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Analysis Of Earthquake Resistant Open Story Building On Etabs Acc To Is:1893-2016

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Abstract
In the present study the seismic response of the building having different percentage of opening at various floor level is investigated. For the analysis of G+10 RCC building carried out using response spectrum method as per 1893:2015 (part-1) criteria using CSI ETABS-2015 software is considered. The building model is analysed by for seismic zone IV and medium soil strata in all cases. The comparison of various seismic zone like story displacement, story drift, overturning moment, story shear force, and story stiffness between the building consisting opening and without opening in the slab is carried out. For the present work, it is observed that as the opening percentage of opening increased (> 45% of the plan area at that floor level), in case of G+10 RCC building, the top story displacement, story drift increases. This is also included in IS 1893-2016 that the opening of the building shall be restricted to maximum upto 50%. It is also observed that with the increase in the percentage of the opening the story stiffness decreases. Feather it is also observed that the shear force and the overturning moment developed at the base level of the building model also decrease with increase in the percentage of opening.

Keywords: ***Seismic Analysis, Story Drift, Story displacement, Overturning Moment, Open Story, ETABS.***

1. Introduction

There are small and the large earthquakes. Large earthquake can be taken down building and cause death and injury to the human. It is the natural phenomena and no one have control on it. In the past several major earthquake cause impact on the buildings. The failure in the multi-story building due to the building. Those causes due to weakness, these weakness result in the failure of the building. Those causes due to the irregularity in the building which could be in vertical irregularity or plane irregularity in the building.
The irregularity in the building is sad to be caused in the building if it consists opening more than 50% of the total floor area of the building at any floor level. As per IS 1983-2016 the opening in the plan should not be more than 50 percentage of total slab area in the building. Diaphragm with variation in stiffness, including those having cut-out open area grater than 50 percent of the gross enclosed diaphragm area, or change in effective diaphragm stiffness is more than 50 percent from one story to the next. Opening in the slab result in the flexibility diaphragm behavior, of the building and hence the loading of the above building will not transfer to the vertical member in proportion to their lateral translational stiffness. The problem is particularly when the opening is close to the edge of the slab. Opening are required to provide in RC slab of the building. Large opening provided in the building for construction of addition stairs, lighting purpose, elevator or cables, ducts or other instrument to Pss through one floor to another floor, mainly in the case of industrial building.

2. LITERATURE REVIEW

Neale, et al. (2011) has been studied the non-linear behaviour of various structural members strengthened with FRP. The analysis was done by using finite element method. In this study the different modelling approaches were carried out. The flexural & shear behaviour of both beam as well as two-way slab were considered. Both the beam & slab was strengthened using two different method. FRP was applied using mechanical fastened method & externally bonded scheme. The main attention was paid to the choice of model for which the results of numerical analysis would match the experimental results. The numerical phenomenon showed that the useful insight phenomenon as compare to experimental.
Muhammed et al. (2012) introduced to strengthen the RC slab where there is need of providing the cuts in existing structures. Since there are several approaches but it is good to select the approach that is cost effective. The paper deals with the CFRP sheets & the steel fibres used as a strengthening material. The model having square opening, rectangular opening, and without opening models are compared with the same model having steel fibres. The results showed that the CFRP increased the load carrying capacity by 30% instead the glass fibres increased the load carrying capacity by 20%.

Kadhim et al. (2013) Studied the strengthening of full Scale RC one-way slab with Cut outs. The study is based on behaviour of one-way reinforced concrete slab with cut out and ways of strengthening by using overlay concrete and Carbon Fiber Reinforced Polymer (CFRP) sheet. The CFRP strengthening of one way slab using nonlinear finite element analysis ANSYS is carried out for result.

Mahmood et al, (2013) studied the numerical behaviour of controlled RC slab strengthened with CFRP laminates using ANSYS. ANSYS is software used for the analysis of various structural and non-structural elements using finite element method. In this study first, the RC slab without CFRP laminate was analysed & then the RC slab was strengthened with CFRP laminates. The finite element analysis was done & then the results were compared with experimental results. It had been showed that there was a little difference in the results of experimental & numerical study.

Itti et al. (2014) Studied Two-way RC slab using ANSYS with and without central opening. The study is based on the variation of the stresses and displacement depends on boundary conditions of slab. The study shows that the displacement is maximum for the simply supported slab and stresses are minimum for the same slab.

Paulose et al. (2014) Studied the behaviour of plates with circular cut-out. In this study, the finite element analysis Package and ANSYS is used to analyse the behaviour of unstiffened plate with circular opening. When these structures are loaded, till there ultimate load capacity the consequent change in the buckling conditions are observed.

3. BUILDING DESCRIPTION

The comparison of IS code 1893:2002 (part-1) and revised IS 1893:2016 (part-1) is studied. for various clauses. The main focus of the present work is to study the effect of floor opening provided in the building and its effect on the structural behaviour.

In the present study the seismic analysis of multi-story building G+10 is carried out. The building is analysed using response spectrum method as per IS 1893:2002(part-1) in ETABS 2015. The buildings having variation in their percentage opening are investigated. The openings are also varied with respect to floor levels (at story levels). The effect of openings in floor of building.

3.2.1 Opening in the plane with variations in percentages

According to IS 1893-2016 the opening in the slab should not have opening more than 50% of the total floor area. The problem is particularly accentuated when the opening is closer to the edges of the slab. A building is sad to be have discontinuity in them in plan stiffens, when floor slab has cut-out or opening of area more than 50 percent of the full area of the slab.

In the present study various models where chosen for the study of the opening as 56.3%, 46.87%, 31.1%, 14%, 0% respectively as shown in fig 4.1, 4.2, 4.3, 4.4, 4.5, and 4.6 where At is total area of the slab and A_O is opening in the slab.

3.2.2 Opening in the Plane at different story level

The percentages of opening are various with respect to the story height in different story level.

3.3 Validation of the present study

3.3.1. Overview

In the present study the validation of the CSI-ETABS 2015 modelling system is carried by comparing base shear with manual calculation, using response spectrum method for seismic analysis of the building.

Considering four story building having 12m story height, consisting plan area as 15m×15m. The building is placed at seismic zone IV, the response reduction factor and importance factor of the building is 5 and 1 respectively. Providing beam of 300×600mm and column section as 300×600mm, assuming the dead load and Imposed load (as per IS 1893:2016) for the building as 4kN and 3kN respectively.

3.3.2. Manual calculation

Given,

Total height for the building = 12m

Seismic zone IV Z = 0.24 (as per IS 1893:2016)
R = 5 and I = 1 (as IS 1893:2016)
Area of the building = 15m×15m
Beam section = 300×600mm
Column section = 300×600mm
D.L =4kN and L.L = 3kN

Step-1 Load calculation for the building

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For the load calculation considering 25% of the imposed load as per the IS 1893:2016)

$$= 4+(0.25\times3) = 4.75\text{kN}$$

Self-weight of the beam = (16×0.3×5×25) ×4.75 = 1710kN-m^2

Self-weight of column = (16×0.3×0.6×3×25)×4.75 = 1026kN-m^2

Self-weight of roof = 15×15×4 = 900kN-m^2

Total load on building section = 1710+1026+3204+900

= 6840 kN-m^2

Step-2 Calculation of time period for the building

$$T_a = \frac{0.09h}{\sqrt{d}}$$

$$= \frac{0.9\times12}{\sqrt{15}}$$

$$= 0.27$$

According to IS 1893:2016 the value of Sa/g = 2.5

Step -3 Calculation of base shear

$$A_h = \frac{ZS_a/gI}{R}$$

Table 3.1 Base Shear calculation

Direction	Time Period (sec)	W (kN)	V_b (kN)
X	0.06	6840	410.86

3.3.3. Calculation of Base shear with CSI-ETABS 2015

IS1893 2002 Auto Seismic Load Calculation

This calculation presents the automatically generated lateral seismic loads for load pattern Ex according to IS1893 2002, as calculated by ETABS.

Direction and Eccentricity

Direction = X

Structural Period

Period Calculation Method = Program Calculated

Factors and Coefficients

3.2 Table consisting factor and coefficient :-

Seismic Zone Factor, Z [IS Table 2]	Z = 0.24
Response Reduction Factor, R [IS Table 7]	R = 5
Importance Factor, I [IS Table 6]	I = 1
Site Type [IS Table 1] = II	

Table 3.3. Seismic Response

Spectral Acceleration Coefficient, S_a /g [IS 6.4.5]	$\frac{S_a}{g} = 2.5$	$\frac{S_a}{g} = 2.5$

Table 3.4. Equivalent Lateral Forces

Seismic Coefficient, A_h [IS 6.4.2]	$A_h = \frac{ZI\frac{S_a}{g}}{2R}$

Table 3.5. Calculated Base Shear

Direction	Time Period (sec)	W (kN)	V_b (kN)
X	0.06	7219.4675	433.1681

From the above tow result for the base shear it is clear that the smaller variation in the value of the base shear.

Table 3.6. Detailed of modal frame:-

S.No.	Specification	For infill, stiffness and mass irregularity	For setback irregularity
1.	**Structural detail**		
	No. of stories	G+10	G+10
	Story height	3m	3m
	Type of building use	Residential	Residential
	No. of grid in X-direction	9	9
	No. of grid in Y-direction	9	9
	Spacing of the frame in X-axis	3m	3m
	Spacing of the frame in Y-axis	3m	3m
2.	**Material property**		
	Grading of concrete		
	a) Beam	M30	M30
	b) Column	M30	M30
	Design of concrete	25 kN/m^3	25 kN/m^3
	Density of brick masonry	19.5 kN/m^3	19.5 kN/m^3
	Modulus of elasticity of concrete	25×10^3 MPa	25×10^3 MPa
	Modulus of elasticity of masonry	4.125×10^3MPa	4.125×10^3MPa
	Poisson ratio of concrete	0.2	0.2
	Poisson ratio for brick	0.198	0.198
3	**Member property**		
	Thickness of slab	0.200m	0.200m
	Beam size	0.300m × 0.600m	0.300m × 0.600m
	Column size	0.300m × 0.600m	0.300m × 0.600m
	Thickness of wall		
	a) Outer wall	0.250m	0.250m
	b) Inner wall	0.250m	0.250
4.	**Seismic loading**		
	Analysis method	Response spectrum	Response spectrum
	No. of mode used	30 m	30 m
	Seismic zone	IV	VI
	Importance factor (I)	1.2	1.2
	Response reduction factor	5	5
	Soil type	Medium	Medium
	Z	0.24	0.24
	D.L =4KN and L.L = 3KN		

3. MODELING AND ANALYSIS

This chapter describes the three-dimension (3D) RC building considered for the present study. The total height of this building is 30 m with 3 × 3 m bay width and with different plan at different story. The building configuration represent different degree of vertical irregularities in form of different percentage of floor openings. In the present study. Table 4.1 gives the detail specifications of the present building model frame under consideration.

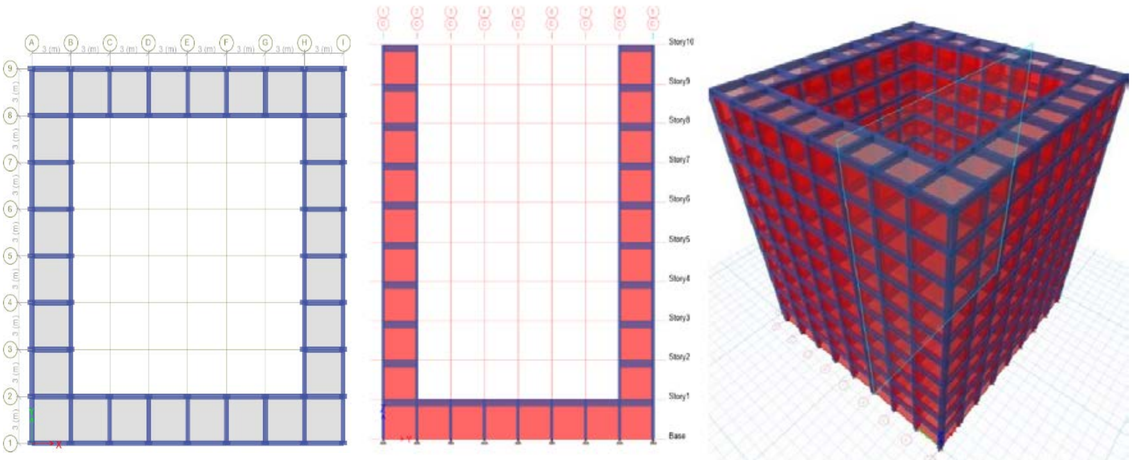
The seismic analysis of building is carried out. The building is considered to be situated in seismic zone IV as per IS 1893-2016 and on medium soil strata. The floor openings are considering with different percentage at different floor levels.

1.1 List of models

There is various modelling system used for the analysis of the building listed blow

Model 1^{st} AB_1: Opening at 1^{st} floor about 56.3% of total floor area, as shown in fig 4.1 and fig 4.6
Model 1^{st} AB_2: Opening at 1^{st} floor about 46.87% of total floor area, as shown in the fig 4.2
Model 1^{st} AB_3: Opening at 1^{st} floor about 31.3% of total floor area, as shown in the fig 4.3.
Model 1^{st} AB_4: Opening at 1^{st} floor about 23.4% of total floor area, as shown in the fig 4.4.
Model 1^{st} AB_5: Opening at 1^{st} floor about 14% of total floor area, as shown in the fig 4.5.
Model 1^{st} AB_6: Opening at 1^{st} floor about 0% of the total floor area, as shown in the fig 4.6.

Model 1^{st} AB_1: No opening at 1^{st} floor.at 56.3%of the total floor area, as shown in Fig 4.7
Model 1-2^{nd} AB_1: No opening from 1^{st} to 2^{nd} floor at 56.3%of the total floor area, as shown in Fig 4.8.
Model 1-3^{rd} AB_1: No opening from 1^{st} to 3^{rd} floor at 56.3%of the total floor area, as shown in Fig 4.9.
Model 1-4^{th} AB_1: No opening from 1^{st} to 4^{th} floor at 56.3%of the total floor area, as shown in Fig 4.10.
Model 1-5^{th} AB_1: No opening from 1^{st} to 5^{th} floor at 56.3%of the total floor area, as shown in Fig 4.11.
Model 1-6^{th} AB_1: No opening from 1^{st} to 6^{th} floor at 56.3%of the total floor area, as shown in Fig 4.12.
Model 1-7^{th} AB_1: No opening from 1^{st} to 7^{th} floor at 56.3%of the total floor area, as shown in Fig 4.13.
Model 1-8^{th} AB_1: No opening from 1^{st} to 8^{th} floor at 56.3%of the total floor area, as shown in Fig 4.14.
Model 1-9^{th} AB_1: No opening from 1
st to 9^{th} floor at 56.3%of the total floor area, as shown in Fig 4.15.
Model 1-10^{th} AB_1: No opening from 1^{st} to 10^{th} floor at 56.3%of the total floor area, as shown in Fig 4.16.



(a) Plan (b) Elevation (c) 3D View

Fig 4.1 Plan Elevation and 3D-view of model 1^{st} AB_1

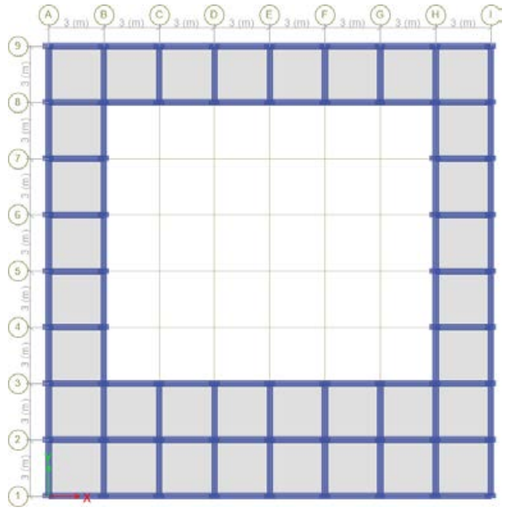


Fig 4.2: Plan of model 1st AB_2

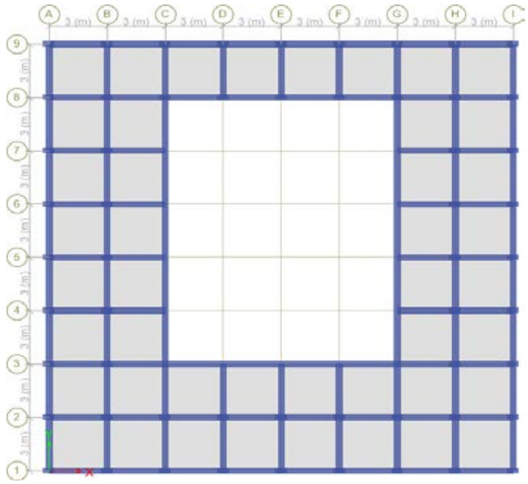


Fig 4.3: Plan of model 1st AB_3

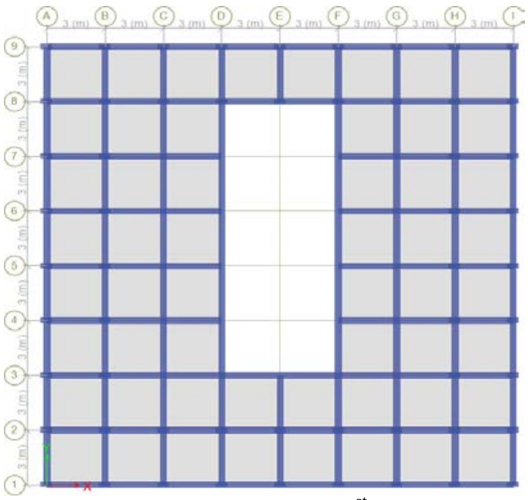


Fig 4.4: Plan of model 1st AB_4

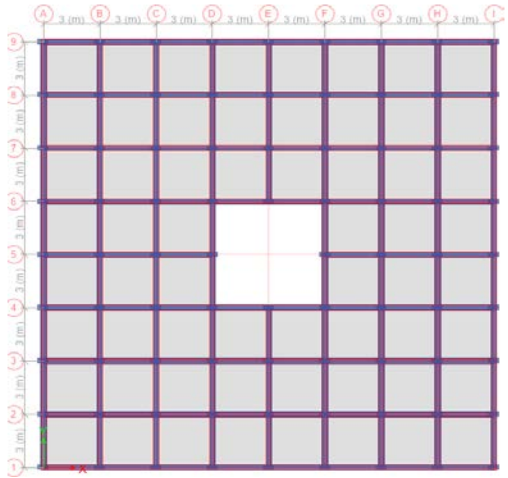


Fig 4.5: Plan of model 1st AB_5

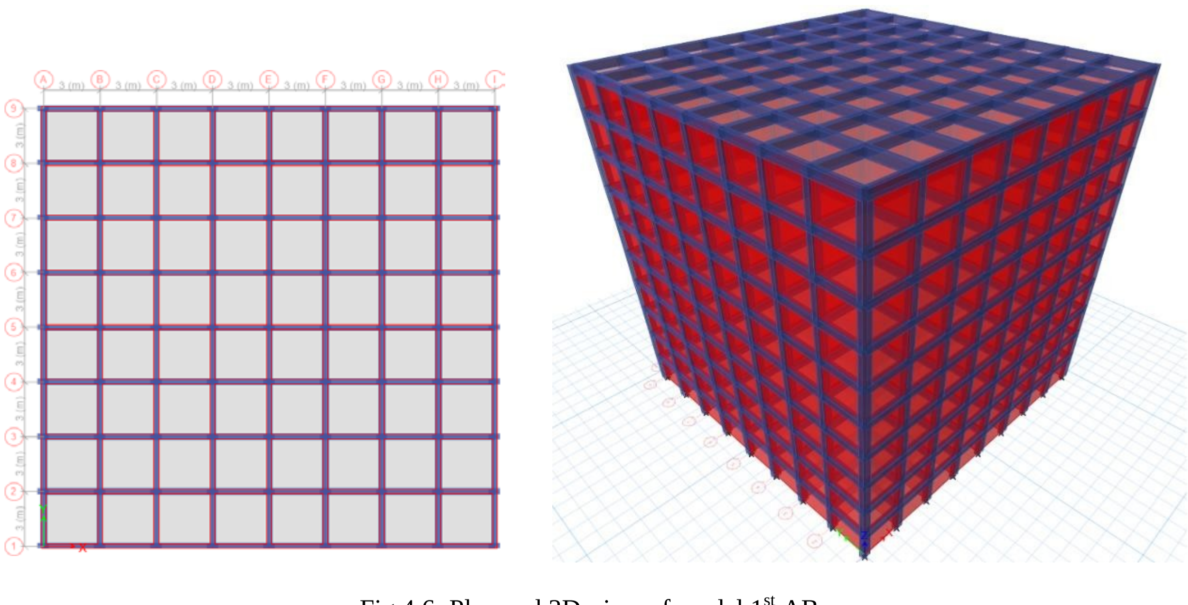


Fig 4.6: Plan and 3D-view of model 1st AB_6

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4. RESULTS AND INFERENCES

After modelling and analysis all the regular and irregular modelling systems in the Etabs using response spectrum analysis method (RSM) the following conclusion is considered for the modelling system. Different seismic response is concluded for the modelling system which are Story Displacement, Story Drift, Story overturning moment, Story Shear force, Story Stiffness. The results are evaluated with the help of the tables and figures. The maximum parameter is considered for the following analysis up to the top of the story level.

The analysis for the effect of the opening in the slab are shown with help of the Fig and tables of different models having opening at different story levels, the percentage of the opening is fixed at 56.3% of the total floor area of the slab and the opening is differing with respect to the opening. According to IS 1893:2016 the opening should not be more than 50% of the total floor area.

.5.2.1.1 Displacement in the story having 56.3% floor opening at different story height

Fig. 5.1 shows the max. displacement at each floor for different model A under consideration (in Chapter 4). Table 5.1 gives the max. displacement values for the different models A. It can be observed that the max. displacement has occurred in 1st and 1-2nd A model, as these models have the more percentage of opening as compared to other models. Therefore, it can be observed that the displacement is reduced if the opening in the buildings is provided above the 3rd floor level.

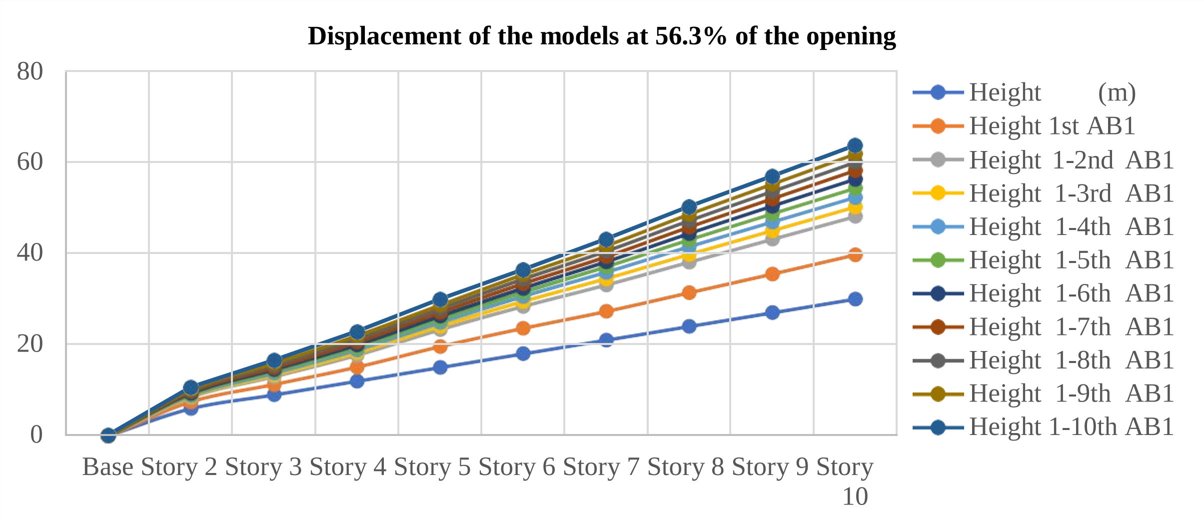

Fig 5.1 Displacement of the models at 56.3% of the opening

5.2.1.4 Maximum Story Stiffness

Fig. 5.4 shows the story stiffness at each floor for different model AB_1 under consideration (in Chapter 4). Table 5.4 gives the max. story stiffness values for the different models AB_1. It can be observed that the max. stiffness has occurred in AB_1 model, at story-1. As the filling is more at 1st story level the stiffness is also higher.

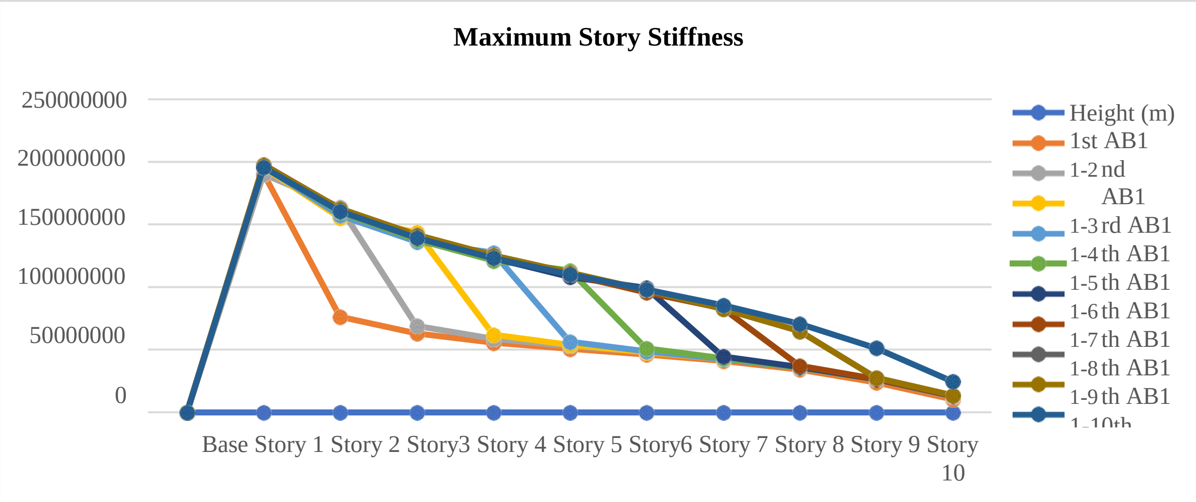

Fig. 5.2 Maximum Story Stiffness.

5.2.1.2 Maximum story drift

Fig. 5.2 shows the max. drift at each floor for different model AB_1 under consideration (in Chapter 4). Table 5.1 gives the max. drift values for the different models AB_1. It can be observed that the max. drift has occurred in 1st and 1-2nd A model, as these models have the more percentage of opening as compared to other models. Therefore, it can be observed that the displacement is reduced if the opening in the buildings is provided above the 3rd floor level.

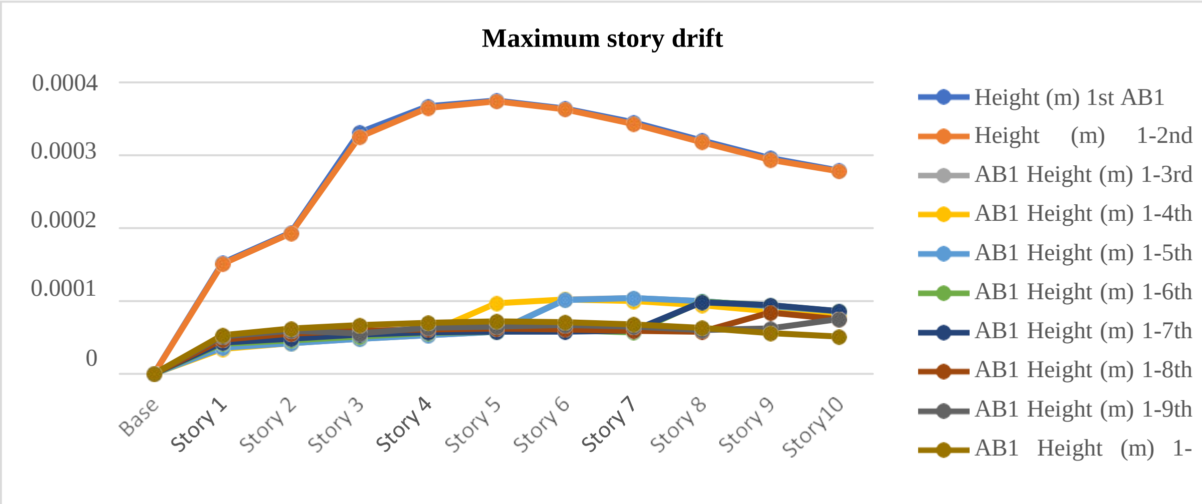

Fig 5.2 Maximum Story Drift

5.2.1.3 Maximum story shear force

Fig. 5.3 shows the max. shear force at each floor for different model AB_1 under consideration (in Chapter 4). Table 5.3 gives the max. shear force values for the different models AB_1. It can be observed that the max. shear force has occurred in 1-7nd AB_1 model, at story-1.

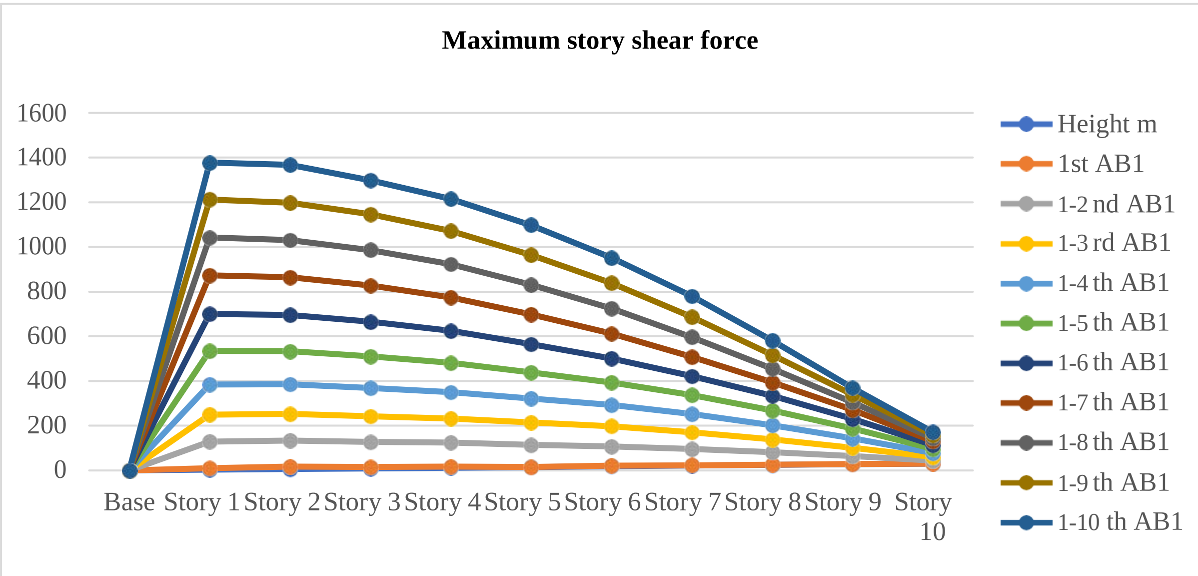

Fig 5.3 Maximum Shear force

5.2.1.5 Maximum Overturning Moment

Fig. 5.5 shows the max. overturning moment at each floor for different model AB_1 under consideration (in Chapter 4). Table 5.5 gives the max. overturning moment values for the different models AB_1. The maximum overturning moment has occurred at the base of the building and it is observed that it is maximum if openings are provided beyond 7th story.

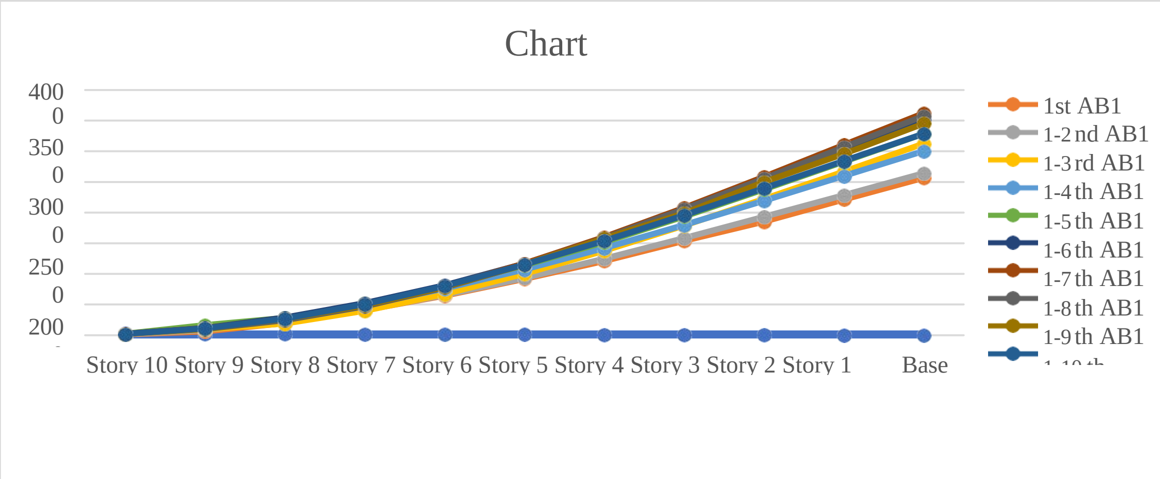

Fig 5.5 Maximum Overturning moment

5. Conclusions

1. It can be observed that the max. displacement and story drift has occurred in 1st A and 1st AB_1 model. As the percentage of opening is increases with respect to floor level the displacement and story drift is also increases. Therefore, the displacement and story drift are reduced if the opening in the buildings is provided above the 3rd floor level and it should be less than 45% (of the plan area at the floor level).
2. It can be observed that the max. shear force has occurred in 1-7nd A and 1st AB_1 model, at base. It is also observed that as we increase the percentages of opening the shear force is decreases.
3. It can be observed that the max. stiffness has occurred in 1-10th A and 1st AB_6 model, at story-1. As the filling is more at 1st story level the stiffness is also higher.
4. The max. overturning moment values for the different models 1-7th A and 1st AB_6. The maximum overturning moment has occurred at the base of the building and it is observed that it is maximum if openings are provided beyond 7th story.

From the above discussion it is observed that as the percentages of opening increases (> 45 % of the plan area at that floor level) in case of G+10 RC building, the top story displacement, story drift increases. This is also included in the IS1893-2016 that openings in a building shall be restricted to maximum up to 50%. It is also observed that with the increase in the percentage of opening the story stiffness decreases. Further, it is also observed that the shear force and overturning moment developed at base level of the building model also decreases with increase in percentage of opening.

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