iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 Issue: V Month of publication: May 2018

DOI: http://doi.org/10.22214/ijraset.2018.5474

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue V, May 2018- Available at www.ijraset.com

Seismic Coaction of Shear Wall & Reinforced Cement Concrete Bracing System in High Rise Commercial Buildings using STAAD Pro

Shahid Ul Islam[1], Rajesh Goel[2], Pooja Sharma[3]
[1]M.Tech in Structural Engineering, [2]Assistant Professor, [3]HOD Department of Civil Engineering, Desh Bhagat University, Punjab (India)

***Abstract*: In earthquake prone zones the structures are designed to withstand seismic or lateral forces along with the gravity loads. In that respect several earthquake resistant systems namely; shear wall system, bracing system, diagrid etc., have been suggested over a period of time. This study observed the combined performance of shear wall and RCC bracing system, and also the effect of their relative position in high rise commercial building (G+10). The shear walls provide the stiffness to restrain lateral loads and also help in distribution of gravity loads whereas the RCC bracing results in higher stiffness and stability as a potential advantage over other bracings. The study also aimed the comparison of performance of shear wall & RCC bracing system in high rise commercial buildings under seismic loading. The total of 6 structural configurations viz., Moment resisting frame (Model 1), MRF stiffened with RCC bracing system (Model 2), MRF stiffened with shear wall system (Model 3), MRF stiffened with both shear wall and RCC bracing system (Model 4A, Model 4B, & Model 4C) were modelled and then analysed.**

Analysis has been done in accordance with 1893:2002 using STAAD Pro V8i software. The seismic parameters taken into consideration are base shear and storey displacement. The post analysis results concluded that Model 4C (6. Moment Resisting Frame with shear wall placed at two longitudinal bays at corner 1, and at two transverse bays at corner 4, while as RCC X-bracing system is placed in similar way as shear wall at corner 2 and 3) is more efficient, safe and economical in earthquake as compared to other analysed models.

***Keywords*: Reinforced Cement Concrete Bracing, Storey Displacement, Base Shear, Seismic Analysis, Story Drift**

I. INTRODUCTION

Generally, the purpose of high rise structures is to transfer the primary gravity loads viz. dead load and live load safely. In addition the structure should withstand lateral forces caused by earthquake or wind depending upon the terrain category. The lateral loads produce sway moments and induce high stresses, thus reduces the stability of the structure. In order to resist lateral loads the structure stiffness is more important parameter than strength. Earthquake induces lateral forces which transfer through the beams and columns forming the lateral load resisting system of structure. The lateral load resisting systems that are widely used are rigid frame, shear wall, diagrid structural system, wall frame, braced tube system, outrigger system and tubular system. Shear walls have very high in plane stiffness and strength, which can be used to simultaneously resist large horizontal loads and support gravity loads, making them quite advantageous in many structural engineering applications. Lateral bracing systems provides stiffness and stability to the structure, and is economical.

The BIS code IS 1893:2002 is taken as criteria for earthquake resistant design of structures. This standard provides basis for calculation of base shear, torsion, and design lateral force in structure due to lateral seismic action. These parameters are affected by nature of foundation soil, material, size, shape, type of structure, duration of seismic activity and ground motion characteristics. It also provides the limitations of storey drift.

The various parameters like base shear, storey drift, and storey displacement are taken into consideration for the analysis and comparative study of the structure with different lateral load resisting systems. The analysis is done using engineering software, STAAD Pro.

II. LITERATURE REVIEW

The relevant literature on lateral load resisting systems used in high rise buildings was reviewed and presented here.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue V, May 2018- Available at www.ijraset.com

Kiran.T et al. (2017) [1] performed comparative study on 30-storey RCC frame with shear walls and Hexagrid system using ETABs V.13. The present study concluded that in case of RCC frame base shear is least and the storey displacement is maximum as compared to RCC frame with shear wall and Hexagrid system.

Abhinav et al. (2016) [2] analysed 11-storey RCC building with shear walls using STAAD Pro software. The location of shear walls was main objective. The present study concluded that shear wall along the periphery is much more efficient than other models.

Md. Samdani Azad et al. (2016) [3] studied RCC high rise building with shear walls and bracing system using ETABS 9.7 software. Six models as per different location of shear wall have been prepared for comparative study. It has been concluded from the results that model having shear wall at middle portion was safest among all.

Priyanka Soni et al. (2016) [4] have analysed multi-storey building of different shear wall locations and heights using STAAD Pro. software. The three building models viz., G+10, G+20 and G=26 were taken into consideration for comparative study. It has been concluded that shear wall at middle is most preferable.

Kevadhkar and Kodag [5] studied RCC building with three models as MRF, different shear wall systems and different bracing systems and they found that X-braced system increases the stiffness and reduces the inter storey drift, lateral displacement and performance point than shear wall system.

Numan and Islam [6] concluded from their study the maximum displacement of the structure decreases after application of X-braced system as compared to different types of steel system. Also by application of bracing system the bending moment and shear forces reduces in columns.

Mohd Atif et al. (2015) [7] have performed comparative study on seismic analysis of G+15 storey building stiffened with bracing and shear wall. The performance of the building is analysed in Zone II, Zone III, Zone IV, and Zone V. The analysed structure is symmetrical, G+15, Ordinary RC moment-resting frame (OMRF). Modelling of the structure is done as per STAAD.Pro.V8i software. From the results it has been concluded that shear wall elements are very much efficient in reducing lateral displacement of frame as a drift and horizontal deflection in shear wall frame are much less than that induced in braced frame and plane frame.

III. OBJECTIVE OF STUDY

This study proposes the use of both shear wall and RCC X-bracing system in same structure to make a structure safe and economical. The main objectives of this dissertation are:

A. To study the seismic behaviour of RCC high rise commercial building stiffened with both shear walls and RCC X-bracing system subjected to seismic load.
B. To study the effect on seismic performance of high rise commercial building due to different relative positions of shear wall and RCC X-bracing system.
C. To evaluate the seismic parameters for RCC frame, RCC frame with RCC Bracing system, and RCC frame with shear wall.
D. To compare the results of different models based on use and relative position of shear wall and RCC X-bracing system.
E. To figure out the most safest and economical model as per seismic parameters namely base shear and storey displacement.

The seismic performance of high rise commercial building is determined on the basis of following parameters:

Base Shear – To calculate the total design lateral force at the structure and to analyse the effect of different relative locations of shear wall and RCC X-bracing system.

Storey Displacement – To evaluate the lateral storey displacement with respect to base that occurs in each storey of high rise buildings due to lateral load.

IV. MODELING AND ANALYSIS

The reinforced cement concrete commercial building of 11 Storey (G+10) a typical floor plan with 3 bays 5m each along both longitudinal and transverse directions as shown in Figure 1.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue V, May 2018- Available at www.ijraset.com

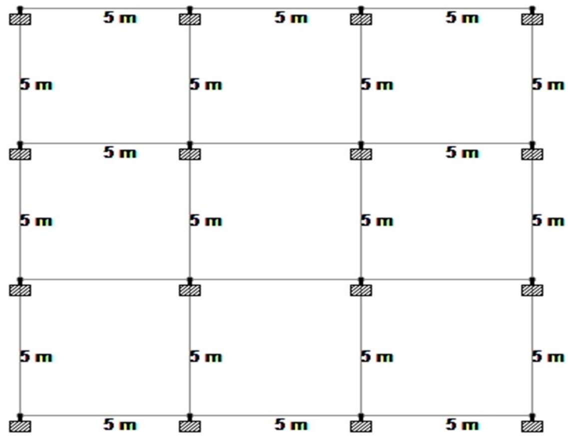


Figure 1 Building Plan

The structural details, loading details and seismic parameters of the structure are given as;

TABLE 1
Structural Details of a Building

Structure	SMRF
Number of Storey	G+10
Type of building	Commercial
Storey Height	4.0 meters
Neck Column Height	2.0 meters
Grade of concrete	M30
Grade of steel	Fe 415
Young's modulus of concrete	2.74 X 10^7 KN/m^2
Young's modulus of steel	2.00 X 10^8 KN/m^2
Density of RCC	25 KN/m^2
ThicKNess of slab	0.150mm
Beam size Plinth Beam Beam (GF & 1^{st} Storey) Beam (2^{nd} – 10^{th} storey)	 0.75m x 0.65m 0.65m x 0.55m 0.55m x 0.45m
Column size Neck column Column (GF & 1^{st} Storey) Column (2^{nd} – 10^{th} storey)	 0.75m x 0.65m 0.65m x 0.55m 0.55m x 0.45m
Bracing size	0.45m x 0.45m
Shear wall thickness	0.23m

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue V, May 2018- Available at www.ijraset.com

TABLE 2 Loading Details

Load Type	Load Intensity
Dead Load Self-weight of RCC Self-weight of Brick masonry	 25 KN/m^3 20 KN/m^3
Live Load On floors On roofs	 3 KN/m^2 2 KN/m^2

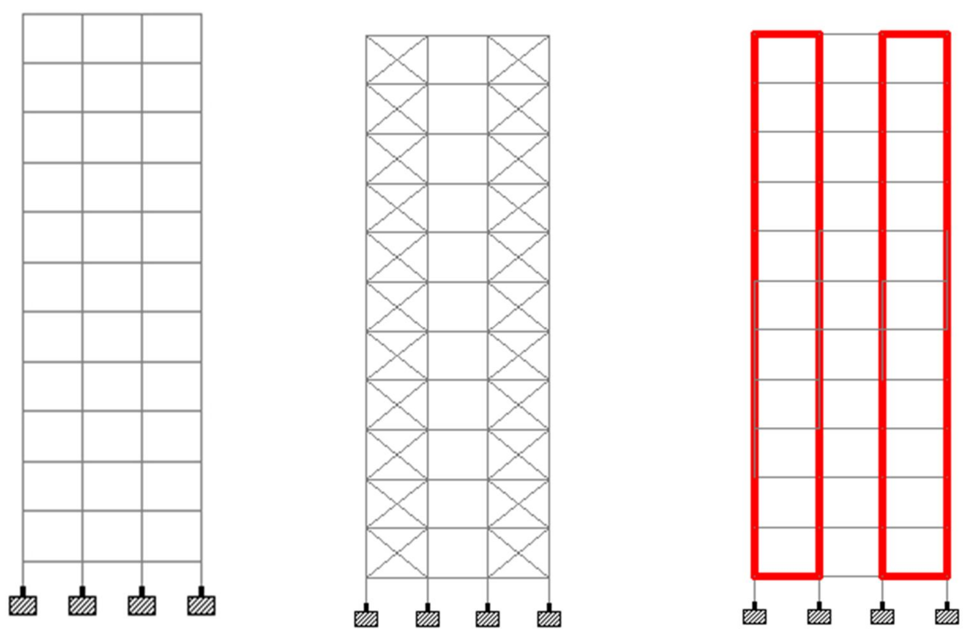
TABLE 3 Seismic Parameters

Seismic Zone	V
Importance Factor	1
Response Reduction Factor	5
Soil Type	Medium (2)

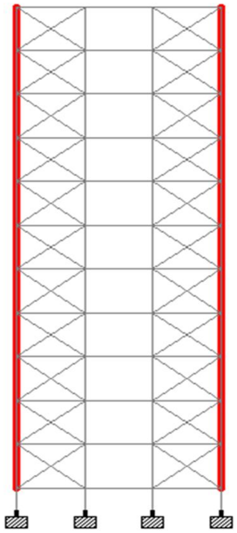
A. Modelling

The modelling of the structure is done by using engineering software STAAD Pro V8i. The different types of moment resisting frames considered for analysis are as follows;

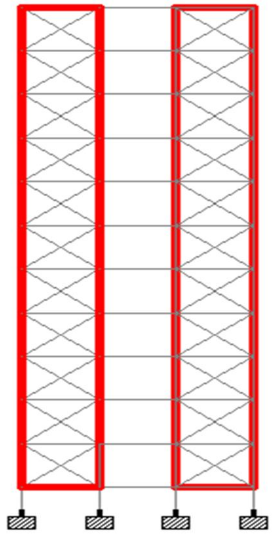
1) Moment Resisting Frame (Model 1)
2) Moment Resisting Frame with RCC X-Bracing System (Model 2)
3) Moment Resisting Frame with Shear Wall System (Model 3)
4) Moment Resisting Frame with shear walls positioned at the transverse bays of each corner and RCC X-bracing system positioned at the longitudinal bay of each corner (Model 4A)
5) Moment Resisting Frame with shear walls and RCC X-bracing system positioned at alternate bays at each corner (Model 4B)
6) Moment Resisting Frame with shear wall placed at two longitudinal bays at corner 1, and at two transverse bays at corner 4, while as RCC X-bracing system is placed in similar way as shear wall at corner 2 and 3 (Model 4C)



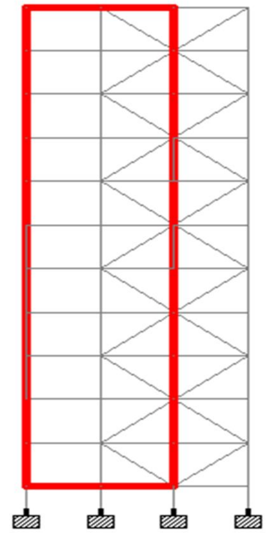
(a) Model 1 (b) Model 2 (c) Model 3



(d) Model 4A



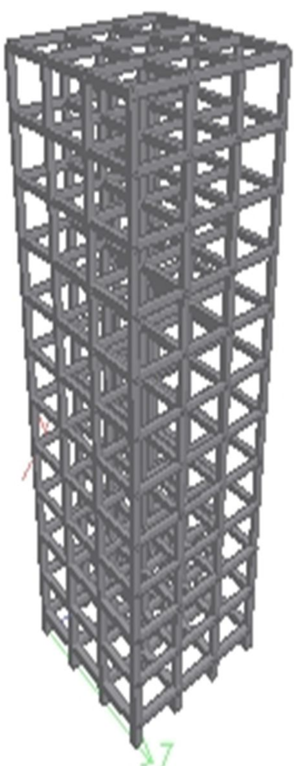
(e) Model 4B



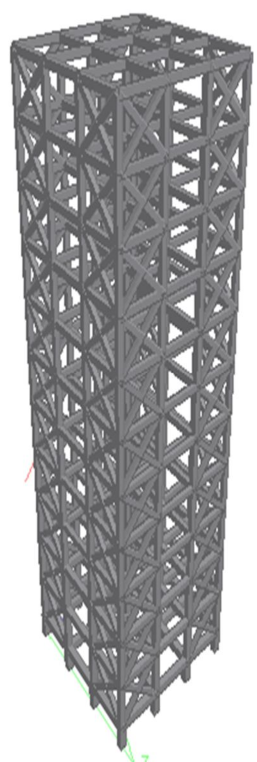
(f) Model 4C

Figure 2 Configurations of Different Models

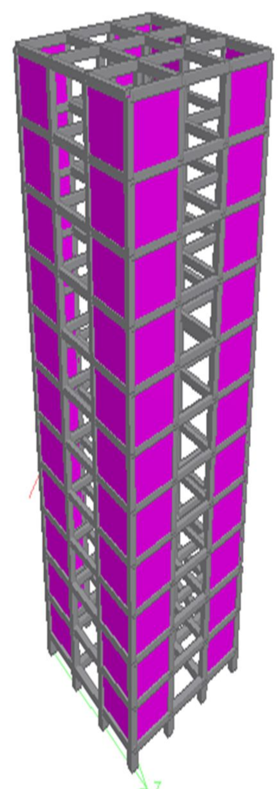
The front view of models doesn't display the information of entire structure, so for better understanding of the models rendered view of each model is given below. In rendered view the shear walls are being represented as purple surfaces while as bracings hold the same colour as the whole structure do i.e., grey.



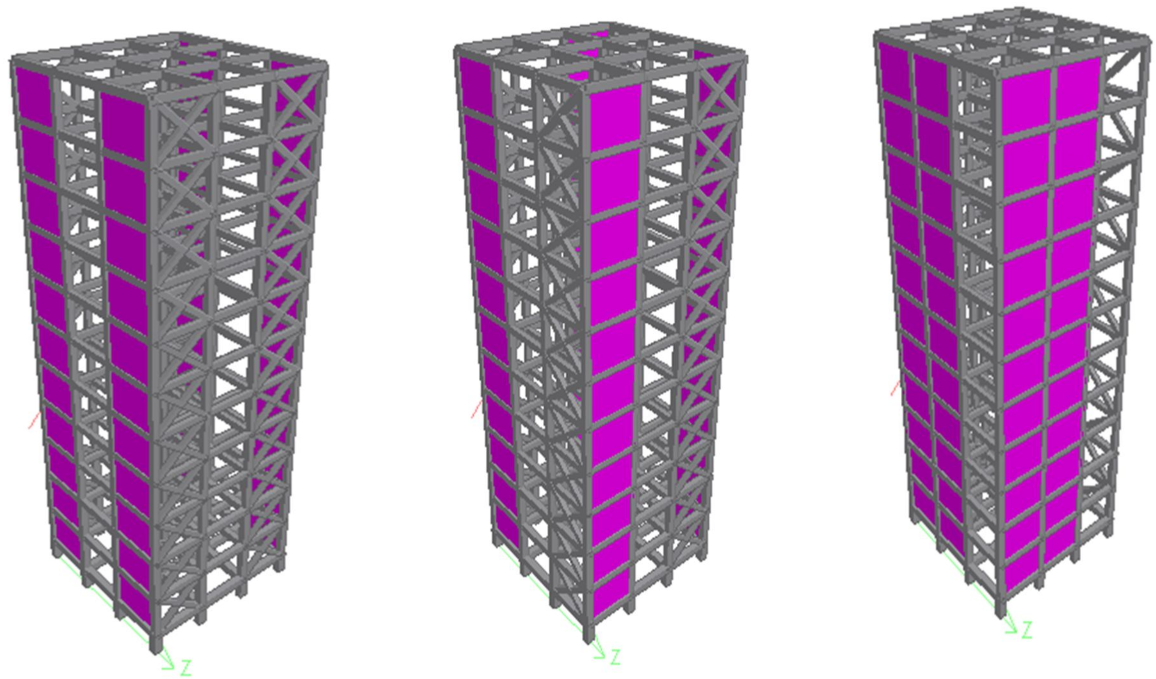
(a) Model 1



(b) Model 2



(c) Model 3



(d) Model 4A (e) Model 4B (f) Model 4C

Figure 3. Rendered Views of Different Models

B. Analysis

The analysis of structures as per IS 1893:2002 by static analysis method is done using Bentley's software, STAAD PRO V8i. All mentioned building models are analysed as per requirement of IS 456 – 2000 and IS: 875:1987. The lateral loads and load combinations considered in seismic analysis are taken into consideration as per IS 1893:2002.

The sample calculation of Model 1 (Moment Resisting Frame) is given below:

Step 1) Design Parameters:

The seismic parameters required for the analysis of structure are taken as per table 2.1.1, table 2.1.2, and table 2.1.3.

Step 2) Seismic Weight:

Self-Weight:

Self-weight of columns = Cross-sectional area of column x height of column x No. of columns x unit weight of RCC

Column1 = (0.75 x 0.65) x 2 x 16 x 25 = 390 KN

Column2 = (0.65 x 0.55) x 4 x 32 x 25 = 1144 KN

Column3 = (0.55 x 0.45) x 4 x 144 x 25 = 3564 KN

Total = 5098 KN

Self-weight of Beams = Cross-sectional area of beam x length of beam x No. of beams x unit weight of RCC

Beam1 = (0.75 x 0.65) x 5 x 24 x 25 =1462.5 KN

Beam2 = (0.65 x 0.55) x 5 x 48 x 25 = 2145 KN

Beam3 = (0.55 x 0.45) x 5 x 216 x 25 = 6682.5 KN

Total = 10290 KN

Member Load:

Member load = total length of beam per floor x no. of floors x (height of wall x thicKNess) x Unit weight of brick masonry

= 120 x 12 x (4 x 0.230) x 20 = 26496 KN = 26640KN

(Because we have taken load intensity for member load as 18.5 instead of 18.4)

Floor weight

Floor weight = area of floor x no. of floors x thickness of slab x unit weight of RCC
= (15 x 15) x 12 x 0.150 x 25 = 10125 KN
Live Loads: As per 1893, only 50 % of total live load is considered for evaluating seismic load as live load is more than $3KN/m^2$.
Floor load = 0.50 x 11 x (15 x 15) x 4 = 4950 KN
Roof load = 0.25 x 1 x (15 x 15) x 2 = 112.5 KN
Total seismic weight of the structure is the algebraic sum of above calculated weights as given below;
Total seismic weight = 5098 KN + 10290 KN + 26640 KN + 10125 KN + 4950 KN + 112.5 KN
W = 57215.5 KN
Step 3) Fundamental Period:
$T = 0.075h^{0.75} = 0.075 \times 46^{0.75} = 1.324$ sec.
Step 4) Seismic Coefficient:
$A_h = \frac{Z}{2}\frac{I}{R}\frac{S_a}{g} = \frac{0.36}{2}\frac{1}{5} 1.027 = 0.0370$
Step 5) Design Base Shear (V_b):
$V_b = A_h W = 0.0370 \times 57215.5$
$V_b = 2116$ KN
STAAD Pro output is same as calculated manually as shown below;

```
*************************************************************
*                                                           *
* TIME PERIOD FOR X 1893 LOADING =     1.32474 SEC          *
* SA/G PER 1893=     1.027, LOAD FACTOR= 1.000              *
*      FACTOR V  PER 1893=     0.0370 X  57215.53           *
*                                                           *
*************************************************************
```

```
*************************************************************
*                                                           *
* TIME PERIOD FOR Z 1893 LOADING =     1.32474 SEC          *
* SA/G PER 1893=     1.027, LOAD FACTOR= 1.000              *
*      FACTOR V  PER 1893=     0.0370 X  57215.53           *
*                                                           *
*************************************************************
```

Figure 4. STAAD Output of Base Shear in X and Z direction

Step 6) Lateral Load Distribution
The lateral force results from STAAD Pro shown in below:

TABLE 4 Lateral force results for model 1

Storey	Height (m)	Lateral Force (kN)
12	2	441.407
11	6	415.844
10	10	340.407
9	14	272.515
8	18	212.165
7	22	159.36
6	26	114.098
5	30	76.380
4	34	46.205
3	38	25.692
2	42	9.410
1	46	1.106

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue V, May 2018- Available at www.ijraset.com

V. RESULTS AND DISCUSSIONS

A. Base Shear

The comparative representation of given six models on the basis of maximum base shear is shown as below:

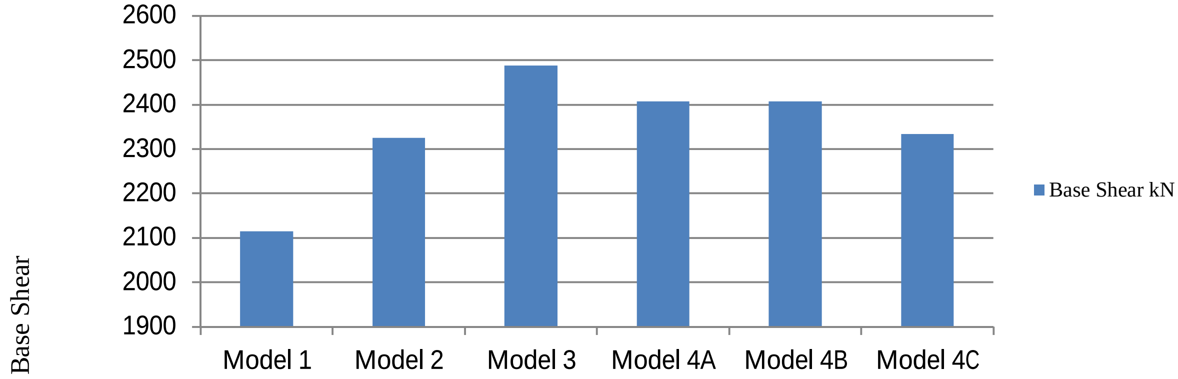


Figure 5. Base Shear

The structure with maximum base shear is more rigid, thus showing better seismic performance. It is observed that base shear varies directly with stiffness of the structure. The maximum base shear among given six models is shown by model 3 (MRF with shear wall system at corners). But the model 3 is less economical of all the models. Among the MRFs stiffened with both shear wall and RCC bracing system i.e., model 4A, model 4B and model 4C, model 4A and 4B results in more base share but are less economical than model 4C.

B. Storey Displacement

Storey displacement is defined as the total displacement of the storey with respect to ground or base. From the post analysis results it is found that the storey displacement in case of structures stiffened with shear walls (Model 3) is more as compared to structures stiffened with either RCC X-Bracing system or both shear wall and RCC X-Bracing system in lower storeys (storey 1-9),whereas the storey displacement in case of structures stiffened with shear walls (Model 3) is less as compared to structures stiffened with either RCC X-Bracing system or both shear wall and RCC X-Bracing system in upper storeys (storey 10-12) as shown in the graph above. Among the given six models, model 3 (Moment Resisting Frame with shear wall system) and model 4C (Moment Resisting Frame with shear wall & RCC X-Bracing system system) show the least storey displacement. The model 4C is economical than model 3, thus we found that the use and suitable relative location of both shear wall and RCC X-Bracing system can enhance the seismic performance of the structure and makes it more economical.

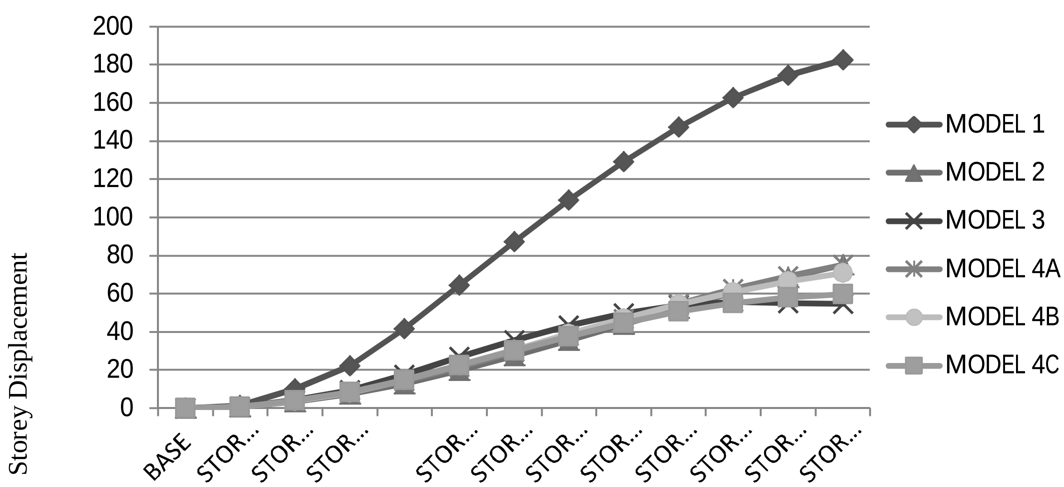


Figure 6. Storey Displacement

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue V, May 2018- Available at www.ijraset.com

The following figure shows the effect of relative location of shear wall and RCC X-Bracing system on the seismic performance of the structure.

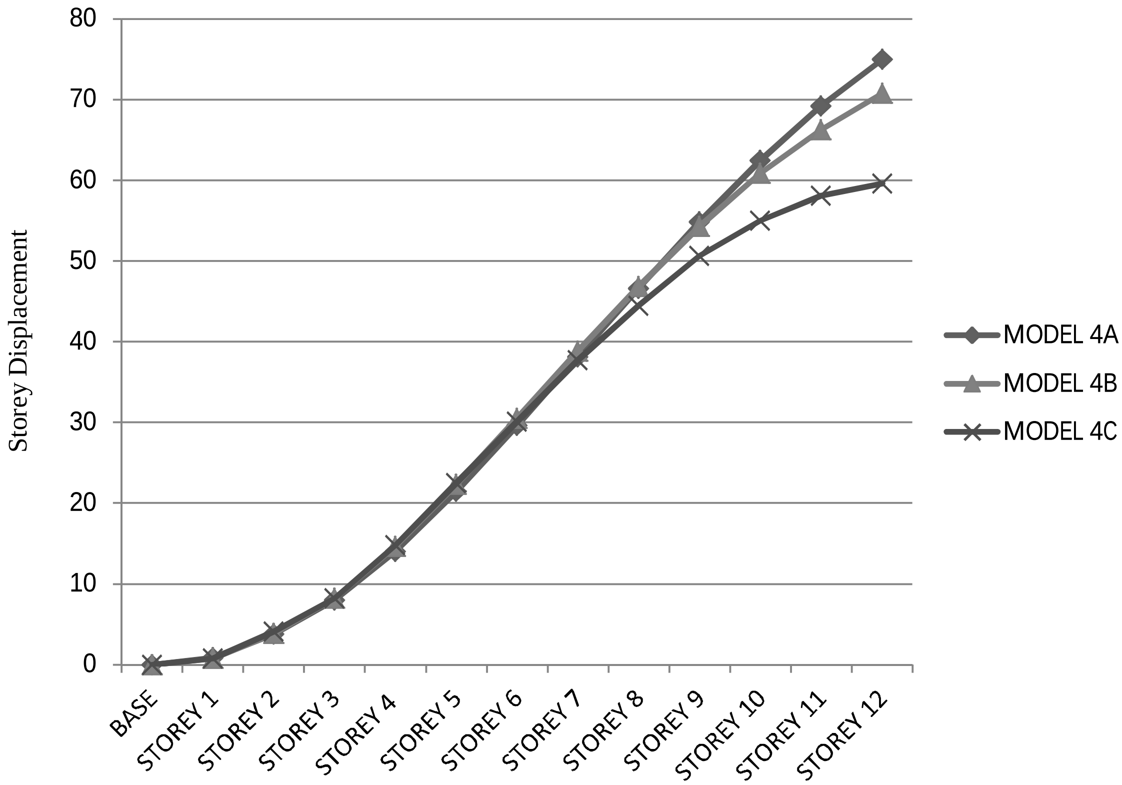


FIGURE 7. STOREY DISPLACEMENT OF ALL MODELS STIFFENED WITH BOTH SHEAR WALL & RCC X-BRACING SYSTEM

VI. CONCLUSIONS

In this study the different models based on the use and location of shear walls and RCC X-Bracing system were studied and the seismic parameters in terms of base shear and storey displacement were compared. The following conclusions are made based on the post analysis results:

A. In high rise buildings, the parameters like lateral strength and stiffness are more important. So for this purpose shear walls and RCC bracing system are adopted to enhance both these parameters. Moment resisting frames show higher storey displacement thus are weak as compared to other MRFs stiffened with shear wall and RCC bracing system.

B. The base shear of buildings with shear wall and RCC bracing system is more as compared to the buildings without shear wall and bracing system which results in the increase of stiffness of building.

C. The storey displacement of the building is reduced by the use of shear wall and RCC bracing system.

D. The top storey displacement for model 2 (The RCC X-bracing system paced at the 4 corners on both transverse as well as longitudinal bays) is reduced by 58.7 %, for model 3 (MRF stiffened with shear wall system at corners) is reduced by 69 %, and that for model 4C (MRF stiffened with both shear wall and RCC X-bracing system) is reduced by 67% when compared to bare MRF.

E. It is concluded that the storey displacement in case of structures stiffened with shear walls (Model 3) is more as compared to structures stiffened with either RCC X-Bracing system or both shear wall and RCC X-Bracing system in lower storeys (storey 1-9), whereas the storey displacement in case of structures stiffened with shear walls (Model 3) is less as compared to structures stiffened with either RCC X-Bracing system or both shear wall and RCC X-Bracing system in upper storeys (storey 10-12).

F. The model 3 and model 4C are the safest and show least storey displacement.

G. It is found that the RCC bracing also increases the primary strength of the structure.

H. The most effective relative locations of shear wall and RCC X-bracing system is provided in Model 4C (shear wall is placed at two longitudinal bays at corner 1, and at two transverse bays at corner 4, while as RCC X-bracing system is placed in similar way as shear wall at corner 2 and 3).

I. The model 4C is the safest and most economical of all the six models analysed.

VII. ACKNOWLEDGEMENT

This research was supported by Desh Bhagat University, Punjab, India. I sincerely thank my guide and advisor Dr Rajesh Goel, Professor in Civil Engineering for his guidance, suggestions, and continuous support throughout my Project. I greatly appreciate all the support that he has been given to me, both on this thesis and during the entire period in which I have been working for him.

My profound thanks to Dr Pooja Sharma, Professor and Head of the Department of the Civil Engineering, Desh Bhagat University for her valuable suggestions and help throughout this dissertation work. For the assistance and help she provided as being my co-advisor here at DBU, and also during my thesis work. Finally, my special thanks to all my professors & friends, who rendered valuable help throughout the completion of my Master's in Technology.

REFERENCES

[1] Kirtan. T, N. Jayaramappa, “Comparative Study of Multi-Storey RC Frame With Shear Wall and Hexagrid System” Paripex- Indian Journal of Research, Volume: 06, Issue: 01, pp. 814-817, ISSN 2250-1991, January 2017

[2] Jayesh Venkolath, Rahul Krishnan K, “Optimal Diagrid Angle of High-Rise Buildings Subjected to Lateral Loads” International Research Journal of Engineering and Technology (IRJET), Volume: 03 Issue: 09, pp. 841-846, e-ISSN: 2395 -0056 p-ISSN: 2395-0072, September 2016

[3] Seismic design of building structures by Micheal R lindeberg, PE and Majid Baradar, PE

[4] V. Abhinav, Dr. S. Sreenatha Reddy, M. Vasudeva Naidu, Prof. S. Madan Mohan, “Seismic Analysis of Multi Story RC Building with Shear Wall Using STAAD.Pro” International Journal of Innovative Technology and Research (IJITR), Volume: 4, Issue: 5, pp. 3776-3779, ISSN 2320 –5547, August 2016

[5] Md. Samdani Azad, Syed Hazni Abd Gani, “Comparative Study of Seismic Analysis of Multi-story buildings with Shear Walls and Bracing Systems” International Journal of Advanced Structures and Geotechnical Engineering (IJASGE), Volume: 05, Issue: 03, pp. 72-77, ISSN 2319-5347, July 2016

[6] Priyanka Soni, Purushottam Lal Tamarkar , Vikky Kumhar, “Structural Analysis of Multi-storey Building of Different Shear Walls Lcation and Heights” International Journal of Engineering Trends and Technology (IJETT), Volume: 32, pp. 50-57, February 2016

[7] M.D. Kevadkar and P.B. Kodag, Lateral Load Analysis of R.C.C. Building, IJMER,Vol.3, Issue.3, 2013, pp-1428-1434.

[8] Nauman Mohammed and Islam Nazrul, Behaviour of Multi-storey RCC Structure with different type of Bracing System (A Software Approach), IJIRSET, New Delhi, 2013, pp 7465-7478.

[9] Mohd Atif, Laxmikant Vairagade, Vikrant Nair, “Comparative Study on Seismic Analysis of Multi-storey Building Stiffened with Bracing and Shear Wall” International Research Journal of Engineering and Technology (IRJET), Volume: 02, Issue: 05, pp. 11581170, e-ISSN: 2395-0056, p-ISSN: 2395-0072, 2015

[10] Earthquake-Resistant Structures Design, Build, and Retrofit Mohiuddin Ali Khan, PH.D., P.E., C. ENG., M.I.C.E. (LONDON)

[11] Comparative Study of The Effects of Wind and Earthquake Loads on High-rise Buildings Khaled M. Heiza* Magdy A. Tayel Civil Engineering Department, Faculty of Engieering, Menoufiya University, EGYPT.

[12] Codes: IS 456 : 2000 - Bureau Of Indian Standards & IS 1893 : 2002 - Bureau Of Indian Standards, and 13920 : 1993 – BIS.

[13] STAAD pro V8i technical reference manual.