Jumping Load Seismic Analysis Study of Multistorey Building due to Floating Column

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Abstract**-** *For seismic evaluation of buildings having various geometrical discontinuities firstly we need to carry out seismic analysis of a building by one of methods including time history method, response spectra method and static equivalent method. Untill now we have analyzed building by static equivalent method manually.*

Further buildings have been similarly analyzed computationally using STAAD.Pro by static equivalent method by varying its geometrical features of building. Effects due to various discontinuities can be studied by varying loads and load combinations. here study is made to see mainly effects on building due to floating column, jumping of load which is initiated in building due presence of floating or hanging column. Case study of comparison of such building with or without floating column is performed. Initially G+ 3 building is considered without floating column as reference model and then for different models were made such that in each case position of floating column was at different floor level. As the provision of hall which demands its area without column in each case were changed. Four such cases were considered designing hall at different floor levels of building and the results of these cases are compared.

Keywords**-** Floating Column, Jumping load, Staad-pro software, Storey drift, Nodal displacements, Base shear.

I. INTRODUCTION

1. Introduction

Many urban multistory buildings in India today have open first storey as an unavoidable feature. This is primarily being used to accommodate parking or reception lobbies in the first storey. The behavior of a building during earthquakes depends mainly on its overall shape, size and geometry, in addition to how the earthquake forces are carried to the ground. The earthquake forces developed at different floor levels in a building need to be brought down along the height to the ground by the shortest path; any deviation or discontinuity in this load transfer path results in poor performance of the building. Buildings with a few storey wider than the rest cause a sudden jump in earthquake forces at the level of discontinuity. This sudden jump of earthquake forces or load is jumping load .It is observed that overall maximum load of structure or building is transferred through column. Since column is main element in load transfer path it needs to be without geometrical discontinuity thus it gets essential to avoid features like floating column in building.

floating column: A column is supposed to be a vertical member starting from foundation level and transferring the Load to the ground. The term floating column is also a vertical element which (due to Architectural design/ site situation) at its lower level (termination Level) rests on a beam which is a horizontal member. The beams in turn transfer the load to other columns below it.

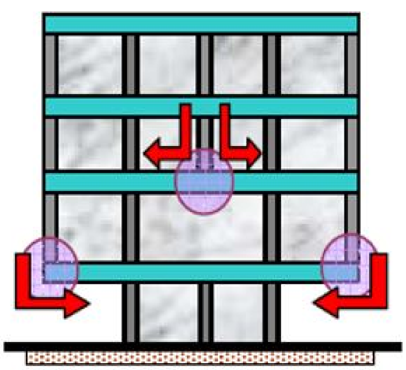

Figure 1. Floating Column
(Source: IITK-BMTPC Earthquake Tip 6)

2. Aim

To study Jumping load seismic analysis of multistoried building

3. Objective

- To study effect of past earthquake.
- To study effect of RC structures.
- To study seismic resistance consideration for seismic resistivity.
- To study continues load path and jumping load concept and its effects.

- To simulate RC structure with jumping load consideration subjected to seismic forces, computational.
- To study effect of geometrical discontinuity leading to load jumping on multistory RC structure.

II. LITURATURE REVIEW

General:

On the basis of the topic selected various literatures were gone through on the reasons and findings related to earthquake the literatures were studies on

- Reasons for earthquake occurrence
- Global and Indian seismic mapping
- Effect of earthquake on engineering & non engineering structures
- Methods to overcome earthquake effect
- Various load consideration and analysis methods for seismic forces
- Effect of geometrical discontinuity on seismic behavior of structure
- Continues load path, ductile designing etc. for seismic resistivity.

The secondary data from various research journals as well as reports are studied and some important learning's are mentioned below.

B. Ghosh et al. (1) carried out a site-specific probabilistic seismic hazard assessment (PSHA to review the potential risk of seismic source zones and the latest earthquake information for India. The PSHA method combined the knowledge of seismic source zones and their associated earthquake recurrence with appropriate attenuation relationships to produce hazard curves in terms of level of ground motion and an associated annual probability of being exceeded. This work indicates that the DBE level seismic hazard is underestimated in these regions. This finding is particularly important for the prevalent low-rise construction typically found in India. It is our opinion that further collaborative research is needed to update the seismic hazard map in the India earthquake code.

Prof R.N. Iyengar et al. (2) developed probabilistic seismic hazard map of India. the reports highlights how surface level hazard at hard rock sites (A-type) can be estimated to develop charts and tables that can be used by government agencies, architects, engineers and other interested groups. The results presented can be directly used on A-type rock sites. For other site classes, corrections have to be applied in terms of approximation prescribed in standard codes or by carrying out local geotechnical studies. The results presented in the report can be used further in city level microzonation, vulnerability analysis and risk evaluation Man

Li, et al. (3) Mapped Earthquake Risk of the World building vulnerability table at national scale and possibility of mortality caused by building collapse was taken into consideration to construct population vulnerability table. Meanwhile, social wealth was taken as social and economic exposure instead of GDP to assess world earthquake economic loss risk. Based on the above conceptions, the earthquake risk of the world is reassessed and mapped in this study at grid, comparable-geographic unit and national levels.

Mohapatra et al. (14) made n Overview of Seismic Zonation Studies in India and discussed discusses a brief history of seismic zoning studies in India through chronological order including the limitations on its use. The Seismic Zonation Map of a country is not only guides about the seismic status and susceptibility of a region, but also indicates the direction of future work. Such observations also point out that there is a clear-cut and urgent need to focus research and development, public awareness, geo-technical competence, enforcement on engineering aspects for earthquakes in India. This study and the work provide a preliminary and rough estimation of seismic zones in India.

Sudhir k Jain et al. (5) studied and showed some of the largest earthquakes of the world have occurred in India and the earthquake engineering developments in the country started rather early. After the 1897 Assam earthquake a new earthquake resistant type of housing was developed which is still prevalent in the north-east India. The Baluchistan earthquakes of 1930's led to innovative earthquake resistant constructions and to the development of first seismic zone map. Most buildings even in high seismic regions of the country continue to be built without appropriate earthquake resistant features. At the higher end of earthquake technology, the gap between state-of-the-practice of earthquake engineering and research in India, bench-marked against the advanced countries, has been widening.

Christopher Arnold (6) studied earthquake effects on buildings this paper explains how various aspects of earthquake ground motion affect structures and also how certain building attributes modify the ways in which the building responds to the ground motion. This paper has discussed a number of key characteristics of earthquake ground shaking that affect the seismic performance of buildings. In addition, a number of building characteristics have been reviewed that, together with those of the ground, determine the building's seismic performance: how much damage the building will suffer. These characteristics are common to all buildings, both new and existing, and all locations. Understanding the ground and building characteristics discussed in this paper is essential to give designers a "feel" for how their building will react to shaking, which is necessary to guide the conceptual design of their building.

C. V. R. Murty (7) studied and concluded that document highlights the poor seismic performance of RC frame buildings with masonry infills, and documents the underlying design and construction factors causing such performance. There is a significant concern in the earthquake engineering community that many of these buildings, already built and standing throughout the world, are potential death traps in future earthquakes. And even the new ones being built can be potentially dangerous if attention is not paid to the critical design, construction and management issues.

G schwegler (8) two 6 storied residential buildings werw converted into office building and to increase structural strength load bearing walls needs to be reinforced or replaced to resist earthquake loads which was carried out by carbon fibre reinforced plastic. The application of CRPF sheets to existing load bearing masonary shear wall singnifically increased its lateral resistance and ductility alternative methods such as reinforced shortcrete or the replacement of wall would have been more expensive besides reinforced shortcrete strenghning would have lead to an additional thickness of 700 mm, which for architectural reasons would not have been acceptable. The CRPF method of masonary walls proves to be a very efficient in field of earthquake resistance design, as it is economical and easy to apply.

A. Dogangun, A. et al. (9) studied seismic performance of masonry buildings during recent earthquakes in turkey many masonry structures collapsed or were severely damaged during the recent destructive earthquakes occurred in Turkey. Thus, in this study, types of masonry structures commonly used in Turkey are summarized and some information about earthquakes occurred between 1992 and 2004 are illustrated. Hollow clay tiles used as brick units have been observed to be the major cause of partial or total collapse of building. Mud-stone masonry structures collapsed or were heavily damaged due to poor mud mortar and insufficient anchorage between mud and stone even during small earthquakes. Many of collapses and damages are attributed to following items in order of importance: Inadequate masonry units, poor mortar, lack of vertical confining elements, irregularities in plane and in vertical direction, inadequate connection of load-bearing walls, insufficient length of load-bearing walls, unconfined gable walls and heavy cantilever elements. Despite these confined masonry buildings did not satisfy requirements given in Turkish Earthquake Code, they behaved better than the unreinforced masonry buildings.

Svetlana Brzev (10) studied earthquake-resistant confined masonry construction and find out some advantages of confined masonary Confined masonry buildings have performed well in several earthquakes worldwide. This construction practice is widely used in many countries and regions for the following reasons: It is based on traditional masonry construction practice; It does not require highly qualified labour (as is the case with RC frame construction); Confined masonry technology falls in between that of unreinforced masonry and RC frame construction, however due to its smaller member sizes and the larger amount of reinforcement it is more cost-effective than concrete construction; It has a broad range of applications - it can be used for single-family houses as well as for medium-rise apartment buildings.

III. CASE STUDY

OBSERVATIONS

To carry out the seismic analysis of the RC structure considering absencia of vertical member i.e. vertical discontinuity, various cases are modeled and analysed as shown in chapter 3.Over here the discussions and observations made are shown considering the various aspects.

The various cases that are analysed are as under

Case 1: Multistoried RC structure G+3 subjected to seismic forces, without any vertical discontinuity.

Case 2: Multistoried RC structure G+3 subjected to seismic forces, with vertical discontinuity at top floor.

Case 3: Multistoried RC structure G+3 subjected to seismic forces, with vertical discontinuity at second floor.

Case 4: Multistoried RC structure G+3 subjected to seismic forces, with vertical discontinuity at first floor.

Case 5: Multistoried RC structure G+3 subjected to seismic forces, with vertical discontinuity at ground floor.

With vertical discontinuity at ground floor level the structures considered over here the part of teaching institute, which demands provision of auditorium halls/seminar halls. Considering the same provision the location of hall is changed in all the cases above. For the same structure the observations are made related to the nodal displacement values at the various column location along the vertical axis namely column along C3 and C17 respectively as shown in plan below.

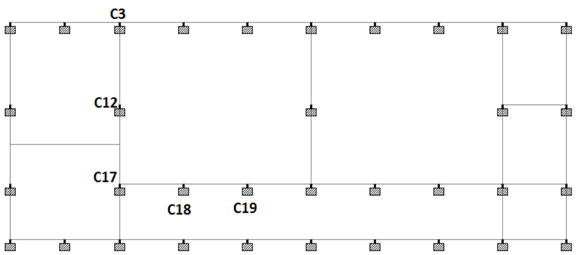

Figure 2. Plan

Table 1. shows nodal displacement for C3

C3	Node no.	Loca-tion (m)	Resultant (mm) max	Rotation		
				rX rad	rY rad	rZ rad
Case 1	189	15.9	110.5	0.004	-0.005	-0.000
Case 2			120.75	0.010	-0.006	0.000
Case 3			122.59	-0.002	0.005	-0.000
Case 4			129.12	-0.003	0.005	-0.000
Case 5			129.3	-0.002	0.005	-0.000
Case 1	153	12.3	91.37	0.006	-0.005	-0.000
Case 2			91.39	0.007	-0.004	-0.000
Case 3			100.43	-0.007	0.004	-0.000
Case 4			106.39	-0.006	0.004	-0.000
Case 5			106.66	-0.006	0.004	-0.000
Case 1	117	8.7	62.55	0.008	-0.002	-0.000
Case 2			61.60	0.008	-0.002	-0.000
Case 3			62.85	0.010	-0.002	-0.000
Case 4			73.05	-0.009	0.002	-0.000
Case 5			73.50	-0.008	0.002	-0.000
Case 1	81	5.1	29.41	0.008	-0.001	-0.000
Case 2			28.86	0.008	-0.001	-0.000
Case 3			28.93	0.008	-0.001	-0.000
Case 4			29.93	0.010	-0.001	0.000
Case 5			36.95	-0.008	0.001	-0.000
Case 1	45	1.5	3.32	0.004	-0.000	-0.000
Case 2			3.25	0.004	-0.000	-0.000
Case 3			3.25	0.004	-0.001	-0.000
Case 4			3.24	0.004	-0.000	-0.000
Case 5			3.65	-0.005	0.000	0.000
Case 1	03	00	00	0.000	0.000	0.000
Case 2			00	0.000	0.000	0.000
Case 3			00	0.000	0.000	0.000
Case 4			00	0.000	0.000	0.000
Case 5			00	0.000	0.000	0.000

Table 2. shows nodal displacement for C17

C17	Node no.	Loca-tion (m)	Resultant (mm) max	Rotation		
				rX rad	rY rad	rZ rad
Case 1	203	15.9	110.39	0.001	-0.001	0.000
Case 2			130.25	-0.016	-0.001	-0.013
Case 3			130.01	-0.010	0.001	-0.001
Case 4			137.49	-0.011	0.001	-0.001
Case 5			138.21	-0.011	0.001	-0.001
Case 1	167	12.3	91.46	0.002	-0.001	-0.000
Case 2			91.74	0.001	-0.001	-0.000
Case 3			107.77	-0.010	0.002	-0.001
Case 4			115.01	-0.010	0.001	0.000
Case 5			115.78	-0.010	0.001	-0.000
Case 1	131	8.7	62.56	0.003	-0.001	-0.000
Case 2			61.61	0.003	-0.001	-0.000
Case 3			62.86	0.001	-0.000	-0.000
Case 4			80.70	-0.009	-0.002	-0.002
Case 5			86.41	-0.011	0.001	-0.000
Case 1	95	5.1	29.52	0.003	-0.000	-0.000
Case 2			28.94	0.003	-0.000	-0.000
Case 3			29.00	0.003	-0.000	-0.000
Case 4			29.95	0.000	0.001	-0.000
Case 5			58.23	-0.013	0.001	-0.002
Case 1	59	1.5	3.28	0.002	-0.000	-0.000
Case 2			3.21	0.002	-0.000	-0.000
Case 3			3.20	0.002	-0.000	-0.000
Case 4			3.21	0.002	0.000	-0.000
Case 5			3.24	0.000	0.000	-0.000
Case 1	23	00	00	0.000	0.000	0.000
Case 2			00	0.000	0.000	0.000
Case 3			00	0.000	0.000	0.000
Case 4			00	0.000	0.000	0.000
Case 5			00	0.000	0.000	0.000

Table 3. shows drift values for C3

For C3	Node no.	Case 1	Case 2	Case 3	Case 4	Case 5
	189	Na	Na	Na	Na	Na
	153	19.13	29.36	22.16	22.73	22.64
	117	28.82	29.79	37.58	33.34	33.16
	81	33.14	32.74	33.92	43.12	36.55
	45	26.09	25.61	25.68	26.69	33.3
	3	3.32	3.25	3.25	3.24	3.65

Table 4. shows drift values for C17

For C17	Node no.	Case 1	Case 2	Case 3	Case 4	Case 5
	203	Na	Na	Na	Na	Na
	167	18.93	38.51	22.24	22.48	22.43
	161	28.87	30.13	44.91	34.31	29.37
	95	33.04	32.67	33.86	50.79	28.18
	59	26.24	25.73	25.8	26.74	54.99
	23	3.28	3.21	3.20	3.21	3.24

Table 5. shows beam end forces for C13

For C3	Be-am no.	Fx kN	Fy kN	Fz kN	Mx KNm	My KNm	Mz KNm
Case 1	389	121.41	33.16	2.15	-12.94	-4.04	-8.32
Case 2		193.79	111.25	3.127	-2.20	-3.87	108.12
Case 3		282.56	156.49	3.35	-15.60	-5.78	116.61
Case 4		285.34	223.59	4.10	-1.56	-6.85	338.97
Case 5		286.89	224.93	4.77	-1.35	-7.88	329.72
Case 1	310	386.48	94.91	2.03	-14.51	-3.62	101.86
Case 2		470.62	40.61	2.03	-13.81	-3.87	85.21
Case 3		706.44	215.97	2.71	-17.58	-4.34	295.38
Case 4		752.69	171.28	4.33	-0.33	-7.58	346.45
Case 5		752.51	168.78	5.33	0.110	-9.16	318.92
Case 1	231	685.42	110.04	1.55	-11.56	-2.71	200.05
Case 2		764.35	111.29	1.87	-11.47	-3.30	198.54
Case 3		987.12	52.31	2.44	-10.31	-4.42	172.41
Case 4		1212.24	253.39	3.44	-13.76	-5.64	426.12
Case 5		1246.23	203.20	4.71	-11.66	-8.27	346.42
Case 1	152	986.2	128.89	0.87	-7.18	-1.26	366.64
Case 2		1059.28	124.37	1.03	-7.20	-1.58	357.49
Case 3		1276.75	129.44	1.73	-6.65	-2.88	358.21
Case 4		1381.5	-9.54	3.08	2.15	-5.54	-2.61
Case 5		1673.97	76.83	4.37	0.72	-7.48	78.99
Case 1	73	1175.39	117.14	1.39	-3.46	-0.04	388.37
Case 2		1246.10	114.32	1.55	-3.51	-0.21	378.96
Case 3		1460.33	109.04	2.27	-3.28	-1.01	374.98
Case 4		1672.25	125.14	3.56	-2.20	-2.57	362.79
Case 5		1795.34	-27.24	4.76	1.04	-4.26	7.05

Table 6. shows beam end forces for C17

For C17	Be-am no.	Fx kN	Fx kN	Fz kN	Mx KNm	My KNm	Mz KNm
Case 1	403	135.51	4.13	46.44	0.71	-72.62	5.64
Case 2							
Case 3		-79.08	-91.52	-72.98	7.01	133.98	-165.37
Case 4		-83.78	-76.16	-75.05	3.95	129.92	-114.85
Case 5		-87.85	-80.09	-78.97	3.40	137.82	-125.94
Case 1	324	435.02	2.13	76.13	-1.73	-132.90	3.90
Case 2		332.93	4.70	91.01	-5.007	-153.74	6.84
Case 3							
Case 4		28.90	-81.71	-266.57	-2.76	515.29	-173.28
Case 5		29.74	-57.35	-205.16	0.97	362.22	-104.51
Case 1	245	774.66	2.19	95.28	-3.55	-173.17	3.56
Case 2		627.03	-67.10	-12.34	-9.96	22.74	-110.96
Case 3		392.69	4.17	117.97	-2.65	-201.67	6.10
Case 4							
Case 5		33.64	-85.24	-283.47	0.639	546.65	-175.11
Case 1	166	1128.15	0.75	76.46	-2.22	-147.47	0.21
Case 2		1031.05	1.01	75.35	-2.10	-145.01	0.68
Case 3		754.59	1.19	74.37	-1.36	-144.09	1.61
Case 4		410.93	3.65	101.00	1.75	-174.98	5.24
Case 5							
Case 1	87	1340.65	-1.00	93.13	-0.84	-107.63	-0.66
Case 2		1243.31	-0.85	91.19	-0.69	-105.23	-0.38
Case 3		970.76	-0.31	92.28	-0.42	-105.17	0.72
Case 4		625.47	0.81	81.02	0.45	-33.28	3.05
Case 5		235.70	5.49	153.52	2.26	-129.38	6.73

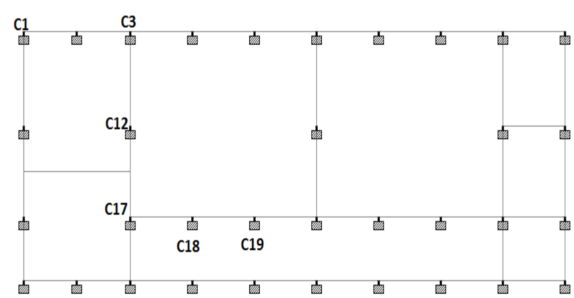

Figure 3.

The table number 3.7 below shows the storey shear values and the base shear value along location C1 and C3 as shown in figure below

Table 7. shows base shear values

C1	Fx (kN)	Fz (kN)	Fx (kN)	Fz (kN)	Fx (kN)	Fz (kN)	Fx (kN)	Fz (kN)	Fx (kN)	Fz (kN)
187	7.99	7.99	8.03	8.03	8	8	7.98	7.98	7.96	7.96
151	19.98	19.98	20.09	20.09	20.02	20.02	19.95	19.95	19.92	19.92
115	9.99	9.99	10.05	10.05	10.01	10.01	9.98	9.98	9.96	9.96
79	3.43	3.43	3.45	3.45	3.44	3.44	3.43	3.43	3.42	3.42
43	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
1	0	0	0	0	0	0	0	0	0	0
	41.64	41.64	41.87	41.87	41.72	41.72	41.59	41.59	41.51	41.51
C3										
183	11.39	11.39	11.45	11.45	11.4	11.4	11.37	11.37	11.35	11.35
153	28.92	28.92	29.09	29.09	28.97	28.97	28.88	28.88	28.83	28.83
117	14.47	14.47	14.55	14.55	14.94	14.94	14.45	14.45	14.42	14.42
81	4.97	4.97	5	5	4.98	4.98	4.96	4.96	4.95	4.95
45	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
3	0	0	0	0	0	0	0	0	0	0
Total Base shear	60.1	60.1	60.44	60.44	60.64	60.64	60.01	60.01	59.9	59.9

maximum displacement is when the columns at ground level is eliminated.

Drift values

The further detail analysis related to the relative different among the stories for various location is shown in table 3.3 and 3.4 in the form of drift value for the exterior nodes along C3. It can be seen that it is maximum for storey no second i.e. first floor and minimum and ground floor i.e. maximum for node no. 81 in (table 6.6) and minimum for node no. 3 (table 3.3)

Out of all 5 cases it can be seen that drift values is minimum when columns are eliminated at top floor i.e. case 2 as in chart 3.1. One comman observations is drawn from chart no from 3.1 and 3.2 that the maximum drift value is at the storey in each case over where the columns are eliminated Whereas for case 4 where column of 1st floor eliminated maximum drift is at 2nd floor level i.e. node no. 19 and so on.

IV. CONCLUDING REMARKS

In the table no. 3.1 the maximum nodal displacement values for each node on the vertical profile for location C3 are tabulated in this table. It can be seen that with elimination of column at ground, first and second floor i.e. case 5, 4 and 3 respectively, the nodal displacement values are comparatively more. In majority of the time the displacement values when the column of ground floor are eliminated (case 5) is more like for node no. 153 (case 5) it is 106.66 and similarly for other nodes. The displacement values in this table are for exterior located column i.e. along C3.

In all these intermediate column members again the maximum displacement is when the jumping load is created at floor 1 (case 5) and subsequently reduces when the column elimination moves from ground to upper floor i.e. case1.

The table no 6.3 (C17) is the T-junction location and thus leads more interest for displacement analysis again like other locations it is observed that for the same node points the

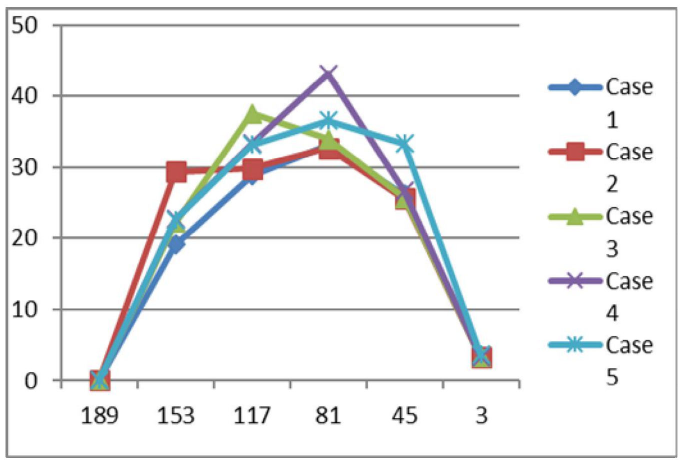

Figure 4.

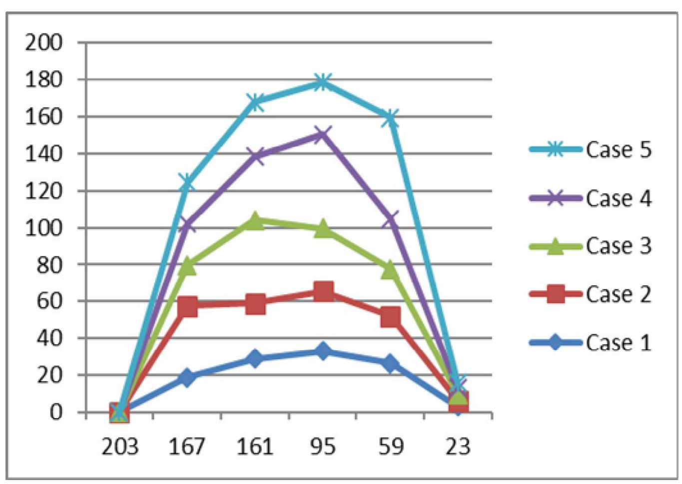

Figure 5.

Further table number 3.5 and 3.6 shows the forces developed in the columns. The fx and fz are the forces along horizontal direction due to seismic storey shear and fy is force downward vertical force i.e. gravity force.

When the columns at the lower end level are eliminated i.e. case 5 the amount of force development as compared to all other case is more.

From table 3.7 it can be seen that the storey shear value is maximum for the storey level just below the top floor and i.e. node number 151 along C1 location and 153 along C3 location further the values of storey shear decreases with decrease in height however, the base shear values is almost constant for all the five cases as can be seen in table.

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