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SESIMIC POUNDING ANALYSIS ON ADJACENT MULTIPLE STOREY BUILDING OF DIFFERENT TOTAL HEIGHTS (ETABS)

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ABSTRACT

Pounding which is impact of adjacent buildings when they vibrate out of phase and separation gap between them is less than minimum distance required for them to vibrate freely due to earthquake excitations has caused building damage during almost every earthquake. Collisions between adjacent structures due to insufficient separations gaps have been witnessed in almost every major earthquake since the 1960. In this present study seismic responses of adjacent buildings subjected to earthquake induced pounding and clarify pounding effect for different heights of buildings. In this present project to observe the seismic pounding effect on buildings, regular 8 and 12 storey adjacent buildings are taken.
To observe the displacement the following options are consider All the listed cases are modelled and analysed by using ETABS software and prepared data base for different studies

Keywords: *Pounding Effect, ETABS, Shear Wall,Static Loads, Seismic Loads and Displacements*

I. INTRODUCTION

There is a day to day increase of usage of land in urban area leading to its scarcity and even if land is available, the cost is high. Developmental activity is another cause for reduction of land in cities. So if the available land chosen is used for construction of a multi-storied building, then there is a reduction in construction time and the money when compared with a building similar plinth area on an individual plot area.

Investigations of past and recent earthquake damage have illustrated that the building structures are vulnerable to severe damage and/or collapse during moderate to strong ground motion. An earthquake with a magnitude of six is capable of causing severe damages of engineered buildings rise to great economic losses. Structures are built very close to each other in metropolitan areas where the cost of land is very high. Due to closeness of the structures, they collide with each other when subjected to earthquake or any vibration.

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

The latest version of ETABS continues in that tradition, incorporating structural element terminology that is used on a daily basis (Columns, Beams, Bracings, Shear Walls etc.), contrary to the common civil engineering programs that use terms such as nodes, members etc. Additionally, it offers many automatic functions for the formation, analysis and design of the structural system in an efficient, fast and easy way. The user can easily create a model, apply any kind of load to it and then take advantage of the superior capabilities of ETABS to perform a start or art analysis and design. ETABS is the solution, whether you are designing a simple 2D frame or performing a dynamic analysis of a complex high-rise that utilizes non-linear dampers for inter-story drift control.

II. ANALYSIS PROCESS

Seismic analysis or earthquake analysis is a subset of structural analysis and is the calculation of the response of a structure to the earthquakes. A structure has the potential to wave back and forth during an earthquake this is called the fundamental mode and is the lowest frequency of the structure response. However, buildings also have higher modes of response, which are uniquely activated during an earthquake.

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Once the structural model had been selected, it is possible to perform analysis to determine the seismically induced forces in the structure. They are different methods of analysis which provide different degrees of accuracy

Based on the type of external action and behavior of structure, the analysis can be further classified as linear static analysis, linear dynamic analysis and non linear dynamic analysis

III. PREWORK ATTACHED

Pounding between closely spaced building structures can be a serious hazard in seismically active areas. Investigations of past and recent earthquakes damage have illustrated several instances of pounding damage (Astaneh-Asl et al.1994, Northridge Reconnaissance Team 1996, Kasai& Maison 1991) in both building and bridge structures. Pounding damage was observed during the 1985 Mexico earthquake, the 1988 Sequenay earthquake in Canada, the 1992 Cairo earthquake, the 1994 Northridge earthquake, the 1995 Kobe earthquake and 1999 Kocaeli earthquake.

An alternative to the seismic separation gap provision in the structure design is to minimize the effect of pounding through decreasing lateral motion (Kasaiet al. 1996, Abdullah et al. 2001, Jankowski et al 2000, Ruangrassamee & Kawashima 2003 Kawashima& Shoji 2000)

Kawashima& Shoji 2000), which can be achieved by joining adjacent structures at critical locations so that their motion could be in-phase with one another or by increasing the pounding buildings damping capacity by means of passive structural control of energy dissipation system or by seismic retrofitting

IV. POUNDING EFFECT

Building collision commonly called pounding occurs during earthquake when, due to their different dynamic characteristics, adjacent buildings vibrate out of phase and there is insufficient separation distance between them.

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Pounding between New & Old Building during 6 April 2009, Aquila Earthquake

Pounding damage

Pounding of adjacent buildings could have worse damage as adjacent buildings with different dynamic characteristics which vibrate out of phase and there is insufficient separation distance or energy dissipation system to accommodate the relative motions of adjacent buildings. Past seismic codes did not give definite guidelines to preclude pounding, because of this and due to economic considerations including maximum land usage requirements, especially in the high density populated areas of cities, there are many buildings worldwide which are already built in contact or extremely close to another that could suffer pounding damage in future earthquakes. A large separation is controversial from both technical (difficulty in using expansion joint) and economical loss of land usage) views.

V. SEPARATION GAP

Pounding which is impact of adjacent buildings when they vibrate out of phase and separation gap between them is less than minimum distance required for them to vibrate freely due to earthquake excitations has caused building damage during almost every earthquake. Bureau of Indian Standards clearly gives in its code IS 4326 that a Separation distance is to be provided between buildings to avoid collision during an earthquake.

Table -1:-Gap Width for Adjoining Structures

S.NO	Type of construction	Gap width/storey ,for design seismic coefficient =0.12
1	Box system or frame with shear walls	15
2	Moment resistant reinforced concrete frame	20
3	Moment resistant steel frame	30

NOTE: minimum total gap shall be 25mm for any other value ,the gap width shall be determined proportionately

For buildings of height greater than 40 metres, it will be desirable to carry out model or dynamic analysis of the structures in order to compute the drift at each storey, and the gap width between the adjoining structures shall not be less than the sum of their dynamic deflections at any level

International Building Code (IBC), specifies that separation gap between adjacent buildings with same property line shall be equal or greater than the Square Root of the Sum of the Squares (SRSS) of adjacent buildings maximum inelastic displacements while the ratio of Absolute Sum (ABS) of maximum inelastic displacements of adjacent buildings has been assigned as the minimum required separation gap by Taiwan Building Code (TBC). Studies conducted by Lin and Weng and Lin depicted that the minimum separation gap calculated from ABS method was 1.6 times greater than the minimum separation gap calculated from SRSS. On the other hand, Iran National Building Code (INBC) roughly accepts minimum separation gap equal to 1% of building height; so edge of each building should be adjusted at least 0.5% of buildings height from its property line.

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

= √ 2 + 2SRSS (2)

VI. OBJECTIVES OF STUDY

This project aims at computing drifts of the adjacent building in pounding effect. Seismic gap between buildings for rigid floor diaphragm idealizations by static analysis using ETABS 9.7.4 Nonlinear. The principal objectives of the study are as follows

1. Generation of three dimensional models of buildings for rigid floor diaphragm idealization to analyze static analysis using ETABS
2. Performing static analysis of rigid floor diaphragm idealization for medium soil at Zone – III
3. Analyzing the displacement of buildings for (G+7) and Eight Storey (G+11) building cases to permit movement, in order to avoid pounding due to earthquake static Analysis
4. Comparison of storey drift in different cases floor diaphragm idealizations for static analysis.
5. Comparison of displacement profiles for frames at different locations for rigid floor diaphragm idealization.

VII. ANALYSIS & DESIGN

The material properties are defined such as mass, weight, modulus of elasticity, Poisson's ratio, strength characteristics etc. The material properties used in the models.

Table-2: Materials and Element Property

Material name	Concrete
Type of material	Isotropic
Mass Per Unit Volume	2.5kN/m^3
Modulus of elasticity	32kN/mm^2
Poisson's ratio	0.2
Concrete strength	20 MPa
Wall thickness	100 mm

Table-3: Primary load cases combinations

LOAD CASE NUMBER	***LOAD TYPE***	**LOAD CASE NUMBER**	**LOAD TYPE**
1	Dead load (D.L)	7	EQ in Negative Y (EQNY)
2	Live load (L.L)	8	WIND in X (WX)
3	Erecting load	9	WIND in Y (WY)
	EQ in X		WIND in

4	(EqX)	10	Negative X(WNX)
5	EQ in Y (EqY)	11	WIND in Negative Y(WNY)
6	EQ Negative X (EqNX)		

The lateral load is transformed to the structural elements through the diaphragm action. The diaphragm is created while modelling the structure. The diaphragm action in the structure denoted by id D1 in each storey. By comparing purpose name id is used for entire structure. For action of diaphragm in each floor the modes are formed in both X and Y direction.

Table-4: Seismic and Wind parameters

Seismic coefficients AS PER IS: 1893-2000			**Wind Coefficients AS PER IS: 875-1987**	
Seismic Zone Factor	0.1		Wind speed (Vb)	50 m/s
Soil Type	III		Terrain Category	I
Importance Factor (I)	1		Structure Class	B
Response Reduction (R)	3		Risk Coefficient k1 factor	1
			Topography k3 factor	1
			Windward coefficient	0.8
			Leeward coefficient	0.5

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VIII. RESULTS OF (G+7, G+12) STRUCTURES

Structures are design in ETABS in systematic way, by applying the materials, gravity and lateral loads. ETABS results are taken to calculating the separation gap between the two adjacent buildings based on these results like
1,Lateral loads to stories
2,Lateral loads to diaphragm
3,Diaphragm drift
4,Max storey displacement
5,Max storey drift

Table-5: max storey drift in two buildings

	STOREY DRIFT				DIAPHRAGM DRIFT			
Cases	EQX	EQNX	EQY	EQNY	EQX	EQNX	EQY	EQNY
CASE-1	0.568	0.734	0.779	0.825	0.568	0.734	0.779	0.825
CASE-2	0.178	0.183	0.133	0.133	0.178	0.183	0.133	0.133
CASE-3	0.140	0.174	0.105	0.108	0.140	0.174	0.105	0.108
CASE-4	0.040	0.053	0.036	0.039	0.040	0.053	0.036	0.039

IX. ANALYSIS RESULTS AND DISCUSSION

1. Effect of lateral loads on stories:

Building -1

The walls in the structure mostly caries compression force and transfer on to the foundation. The entire vertical load of all the stories is carried by ground floor foundations. This force in the wall is from worst load combination of gravity and lateral loads. For each earthquake loads in all cases, the lateral loads to stories are plotted on y-axis against at each storey level. From Fig, it is observed that maximum loads in storey one is 39.78 kN. The difference in maximum lateral loads between stories is varying by position of shear wall in the structures. It indicates that the variation in maximum lateral loads to stories in different cases with storey level and percentage value is 0.99%

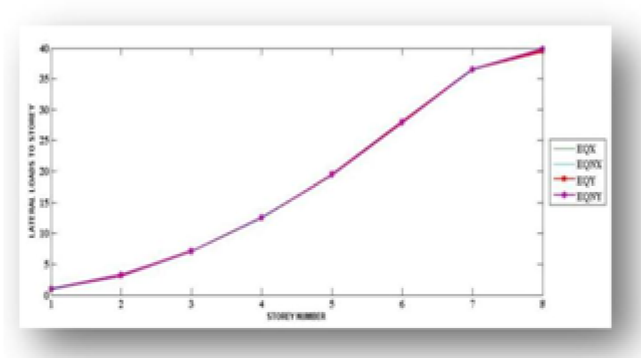

fig-1: lateral load on stories in case-1(G+7)

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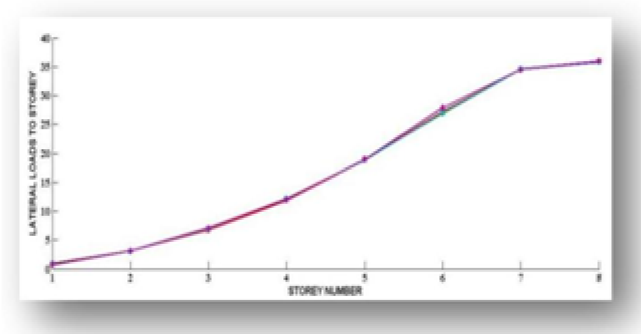

fig-2:lateral loads on stories in case-2(G+7).

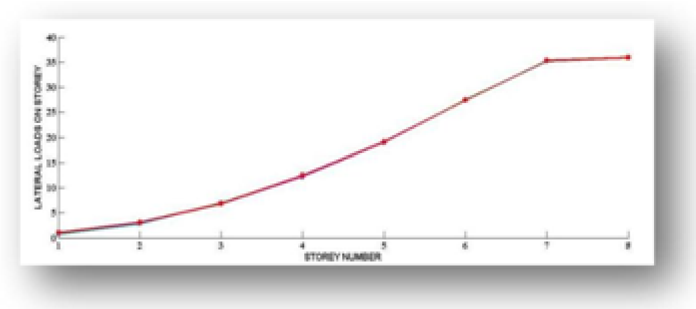

Fig-3: lateral loads to stories in case-3(G+7)

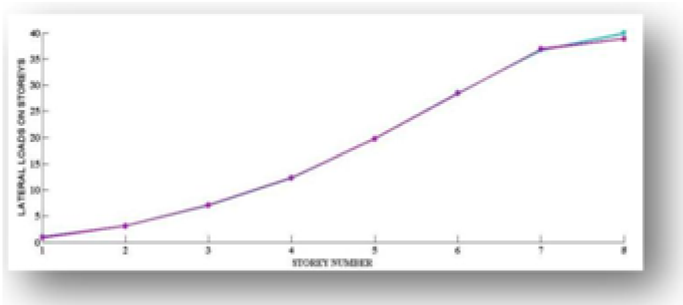

Fig-4: lateral loads to stories in case-4(G+7)

Building-2

For each earthquake loads in all cases, the lateral loads to stories are plotted on y-axis against at each storey level. From Fig, it is observed that maximum loads in storey one is 556.72 kN. It indicates that the variation in maximum lateral loads to stories in different cases with storey level and percentage value is 0.89%.

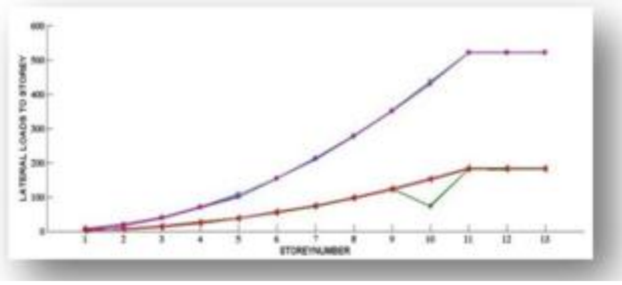

Fig-5: lateral loads to stories in case-1(G+12)

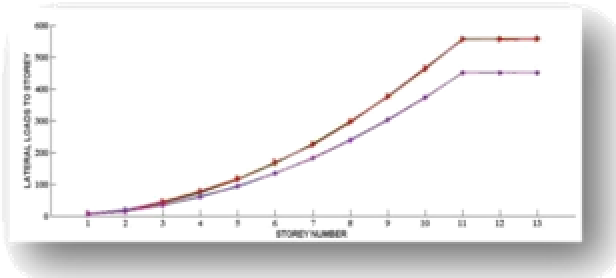

Fig-6: lateral loads to stories in case-2(G+12)

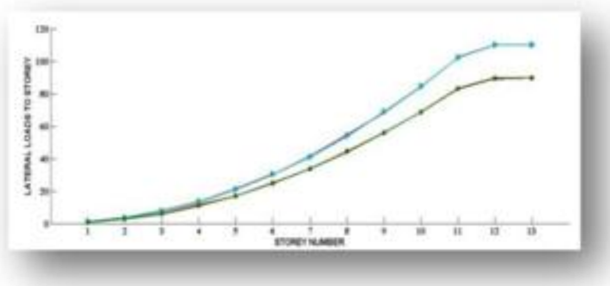

Fig-7: lateral loads to stories in case-3(G+12)

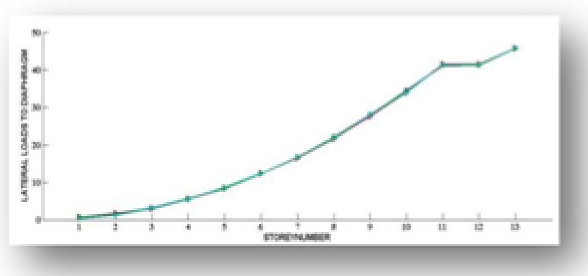

Fig-8: lateral loads to stories in case-4(G+12)

2. Effect of diaphragm drift: Building-1

Most lateral loads are live loads whose main component is horizontal force acting on the structure. The intensity of these loads depends upon the building's geographic location, height and shape. For the diaphragm drift of the structure is plotted on y-axis against each storey level. From Fig, it is observed that maximum diaphragm drift in structures is 0.82 mm. The difference in maximum lateral loads between stories is 0.98% .

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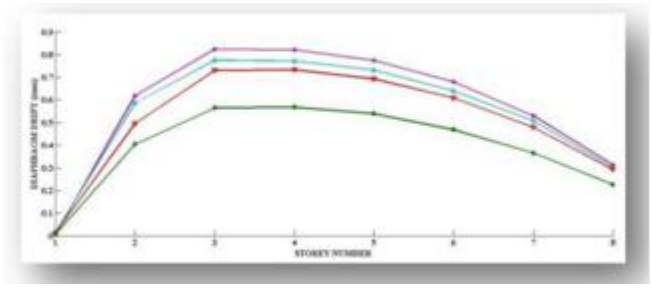

Fig-9: diaphragm drift in case-1(G+7)

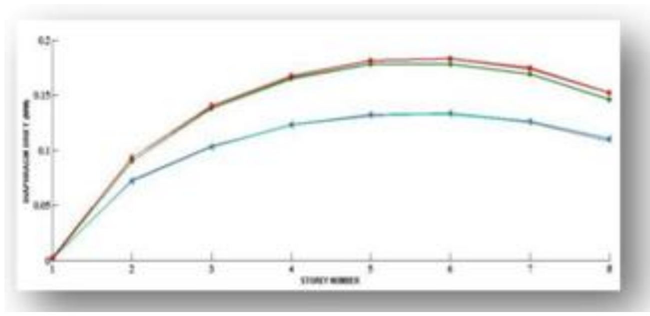

Fig-10: diaphragm drift in case-2(G+7)

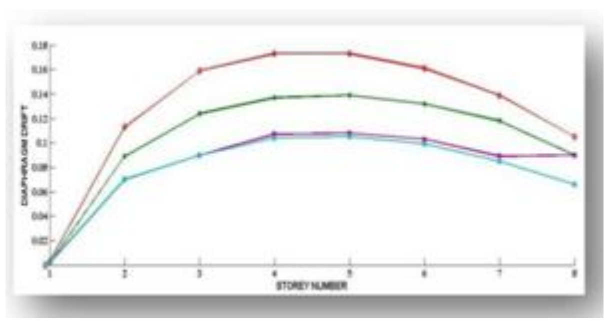

Fig-11: diaphragm drift in case-3(G+7)

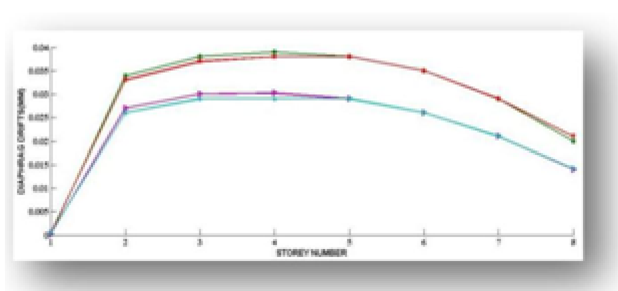

Fig-12: diaphragm drift in case-4(G+7)

Building-2

For the diaphragm drift of the structure is plotted on y-axis against each storey level. From Fig, it is observed that maximum diaphragm drift in structures is 0.74 mm. The difference in maximum lateral loads between stories is 0.94% it is observed from fig.

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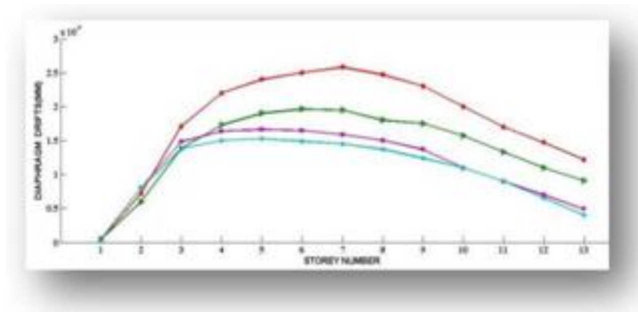

Fig-13: diaphragm drift in case-1(G+12)

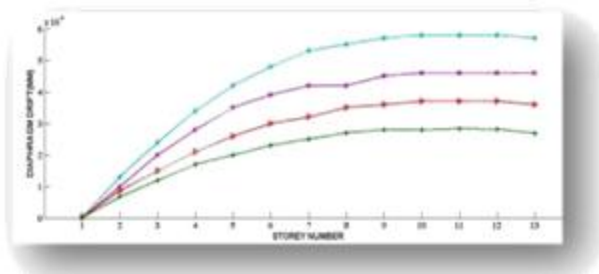

Fig-14: diaphragm drift in case-2(G+12)

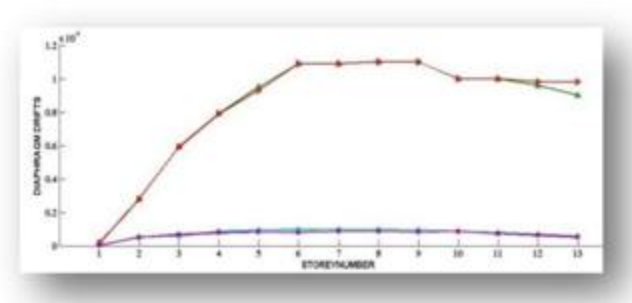

Fig-15: diaphragm drift in case-3(G+12)

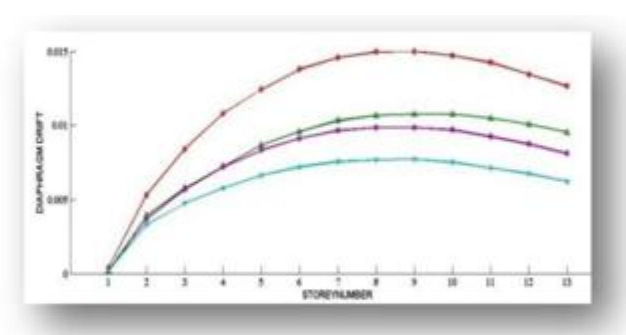

Fig-16: diaphragm drift in case-4(G+12)

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3. Effect of storey drift in structure :

Building-1

One of the major shortcomings high-rise structures is its increasing lateral displacements arising from lateral forces. For the storey drift in the wall is plotted on y-axis against at each storey level. From the Fig, it is observed that maximum storey drift in between storey is 0.824 mm. It indicates that the variation in maximum storey drift with storey level is 0.92%. The difference in maximum lateral loads between stories is varying by position of shear wall in the structures

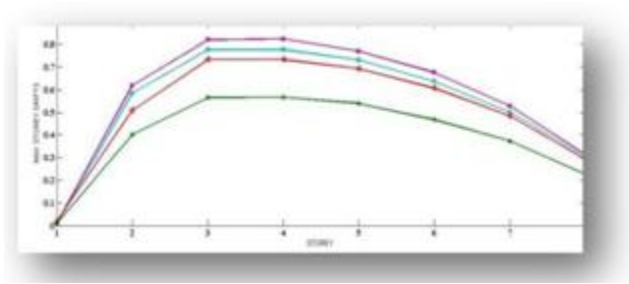

Fig-17 : storey drift in case-1(G+7)

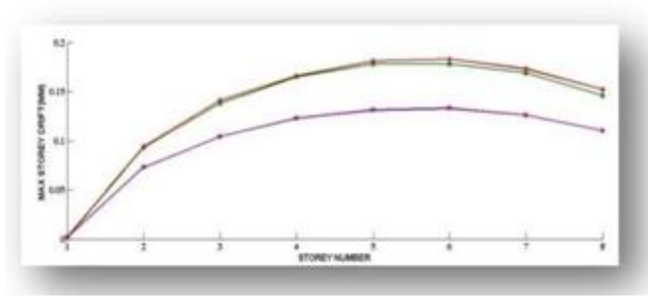

Fig -18: storey drift in case-2(G+7)

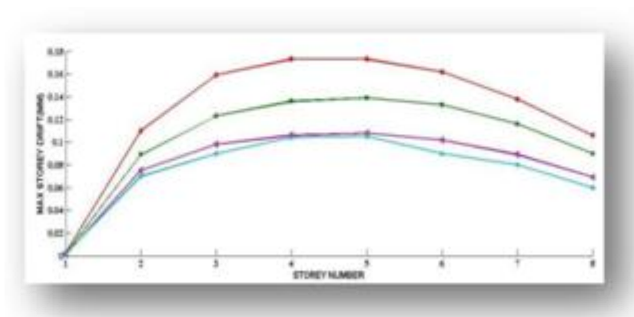

Fig-19 : storey drift in case-3(G+7)

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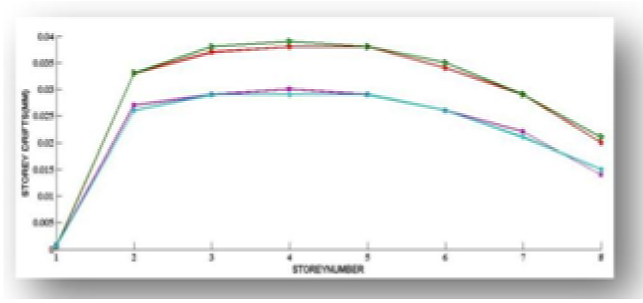

Fig -20: storey drift in case-4(G+7)

Building-2

It is observed that maximum storey drift in between storey is 0.824 mm. It indicates that the variation in maximum storey drift with storey level is 0.92%. The difference in maximum lateral loads between stories is varying by position of shear wall in the structures

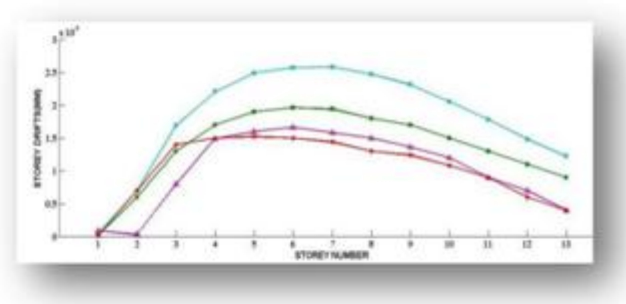

Fig-21: storey drift in case-1(G+12)

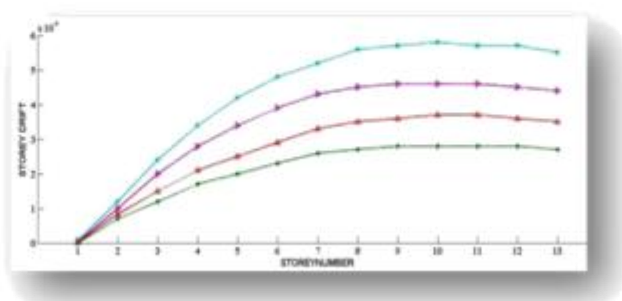

Fig -22: storey drift in case-2(G+12)

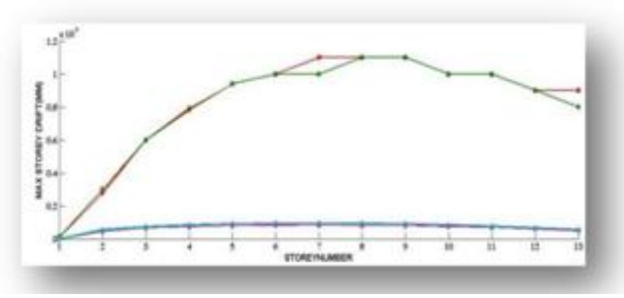

Fig -23: storey drift in case-3(G+12)

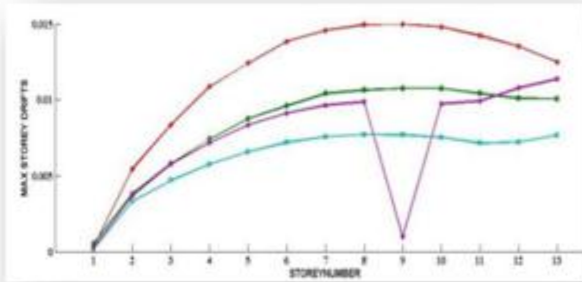

Fig-24 : storey drift in case-4(G+12)

X. CONCLUSION

In this present work ETABS is used to analysis the two adjacent building (G+7, G+12) are considered for the gravity &lateral loads, the following conclusions are drawn from the analysis results.

- It is observed that they is no separation gap between adjacent building in group houses located in zone-3,the analysis is carried out for the pounding effect for the adjacent building the following cases are considered for analysis.
- The lateral storey drift is calculated by manual and ETABS results are tabulated below.
- For the manual calculations the storey drift is not satisfied from the ETABS results, so the analysis is extended to
- case-4, i.e.., the shear wall is model to periphery to the floor plan.
- From the results, the adjacent building should be separation gap is 60 mm.
- The storey drift is satisfied for case-4 from clause-7.11.1(storey drift limitation) in code book IS 1893(part 1):2002 and also satisfied by theoretical methods.
- For the economical point of view fully load bearing wall structure is economical when compared to conventional structure in the mass housing.

Table-6 : storey drift

Storey drift				
cases	EQX	EQNX	EQY	EQNY
1	0.568	0.734	0.779	0.825
2	0.178	0.183	0.133	0.133
3	0.140	0.174	0.105	0.108
4	0.040	0.053	0.036	0.039

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