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Seismic Effect on Staircase in Performance of RC Frame Building

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ABSTRACT

In this research present the comparative static & dynamic analysis of G+9 & G+ 19 storied RC building staircases model with at different location. Based on the parameters like axial forces, shear forces we get a good source of information indicating the optimum location of stairs, i.e. to be given in corner in the RC framed structures.

Keywords: axial forces, shear forces, bending moments, Storey Drift

1. INTRODUCTION

In RC frame structures, beams and columns are the primary structural systems that resist lateral loads. Besides, these primary systems, some elements also participate to resist lateral load, which fall in the category of secondary systems. Secondary system may be structural secondary like structural partition, staircase etc. and non-structural secondary like machinery, storage tanks etc. Concrete staircase, which are structural secondary members are normally designed for non-seismic forces. During earthquakes, performance of stairs has been given low attention in research field and in the field of professional practices.

1.1 Configurations of Staircase:

Architecturally, aesthetically and structurally staircases constitute a very important part of a structure. As the important vertical transport channels, the staircases assume to guarantee persons, goods and materials with emergency escape. They appear in different shapes and forms, each requiring its own method of analysis. Regarding their structural configurations based on pattern of steps in stairs, usually fall in one of the following categories: i) Stairs with cantilever steps that are supported on a shear wall along the stair, ii) Stairs whose steps are supported on a slab, iii) Stairs whose steps are supported on two girders, like simply supported beams, iv) Stairs with free standing landings, with branches perpendicular or parallel to each other, v) Helical stairs which are supported on the slabs of the upper and lower floors, without intermediate supports.

2. METHODOLOGY

2.1 Methodology:

The purpose of the present work is to study the behaviour of staircase at different locations in a building under seismic loads. For this purpose multi-storey BUILDING are considered. Structures are generally subjected to two types of load: static load and dynamic load. The analysis also depends on the behaviour of the structure or structural material.

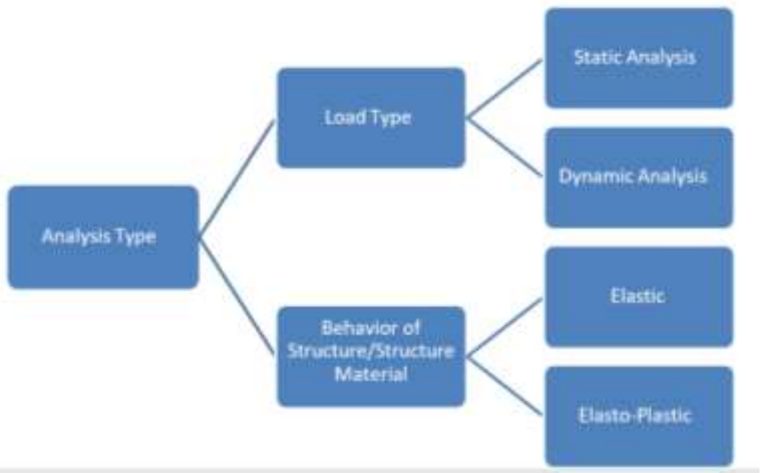


Fig. 2.1 Method of Analysis

In this attempt, following major cases will be analyzed :

1. An extensive survey of the literature on the response of stairs interaction with building at different locations to seismic loading is performed.
2. Provisions related to seismic analysis of stairs in building are presented.
3. Modelling of different height of structures which is ten and twenty is presented.
4. Problems of stairs in front, in interior and in corners of the building are taken and analyzed for static analysis.
5. Problems of stairs in front, in interior and in corners of the building are taken and analyzed by response spectrum for different storey.
6. Plot curve between bending moments and height of building for different zones.
7. Plot curve between shear force and height of building for different zones.
8. Plot curve between axial force and height of building for different zones.

2.2 ANALYSIS PROCEDURES

2.2.1 Equivalent Lateral Force Procedure:

The equivalent lateral force procedure is the simplest method of analysis and requires less computational effort because the forces depend on the code based fundamental period of structures with some empirical modifier. The design base shear shall first be computed as a whole, and then be distributed along the height of the BUILDING based on simple formulas for BUILDING with regular distribution of mass and stiffness. The design lateral force obtained at each floor level shall then be distributed to individual lateral load resisting elements depending upon floor diaphragm action.

2.2.2 Response Spectra Method:

Response Spectra Method is an elastic dynamic analysis approach that relies on the assumption that the dynamic response of a structure may found by considering the independent response of each natural mode of vibration and then combining response in the same way. For analysis, the mass of the structure is assumed to be lumped at the floor levels. Thus, for planer system, only one degree of freedom per floor-Two lateral translation and angle of twist around the vertical axis must be considered.

3. MODELLING APPROACH

3.1 MODELLING APPROACH

The modelling approach includes the development of model, using STAAD Pro, static as well as dynamic analysis has been carried out.

3.2 LOADINGS CONSIDERED

Live Load – 4 kN/m^2 on all the floors below roof and 3kN/m^2 on the roof.

Dead load –12 kN/m^2 on all the floors below roof and 10 kN/m^2 on the roof (including wall and slab load).

Earthquake Load – As per IS 1893 (Part-I):2002

4.3 Modeling Approach

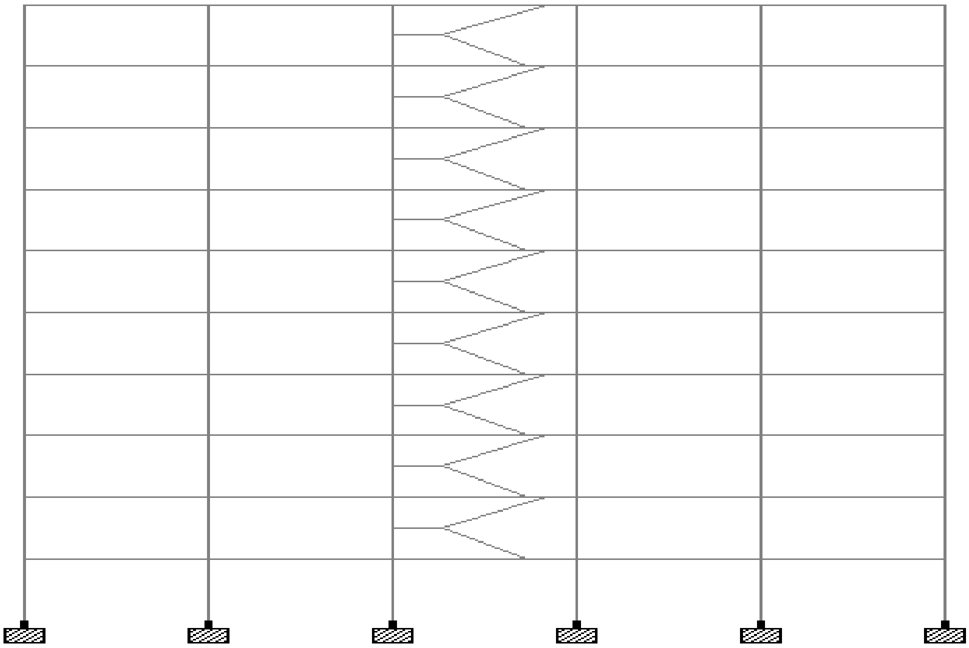


Fig. 3.1 Stairs in front, at center of the building (ELEVATION)

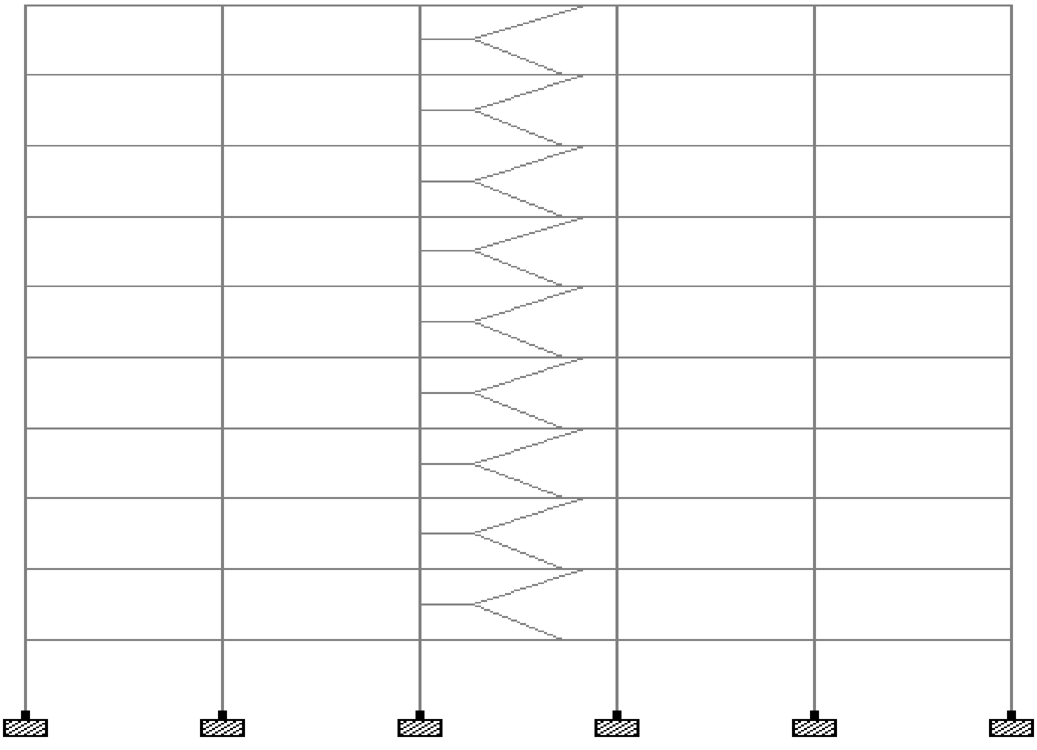


Fig. 3.2 Stairs in interior of the building (ELEVATION)

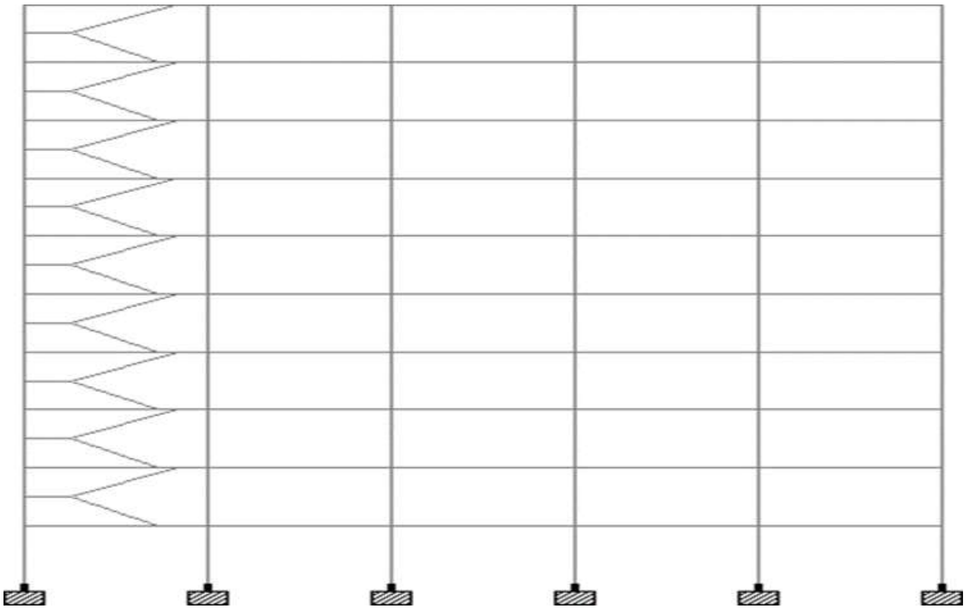


Fig.3.3 Stairs in corner of the building (ELEVATION)

4. RESULT & DISCUSSION

4.1 Results

The analysis results are obtained and the different aspects are obtained in the form of tables and graphs. The results are tabulated for the three models and their all the cases are obtained and given.

4.2 Shear Force Results

Tab 4.1 Shear Force at bottom

	SHEAR FORCE (KN)			
	10 STOREY		20 STOREY	
	STATIC	DYNAMIC	STATIC	DYNAMIC
	ZONE 5	ZONE 5	ZONE 5	ZONE 5
COLUMN A				
case 1 - stairs in front	172.855	123.785	201.594	154.872
case 2 - stairs in interio	167.053	133.593	192.369	164.657
case 3 - stairs in corners	164.574	124.972	192.395	156.706
COLUMN B				
case 1 - stairs in front	179.894	144.898	202.569	171.577
case 2 - stairs in interio	189.93	166.289	212.744	194.114
case 3 - stairs in corners	177.132	148.696	199.695	175.783
COLUMN C				
case 1 - stairs in front	109.275	89.421	128.614	111.428
case 2 - stairs in interio	110.332	101.221	127.665	124.068
case 3 - stairs in corners	110.366	97.38	129.612	121.363

The behaviours are seen to be similar both in static and dynamic load analysis of RC frames. However for 10 stories the maximum values of shear force at bottom in static are found to be more by 1.5 to 1.8 times (40-60KN) then dynamic analysis results.

In all above, both in 10 stories and 20 stories, positive and negative shear force are seen in corner column (column C) while performing static load analysis, whereas no negative shear is seen while performing dynamic load analysis.

Shear force value is found least among all when staircase is placed at corner of building.

4.2 Axial Force Results

Table 4.2 Axial Force at bottom

AXIAL FORCE (kN)				
	10 STOREY		20 STOREY	
	STATIC	DYNAMIC	STATIC	DYNAMIC
	ZONE 5	ZONE 5	ZONE 5	ZONE 5
COLUMN A				
case 1 - stairs in front	2266.492	1510.995	5503.671	3669.115
case 2 - stairs in interior	3688.444	2458.963	7893.298	5262.199
case 3 - stairs in corners	3798.534	2532.356	8245.571	5497.048
COLUMN B				
case 1 - stairs in front	4905.833	3270.556	9502.333	6334.889
case 2 - stairs in interior	5002.18	3334.786	9808.232	6538.822
case 3 - stairs in corners	6430.609	4287.073	12165.921	8110.613
COLUMN C				
case 1 - stairs in front	2227.514	1485.01	5401.903	3601.269
case 2 - stairs in interior	2235.445	1490.297	5523.824	3682.55
case 3 - stairs in corners	1276.032	850.688	3570.639	2380.426

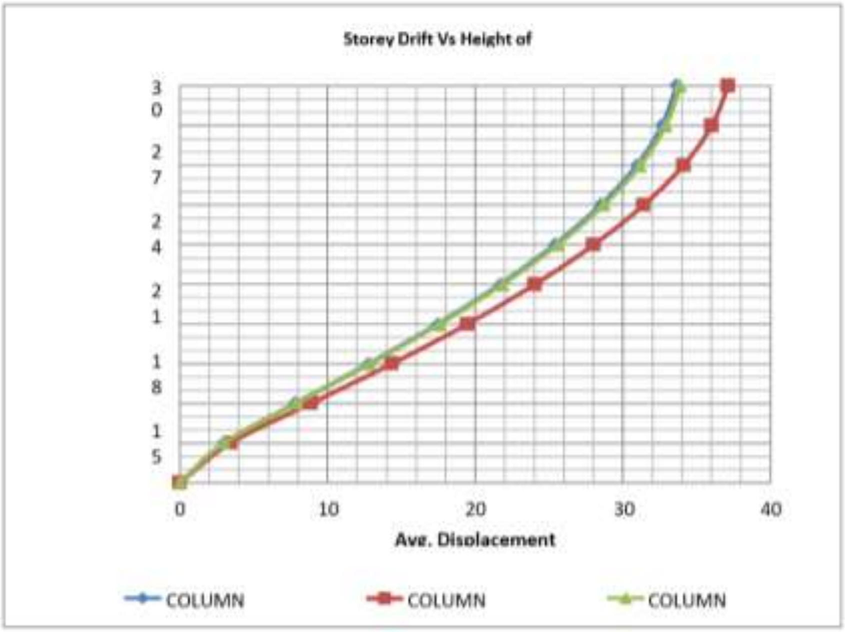
The behaviours are seen to be similar both in static and dynamic load analysis of RC frames. However for 10 stories the maximum values of shear force at bottom in static are found to be more by 1.4 to 1.8 times then dynamic analysis results.

In above, for 20 stories in static load analysis results of corner column (column C), the minimum value of axial force at bottom is in the case when stairs are at corner of the building but at an height of 10 meter, the same case shows maximum values of axial force in the column (with sudden increase) & again sudden decrease is seen for same position for the remaining height of building.

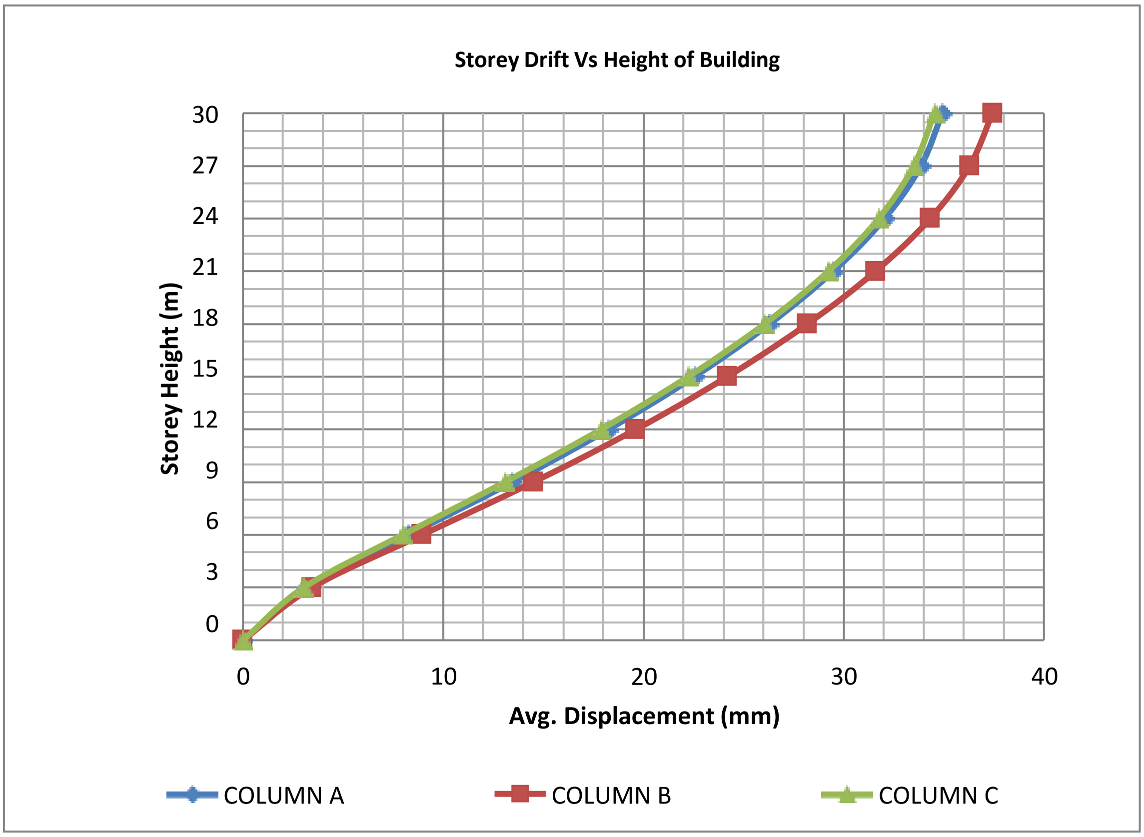
4.3 Storey Drift Diagram

I) for 10 Storey Building

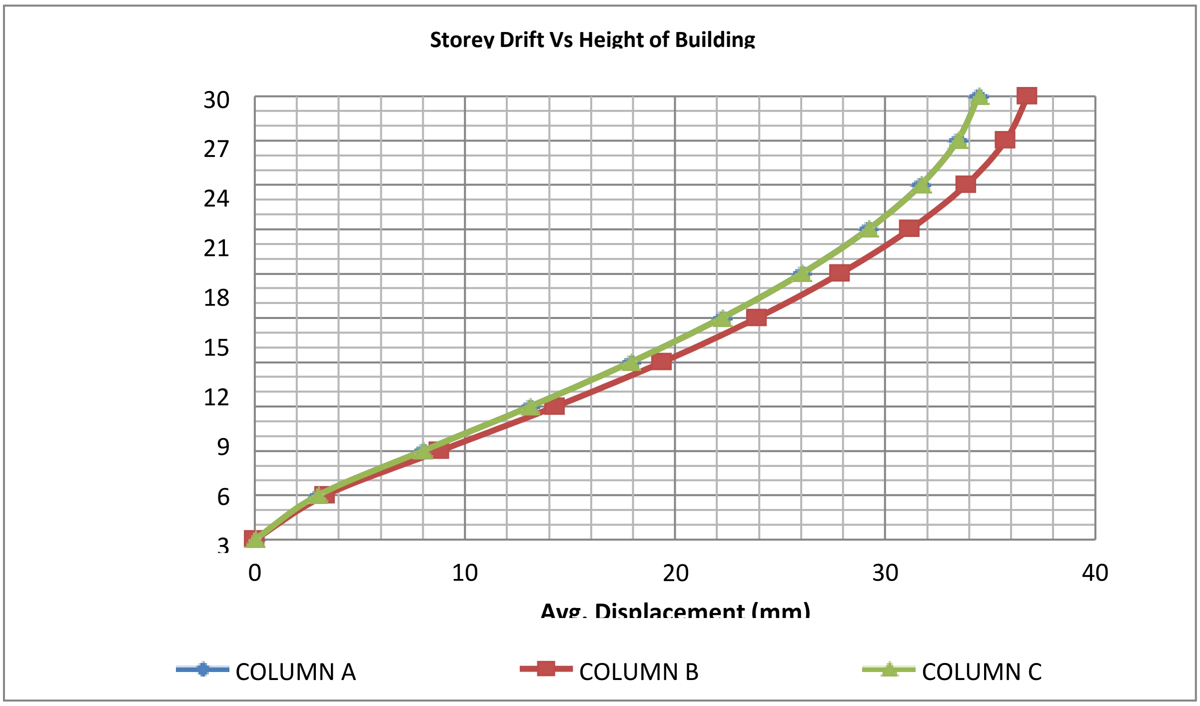
Case-I staircase at center of front of building



Case-II staircase at corner of building

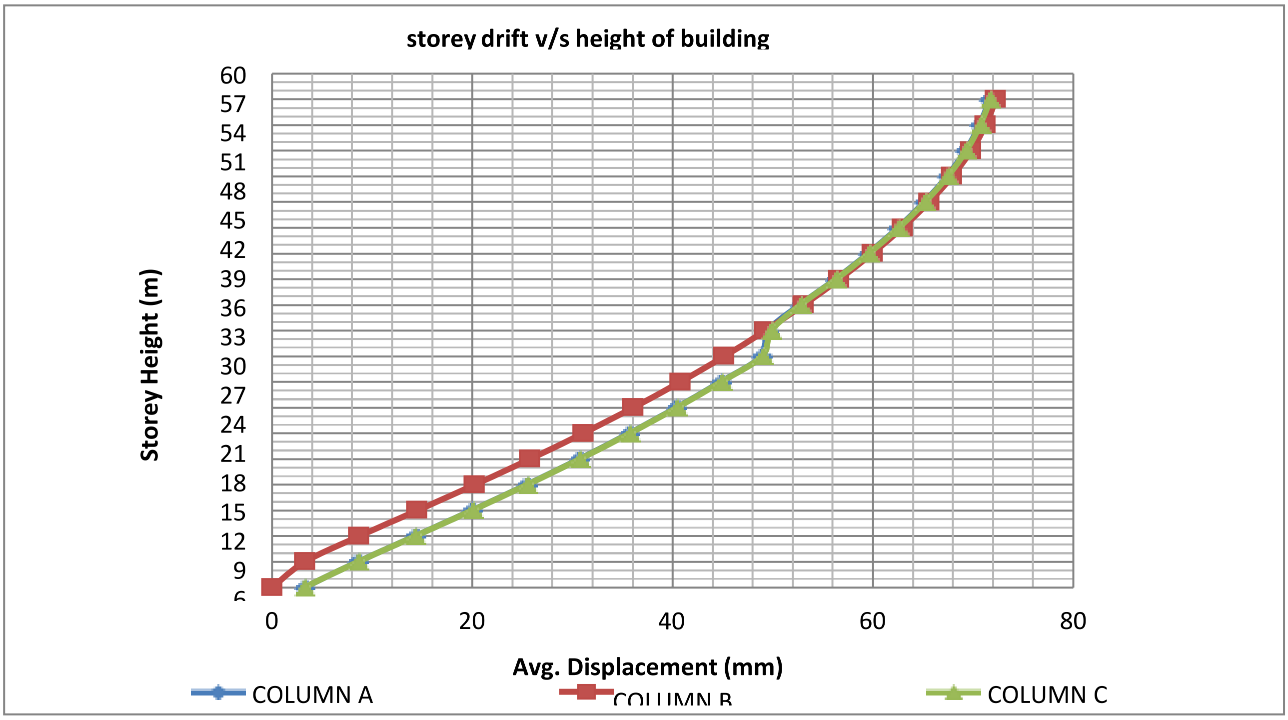


Case-III staircase at interior of building

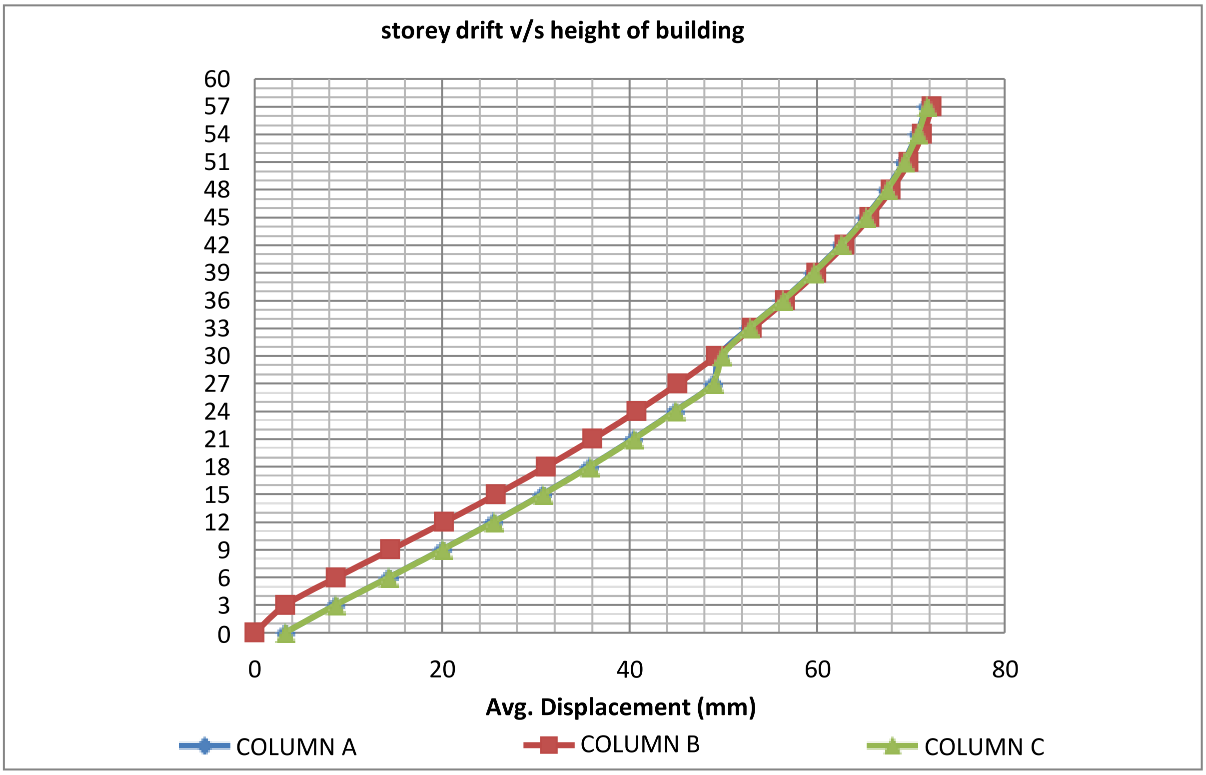


I) for 20 Storey Building

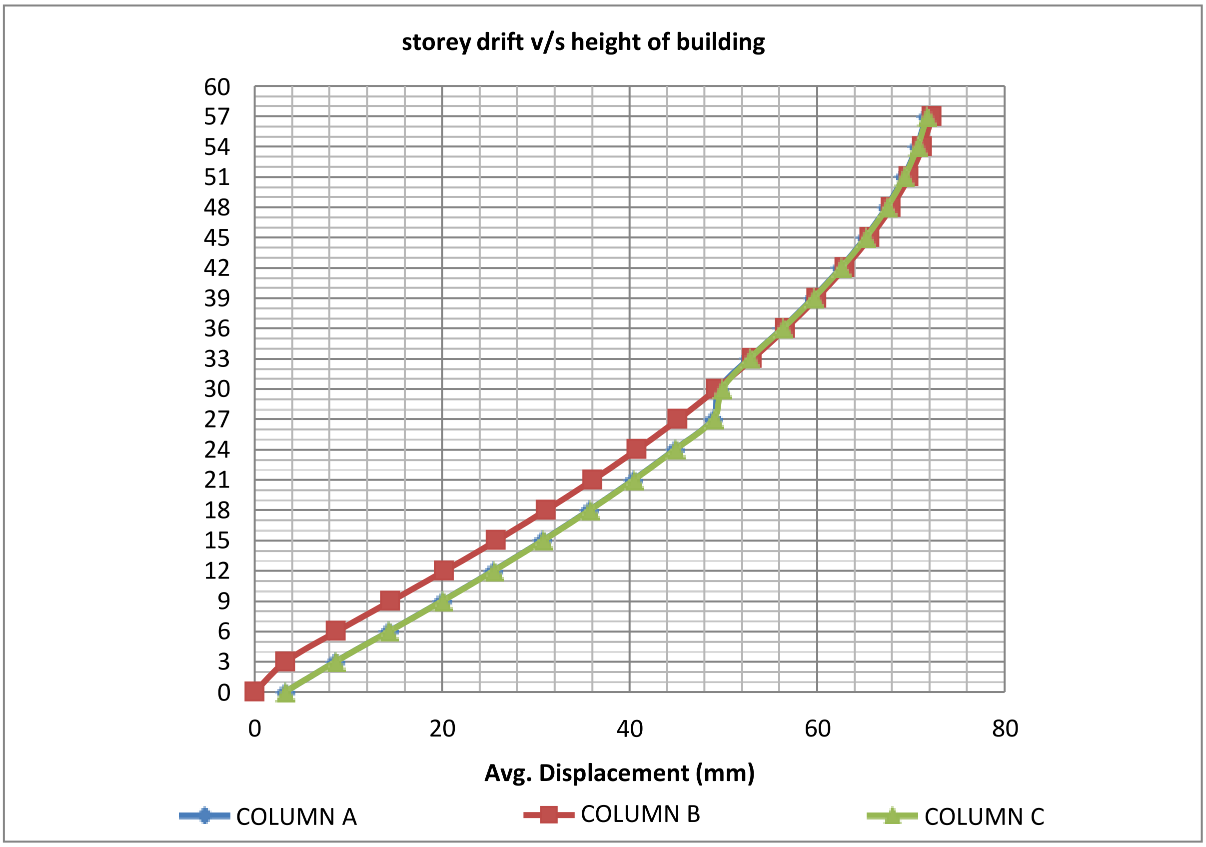
Case-I staircase at center of front of building



Case-II staircase at corner of building



Case-III staircase at interior of building



5. CONCLUSION

From the above results following conclusion has been drawn.

- Shear force are always found to be maximum in all three analyzed columns of the building when the stairs are present in interior of the building under seismic loading for both 10 and 20 stories.
- Shear force are always found to be less in values in all three analyzed columns of the building when the stairs are present either at corner of building or in front at center of the building under seismic loading for both 10 and 20 stories.
- Axial force are found to be more in the column C (at corner) of the building when the stairs are present in interior of the building under seismic loading for both 10 and 20 stories whereas the same column has low axial force when the stairs are at corners.

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