SEISMIC POUNDING EFFECT OF ADJACENT BUILDINGS WITH DIFFERENT HEIGHTS

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Abstract- This project aims at studying seismic pounding effect between adjoining buildings by linear and nonlinear dynamic analysis using ETABS (Non Linear) software. The project is focused towards studying the seismic effects on building structures and ways to manage pounding between adjacent buildings i.e., adjacent buildings with same height and different height using different systematic techniques for buildings located in India having seismic zone IV and medium soil type. The seismic analysis is done by equivalent static method and Time history method for same height and different height. Some of prevention techniques to reduce pounding between adjacent buildings can be by Constructing new Shear walls, cross bracing system and dampers in the structure and having preferred separation gap between adjacent buildings. Finally the results are observed to study the effect of structural displacements and pounding forces between two adjacent buildings.

Keywords- Seismic Pounding, Separation gap, ETABS, Prevention of Structural Pounding by addition of shear walls, Bracings and Dampers.

I. INTRODUCTION

Seismic pounding among adjoining buildings can bring temperate to extreme damages to building structure when an earthquake happens. The adjacent buildings collide and fall down during temperate to strong ground vibrations caused by earthquakes. It is a serious hazard for closely spaced building structures located in seismic active areas where pounding effects are noticeable. Multi storied building structures are liable to seismic pounding. ‘Pounding’ is the collision between adjoining buildings in which two buildings hit each other due to their lateral movements induced by lateral forces. The project is focused to systematically study effects of pounding on building structures and identify seismic hazard mitigation practices like effect of different parting distances and addition of shear walls. These practices can best be investigated in ETABS nonlinear software. Formation and alteration of models, execution of the study, checking and optimization of the design are done through this single interface, graphical displays of outcome, including displacements are produced.

II. SEISMIC POUNDING EFFECT

Pounding is an important cause of rigorous building damages in earthquake. The non-structural damage involves pounding or movement across separation joints between neighboring structures.
The non-structural damage includes pounding or action across separation joints among adjoining constructions. Pounding between two adjoining structures arise

1. Whenever an earthquake occurs.
2. Different dynamic loads.
3. Adjoining buildings vibrate out of phase.
4. At-rest separation is inadequate.

Prevention Measures to Avoid Pounding:
The prevention measures to avoid the seismic pounding between the adjacent buildings here considered are
1. RC Shear Wall
2. Steel Cross Bracings
3. Dampers
In this study,
The RC Shear wall and dampers are considered to prevent the Pounding effect in two adjacent buildings.

III. MODELING AND ANALYSIS

1. The models which is adopted for study are,
   a. Two buildings of same height
      - Model 1: (G+8) storey -Block D1 and D1A.(Fig 1)

   b.Buildings of different heights,
      - Model 2:10 storey (G+10) – Block D1 and D2
2. The type of the building is a Hostel.
3. Grade of concrete is M30 for columns and walls and M25 for beams and slabs.
4. Grade of steel Fe500.
5. The buildings have columns of dimension 300mm x 900mm and
   a. 400mm x 900mm.
6. Beams with dimension
   a. 200mm x 600mm and
   b. 200mm x 850mm.
7. The floor slabs thickness is taken as 125mm.
8. Height of the foundation is 1.5 m.
9. Height of the all stories is 3.3 m.
10. The elastic modulus is taken as ,
    $E = 5000\sqrt{f_{ck}}$ (f_{ck}= grade of concrete).
11. Slabs are defined as area elements having the properties of shell elements with the required thickness.

12. Slabs have been modeled as rigid diaphragm.

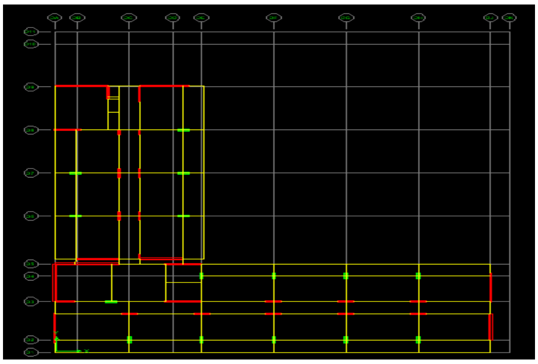

Fig1: Plan for same height of the building (G+8) storey- D1 and D1A

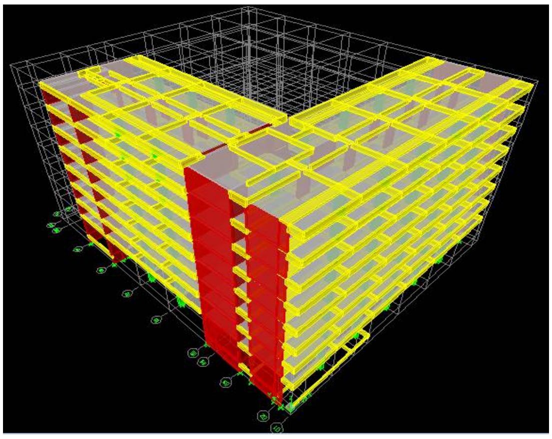

Fig 2: 3D view of model 1 (G+8) storey –D1 and D1A Block

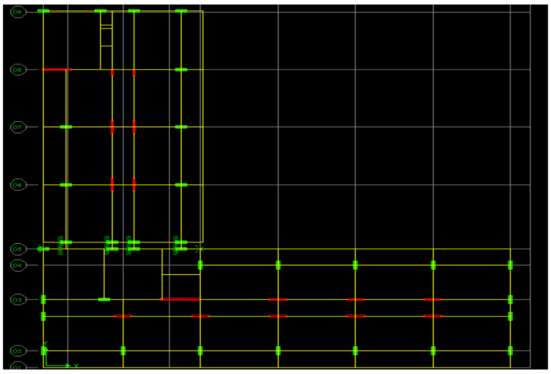

Fig 3: Plan and elevation for same height of building with spring.

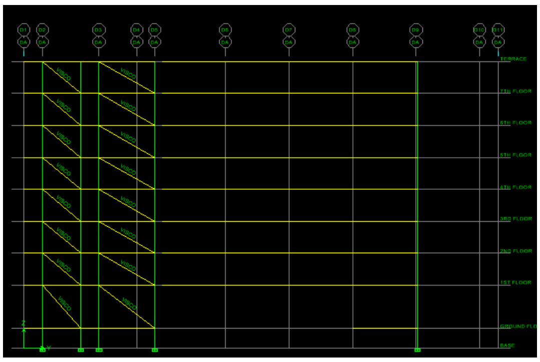

Fig 4: Plan and elevation for same height of building with dampers

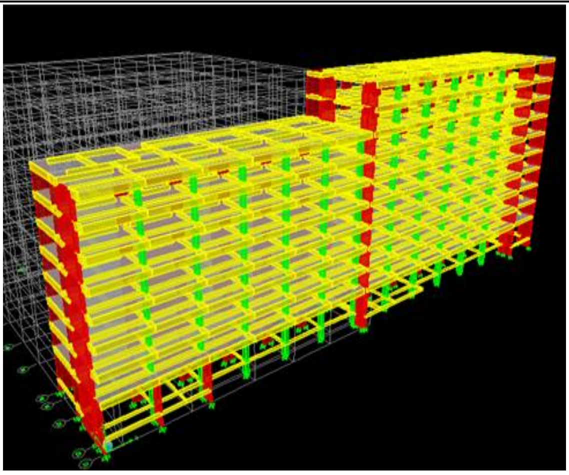

Fig 5: 3D modeling of a building for different floor height.

IV. LOADS CONSIDERED

1. Dead load:

The dead load of the structure is obtained from the Indian code IS 875(part 1)-1987, Table 1. The self weight of the frame sections and area sections are considered by the program automatically.
Floor finishes as uniform area load on slabs = 3.0 kN/m^2.

2 Imposed load:

The imposed load are also called as live load, live load is nothing but variable or moving loads. It is mainly due to the occupants, furniture, temporary stores etc. Except dead load all other loads considered as imposed loads. Live load is taken from the table 1 of IS 875 (part 2) - 1987.
Live load = 2 kN/m^2
Wall load = unit weight of brickwork x wall thickness x wall height.
Unit weight of brickwork = 7.5 kN/m^3
Wall thickness= 0.2 m
Wall load on roof =7.5 x 0.2 x 1.2 =1.8 kN/m (height of parapet wall = 1.2 m)
Wall height = 3.3 m
Wall load on other levels = 7.5 x 0.2 x 3.3
= 4.95 kN/m

3 Earthquake loads

Earthquake loads are defined as lateral loads on the building structure from the Indian code IS 1893:2002 (part1).

- From IS 1893-2002 of Table 2, the Zone factor, Z = 0.24 (zone-IV)
- From IS 1893 -2002 of Table 6, the Importance factor, I=1
- From IS 1893 -2002 of Table 7, Response reduction factor, R = 5.0.
- Type of soil = Type II (Medium soil).
- From IS 1893-2002 (part 1), clause 7.6.2, the fundamental time period of vibration with brick infill panels, Ta = $\frac{0.09\,h}{\sqrt{d}}$ seconds

Sl no.	Block	Time period (seconds)	
		x-direction	y-direction
1	D1	0.399	0.68
2	D1A	0.48	0.68
3	D2	0.46	0.84
4	D3	0.84	0.54
5	D1 & D1A	0.399	0.395
6	D1 & D2	0.335	0.848

Table 1: Time period

V. LOAD COMBINATIONS

1. When more than one type of load acts on the structure, a load combination is considered. Building codes normally indicates a variety of load combinations by means of load causes for each and every load type with a purpose to make sure the security of the building structure.
2. From IS 1893 (Part 1): 2002, Clause 6.3.1, the load combinations that are considered are as follows:
   - Gravity load- 1.5 (DL+LL)
   - Equivalent static analysis-
     1.2 (DL+ LL ± EQX)
     1.2 (DL+ LL ± EQY)
     1.5(DL ± EQX)
     1.5 (DL± EQY)
     0.9(DL±EQX)
     0.9 (DL± EQY)

VI. RESULTS AND DISCUSSIONS

1. Storey Displacements

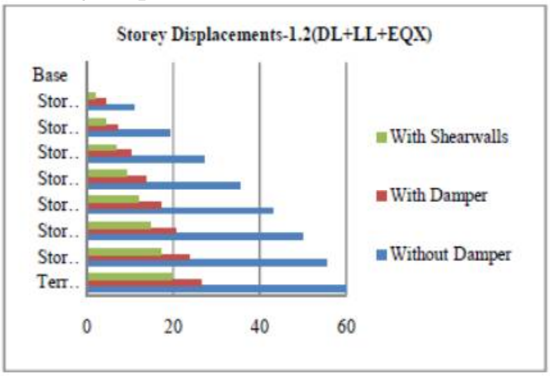

Fig 6: Storey Displacements- 1.2(DL+LL+EQX) -Block D1 & D1A (G+8)

DISCUSSION FOR VARIATION OF DISPLACEMENT

For D1 & D1A (Buildings of same height)

1. From Fig 6, it is found that the top storey displacement for D1 and D1A is 59.80 mm. When dampers were assigned, the top storey displacement was reduced to 55.83% when compared to structure with columns only.
2. Further when shear wall was introduced the displacement was reduced to 68% for load combination 1.2(DL+LL+EQX).
3. For negative combination 1.2(DD+LL-EQX). For structure with dampers, displacement was reduced to 59% and with shear walls it was reduced to 65%.
4. Similarly, for combination, 1.2 (DL+ LL ± EQY) & 1.5(DL ± EQX), the reduction in displacement when bracings were introduced, the reduction varied from 50% - 60% in X-direction and 25 % to 45 % in Y-direction.
5. For shear wall the reduction in top storey displacement was between 60 to 70%.
6. It is found that the pounding effect can be effectively controlled with dampers and shear walls.

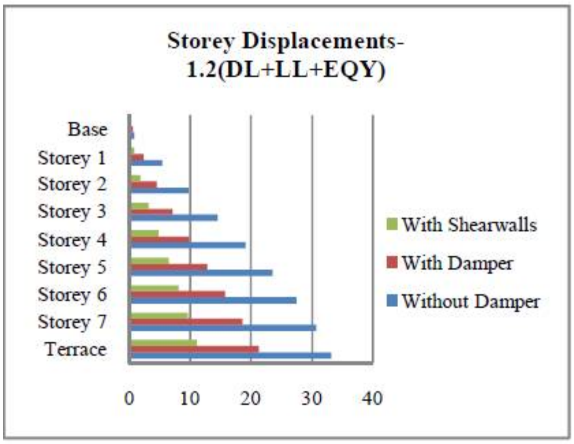

Fig 7: Storey Displacements 1.2(DL+LL+EQY) -Block D1 & D2 (G+8)

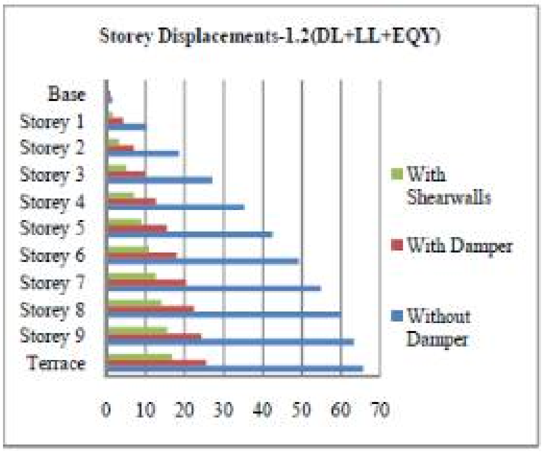

Fig 8: Storey Displacements- 1.2(DL+LL+EQY) for G+10 - Block D1 & D2

DISCUSSION FOR VARIATION OF DISPLACEMENT

For D1 and D2 (G+8) and (G+10) (Buildings of different heights)

1 For load combination 1.2(DL+LL+EQY) for G+8 with dampers the percentage of reduction of displacement varied from 38% and for shear wall 66%. For G+10, the percentage of reduction of displacement for dampers was 61% and 75% for shear walls.

2 Further when shear wall introduced the reduction in percentage of displacement varied from 38% for G+8 and 34% for G+10.

3 Similar patterns were observed for rest of load combinations as tabulated in the graphs.

2. TIME HISTORY ANALYSIS

Block D1 and D1A

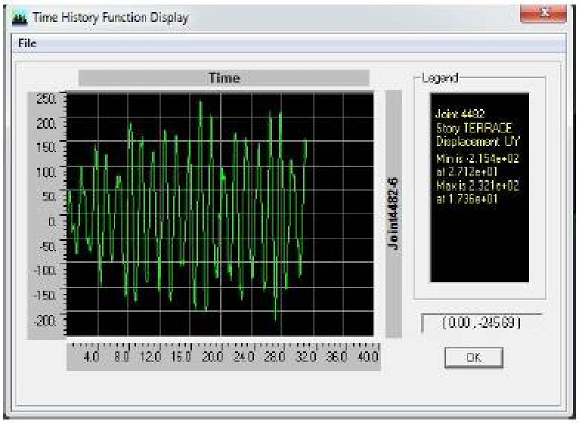

Fig 9: Block D1 and D1A without Dampers

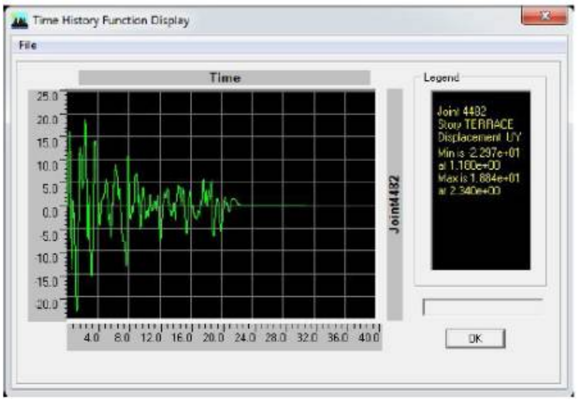

Fig 10: Block D1 and D1A with Dampers

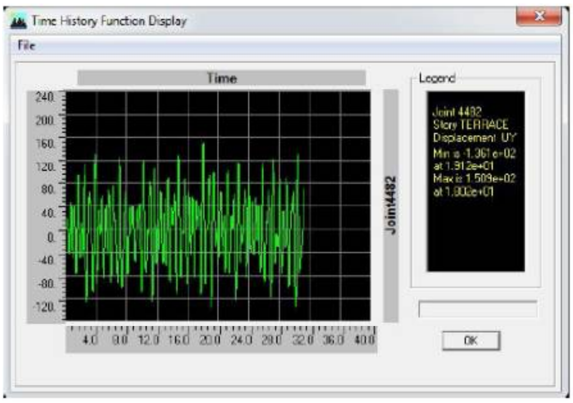

Fig 11: Block D1 and D1A with Shear Walls

Model	Maximum Displacement in mm
Columns	232.1
Columns with Dampers	18.84
Shearwalls	150.9

Table 2: Top Storey Displacement for Time History- D1 & D1A

For D1 and D1a (G+8)

1. From table 2, it is seen that the displacement due to time history analysis shows maximum displacement at top storey for column structure i.e, 232.1 mm. With dampers being introduced into the structure displacements were reduced to about 90% when compared to column structure.
2. From table 2, it can be noticed that when a shear wall is being placed, the displacements were reduced to 32%.
3. D1 & D1A structures are placed perpendicular to each other. Hence, dampers are more effective.

Block D1 & D2

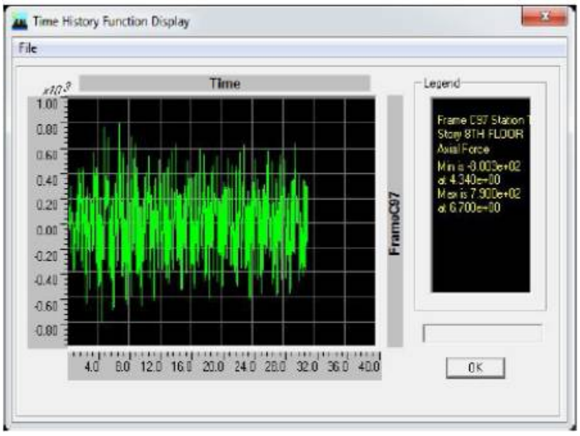

Fig 12: Block D1 and D2 with Columns

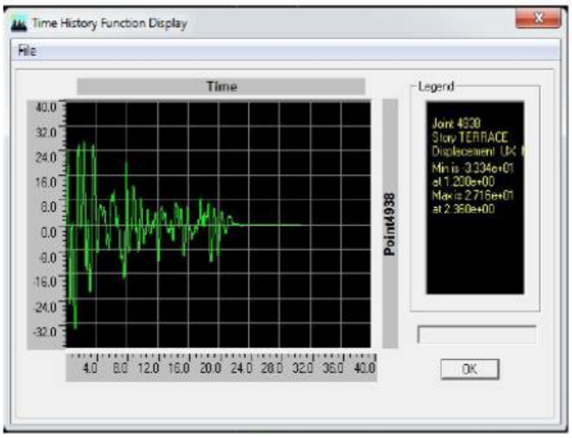

Fig 13: Block D1 and D2 with Dampers

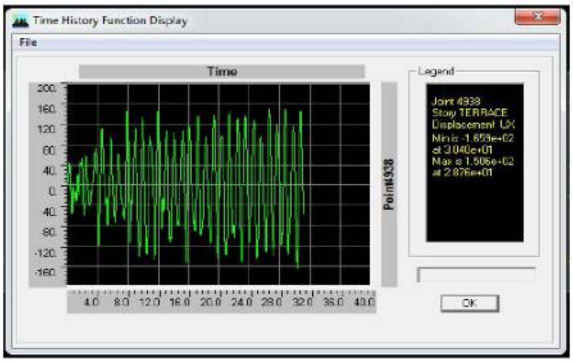

Fig 14: Block D1 and D2 with Columns Shear Walls

Model	Maximum Displacement in mm
Columns	790
Columns with Dampers	271.6
Shearwalls	150.6

Table 3: Top Storey Displacement for Time History- D1 & D2

For D1 and D2 (G+8) and (G+10)

1. From table 3, it is seen that the displacements due to time history analysis shows maximum displacement at top storey for column structure ie, 790 mm. With dampers being introduced into the structure, the displacements were reduced to about 65% as compared to column structure.
2. From table 3, it can be noticed that when a shear wall is placed, displacements were reduced to 81%.
3. D1 & D2 structures are placed parallel to each other. Hence, shear walls are effective.

CONCLUSIONS

1. Addition of dampers into the structure increased the base shear marginally.
2. It is found that the pounding effect can be effectively controlled with dampers and shear walls.
3. For structures with different storey heights placed parallel to each other, seismic pounding effect can be controlled by dampers to about 25 to 40% and by shear walls it can be controlled to about 60 to 75% respectively.
4. For structures with different storey heights placed perpendicular to each other, seismic pounding effect can be controlled by dampers to about 30 to 50% and by shear walls it can be controlled to about 60 to 65% respectively.
5. For structures with same storey heights (G+8) placed perpendicularly, in time history analysis it was seen that with dampers being introduced into the structure, the displacements were reduced to about 90% as compared to column structure. Hence, dampers are effective.
6. For Structures with different storey heights (G+8 & G+10) placed parallel to each other, in time history analysis it was seen that shear walls being introduced into the structure, the displacements were reduced to about 80% as compared to column structure. Hence, shear walls are effective.

REFERENCES

[1] Abdel R and E.Shehata "Seismic Pounding between Adjacent Building Structures" Electronic Journal of Structural Engineering 66-74 (2006).

[2] Khaja Afroz Jamal ,H.S.Vidyadhara "Seismic Pounding of Multistoreyed Buildings" IJRET: International Journal of Research in Engineering and Technology issue 2013, eISSN: 2319-1163 | pISSN: 2321-7308.

[3] Amruta Sadanand Tapashetti, S Vijaya, B Shivakumara Swamy "Siesmic Pounding Effect in Building" International Journal of Advancement in Engineering Technology, Management and Applied Science volume 1, issue 2 july 2014, ISSN No: 2349-3244.

[4] Ravindranatha, Tauseef M H, Shivananda S.M, H Suresh "Prevention of Seismic Pounding between Adjacent Buildings" Civil Engineering Systems and Sustainable Innovations issue 2014, ISBN: 978-93-83083-78-7.

[5] M Phani Kumar and J D Chaitanya Kumar "Seismic Pounding of the Adjacent Buildings with Different Heights" International Journal of Research in Engineering and Technology issue November 2015, ISSN 2319-5991.

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