PARAMATRIC STUDY OF BUILDING SUBJECTED TO SEISMIC POUNDING EFFECT

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Abstract: ***Many land area are covered with agricultural area. Building a high rise building is very important, but high rise buildings have many more problems. Where human live there good life with their family. This less gap between two buildings faced more problems in construction and also problem occurs after construction because of earthquake. During earthquake high rise multistory building faced pounding effect occur on adjacent buildings. By earthquake buildings mode shape will changes and by different mode shape pounding will accurse. By pounding building will damage architectural or structural damage. Pounding force is effected by mass and acceleration of the storey. So if change building element cross section it will change mass and stiffness of the building. By both change pounding force will change. If stiffness of the building element change then deflection of the building is also change. Deflection of the building is effect on pounding force and pounding time. Overall pounding force is depends on stiffness of the building.***

Keywords – Pounding Force, Adjacent Building, ETABS, Seismic Pounding, Bhuj Earthquake

I. INTRODUCTION

Pounding means building collided with each other while earthquake occur because of less distance of separation. By this seismic pounding building will damage partially or fully collapse. Seismic pounding will generate by both building different mode shape, different weight distribution & center of gravity of building is different. Pounding effect was at storey level or at middle of column. By building deflection seismic pounding occur. For control deflection in building assign shear wall, bracing & dampers in building. In IS 4326 "EARTHQUAKE RESISTANCE DESIGN AND CONSTRUCTION OF BUILDINGS CODE OF PRACTICE" gives distance of separation of two adjusted building.

Table I-1 Seismic pounding GAP for different structures

Sr No.	**Type of Construction**	**Gap Width/Storey, in mm for design seismic coefficient ah= 0.1**
1	Box system or frames with shear walls	15.0
2	Moment resistant reinforced concrete frame	20.0
3	Moment resistant steel frame	30.0

In IS 1893:2007 PART 1 "CRITERIA FOR EARTHQUAKE RESISTANCE OF DESIGN OF STRUCTURES" mentioned that, separation should be R times the sum of displacements. R may be replaced by R/2 when two building are at same level. Where R = response reduction factor. Pounding can be developed between high-rise buildings, between low-rise buildings, as well as high-rise and low-rise buildings during earthquake can also take place between a non-structural component and the structure itself as well as between two adjacent components. Earthquakes cause ground shaking; the ground beneath a building is displaced laterally.Observation of pervious earthquakes show certain characteristics related to pounding. Buildings of similar height and with similar structural systems tend to suffer less damage than buildings of different height and with different structural system. This is due to the fact that buildings with the same height will have similar natural frequencies and will tend to move in-phase relative to one another. Time history analysis is known as to be most sophisticated and accurate technique for dynamic analysis of building. In this study time history analysis are performed by considering the past earthquake vibration data, which can be find on some website for analysis. For time history analysis in ETABS software assign steps and time interval for analysis. Steps and time interval set a time for analysis in second. Mostly step is 1000 and time interval is 0.01 second which is analysis time is 10 second. If steps and time interval change analysis result is also change. Steps and time interval effect on analysis time and need more RAM for analysis.

II. AIM AND OBJECTIVE

Aim of the study is to do the parametric study of seismic pounding effect on multi-storey building.

1. To analysis seismic pounding effect on building for different height and different width.
2. To analysis the effect of seismic pounding effect for step back.
3. To analysis seismic pounding effect on building for different position of building,
4. To analysis the effects of seismic pounds on building for different cross section of beam and column.
5. To analysis the effect of seismic pounding affect no building for different storey height of building.

III. WORK METHODOLOGY

In order to observe pounding between two adjacent buildings, two RC building are selected which is G+4 and G+3 storey buildings. Both buildings have same geometry. Both building have 2 and 1 number of bay in X and Y direction and width of the bay is 5 m. building details are given below, Two building are model in ETABS 2016 with all assume data.

Table III-1 Selected Material

1	Concrete grade	M30
2	Steel grade	Fe 415

Table III-2 Size of Structure

1	Beam size	230 mm X 300 mm
2	Column size	300 mm X 300 mm
3	Slab thickness	150 mm

Table III-3 Load on Building

1	Self-weight	Software define
2	Live load	2 kN/m^2 (on Floor) 3 kN/m^2 (on Terrace)
3	Wall thickness	230 mm (Outer wall) 115 mm (Inner wall)
4	Floor Finish	1.5 kN/m^2
5	Earthquake	Bhuj earthquake (2001)

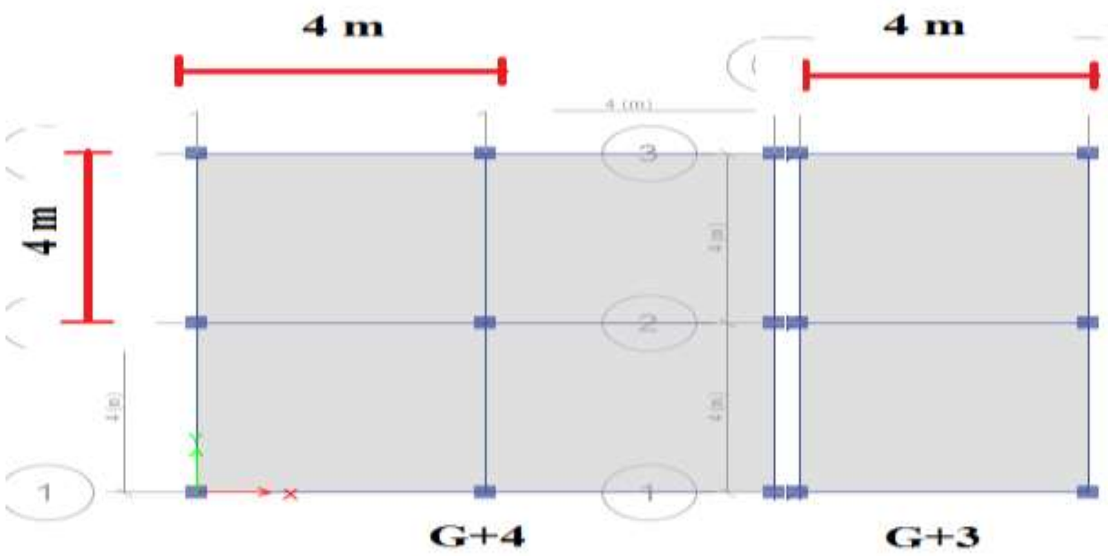


Figure III-1 Plan of the Building

LINK STIFFNESS CALCULATION

The link is defined as gap element. The gap element is activated when the gap becomes zero and usually gap elements are active in compression phase and becomes inactive in tension phase. The stiffness of the gap element is usually considered as 10^2 and 10^4 times the stiffness of the adjacent RC building or connected element.

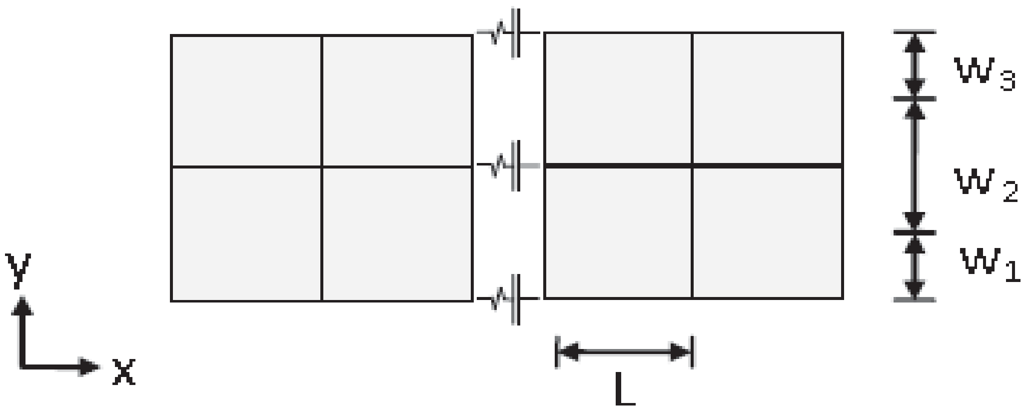


Figure III-2 Shows the plan of two colliding floors showing axial element stiffness

Above figure it just for explication; it's not a part of project.

$K = \frac{EA_I}{L} \times 100$

Where,

$A_I = W_I \times t$

E= Young's modulus

t= Slab thickness

W_I= Average element width

IV. RESULT AND DISCUSSION

In this project make compression between some different cases like height different, width and length different, step back of buildings, different position of the building, change cross section of beam and column and change storey height of the building.

CHANGE IN HEIGHT

First have to discussion about change height of the building. All cases compression use top storey first link maximum pounding force. At every link pounding force different, so for the compression all the time use a first link at top story for compression.

At below table show a maximum pounding force at top storey first link.

Table IV-1 Maximum pounding force table for G+5 storey building

Sr No.	Right hand side building	Left hand side building	Building height ratio	Pounding force in kN
1	G+5	G+5	1	9.67
2	G+5	G+4	1.192308	74.35
3	G+5	G+3	1.47619	119.48
4	G+5	G+2	1.9375	121.03
5	G+5	G+1	2.818182	62.88

Graph IV-1 Maximum pounding force graph for G+5 storey building

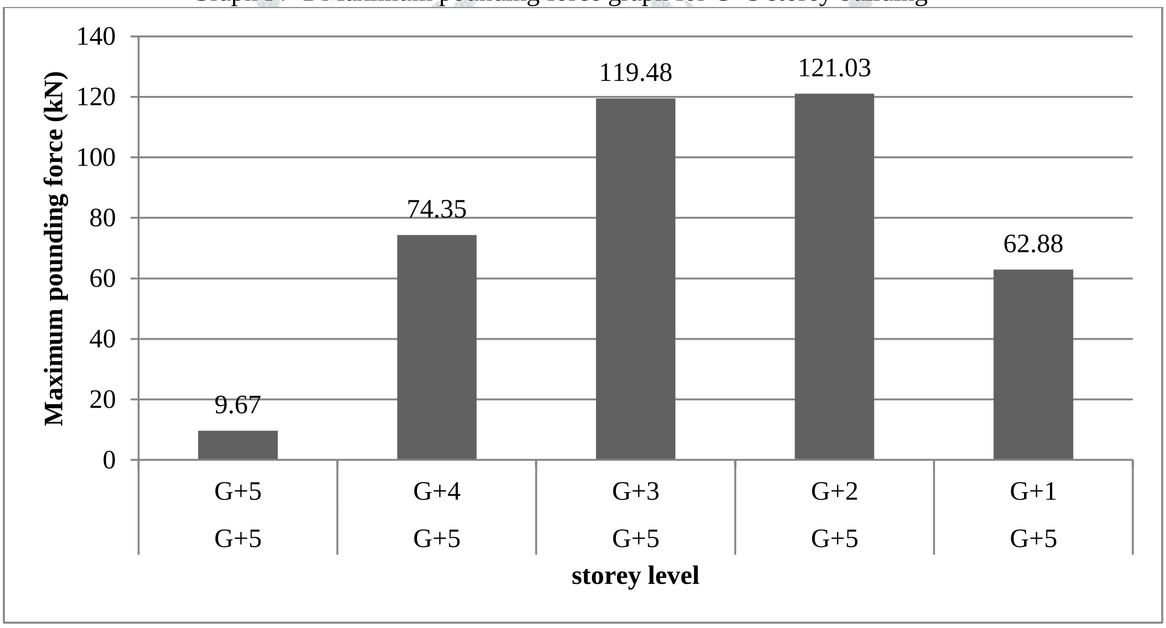
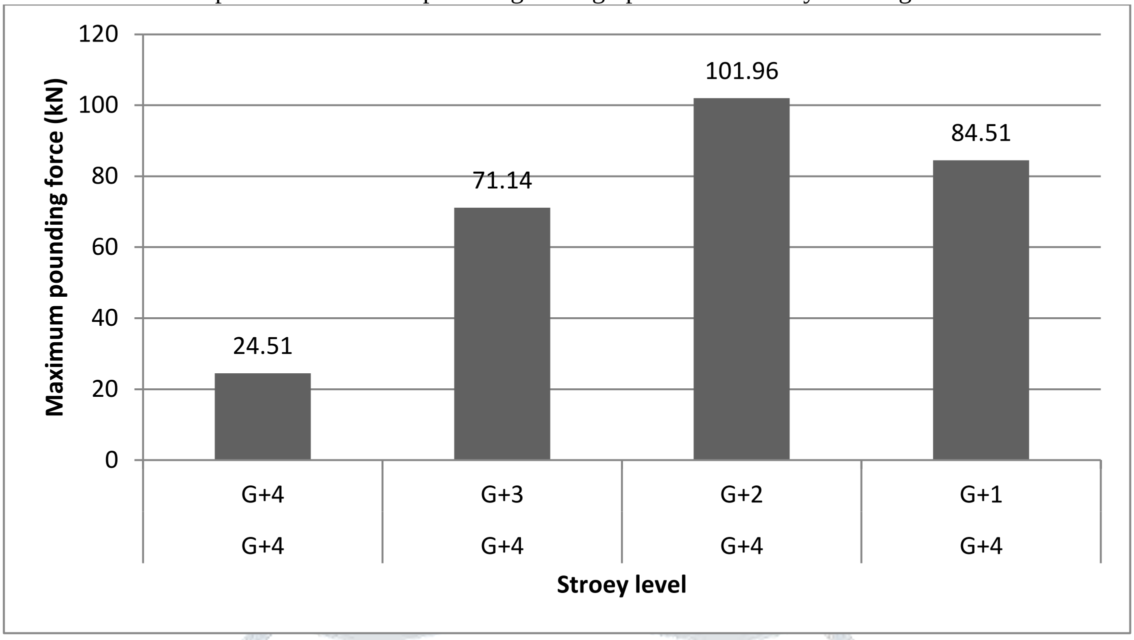


Table IV-2 Maximum pounding force table for G+4 storey building

Sr No.	Right hand side building	Left hand side building	Building height ratio	Maximum pounding force in kN
1	G+4	G+4	1	24.51
2	G+4	G+3	1.24	71.17
3	G+4	G+2	1.62	101.96
4	G+4	G+1	2.36	84.51

Graph IV-2 Maximum pounding force graph for G+4 storey building



By above table and graph show that pounding force increase while left hand side building floor decrease but after ratio of the both building goes more than 2 the pounding force decrease. But by this both case pounding force decreases at G+1 storey building. So by this both case not conclude that there is pounding force is decreases at ratio 2. If at high rise building it will change. At a same height building pounding force is very less because there is same mode shape of the buildings. Pounding force is effected by displacement of the both buildings, like G+5 and G+4 storey same height building displacement are same.

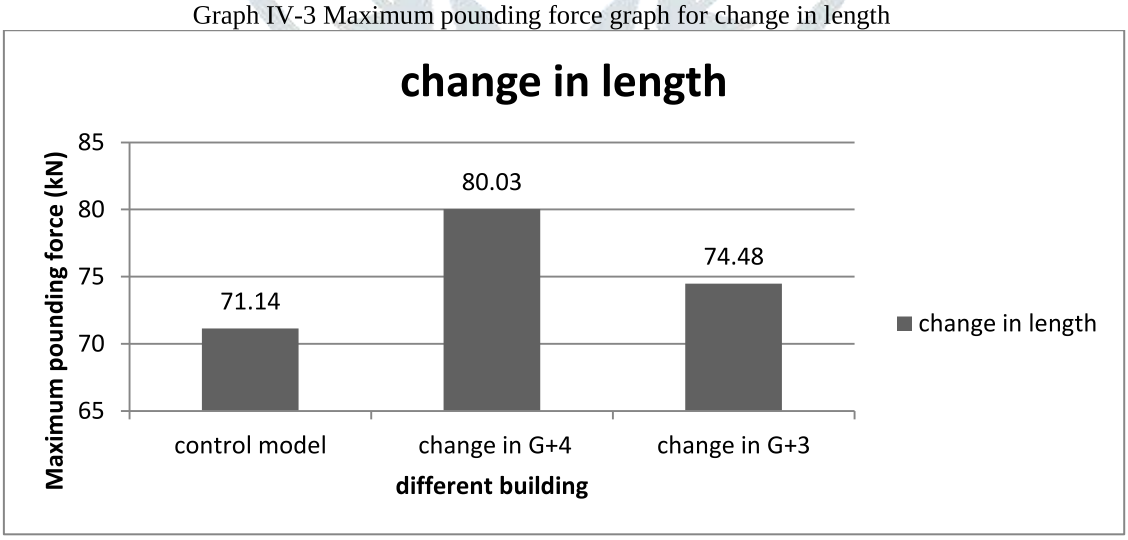
Change in length and width

For change length and width of the building increase one bay in X direction and Y direction. X direction means change in length and Y direction means change in width. In Y direction change in both side like front and back. By changing length and width it will change in lumped mass of the storey and change in position of the center of gravity.

Table IV-3 Maximum pounding force table for change in length

Sr No.		Pounding force (kN)	Percentage difference
1	Control model	71.14	
2	Change in G+4	80.03	12.50%
3	Change in G+3	74.48	4.69%

Graph IV-3 Maximum pounding force graph for change in length



Form above table shows that there is change in lumped mass is more effect then change in position of center of gravity. Assume by plan there is G+3 have M lumped mass then G+4 have 2M lumped mass because there is 2 bays in G+4 storey building. Then pounding force is 71.14 kN, but while change in length in G+3 storey building then both building have same lumped mass is 2M. At that time pounding force increases just 4.69%. While change in length the center of gravity just move at 2 m away from control model position. While change length in G+4 storey building then lumped mass increase at 4M and G+3 lumped mass are M. there lumped mass difference is increases pounding force 12.50%. At both condition centers of gravity are just move 2 m in X direction.

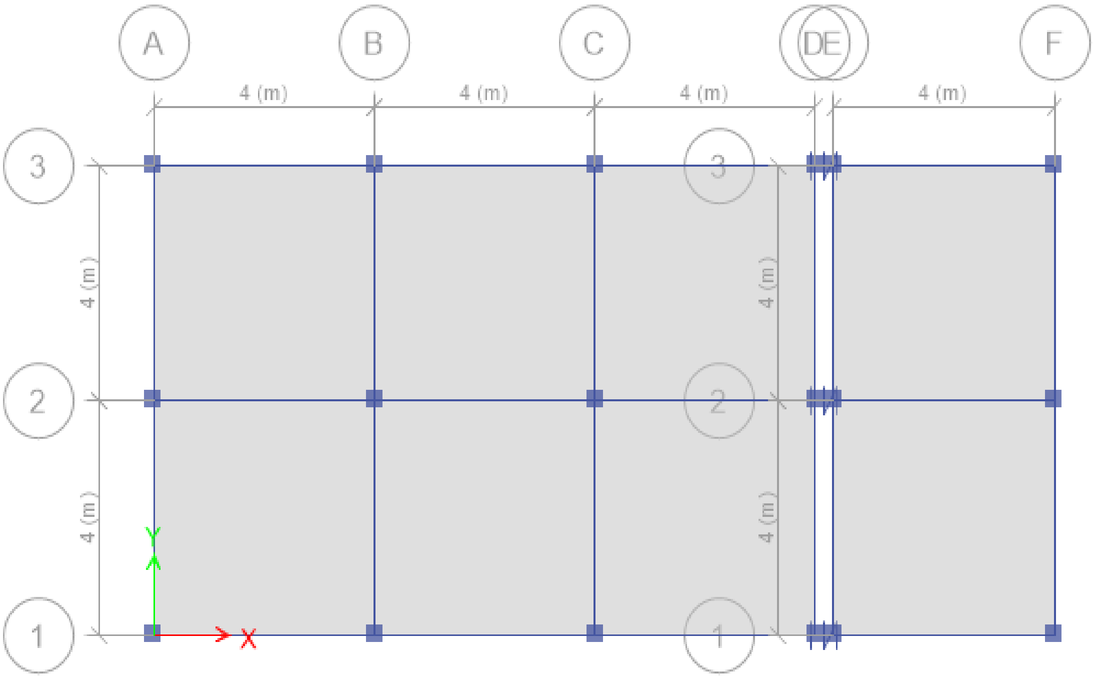


Figure IV-1 Change length in G+4 storey building

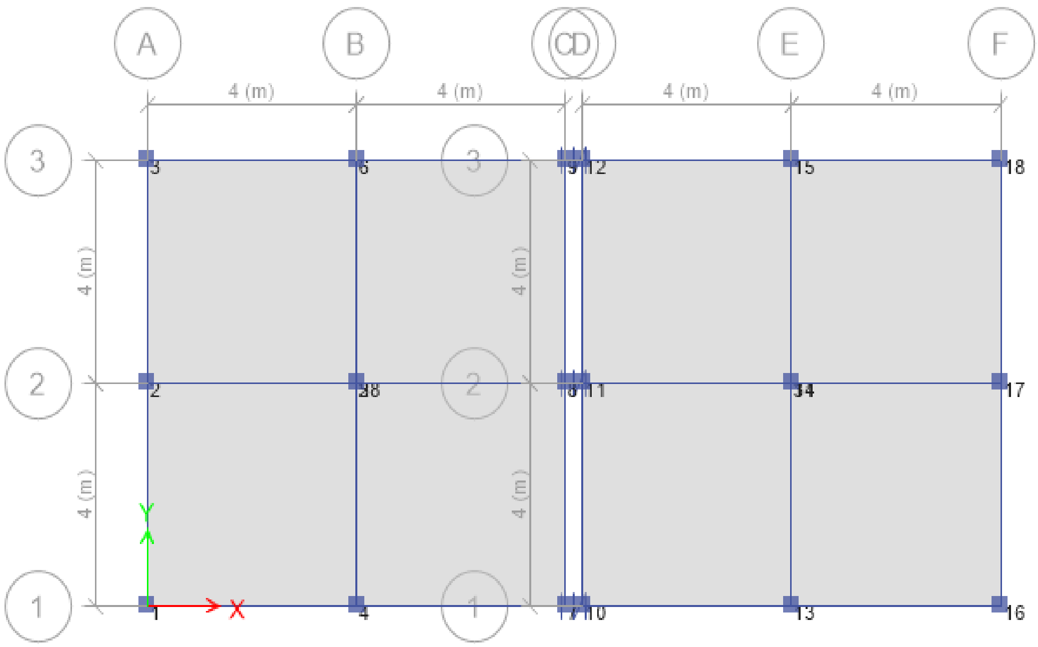


Figure IV-2 Change length in G+3 storey building

Table IV-4 Maximum pounding force table for change in width in back side

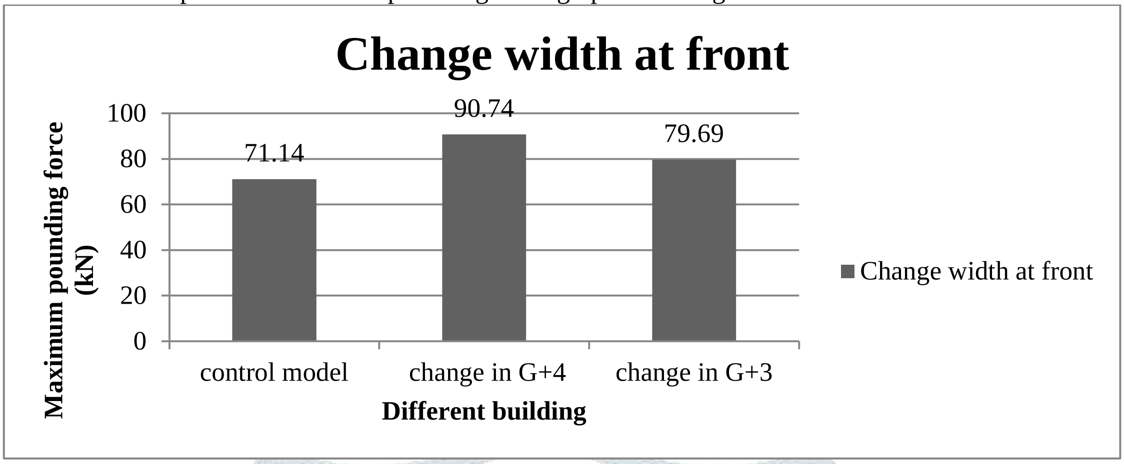
Sr No.		Pounding force (kN)	Percentage difference
1	Control model	71.14	
2	Change in G+4	84.5	18.78%
3	Change in G+3	124.53	75.05%

Table IV-5 Maximum pounding force table for change in width in front side

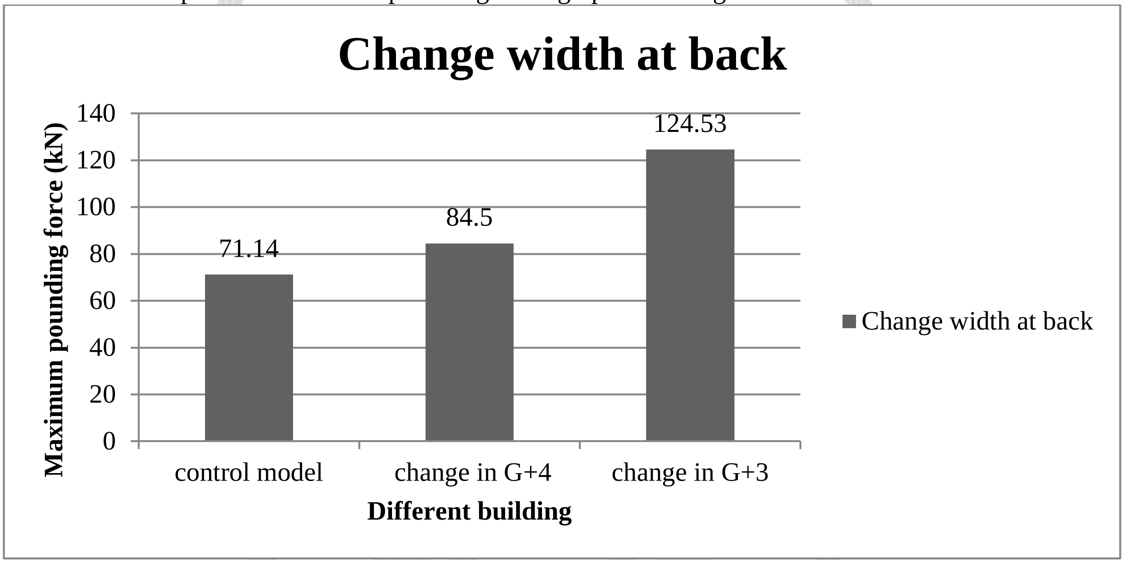
Sr No.		Pounding force (kN)	Percentage difference
1	Control model	71.14	
2	Change in G+4	90.74	27.55%
3	Change in G+3	79.68	12.02%

By above table shows that there is lumped mass change and change in center of gravity position will effect on pounding force. In lumped mass change in G+3 storey building there is lumped mass is increases just sum of one M, but change in lumped mass will change the position of center of gravity of building. Center of gravity are move in Y direction. By move in Y direction there is torsion moment are effect on pounding. That's why percentage difference is more than change in length. By above table there is lumped mass is increase sum of 2M in G+4 and sum of one M in G+3, but pounding force is more when change width in G+3 then change width in G+4. Because G+3 more effected by twisting moment.

Graph IV-4 Maximum pounding force graph for change width at front side



Graph IV-5 Maximum pounding force graph for change width at back side



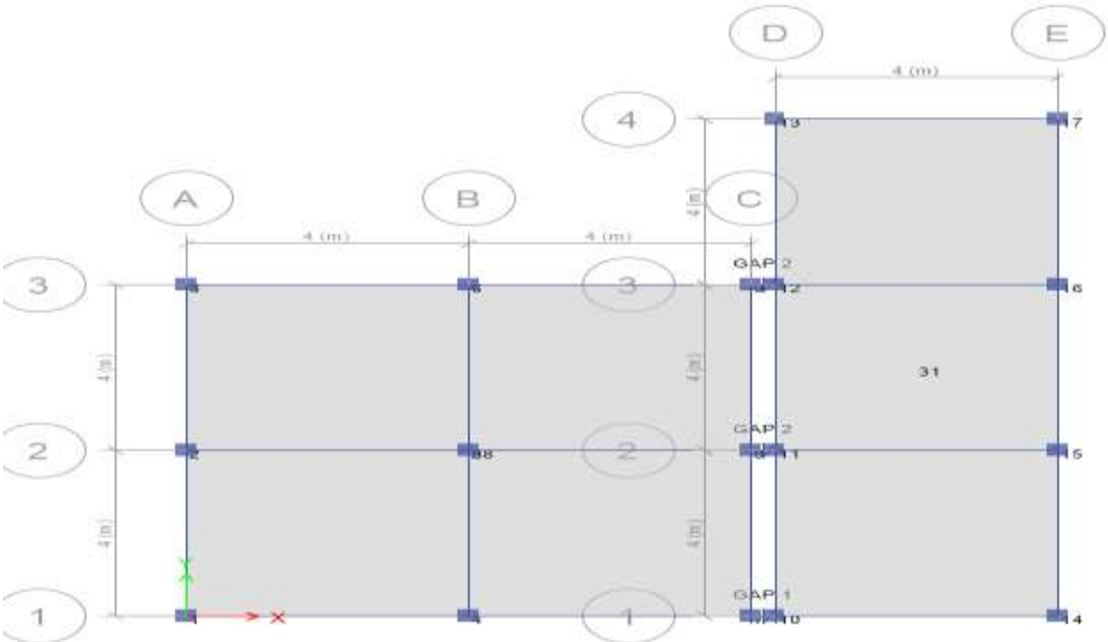


Figure IV-3 Change in width back side at G+3 storey building

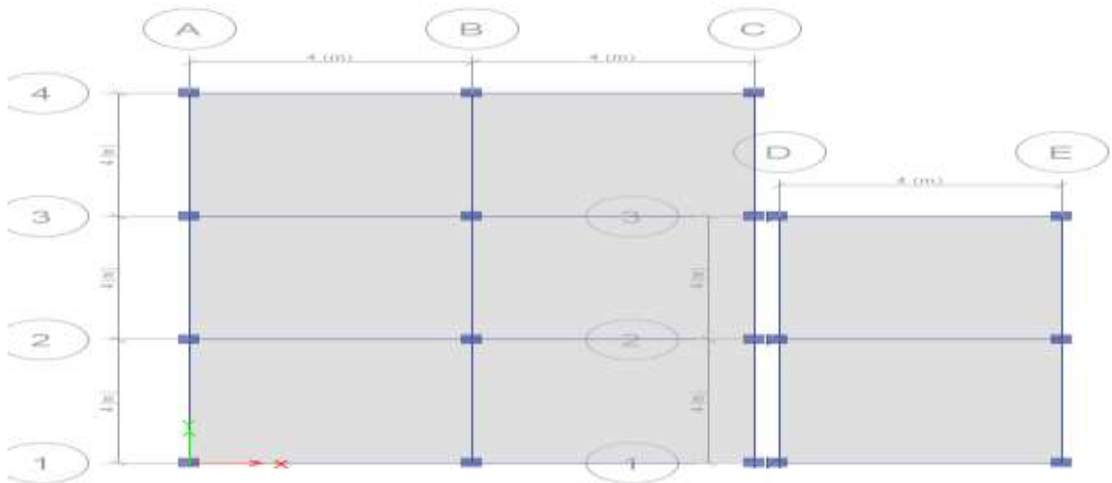


Figure IV-4 Change in width back side at G+4 storey building

STEP BACK OF BUILDING

By step back building there is change in position of center of gravity. In this case there is no change in lumped mass but only change in position of center of gravity. By step back center of gravity will move 4 m away in Y direction, but no change is lumped mass, so by this case understand the effect of center of gravity position for pounding force. In this case step back 4 m and 6 m both building one by one. In this case center of gravity also shift 4 m and 6 m. below table shows maximum pounding force at top storey.

Table IV-6 Maximum pounding force table for step back G+3 storey building

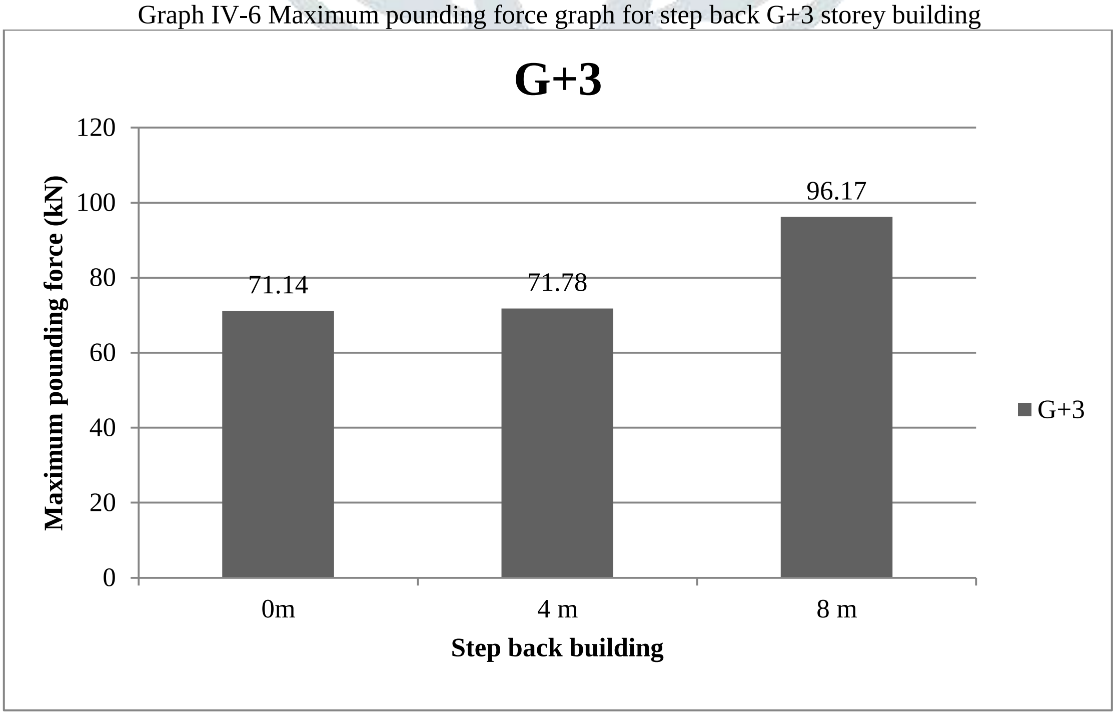
Sr No.	G+3 storey building	Maximum pounding force (kN)	Percentage difference
1	0 m	71.14	
2	4 m	71.78	0.90%
3	8 m	96.17	35.18%

Table IV-7 Maximum pounding force table for step back G+4 storey building

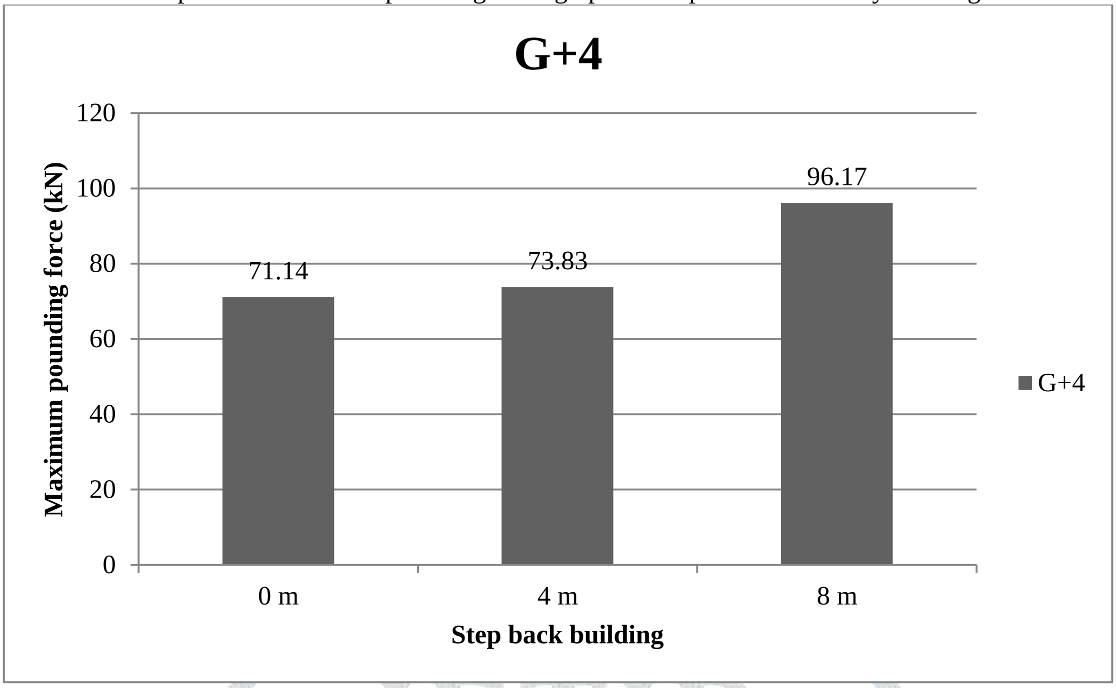
Sr No.	G+4 storey building	Maximum pounding force (kN)	Percentage difference
1	0 m	71.14	
2	4 m	73.83	3.78%
3	8 m	96.17	35.18%

By above table shows that there is pounding force increases by step back, because by step back there is center of gravity change there is position. Center of gravity shift Y direction. By step back there is effect by torsion moment. In both building center of gravity change their position. In both building same percentage difference are shown in table.

Graph IV-6 Maximum pounding force graph for step back G+3 storey building



Graph IV-7 Maximum pounding force graph for step back G+4 storey building



POSITION OF G+3 STOREY BUILDING

In this case change a position of G+3 storey building. Provide a G+3 building at different positions, like all corners, back side and front side of the building. In this case lumped mass of the storey is not change, but a distance at both building center of gravity is change in X direction and Y direction both.

Table IV-8 Maximum pounding force table for position of G+3 storey building

Sr No.	Description	Pounding force (kN)	Percentage difference
1	Control model	71.14	1.75%
2	Interchange location	72.26	
3	Back-Back corner	96.17	18.77%
4	Back-Front corner	96.17	
5	Front-Back corner	114.22	
6	Front-Front corner	114.22	

Above table shows that there is pounding force is change if change distance between center of gravity in X direction. While Y direction center of gravity is not effect on pounding force. There is Y direction center of gravity distance it will generate torsion moment in building. While X direction center of gravity distance generate linear displacement in building. So torsion moment pounding force always same because acceleration of the storey is same, but linear impact is change because this impact is affected by displacement of the storey. Back and front side building effect differently because there is torsion moment and linear displacement is different compare to control model.

CHANGE IN CROSS SECTION OF BEAM

In this case use beams sizes are 230 mm x 230 mm, 230 mm x 300 mm, 300 mm x 300 mm, 300 mm x 350 mm and 350 mm x 350 mm in both buildings.

Table IV-9 Maximum pounding force table for change cross section of beam G+3 storey building

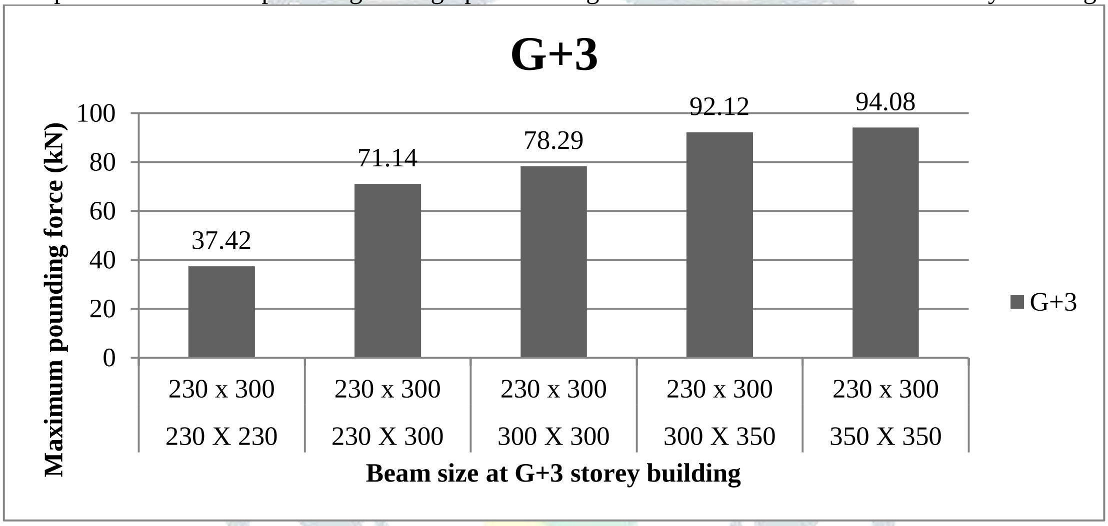
Sr No.	Beam cross section		Maximum pounding force (kN)	Percentage difference change depth	Percentage difference change width
	G+3	G+4			
1	230 mm x 230 mm	230 mm x 300 mm	37.42	90.11%	
2	230 mm x 300 mm	230 mm x 300 mm	71.14		10.05%
3	300 mm x 300 mm	230 mm x 300 mm	78.29	17.67%	
4	300 mm x 350 mm	230 mm x 300 mm	92.12		2.13%
5	350 mm x 350 mm	230 mm x 300 mm	94.08		

Table IV-10 Maximum pounding force table for change cross section of beam in G+4 storey building

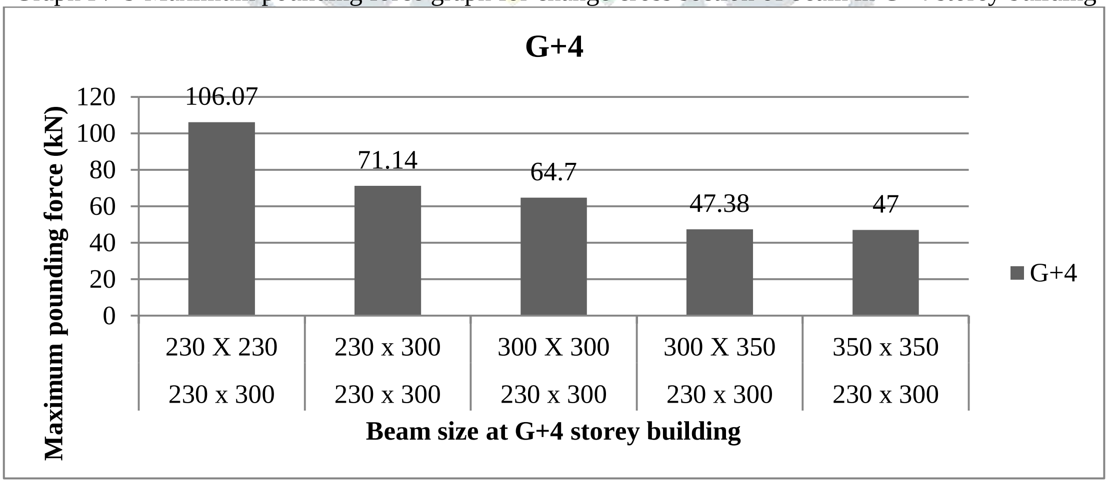
Sr No.	Beam cross section		Maximum pounding force (kN)	Percentage difference change width	Percentage difference change depth
	G+3	G+4			
1	230 mm x 300 mm	230 mm x 230 mm	106.07	32.93%	
2	230 mm x 300 mm	230 mm x 300 mm	71.14		9.05%
3	230 mm x 300 mm	300 mm x 300 mm	64.7	26.77%	
4	230 mm x 300 mm	300 mm x 350 mm	47.38		0.80%
5	230 mm x 300 mm	350 mm x 350 mm	47		

By above table shows that there is pounding force in increases when cross section of the beam increases in G+3 story building, but in will decrease when cross section of beam increases in G+4 storey building. In above table shows a percentage difference is decreases. It is shows that in any condition there is pounding occurs, because after some cross section of the beam it will become zero. At zero shows that there is no change in pounding force. This shows some maximum and minimum pounding force.

Graph IV-8 Maximum pounding force graph for change cross section of beam in G+3 storey building



Graph IV-9 Maximum pounding force graph for change cross section of beam in G+4 storey building



CHANGE IN CROSS SECTION OF COLUMN

Column sizes are 230 mm x 230 mm, 230 mm x 300 mm, 300 mm x 300 mm, 300 mm x 350 mm, 350 mm x 350 mm.

Table IV-11 Maximum pounding force table for change cross section of column in G+3 storey building

Sr No	Column cross section		Maximum pounding force (kN)	Percentage difference change depth	Percentage difference change width
	G+3	G+4			
1	230 mm x 230 mm	300 mm x 300 mm	7.87	642.32%	
2	230 mm x 300 mm	300 mm x 300 mm	58.42		21.77%

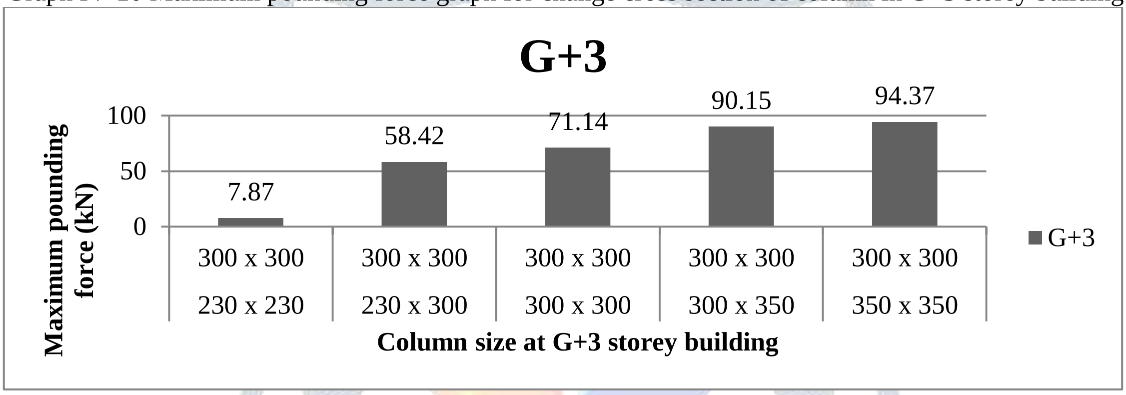
3	300 mm x 300 mm	300 mm x 300 mm	71.14	26.72%	
4	300 mm x 350 mm	300 mm x 300 mm	90.15		4.68%
5	350 mm x 350 mm	300 mm x 300 mm	94.37		

Table IV-12 Maximum pounding force table for change cross section of column in G+4 storey building

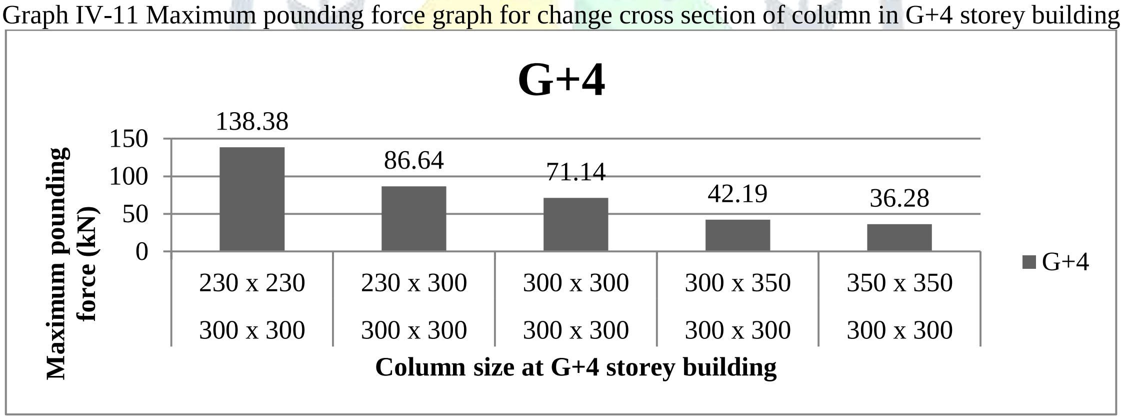
Sr No	Column cross section		Maximum pounding force (kN)	Percentage difference change depth	Percentage difference change width
	G+3	G+4			
1	300 mm x 300 mm	230 mm x 230 mm	138.38	37.39%	
2	300 mm x 300 mm	230 mm x 300 mm	86.64		17.89%
3	300 mm x 300 mm	300 mm x 300 mm	71.14	40.69%	
4	300 mm x 300 mm	300 mm x 350 mm	42.19		14.01%
5	300 mm x 300 mm	350 mm x 350 mm	36.28		

By above all table shows that change cross section of column is same behavior as change cross section of beam. By above table stiffness of column is more effective then stiffness of beam. Shorter building stiffness and higher building stiffness are both building effect on pounding force. Shorter building stiffness will be providing less but this less stiffness beam and column are failed in earthquake. Higher building stiffness will be providing high but this high stiffness beam and column are become uneconomical.

Graph IV-10 Maximum pounding force graph for change cross section of column in G+3 storey building



Graph IV-11 Maximum pounding force graph for change cross section of column in G+4 storey building



CHANGE STOREY HEIGHT OF BUILDING

In this case change a storey height of the building. In this case change storey height 3 m to 3.6 m. Change a storey height it will change column length. This height change will change stiffness of the column. Length of column is inversely proposal to stiffness of column.

Table IV-13 Maximum pounding force table for change storey height

Sr No	Storey height		Maximum pounding force in kN
	G+3	G+4	
1	3 m	3 m	71.14
2	3 m	3.6 m	84.3
3	3.6 m	3 m	22.48
4	3.6 m	3.6 m	96.33

V. CONCLUSION

- G+5 and fewer storey building pounding force reduce pounding force after ratio becomes more then 2.
- Pounding force will be effected by both building's displacement.
- Linear displacement is less effective than torsion moment.

- Change step back 8 m then pounding force is 35% more, because there is torsion moment are effect.
- Change depth of beam the pounding force change will be more than 15%, but change width of beam the pounding force change will be less than 15%.
- Change storey height of building will also increases pounding force.
- Stiffness of element will effect on pounding force.
- All the cases conclude that there is pounding will occur at any condition. That's why need a sufficient separation gap.
- Pounding force is depends on many things like, mass of the storey, stiffness of element, distance between center of gravity, earthquake intensity and soli condition.

VI. FUTURE SCOPE

- Check height ratio for high rise building like G+10 or high building.
- Change width and length of bay.
- Change earthquake and zone of earthquake.
- Change construction material like steel and RCC.

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