SOIL STRUCTURE INTERACTION OF A STRUCTURE SUPPORTED ON DIFFERENT FOUNDATIONS

Ravina Meshram[1], l. R. Wankhade[2]

[1]Research Scholar, [2]Professor, Applied Mechanics Department,

Government College of Engineering, Amravati (India)

ABSTRACT

An earthquake is the recognizable trembling of the surface of the earth, which results in the sudden release of kinetic energy in the form of seismic waves. It could be violent enough to cause damages to structures and thus result in great human casualties along with the huge economic loss. The past earthquake studies shows that the interaction of soil and foundation plays a significant role in the response of structure. Also the response of structure during an earthquake is influenced by three linked systems i.e.: the structure, the foundation and the soil surrounding the foundation. Therefore, in the present scenario, seismic analysis of buildings is utmost important.

In this paper, the procedure of static structural, modal analysis and harmonic analysis is stated. The effect of soil-structure interaction on a four storeyed, two bay frame resting on pile and embedded in the cohesive soil is examined by static and dynamic analysis. The finite element based software program ANSYS Workbench 14 is used for the purpose of analysis. Comparisons between responses of the superstructure considered include storey displacements at respective storeys by research paper, static analysis and dynamic analysis is carried out.

Keywords: Soil structure interaction, dynamic analysis approaches, static structural analysis, dynamic modal analysis, Storey displacement,

I. INTRODUCTION

When the relative movement of the tectonic plates leads to shaking of earth's crust causing earthquake. The magnitude of earth shaking varies from very low to high where ground gets separated. Depending on the capacity of structure and magnitude of earthquake, the earthquake may lead to serious damage of the structure. Most of the civil engineering structures involve some type of structural element which in direct contact with ground surface. However, structure and ground are independent to each other and can be seen when earthquake or any other external forces acts on these system neither the ground does not displace, nor does the structure displace. This phenomena is called soil structure interaction (SSI). During Earthquake loading the waves travels always with kinetic energy from ground to the surrounding soil mass as well as the structural part in contact with it. A fraction of the kinetic energy released from earthquake waves is transferred into buildings through soil. The exact estimation of transfer of wave energy from soil to structure and again from structure to soil broadly can be divided into two phenomena like a) kinematic interaction and b) inertial interaction. Such response of SSI which is related with the structural stiffness is referred to as kinematic interaction where as such response of SSI which is related with the structural mass is referred to as inertial interaction.

There are two different approaches that have been adopted in the past to examine the problems of Soil Structure Interaction an assimilate the effect of soil conformity in the dynamic analysis:

• Direct approach

• Sub-structure approach

1. Direct Approach:

In this approach, the soil and structure are assembled together in a single step computing for inertial and kinematic interaction. Inertial interaction acts in structure due to its own strokes giving rise to base shear and moment, which in turn stimulates displacements of the foundation relative to free-field motion. Whereas, the kinematic interaction acts due to existence of stiff foundation elements in or on the soil including foundation motion to vary from free-field motion.

2. Sub-structure Approach:

In this sub-structure approach, the analysis run-down into several steps i.e. the principal of superposition is used to dissociate the two primary causes of SSI i.e. impotence of foundation to adapt the free-field deformation and the reaction of dynamic response of foundation-structure system on the adjustability of supporting soil. In comparison with the direct approach, sub-structure approach is much more complex in assembling the SSI system.

Types of foundation:

The type of foundation system is one of the governing parameter in which interaction parameter depends. For selecting the type of foundation best suited for mid-rise building in high risk seismic zones, design engineers may consider that a shallow foundation, a pile foundation and pile-raft foundation can best to carry static and dynamic loads. However, different types of foundation behave differently during earthquakes, depending upon the soil structure interaction where the properties of the in-situ soil and type of foundation change the dynamic characteristics i.e. natural frequency and damping of soil foundation structure systems. In order to investigate the different characteristics of soil structure interaction and the influence on the seismic response of building frames selection of particular type of foundation should be necessarily done.

II. NECESSITY

When earthquake comes, it damages to the structure not only depends on the behaviour of super structure but also on the sub-soil below it. It was also observed that large concentration of damage in specific areas during an earthquake is due to site dependent factors related to surface geological conditions and local soil. Since then, many researchers have studied the behaviour of the soil subjected to the dynamic loading. Besides field observations, investigations were done experimentally, analytically and numerically. From these investigations, it was understood that the response of soil to dynamic loads plays a major role in the damage of structures. The behaviour of soil becomes much complex and several factors needs to be considered. Therefore, soil-structure interaction (SSI) has been recognized as an important factor that may significantly affect the relative building response, the motion of base and motion of surrounding soil. The former is a result of wave nature of excitation and is manifested through the scattering of incident waves from building foundation and through filtering effect of the foundation that may be stiffer than the soil and therefore may not follow the higher frequency deformations of soil. This interaction depends on frequency, angle of incidence and type of incident waves, as well as shape of foundation and on the depth of embedment. It develops due to presence of stiff foundation elements on or in soil cause foundation motion to deviate from free-field motions. The later is due to inertia forces of building and of the foundation which act on soil due to contact area. It develops in structure due to its own vibrations which gives rise to base shear and base moment, which in turn cause displacements of the foundation relative to free field.

3. Types of Analysis

3.1 Linear Static Structural Analysis:

The static structural analysis can be either linear or nonlinear. A static structural analysis determines the displacements, stresses, strains, and forces in structures or components caused by loads that do not induced significant inertia and damping effects. Steady loading and the response conditions are assumed i.e. the loads and the structure response are assumed to vary slowly with respect to time. A static structural load can be performed using ANSYS, ABAQUS and Samcef solver. Linear static response of structural optimization using finite element method for linear static analysis has been significantly developed.

3.2 Modal Analysis with respect to Harmonic response analysis:

Modal analysis in the ANSYS family of products is a linear analysis. Modal analysis is used to determine the vibration characteristics i.e. natural frequencies and modes shapes of a structure or a machine component while it being designed. In ANSYS, it is starting point for another, more detailed, dynamic analysis such as transient dynamic analysis, harmonic response analysis or a spectrum analysis. After determining frequencies by modal analysis, this frequencies data is used to calculate the parameters like displacement, storey shear, etc. by using harmonic response analysis. Harmonic response analysis are used to determine the steady state response of the structure to loads that vary sinusoidal with time thus enable to verify the design to successfully overcome resonance, fatigue, and other harmful effects of forced vibrations.

IV. MODELING OF THE SUPERSTRUCTURE AND SUB-STRUCTURE

4.1 Super-structure

A finite element modelling is done for the superstructure along with the supporting system using finite element software ANSYS (Workbench 14). The slab of the frame is idealized as three dimensional four-nodded shell elements. Beams and columns of the superstructure frame are idealized as three dimensional two-nodded beam elements.

4.2 Sub-structure

Pile of the sub-structure is idealized as three dimensional six nodded beam elements. Soil is modelled by using Drucker Prager model. A homogeneous deep sandy soil volume of 20m × 20m × 6m is considered for this study.

International Journal of Innovative Research in Science and Engineering
Vol. No.3, Issue 03, March 2017
www.ijirse.com
ISSN (O) 2454-9665
ISSN (P) 2454-0663

4.1 Description of the Building Model

A Three dimensional model of G+4 RCC frame were considered. The model specification and the loading data are given in Table 1

Table 1: Model Description for both cases of analysis

Description	Value
Number of Stories	4
Height of Storey	3 m
Grade of steel	Fe 415
Grade of Concrete	M25
Density of RC members	25 kN/m3
Lateral load on joint	250Kn
Slab thickness	200 mm
Column size	0.3m *0.3 m
Beam size	0.3m*0.3m
Volume of sand	20m*20m*6m

.

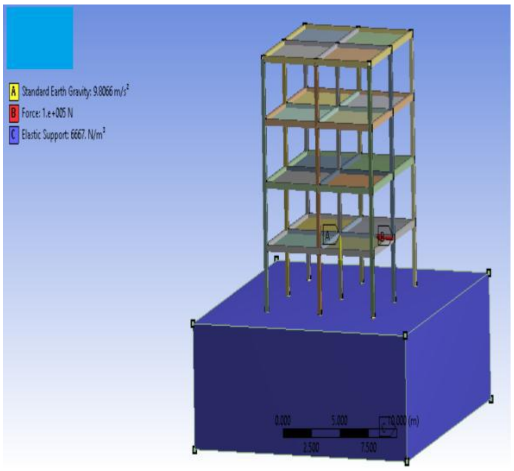

Fig. 1: Extruded model of the building frame resting on piles in contact with the soil

This frame is designed for gravity loads and joint forces in ANSYS Workbench 14. Static structural analysis and Modal and harmonic response analysis is performed on designed frame. Comparison of structural displacement with respect to storey height of rigid base using ANSYS Workbench 14.

V. RESULTS

The results obtained by the static structural analysis and modal dynamic analysis for the given building are as shown in figures.

For case 1: By Considering rigid base calculating storey displacement.

Storey height(m)	Storey displacement obtained from ANSYS by static structural analysis.(mm)	Storey displacement obtained from ANSYS by modal dynamic analysis.(mm)
12	11.688	11.51
9	8.54	9.91
6	6.49	6.19
3	3.2467	2.47
0	0	0

Table 2: Showing results for static structural and modal dynamic analysis.

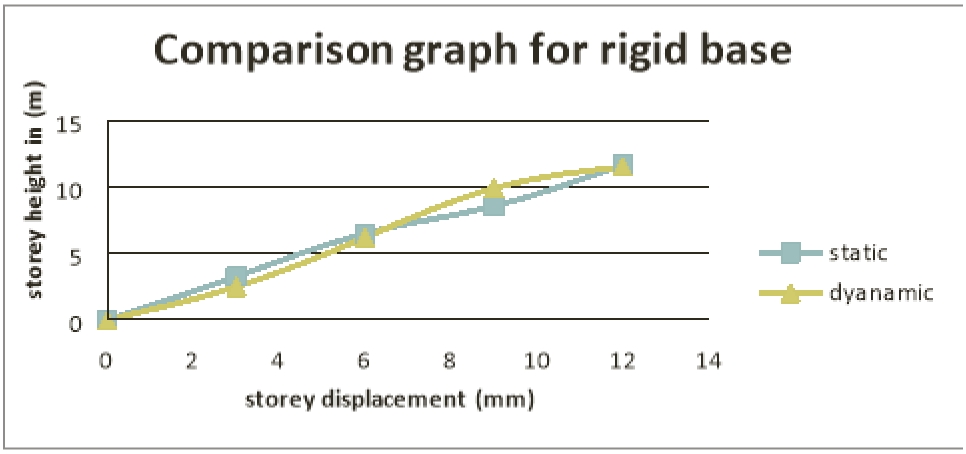

Fig. 2: Showing comparison graphs between static and dynamic analysis

For case 2: By Considering pile foundation of 300mm pile diameter calculating storey displacement.

Storey height(m)	Storey displacement from literature paper [7](mm)	Storey displacement obtained from ANSYS by static method.(mm)
12	52.407	51.03
9	48.583	45.372
6	38.604	39.7
3	24.632	22.686
0	0	0

Table 3: Showing results for static structural and modal dynamic analysis for 300mm pile dia.

ISSN (O) 2454-9665
ISSN (P) 2454-0663

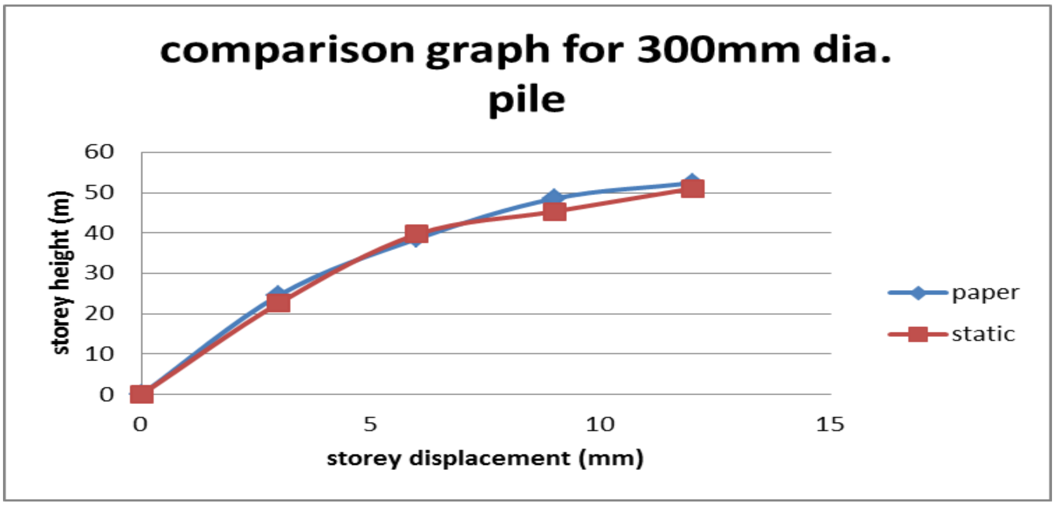

Fig. 3: Showing comparison graphs between static and dynamic analysis for 300mm pile dia.

V. CONCLUSION

Following are the salient conclusions obtained from the present study:

1. Detail study of soil structure interaction is studied.
2. The computational method used for soil structure interaction is studied.
3. Soil structure interaction of a frame is analysed and comparing the results with static and dynamic analysis and they found to be nearly same.
4. Graphs of storey displacement is plotted with respect to storey height.

REFERENCES

1. Bhojegowda V T , Mr. K.G. Subramanya, “Soil Structure Interaction of a Framed Structure supported on different foundation”,International Research journal of engineering and technology, volume: 02, 2015, pp-ISSN: 2395-0072.
2. Lewis Edgers, Masoud Sanayei, “ Modelling the Effects of Soil-Structure Interaction on a tall building bearing on a Mat Foundation” , Civil engineering practice, 2005.
3. Mengke Li, Xiao Lu, Xinzheng Lu, “ Influence of Soil-Structure Interaction on seismic collapse resistance of super tall buildings”, journal of rock mechanics and geotechnical engineering 6, 2014, pp. 477-485.
4. H.Matinmanesh and M. Saleh Asheghabadi, “ Seismic Analysis on Soil-Structure Interaction of Buildings over Sandy soil”, procedia engineering 14, 2011, pp. 1737-1743.
5. Rolf Katzenbach, steffen Leppla, “ Realistic Modelling of Soil-Structure Interaction for High-Rise Buildings”, procedia engineering 117, 2015,pp. 162-171.