Performance of Steel Braced Shear Wall

[1]Nitin Vishwakarma, [2]Hardik Tayal

[1]M.E Student , [2]Structural Design Engineer
[1]Department of Civil and Environmental Enginering,
[1]National Institute of Technical Teacher' Training and Research, Bhopal, India

Abstract—From past for medium rise RCC structure Shear Wall is commonly used and steel bracing used in steel structures only; but now the concept of bracing system is extended to concrete structures. Recent researches show that both structural systems can be implemented altogether in medium rise building. These structural systems have some merits and some demerits also. So, there is need to develop a system which has benefits of both system and this leads to the concept of Optimization. This research paper deals the behavioral study of Steel Braced optimized Shear wall. For this purpose actual G+20 storey in Gurgaon, India (Seismic Zone IV) having Shear Wall system, considered for study. Several cases are considered with Shear wall with different bracing pattern and performance of building is observed with different cases and compares with the performance of actual building.

Index Terms— Lateral Load Resisting System, Shear Wall, Steel Bracing, Structural System, Steel Braced optimized Shear Wall, Seismic Design , Response Spectrum Analysis

I. INTRODUCTION

The height of building is relevant and cannot be decided in arbitrary boundary either in connection with height or in numerousness of stories. But, can be defined as behaviour influenced by lateral forces due to Wind and Earthquake or in proportion of both because of its height. Buildings are design for strength, serviceability, stability and human comfort; design of building basically contain conceptive design, approximate analysis, preparatory design and optimization for the conduction of lateral load and gravity load safely. Earthquakes have become frequent issue all over the globe. The intenseness, locality and period of event of earthquake is very laborious to forecast. Structures enough designed for ordinary loads like dead, live, wind etc. may not be essentially unharmed against earthquake load. Practically it is impossible to design structures to stay within elastic limit during earthquake which is economical feasible. Structures primarily have proper earthquake resisting characteristic to safely counteract huge side forces that are enforced on them during habitual earthquakes. Ordinary structures for residence are commonly built to safely conduct their own burden. Low lateral loads action by wind and therefore, effect inadequately under huge lateral forces cause by even moderate extent earthquake. These side forces can cause the crucial stresses in a structure, which could overreach a situattion of anxiety to the occupants, Using an appropriate structural system is significant to good seismic performance of buildings.

Earthquake resisting buildings should embrace minimum lateral stiffness at least, so that buildings do not sway too much all through minute levels of vibration. Moment frame buildings may perhaps not be fitted to undertake this always. When lateral displacement is huge in a building with moment frames only, structural walls, often ordinarily called Shear walls, can be induce to help conquer overall displacement of buildings, because these vertical plate-like structural elements have large strength and plane stiffness. Therefore, the structure of the building having moment frames with definite bays in each direction having structural walls. Shear wall system resists side forces by combined axial, flexure and shear action. Also, Shear walls aids in reducing reduce shear and moment force on beams and columns in the moment frames of the building, when provided along with moment frame. Structural walls should be provided all through the height of through the height of buildings for best earthquake performance. Also, walls offer best performance when rests on hard soil strata. But sometimes Shear wall with Basic moment frame is economically unattractive. The other most beneficial and practical mode of enhancing the seismic strength is to extend the energy absorption ability of building by combining bracing elements in frame. In steel structures, bracing members are extensively used to overcome lateral displacement and disperse energy during vigorous ground motions. The braced frame can hold a maximum degree of energy exerted by earthquakes. This belief is extended to concrete frames. The distinct aspects such as shape and size of the building, location of bracing and shear wall in the building, distribution of stiffness and distribution of mass significantly restraint the behaviour of structures. In Frame, bracing system boosts the performance by increasing its capability and lateral stiffness; Loads could be transfer into braces and away from frame by passing weal columns and the stiffness is maintained up to peak strength by the augmentation of bracing system.

This, improvement in behaviour of Structure is always a challenge for designer to select proper systems for resisting lateral loads. For medium rise building shear wall and bracing system could be a choice. Shear wall system when compared to bracing system does not sound economical ,but are capable of resisting large lateral force as it offers more stiffness then bracing system. When it comes to economy, appearance of Structure the lateral load resisting structural system must be selected appropriately and hence there is need for the optimization of these systems. This research paper deals with optimization of shear wall by using bracing. For this purpose actual G+20 storey RCC storey is considered for study having shear wall located at different position. In this study this shear wall system is optimized by bracing done by removing shear wall of some section and replace it with bracing such that two shear wall are braced with steel bracings. Different models were modelled with distinct bracing pattern, behaviour of building is analysed having these structural systems in study, the results obtained in terms of base shear, storey drift, storey forces , modal time period from analysis is then compared and observed. The rest section is organized as follow: Section 2 contains past related work review, methodology adopted is discussed in section 3, Section 4 gives Building and Material specification, Section 5 contains Load details, section 6 consists results and discussion and conclusions and future scope discussed in section 7.

II. RELATED WORK

This section deals with past study performed by researchers on seismic analysis of the Reinforced concrete frame having Shear wall, Braced Concrete buildings and found to be very resourceful and fact full. In paper title "Effect of Shear Wall and Bracing on Seismic Performance of Vertical Irregular Reinforced Concrete Buildings" in this research author investigated the structural behaviour of the buildings with shear wall at different locations and compared them in terms of storey drift, average displacement and member forces induced in various members of the building and To resist earthquakes and wind force a braced building is designed and concluded that lateral strength and stiffness increases due to shear wall and bracings[1]. And in paper title "Comparative Study on Seismic Analysis of Multi-storey Building stiffened With Bracing And Shear Wall" author did seismic analysis of G+15 building stiffened with Bracing and Shear wall. The performance is analysed in Zone II, Zone III, and Zone IV [2].

These work in paper [3], [4], [5], [6], [7], [8], [9], [10] helps in understanding the main consideration factor that leads the structure to perform poorly during earthquake in order to achieve their appropriate behaviour under future earthquakes, Structures need to have suitable earthquake resisting features to safely resist large lateral forces that are imposed on them during Earthquake. From previous researches it is found that Shear wall are efficient in both terms of construction cost and effectiveness in minimizing Earthquake damage in structure, also the braced frames can absorb great degree of energy exerted by Earthquake.

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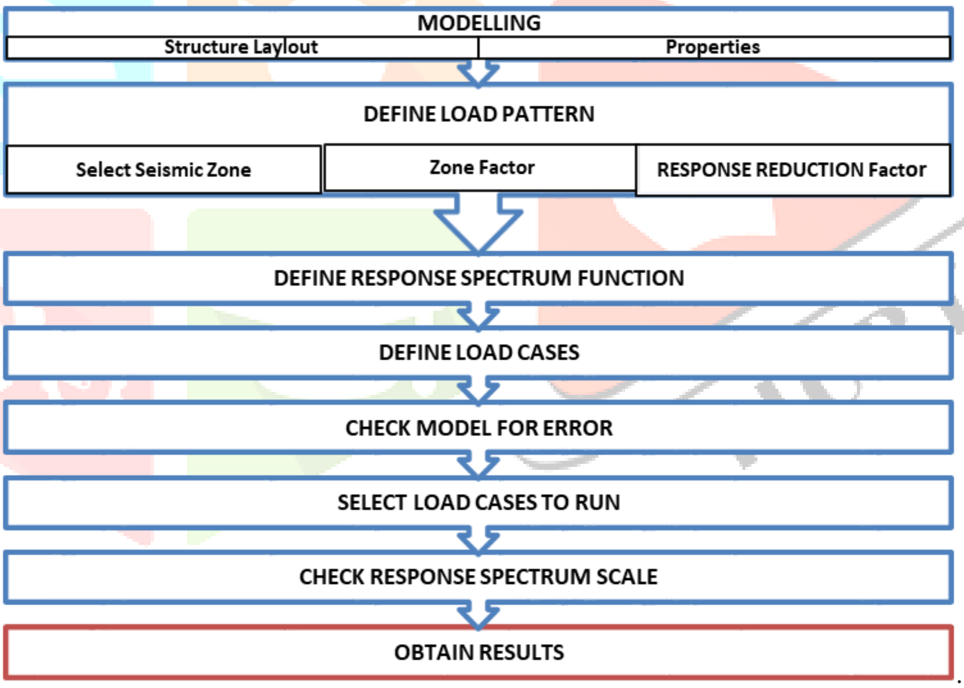
III. METHODOLOGY



IV. *Fig 1 Methodology adopted*

The method adopted to obtain results is for only one model, all model results are obtained using same above steps.

SOFTWARE IN USE

ETABS (Integrated Analysis, Design and Drafting of Building System) is developed by CSI (Computers & Structure. Inc). CSI ETABS 2016 Version 16.2.0 is a practical general purpose structural program has been used widely among researchers and industries. ETABS is an elaborated and exceptional purpose analysis and design software program developed particularly for tall building system. It is capable of handling the tallest and most complex structure models arrangement.

IV. BUILDING DESCRIPTION AND MATERIAL SPECIFICATION

Building is considered for study is a residential building present in Gurgaon, Delhi, India. In this building RCC shear wall is present at different location as shown in plan in fig 2.The building has two Outside face L and R consists of complete shear wall as shown in fig 2. This two outer faces of shear wall is optimized by reducing the section of shear wall from bottom to top and brace the shear wall with bracing. The proposed plan of building is shown in fig 3 In this study total four model has been studied MODEL 1 – In this actual building is considered, MODEL 2- Building in which Shear wall two outer faces optimized with Diagonal Bracing., MODEL 3- Building in which Shear wall of two outer face optimises with cross bracing. MODEL 4 – Building in which Shear wall of two outer faces optimized with Chevron Bracing. All models are modelled by following Indian Standards and is analysed by Response Spectrum Method

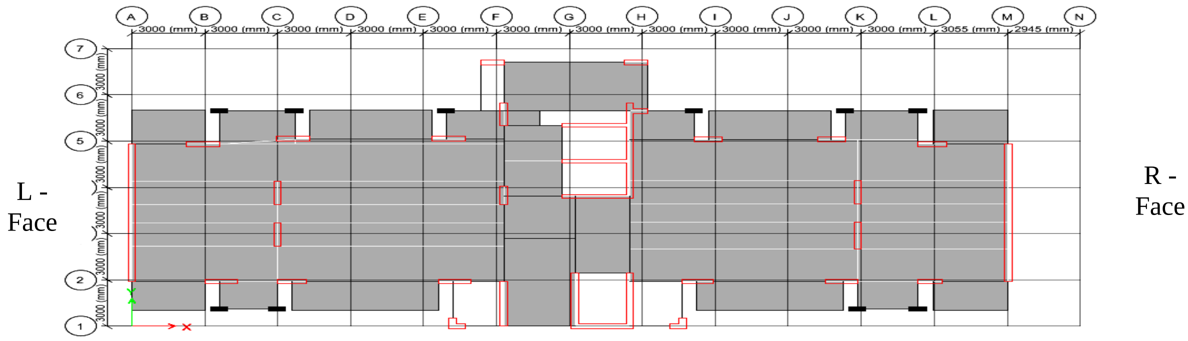


Fig 2 Plan View of actual Building

Building has beam of size 230mm x 450 mm, 230 mm x 600 mm and 300mm x 600 mm using M25 grade concrete, column of size 300mm x 750mm and300 mm x 750 mm using M 35 grade concrete, Shear Wall of size 230,250 and 300mm in thickness, Slab are 130,150 and 275 mm in thickness material used is M 25 concrete. Section Shape of column and beam are rectangular. ISA 90 x 90 x 8 mm double angle connected back to back is used for Bracing. Total height of building is 77.575meters. Typical storey height is given in table 1 and Material properties are mentioned in table 2.

Table 1 Height of Storey

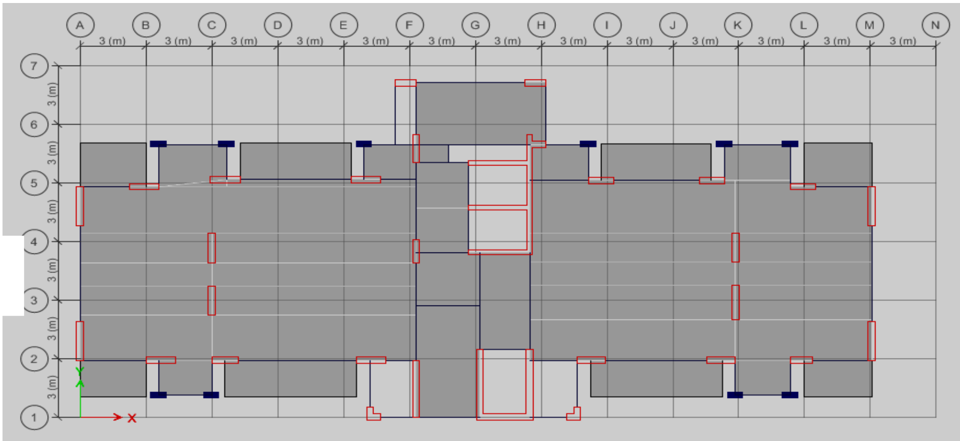
Name	Height(mm)
Tank Level	3000
Terrace to 2nd Storey	3300
1st Storey & Stilt Level	4000
Basement-1	4000
Base	0

Table 2 Material Specification

Name	Type	Modulus of Elasticity MPa	Unit Weight kN/m³	Design Strength MPa
Fe415	Rebar	200000	76.9729	Fy=415 (Yield Strength)
Fe500	Rebar	200000	76.9729	Fy=500 (Yield Strength)
M25	Concrete	25000	24.9926	Fc=25 (Compressive Strength)
M30	Concrete	27386.13	24.9926	Fc=30 (Compressive Strength)
M35	Concrete	29580.4	24.9926	Fc=35 (Compressive Strength)

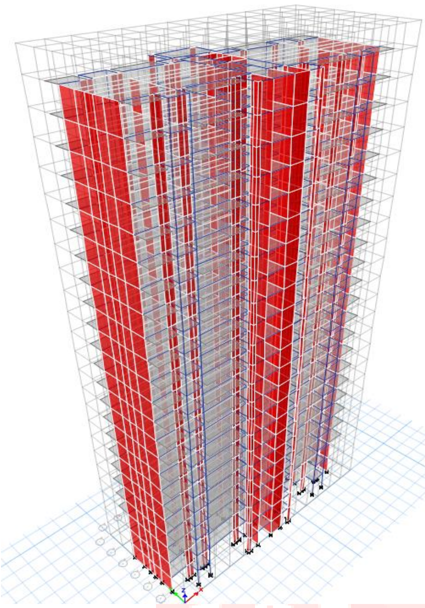
All models have same storey height mentioned above and drawn according to same plan .Model 1 have plan shown in fig 2 and plan of remaining model is shown in fig 3. 3 D view and elevations of models are shown in fig 4.

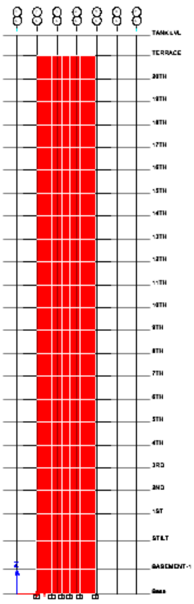
L - Face

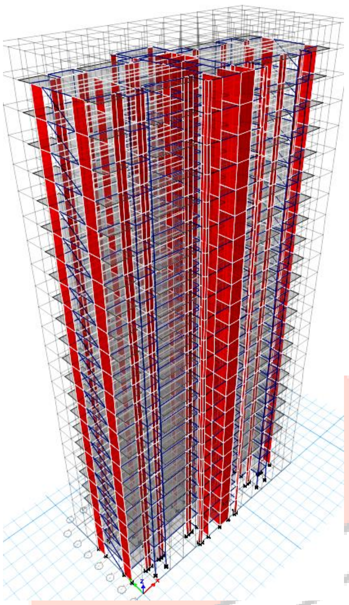


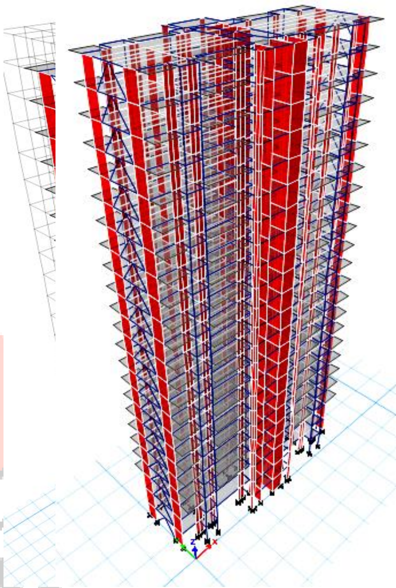
R - Face

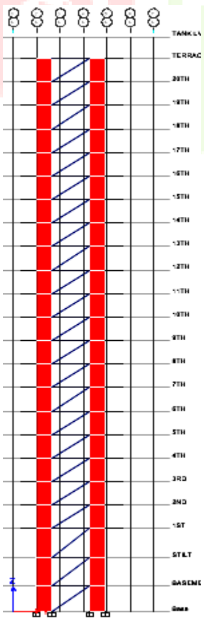
Fig.3 Plan View of Proposed Building

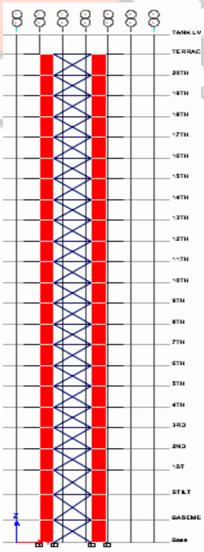












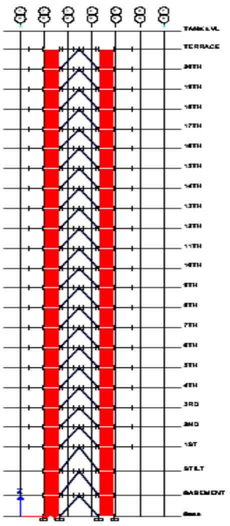


Fig 4 3-D and Elevation View of models from L and R face

V. LOADING DETAILS

V.I Static Loading

Dead Load

- Self Weight of Structural Members calculated automatically using Self Weight Multiplier in ETABS.
- Uniform Load on Slab i.e. Floor finish Load (60 mm thick flooring) plus Partition load = 1.5 KN/m^2
- Uniform Load On Beams: Wall Load = 13.5 KN/m^2

Imposed Load

- Balcony, Lobby = 3 KN/m^2
- Rooms = 2 KN/m^2
- Parking Area = 5 KN/m^2

V.II Seismic parameter

- Damping Coefficient = 0.05
- Modal Combination = CQC
- Seismic Zone IV (Z) = 0.24
- Importance factor (I) = 1
- Response reduction factor = 5

Where CQC = Complete quadratic combination

V.III Load Combination

1.5 D.L	1.2 D.L + 1.2 L.L ± 1.2 EQy	0.9 D.L ± 1.5 EQx
1.5 D.L + 1.5 L.L	1.5 D.L ± 1.5 EQx	0.9 D.L ± 1.5 EQy
1.2 D.L + 1.2 L.L ± 1.2 EQx	1.5 D.L ± 1.5 EQy	

Where, D.L is Dead Load, L.L is Live Load, EQx and EQy are Earthquake Loads in X and Y direction respectively.

V.IV Response spectrum function as per IS1893:2002

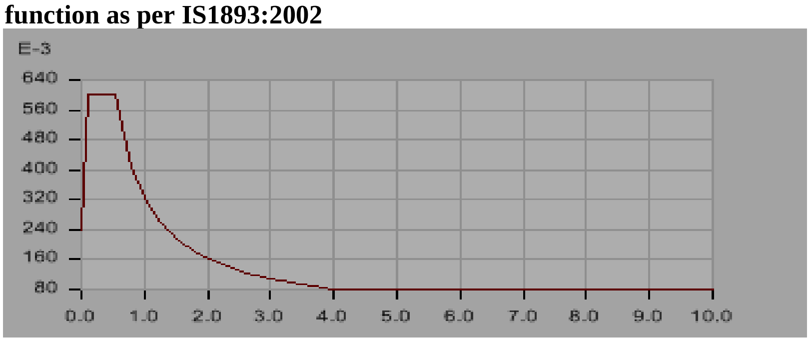


Fig. 5 Response Spectrum Curve

VI. RESULTS AND DISCUSSION

VI.I Storey forces

VI.I.I Shear Force

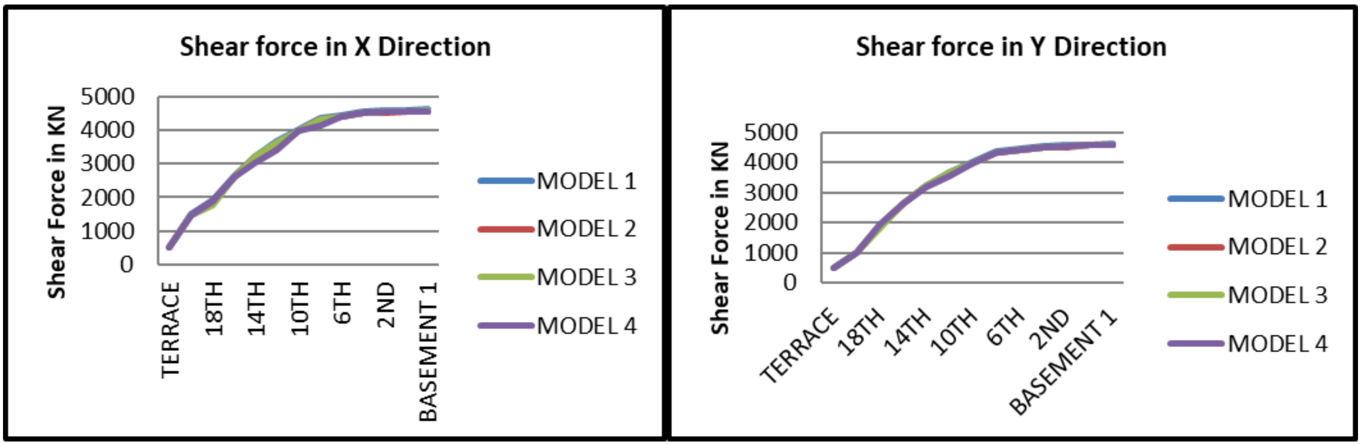


Fig 6 Comparison of Shear force in X and Y direction

VI.I.II Maximum torsion

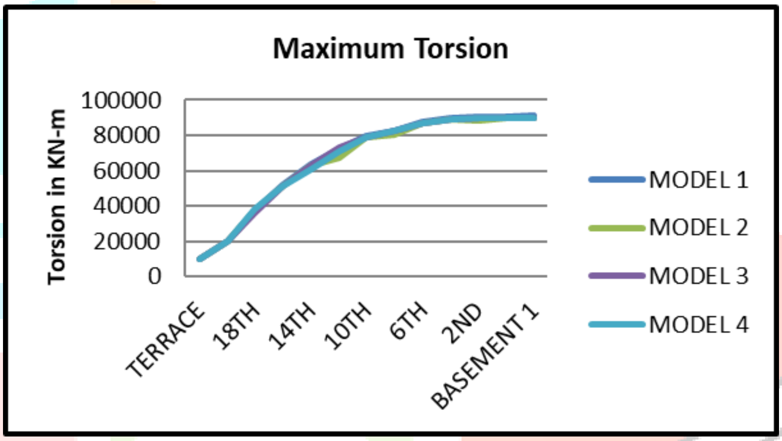


Fig 7 Maximum Torsion

VI.I.III Maximum Bending moment

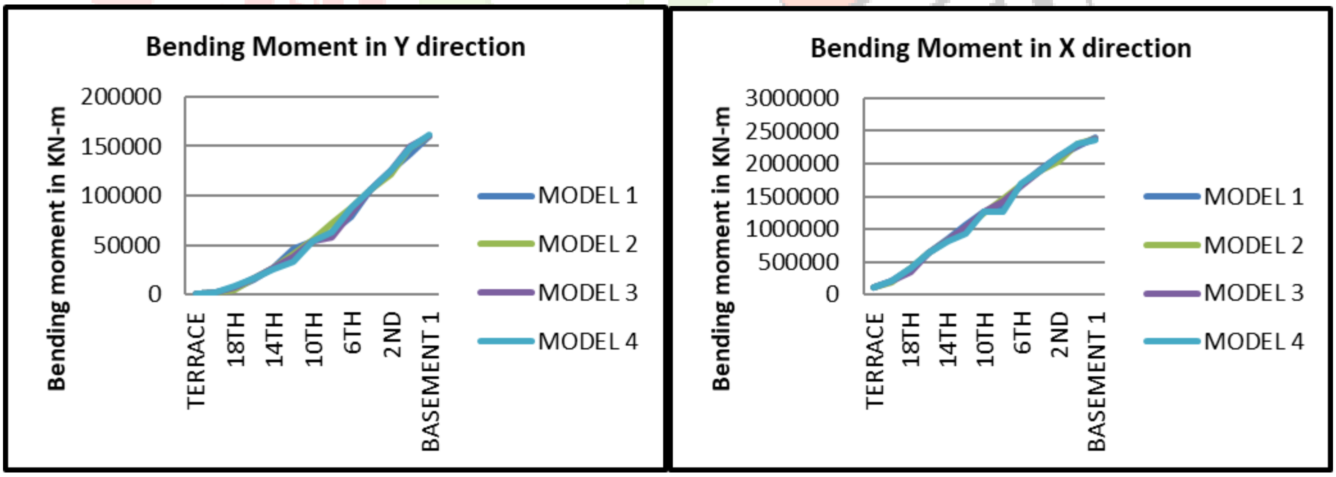


Fig 8 Bending Moment Comparison

VI.II Storey drift

Storey drift

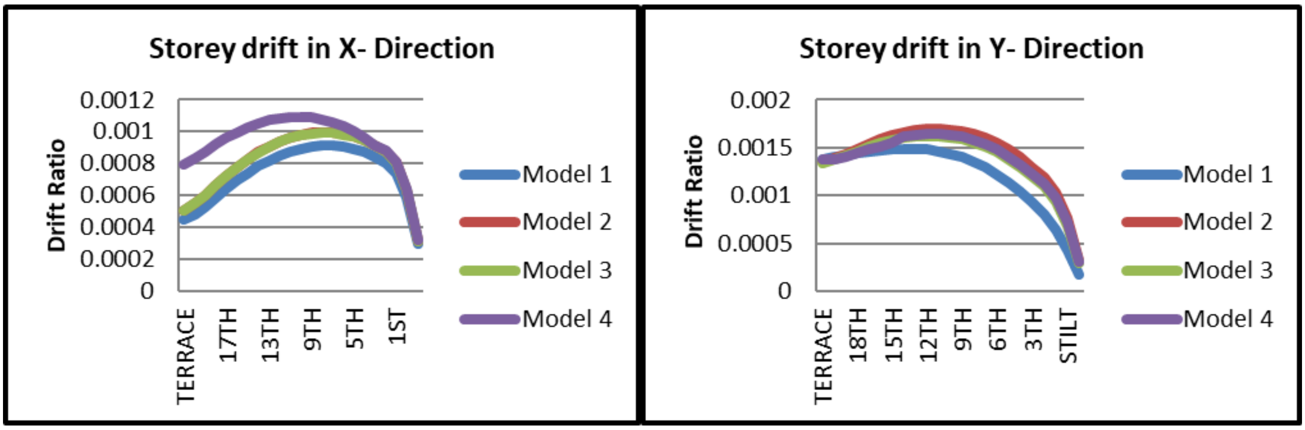
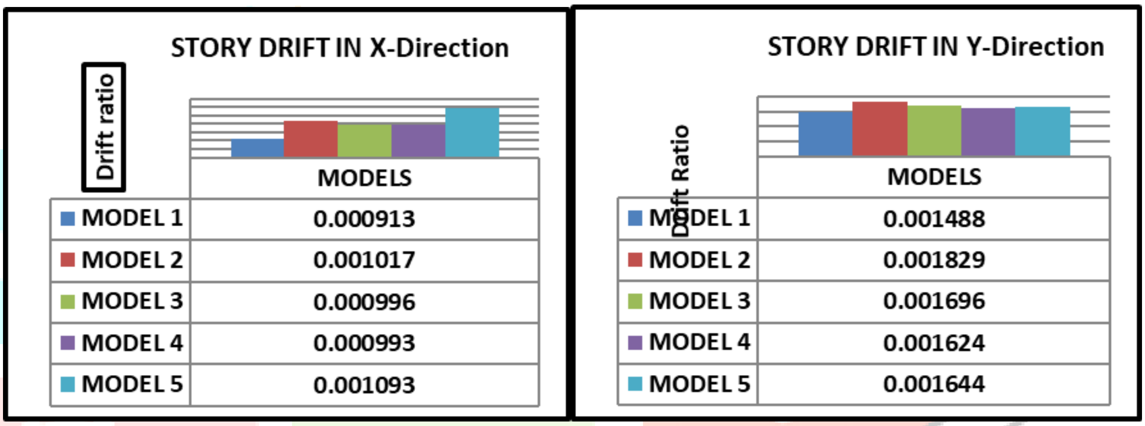


Fig 9 Storey drift of Models

Maximum Storey drift

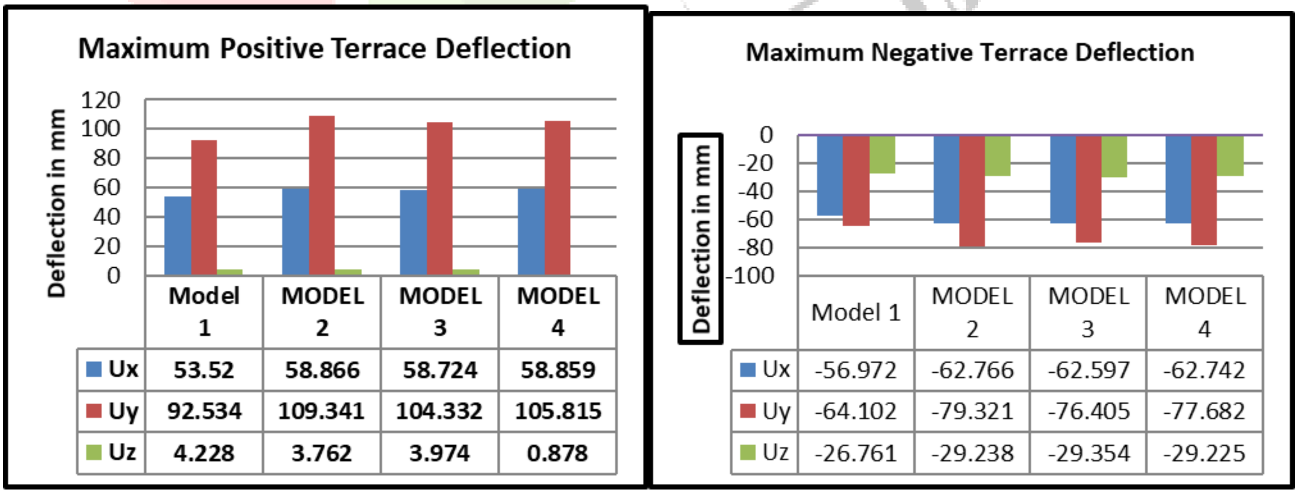


	MODELS (X-Direction)
MODEL 1	0.000913
MODEL 2	0.001017
MODEL 3	0.000996
MODEL 4	0.000993
MODEL 5	0.001093

	MODELS (Y-Direction)
MODEL 1	0.001488
MODEL 2	0.001829
MODEL 3	0.001696
MODEL 4	0.001624
MODEL 5	0.001644

Fig 10 Maximum storey drift comparison

VI.III MaximumTerrace Deflection



	Model 1	MODEL 2	MODEL 3	MODEL 4
Ux	53.52	58.866	58.724	58.859
Uy	92.534	109.341	104.332	105.815
Uz	4.228	3.762	3.974	0.878

	Model 1	MODEL 2	MODEL 3	MODEL 4
Ux	-56.972	-62.766	-62.597	-62.742
Uy	-64.102	-79.321	-76.405	-77.682
Uz	-26.761	-29.238	-29.354	-29.225

Fig 11 Maximum positive and Negative Terrace Deflection

VI.IV Base Shear

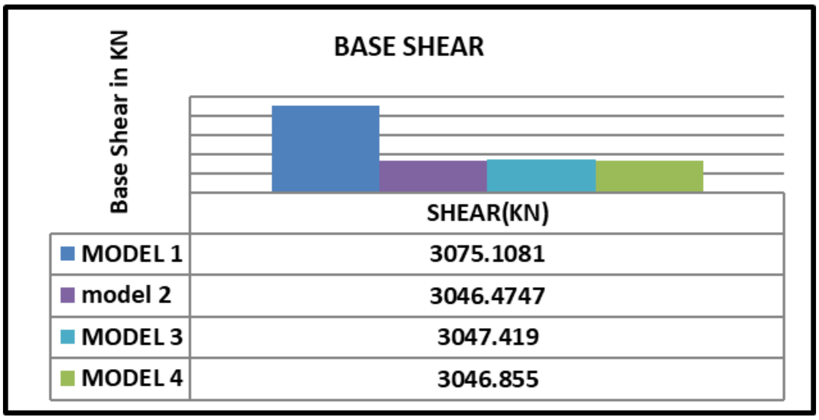


Fig 12 Base Shear

VI.V Time period

Time period as per as IS 1893:2002 part 1 clause no 7.6.1 for RC frame Building, is equal to

Ta = **$0.075\ h^{0.75}$** Where, h is height of building in metre
= $0.075 \times (77.575)^{0.75}$
= **1.96 sec**.

Time period from modal analysis is presented in table 4.1

Table 3 Modal Period

Model	Modal period from First mode shape
MODEL 1	2.16sec
MODEL 2	2.37sec
MODEL 3	2.33sec
MODEL 4	2.34sec

V.II CONCLUSION AND FUTURE SCOPE

- Shear wall elements are very much effective in dropping lateral displacement of frame as drift and horizontal deflection induced in shear wall frame are much less than that induced in braced frame and plane frame.
- Shear wall structure will provide large stiffness to the building by reducing the damage to the structure.
- Steel bracing can be used to strengthen or retrofit of existing structures or can be used as a substitute to other strengthening pr retrofitting techniques. As the height of building will not change considerably, it could be advantageous concept.
- Steel bracing carryover lateral load by axial load mechanism and decreases shear and flexure demands on beam and column. In building frame having X type bracing system will have minimum probable bending moments as comparison to other bracing.
- Total weight of building will not change extensively by the usage of bracing system and thereby reduces base shear of building. X type bracing reduces lateral displacement about 35 % to 45 % and reduced maximum displacement. .
- Performance of building under seismic load can be studied by varying the position of steel braced shear wall..
- Also effect Shear wall with braced opening can be investigated under dynamic loading.

ACKNOWLEDGEMENT

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