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Seismic Analysis and Retrofitting of a Multi-Storey RC Building

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Abstract - *Seismic analysis is a part of structural analysis and it deals with the calculation of the response of a building structure to earthquake. Steel braced frame is one of the structural systems used to resist earthquake loads in multi-storied buildings. Many existing reinforced concrete buildings need to retrofit to overcome the deficiencies to resist seismic loads. The use of steel bracing systems for strengthening or retrofitting seismically inadequate reinforced concrete frames is a viable solution for enhancing earthquake resistance. A G+10 storey building is analysed for seismic zone III as per IS 1893(Part 1):2002 using ETABS 2016 software in the present study. The seismic performance of reinforced concrete buildings rehabilitated using concentric steel bracing is investigated. The bracing is provided for peripheral columns. The building is analysed for models with X type bracing, Diagonal bracing, V type bracing, Inverted V type bracing, Combined V type bracing and K type bracing and compared with an Un-braced frame.*

***Key Words*: Seismic performance, ETABS, Rehabilitation, Retrofitting, Strengthening**

1. INTRODUCTION

India is one of the most earthquake prone countries in the world and has experienced several major or moderate earthquakes during the last 15 years. About 50-60% of the total area of the country is vulnerable to seismic activity of varying intensities. Earthquake is a sudden shaking of the ground caused by movement of the tectonic plates relative to each other, both in the direction and magnitude. This creates horizontal forces in the structures, which is termed as seismic forces. In order to withstand this, the structure has to be designed also for seismic loads. The existing buildings can become seismically deficient since design codes requirements are constantly upgraded due to advancement in engineering knowledge. Hence the existing structure should be made seismic resistant by incorporating various seismic retrofitting techniques to meet the present safety requirements and codal provisions.

2. DECISION TO BRACE STRUCTURE

The main step in the process leading to retrofitting a structure with a steel bracing scheme is the evaluation of the seismic adequacy of the structure consists of comparing performance requirement with expected behavior under seismic loads. If the structure is found inadequate the owner must choose between retrofitting or replacement. The choice of the bracing system configuration includes selecting frames and bays to be braced and selecting bracing patterns. A steel bracing system can be inserted in a frame to provide lateral stiffness, strength ductility, hysteretic energy dissipation or any combination of these. The braces are effective for relatively more flexible frames, such as those without infill walls. The braces can be added at the exterior frames with least disruption of the building use.

Table -1: DESCRIPTION OF THE BUILDING

Type of frame	Reinforced Concrete Frame
RC Building	G+10 Storey Building
Storey Height	3 m
Base storey height	1.5 m
Beam size	250mm X 300mm
Column size	250mm X 600mm
Thickness of slab	125mm
Steel bracing used	ISA 100X100X10mm
Live load	3 KN/m²
Floor finish	1 KN/m²
Compressive strength of concrete	25 N/mm²
Yield strength of steel	415 N/mm²
Seismic zone	III
Zone factor	0.16
Sub-soil type	Medium
Importance factor	1
Response reduction factor	5
Method of Analysis	Linear static method

3. MODELLING IN ETABS

Seismic analysis is carried out on building models using ETABS 2016 Software with M30 grade of concrete.

No. of bays in X direction = 05
No. of bays in Y direction = 05
Spacing of grid in X & Y direction = 4m

The models with various bracing installation are analysed in ETABS 2016. Plan, elevation and 3D modelling of structures are given below:

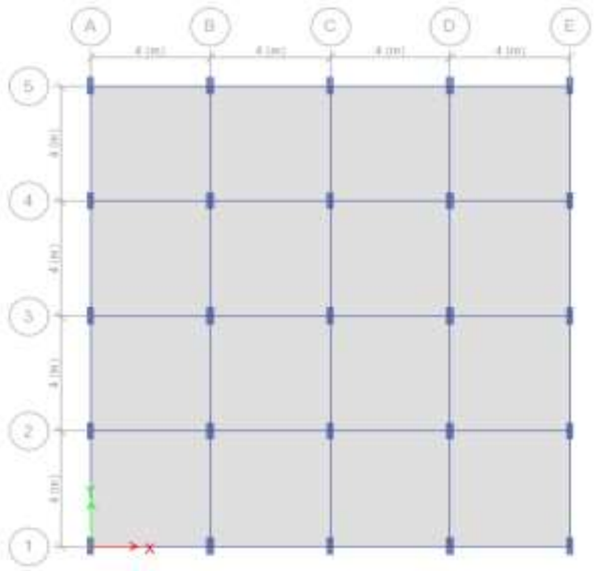

Fig -1: Plan of Building

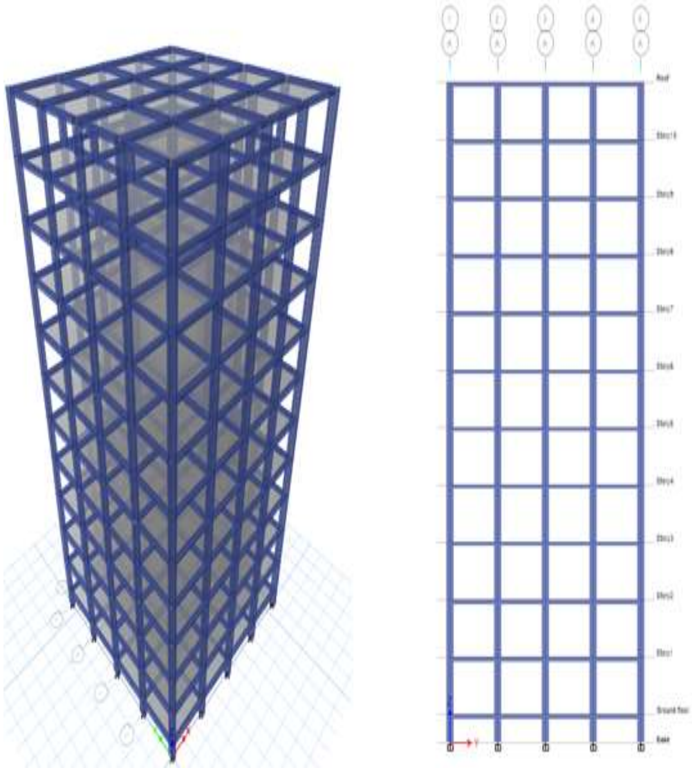

Fig -2: Model of Un-braced G+10 storey building

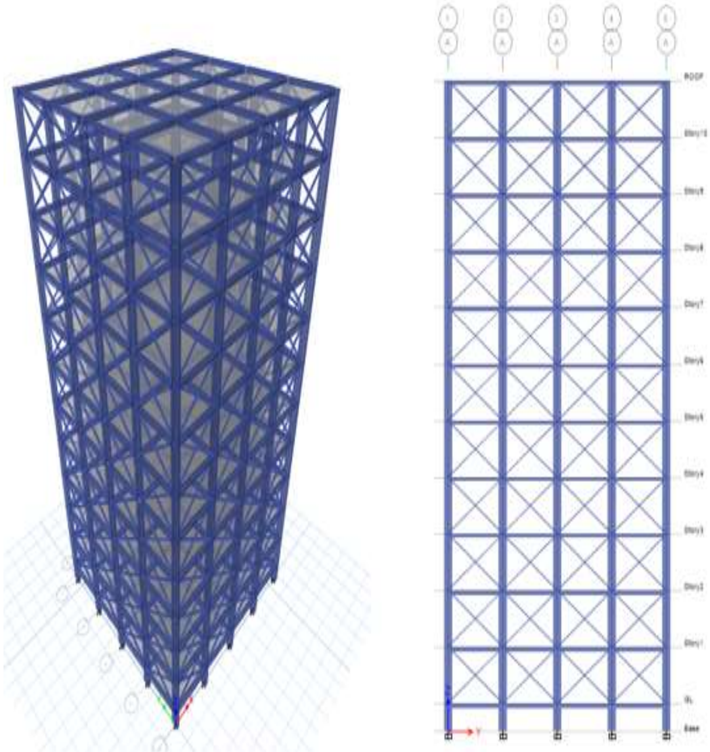

Fig -3: Model of G+10 storey building with 'X' type bracing

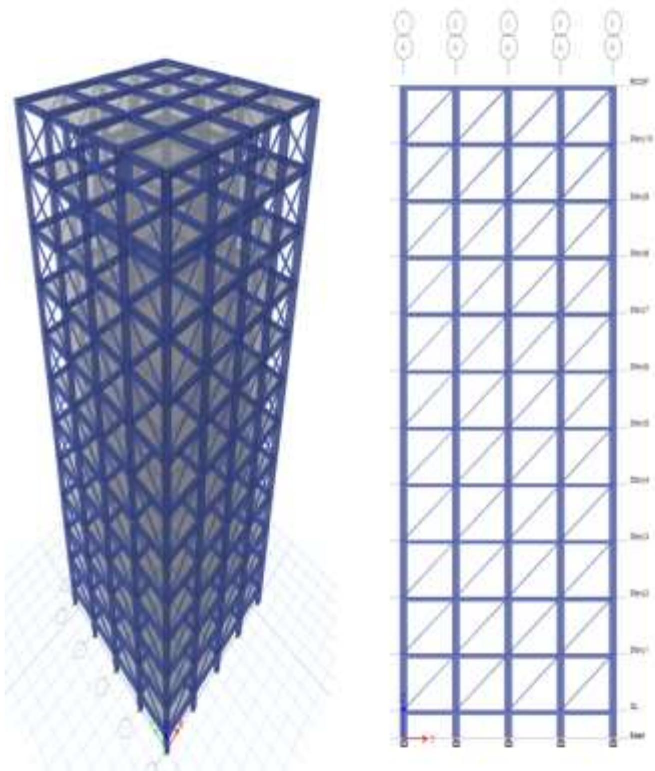

Fig -4: Model of G+10 storey building with Diagonal bracing

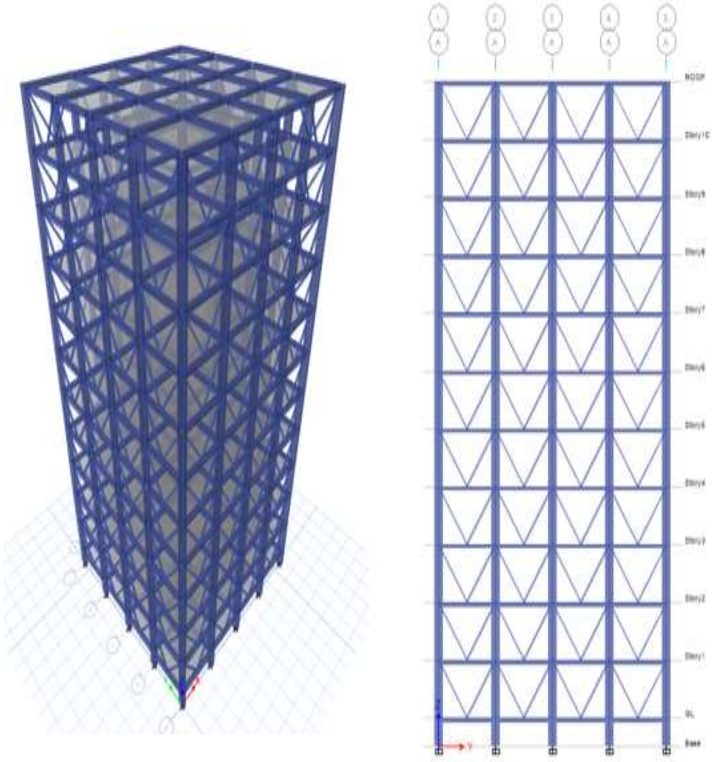

Fig -5: Model of G+10 storey building with 'V' type bracing

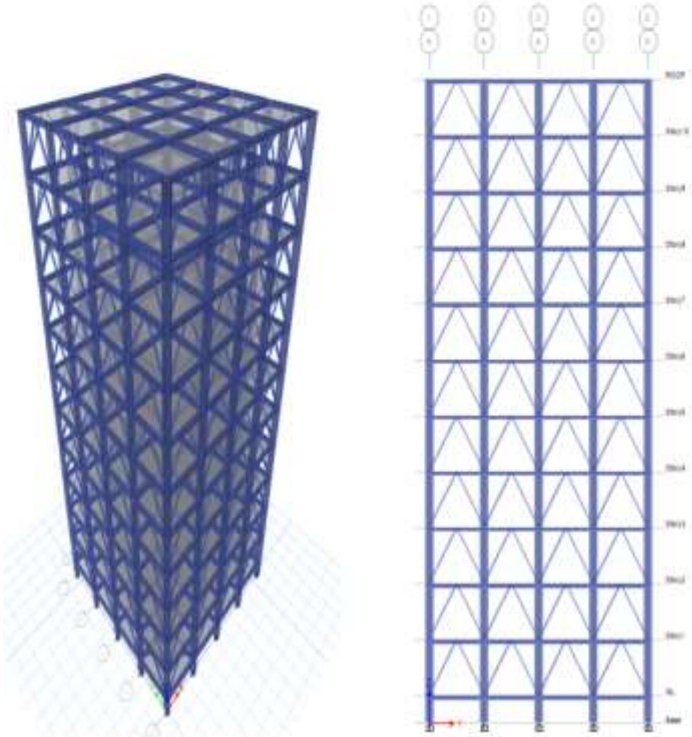

Fig -6: Model of G+10 storey building with Inverted 'V' type bracing

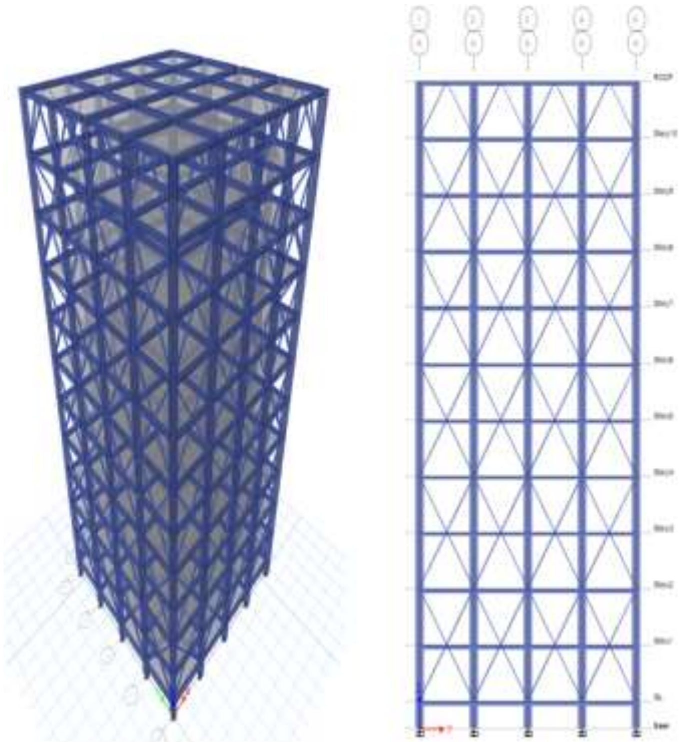

Fig -7: Model of G+10 storey building with Combined 'V' type bracing

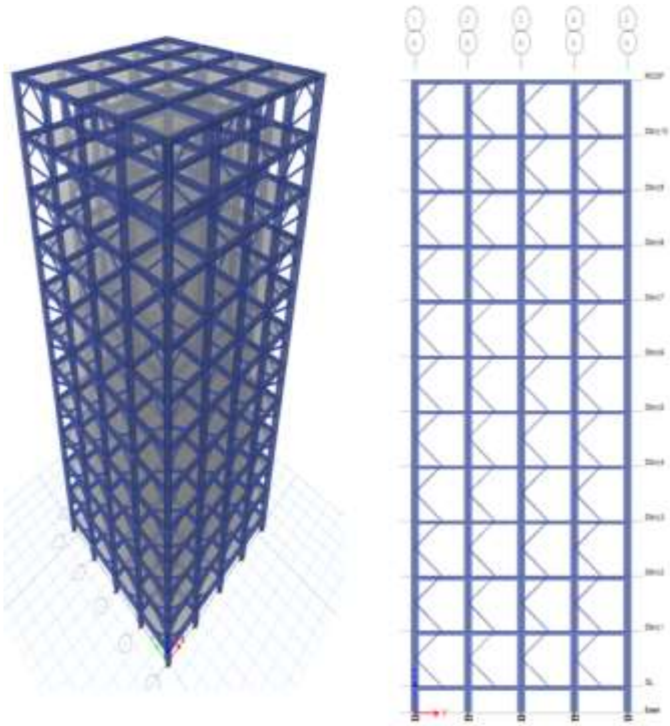

Fig -8: Model of G+10 storey building with 'K' type bracing

4. RESULTS AND DISCUSSIONS

4.1 Lateral Displacement

It is observed from the current analysis that the lateral displacement is reduced to largest extent for 'X' type of bracing system, while the displacement is maximum for the un-braced system. The displacement is reduced sequentially for bracing type inverted 'V', combined 'V', 'V' type, diagonal bracing and 'K' bracing. These patterns are observed due to increased stiffness provided by the respective bracings. Top roof displacement for the system with 'X' type bracing is reduced by 64.78% in X direction as compared to that of un-braced system.

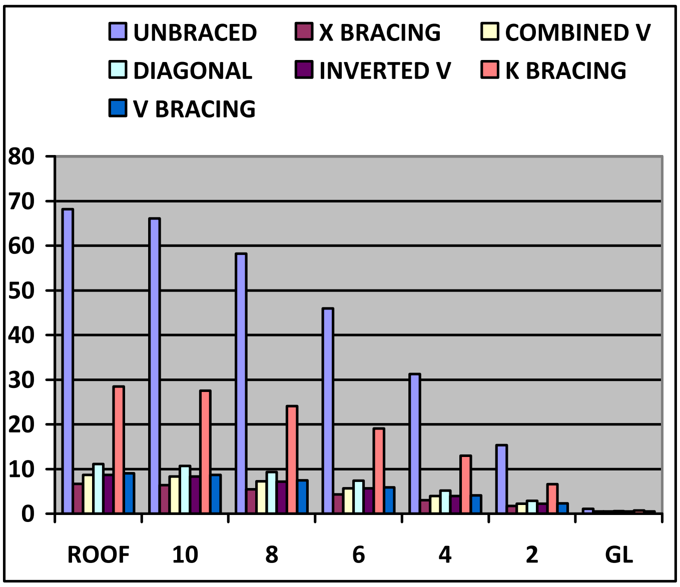

Chart 1: Lateral displacement in X direction (mm)

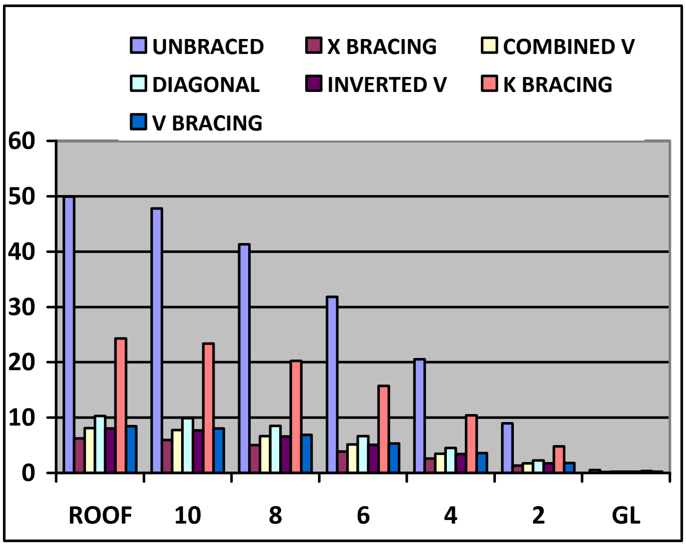

Chart 2: Lateral displacement in Y direction (mm)

4.2 Storey Drift

It can be observed from the graph that the story drifts are reduced to largest extent for X type of bracing systems, while these are maximum for the system without bracing.

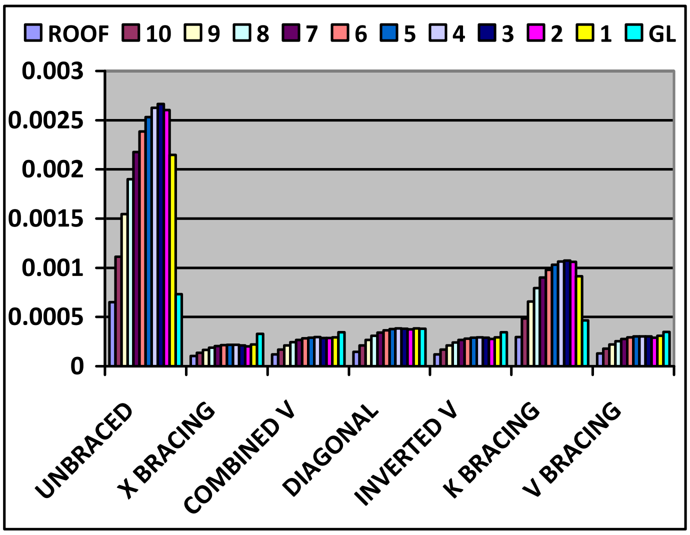

Chart 3: Storey drift in X direction

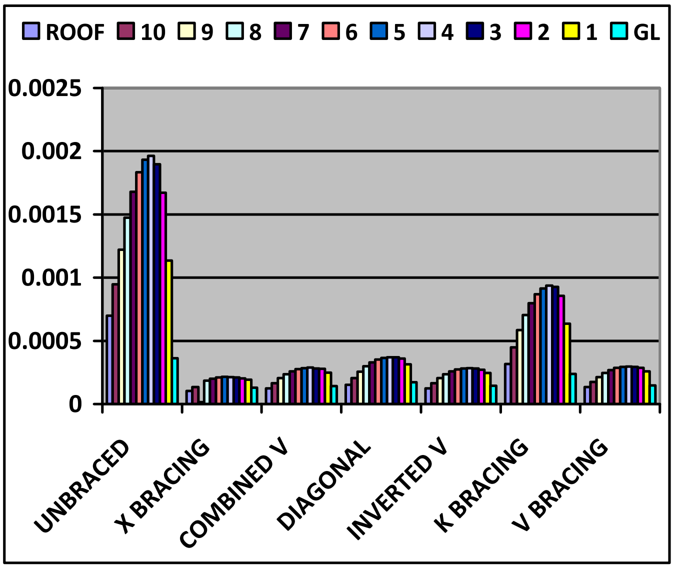

Chart 4: Storey drift in Y direction

4.3 Base Shear

It is observed from the analysis result that the base shear is maximum for 'X' type bracing systems, while it is minimum for the un-braced system. The base shear are increasing in sequentially for 'K' type bracing, diagonal bracing, 'V' type bracing, combined 'V' type bracing, inverted 'V' type bracing and 'X' type bracing.

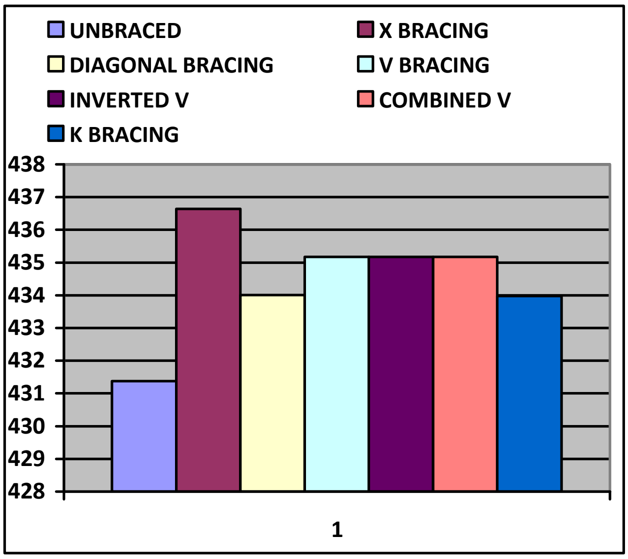

Chart 5: Base shear in X & Y direction

3. CONCLUSIONS

After the analysis of the G+10 storey building with different types of structural systems, it has been conclude that:

1. The displacement of the structure decreases after the application of bracing system.

2. The maximum reduction in the lateral displacement occurs after the application of 'X' type bracing system which gives the value of 6.7008mm in X direction and 6.2478mm in Y direction while it is 68.1392mm, 49.9054mm in X and Y direction respectively in case of un-braced structure.

3. Lateral displacement and storey drifts are minimum for inverted 'V' braced frame as compared to 'V' braced frame.

4. The performance of 'X' type of bracing system is better than the other specified bracing systems. Steel bracings can be used to retrofit the existing structure. It is concluded that arrangements of bracing systems has considerable effect on seismic performance of the building.

5. In comparison of 'X' bracing system and un-braced structure, storey drift is reduced to large extent for 'X' type of bracing system. After analysis in ETABS it gives the value 0.00013 for 'X' bracing and 0.000699 for un-braced structure.

6. The concept of using steel bracing is one of the advantageous concept which can be used to strengthen or retrofit the existing structures.

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