Comparative Study of V & X Bracing on Seismic Performance of Steel Structure Considering SSI

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Abstract-*In order to study structural behavior under seismic excitation forces, it is prominent to study the effects of soil structure interaction (SSI). In present study, attempts have been made to study the influence of soil structure interaction on seismic behavior of steel structure considering two different bracing systems V and X bracing. Usually the structural behavior is analyzed assuming the fixed support conditions at the base of structure. In conventional method the foundation flexibility of soil mass is ignored which is likely to affect the structural response of building. The soil flexibility is integrated in the analysis of structure using Winkler's spring model approach. For analysis G+11 multi storey steel building is considered with two different bracing arrangements. Three different soil strata's i.e. hard, medium and soft are used for SSI study. The dynamic analysis is carried out in STAAD.ProV8i SS6 software using response spectra of IS 1893-2002. The effect of SSI on various parameters like base shear, natural time period, storey drift, storey displacement, etc are studied and discussed. To get real behavior of superstructure the subgrade must be modeled adequately well. The study reveals that the SSI significantly affects the performance of the structure.*

Keywords-Soil Structure Interaction (SSI), Seismic behavior, Steel structure, Bracing system, Response spectrum method.

I. INTRODUCTION

1.1 General:

An earthquake is a shaking of the ground caused by sudden rupture and movement of large tectonic plates. Earthquakes are either tectonic or non-tectonic, about 90 percent of earthquakes are tectonic and 10 percent earthquakes are due to volcanism, manmade effect etc.The Indian sub-continent has a history of devastating earthquakes. After Killari (1993), Jabalpur (1997), and Bhuj (2001) earthquake it is clear that no part of the country is free from the seismic hazard. The main reason for the high intensity of earthquake in India is because of the movement of Indian plate towards the Eurasian plate at the rate of 49mm per year approximately. Geographical statistics shows that the India has almost 54 percent of land vulnerable to seismic hazards. The advance countries like USA, Japan are already constructing the structures which can resists the earthquake of magnitude 7 and above. Unfortunately in India not much awareness has been created in society, about the importance of constructing earthquake resisting structures.

1.2 Need of soil structure interaction:

In India from last few decades there is significance increase in the infrastructural development of country. There is gradually increase in size and embedment of structure. Since the structure are huge and heavy the effect like SSI are to be considered during the design procedure of such structures. The effect of SSI on structure is not considered in early stage of construction practices. But since last3-4 decades it has achieved prominent importance to consider the SSI while designing the structure. The effect of SSI for light structure such as low rise building can be neglected but its effect on heavy structure like high rise buildings, bridges, tall chimneys, nuclear power plants (NPP), elevated highways becomes prominent for better performance of structure during earthquake.

Many researchers have suggested different methods to study the effect of soil structure interaction during last few decades. Winkler's spring model (1867) represents the soil medium as of identical but mutually independent, closely spaced, discrete, linearly elastic springs. George G Gazetas (1991) has presented complete set of algebraic formulas and dimensionless charts for readily computing the dynamic stiffness of springs which represents the soil medium. [8] H.R.Tabatabaiefar et al. (2010) studied the seismic behavior of steel structure on soft soil considering soil structure interaction [2].

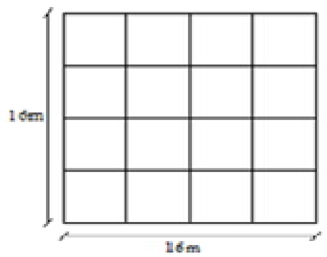
1.3 Objective of study:

The primary objective of this work is to study the seismic response of Steel frame structure by response spectrum analysis using STAAD.PRO V8i SS6 software. The study has been carried out to investigate the influence of soil structure interaction with different bracing arrangements in steel structure, also to understand the influence of SSI on the seismic performance of steel structure considering three different soil strata's.

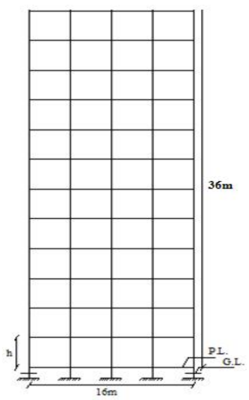
II. STRUCTURAL MODELLING

For the analysis of work a high rise steel frame building G+11 floors is considered. The behaviour of this building is studied during earthquake excitation forces considering the soil structure interaction. The building is 36m high and width is 16m, height of typical storey is 3m. Building is symmetrical along both the X and Y-axis having 4 bays on each side, each bay of 4m.Raft footings are considered to be resting on three types of soil strata's namely, hard soil, medium soil and soft soil.

A. Plan And Elevation Of Building



(a) Plan



(b) Sectional Elevation

Table1
Soil Elastic Constants

Soil type	Modulus of Elasticity (kN/m^2)	Unit Wt. (γ)	Poisson Ratio (μ)
Hard	65000	16	0.3
Medium	35000	16	0.4
Soft	15000	16	0.3

Table 2
Geometric & Material Properties Of Building

Description	Data
Number of story	12
Number of Bays in X direction	4
Number of Bays in Y direction	4
Bay width in X direction	4m
Bay width in Y direction	4m
Storey height	3m
Section used for beam	ISMB 400
Built up section used for Column	FR 2ISMC 400
Foundation type	Raft

B. Winklers spring model

Soil structure interaction is carried out by using Winkler's approach [1] by considering equivalent springs with six degree of freedom (fig.1) which represents the soil medium. Each spring has specific stiffness which depends upon the properties of respective soil conditions. The stiffness is calculated by George Gazetasformulas [8] and shown in table 3.

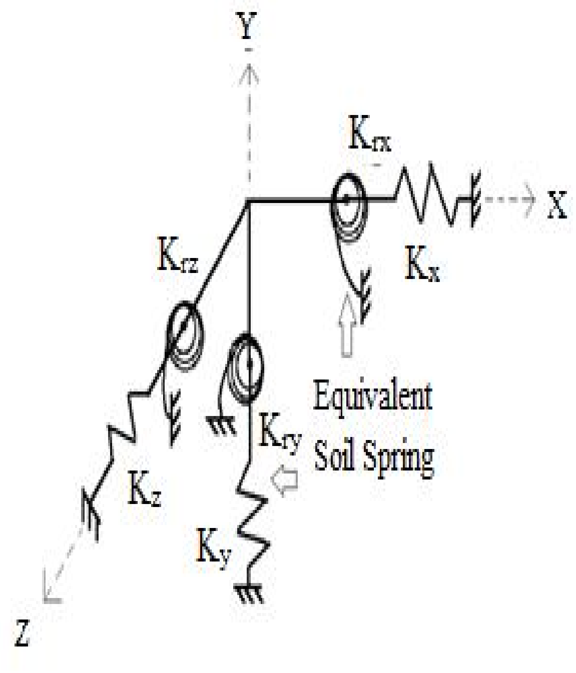


Fig.1 Equivalent spring stiffness

Where, Kx, Ky, Kz = Stiffness of equivalent soil springs along the translational DOF along X, Y and Z axis. Krx, Kry, Krz= Stiffness of equivalent soil springs along the rotational DOF along X,Y and Z axis.

Table 3
Sring Stiffness Formula (G Gazetas)[8]

Degrees of freedom	**Stiffness of equivalent soil spring**
Horizontal (lateral)	$[2GL/(2-\nu)](2+2.50\chi^{0.85})$ with $\chi = (A_b/4L^2)$
Horizontal (longitudinal)	$[2GL/(2-\nu)](2+2.50\ \chi^{0.85})$ -$[0.2/(0.75-\nu)]GL$ $[1-(B/L)]$ with $\chi = A_b/4L^2$
Vertical	$[2GL/(1-\nu)](0.73+1.54\chi^{0.75})$ with $\chi = A_b/4L^2$
Rocking (about Longitudinal)	$[G/(1-\nu)]I_{bx}^{0.75}(L/B)^{0.25}\ [2.4+0.5(B/L)]$
Rocking (about Lateral)	$[G/(1-\nu)]I_{by}^{0.75}(L/B)^{0.15}$
Torsion	$3.5G\ I_{bz}^{0.75}(B/L)^{0.4}(I_{bz}/B^4)^{0.2}$

Table 4
Calculated Spring Stiffness For Soil Spring

Degee of Freedom	**Calculated Stiffness of Soil**		
Type of Soil	Hard	Medium	Soft
Horizontal(lateral direction)	208566.75	106586.5	45928.98
Horizontal(longitudinal direction)	208566.75	106586.5	45928.98
Vertical	290756.62	150856.1	68123.76
Rocking(about longitudinal)	515024.42	254812.2	109542.17
Rocking(about lateral)	548242.36	262842.6	113281.13
Torsin	1025766.1	52176.21	19012.87

III. PARAMETRIC STUDY

The effect of different base condition on seismic performance of steel structure is studied considering soil structure interaction (SSI). Effect of SSI on steel structure is carried out considering the following parametric study.

C. Base shear

The variation of base shear in both X- bracing system and V- Bracing system is represented as follow;

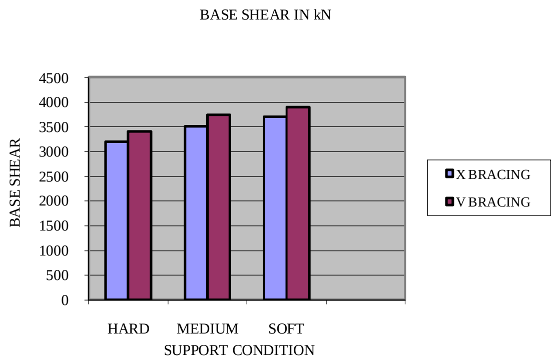


Fig. 2 Base shear in X and V Bracing building

From Fig.2 it is observed that the base shear significantly decreases in X-bracing building as compared to base shear in V bracing system. Also base shear in X-bracing decreases with flexibility of soil. While on other hand in V-bracing it increases with increase in flexibility of soil.

D. Lateral deflection

The variation of lateral deflection in both X- bracing system and V- Bracing system is represented as follow;

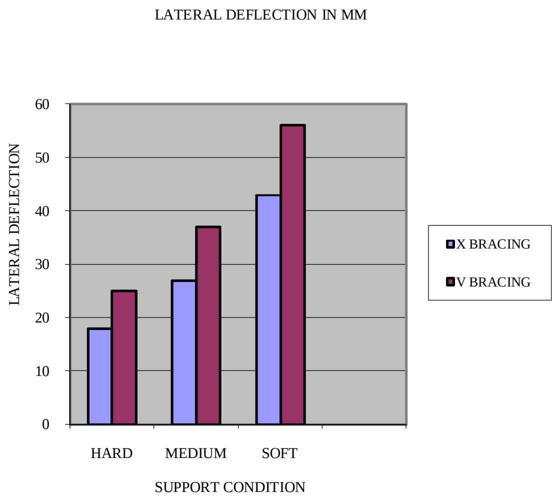


Fig. 3 Lateral deflection in X and V Bracing building

From above figure it can be noticed that deflection in V-braced steel structure is much more than the deflection in X-braced steel structure. The deflection goes on increasing with increase in the flexibility of soil. In both the bracing system the lateral deflection is increased with the flexibility of soil.

E. Time period

Time period as per IS 1893 (Part 1) 2002 clause no.7.6.2. is equal to;

$T_a = (0.095h)/(B)^{0.5}$

$T_a = 0.855$ sec

Table 5

Modal Time Period

Type of bracing	Modal period for 1st mode shape		
	Hard	Medium	Soft
X-bracing	2.5	2.8	3.0
V-bracing	2.65	2.75	3.1

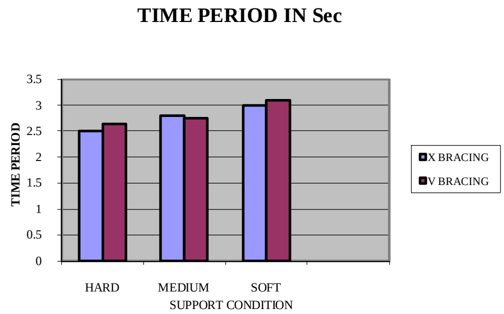


Fig. 4 Time period in X and V Bracing building

From above figure it is observed that time period for X-bracing is less as compared to the time period of V-bracing structure. Time period increases with increase in the flexibility of soil as we can see in above graph.

IV. CONCLUSION

- Base shear and lateral deflection in X-braced steel structure is less as compared to the V-braced structure.
- Time period of structure increases due to SSI effect. It increases with the flexibility of soil; time period is main parameter which regulates the seismic performance of structure. Thus evaluation of this parameter without considering SSI effect may cause severe error in seismic design of building.
- Considering SSI effect is prominent for steel structure building since support conditions on site are not rigid, it possess some flexibility due to different soil conditions.
- Winkler's approach has proved to be a very useful method for studying the effect of soil structure interaction phenomena the word "data" is plural, not singular.

REFERENCES

[1] S.A.Halkude, M.G.Kalayanshetti, Barelikar S.M. (2014) "Seismic response of R.C. frames with raft footing considering soil structure interaction" J Gate IJCET Vol No.4.

[2] H.R.Tabatabaiefar, B. Samali, B.Fatahi (2010) "Seismic behavior of steel moment resisting buildings on soft soil considering soil structure interaction" Research Gate

[3] M.E.BoostaniDarmian, M.AzhdaryMoghaddam, and H.R.Naseri (2011) "Soil structure interaction in steel braced structure with foundation uplifts", IJRRAS, Vol.7, Issue 2

[4] S.Hamid Reza Tabatabaiefar, BijanSamali, BehzadFatahi (2013) "Seismic behavior of building frams considering dynamic soil structure interaction" ASCE, International journal of geomechanics.

[5] K.K.Sangle, K.M.Bajoria,V.Mhalungkar(2012)"Seismic analysis of high rise steel frames with and without bracing", 15 WCEE, LISBOA

[6] Vaishali M. Thormal, Dr.K.B. Ladhane, Prof. V.R.Rathis(2014)"Effect of Soil structure interaction on response of multistory building",IJERT,Vol. 3, Issue 8

[7] S.A.Halkude, M.G.Kalayanshetti, V.A.Kadlag (2015) "Push over analysis of R.C. frames considering soil structure interaction", International journal of current Engineering and Technology, Vol.5, NO.1.

[8] George Gazetas(1991)"Formulas and charts for impedances of surface and embedded foundations" ASCE