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A Comparitive Study of Pounding Effect on Multi-Storied Building with and without Shear Wall

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Abstract:- Dynamic impacts caused on buildings by wind and earthquake loads.There are many effects due to earthquakes, one of the effects that is recently seen is pounding.Pounding of adjacent buildings happens because of their completely different dynamic characteristics similarly as depleted separation distance between them. Though earthquake loading is usually thought of in structural design, pounding of adjacent buildings isn't usually considered and typically causes extremely surprising damages and failures. In this study, pounding effect was numerically investigated in four different heights of multi-storied buildings in different zone (III andV) are analysed by usingETABSwith and without pounding effect. The pounding effect is also analysed with and without shear walls condition. The story displacements, story drifts and base shears are computed, and comparisons are drawn from varying heights and with and without shear wall condition. To analyse the structure, Response spectrum analysis is used.

Keywords:- *Pounding, Separation distance, Shear wall, Height.*

I. INTRODUCTION

Dynamic impacts caused on buildings by wind and earthquake loads. Earthquakes are known as one of the most unpredictable and devastating of all natural disasters; however, because of the unpredictable nature of their occurrence, it is difficult to prevent the loss of human lives and property destruction if structures are not designed to withstand such earthquake forces.Due to the construction of high-rise buildings in previous decades, the pounding of adjacent buildings during earthquakes is one of the causes of structural damage**.**During earthquakes, structural pounding refers to the lateral impacts between buildings.It happens when the vibrations of nearby structures are out of phase, and the at-rest space between them is insufficient to accommodate their relative motions.In metropolitan cities, buildings are often very enclosed due to the need to use more land due to high population density. Therefore, for metropolitan cities located in active seismic zones, the damming of adjacent buildings can present a potentially serious problem. Some of the native damages happen because of the surprising lateral impact force due to pounding that isn't sometimes thought of in building design. Typically, it should cause building's collapse beneath a stronger earthquake.

The pounding effect on buildings can be mitigated in two ways:

- Cast-in-place reinforced concrete walls or elastic materials between adjacent structures can be used to reinforce the structural system.
- By keeping a safe separation between adjacent objects.
- The Bureau of Indian Standards clearly states in it IS code 4326 that a separation distance between buildings is required to avoid collisions during the earthquake involved. The code mentioned in Table 1 is as follows:

SI.NO	Type of Constructions	Gap Width/Storey, in mm for Design Seismic Coefficient αh =0.1
1	Box system or frames with shear walls	15
2	Moment resistant reinforced concrete frame	20
3	Moment resistant steel frame	30

Table 1: Seismic pounding gap for different structural system

IS1893(Part 1):2016, mentions that the separation should be R times the sum of the displacements. R can be replaced by R/2 when two buildings are of the same level, where R is the response reduction factor (Clause 7.11.1). According to FEMA: 273-1997: The distance between adjacent structures should be less than 4% of the height of the building and higher to avoid pounding, also the equations for calculating gap are:

$$S = U_a + U_b (ABS) \qquad (1)$$

$$S = \sqrt{U_a^2 + U_b^2} (SRSS) \qquad (2)$$

Where in above equation, S = separation distance and Ua, Ub= peak displacement response of adjacent structures A and B, respectively.

II. OBJECTIVES OF THE STUDY

- To determine storey drifts, storey displacements and base shear for different zone(III and V) for different heights under medium soil condition.
- To determine storey drifts, storey displacements and base shear for different zone (III and V) for different heights under medium soil condition due to pounding effect with and without shear wall.
- To compare storey displacements, storey drifts and base shear due to pounding effect with and without shear wall.

III. METHODOLOGY

This study was performed by analysing reinforced concrete frames using response spectrum analysis in ETABS software. Seismic and pounding responses of four multi-storey structures are studied in aspects of displacement and pounding force. The type of poundinganalysed is the pounding effect when a shorter building collides with an adjacent taller building. In addition, the effects of variationof gap and adding shear walls are also studied. For the linear method, the building in zone V of the earthquake is taken into account.

IV. MODELLING AND ANALYSIS

Modelling of the buildings done by considering the data which are given in Tables as follows:

S.No	Seismic zone	Zone-III	Zone-V
1	Zone factor	0.16	0.36
2	Response reduction factor	5	5
3	Importance factor	1	1

Table 2: Seismic parameters

Member	Storey range	Grade of Concrete	Dimensions(mm)
Beams	1 to 8	M35	300*450
	9 to 16	M35	300*450
	17 to 23	M30	300*450
Columns	1 to 4	M45	300*600
	5 to 12	M40	300*600
	13 to 20	M35	300*450
	21 to 23	M30	300*450
Slabs	1 to 16	M35	125
	17 to 23	M30	125

Table 3: (G+22) properties

Member	Storey range	Grade of Concrete	Dimensions(mm)
Beams	1 to 8	M35	300*450
	9 to 16	M35	300*450
	17 to 19	M30	300*450
Columns	1 to 4	M45	300*600
	5 to 12	M40	300*600
	13 to 19	M35	300*450
Slabs	1 to 16	M35	125
	17 to 19	M30	125

Table 4: (G+18) properties

Member	Storey range	Grade of Concrete	Dimensions(mm)
Beams	1 to 8	M35	300*450
	9 to 15	M30	300*450
Columns	1 to 4	M45	300*600
	5 to 12	M40	300*600
	13 to 15	M35	300*450
Slabs	1 to 16	M35	125
	17 to 19	M30	125

Table 5: (G+14) properties

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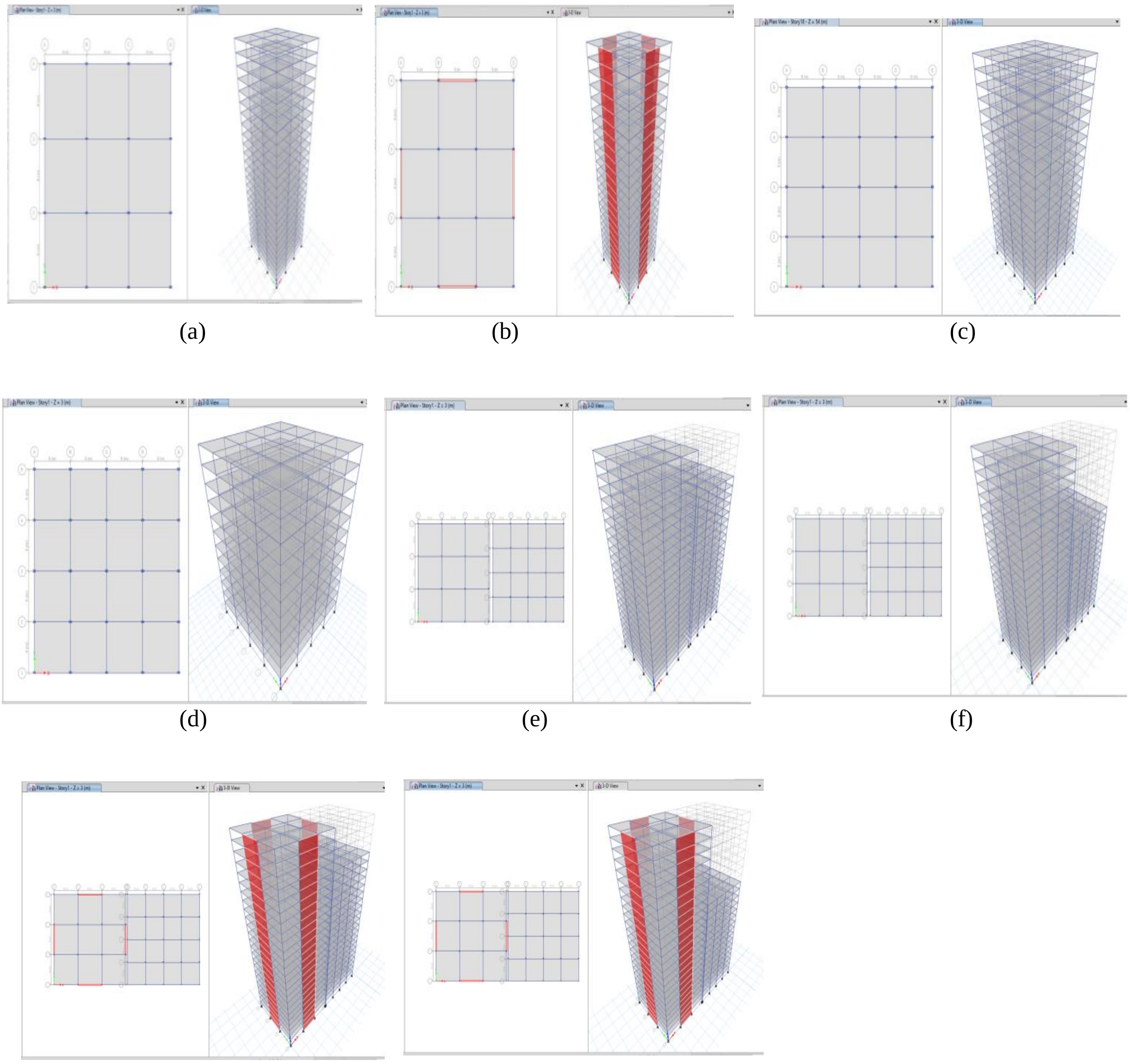
Member	Storey range	Grade of Concrete	Dimensions(mm)
Beams	1 to 11	M35	300*450
Columns	1 to 4	M40	300*500
	5 to 11	M35	300*450
Slabs	1 to 11	M35	125

Table 6: (G+10) properties



(a) (b) (c) (d) (e) (f) (g) (h)

Fig. 1: (a) Plan and 3D view of (G+22) building without shear wall., (b) Plan and 3D view of (G+22) building with shear wall. (c) Plan and 3D view of (G+18) building.,(d) Plan and 3D view of (G+10) building., (e) Plan and 3D view of (G+22 and G+18) buildings without shear wall., (f) Plan and 3D view of (G+22 and G+14) buildings without shear wall., (g) Plan and 3d view of (G+22 and G+18) buildings with shear wall., (h) Plan and 3D view of (G+22 and G+14) buildings with shear wall.

V. RESULTS AND DISCUSSIONS

Following parameters of the result obtained from analysis of the considered buildings.

A. Without Pounding effect

a) Storey displacement

Storey displacement of the buildings without founding effects are shown in Figure 2 as follows:

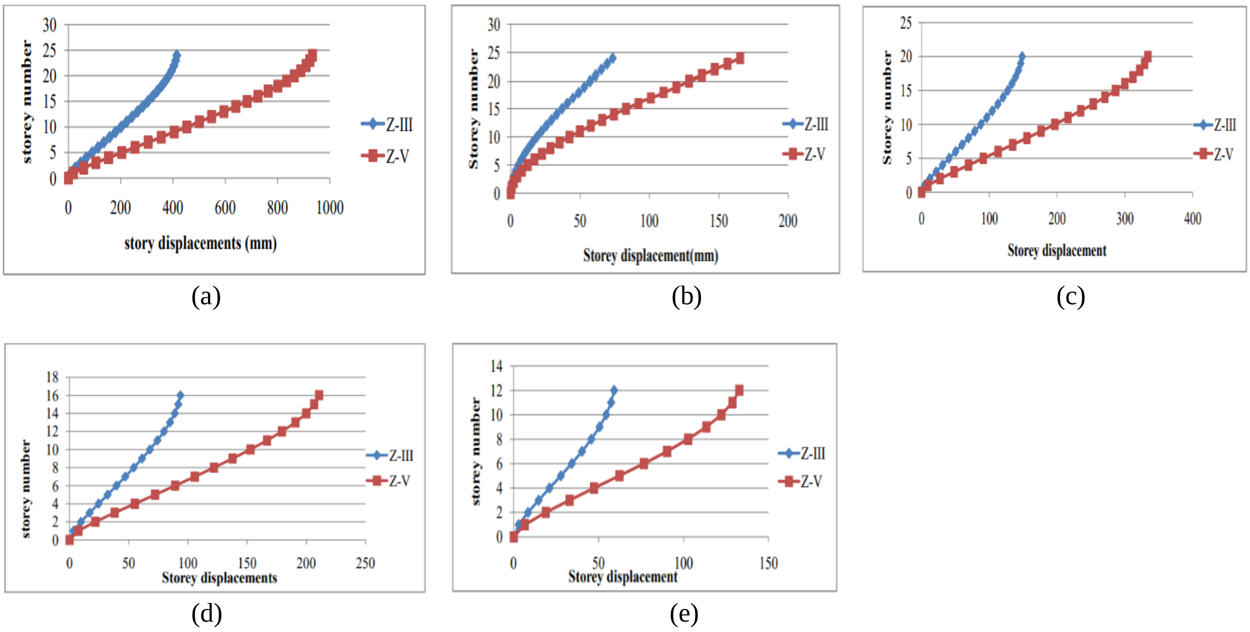


Fig. 2: (a) Storey displacements of G+22 without SW in zone(III and V)., (b) Storey displacements of G+22 with SW in zone(III and V)., (c) Storey displacements of G+18 without SW in zone (III and V)., (d) Storey displacements of G+14 without SW in zone (III and V)., (e) Storey displacements of G+10 without SW in zone(III and V).

From the Figure 2, it is observed that the storey displacement in the buildings without shear wall is greater than the buildings with shear walls. It is concluded that variation of storey displacement in zone-III is 55.5% lesser than the zone-V.

b) Storey drift

Storey drift of the buildings without pounding effects are shown in Figure 3 as follows:

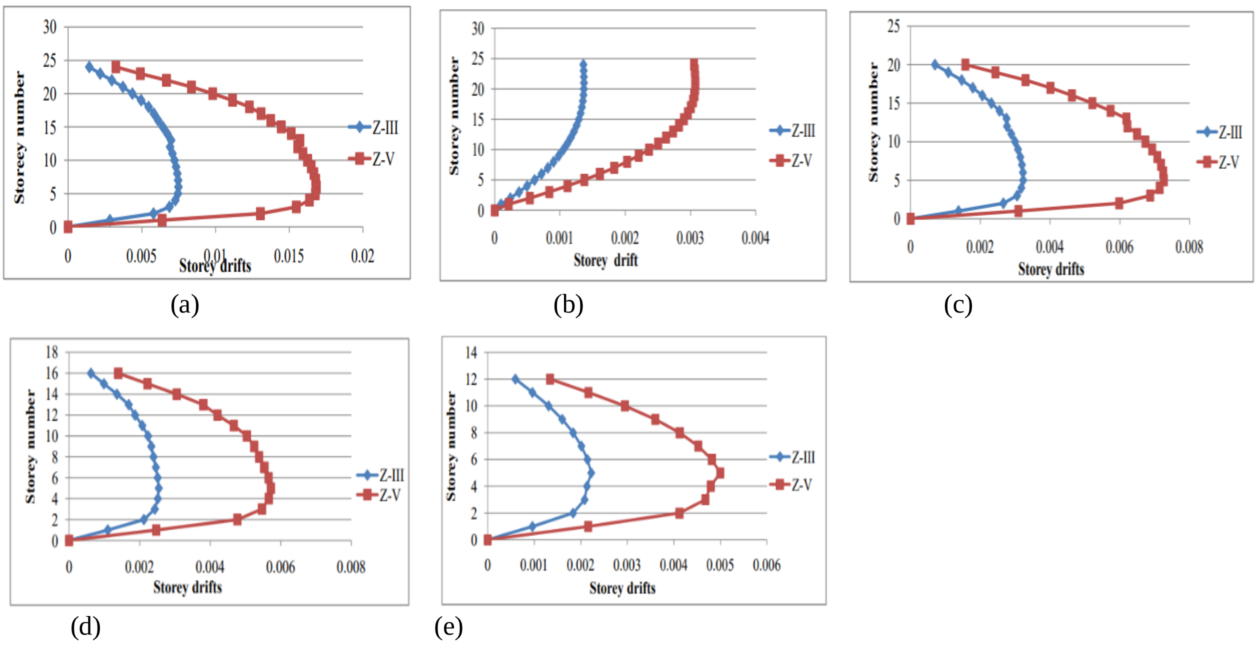


Fig. 3: (a) Storey drifts of G+22 without SW in zone (III and V)., (b) Storey driftsof G+22 with SW in zone (III and V)., (c) Storey drifts of G+18 without SW in zone (III and V)., (d) Storey drifts of G+14 without SW in zone (III and V). (e) Storey drifts of G+10 without SW in zone(III and V).

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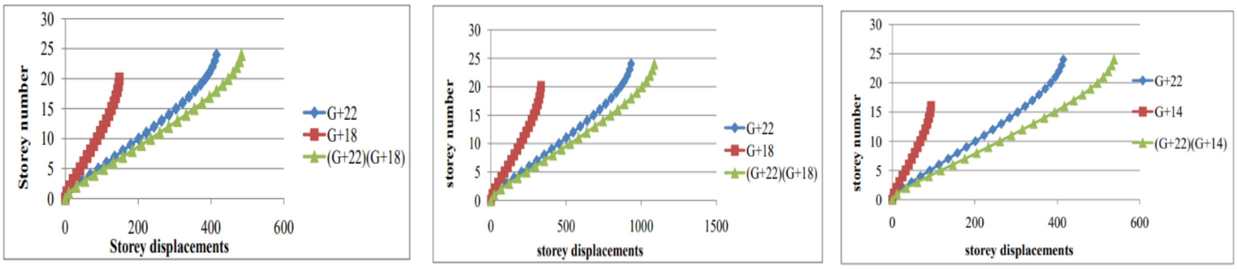
From the Figure 3, it is observed thatstorey drift in the buildings with shear wall increase uniformly by increasing number of storey and the amount of drift is lesser than buildings without shear walls.It is concluded that storey drift in zone-III is 55% lesser than zone-V.

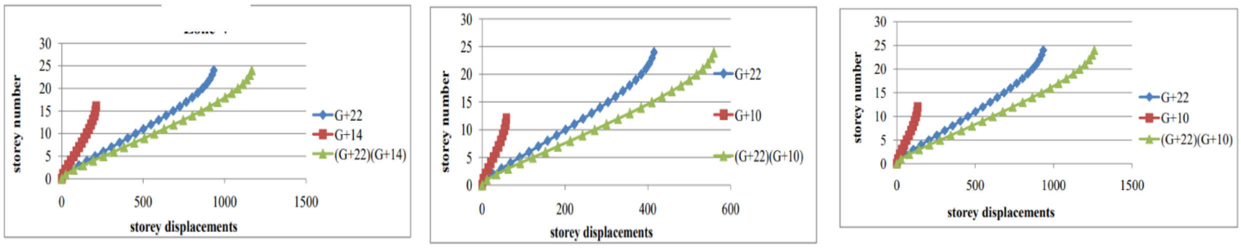
B. Pounding phenomenon(without shear wall)

a) Storey displacement

Storey displacement of the buildings without shear walls due to pounding effects are shown in Figure 4 as follows:



(a) (b) (c)



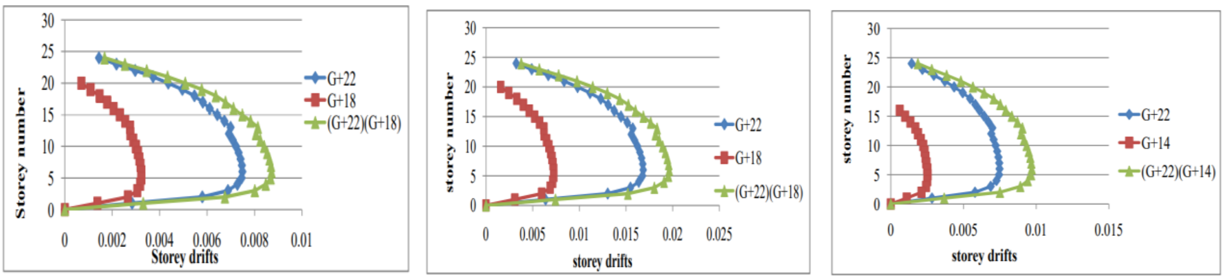
(d) (e) (f)

Fig. 4: (a) Storey displacement of G+22, G+18 and (G+22)G+18) in zone-III., (b) Storey displacement of G+22, G+18 and (G+22)G+18) in zone-V., (c) Storey displacement of G+22, G+14 and (G+22)G+14) in zone-III. (d) Storey displacement of G+22, G+14 and (G+22)G+14) in zone-V., (e) Storey displacement of G+22, G+10 and (G+22)G+10) in zone-III., (f) Storey displacement of G+22, G+10 and (G+22)G+10) in zone-V.

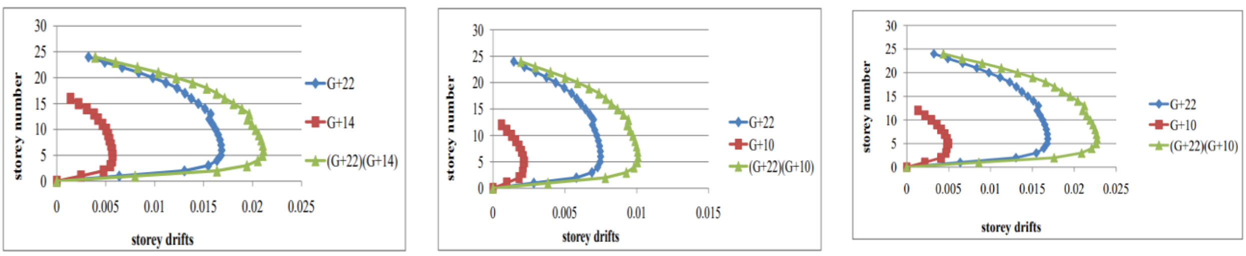
From the Figure 4, it is observed that due to pounding effectstorey displacement of (G+22)(G+18), (G+22)(G+14), (G+22)(G+10) at the top storey greater than individual storey displacement of G+22, G+18, G+14 and G+10 in both zones.

b) Storey drift

Storey drift of the buildings without shear walls due to pounding effects are shown in Figure 5 as follows:



(a) (b) (c)



(d) (e) (f)

Fig. 5: (a) Storey drift of G+22, G+18 and (G+22)G+18) in zone-III., (b) Storey drift of G+22, G+18 and (G+22)G+18) in zone-V., (c) Storey drift of G+22, G+14 and (G+22)G+14) in zone-III., (d) Storey drift of G+22, G+14 and (G+22)G+14) in zone-V. (e) Storey drift of G+22, G+10 and (G+22)G+10) in zone-III., (f) Storey drift of G+22, G+10 and (G+22)G+10) in zone-V.

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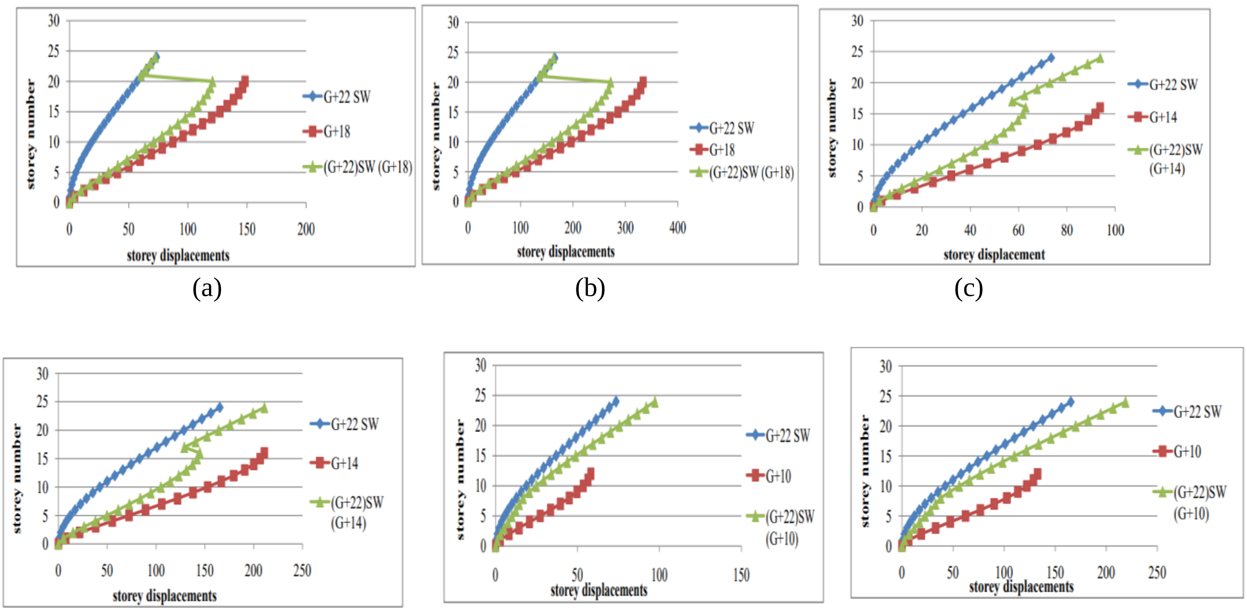
From Figure 5, it is observed that due topounding effect storey drift of (G+22)(G+18), (G+22)(G+14), (G+22)(G+10) at the top storey greater than individual storey displacement of G+22, G+18, G+14 and G+10.Storey drift variation due to pounding effect is 34.8% greater than individual ones in both zones.

C. Pounding phenomenon (with shear wall)

a) Storey displacement

Storey displacement of the buildings with shear walls due to pounding effects are shown in Figure 6 as follows:



(a) (b) (c)

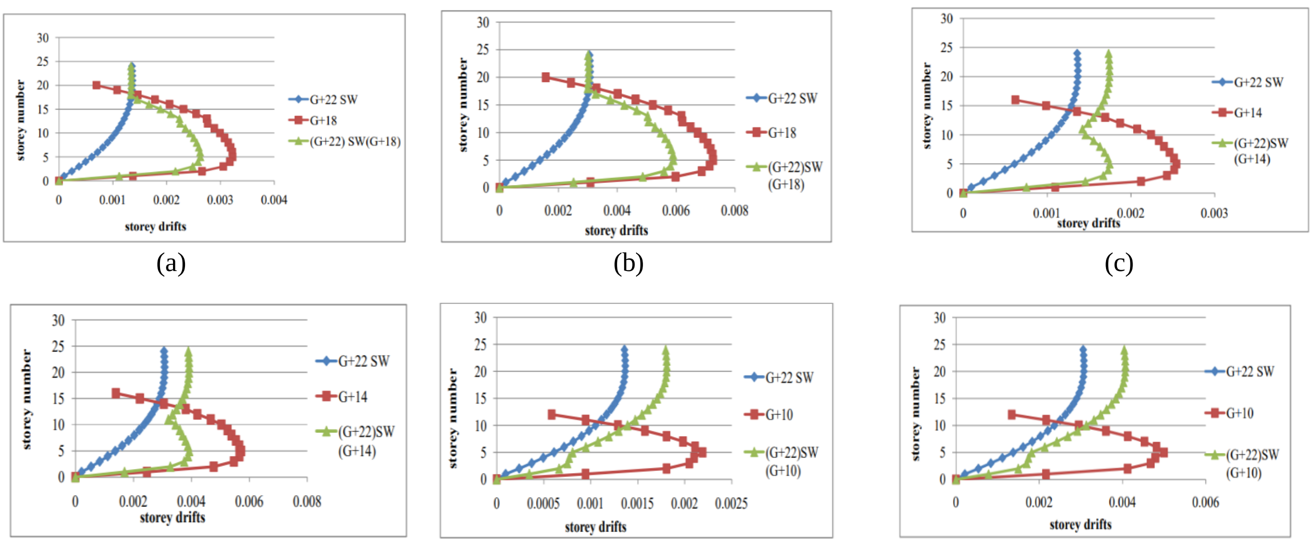
(d) (e) (f)

Fig. 6: (a) Storey displacement of G+22, G+18 and (G+22)G+18) in zone-III., (b) Storey displacement of G+22, G+18 and (G+22)G+18) in zone-V., (c) Storey displacement of G+22, G+14 and (G+22)G+14) in zone-III., (d) Storey displacement of G+22, G+14 and (G+22)G+14) in zone-V., (e) Storey displacement of G+22, G+10 and (G+22)G+10) in zone-III., (f) Storey displacement of G+22, G+10 and (G+22)G+10) in zone-V.

From the Figure 6, it is observed that in due to pounding effect on building in zone - III and zone - V the maximum storey displacement occurred at the top corner of smaller building, which is one of the critical regions for pounding.

b) Storey drift

Storey drift of the buildings with shear walls due to pounding effects are shown in Figure 7 as follows:



(a) (b) (c)

(d) (e) (f)

Fig. 7: (a) Storey drift of G+22, G+18 and (G+22)G+18) in zone-III., (b) Storey drift of G+22, G+18 and (G+22)G+18) in zone-V., (c) Storey drift of G+22, G+14 and (G+22)G+14) in zone-III., (d) Storey drift of G+22, G+14 and (G+22)G+14) in zone-V., (e) Storey drift of G+22, G+10 and (G+22)G+10) in zone-III.,(f) Storey drift of G+22, G+10 and (G+22)G+10) in zone-V.

According to Figure 7, it is observed that the story drift due to pounding effects is greater than the individual buildings in both zones (III and V).

VI. CONCLUSIONS

A. Without shear wall

- Maximum storey displacement and storey drift of (G+22), G+18) in zone (III&V)due to pounding effect is 16.5% greater than the (G+22) building without pounding.
- Maximum storey displacement and storey drift of (G+22)(G+14) in zone (III&V)due to pounding effect is 29.5% greater than the (G+22) building without pounding.
- Maximum storey displacement and storey drift of (G+22)(G+10) in zone (III&V)due to pounding effect is 34.8% greater than the (G+22) building without pounding.

B. With shear wall

- Maximum storey displacement and storey drift of (G+22)(G+18)with shear wall due to pounding effect is 64.3 % greater than the (G+22) without pounding.
- Maximum storey displacement and storey drift of (G+22)(G+14) with shear wall due to pounding effect is 27.5% greater than the (G+22) building without pounding.
- Maximum storey displacement and storey drift of (G+22)(G+10) with shear wall due to pounding effect is 32.3% greater than the (G+22) building without pounding.

C. With variation in heights

- Maximum storey displacements of (G+22)(G+14) in zone(III&V) compared with (G+22)(G+18) is increases by 11.1% and 7.27% respectively.
- Maximum storey displacements of (G+22)(G+10) in zone(III&V) compared with (G+22)(G+14)increases by 4% and 8% respectively.
- Maximum storey displacements of (G+22)(G+10) in zone(III&V) compared with (G+22)(G+18increases by 15.7% .
- Maximum storey displacements of (G+22)(G+14) with shear wall in zone(III&V) compared wi(G+22)(G+18) with shear wall decreases by22.3%.

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