INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

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SEISMIC ANALYSIS OF RETROFITTED RCC BUILDING WITH CROSS BRACING SYSTEM

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Accepted Date: 15/03/2016; Published Date: 01/05/2016

Abstract: A 20 storied RCC frame with cross bracing (X) are analyzed placing the bracing at top and middle floors of building peripheries using SAP2000. The dynamic analysis is performed for different locations of bracing to examine the effect on the building in terms of storey displacement, drift and base shear. It is concluded from the analysis that the cross bracing reduces the storey displacement and drift, and increases lateral stiffness of the building frame. Retrofitting with bracing is a feasible option for strengthening the structure against lateral loads due to earthquake.

Keywords: Retrofit, seismic performance, Lateral Displacement, Base Shear, Storey Drift, X type bracing

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Access Online On:

www.ijpret.com

How to Cite This Article:

Akil Ahmed, IJPRET, 2016; Volume 4 (9): 341-350

PAPER-QR CODE

INTRODUCTION

The buildings are damaged due to faulty design or construction or due to limitations in the code. Most of the damaged buildings are repairable and may be retrofitted to re-use it. The purpose of the retrofitting is to remove the fear of the dweller, to make it seismically resistant against lateral load due to earthquake. There are many retrofitting strategies. Steel cross bracing is one of them and it is easy to erect, economic, takes less space during retrofitting work.

The retrofitting contributes to the lateral strength and stiffness of the building frame and reduces the lateral displacement due to lateral loads. The retrofitting strategies may be employed to other natural hazards such as cyclone, heavy wind etc. It is also applicable to historical structures and government buildings, hospital etc. It increases the life of the damaged structures and global load carrying capacity of the building.

Providing cross steel bracing is one of the feasible options for RCC building frames. It is prefabricated and light in weight. It causes less disturbances to the dwellers during its erection. While large opening in the building frame is required, it is the best option. It increases the lateral strength and stiffness laterally; conversely it reduces the lateral displacement and inter-storey drift.

2. LITERATURE REVIEW

Islam Nazrul (2013) presented an analysis on behavior of multistory RCC structure having different bracing systems. After the analysis, it had been concluded that the displacement of the structure decreases for adding bracing system to the existing structure.

Lydia Sarno et.al (2008) performed analysis on seismic performance of Moment resisting frames (MRFS) made of steel having retrofitted with different bracing systems. For the analysis, special concentrically braces, buckling restrained braces and mega braces (MBFS) were used. The results of the performed inelastic analyses demonstrate that moment resisting braced frames (MBFS) are the most cost effective.

Nitin Bhojkar and Mahesh Bagade (2015) studied the seismic analysis of RCC frame buildings with different types of bracing. The total weight on the existing building will not change significantly due to using steel bracing. The lateral displacement of the building reduces up to 65% and stiffness of the frame increases for using X type of bracing system.

Shachindra Kumar Chadhar, Dr. Abhay Sharma (2015) considered fifteen story building inverted V bracing system and V type bracing system for analysis. The former one significantly reduces the bending moment and shear force than the later one. From the result, it is found that double angle section better than ISMB and ISMC section.

Dr. R. B. Khadiranaikar (2013) investigated seismic performance of RC Frame with steel bracings. The estimated inter storey drift values ranges between 0.3 to 0.4% for inverted V bracing while 0.2 to 0.3% and 0.5 to 2.5 % for V bracing and un-braced frame respectively. The energy absorbed by inverted V bracing system is 43 to 49 %, which is more than the V bracing systems.

Venkatesh S.V., Sharada Baih (2013) studied the difference in structural behavior of 3-dimensional two-bays and three-bays having 10 storeys basic moment resisting RC frames with steel bracings of LLRS. The linear dynamic analysis was performed and maximum values of joint displacements, support reactions, beam forces and forces in steel bracings were analyzed. It is found that the lateral load resisting system increases in the presence of steel bracings.

Viswanath K.G, Prakash K.B (2015) investigated the seismic performance of rehabilitated reinforced concrete buildings with concentric steel bracing. A four storey building is analyzed. Steel bracings reduce flexure and shear demands on beams and columns. It is also found that steel bracings transfer the lateral loads through axial load mechanism. For using X type bracing systems, the lateral displacements of the building reduce.

Mustafa Taghdi, and Michel Bruneau studied two masonry walls without reinforcement and with partially reinforcement. The concrete walls had minimum reinforcement. Those walls were tested under constant gravity load together with incrementally increasing in-plane lateral deformation reversals. From the test results, it is found that the complete steel-strip system significantly increased the in-plane strength and ductility of low-rise unreinforced and partially reinforced masonry walls, and lightly reinforced concrete walls.

Mahmoud R. Maher (2008) analyzed the results of experimental and numerical investigations for evaluating the level of capacity interaction between the two systems are discussed. Based on these findings, guidelines are provided for the seismic design of the internally cross-braced RC frames with direct connections.

3. Modeling

The RC building used in this study is twenty storied (G+19) building having same floor plan with 4 bays having 5 m distance along longitudinal direction and 4 bays having 5 m distance along transverse direction as shown in figure (figure 1 to 6).

No. of stories = 20

No. of bays (in X & Y direction) = 4

Bay spacing (in X & Y direction) = 5 m

Story height = 3 m

Building type = residential building

Load considered:-

Live load = 4 kN/sqm

Wall Load = 230 mm thick wall with plaster (13.0 kN/m)

Beam size = 300 X 600 mm

Column size = 450 X 650 mm

Grade of concrete = M25 for beam

Grade of concrete=M35 for column

Grade of Steel = Fe500

Bracings = ISA100 X100 X10

Bracing used = cross bracing

Seismic Zone: IV

Zone factor, Z = 0.24

Importance factor, I = 1.00

The load cases considered in the seismic analysis are as per IS 1893 – 2002.

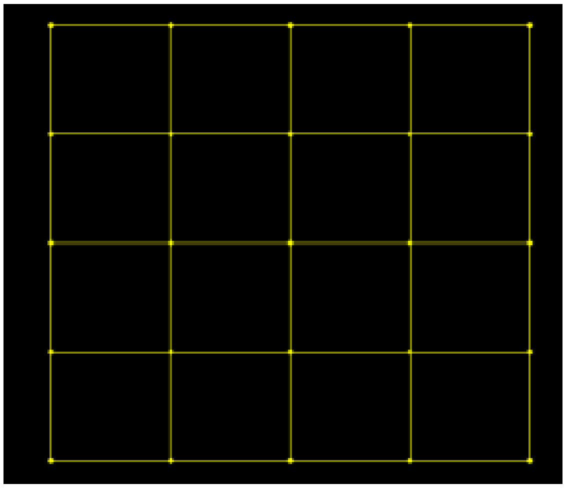

Figure 1: Plan of 20 storey building

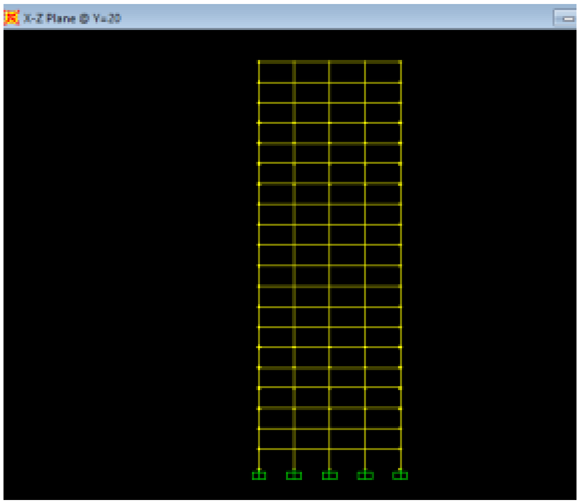

Figure 2: Front elevation

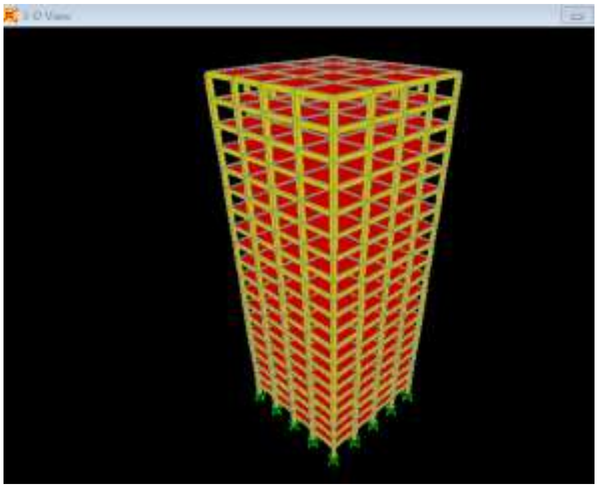

Figure 3: Model 1- building without bracing

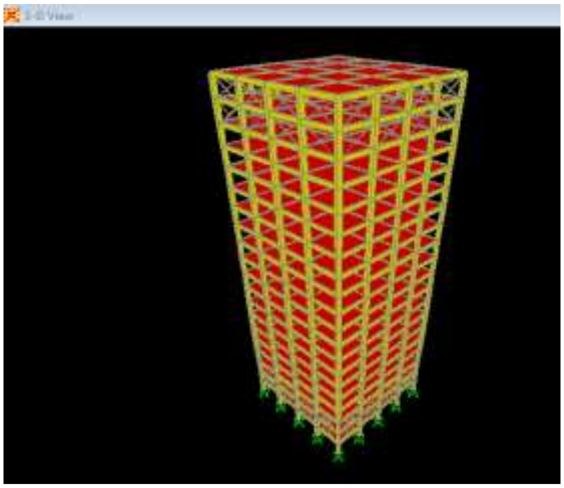

Figure 4: Model 2 - building with bracing at top

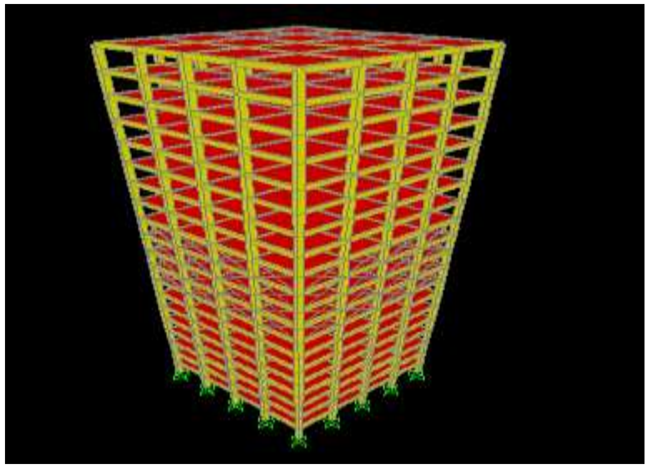

Figure 5: Model 3 - building with centre bracing

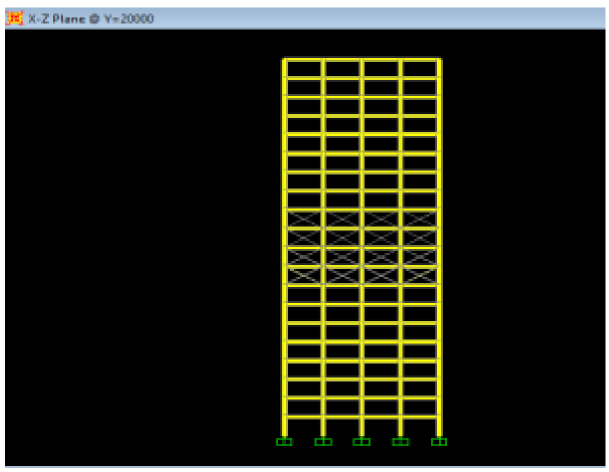

Figure 6: Building with centre bracing (elevation)

4. RESULTS AND DISCUSSION

Steel bracing system is the one of viable options for seismic retrofitting of the building frame. The purpose of the retrofitting is to overcome the deficiency in strength and stiffness against horizontal load due to earthquake. Steel bracing is easy to erect, economical, occupied less space during erection. In this study, the seismic performance is evaluated for rehabilitated 20 storied RCC building frames with cross bracing. The location of the bracing is examined placing at top, centre of the building at the periphery. The performance of the building is calculated in terms of story displacement. The reduction in lateral displacement is found out. It is found that the cross bracing increases the structural stiffness and reduces the maximum inter-storey drift of the frames (tables 1 and 2, figures 7 and 8).

Table 1: Base shear (kN) in X and Y direction

Models	X direction	Y direction
1	1314.915	1202.991
2	1391.261	1281.744
3	1405.622	1284.845

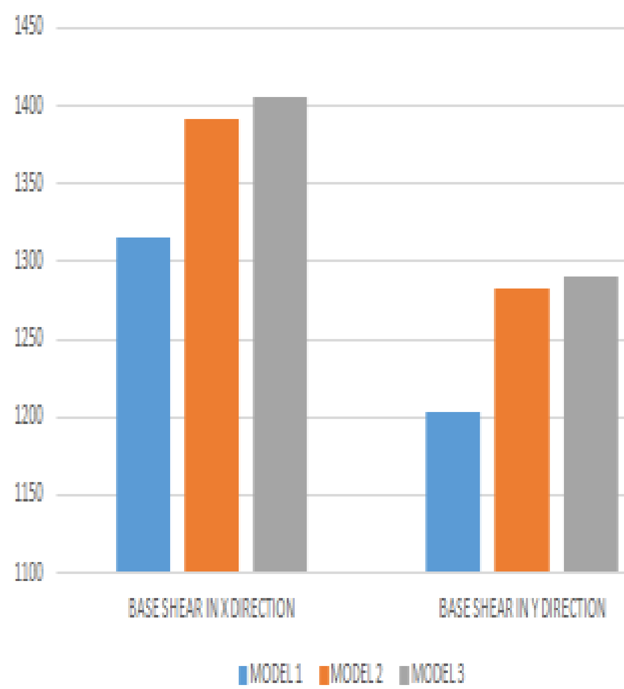

Figure 7: Base shear (kN) in X and Y direction

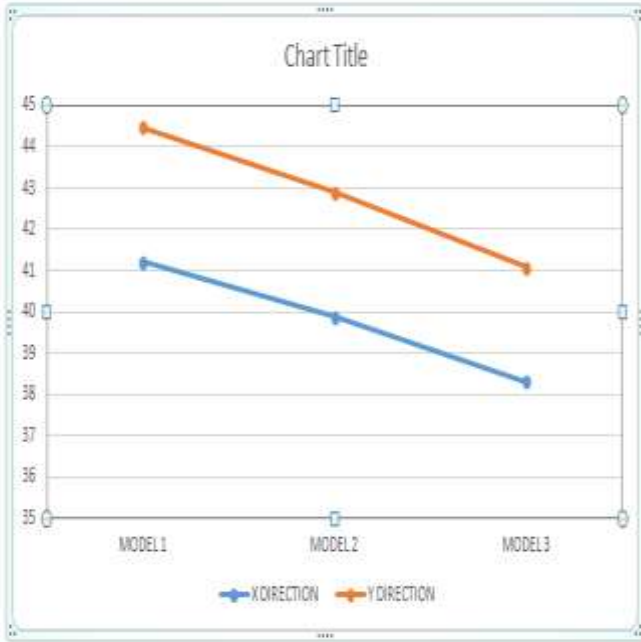

Figure 8: Maximum lateral displacement (mm) in X and Y direction

Table 2. Maximum Lateral displacement (mm) in X and Y direction

Models	X direction	Y direction
1	41.2055	44.4851
2	39.8793	42.9049
3	38.3029	41.0787

5. CONCLUSION

Story drifts are reduced using X type of bracing systems. Stiffness of the building is increases. From the analysis and design of twenty storied RC frames with or without bracings at different locations, we observe that Model-3 (RC Frame with bracings at centre of storey) is most efficient than Model 1 and Model 2. Because it is having lesser joint displacement values and maximum base shear for the same loading and member sizes.

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