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EFFECT OF SETBACK RATIO ON SEISMIC PERFORMANCE OF RC STRUCTURES

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Abstract – *This paper presents the effect of setback ratio on seismic performance of 11 storeyed (G+10) RC building. Five frames with different setback ratios viz. 0, 0.2, 0.4, 0.6 and 0.8 are modeled using ETABS (Version 2015) software. Response spectrum analysis is carried out as per IS 1893–Part 1 (2002). Seismic parameters like storey displacement, storey drift ratio and storey shear are calculated for seismic zone IV. The considered RC setback frames showed variation in seismic parameters due to unequal distribution of mass. This paper describes the importance of vertical geometric irregularities in RC structures, which should be analyzed seismically with proper understanding.*

Key Words: Setback building, Setback ratio, Response Spectrum Analysis (RSA), Storey displacement, Storey drift ratio, Storey shear.

1. INTRODUCTION

Earthquakes are the most catastrophic of all natural disasters, which cause large release in strain energy at the fault line which travel as seismic waves through the Earth's layers, leading to trembling movement of ground. The behaviour of structures during earthquake depends on many factors such as distribution of mass, stiffness and strength in both vertical and horizontal planes. There are two types of irregularities viz. plan irregularities and vertical irregularities prevail in framed structures. Setbacks in structures are the common type of vertical geometric irregularity. Setback buildings are the buildings with abrupt reduction of lateral dimensions at different floor levels of the elevation. As per Cl. 7.1 of IS 1893–Part 1 (2002), setback ratio of a building is defined as the ratio of horizontal distance between the edge of building and extreme end of setback (A), and the maximum horizontal plan dimension of building (L). This is explained pictorially in Fig. 1.

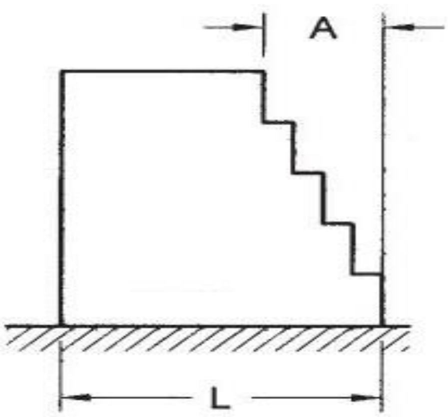


Fig -1: Definition of setback ratio as per IS 1893–Part 1 (2002)

2. **BUILDING DESCRIPTION:** Table 1 shows the description of developed RC setback frames considered in the present study.

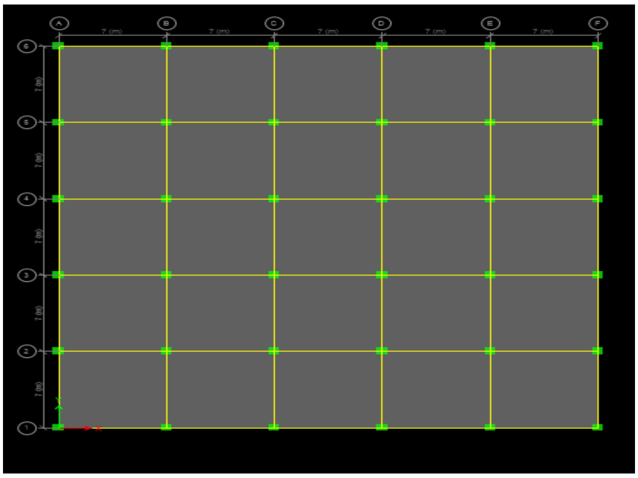
Table -1: Description of developed RC setback frame models

Sl. No.	Parameter	Remarks
1	Type of structure	Commercial
2	Number of stories	11 (G+10)
3	Bay width along X direction	7 m
4	Bay width along Y direction	7 m
5	Height of typical floor	3.5 m
6	Total height of building	37 m
7	Column size	650x700 mm
8	Beam size	300x600 mm
9	Slab thickness	150 mm
10	Masonry wall thickness	300 mm
11	Live load	4 kN/m^2
12	Floor finish	2 kN/m^2
13	Masonry load	16 kN/m
14	Soil type	Type II-Medium soil
15	Grade of concrete	M30
16	Grade of steel	Fe500
17	Density of concrete	25 kN/m^3
18	Density of concrete block	18 kN/m^3
19	Damping ratio	5 %
20	Seismic zone	IV
21	Response reduction factor, R	5
22	Importance factor, I	1

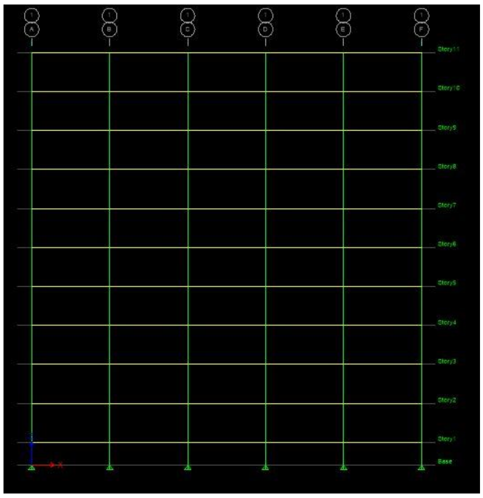
Table 2 shows the details of RC models with different setback ratios considered for seismic analysis. Figure 2 shows the plan and front elevations of all the developed RC frame models.

Table -2: Setback ratios of models

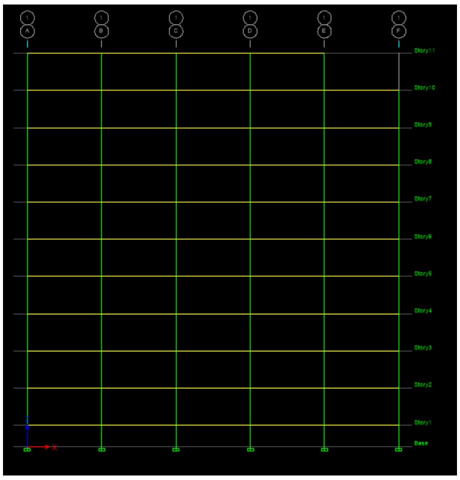
Sl. No.	Model Identity	Setback ratio
1	S1	0
2	S2	0.2
3	S3	0.4
4	S4	0.6
5	S5	0.8



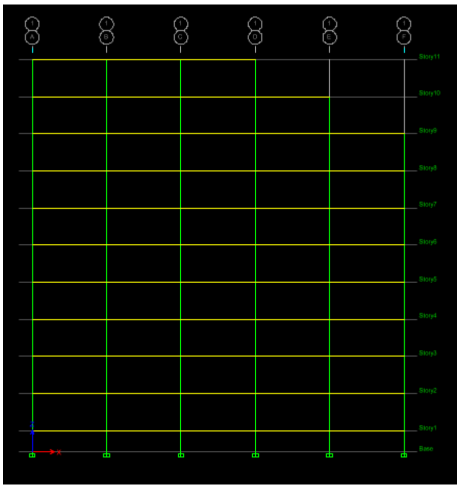
Plan



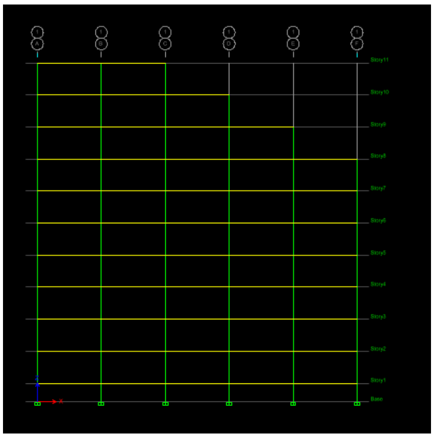
Front elevation : Model S1 (Setback ratio – 0)



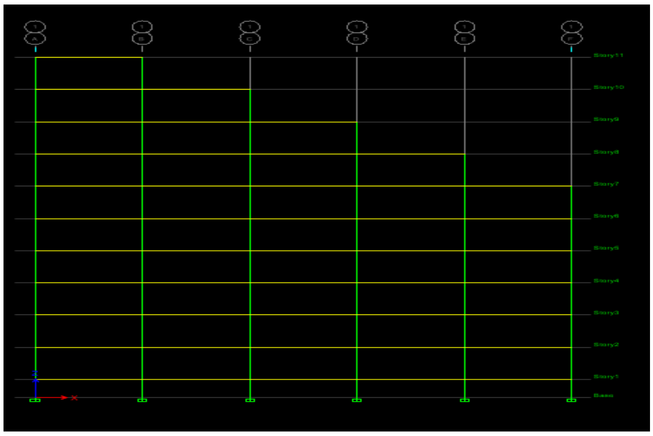
Front elevation : Model S2 (Setback ratio – 0.2)



Front elevation : Model S3 (Setback ratio – 0.4)



Front elevation : Model S4 (Setback ratio – 0.6)



Front elevation : Model S5 (Setback ratio – 0.8)

Fig -2 : Plan and front elevations of all the developed RC models with different setback ratios

1. SEISMIC ANALYSIS

The developed RC frame models are subjected to Response Spectrum Analysis (RSA) as per IS 1893–Part 1 (2002) codal provisions. Different seismic parameters like storey displacement, storey drift ratio and storey shear are obtained for all the developed RC frame models from the analysis.

2. RESULTS AND DISCUSSION

Figures 3 and 4, Figs. 5 and 6, and Figs. 7 and 8 show respectively the variation of storey displacement, storey drift ratio and storey shear over the number of storeyes in X and Y directions, obtained for all the RC setback frame models by Response Spectrum analysis (RSA).

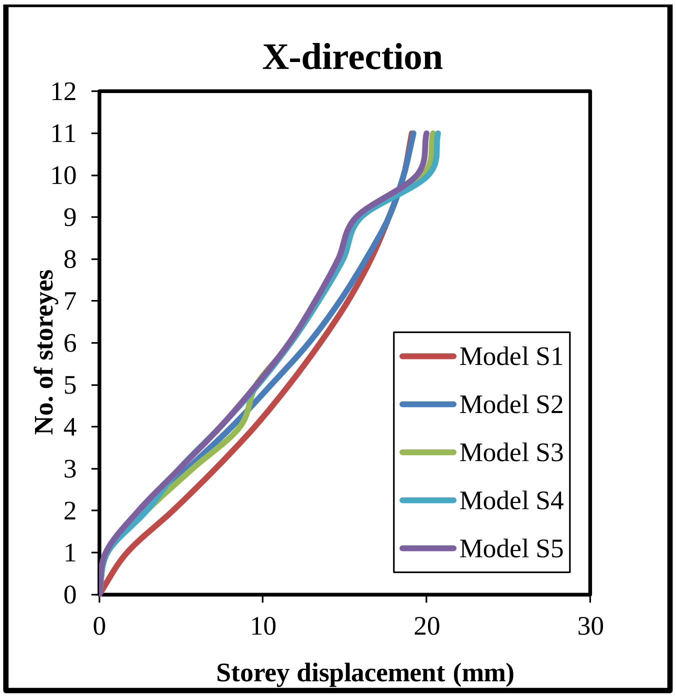


Fig - 3 : Variation of storey displacement in X–direction

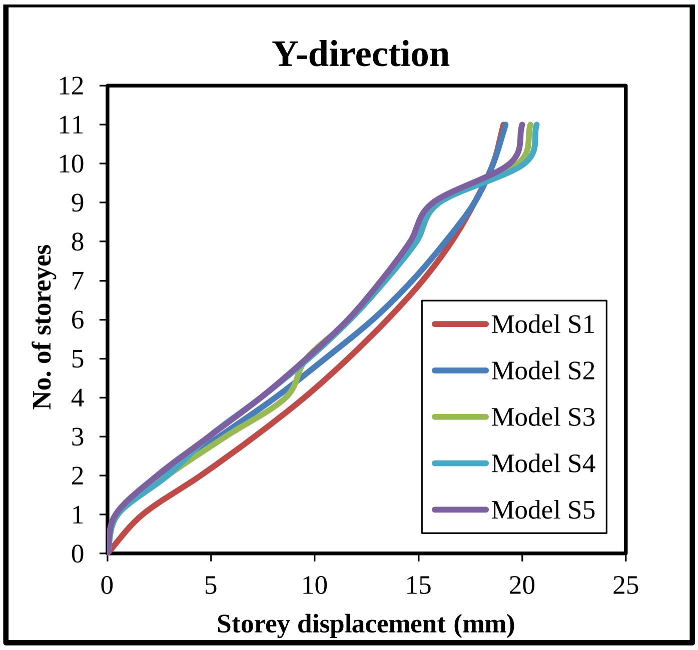


Fig -4 : Variation of storey displacement in Y–direction

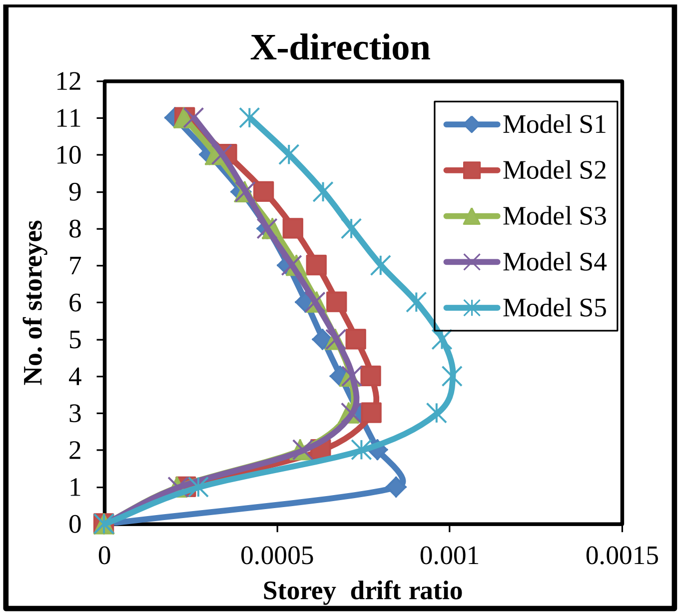


Fig -5 : Variation of storey drift ratio in X–direction

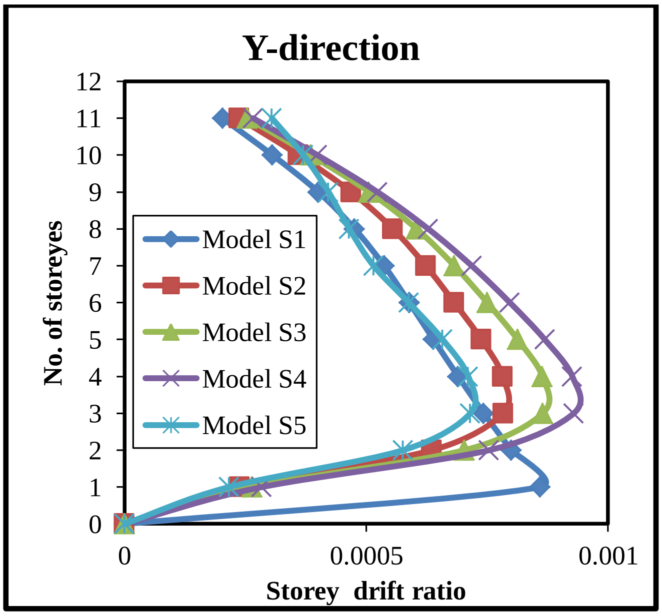


Fig -6 : Variation of storey drift ratio in Y–direction

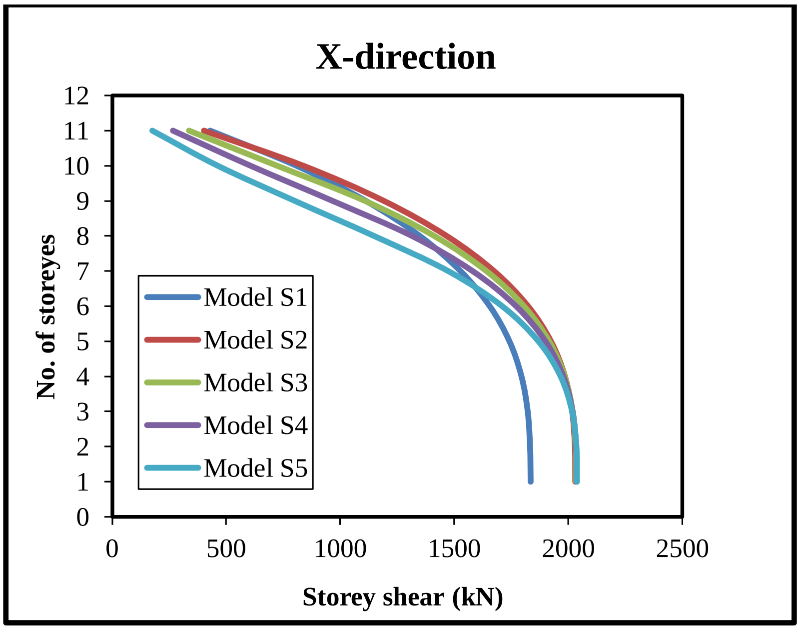


Fig - 7 : Variation of storey shear in X–direction

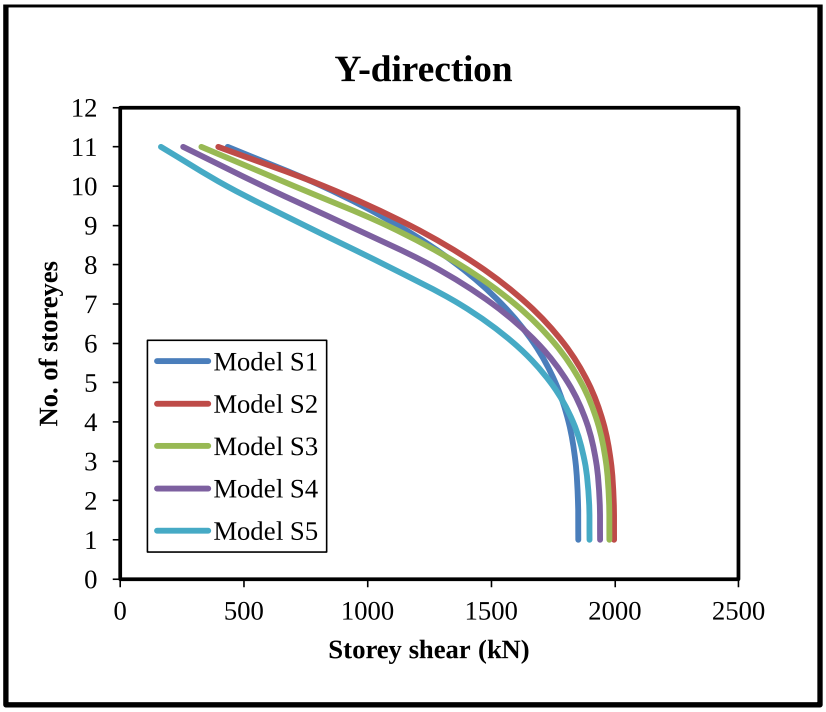


Fig -8 : Variation of storey shear in Y–direction

From Figs. 3 to 8, it can be observed that all the models show relativley similar variation of sesimc paramertes in both X and Y directions.

The maximum storey displacement values (i.e. at the top storey) obtained in X and Y directions by RSA for all the developed RC models with different setback ratios are shown in Fig. 9. RSA predicts the Model S4 having 0.6 setback ratio and the Model S1 with zero setback ratio to show maximum and minimum displacement in X and Y directions respectively.

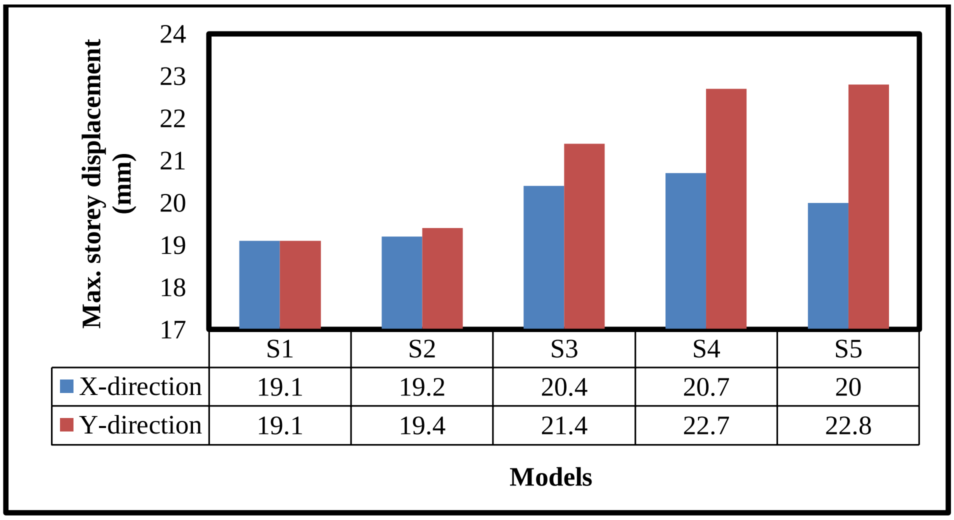


Fig - 9 : Maximum storey displacement in X and Y directions

The maximum storey drift ratio values obtained in X and Y directions from RSA for all the developed RC models with different setback ratios are shown in Fig. 10. Maximum storey drift ratio obtained from all the models are within the maximum allowable limit as specified by Cl. 7.11.1 of IS 1893–Part 1 (2002). Further, Model S3 having setback ratio 0.4 and Model S5 with setback ratio 0.8 respectively show minimum drift ratio in X and Y directions.

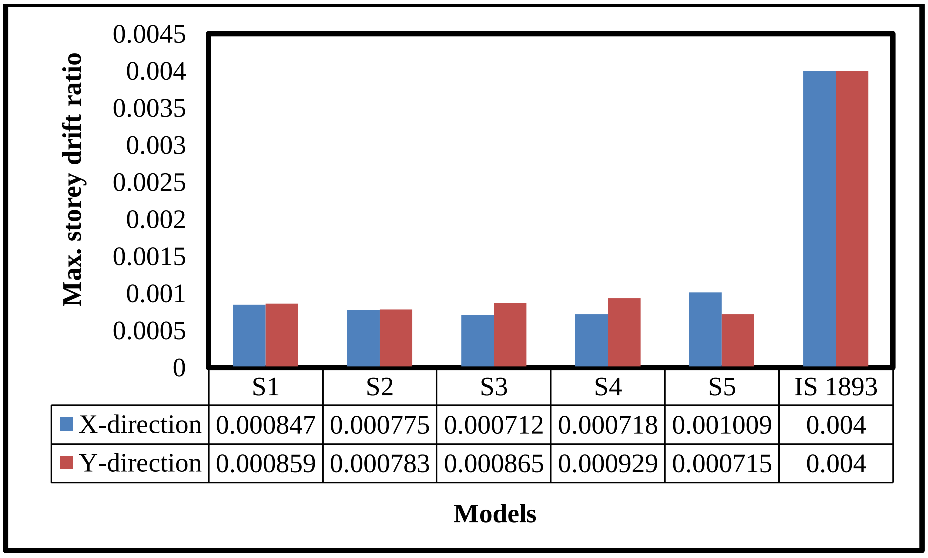


Fig - 10 : Maximum storey drift ratio in X and Y directions

The maximum storey shear (i.e. Base shear) values obtained in X and Y directions due to lateral forces, for all the developed RC models with different setback ratios are shown in Fig. 11. Minimum base shear value in both X and Y directions is observed in model S1 (with zero setback ratio) where as Models S2, S3, S4 and S5 with respective setback ratios 0.2, 0.4, 0.6, 0.8 show relatively same base shear in X-direction. Further, model S2 shows highest value of base shear in Y-direction.

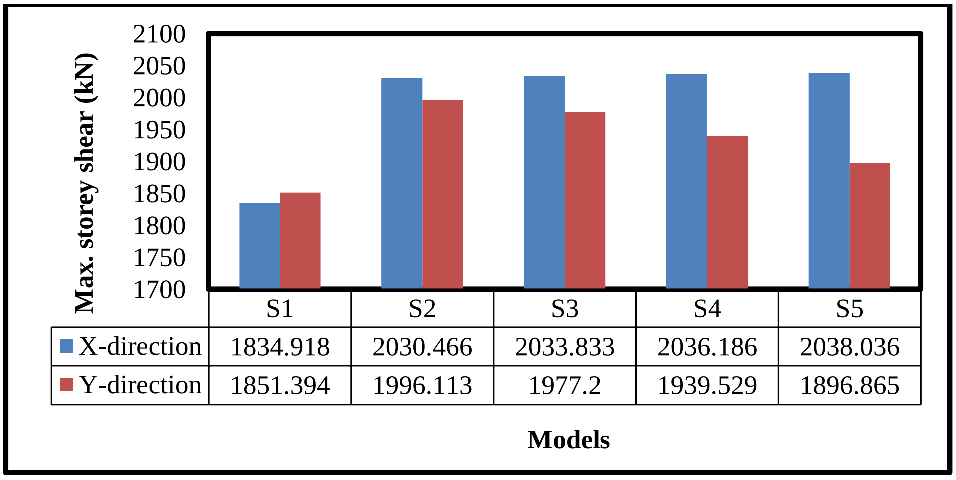


Fig -11 : Maximum storey shear in X and Y directions

CONCLUSIONS

In the present study, using ETABS (Version 2015) software, effect of vertical irregularities on 11 (G+10) storeyed RC bare frames is investigated by considering different setback ratios viz. 0, 0.2, 0.4, 0.6 and 0.8. Seismic parameters such as storey displacement, storey drift ratio and storey shear are found out for seismic zone IV using Response Spectrum Analysis (RSA) considering the stipulations laid down in IS 1893–Part 1 (2002) code.

The important conclusions drawn from the present study are explained below considering the results obtained from RSA.

1. Model S4 having 0.6 setback ratio and Model S1 with zero setback ratio show respective maximum and minimum displacement in both X and Y directions.
2. Model S3 having setback ratio 0.4 and Model S5 with setback ratio 0.8 respectively show minimum drift ratio in X and Y directions.
3. All the models show similar variation of storey shear in both X and Y directions. Also, minimum base shear value in both X and Y directions is observed in Model S1 (with zero setback ratio), whereas Models S2, S3, S4 and S5 with respective setback ratios 0.2, 0.4, 0.6, 0.8 show relatively same base shear in X-direction. Further, Model S2 shows highest value of base shear in Y-direction.

As the considered RC setback frames show variation in seismic parameters viz. storey displacement, storey drift ratio and storey shear due to unequal distribution of mass, vertical geometric irregularities in RC structures should be analyzed seismically with proper understanding.

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