Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 2, Number 12; April-June, 2015 pp. 32-35

http://www.krishisanskriti.org/jceet.html

Mitigation of Seismic Pounding between Adjacent RC Buildings

S.S. Deshpande[1] and L.R. Wankhade[2]

[1]Post-Graduate Student, Applied Mechanics Department, Government College of Engineering Amravati, Maharashtra
[2]Applied Mechanics Department, Government College of Engineering Amravati, Maharashtra
E-mail: [1]engrshree@gmail.com, [2]lrwankhade23@gmail.com

Abstract—*It has been observed from the past earthquake records that major damage to the building takes place due to the pounding between adjacent buildings during an earthquake. Sometimes it results in collapse of the building. Among the all possible structural damage pounding between the structures is commonly observed. Hence, a study on seismic pounding and its mitigation techniques is carried out. The paper contains equivalent static analysis, Response spectrum Analysis, and time history analysis of seismic pounding between the adjacent buildings using ETABS nonlinear software. Two buildings of 15 storey and 10 storey are analyzed with and without shear wall, bracing. The results are obtained in the form of storey displacements.*

Keywords: *Adjacent Buildings, Mitigation of seismic pounding, Seismic Pounding, Shear wall, Bracing.*

1. INTRODUCTION

An earthquake is capable of causing severe damage to structures; especially the earthquake having higher magnitude causes large damage to the structures. In case of the adjacent buildings significant damage is caused due to earthquake vibrations which sometimes result in the seismic pounding. The term seismic pounding is the process of repeated and heavy striking of buildings due to the earthquake vibration. Particularly in India past earthquakes caused large destruction due to the seismic pounding. The annual energy dissipation in India and its surrounding area is identical to an earthquake having the magnitude in between 5.5 to 7.3[1]. Therefore in case if the two buildings are close to each other, it is anticipated that they will result in to seismic pounding. Such types of the cases are easily seen in metropolitan areas where the cost of land is much higher than the other areas of that particular region. If the buildings situated in the metropolitan areas are not properly spaced then there should have safe and economical retrofitting method to mitigate seismic pounding [2-3]. In case of stiff structural systems pounding is critical, especially in case of highly out of phase system [4].

Most of the studies were carried out on structural pounding considering single degree of freedom as a base and lesser work is done on seismic pounding between multistory buildings. Recent study consists of seismic hazard mitigation practices like effect of different separation distances and effect of addition of shear walls and bracing are investigated in ETABS nonlinear software [5, 6, 7].

1.1 Seismic pounding mitigation

In general effect of seismic pounding can be mitigated either by providing proper separation distance or by providing different mitigation techniques such as using shear walls, bracing system, dampers etc. [8]

(a) By providing adequate separation distance

According to IS1893:2002(Part1), the separation distance 'S' should be 'R' times sum of displacements. 'R' may be replaced by 'R/2' if the two buildings are having the same levels where 'R' is response reduction factor [9]. FEMA 273: 1997 mentioned that separation distance between buildings shall be less than 4% of the building height and above to avoid seismic pounding [10]. And also gives the equations for calculating the minimum gap necessary between adjacent buildings.

$$\mathrm{S} = \mathrm{U_a} + \mathrm{U_b}\ \text{(ABS)} \qquad \text{(I)}$$

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

Where 'S' is separation distance and $\mathrm{U_a}$ and $\mathrm{U_b}$ are peak displacement response of adjacent buildings.

(b) By providing different mitigation techniques

Seismic pounding can be reduced to large extent by providing special type of structural system. It includes use of shear wall, bracing, dampers etc. IS 4326:1993 gives an idea for providing the separation necessary in case of special type of structural system which is applicable for the building having storey height below 40m [11]. For the buildings having height more than 40m code suggests to carryout separate dynamic analysis and the gap width should not be less than sum of the dynamic deflection of building at any level.

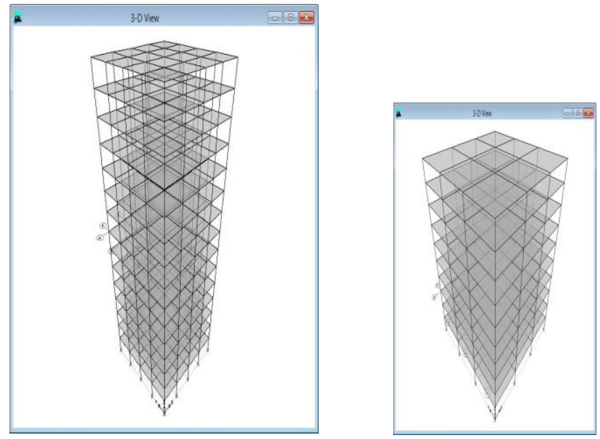
2. METHODOLOGY

Seismic pounding causes huge destruction to the structure. Thus the present study consists of analysis of RC frame with and without shear wall in ETABS nonlinear software. Seismic pounding response between the adjacent multi-storey buildings is analyzed considering displacement as main aspect. For linear earthquake building in zone V is considered and equivalent static analysis, response spectrum analysis, time history analysis is carried out in ETABS.

Equivalent static analysis defines a series of forces acting on a building to represent the effect of earthquake ground motion, typically defined by a seismic design response spectrum. The assumption made that the building responds in its fundamental mode. For this to be true, the building must be low-rise and must not twist significantly when the ground moves. Response spectrum is a plot between peak response (Displacement, velocity, acceleration) of series of oscillator and variable natural frequency. Response spectrum analysis is an important tool for calculating response of the structure subjected to seismic vibrations. Hence, if we calculate the natural frequency of the structure, then we can estimate peak response of the building which can be calculated by reading the value from the ground response spectrum for the particular frequency. In case of the time history analysis the actual vibration that the structure posses in the earthquake is given.

3. STRUCTURAL MODELING AND ANALYSIS

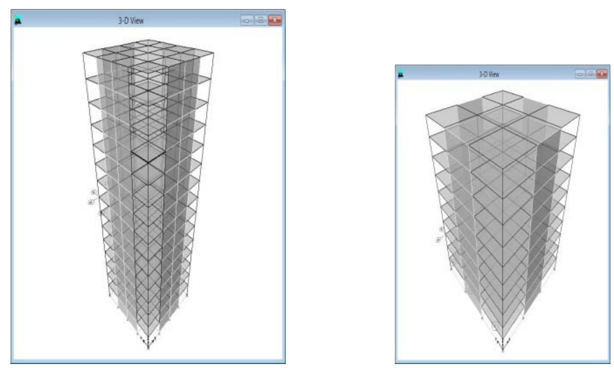
In order to calculate the seismic pounding between adjacent buildings, Two RC buildings (15 storey and 10 storey) are selected. The two buildings are separated by distance 50mm subjected to dead and dynamic loading. Both buildings are analyzed in ETABS nonlinear software. Building ‘A’ is of 15 storey having 4 numbers of bay in X and Y direction. Width of each bay is 4m and height of each storey is 3m.For Building ‘A’ column having size (0.50X0.50)m^2 and beam is of size (0.30X0.50) m^2. The thickness of slab is 120mm. Building ‘B’ is of 10 storey same loading, material and posses column having size (0.45X0.45) and beam size (0.23X0.40).The buildings are in zone V having importance factor is 1 and response reduction factor is 5. M25 grade of concrete is used. Concrete frame design preference is given to IS456:2002 for concrete section and IS800:2007 for steel section. Equivalent static, Response spectrum and time history analysis is carried out. Various mitigation techniques such as shear wall and bracing system are applied.



(a) Building ‘A’ (b) Building ‘B’

Fig. 1: 3D view of 15 Storey and 10 storey structure

For mitigating seismic pounding shear wall is applied at the middle bays of both the buildings.



(a) Building ‘A’ with Shear wall (b) Building ‘B’ With Shear wall

Fig. 2: 3D view of 15 Storey and 10 storey structure with shear wall

Now for mitigating the seismic pounding between adjacent RC building steel bracing is applied to the structures at the middle of the bay replacing shear wall.

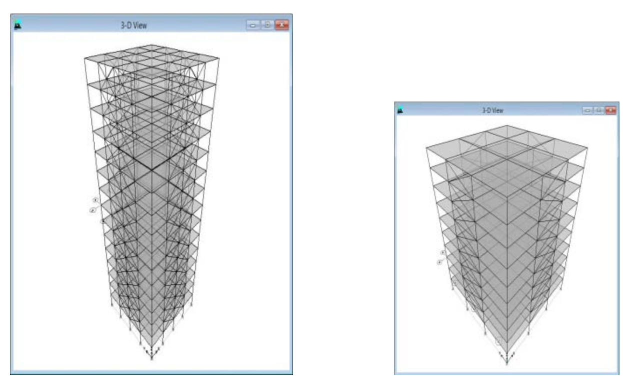
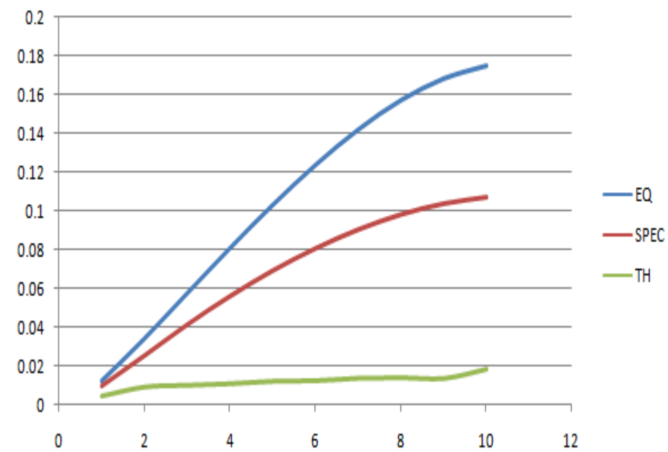


Fig. 3: **3D view of 15 Storey and 10 storey structure with bracing system.**



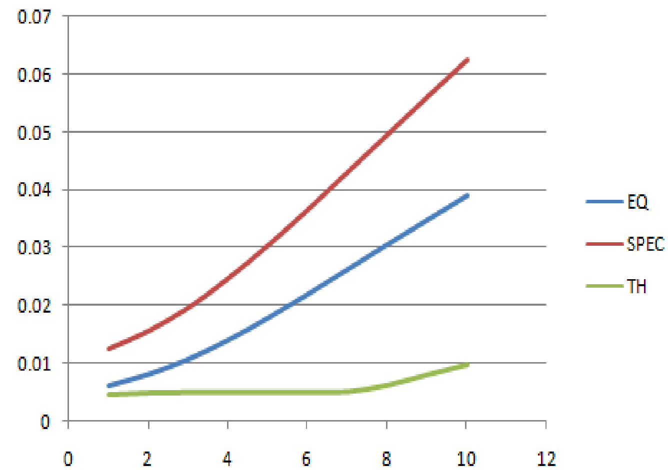
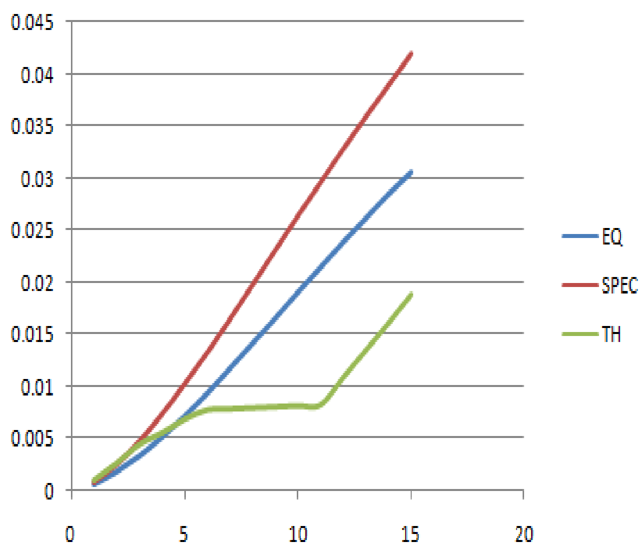


Fig. 4: **Graph for Storey vs. Displacement for 15 and 10 storey**



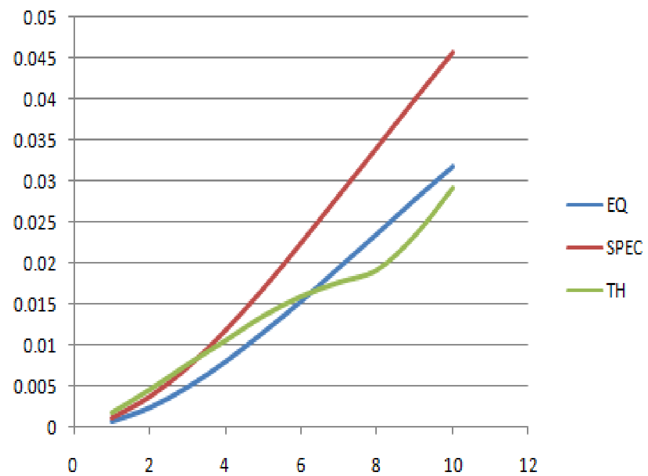
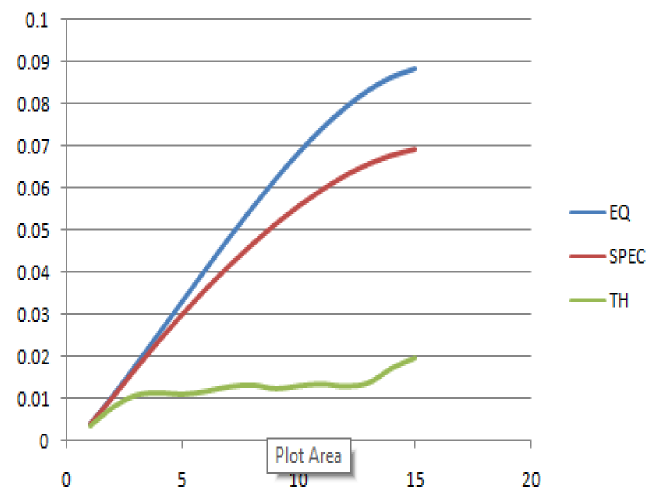


Fig. **5: Graph for Storey vs. Displacement for 15 and 10 storey using shear wall**



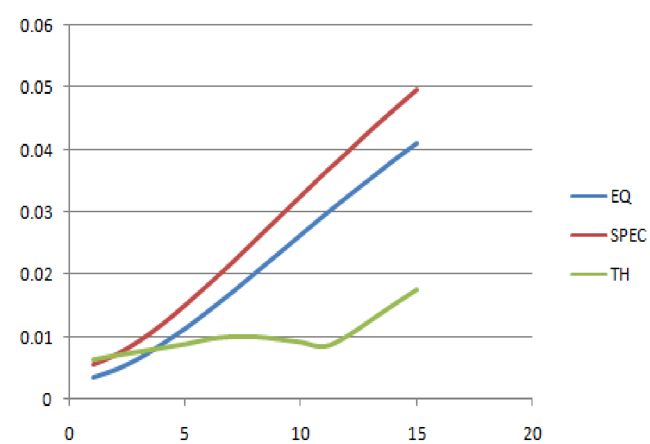


Fig. **6: Graph for Storey vs. Displacement for 15 and 10 storey using steel bracing**

4. CONCLUSIONS

Pounding between the structures is highly nonlinear phenomenon. During the earthquake huge amount of pounding force acts on building, it is impossible to absorb the pounding force completely but we can able to mitigate the pounding force to a large extent. The results obtained in response spectrum analysis are plotted in the form of graph. From that following conclusions are made

1. As increase in the separation distance decreases pounding force, provision of an adequate separation distance mentioned in the IS codes reduces the possibility of seismic pounding. Among the all codes mentioned earlier FEMA-273 provides larger separation distance between the adjacent buildings since the separation distance is 4% of storey height.
2. Adjacent buildings having the same seismic behavior need not to provide minimum separation gap as mode shapes are equal and are in same direction.
3. Response of building is highly affected by the pounding force acting in the longitudinal direction of the building. The story displacement of the building depends on the magnitude of the pounding force in longitudinal direction.
4. Shear wall resists the longitudinal displacement of the structures which results in mitigation of pounding force in large extent.
5. Bracing reduces the longitudinal displacement of the structures but as compared to shear wall it is less effective in mitigation of seismic pounding.
6. It has been seen that, In the process of seismic pounding structure having the shorter time period posses greater acceleration where as the structures having the larger time period experience greater displacement.

REFERENCES

[1] Shehata E.Abdel Raheem, Seismic pounding between adjacent building structures, *Electronic Journal of Structural Engineering* , Vol. 6, pp.66-74,2006.

[2] A. Hameed, M. Saleem, A.U. Qazi, S. Saeed and M. A. Bashir, Mitigation of seismic pounding between adjacent buildings, *Pakistan Journal of Science*, Vol.64 No:4 December 2012.

[3] Shoushtari A. V.,Seismic Behaviour of Tall Building Structures by Friction Damper, MSc. Thesis, *Faculty of Civil Engineering, University of Technology*, Malaysia (2010).

[4] S. Muthukumar and R. DesRoches, A Hertz contact model with nonlinear damping forsimulation, *Earthquake Eng. and Structural Dynamics*,Vol.35,pp811-828,2006.

[5] K.A.Jamal,H.S.Vidyadhara, Seismic pounding of multi-storey buildings, *International Journal of Research in Engineering and Technology*,PISSN:2321-7308.

[6] A. Hameed, M. Saleem, Mitigation of seismic pounding between adjacent buildings**,** *Pakistan Journal of Science (Vol. 64 No. 4 December, 2012)*

[7] Umesh.R.Biradar1, Shivaraj Mangalgi, Seismic response of reinforced concrete structure by using different bracing systems, *IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308*

[8] IS1893(Part I):2002, *Indian Standard Criteria for Earthquake Resistant Design of Structures*, Part 1 General Provisions and Buildings, (Fifth Revision).

[9] FEMA-273(1997), NEHRP guidelines for the seismic rehabilitation of buildings, Washington DC.

[10] IS 4326-2005: 1993, *Indian Standard Code of Practice for Earthquake Resistant Design and Construction of Building* (Second Revision).

[11] Rajaram C., Pradeep K. Ramancharla, Study on Impact Between Adjacent Buildings: Comparison of Codal Provisions, *15th World Conference on Earthquake Engineering*, September 2012