A STUDY ON EFFECT OF ASPECT RATIO ON RC FRAMES SUBJECTED TO SEISMIC AND WIND LOADS

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***Abstract**: In the present study, performance of G+12 storeyed RC framed structures with different aspect ratios is investigated for seismic and wind loads using ETABS 2017 software. Aspect ratios varying from 0.25 to 2.0 are considered for the analysis. Aspect ratios of the models are chosen in such a way that Y-direction plan dimension is kept constant whereas X-direction plan dimension values are increased. Seismic parameters such as storey displacement, storey shear, storey drift ratio, storey stiffness and overturning moment are obtained using Response Spectrum Analysis for seismic zone III considering IS 1893–Part 1 (2016) codal provisions. Lateral displacement due to wind load is also determined as per IS 875–Part 3 (2015) codal provisions considering a basic wind speed of 33 m/s. Storey shear, storey stiffness and overturning moments increase with increase in aspect ratio in both the directions. Storey displacement due to earthquake and lateral displacement due to wind decrease with increase in aspect ratio in X-direction and behave oppositely in Y-direction. It is preferred to have structures with an aspect ratio of 1.0.*

***Keywords:** Aspect ratio, ETABS, Response spectrum analysis, Wind load analysis.*

I. INTRODUCTION

An earthquake is a sudden tectonic movement of the earth due to slippage or rupture of fault within the earth's crust which results in abrupt release of elastic energy stored in the rocks. Due to release of this energy, the seismic waves are created. Earthquake may also be caused by landslides, volcanic activity, nuclear tests, mine blasts etc. Earthquake is measured on a Richter's scale. As per IS 1893-Part 1 (2016), India's earthquake zoning map is divided into four seismic zones viz. II, III, IV and V. Zone II experience the lowest seismicity and zone V experience the highest seismicity. Structures are subjected to horizontal load due to wind forces acting on them. Wind load on a structure is calculated as per IS 875-Part 3 (2015). Wind load on a structure depends on the velocity of wind and the extent of time of wind acting on the structure. Aspect ratio is the ratio of length to the width of structure. Aspect ratio plays a major role when the structure is subjected to lateral loads due to earthquake and wind. When these loads acts on the structure, inertia force is developed in the structure, this inertia force is then transferred to the soil through the foundation. Hence, for the effective transfer of this load to the soil, geometry of the structure plays a major role and aspect ratio helps in choosing the suitable geometry to the structure.

II. BUILDING DESCRIPTION

Table 1 show the shows the parameters and description of the developed RC framed structure models.

Table 1: Parameters of the developed RC framed structure models

Sl. No.	Parameter	Remarks
1	Structure type	G+12
2	Total No. of storeyes	G+12
3	Total height of building from GL to terrace	41.6
4	Total height of building from Base to terrace	43.1
5	Spacing of bays in X-direction	5 m
6	Spacing of bays in Y-direction	5 m
7	Size of column	450 x 450 mm

Sl. No.	Parameter	Remarks
8	Size of beam	230 x 450 mm
9	Thickness of slab	150 mm
10	Typical storey height	3.2 m
11	Base storey height	1.5 m
12	Height of parapet wall	0.9 m
13	Grade of concrete for structural components	M 30
14	Grade of steel (rebar)	Fe 500
15	Density of concrete	24 kN/m^3
16	Live load on floor	4 kN/m^2
17	Live load on terrace	1.5 kN/m^2
18	Parapet wall load	5 kN/m
19	Soil type	Medium
20	Zone	III
21	Zone factor	0.16
22	Importance factor (EQ)	1
23	Response reduction factor	3
24	Basic wind speed	33 m/s
25	Terrain category	1
26	Risk coefficient factor (k1)	1
27	Terrain roughness and height factor (k2)	1
28	Topography factor (k3)	1
29	Structure class	B
30	Windward coefficient	0.8
31	Leeward coefficient	0.5

Table 2 show the aspect ratios of the developed RC framed structure models.

Table 2: Aspect ratios of the developed RC framed structure models

Sl. No.	Model	Plan dimension (m)		Aspect ratio
		X-direction	Y-direction	
1	M 1	5	20	0.25
2	M 2	10	20	0.5
3	M 3	20	20	1.0
4	M 4	30	20	1.5
5	M 5	40	20	2.0

Figure 1 shows the details of different aspect ratios of RC structures modeled in ETABS 2017 software.

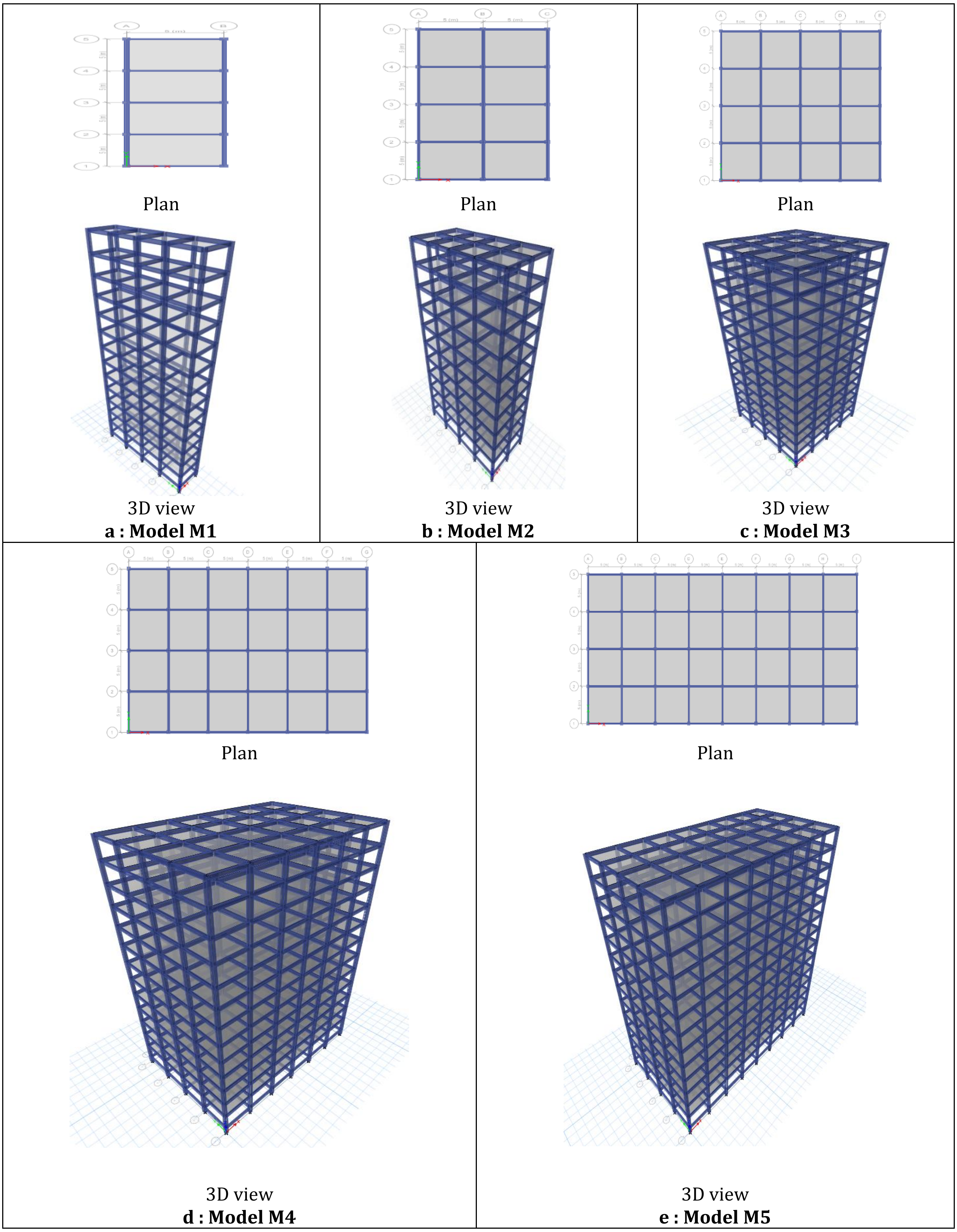

Fig. 1 : Models of different aspect ratios generated in ETABS software

III. SEISMIC AND WIND ANALYSIS OF MODELS

Using ETABS 2017 software, the RC framed structure models are subjected to Response Spectrum Analysis (RSA) as per IS 1893-Part 1 (2016) and Wind Load Analysis (WLA) as per IS 875-Part 3 (2015). At each storey level, seismic parameters such as displacement, drift, shear, stiffness, overturning moment and lateral displacements due to wind loads are obtained from the analyses for all the developed RC framed structures.

IV. RESULTS AND DISCUSSION

Figures 2 to 13 show the variation of storey displacement, storey drift ratio, storey shear, storey stiffness, overturning moment and lateral displacement over the number of storeys in both X and Y directions obtained for all the RC framed structure models by RSA and WLA respectively.

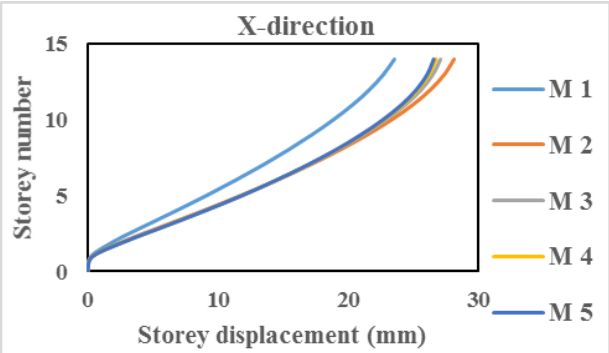

Fig. 2 : Storey displacement in X-direction of all the models

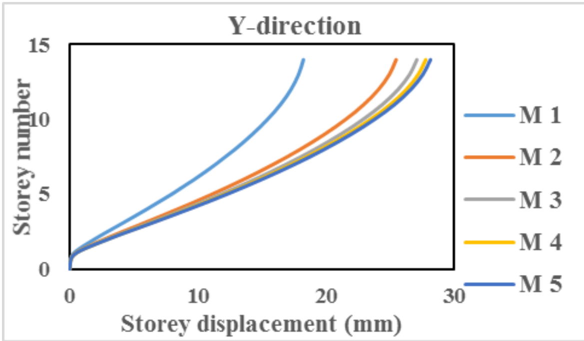

Fig. 3 : Storey displacement in Y-direction of all the models

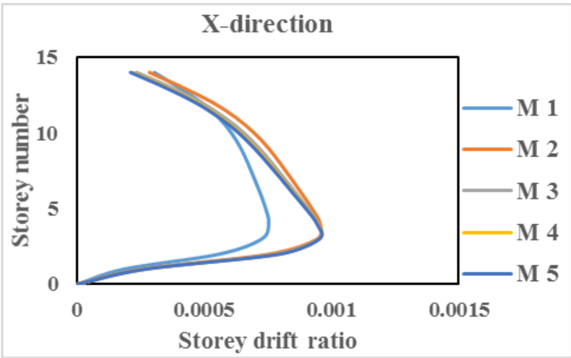

Fig. 4 : Storey drift ratio in X-direction of all the models

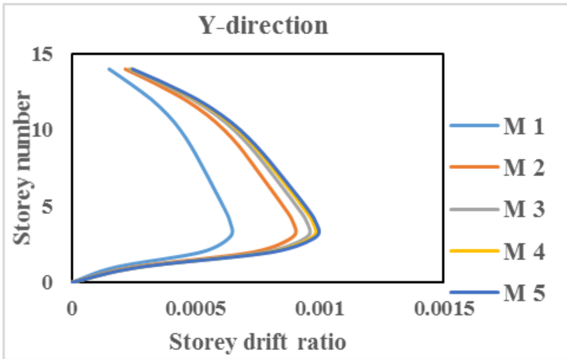

Fig. 5 : Storey drift ratio in Y-direction of all the models

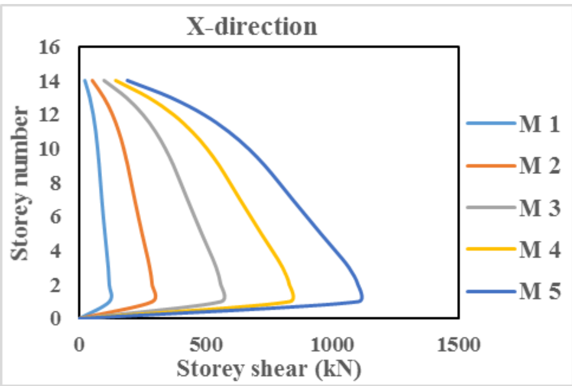

Fig. 6 : Storey shear in X-direction of all the models

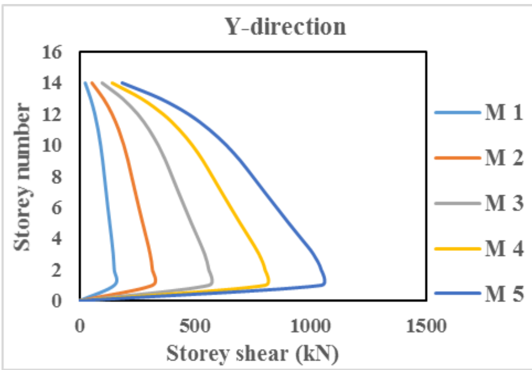

Fig. 7 : Storey shear in Y-direction of all the models

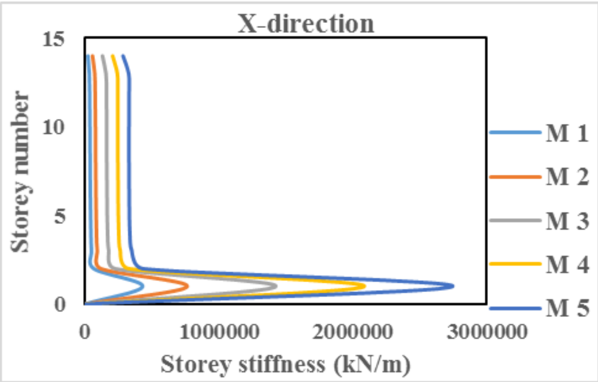

Fig. 8 : Storey stiffness in X-direction of all the models

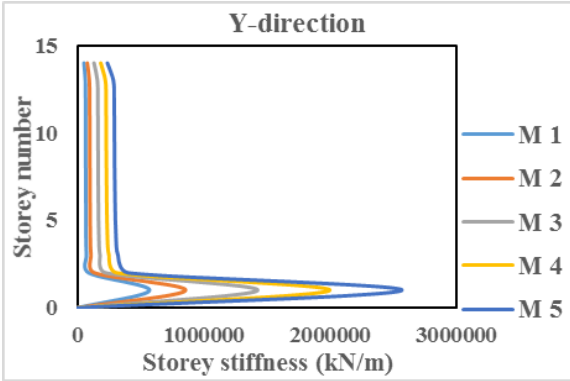

Fig. 9 : Storey stiffness in Y-direction of all the models

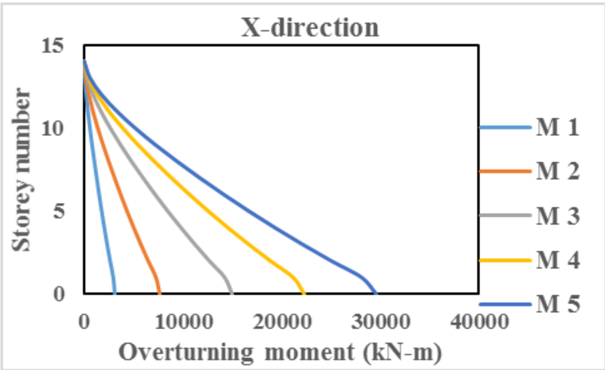

Fig. 10 : Overturning moment in X-direction of all the models

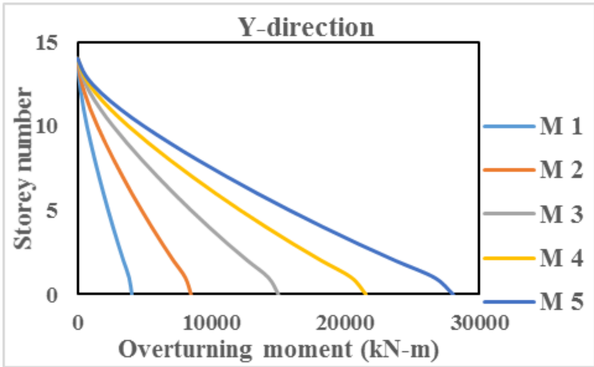

Fig. 11 : Overturning moment in Y-direction of all the models

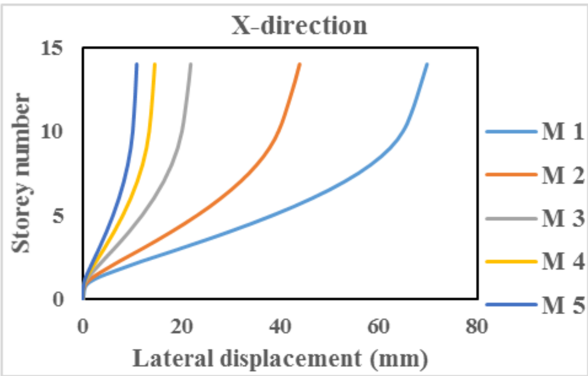

Fig. 12 : Lateral displacement in X-direction of all the models

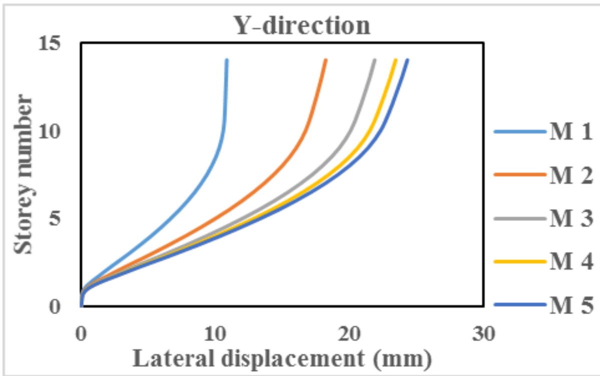

Fig. 13 : Lateral displacement in Y-direction of all the models

From Figs. 2 to 13 storey shear, storey stiffness and overturning moments increase with increase in aspect ratio in both the directions. Storey displacement due to earthquake and lateral displacement due to wind decrease with increase in aspect ratio in X-direction and behave oppositely in Y-direction.

Figures 14 to 25 show the variation of maximum storey displacement, storey drift ratio, storey shear, storey stiffness, overturning moment and lateral displacement for all the tall structure models by RSA and WLA respectively.

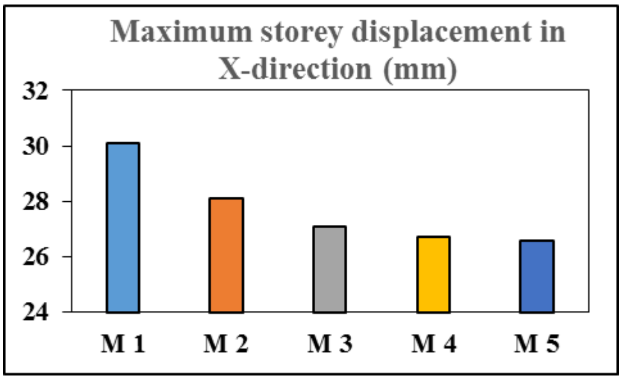

Fig. 14 : Maximum storey displacement in X-direction for all the models

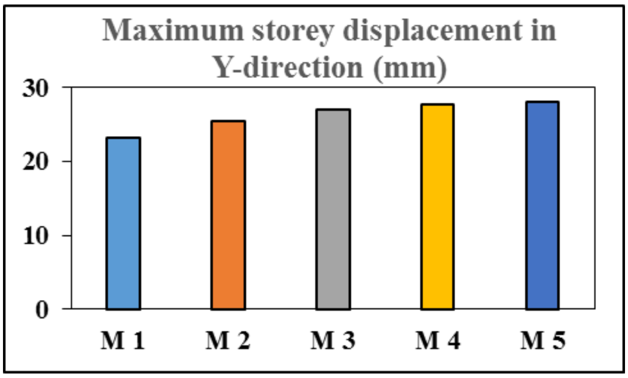

Fig. 15 : Maximum storey displacement in Y-direction for all the models

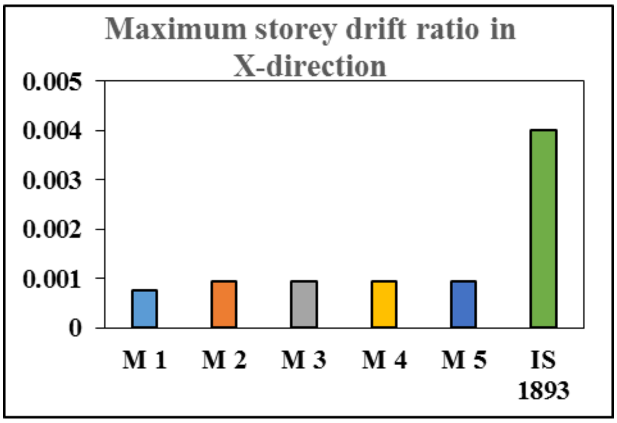

Fig. 16 : Maximum storey drift ratio in X-direction for all the models

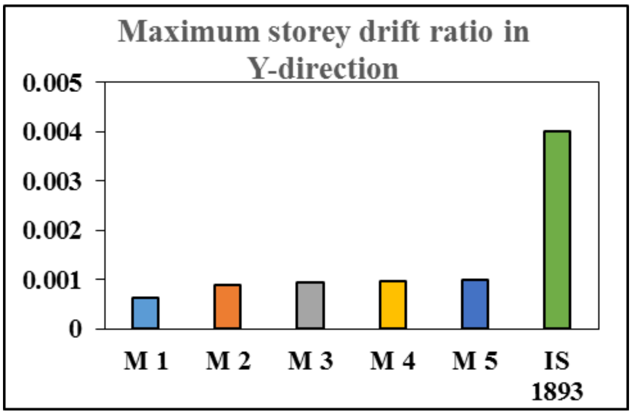

Fig. 17 : Maximum storey drift ratio in Y-direction for all the models

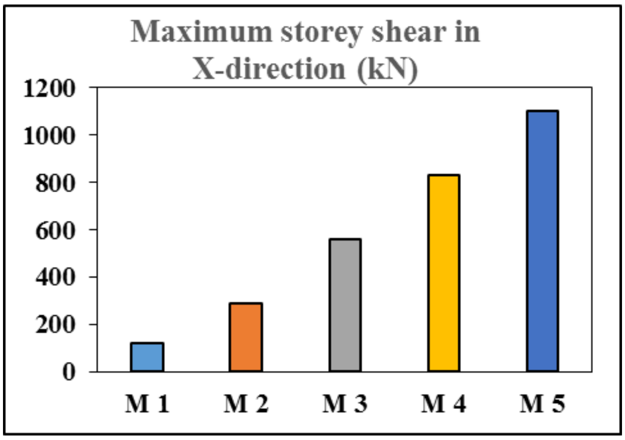

Fig. 18 : Maximum storey shear in X-direction for all the models

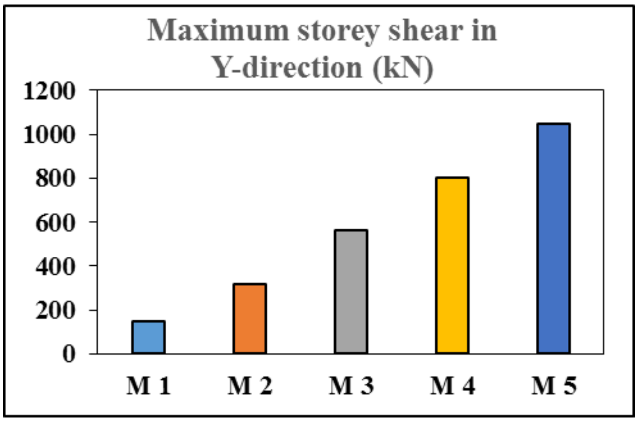

Fig. 19 : Maximum storey shear in Y-direction for all the models

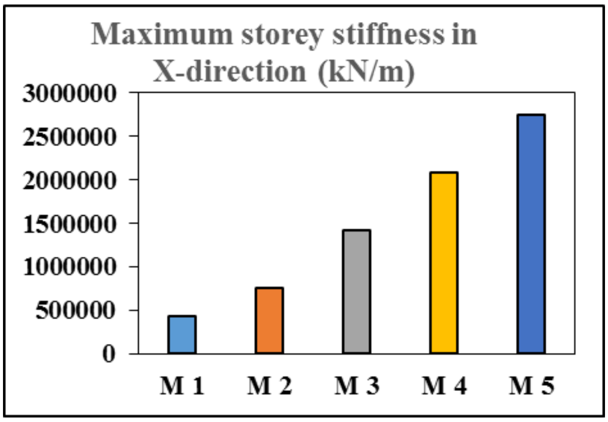

Fig. 20 : Maximum storey stiffness in X-direction for all the models

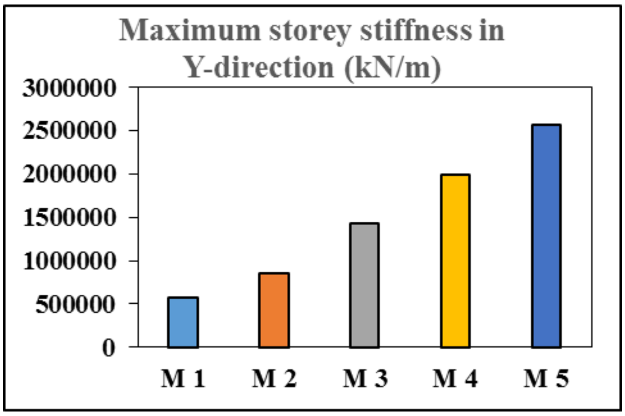

Fig. 21 : Maximum storey stiffness in Y-direction for all the models

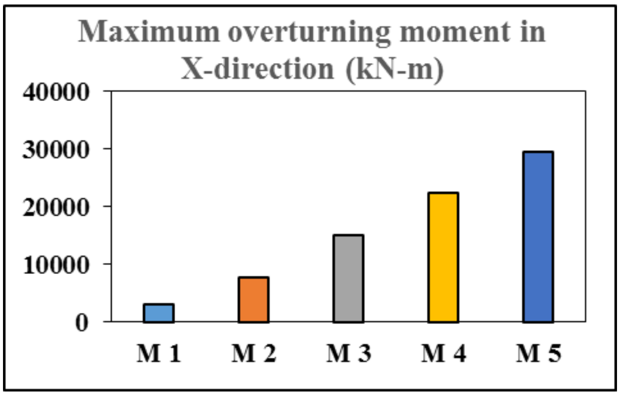

Fig. 22 : Maximum overturning moment in X-direction for all the models

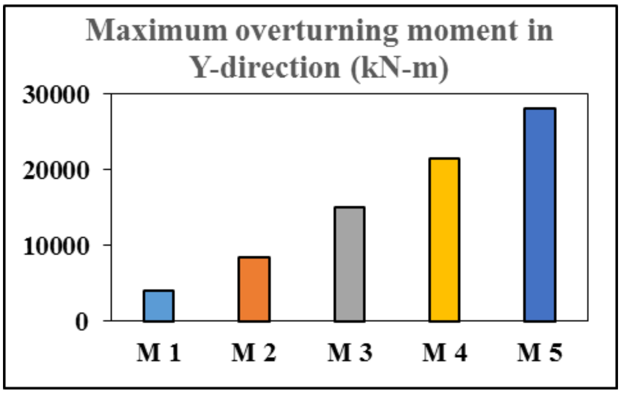

Fig. 23 : Maximum overturning moment in Y-direction for all the models

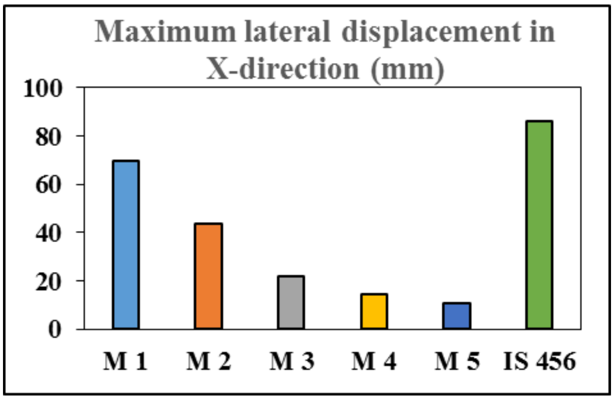

Fig. 24 : Maximum lateral displacement in X-direction for all the models

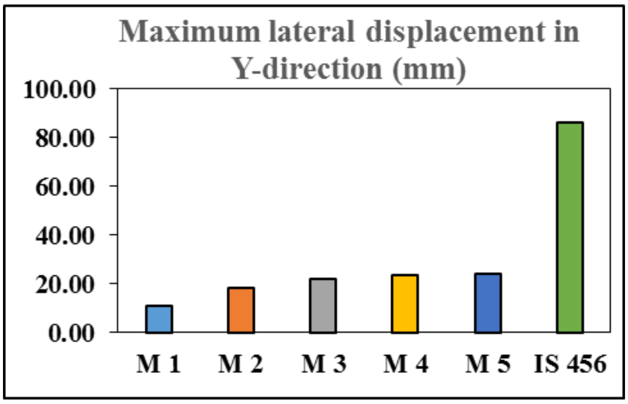

Fig. 25 : Maximum lateral displacement in Y-direction for all the models

Maximum storey displacement in X-direction decreases with increase in aspect ratio. Whereas, storey displacement in Y-direction increases with increase in aspect ratio. Maximum value of storey displacement in X-direction is observed in Model M 1 of aspect ratio 0.25 and maximum displacement in Y-direction is observed in Model M 5 of aspect ratio 2.0. In both X and Y directions, the storey displacement values increase with increase in the values of aspect ratio.

Maximum storey drift ratio in both X and Y directions increases with increase in aspect ratio. Maximum value of storey drift ratio for both X and Y directions is observed in Model M 5 of aspect ratio 2.0. However, maximum storey drift ratio value observed in all the models is within the allowable limit as specified in Cl. 7.11.1 of IS 1893-Part 1 (2016).

Maximum storey shear in both X and Y directions increases with increase in aspect ratio. Maximum value of storey shear for both X and Y directions is observed in Model M 5 of aspect ratio 2.0. In both X and Y directions, the storey shear values decrease with increase in aspect ratio values.

Maximum storey stiffness in both X and Y directions increases with increase in aspect ratio. Maximum value of storey stiffness for both X and Y directions is observed in Model M 5 of aspect ratio 2.0. In both X and Y directions, the storey stiffens values decrease with increase in aspect ratio values.

Maximum overturning moment in both X and Y directions increases with increase in aspect ratio. Maximum value of overturning moment for both X and Y direction is observed in Model M 5 of aspect ratio 2.0. In both X and Y directions, the overturning moment values decrease with increase in the values of aspect ratio.

Maximum value of lateral displacement in X-direction is observed in Model M 1 of aspect ratio 0.25 and maximum value in Y-direction is observed in Model M 5 of aspect ratio 2.0. However, maximum lateral displacement value [i.e. (H/500), where H is total height of the structure] observed in all the models is within the allowable limit as specified Cl. 20.5 of IS 456 (2000). In X-direction, maximum lateral displacement values decrease with increase in the values of aspect ratio, where as in Y-direction, opposite behavior is observed.

V. CONCLUSIONS

In the present study, performance of G+12 storeyed RC framed structures with different aspect ratios is investigated for seismic and wind loads using ETABS 2017 software. Aspect ratios varying from 0.25 to 2.0 are considered for the analysis. Aspect ratios of the models are chosen in such a way that Y-direction plan dimension is kept constant whereas X-direction plan dimension values are increased. At each storey level, seismic parameters such as displacement, shear, drift ratio, stiffness and overturning moment are obtained using Response Spectrum Analysis (RSA) for seismic zone III as per IS 1893–Part 1 (2016). Further, lateral displacement due to wind load is also determined as per IS 875–Part 3 (2015) considering a basic wind speed of 33 m/s. The important conclusions drawn from the present study are as follows.

1. All the models exhibit similar kind of variation in storey displacement. However, displacement in X-direction is found to be more than that of Y-direction in Model 1 of aspect ratio 0.25.
2. Maximum storey displacement in X-direction decreases with increase in aspect ratio. Whereas, maximum storey displacement in Y-direction increases with increase in aspect ratio.
3. Storey drift ratio in Y-direction is found to be lesser than that of X-direction up to aspect ratio of 1.0 and for the models with aspect ratio greater than 1.0, storey drift ratio in Y-direction is found to be more than that of X-direction.
4. Maximum storey drift ratio in both X and Y directions increases with increase in aspect ratio. Maximum value of storey drift ratio for both X and Y directions is observed in Model M 5 of aspect ratio 2.0. However, in all the models, maximum storey drift ratio is within the allowable limit as per IS 1893-Part 1 (2016).
5. Storey shear in X-direction is found to be less than that of Y-direction up to aspect ratio of 1.0 and for the aspect ratios greater than 1.0, storey shear in X-direction is found to be more than that of Y-direction.
6. Maximum storey shear in both X and Y directions increases with increase in aspect ratio. Maximum value of storey shear for both X and Y directions is observed in Model M 5 of aspect ratio 2.0.
7. Storey stiffness in X-direction is found to be less than that of Y-direction up to aspect ratio of 1.0 and for the aspect ratios greater than 1.0, storey stiffness in X-direction is found to be more than that of Y-direction.
8. Maximum storey stiffness in both X and Y directions increases with increase in aspect ratio. Maximum value of storey stiffness for both X and Y directions is observed in Model M 5 of aspect ratio 2.0.
9. Overturning moment in X-direction is found to be less than that of Y-direction up to aspect ratio of 1.0 and for the aspect ratios greater than 1.0, storey stiffness in X-direction is found to be more than that of Y-direction.
10. Maximum overturning moment in both X and Y directions increase with increase in aspect ratio. Maximum value of overturning moment for both X and Y direction is observed in Model M 5 of aspect ratio 2.0.
11. In Model 1 of aspect ratio 0.25, lateral displacement due to wind load in X-direction is found to be much larger than that of Y-direction. For all the models, the lateral displacement in X-direction decreases with increase in aspect ratio from 0.25 to 2.0 and in Y-direction, it increases with increase in aspect ratio.
12. Maximum value of lateral displacement in X-direction is observed in Model M 1 of aspect ratio 0.25 and maximum value in Y-direction is observed in Model M 5 of aspect ratio 2.0. However, in all the models, maximum lateral displacement is within the allowable limit as per IS 456 (2000).

Concluding Remarks: Storey shear, storey stiffness and overturning moments increase with increase in aspect ratio in both the directions. Storey displacement due to earthquake and lateral displacement due to wind decrease with increase in aspect ratio in X-direction and behave oppositely in Y-direction. It is preferred to have structures with an aspect ratio of 1.

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