Note – As per IS 1893 (Part 1) : 2002 , Table 2, Pg. No. 16

8) *Degree of Freedom* – It is defined as the minimum number of independent coordinates required to determine completely the position of all parts of a system at any instant of time.
9) *Single Degree of Freedom (SDOF)* – An SDOF system is one whose motion is governed by a single, second order differential equation. Only two variables, position and velocity are needed to describe the trajectory of the system (i.e. allows movements along one axis). Ex – A vertical cantilever with the mass concentrated at its tip.
10) *Multi Degree of Freedom (MDOF)* – An MDOF system are defined as those requiring two or more coordinates to describe their motion (i.e. allows movement along several axis). Ex – A multi storey frame with masses concentrated the storey levels.
11) *Response Spectrum* - The representation of the maximum response of idealized single degree freedom systems having certain period and damping during earthquake ground motion. The maximum response is plotted against the undamped natural period and for various damping values and can be expressed in terms of maximum absolute acceleration, maximum relative velocity or maximum relative displacement.
12) *Response Reduction Factor (R)* – It is the factor by which the actual base shear force, that would be generated if the structure were to remain elastic during its response to the Design Basis Earthquake (DBE) shaking, shall be reduced to obtain the design lateral force.
13) *Moment Resisting Frames* – It is a frame in which members and joints are capable of resisting forces primarily by flexure.
a) *Ordinary Moment Resisting Frame (OMRF)* – It is a moment resisting frame not meeting special detailing requirements for ductile behaviour. An ordinary moment resisting frame consists of beams and columns which are rigidly connected. The components of a moment frame should resist both gravity and lateral load. The response reduction factor (R) for OMRF is 3.
b) *Special Moment Resisting Frame **(SMRF)*** It is a moment resisting frame specially detailed to provide ductile behaviour and comply with the requirements. The response reduction factor (R) for SMRF is 5.

14) *Base Shear* – It is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of the structure. It is calculated using the seismic zone, soil material and building code lateral force equations.
15) *Storey Drift* – It is the displacement of one level relative to the other level above or below.
16) *Storey Shear (V_i)* – It is the sum of design lateral forces at all levels above the storey under consideration.
17) *Diaphragm* – It is a horizontal or nearly horizontal system, which transmits lateral forces to the vertical resisting elements, for example reinforced concrete floors and horizontal bracing systems
18) *Mode Shape* – A mode shape is the deformation that the component would show when vibrating at the natural frequency. The mode shapes tell us which regions would experience high stresses if the deformed shape is similar to the mode shape.

19) *Modal Mass (M_k)* – Modal mass of a structure subjected to horizontal or vertical, ground motion is a part of the total seismic mass of the structure that is effective in mode k of vibration. The modal mass for a given mode has a unique value irrespective of scaling of the mode shape.
20) *Modal Participation Factor (P_k)* – Modal participation factor of mode k of vibration is the amount by which mode k contributes to the overall vibration of the structure under horizontal and vertical earthquake ground motions. Since the amplitudes of 95% mode shapes can be scaled arbitrarily the value of this factor depends on the scaling used for mode shapes.

III. DISCUSSION

Above literature survey depicts the following -

1) Different parameter such as soil structure interaction, and location of walls influences time period, displacement and base shear of building
2) Shear walls located in the central part of the multi-storeyed building gives lesser displacement and more base shear compared to other locations.
3) Base reaction is more when soil structure interaction is considered while analysing the structure
4) Time Period of the structure increases when soil structure interaction is considered
5) Time History Analysis is accurate but very resource consuming on the other hand response spectrum is quick but marginally uneconomical.

IV. CONCLUSION

Time History Analysis and Response Spectrum Analysis both are the methods of Dynamic Analysis. It is considered that Time History Analysis gives more accurate results as compared to Response Spectrum Analysis. Time History Analysis give more precise approximation of internal stresses and also the time and position of the cracks emerging in the structure while Response Spectrum over estimates the stresses but it saves time and resources.

REFERENCES

[1] M Roopa, H. G. Naikar, Dr. D. S. Prakash, (2015) "Soil Structure Interaction Analysis on a RC Building with Raft foundation under Clayey Soil Condition", International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 IJERTV4IS120402
[2] Mohd Ahmed, Mahmoud H. Mohamed, Javed Mallick, Mohd Abul Hasan, (2014) "3D-Analysis of Soil- Foundation-Structure Interaction in Layered Soil" Open Journal of Civil Engineering, 2014, 4, 373-385.
[3] Rahul Raghunath Kharade, M V Nagendra (2020) "Study of Soil Structure Interaction on Framed Structure using ETABS" International Journal of Engineering Research & Technology (IJERT) Volume: 07 Issue: 08 | Aug 2020
[4] Rahul Sawant, Dr. M. N. Bajad "Effect of soil-structure interaction on high rise rc building", IOSR-JMCE, Volume 13, Issue 1 Ver. IV, PP 85-91, 2017
[5] Anand Jain, Dr. S.R. Parekar (2020) "Effects of Soil Structure Interaction on RC Frame Building" International Journal of Engineering Research & Technology (IJERT) Volume: 07 Issue: 05 | May 2020
[6] Nimisha Ann Sunny and Dr. Alice Mathai (2017) "Soil Structure Interaction Analysis of Multi Storey Building" International Journal of Engineering Research & Technology (IJERT) Volume 3 | Issue 11 | May 2017
[7] Mr. A. A. Matale (2017) "Soil - Structure Interaction of Multi-storey R.C.C. Frames" ISSN NO: 2454-1958 , Volume 2 : Issue 2 - February 2017
[8] Ahmed, M., Mohamed, M.H., Mallick, J. and Hasan, M.A. (2014) 3D-Analysis of Soil-Foundation-Structure Interaction in Layered Soil. Open Journal of Civil Engineering, 4, 373-385.
[9] Vaishali M. Tormal, Dr. K. B. Ladhane and Prof. V. R. Rathi (2014) "Effect of Soil Structure Interaction on Response of Multi-storey Building" International Journal of Engineering Research & Technology (IJERT) Vol. 3 Issue 8, August – 2014
[10] IS. 456: 2000, Indian Standard Plain and Reinforced Concrete - Code of Practice, Bureau of Indian Standards, New Delhi.
[11] IS: 875 (Part I) - 1987, Indian Standard Code of Practice for Design Loads (Other than Earthquake) (Dead Loads) for Buildings and Structures, Bureau of Indian Standards, New Delhi.
[12] IS: 875 (Part 2) - 1987, Indian Standard Code of Practice for Design Loads (Other than Earthquake) (Imposed Loads) for Buildings and Structures, Bureau of Indian Standards, New Delhi.
[13] IS 1893 (Part 1):2002, Indian Standard Criteria for Earthquake Resistant Design of Structures, Bureau of Indian Standards, New Delhi.