Seismic Analysis of Pounding in Building Structures

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Abstract: **- Building pounding occurs when two adjacent building collide each other. Earthquake can cause pounding when adjacent buildings have little or no gap. The building pounding can be reduced in different ways, one of the main factor considered in that is the separation gap. Proper separation gap reduce pounding in buildings but on the other hand due to high urbanisation and less availability of land in future lead the designer to construct building in less separation gap. This will lead to structural pounding, but by using proper steps the damage caused by this can be reduced. This study explains the reduction of pounding in buildings by the use of bracings(X, V& Diagonal) and dampers. The results are compared with local bracing systems. Non-linear analysis was performed in this study. After the comparison of the results the story displacement was found to be reduced considerably by using bracing systems.**

Key words: **separation gap, pounding, non-linear analysis**

I. INTRODUCTION

As a result of high urbanisation, the need to build closely spaced buildings forces the designer to take the consideration earthquake induced interaction between insufficiently separated structures. Building pounding occur when two adjacent buildings collide each other. Earthquake can cause pounding when adjacent buildings have little or no gap separation. Figures below shows the change in loads can lead to catastrophic collapse of one or both buildings.

Two types of pounding can occur

1. Local damage at the point of impact
2. Global damage resulting from the energy and momentum transfer caused by collision

Fig 1: Izmut earthquake, Turkey 1999 source: **http://www.world-housing.net/**whereport1view.php? Id=100031

Fig 2: Damage of a four-story conventional building due to pounding with its adjacent two-story building, during the L'Aquila earthquake in Italy, in April 2009

Pounding is one of the main causes of severe building damage in earthquake. The non-structural damage involves pounding or movement across separation joints between adjacent structures. Seismic pounding between two adjacent buildings occur

- During an earthquake
- At different dynamic characteristics
- When adjacent buildings vibrate out of phase
- At, rest separation is insufficient

Inter-story pounding effect is studied by Maria J Favvata (2017), which means pounding of column to the adjacent slab with lesser height. In this evaluate different seismic demand. The local capacity of column is the important factor in inter-story pounding. Local performance of column suffer hit. It is important that the local performance of a separate story. That is pounding may be severe for building with different story height. The building with lesser height hit the column of the adjacent building with greater height, that column behaves critical. In this the effects of local bracing system and global system was compared. The main objective of this study is to reduce the inter-story pounding by introducing bracing and dampers. The local performance of both of this are compared non-linear analysis was performed.

II. METHODOLOGY

To study pounding, a three dimensional reinforced concrete moment resisting frame building can be taken and analysed in ETAB 2015. The building pounding can be analysed by using adjacent buildings with different story height. The building models are (G+5) & (G+8), (G+5) & (G+11) and (G+5) & (G+5). The foundation should be rigidand all the columns in models are fixed at base. The height of the all the stories are 3m and the foundation height is 1.5m. The slab thickness of each of buildings taken as 125mm. live load on the floor is taken as 3kN/m2 and the wall load can be taken as 7.5kN/m. The grade of concrete is taken as M-20. The building consist of rectangular columns with dimensions 550mm x 1000mm, all the beams with dimension 350mm x 600mm. the gap element should be assumed as 50mm.

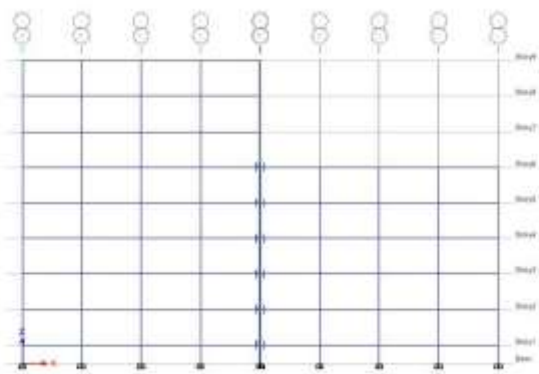

Fig 3: elevation view of (G+5) & (G+8) story building

Time history analysis can be performed in each model. The model with bracing system can be compared with local bracing. Local bracing means bracing provided at only one story. Mainly pounding can be occurring in adjacent building with lesser separation distance. This may result in inter-story pounding. In this local bracing system can be introduced in that story and reduce the displacement thereby reducing damage. The below figure show the normal bracing system and local bracing system.

Gap element

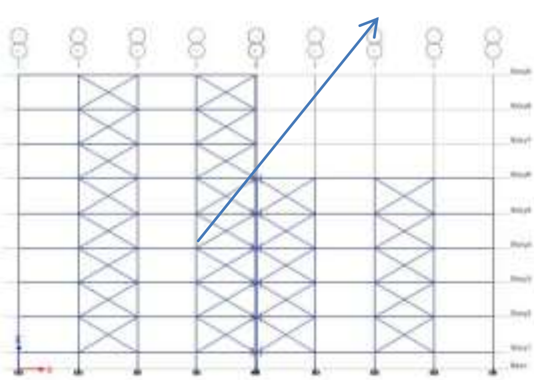

Fig 4: Normal X bracing

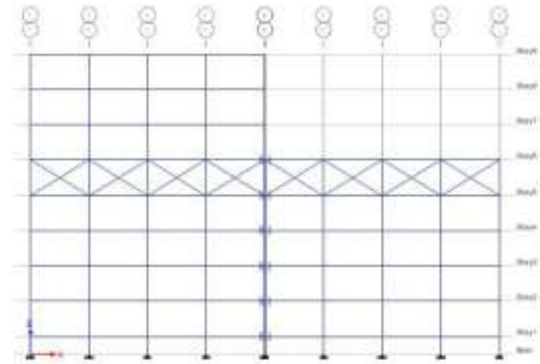

Fig 5: Local X bracing

III. RESULTS AND DISCUSSIONS

The non-linear time history analysis was completed. The analysis is compared with building without pounding case. After the analysis it is clear that the local bracing system show better result. In that the X bracing show better than other bracing system and also damper shows better result in normal case. But by using local damper it shows poor result compared to normal case. But in some cases X &V bracing show comparatively same results in some stories. The displacement vs. story graph can be plotted

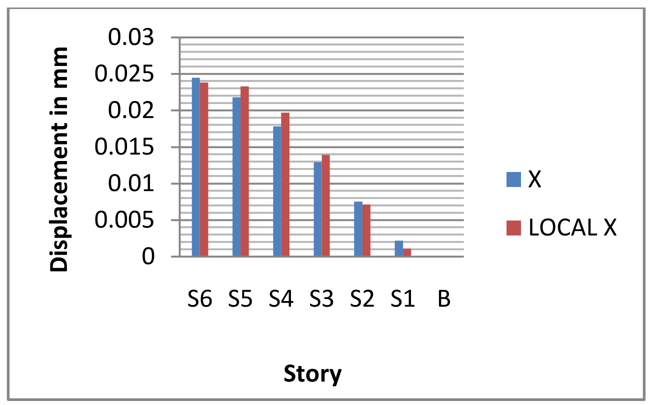

Fig 6: (G+5) & (G+5) story building X bracing

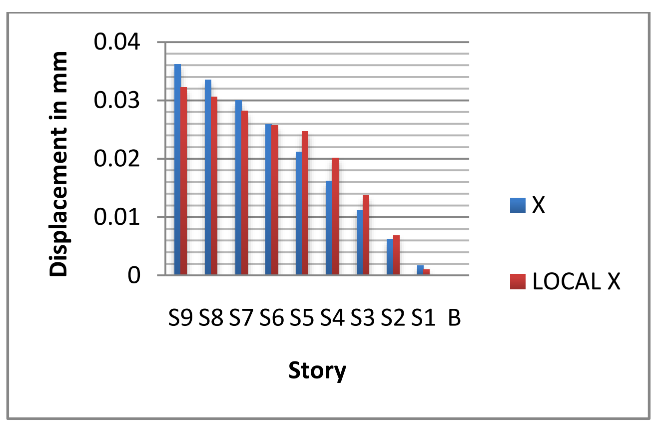

Fig 7: (G+5) & (G+8) story building X bracing

The figures show comparison between local and normal bracing system. From the results it can be seen that local bracing system shows less displacement than normal bracing system.

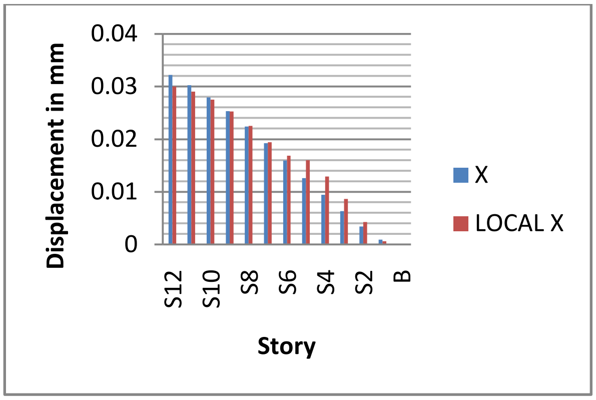

Fig 8: (G+5) & (G+11) story building X bracing

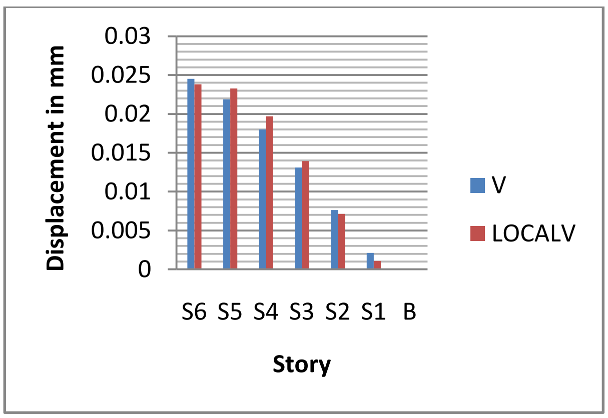

Fig 9: (G+5) & (G+5) story building V bracing

This figure explains the variation of displacement for different stories by using different types of bracing systems and dampers. The top story values of displacement for X, V, diagonal and damper for eight story building are 0.03616, 0.03604, 0.0354 and 0.03266. And also top story displacement values of X, V, diagonal local bracing systems and dampers are 0.03219, 0.03241, 0.03289 and 0.03343.

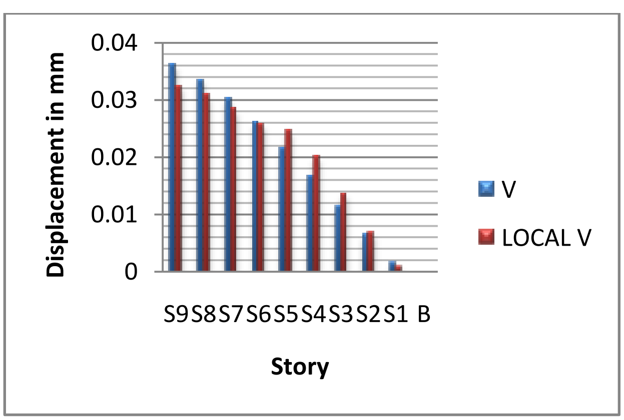

Fig 10: (G+5) & (G+8) story building V bracing

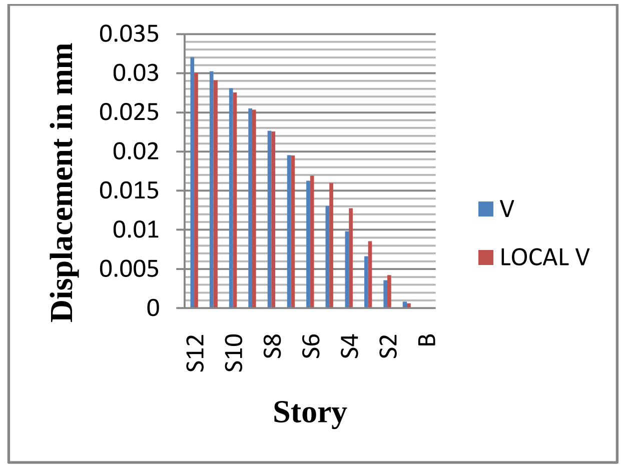

Fig 11: (G+5) & (G+11) story building V bracing

The top story displacement values of X, V, diagonal bracings and dampers for five story building are 0.02449, 0.02451, 0.02483 and 0.02391.

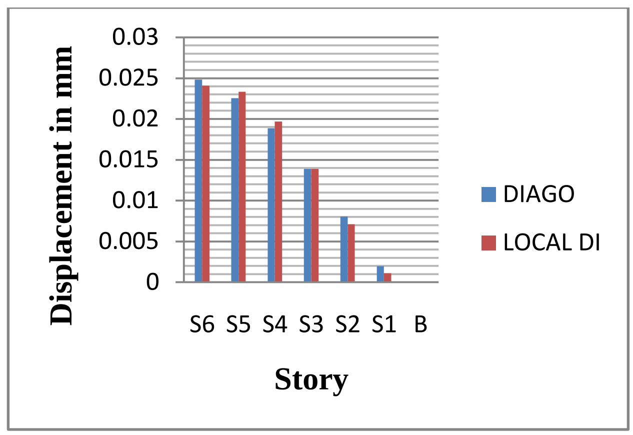

Fig 12: (G+5) & (G+5) story building diagonal bracing

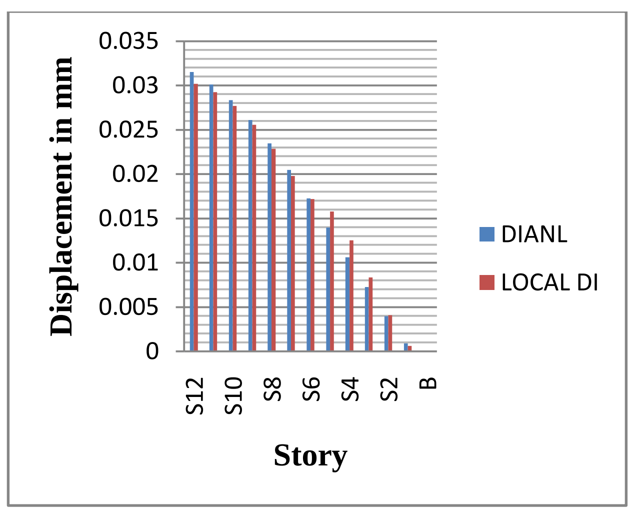

Fig 14: (G+5) & (G+11) story building diagonal bracing

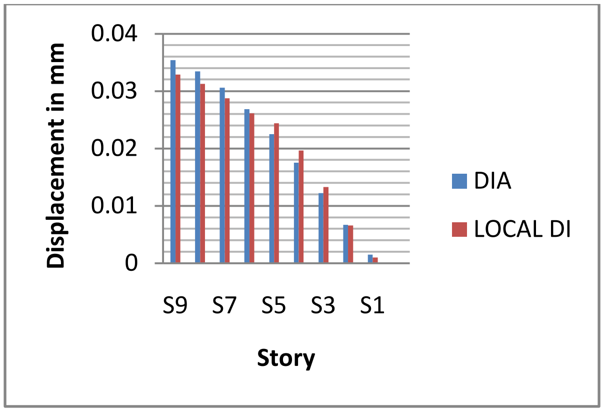

Fig 13: (G+5) & (G+8) story building diagonal bracing

The local displacement values X, V, diagonal bracing and dampers are 0.02383, 0.02381, 0.02407 and 0.02413.

The top story displacement values of eleven story building for X, V, diagonal and dampers are 0.03218, 0.03204, 03152 1nd 0.02857 the local displacement values of this are 0.03001, 0.03005, 0.03019 and 0.02998.

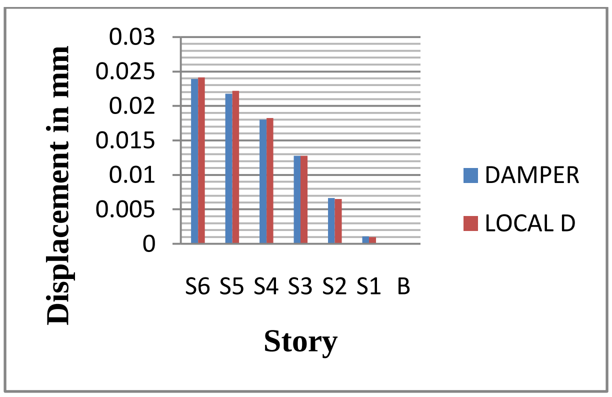

Fig 14: (G+5) & (G+5) story building damper

This shows that the X bracing shows better result than other bracing system. This is because X bracing usually seen with 2 diagonal supports, these support compression and tension forces. Depending on the forces, one brace may be in tension while the other is slack. It helps make building studier and more likely to withstand lateral forces.

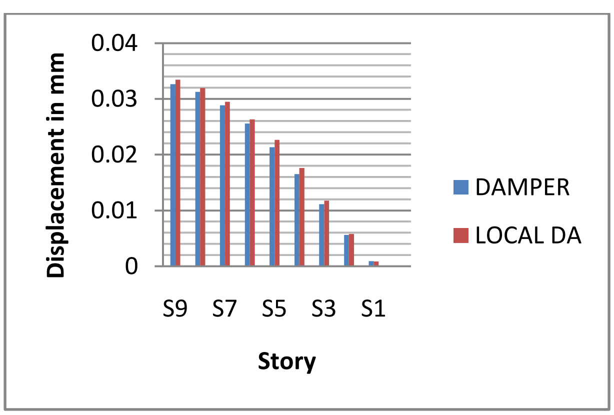

Fig 13: (G+5) & (G+8) story building damper

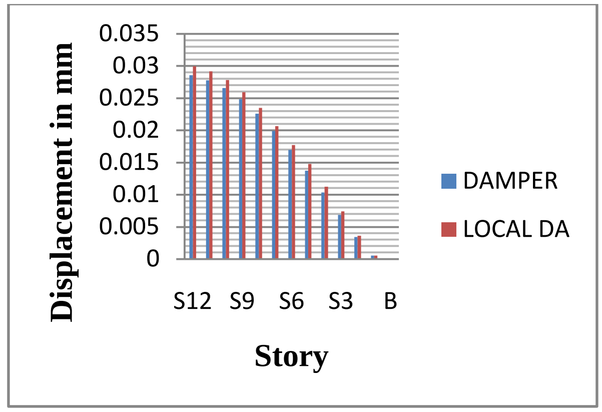

Fig 14: (G+5) & (G+11) story building damper

From results it is clear that the local bracing system perform better than normal bracing system. This is because the, in local bracing system provide the stiffness to that story. In pounding the local damage at the point of impact is occurred so providing bracings in that area result in better performance.

IV. CONCLUSION

Time historyanalysis of adjacent building with seismic gap was carried out using ETAB 2015. The buildings are stiffened by various bracing systems and dampers. For constructing high rise buildings, the designer should consider the effect of pounding for closely spaced buildings. Structural behaviour of closely spaced building may differ by introducing gap elements between them. From the analysis it was clear that the X bracings show lesser lateral displacement than that of the other bracing systems. The damper provided in that show lesser displacement compared to local bracing system.The local bracings provided in buildings show low value of displacement compared to global system. But the local damper should not behave good compared to global system. Both X bracing and damper resist the lateral force in a good manner but X bracing is more economical than damper.

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