ANALYSIS OF SEISMIC POUNDING EFFECT BETWEEN NEIGHBORING BUILDINGS HAVING DIFFERENT STRUCTURAL SYSTEMS

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Abstract: Investigation of previous and recent earthquake damages have shown that the buildings are subjected to severe destruction or collapse during the earthquake ground motion. Among the probable structural damages, seismically induced pounding has been usually witnessed in most of the earthquakes. During the earthquake, Building vibrates out phase due there different dynamics characteristics. Such buildings are usually separated by expansion joint which is insufficient to accommodate the lateral out of phase movements of the buildings during the earthquake. Most of the earlier studies on seismic pounding are confined to a simple 2D and 3D structures having conventional beam- column structural system consist of limited number of storeys and limited number of bays .Thus, after reviewing the existing literature it was felt that a comparative study on seismic pounding effect on different type of structural system is required. The main aim of this study is to understand the behavior of structural pounding on different structural system namely, conventional beam - column system adjacent to beam - column system, beam - column system adjacent to flat slab system and a flat slab system adjacent to a flat slab system. In order to observe pounding effect, Time history analysis is carried out by taking 1944 Elcentro earthquake data which is to be known as above average earthquake.

Key Words: Seismic pounding, Earthquake, SAP 2000, Flat slab system, beam -column system.

I. INTRODUCTION

The Seismic pounding is simply known as collision or hammering of the adjacent buildings which are of different dynamic characteristics during the earthquakes. The main reason for the seismic pounding is a lack of gap in between the adjacent buildings. The pounding phenomenon is mostly observed in the ancient buildings that were built earlier the advent and fame of earthquake resistant design principles. Although many present codes specify a minimum seismic gap, it is still inadequate as codes necessarily lag behind the current research and fail to include the effect of other parameters that affect the structural deformation. Pounding damage was observed during the 1985 Mexico earthquake, the 1988 Sequenay earthquake in Canada, 1995 Kobe earthquake and 1944 Elcentro earthquake. 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 (1.Abdel and Shehata, 2006). Past seismic codes did not give definite guidelines to avoid pounding, due to economic considerations including maximum and usage requirements, especially in the high density populated areas of cities, there are so 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 an expansion joint and economical loss of land usage] views (2. A Hameed et.al, 2012). The highly congested building system in many metropolitan cities constitutes a major concern for seismic pounding damage.

The most simplest and effective way for pounding mitigation and reducing damage due to pounding is to provide enough separation gaps, but it is sometimes difficult to be implemented due to the high cost of land. An alternative to the seismic separation gap provision in the structure design is to minimize the effect of pounding through decreasing lateral motion. The main objective and scope are to evaluate the effects of structural pounding on the global response of building structures, to determine the minimum seismic gap between buildings and provide engineerswith practical analytical tools for predicting pounding response and damage.

II. METHODOLOGY

To understand the behavior of structural pounding on different structural system three models have been considered for the purpose of the study they are as follows.

1. Building with Beam Column system adjacent to beam column system.
2. Building withBeam column system adjacent to Flat slab system.
3. Building with Flat slab system adjacent to Flat slab system.

TABLE 1

The details of the buildings are as follows.

Sl No.	Item		Building A		Building B	
1	No. of floors		Building :(G+8)		Building :(G+6)	
2	Different type of Structural system considered are	1	Conventional Beam – column System		Conventional Beam - column System	
		2	Conventional Beam - column System		Flat slab system	
		3	Flat slab system		Flat slab system	
3	Floor height(in m)		3.2		3.2	
4	No. of Bays		In X direction	In Y direction	In X direction	In Y direction
			4	4	4	4
5	Width of the bays(in m)		4	5	3	5
6	Size of the column					
6.a	External column(mm^2)		400x800		300x750	
6.b	Internal column(mm^2)		550x1000		300x900	
7	Beam Size(mm^2)		350x600		300x450	
8	Slab thickness		For the Conventional Beam - column System thickness of the slab is 150 mm and that of Flat slab system is 150 mm and the drop thickness is 200 mm and is designed as per IS 456-2000			
9	Grade of concrete		M-25 for column and M-20 For other structural members			

To observe pounding, a three-dimensional reinforced concrete moment resisting frame buildings is taken and analyzed in SAP2000. Live load on the floor is taken as 3kN/m^2 and on the roof is 1.5kN/m^2. Floor finish on the floor is 1kN/m^2 and weathering course on the roof is 1kN/m^2. The seismic weight is calculated conforming to IS 1893-2002. The Unit weight of concrete is 25kN/m^{3,} modulus of elasticity and shear modulus of concrete have been taken as $E = 2.5 \times 10^7$ kN/m^2 and $G = 1.06 \times 10^7$ kN/m^2. The foundation height is 1.5m from the normal ground level. The building is analyzed as special moment resisting frame considered to be situated in seismic zone IV having medium soil and intended for residential use. These buildings are separated by expansion joint of 100mm. Both buildings are analyzed in SAP2000 and are designed as per IS 456-2000. Both buildings are subjected to gravity and dynamic loads. Soil structure interaction has not been considered and the columns have been restrained in all six degrees of freedom at the base. Pounding analysis carried out at roof level of G + 6 storey, to study the positive displacement of eight storey and negative displacement of six storey, as we are going to consider the worst condition due to its different dynamic characteristics of the both the building. After analyzing these two buildings in SAP2000 under Time History record of 1944 Elcentro earthquake, the behavior of the buildings i.e. Displacement with respect to time was observed.

1.Beam column system adjacent to the Beam column system:

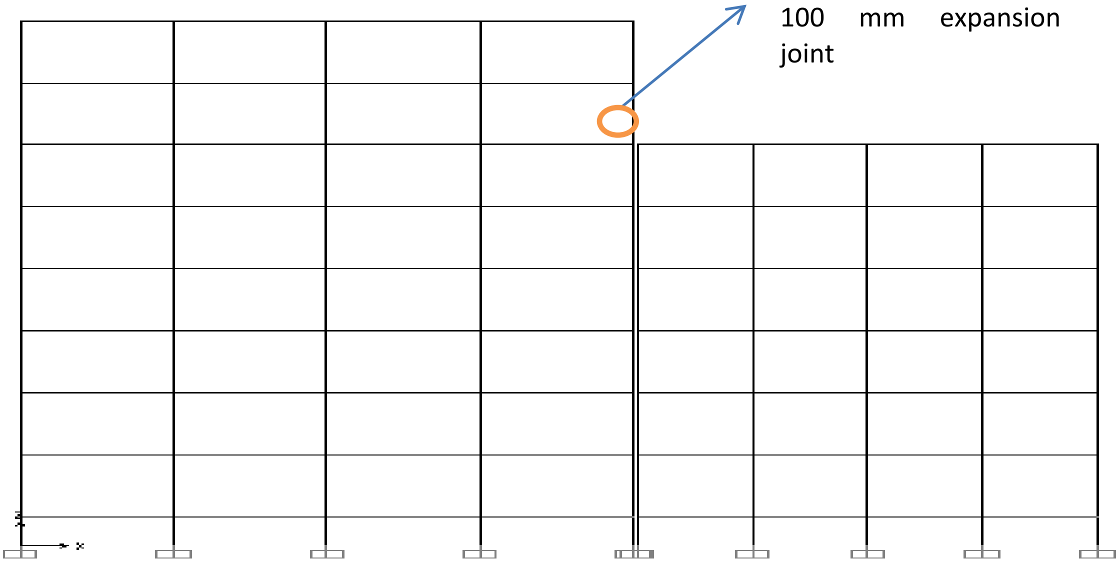

Fig.1Elevation view of beam column system adjacent to beam column system.

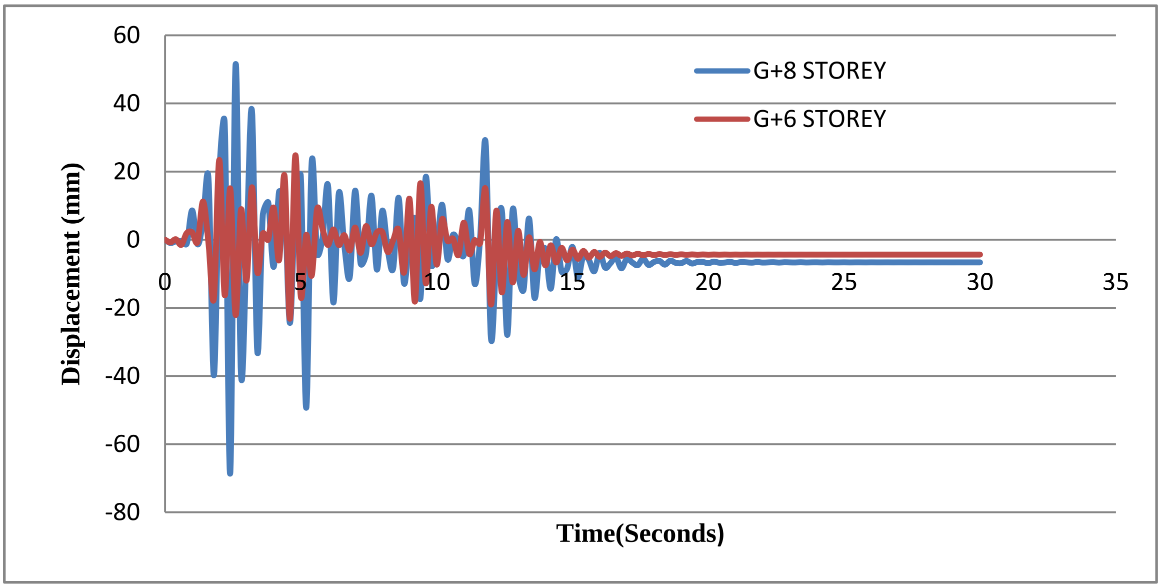

Fig 2Time vs. displacement graph of beam column system adjacent to beam column system at sixth floor level.

From the figure – 2 it was observed that maximum positive displacement of G+8 storey building is 51.41mm at 2.6 seconds and maximum negative displacement of G+6 storey building is 23.18mm at 4.6 seconds. From the figure, it is noticed that maximum out of phase movement of both building is (51.41+23.18)-100= 25.41mm which is lesser than the given expansion joint, hence no chance of pounding at any interval of time.

2.Beam column system adjacent to Flat slab system:

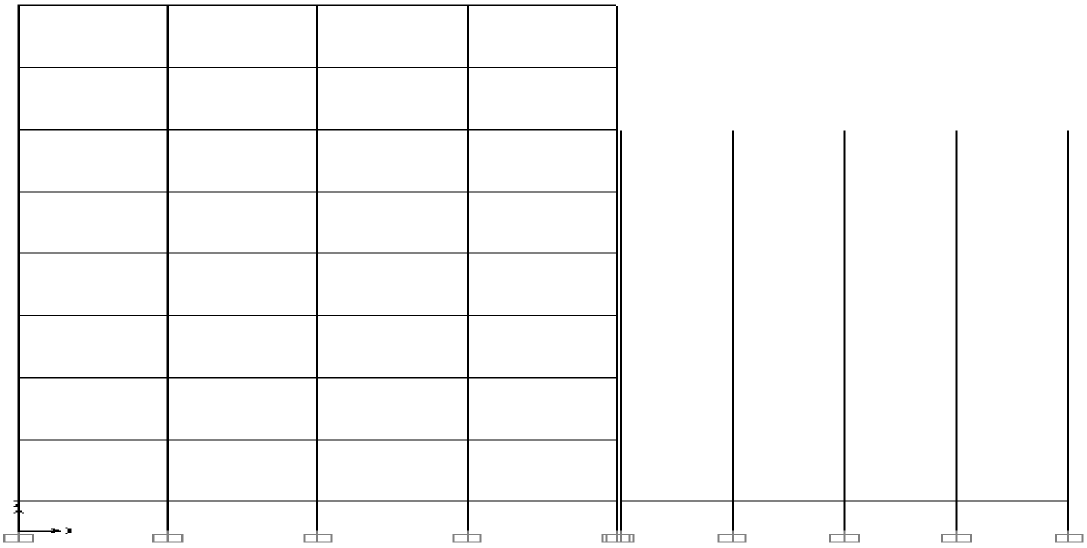

Fig.3 Elevation view of beam column system adjacent to Flat slab system

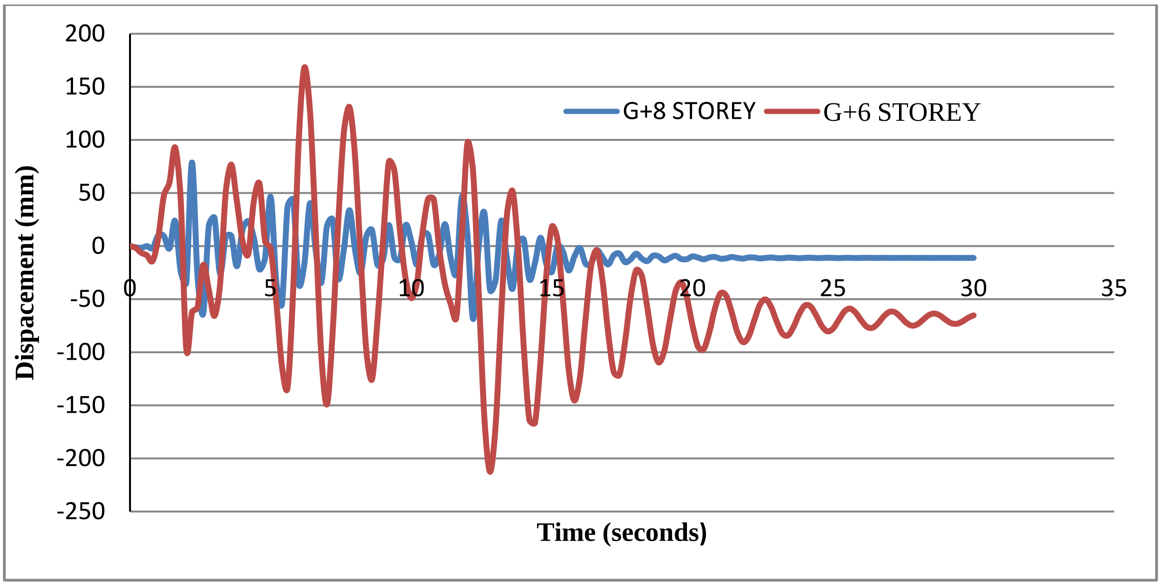

Fig.4Time vs. displacement graph of beam column system adjacent to flat slab system at sixth floor level.

From the figure - 4 it was observed that maximum positive displacement for G+8 storey building is 80.30 mm at 2.2 seconds and maximum negative displacement of G+6storey building is 212.53 mm at 12.8 seconds. From the figure it is noticed that maximum out of phase movement of both building is (78.72+212.53)-100= 191.25 mm which is greater than the given expansion joint, hence which is unable to accommodate this out of phase movement, and adjacent buildings will strike or collide each other.

3. Flat slab system adjacent to Flat slab system.

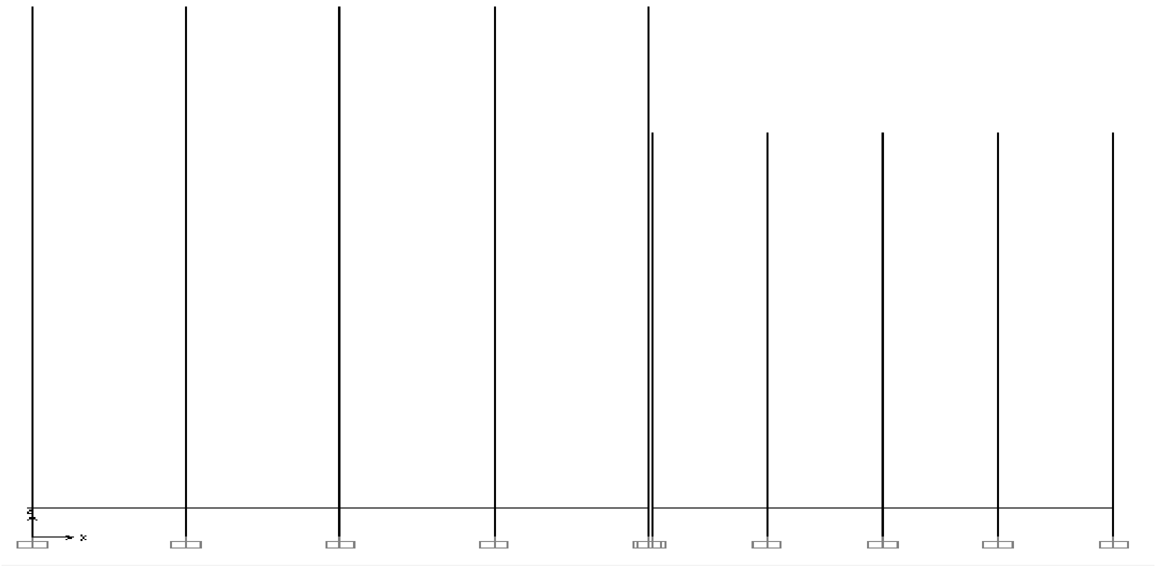

Fig. 5 Elevation view of Flat slab system adjacent to Flat slab system

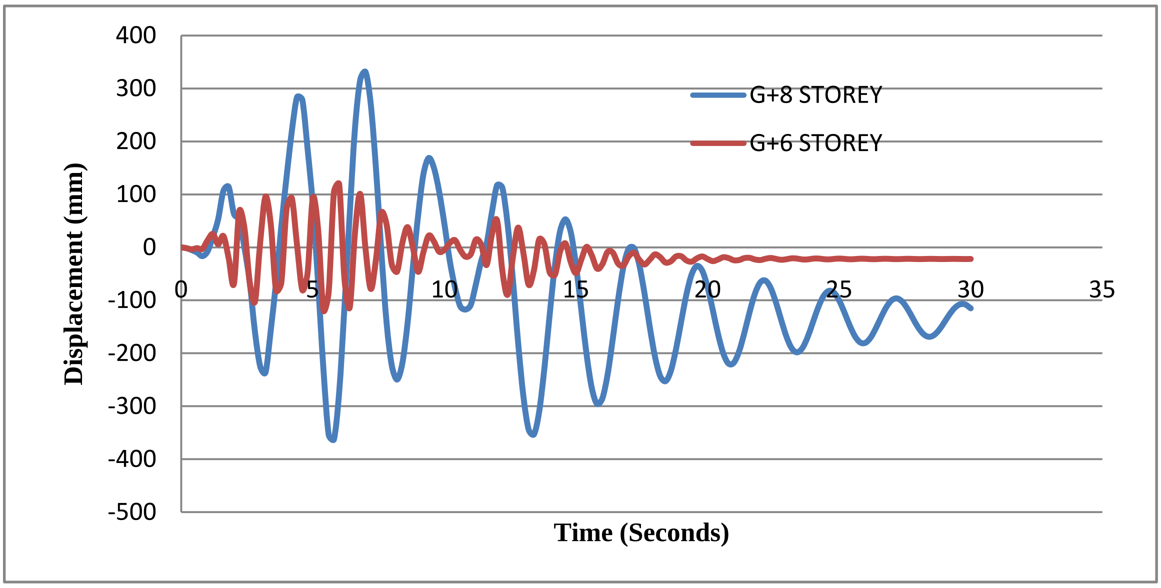

Fig.6Time vs. displacement graph of flat slab system adjacent to flat slab system at sixth floor level.

From the figure - 6 it was observed that maximum positive displacement for G+8 storey building is 331.36 mm at 7.0 seconds and maximum negative displacement of G+6 storey is 118.82 mm at 5.4 seconds. From the figure it is noticed that maximum out of phase movement of both building is (331.36+118.82)-100= 350.18 mm which is greater than the given expansion joint, hence which is unable to accommodate this out of phase movement, and adjacent buildings will strike or collide each other.

III. CONCLUSIONS

- The stiffness of the flat slab system is less in comparison with beam – column system and hence design engineer have to give more importance while designing such type of structures.
- At the time of design, Design Engineer has to ensure that there will be no pounding between adjacent buildings.
- It is better to leave set back/safe separation gap according to FEMA 273-1997 when the buildings are in early stage of design.

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