Raft Foundation with SSI and without SSI Effects on Different Storey

[1]Meghna Modi, [2]Noopur Shah,
[1] ME Research Scholar, [2]Assistant Professor
[1]Department of Civil Engineering,
[1]SALITER, Ahmedabad, India

***Abstract* - In practice, conventional method of analyzing the structure is by applying its base as FIXED/HINGED. In conventional structural design, SSI effects are not considered. In the present paper, an attempt has been made to carry out a parametric study for analysis of 3 bays x 3 bays space frames will be analyzed. The space frame is supported by raft foundation on Winkler's spring bed. Winkler's spring base is applied in STAAD.Pro by assigning nodal springs having value equal to soil stiffness at the base of discretized plate. The space frame is subjected to various combinations of gravity and earthquake loads. The space frame is analyzed keeping its base fixed and spring (soil) based on and plate mat based on the result of analysis, it is designed as per IS: 456 (2000) and IS: 1893 (2002). Based on Winkler's hypothesis, the soil beneath the footing is modeled as bed of linear springs having stiffness equal to the modulus of subgrade reaction of the soil. The interactive analyses are carried out for 3 different values of modulus of subgrade reaction. A comparison of the maximum nodal displacements of the frame and the time period of the whole structure is done.**

***Keyword* - Soil Structure Interaction (SSI), Winkler Hypothesis, STAAD.Pro**

I. INTRODUCTION

All problems in Civil Engineering involve interaction of structural elements with ground. When forces are applied externally to the structural element, the physics of the problem dictates the structural Element and ground to deform in a compatible manner. This is because of inherent intendancy of structural-element displacements and ground displacements by the virtue of their intimate physical contact. Therefore, these types of problems are broadly referred to as Soil-structure interaction (SSI) problems.

In conventional structural design, SSI effects are not considered. Neglecting SSI effect for a relatively flexible structure founded on hard soil is reasonable. But, for a relatively stiff structure founded on either soft or medium soil neglecting SSI has a great impact on structural response and design. IS 1893(Part I):2002 suggests that SSI may not be considered in the seismic analysis of structure supported on rock or rock like material. But, the code does not provide a standard procedure for considering SSI in the seismic analysis, hence the guidelines given by FEMA 356 has been considered to incorporate the SSI effect in the seismic analysis of RC building.

The strength of building and foundation are the two things to be considered while studying the behavior of the structure. Foundation is that part of structure to transmit loads from structure in to the sub-soil. Raft foundations are required on soil of low bearing capacity and are useful in reducing differential settlement. It is commonly used beneath multistoried building, silo clusters, chimney etc. [1] [2]

II. SOIL STRUCTURE INTERACTION MODELS

Basically there are two types of derivation approaches used for models of SSI problems; structural and continuum approach. The structural approach has a rigid base from which subgrade and superstructure are built up with structural elements, such as flexural elements, springs, etc. The other alternative, continuum approach is based on three partially-differential equations (compatibility, constitutive and equilibrium) which are governing the behavior for the subgrade as a continuum (Teodoru, 2009). When combining the two derivation approaches, the method is called a hybrid derivation approach.

III. CONVENTIONALLY FIXED BASED MODEL

Fixed base analysis has been carried out on a regular multistory frame in the present study. Different combinations of dead load, imposed load and seismic load as per the relevant code provisions have been considered and the critical values of stresses and displacements are evaluated. The analytical models of the frame include all components that influence the mass, strength, stiffness and deformability of structure. [3]

IV. WINKLER MODEL

Effect of SSI is considered by Winkler model. It is also the oldest and simplest method to model the subgrade. Winkler's idealization represents the soil medium as a system of identical but mutually independent, closely spaced, discrete, linearly elastic springs. The merit of this model is that it uses only one parameter (the modulus of sub-grade reaction, better known as the "k" parameter) to represent the soil. The load deflection equation for this case can be written as:

$$P = k \times delta$$

Where P is load, delta is settlement and k is modulus of subgrade reaction. [2]

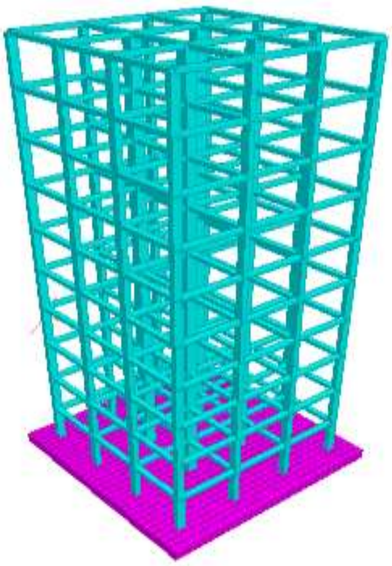

Fig.1 Winkler Model

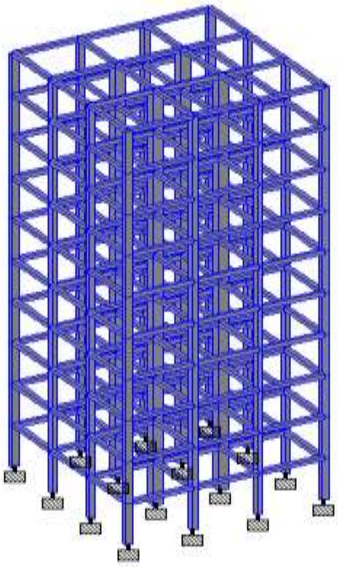

Fig.2 Fixed Based Model

V. METHODOLOGY

Hard Soil, Medium Hard Soil and Soft Soil are the three types of soil upon which the structural frames are considered to be resting. The details of building frames, foundation and soil mass considered for the study are given in Table I.

VI. DESCRIPTION OF THE BUILDING

A 3x3 bays with G+8, G+12 and G+15 storey R.C. Frame building is considered for the present study to investigate SSI effects on tall buildings. The plan dimension of the building is 12.0 m by 12.0 m and the height of the building is 32 m, 44.8 m, and 54.4m from the ground level for G+8, G+12 and G+15 storey building respectively.

Table 1: Building Details

Component	Description	Data
Frame	No. of Storey	G+8, 12 and 15
	No. of bays in X and Z direction	3 x 3 bays
	Storey height	3.2m
	Bay width in X and Z direction	4m x 4m
	Size of beam	300mm x 450mm
	Size of column	600mm x 600mm
	Thickness of slab	125mm
Foundation	Soil Bearing Capacity	120 kN/m^2
		200 kN/m^2
		300 kN/m^2
	Poissons Ratio of Concrete	0.5

VII. RESULTS

Table 2: Maximum Nodal Displacement

Maximum Nodal Displacement			
Model	SBC kN/m^2	Fixed Based mm	Winkler Model mm
G+8	120	101.71	206.948
	200	82.33	148.083
	300	60.904	93.665
G+12	120	61.524	166.138
	200	50.103	106.306
	300	36.841	67.498

Table 3: Time Period

Time Period			
Model	SBC kN/m^2	Fixed Based Sec	Winkler Model Sec
G+8	120	2.826	3.62
	200	2.826	3.328
	300	2.826	3.172
G+12	120	2.577	3.73
	200	2.577	3.324
	300	2.577	3.101

G+15	120	80.998	195.637
	200	66.955	130.27
	300	48.497	85.089

G+15	120	3.23	4.374
	200	3.23	3.974
	300	3.23	3.757

VIII. CONCLUSIONS

Present paper investigates the effect of soil structure interaction on the structural behavior of a building during an earthquake. Variation in Time period and Maximum nodal displacement are observed. The analysis results shows that soil structure interaction shows significant changes in the response of building during an earthquake which is not addressed by IS1893 explicitly. Maximum nodal displacement results gives higher value in winkler model compared to fixed based model when applying different soil bearing capacity. Time period also gives higher value of winkler model then fixed based model. Soil structure interaction effect is more in winkler model compare to fixed base model. Soil Structure Interaction effects is more significant in a soft soil compared to the hard soil.

IX. REFERENCES

[1] Miss. Anjali B, Dr. Raji. M, “Seismic Analysis and Soil Structure Interaction of Multistoried Building with Different Types of Footing.” International Journal of Engineering Research & Technology (IJERT), 2015

[2] Dr. D. Daniel Thangaraj, Dr. K. Ilamparuthi, “Parametric Study on the Performance of Raft Foundation with Interaction of Frame” EJGE, 2010

[3] Nithya Chandran J, Abhilash Rajan, Soni Syed, “Seismic Analysis of Building with Underground Stories Considering Soil Structure Interaction.” International Journal of Emerging Technology and Advanced Engineering Volume 4, Issue 11, November 2014