SEISMIC RESPONSE OF R.C. STRUCTURES WITH DIFFERENT STEEL BRACING SYSTEMS CONSIDERING SOIL-STRUCTURE INTERACTION

[1]Kishor Shinde, [2]Shrirang Tande
[1]MTech (Structure), Walchand college of Engineering, Sangli, Maharashtra, India
[2]Professor, Applied Mechanics Department, Walchand college of Engineering, Sangli, Maharashtra, India

Abstract : The main objective of the study is to investigate the Seismic Response of R.C. Structures with Different Steel Bracing Systems Considering Soil-Structure Interaction. Steel bracing is a highly efficient and economical method of resisting horizontal forces in a RC frame structure. Bracing has been used to stabilize laterally the tallest building structures. the seismic performance of the steel X, Chevron, Inverted diagonal and Eccentrically braced frame structures are investigated considering SSI. The seismic response of a structure is greatly influenced by Soil Structure Interaction (SSI). In this study the effect of soil flexibility on the performance of building frame is investigated. The study is carried out by replacing soil by spring of equivalent stiffness (Discrete Support). Symmetric space frames resting on isolated footing of configurations 4X4 bay 12 storey(4X4X12) is considered with fixed base and flexible base. The spring model is developed by using stiffness equation along all 6 DOF using SAP-2000. For SSI study three types of soil are considered i.e. Hard, Medium Hard and Soft Soil. The dynamic analysis is carried out using Response Spectrum, given in IS1893-2002. The influence of soil structure interaction on various structural parameters i.e. natural time period, base shear, roof displacement, max. column reaction are presented. The study reveals that the SSI significantly affects on the response of the structure as well as bracing system.

***IndexTerms* - Bracing system, Isolated footing, Response spectrum , SAP2000 ,Soil structure interaction (SSI)**

I. INTRODUCTION

Some recent earthquakes (Kobe, 1995) highlighted that seismic behavior of a structure is highly influenced not only by the super structural response but on the response of the foundation and ground. Hence, the seismic analysis of a structure strongly recommends the usage of a whole structural system considering the superstructure, foundation and ground giving rise to an area called Soil Structure Interaction (SSI). SSI is the phenomenon where the response of the soil influences the motion of the structure and vice versa. In conventional structural design method, 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 – 2002 strongly recommends that SSI may not be considered in the seismic analysis of structure supported on rock or rock like material. But, the code does not suggest a standard procedure for considering SSI in the seismic analysis, hence the guidelines given by FEMA 356 and FEMA 440 has been considered to incorporate the SSI effect in the seismic analysis of RC building. The seismic analysis of RC building is done by creating a 3D model in SAP 2000 using response spectrum

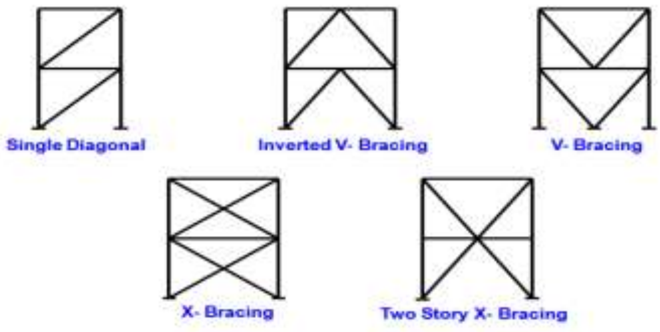
1.1 Soil-Structure Interaction (SSI)

Soil-Structure Interaction (SSI) is phenomena in the response of structures caused by the flexibility of the foundation soils, as well as in the response of soils caused by the presence of structures. Analytic and numerical models for dynamic analysis typically ignore SSI effects of the coupled in nature structure foundation-soil system. It has been recognized that SSI effects may have a significant impact especially in cases involving heavier structures rest on soft soil conditions.

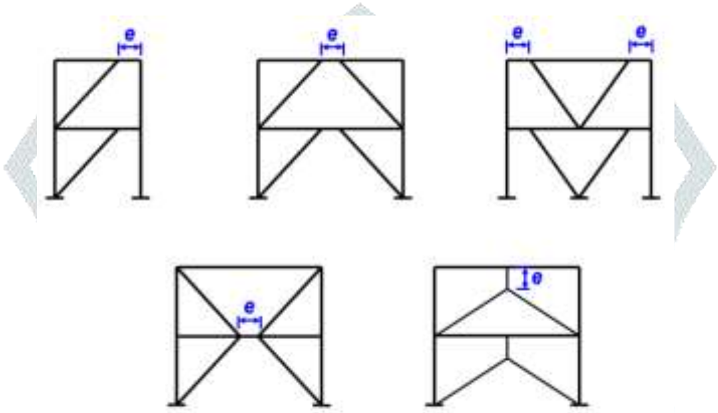
1.2 Bracing systems

Steel bracing is a highly efficient and economical method of resisting horizontal forces in a RC frame structure. Bracing has been used to stabilize laterally the tallest building structures.

- **Concentrically braced frames-**



- **Eccentrically braced frames-**



II. OBJECTIVE OF STUDY

This proposed work is to be focused on the Seismic Response of R.C. Structures with Different Steel Bracing Systems Considering Soil-Structure Interaction resting on isolated footing.

I. Modeling and analysis of regular R.C. building

II. Modeling and analysis of building with Different Bracing Systems

III. Comparison of building with fixed foundation & with SSI

IV. Comparison of various bracing systems used

III. PROBLEM FORMULATION

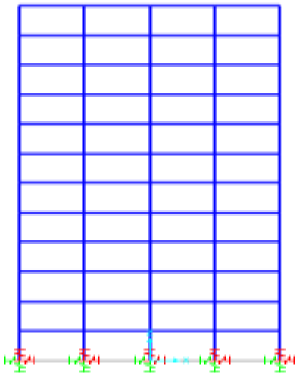
For this study, an 12-storey with 4 bays frame (Each bay span 5 m) and floor height 3.0m, regular in plan is considered. This building is considered to be situated in seismic zone 'iv' and designed in compliance to the Indian Code of Practice for Earthquake Resistant Design of Structures. The building is modeled using software SAP 2000 and analyzed by response spectrum method.. Model is studied for comparing, base shear, time period, top storey displacement and storey drift as follow:

Following models are considered for this study.

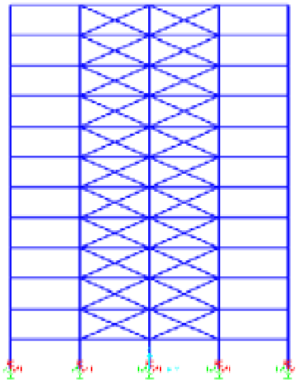
1) Regular building and

2) Four models with different bracing systems.

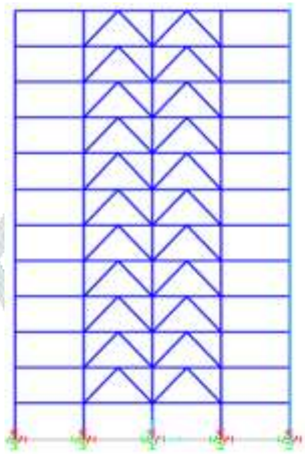
3.1 Models



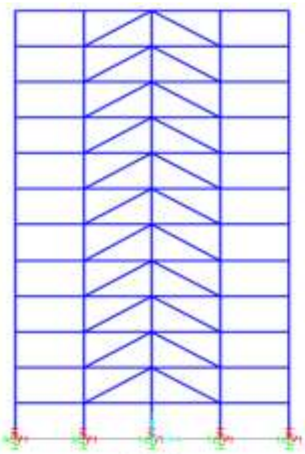
MODEL 1



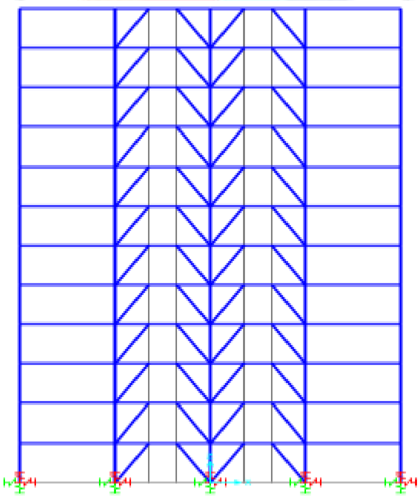
MODEL 2



MODEL3



MODEL 4



MODEL 5

3.2 Common data for all models

Table -1: General Details of the Models

No. of stories	12 (G+11)
Floor to Floor Height	3 m
Beam size	250 mm X 600 mm
Column size	600 mm X 700 mm
Thickness of slab	150 mm

Density of the concrete	25 kN/m^3
Soil Type	Medium
Zone factor (Z)	0.24
Importance factor (I)	1
Response reduction factor (R)	5
Grade of Concrete	M30
Grade of Steel	Fe 415

Gravity Load	Value
Floor Finish	1 kN/m^2
Roof Finish	1.0 kN/m^2
Live Load	3.0 kN/m^2
Roof Live	1.5 kN/m^2
Wall Load	10.8 kN/m
Parapet Wall Load	6.6 kN/m

Table -2: Gravity Loads Assigned to The RC Building

Table -3: Soil parameters

Soil type	Designation	Modulus of elasticity (kN/m^2)	Poisson's ratio (μ)
Hard soil	E-65000	65000	0.3
Medium soil	E-35000	35000	0.4
Soft soil	E-15000	15000	0.4

Table -4: Stiffness of Equivalent Soil Spring (kN/m)

Soil type	E-65000	E-35000	E-15000
Translation along x-axis(Kx)	526897.67	279914.38	119963.31
Translation along y-axis(Ky)	537167.16	285370.06	122301.45
Translation along z-axis(Kz)	333687.09	194650.80	83421.77
Rocking about x-axis(Kox)	573497.78	334540.37	143374.45
Rocking about y-axis(Koy)	746883.61	435682.10	186720.90
Torsion about z-axis(Koz)	935495.91	467747.95	200463.41

IV. RESULTS AND DISCUSSION

4.1 For the problem Response Spectrum Analysis is carried out for Bare frame. The models are checked for time period, base shear, and maximum top displacement and maximum column reaction.

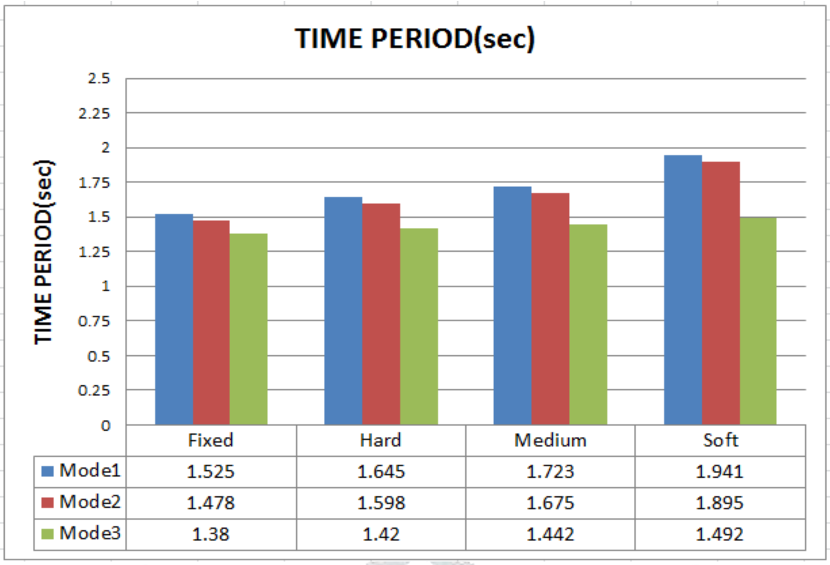


Chart -1: Comparison of Time Period

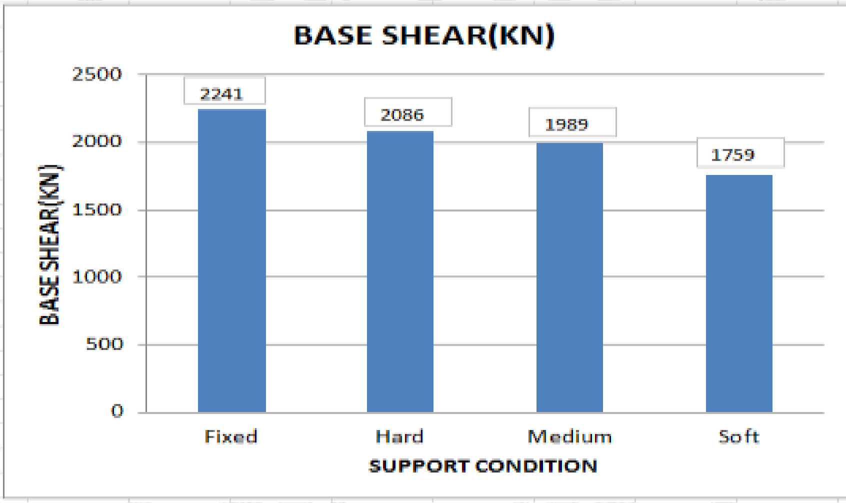


Chart -2: Comparison of Base Shear

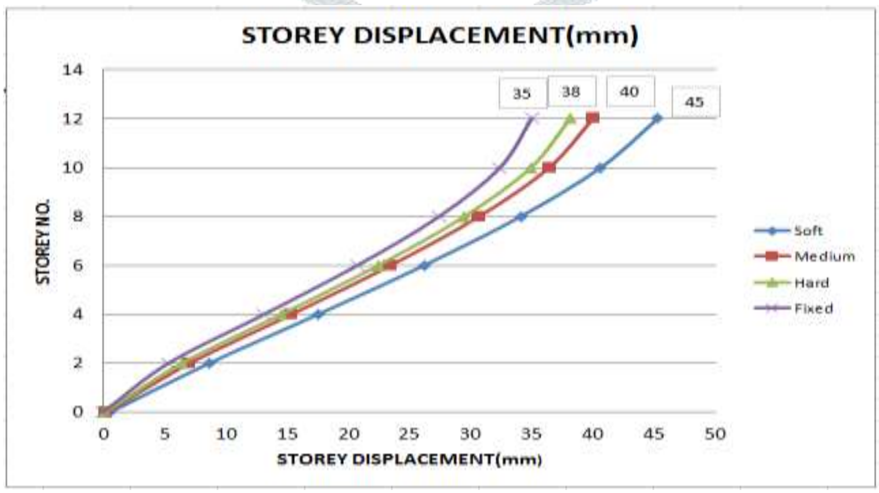


Chart 3 -: Comparison of Roof Displacement

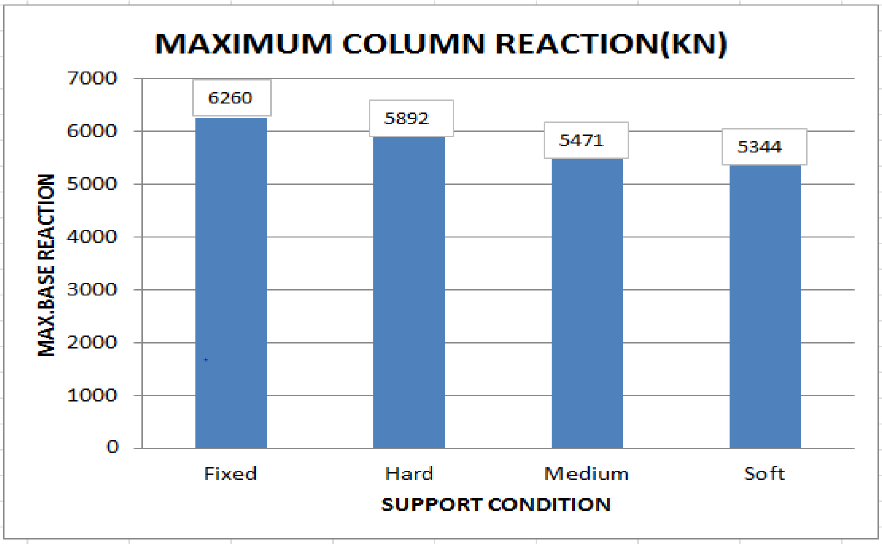


Chart 4 -: Comparison of max. column reaction

4.2 For the problem Response Spectrum Analysis is carried out for frame with different bracing systems. The models are checked for time period, base shear, and maximum Roof displacement

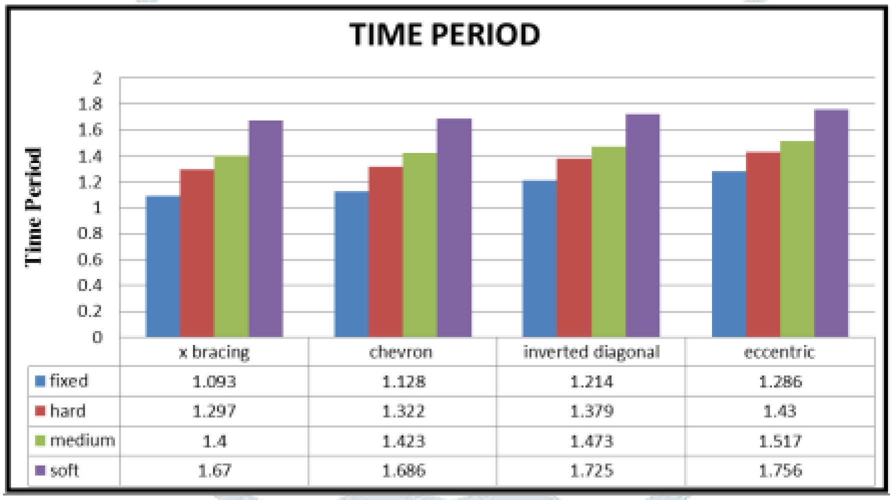


Chart -5: Comparison of Time Period

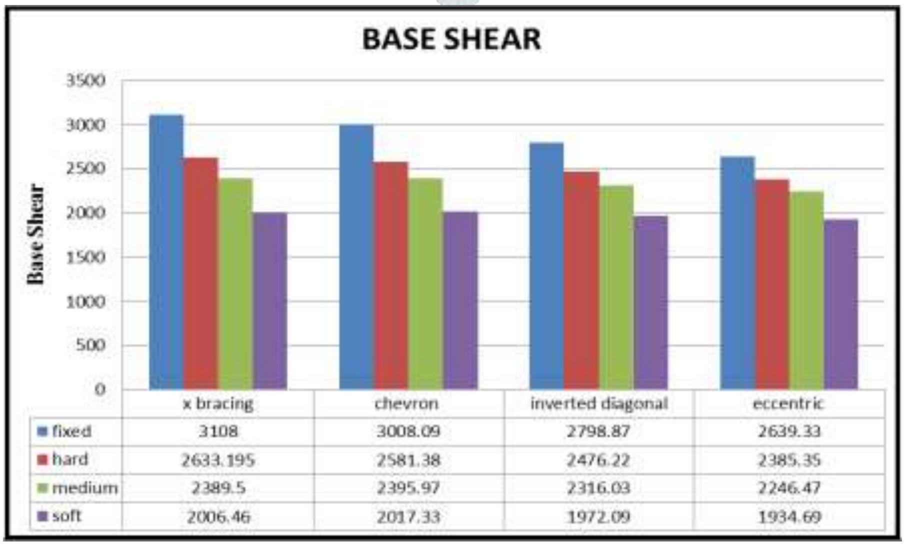


Chart -6: Comparison of Base Shear

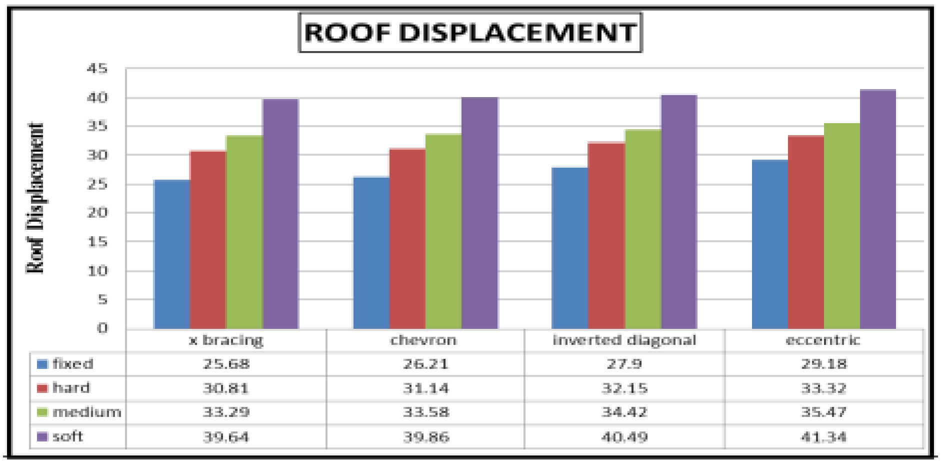


Chart 7 -: Comparison of Roof Displacement

V. CONCLUSIONS

1. It is concluded that the natural period of structure increases due to SSI effect. For soft soil the effect is more prominent. It is 27% greater than initial value.
2. Increase in soil flexibility causes decrease in base shear in both directions. For soft soil base shear decreases with higher rate. Base shear decreases up to 21.5%.
3. Roof displacement is also observed to increasing due to incorporation of SSI. For soft soil roof displacement is higher than fixed support condition. It increases up to 29%.
4. This study shows that adding the braces to the core of building reduces the drift much more than adding them to the facades.
5. For both cases i.e. fixed and considering SSI effect , among all position and orientation of bracings the building with X bracing has the least roof displacement. Therefore X bracing gives better performance during earthquake.
6. The stiffness characteristics depending on the dynamic soil properties and the dimensions of the shallow foundation ,controls the SSI effect on the structure significantly.
7. This study reveals that the Mid diagonal and eccentric bracing shows least variation in all parameters with change in soil flexibility among all bracings

REFERENCES

[1] Shehata E. Abdel Raheem, Mohamed M. Ahmed, Tarek M. A. Alazrak (2015) "Evaluation of soil-foundation-structure interaction effects on seismic response demands of multi-story MRF buildings on raft foundations" International Journal of Advanced Structural Engineering (IJASE) ISSN 2008-3556 Volume 7 .

[2] Dhanaraj M. Patil, Keshav K. Sangle (2015) "Seismic Behaviour of Different Bracing Systems in High Rise 2-D Steel Building" The institution of Structural Engineers,Elsevier.

[3] Halkude S.A., Kalayanshetti M.G., Barelikar S.M. (2014) "Seismic response of R.C. frames with raft footing considering soil structure interaction" *J Gate IJCET* Vol No.4, pp. no. 1424 .

[4] Dr. S. A. Halkude, Mr. M. G. Kalyanshetti, Mr. S. H. Kalyani (2014) "Soil Structure Interaction Effect on Seismic Response of R.C. Frames with Isolated Footing" International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 3 Issue 1, January – 2014.

[5] Rishi Mishra, Dr. Abhay Sharma,Dr.vivek garg, "Analysis of RC Building Frames for Seismic Forces Using Different Types of Bracing Systems", International Research Journal of Engineering and Technology (IRJET), ISSN: 2278-0181, Vol. 3 Issue 7, July – 2014

[6] Dr. R. B. Khadiranaikar, Yallappa Halli, "Seismic Performance of RC Frame With Steel Bracings" International Research Journal of Engineering and Technology (IRJET), ISSN: 2278-0181, Vol. 3 Issue 8, August – 2014 D. Kornack and P. Rakic, "Cell Proliferation without Neurogenesis in Adult Primate Neocortex," Science, vol. 294, Dec. 2001, pp. 2127-2130, doi:10.1126/science.1065467.

[7] Dhiraj raj,Bharathi M. , "effects of soil-structure interaction on regular and braced rc building",Research Gate, Proceedings of Indian Geotechnical Conference, December 22-24, 2013, Roorkee.

[8] Boostani Darmian M.E., AzhdaryMoghaddam M., and Naseri H.R. (May 2011) "Soil structure interaction in steel braced structure with foundation uplifts" *IJRRAS*, Vol.7, Issue 2, pp. no. 185

[9] H.R. Tabatabaiefar, B. Fatahi & B. Samali "Seismic Behaviour of Steel Moment Resisting Buildings on Soft Soil Considering Soil-Structure Interaction"14 ECEE,2014.

[10] I.S. 875 (Part 1,2,5): 1987, "Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures", Bureau of Indian Standards New Delhi.

[11] Mr. Kotkar R.K. , Prof. Patankar J. P. "Effect of Soil Structure Interaction on Buildings with Stiffness Irregularity under Seismic Load", International Research Journal of Engineering and Technology (IRJET), Volume: 04 Issue: 07,2017.

[12] FEMA-356, (2000) Prestandard and Commentary for the Seismic Rehabilitation of Buildings. US Federal Emergency Management Agency

[13] I.S. 1893 (Part 1): 2002, "Criteria for Earthquake Resistant Design of Structures (part 1) General Provisions and Buildings (Fifth Revision)", Bureau of Indian Standard.