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A Performance Study of Response of (G+20) Regular and Braced RC Building Under the Effect of Soil Structure Interaction (SSI)

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Abstract - *In the construction of high rise structure the **SOIL STRUCTURE INTERACTION (SSI)** should be consider in evaluation of stiffness and strength of structure. Usually in the seismic design of ordinary bldg, soil structure interaction is neglected. But the lateral loads (Seismic & wind forces) work as an main role in the construction of high rise structures. The structure is analyzed for its structural behavior assuming base condition as fixed base. it is observed that effect of soil structure interaction is changes as the flexibility of soil varies. i.e., for fixed as well as for various flexible base conditions, i.e., for hard, medium and soft soil. In this study G+20 structure is analyzed with the help of STAAD-Pro V8i software, by equivalent static method with Winkler's approach method. considering three different soil types and compared with different arrangements of bracings system. This study reveals that SSI significantly affects the response of structure. The different parameters like Base shear, roof Displacement, Drift-ratio are considered to evaluate the output of plane frame and structures with different bracing system of models. and it is represented in the form of tables & graphs which will help us to understand the behavior of braced structure under the effect of soil structure interaction and also to suggest the better performance among the structures.*

Key Words: (**Equivalent Static Method, Soil Structure Interaction, Winkler's Theory, Seismic Forces, Bracings, Staad-pro V8i**)

1. INTRODUCTION

An Earthquake occurs because 0f moment of large tectonic plates and due to out come of manmade unexpected rupture. In the era 0f fast growing urbanizati0n due to paucity of land, structure are constructed on available relatively softsoil which 0therwise were deemed t0be unsuitable for constructi0n in the past.

India is gradually developing in size & integral 0f structure, where as buildings are heavy and large with the effect of SSI is not considered at the starting but from last 3 to 4 decades, the consideration of SSI effect while designing the structure is become important. The out-turn of SSI effect for low rise building can be neglected. And for heavy buildings i.e. bridges, tall structures, silos-tall chimneys, highways are considered.

1.1 SOIL STRUCTURE INTERACTION

SSI account with Interaction between structure & sub s0il. The phen0mena maybe defined as "The process in which the response of soil influences the motion of structure & motion of structure influence the response of the s0il is termed as SSI".

When the structure is founded 0n soft or medium soil. Thus, there is an interaction between the structure behavi0r and the foundation soil response known as the soil structure interaction (SSI).the structure interacts with soil medium the behavior to the lateral load on the structure. Soil doesn't show the similar characters with the different surrounding area, environmental & climatic conditions. Soil interaction effect is more in the heavier and softer soil medium

1.2 WINKLER'S THEORY

According to Winkler's-approach the deformation of foundation due to applied load is restricted to loaded regi0ns 0nly. The basic difficulty with the use of Winkler's model is to determine the stiffness elastic springs which is replaced with foundation below the soil. The care should be taken to analyses the behavior 0f subgrade stiffness numerically to use in a practical pr0blem.

The G.GAZETAS formulas are used for determination 0f spring constants which are given in above Table I..,

Degree Of Freedom	Stiffness Of Equivalent Soil Spring
Vertical	$[2GL/(1-v)](0.73+1.54\alpha^{0.75})$ with $\alpha = A_b/4L^2$
Horizontal(lateral direction)	$[2GL/(2-v)](2+2.50\alpha^{0.85})$ with $\alpha = A_b/4L^2$
Horizontal (longitudinal direction)	$[2GL/(2-v)](2+2.50\alpha^{0.85})-[0.2/(0.75-v)]GL[1-(B/L)]$with $\alpha = A_b/4L^2$
Rocking (about longitudinal)	$[G/(1-v)]I_{bz}^{0.75}(L/B)^{0.25}[2.4+0.5(B/L)]$
Rocking (about lateral)	$[G/(1-v)]I_{by}^{0.75}(L/B)^{0.15}$
Torsion	$3.5GI_{bz}^{0.75}(B/L)^{0.4}(I_{bz}/B^4)0.2$

Table- I:Spring Stiffness Formulae

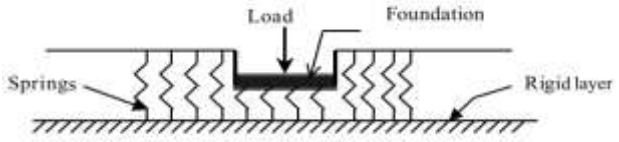


Fig.1.2 Winkler foundation

1.3 AIMS AND OBJECTIVES OF THE PRESENT STUDY

1. To analysis the Impact of soil structure-interaction(SSI) with different arrangements of bracing in RCC building.
2. To investigate the influence of soil structure interaction taking into consideration 3 dissimilar soil strata's by the method of Winkler's-Approach theory.
3. For the better performance of RCC structure to investigate the suitable arrangement of bracing system with effect of SSI..

1.4 METHODOLOGY

1. The study is carried out in the form of modeling and analysis, by using the non linear static method by the Staad-Pro V8i software.
2. By comparing the Winkler Approach and Elastic Continuum approach (FEM) method for SSI, the Winkler Approach gives accurate reaction results as well as good physical behavior of soil.
3. The above studies, along with assumed cases of RCC buildings of with various types of bracings, should be the basis for choices of promising structural systems. These structural systems were to be further studied in the project.
4. Finally, the report ends with results of comparison between the conventional building with different types of Braced RCC building by using Winkler approach under the effect of SSI.

Table -II: Calculated Soil-Stiffness Of the Spring

Stiffness Of the Spring	Soil type	
	Medium	Soft
Vertical	94583.33	40535.71
Horizontal(Lateral Direction)	878906.25	376674.107
Horizontal(Longitudinal Direction)	878906.25	376674.107
Rocking (About Longitudinal)	146416768.9	62750043.8
Rocking(About Lateral)	50488541	21637946.4
Torsion	11646.753	4991.4654

2. LITERATURE REVIEW

Dhiraj Raj*, Bharathi M(2013) – According to this paper author considered G+4 RC bldg. which is located in seismic zones of IV & V on different type of soil i.e., hard, medium and soft soil. The bldg is analyzed as per IS1893(PART-I) with fixed foundation RC bldg of diff braces having different location. This study reveals that time period of structure with braces the SSI effect increases by 100% . When compared to same type of bldg found on type-3 soil with fixed base. The increase in time period is 50% and increases in the storey drift also. When the founded on type-2 soil with the fixed base.

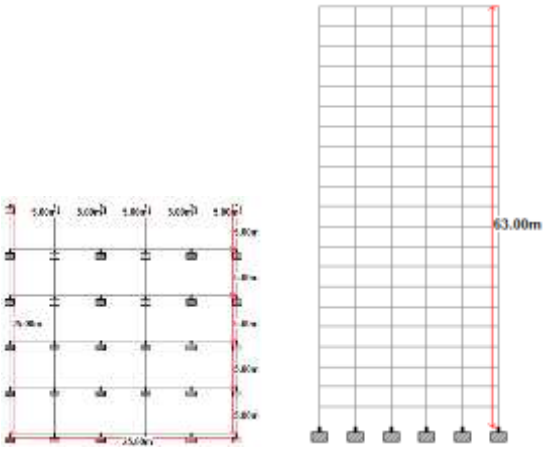
S.M.Barelikar et al., S.A.Halkude (2014) – This study contains of RC frame resting on raft footing. By the help of 2 different approaches of winklers (spring) model, and elastic continuum (FEM) model. The different parameters are checked on the effect of soil structure i.e., baseshear, displacement, fundamental time period etc.. were studied. It is examined that SSI constanly affects the structural performance.

N. Anand , R.M. Jenifer Priyanka, (2012) – The ten st0rey RCC frame with rigid and flexible base is analysed in Staad-Pr0 . With the help of Response spectrum meh0d for different soil starta hard, s0ft, and medium with considering zone-IV has been analyzed. Base shear, Deflection, storeydrift, column moment and axial forces are calculated f0r both Base 0ondition.

3. MODELLING AND DETAILS OF STRUCTURE

In this thesis main structure is of G+20 RCC building with different bracing arrangements are considered. Using the spring stiffness formula' s (as per Winkler's theory) the stiffness of soil flexibility with respective structure is found in the software [Staad Pro V8i]. Present project is considered a plan of G+20 RCC structure, having geometry for analysis. The structure is investigated for 3foundation soils: HARD , SOFT, MEDUIM with various types of bracings and there position, orientation, and foundation with and without SSI, have been considered for analysis.

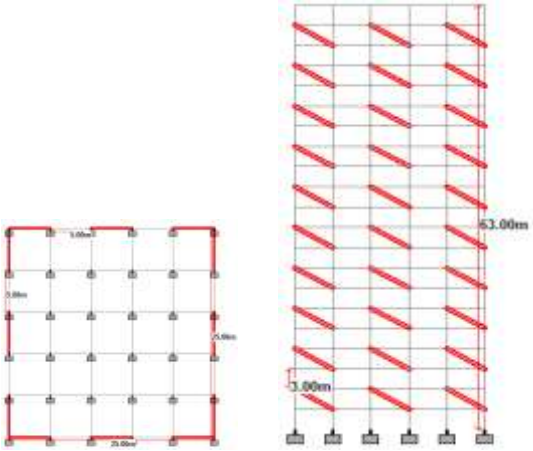
The floor to floor height is 3m and 5m C/C and the area is 25 x25m is taken as the bay width on both side of the X & Y axes in the plan of structure.



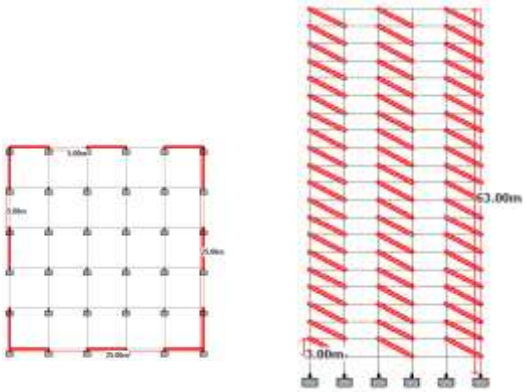
Model.1 Plan & elevation of the structure

Table - III: Sizes of Structural Members

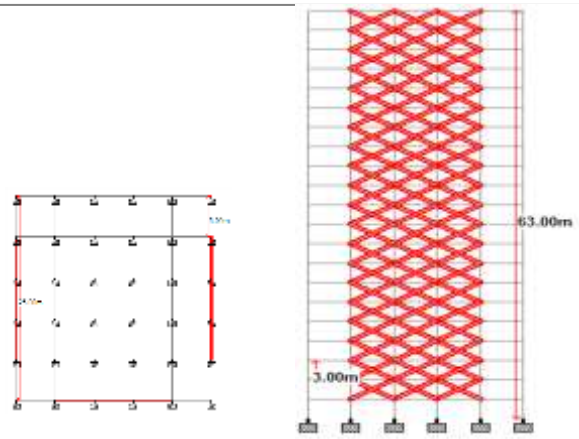
Sr. No	Structural Member	Size
1	Columns for Ground floor to 14th floor	690mm X 690mm
2	Columns on 15th & 20th floor	450mm X 450mm
5	Beams	450mm X 400mm
6	Thickness of slab	150mm
8	Exterior and Interior wall thickness	230 mm
9	For all type of bracing (X-bracing, diagonal bracing, alternate bracing)	140mm X 140mm



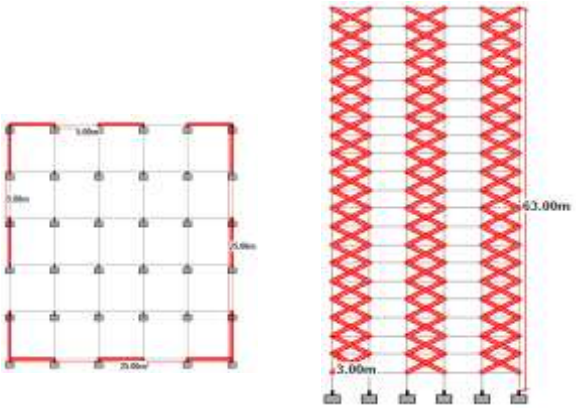
Model.2 Plan & elevation of the structure Cross bracings are diagonally @ alternate corners of structure



Model.3 Plan & elevation of the structure Cross bracings are @ alternate periphery of structure



Model.4 Plan & elevation of the structure X bracings are @ mid of structure



Model. 5 Plan & elevation of the structure X bracings are @ periphery of structure

4. RESULT AND DISCUSSION

From seismic behavior 0f RC structure with and without bracing-arrangement with various support condition, the results are Obtained from the software (STAAD-PRO V8i) are discussed and observed.

TABLE-IV : BASE SHEAR in (kN)

MODELS	TOTAL BASE SHEAR		
	HARD	SOFT	MEDIUM
MODEL -1	3521.7163	5894.50	4795.52
MODEL -2	3526.1421	5901.9116	4801.55
MODEL -3	3530.569	5909.321	4807.583
MODEL -4	3539.350	5924.142	4819.641
MODEL -5	3539.423	5925.144	4819.641

TABLE-V : ROOF DISPLACEMENT in (mm)

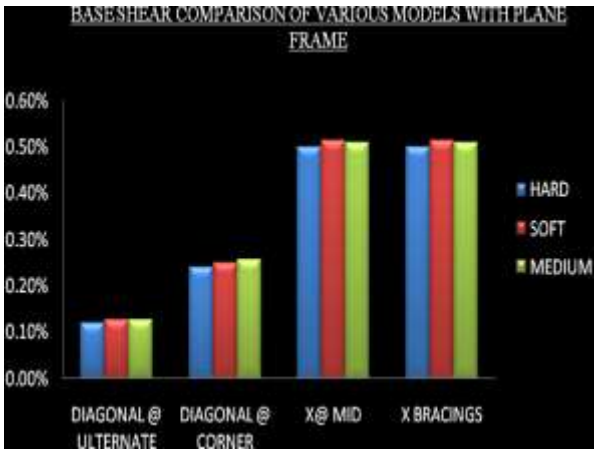
MODELS	ROOF DISPLACEMENT		
	HARD	SOFT	MEDIUM
MODEL -1	152.681	219.685	288.633
MODEL -2	123.831	183.234	224.884
MODEL -3	109.350	166.109	203.961
MODEL -4	81.462	125.295	152.914
MODEL -5	100.557	155.293	189.7

TABLE-VI : STOREY DRIFT in (mm)

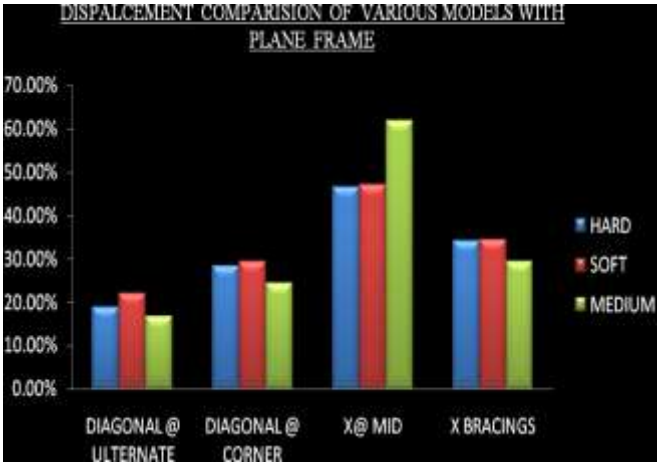
MODELS	STOREY DRIFT		
	HARD	SOFT	MEDIUM
MODEL -1	2.727	4.03	5.535
MODEL -2	2.636	3.977	4.881
MODEL -3	3.056	4.597	5.582
MODEL -4	2.182	3.381	4.081
MODEL -5	3.376	5.052	6.14

4.1DISCUSSION

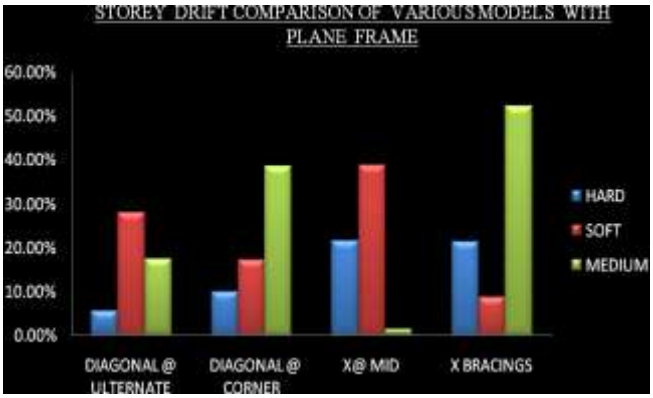
GRAPH –I: BASE SHEAR COMPARISION OF VARIOUS MODELS WITH PLANE FRAME



GRAPH –II: DISPLACEMENT COMPARISION OF VARIOUS MODELS WITH PLANE FRAME



GRAPH –II: STOREY-DRIFT COMPARISION OF VARIOUS MODELS WITH PLANE FRAME



5. CONCLUSIONS

a) Base Shear

The base shear 0f the building rises due t0 SSI effect, the effect of base shear is m0re as soil strata bec0mes s0ft. the base shear is high in the structure with **X- bracing** 5924.14 in flexible base , and less in the structure with alternate diagonal bracing 3526.14. therefore the total increment of base -shear is 15% to 50% from hard to flexible base.

b) Roof Displacement

From upshot of analysis the displacement is decreses in structure with **X- bracing @ mid** is 125.295mm in medium soil, where as increased in structure with 224.884mm. so the decrement of displacement in structure ranges from 62% to 16% from hard soil to soft soil.

c) Storey Drift

Certain floors of structure sways more, so by the outcome it can be decided that by decreasing the storey drift of the structure , the destruction can be minimized. In structure with **X- bracing @ mid** is reduced by 38.91% in flexible base compared to other structures.

According to above parameters we can prefer the building with the **X –Bracing @ Mid** of the structure is suitable for better performances in soft or flexible base. It can resist the seismic forces and reduces damages, so it is safe and economical.

SCOPE FOR FURTHER STUDY

1. The analysis can be further extended for unsymmetrical buildings.
2. For the different foundation types i.e raft- footing, isolated and pile foundation etc. the soil structure interaction can be investigated.
3. Similarly SSI is investigated for composite structure.
4. Elastic Continuum Method is used for various soil models.
5. The time history method, Non linear dynamic Analysis, Response spectrum Analysis etc,, are used for further study for realistic and better assessment of structural response under seismic forces

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