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Pounding Effects on Buildings under Seismic Loads

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Abstract: ***Seismic pounding is a very prevalent phenomenon observed in metropolitan towns with densely packed structures without adequate gap in separation.***

Pounding can cause severe structural harm and boost the risk level. Although there are structures that are resistant to earthquake, it is hard to regulate pounding impacts. The simplest way to decrease the impact of pounding is by maintaining an adequate separation gap between structures and this is not everywhere practical. There comes, shear walls and braces to enhance the stability of structures.

This project deals with the behaviour of adjacent buildings affected by seismic pounding. The assessment considers a comparative assessment of buildings, structures with and without shear walls and symmetric structures and asymmetric structures of equal and unequal height.

Building codes provides rules for structural engineering practice and play a significant role in transferring technology from studies and research to practice.

Keywords: pounding effect, shear walls, symmetric and asymmetric buildings, and base reactions.

I. INTRODUCTION

In metropolitan places, structures are very close to each other because of fast rise in urban development and the real-estate value. These buildings collide with each other when subjected to earthquake or any loads due to their closeness. The phenomenon pounding occurs when the adjacent buildings start vibrate out of phase during the earthquake which causes collision amongst the neighbouring buildings.

If the separation distance between adjacent buildings is not enough during seismic activities to compensate the relative motion, the pounding occurs.

A. What is Pounding Effect?

Pounding effect refers to collision between adjacent structures under seismic loads and it is occurred when structures with different dynamic properties, without proper separation gap between them.

B. Pounding can be Caused By

Seismic Pounding can be caused from the following:

1) Nearby buildings with the equal height and the equal floor level.
2) Nearby buildings of different height with the same floor level.
3) Nearby structures with different overall heights and with different floor levels.
4) Structures which are situated in a line or row.
5) Parts of the same buildings which are linked by one or more bridges or joints.
6) Pounding occurs along the unsupported components in building results in serious pounding damage.
7) The structures built according to the old codes that was vague on separation distance.
8) Buildings with uneven lateral load-resistance structures and torsional rotations, pounding can occur near the building premises around the nearby buildings.

C. Shear Walls.

Shear walls are structural elements of a reinforced concrete framed structure designed to withstand lateral forces including wind loads. They are used in tall buildings subject to lateral wind and seismic movements. This approach increases height of the storeys, hence increases the cost of buildings. . The best position for the shear walls is in the middle of every half of the tower, but this is never feasible, so they are usually at the ends.

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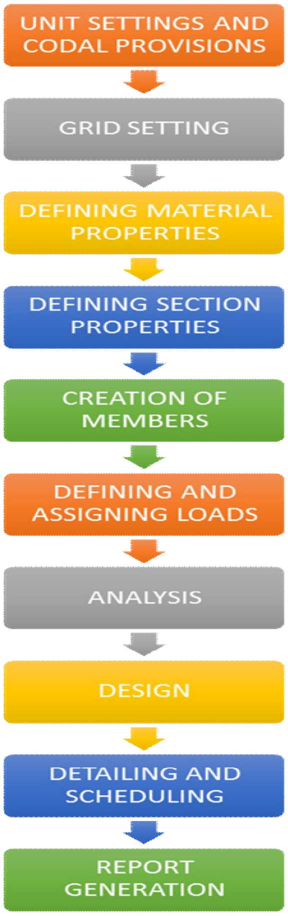
II. OBJECTIVE OF THE STUDY

A. Seismic pounding is a serious phenomenon which involves local damage to structures during earthquakes.
B. The main objective of the project is to study pounding effect on different types of reinforced buildings.
C. Pounding effect is considered for symmetric (rectangular shape) adjacent buildings of different height and asymmetric (L-shape) adjacent buildings of same height.
D. A comparative study is done by analysing different parameters like storey response factors, deflections, and drift along with separation gaps with the help of E-TABS (2013).
E. Comparing analysis results of impacts of seismic and wind interactions in adjacent buildings with and without shear wall using E-TABS.

III. METHODOLOGY.



IV. STRUCTURAL MODELLING

The present study is by using ETABS 2013 technology to analyse the performance of symmetric and asymmetric adjacent framed structures with and without shear walls exposed to Zone V earthquake forces. Assumed separation distance is taken as 0.5m by trial and error method.

Four models are considered for the purpose of the study.
1) Six storey (G+6) and eight storey (G+8) adjacent buildings with shear walls.
2) Six storey (G+6) and eight storey (G+8) adjacent buildings without shear walls.
3) Two eight storey (G+8) adjacent buildings with shear walls.
4) Two eight storey (G+8) adjacent buildings without shear walls.

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A. Design Data For Symmetric Adjacent Buildings

1) Without Shear Wall

a) Material Properties

i) Grade of concrete: M30 , M25

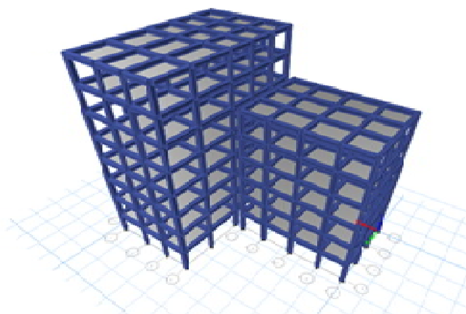
ii) Grade of steel: Fe415 for all beams, columns and slabs.

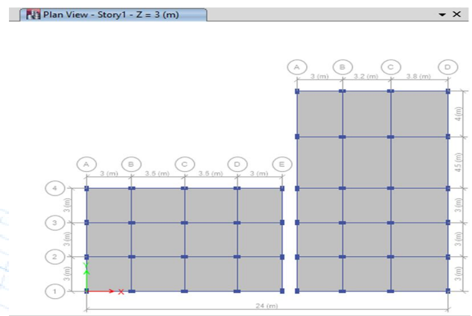
b) Section Properties

i) Column Size: Rectangular Columns = 230mm*400mm.

ii) Beam Sizes = 230mm*450mm.

iii) Slab Sizes: Thickness = 125mm.





2) With Shear Wall

a) *Material Properties*

i) Grade of concrete: M30 , M25

ii) Grade of steel: Fe415 and HYSD 500 for beams, columns and slabs.

b) Section properties

i) Column Size: Rectangular Columns = 230mm*400mm.

ii) Beam Sizes = 230mm*450mm.

iii) Slab Sizes: Thickness = 125mm.

iv) Shear wall thickness = 230mm.

v) Floor finishing load =1.5kN/m2

vi) Live load =4.5kN/m2

c) Seismic Data

(Using Code IS1893:2002)

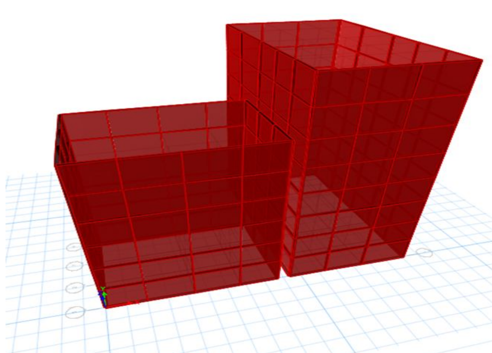
i) Zones : V

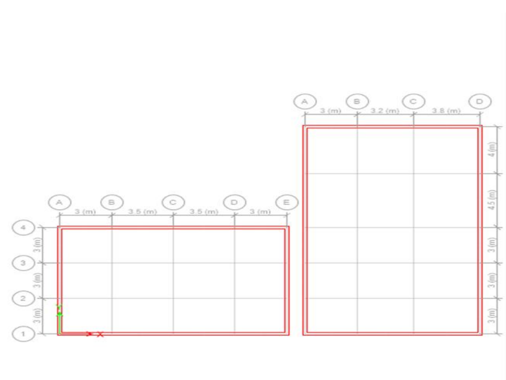
ii) Soil type : Type II (Medium)

iii) Importance Factor, I : 1

iv) Response Reduction Factor, R : (SMRF).

v) Damping : 5%





B. Design Data For Asymmetric Adjacent Buildings

1) Without Shear Wall

a) Material Properties

i) Grade of concrete: M30 , M25

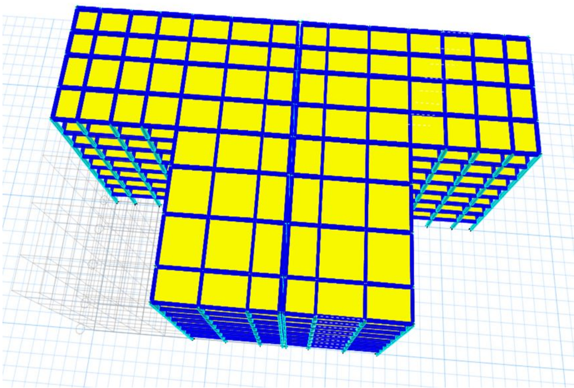
ii) Grade of steel: HYSD 500 for beams, columns and slabs.

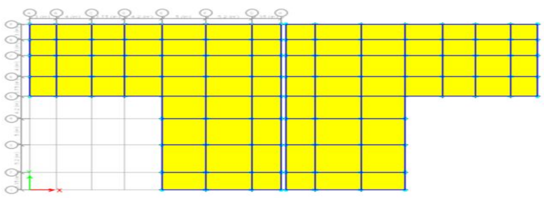
b) Section Properties

i) Column Size: Rectangular Columns = 230mm*450mm.

ii) Beam Sizes = 230mm*450mm.

iii) Slab Sizes: Thickness = 150mm.





2) With Shear Wall

a) Material Properties

i) Grade of concrete: M30 , M25

ii) Grade of steel: Fe415 and HYSD 500 for beams, columns and slabs.

b) Section Properties

i) Column Size: Rectangular Columns = 230mm*450mm.

ii) Beam Sizes = 230mm*450mm.

iii) Slab Sizes: Thickness = 150mm.

iv) Shear wall thickness = 230mm.

c) Seismic Data

(Using Code IS1893:2002)

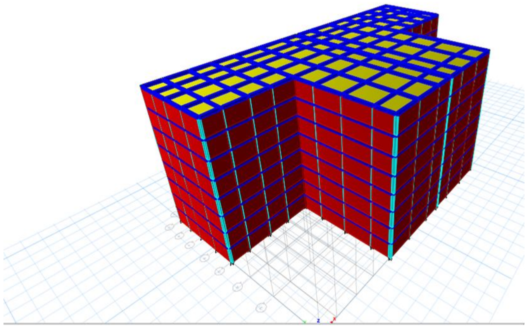
i) Zones : V

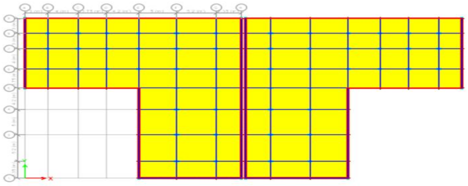
ii) Soil type : Type II (Medium)

iii) Importance Factor, I : 1

iv) Response Reduction Factor, R : 5(SMRF).

v) Damping : 5%





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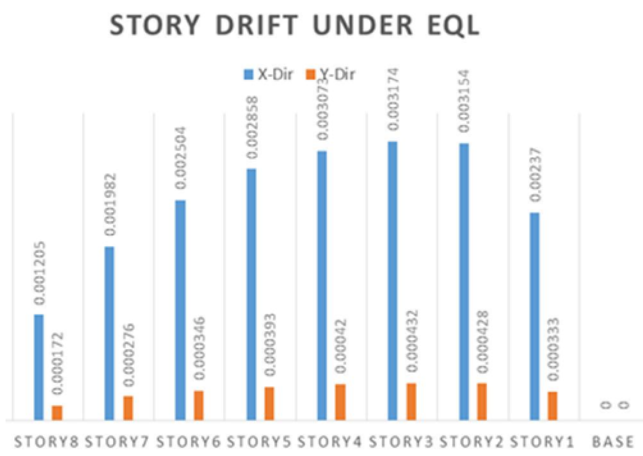
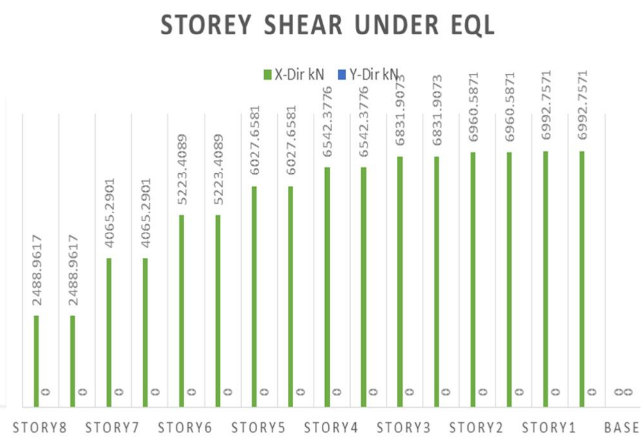
V. RESULTS AND DISCUSSIONS

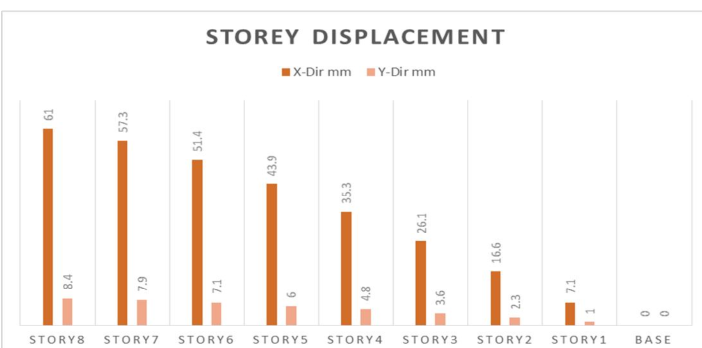
A. For Asymmetric L Buildings without Shear Wall

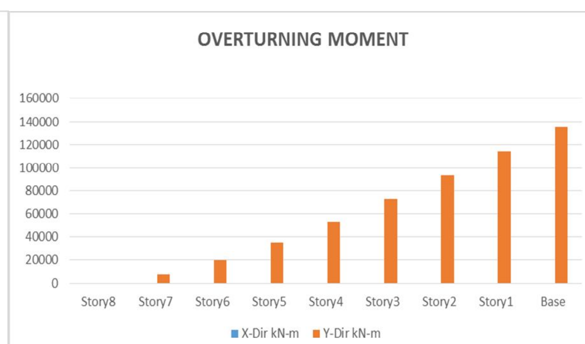
Storey drift is shift of one storey of building relative to the level below or above when earthquake occur. It is observed that at third storey level there is the maximum drift. Storey drifts are increased in first, second, third and fourth stories under earthquake loads and decreasing towards higher floor levels. The storey drift should not go beyond 0.004 or 0.005.Storey drift can be decreased by increasing the column and beam sizes.

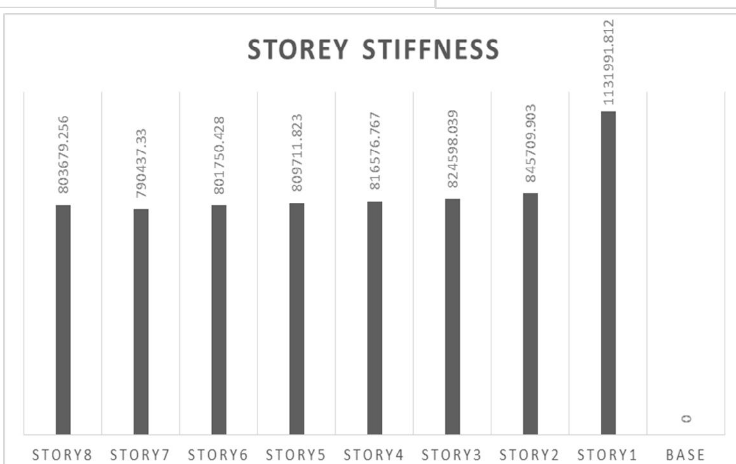
Storey shear is decreasing towards top floors and it is maximum in ground floor. Storey shear is caused by a portion of dead loads and live loads acting on each floors. It will be minimum at the topmost level of the building and maximum at the bottom of the structure. Overturning moment is maximum at base and minimum at the top. Storey displacement is displacement of stories with respect to the base of the building and it will be increasing towards top stories of the building. Storey stiffness is the ratio of storey shear to storey drift. In this graph we can observe it is maximum at the base and decreases gradually as we going up and maintaining a stable values throughout the height with slight variations.











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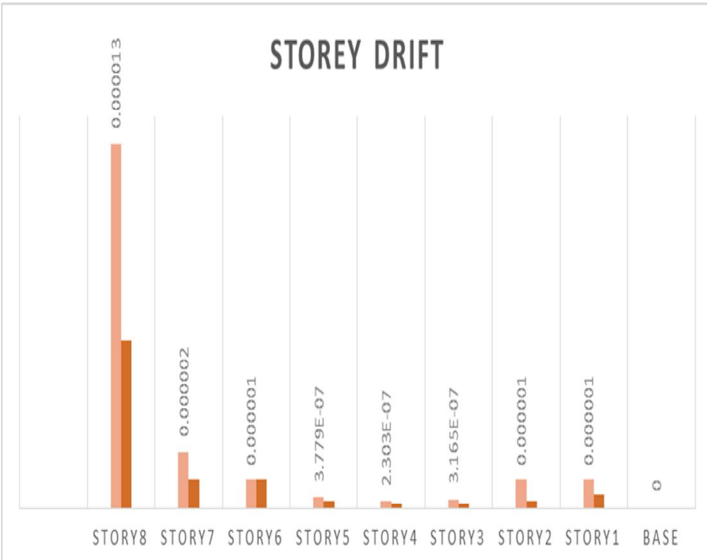
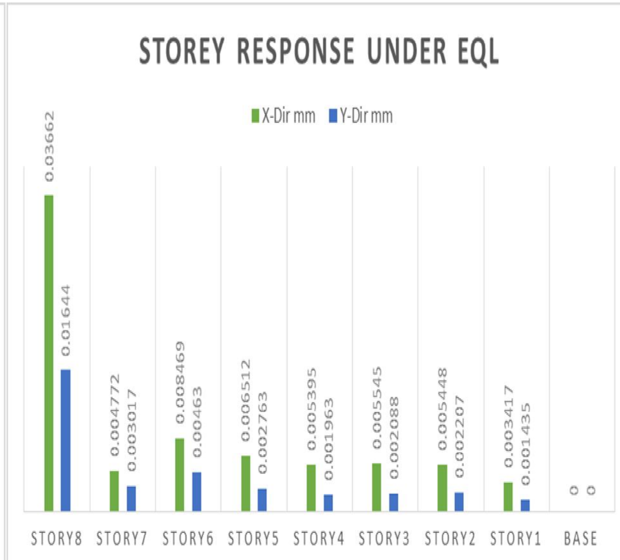
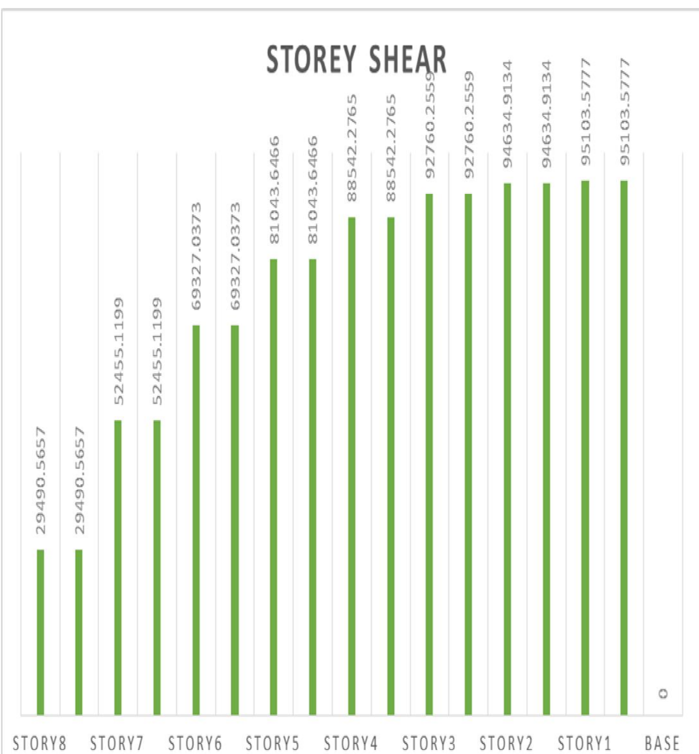
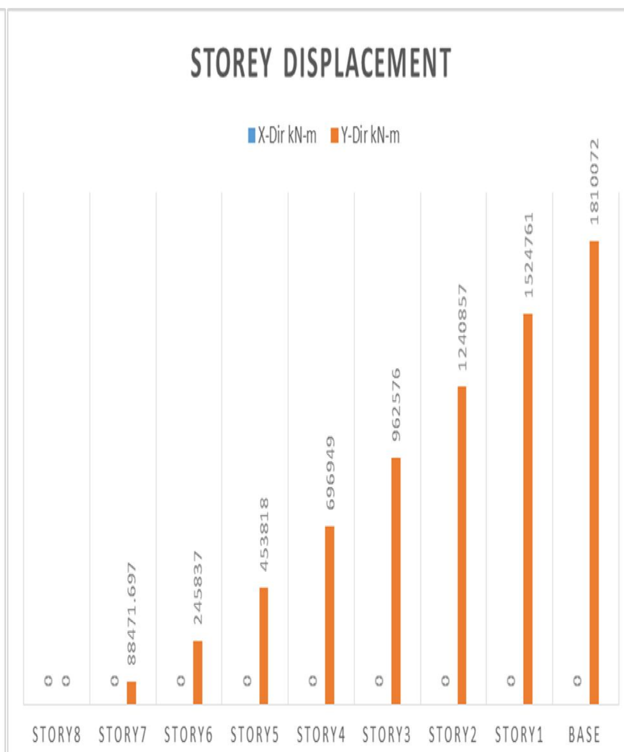
B. For Asymmetric L Buildings with Shear Wall

For structures with shear wall, storey drift is found to be very less and it is increasing towards the top of the building. Here it is observed that maximum variation occurs at the top storey and base is not affected. A gradual increase is seen up to storey 5 and at storey 6 there is a slight increment and later it decreases and steadily increased at the top storey. The storey shear is maximum at base and its gradually decreasing around the top. As we know dead load will be more in bottom floors than upper floors. As seismic forces are greater at base level, storey displacement will be higher in bottom storeys and it will be gradually decreasing towards top storeys.









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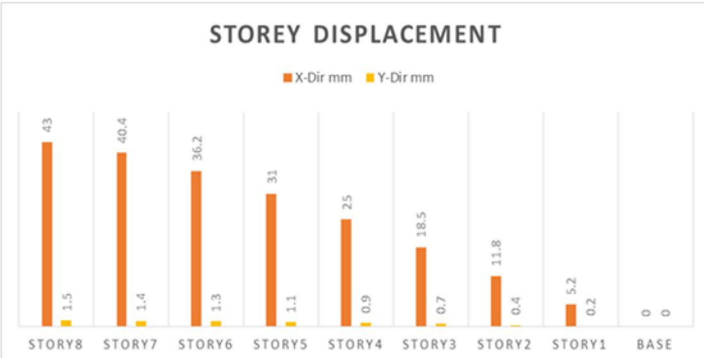
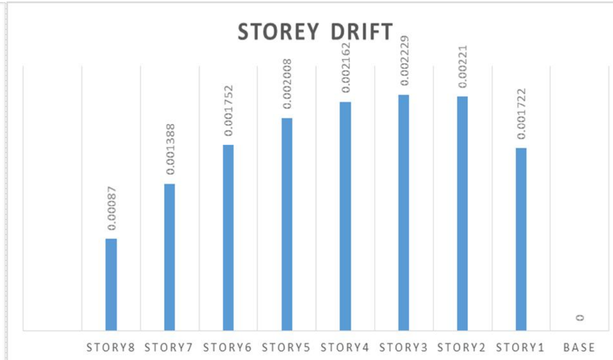
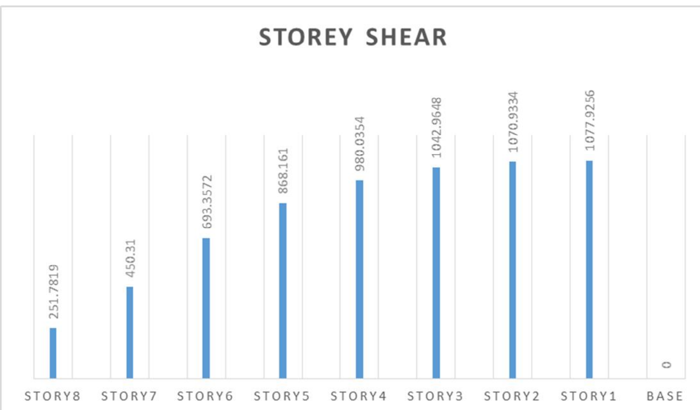
C. For Symmetric Buildings without Shear Wall

For symmetric buildings doesn't provided with shear wall, it is observed that the storey displacements are maximum at the top level storey and minimum at the base. As it is observed, all the values dint exceed the limit value of storey drift. It is visible that at storey 3 drift is maximum and at the top floor it is minimum. A slight decline in story shear can be observed from the first storey to the top storey. It is clear that at top levels stiffness is low and at the base level stiffness is more.

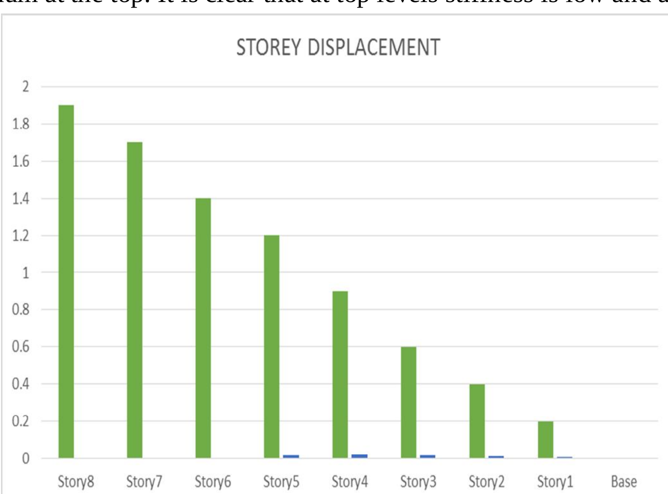


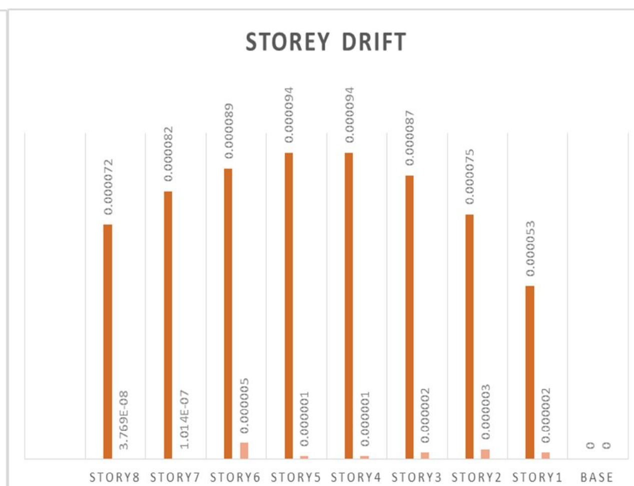


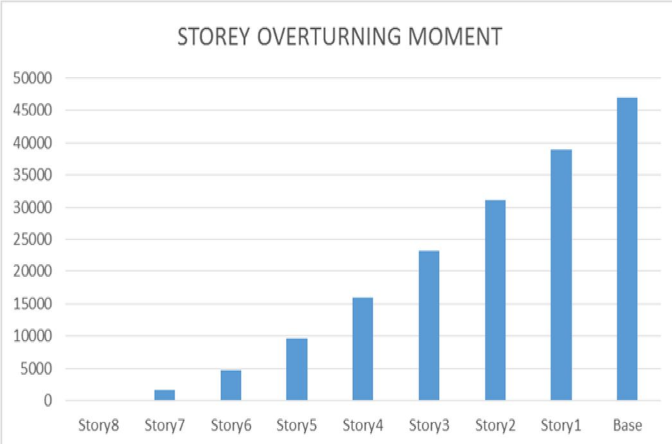


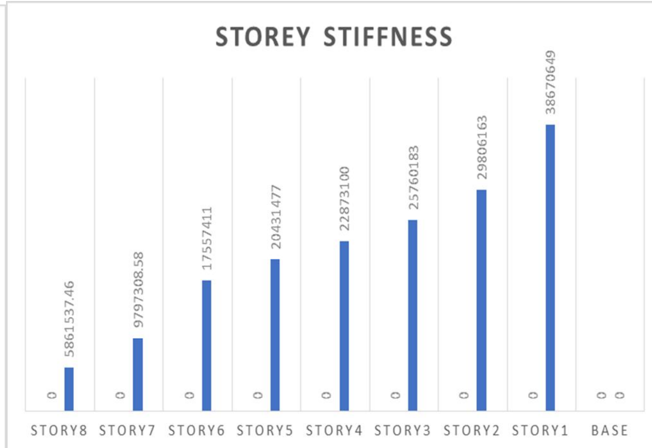
D. For Symmetric Buildings with Shear Wall

Top levels are more vulnerable for displacement and its increasing in a gradual rate difference of 0.2 from the base level of the structures. It is observed that at storey 5 and storey 4 storey drift is maximum. Overturning moment is maximum at base and minimum at the top. It is clear that at top levels stiffness is low and at the base level stiffness is more.









VI. CONCLUSIONS

Major earthquakes have significantly impacted large metropolitan areas in recent years, resulting in drastic pounding damage. In this study, it was established and analyzed the factors that influence seismic pounding of neighboring buildings. Pounding forces can be estimated using commercial software packages such as ETABS for measuring pounding forces using nonlinear gap elements between adjacent building levels. . A detailed study of the project pointed to the following conclusion:

A. It is concluded in this study that the installation of nearby buildings with similar floor levels and separation gaps significantly reduces the pounding effects.
B. Performance of Symmetrical buildings is better than Asymmetrical buildings.
C. For adjacent buildings the structural damage is more for unequal heights compared to equal heights, due to difference in their masses and periods.
D. It has been found that asymmetric neighbouring buildings with same heights are less affected to acceleration.

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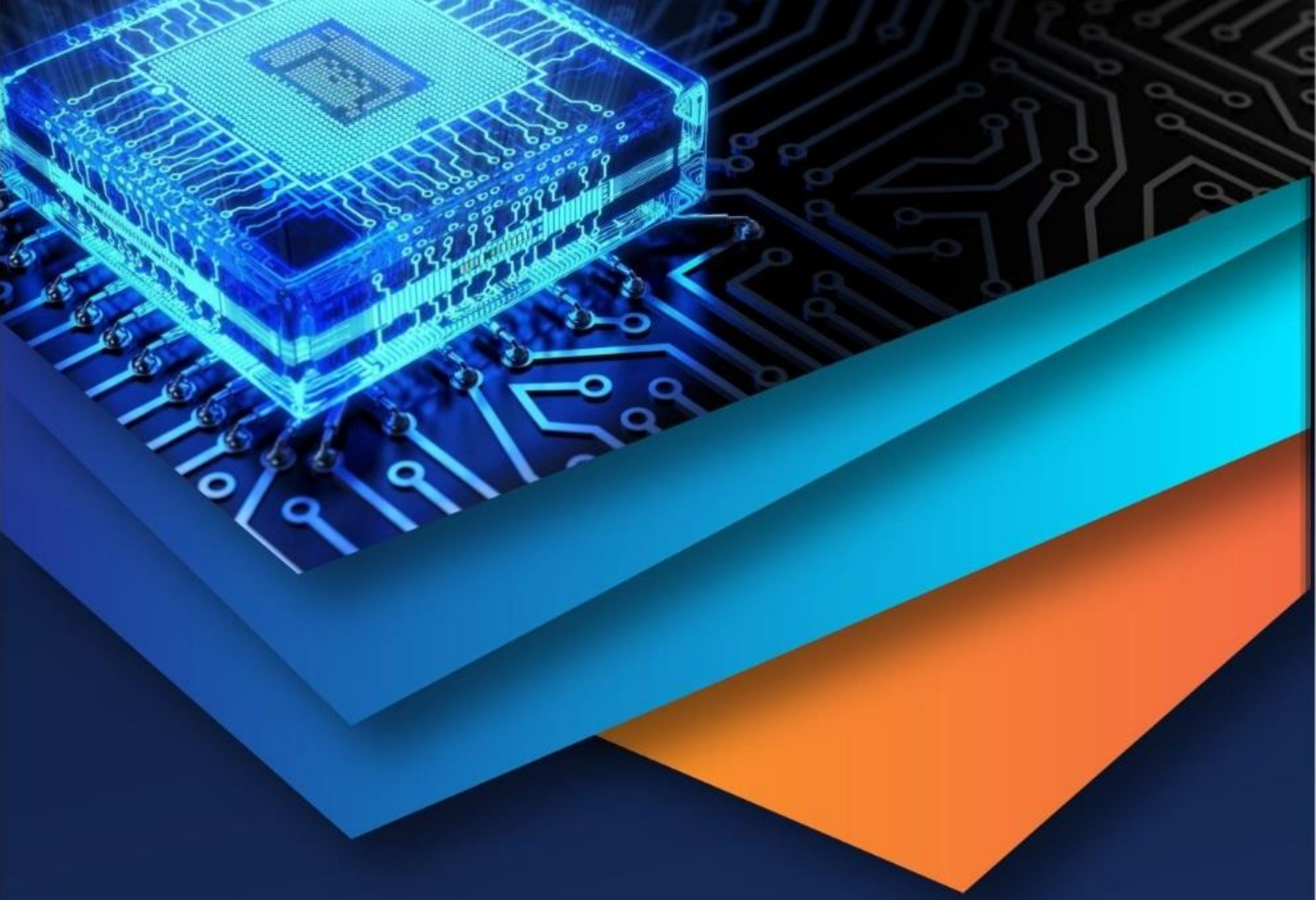

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