Dynamic Analysis of Adjacent RCC Buildings for Pounding Effect

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Abstract - *Regarding to past earthquakes harms it has shown that structures are tend to serious damages and collapse during normal or strong earthquakes. An earthquake of magnitude 6 is capable of damaging of buildings, bridges, industries, port facilities causes economic loss. Thus another major effect causing the damage during the earthquake due to the effect of pounding between the adjacent buildings which are closely or narrow spaced which causes severe damage.*

In this paper the effect of providing the gap element between the two adjacent RCC buildings, considering the different cases. Mainly how the gap element effects the displacements and storey drifts, which is caused when the Earthquake forces acts on the adjacent buildings provided with gap element. Tabs 2013 (version 13.1.1) is the software used for the analysis.

Key Words: Seismic Pounding, Gap element, Response Spectrum Analysis, displacement, storey drift

1. INTRODUCTION

"Pounding effect" mainly refers to the colliding of the two adjacent buildings which are closely spaced such that it causes severe damages upon the acting of earthquake forces. There are various causes for the damage due to pounding one of it is different material and dynamic properties. Thus highly congested building system in many metropolitan cities constitutes a major apprehension for seismic pounding damage. The simplest and most appropriate way for pounding mitigation is to provide safe separation gap, but it is sometimes difficult to fulfill due to the high cost of land. An alternative to the seismic separation gap provision in the structure design is to reduce the effect of pounding through decreasing lateral displacement by introducing the stiffeners like RC walls, Bracings, dampers and providing the Gap Elements etc. The gap element used in this study refers to the expansion joint which caters towards the expansion and contraction of the building that occurs during the earthquake.

1.1Gap Element: it is the link elements, it is a compression member or element which is required to access the force of pounding and to stimulate the effect of pounding the main purpose of the link or gap element is to transmit the force through the link only when contact occurs and the gap is closed. In this study in order to know the effect on displacement and storey drifts cause during the earthquake by providing the gap element as a link thus connecting the structures from node to node as shown in the fig showing the connection of the buildings by providing the gap element the stiffness of the gap element is usually considered as 10^2 to 10^4 times the stiffness of the adjacent RC building or the connected element of the building here the shorter building is considered as stiffer than the taller building.

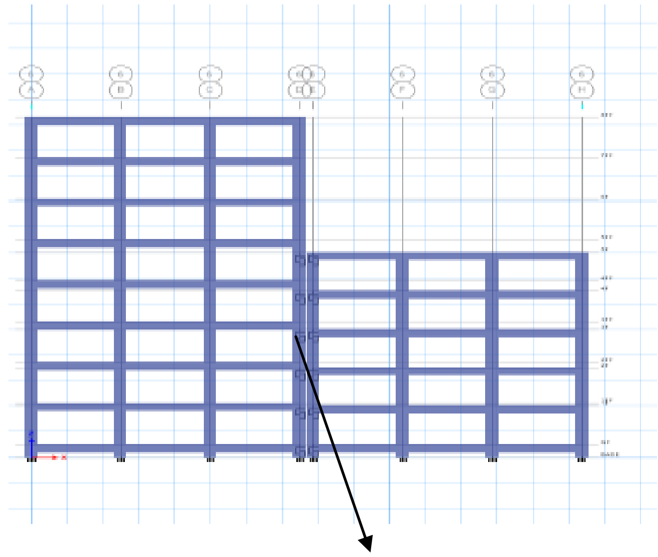

Fig: Gap Element provided in Etabs

The stiffness of the gap element is found as below.

$K = (A x E x 10^2)/L$

Where,

K= stiffness of the gap element

A= W x t

E= Young's Modulus

t = Slab Thickness

W= Average Element Width

2. Objectives of the study:

- Study on 3D building during earthquake by considering seismic pounding effect three different cases are considered.
- Seismic pounding effect is also considered by considering different gap element

- Seismic behaviour is studied by analysing the displacement values and the storey drifts values by linear Response Spectrum Analysis.

Graph is plotted for various gaps and conditions and giving an idea how pounding will effect the 3D building

3. Review of literature

Jagruti Patil1, Dr. Prof.R.S.Talikoti(2016) in this study the effect of GAP between the buildings is studied in detail using Etabs software they have considered two building G+12 and G+7 the gap taken is 50mm,80mm,110mm and 140mm with each 30mm difference the shorter building is considered as stiffer and the stiffness of the Gap element is calculated on the shorter buildings stiffness and the buildings are joined by the gap element the various parameters such as pounding force at every level, deformation of the link etc are compared and conclusions are derived on these aspects of the study.

Arpitha K , Umadevi R (2016) in this study the effect of the pounding effect on the two adjacent buildings G+7 and G+4 considered for time history analysis for the respective six different cases with same level different level and with setback of some distance. The gap element of 80mm is used in the analysis and the impact force in time history analysis displacement using the RSA and the respective conclusions are derived.

Ravindranatha, Pradeep Karanth, Shivananda S.M, H.L Suresh(2015) in this study the pounding effect is analyzed on the two adjacent buildings (G+10) and (G+7) the expansion joint or the gap element of 80mm is used the two adjacent buildings are analyzed for various cases such as same and different floor level as well as floor to mid column and setback by using the time history analysis of electro which is the above average earthquake and the positive and negative displacement caused due to pounding forces is studied and the study is done by using bracing systems conclusions based on the obtained results

A.B.Shirole (2015) The neighboring structures amid a seismic tremor may crash against each other when, inferable from their diverse element qualities, the structures vibrate out of phase and very still partition distance of separation is deficient to suit their comparative movements. Seismic beating can bring about extreme harm to the structures. Such structures are generally isolated by a development joint which is inadequate to suit the horizontal developments of structures under seismic tremors. This exploration work covers the moderation methods of beating between adjoining structures because of seismic tremors. Utilization of shear divider, propping framework and rubbing dampers are proposed as could be allowed relief procedures.

4. Building modeling

Two adjacent buildings of seven (G+7) and four storey (G+4) are considered for the study. The gap elements considered are 50, 80, 110 and 140 mm for each respective case mentioned below respectively. The Response Spectrum Analysis is carried out for each of the case

Case1: Adjacent Buildings at equal floor level with different storey height.

Case 2: Adjacent Buildings at equal floor level and storey height.

Case 3: Adjacent Buildings with a setback of 3m with equal floor level with and different storey height.

Building Parameters

Beam Sections (mm)	Column Sections (mm)
230X450	300X400
450X550	600X600
550X650	700X700
Slab Sections	All Slabs are 150mm Thick

Load Configurations

Wall Loads	
For 3m Storey Height	14.72KN/m^2
For 3.2m Storey Height	13.8 KN/m^2
Live Load	3.0 KN/m^2
Live Load on Roof	1.5 KN/m^2
Floor Finish	1.2 KN/m^2

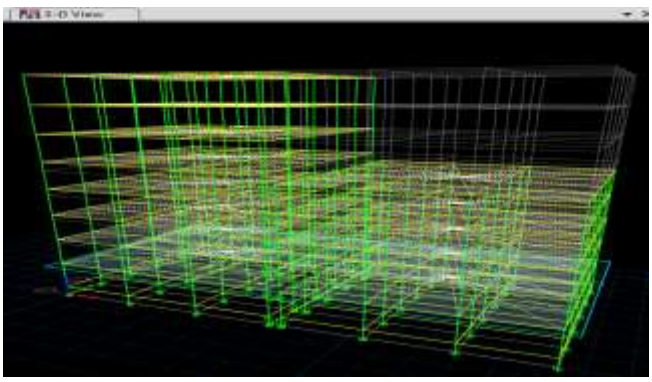

Fig 1: 3D Model of Case1

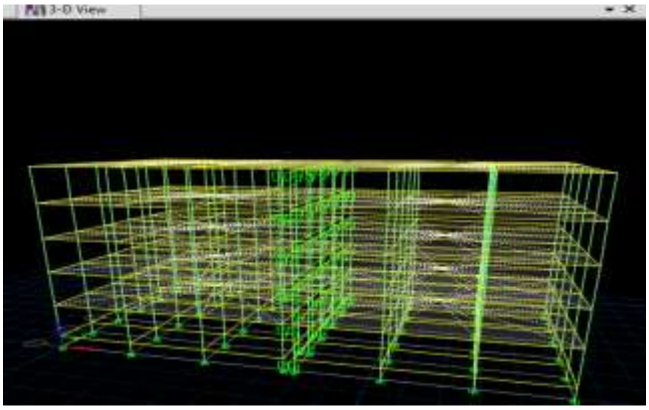

Fig 2: 3D Model of Case2

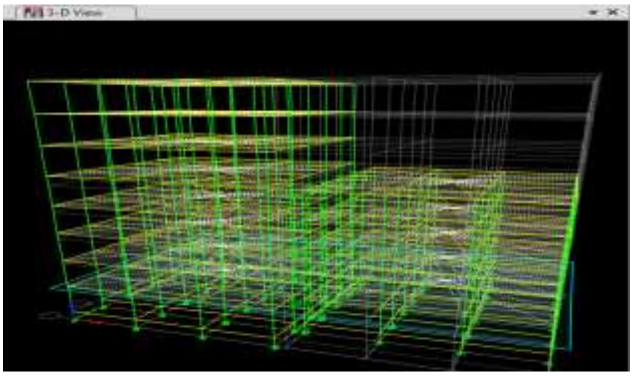

Fig 3: 3D Model of Case3

4.1 Structural Analysis:

Response Spectrum Analysis (RSA)

Here this study only involves Z (Zone factor) = 0.36 value for Zone V.

I (Importance factor) = 1.0, value according clause 6.4.2 of IS 1893

R (Response Reduction Factor) = 3.0 value for Reinforced Concrete frame.

Sa/g (Spectral Acceleration Coefficient) for the Soil type III (Weak Soil)

The effect of seismic pounding between the 2 adjacent buildings is studied using the Response spectrum Analysis procedure as with respect to the Code of practice IS 1893.

5. Results and Discussions:

The displacement and storey drift has been found in both X-direction and Y-direction for seven storey and four storey buildings and the maximum displacements and storey drift values are noted and tabulated. Response Spectrum Analysis (RSA) is carried out.

5.1 Maximum Displacement for 7 storey building considering all the cases

Building	Cases	Storey	Maximum Displacement (mm)	Gap Element (mm)
G+7	Case 1	7F	43.3	50
G+7	Case 1	7F	56.5	80
G+7	Case 1	7F	107.1	110
G+7	Case 1	7F	107	140

Table 5.1: Maximum Displacement for 7 storey building considering all the cases

5.2 Maximum Displacement for 4 storey building considering all the cases

Building	Cases	Storey	Maximum Displacement (mm)	Gap Element (mm)
G+4	Case 2	4F	32.3	50
G+4	Case 2	4F	50.4	80
G+4	Case 2	4F	74.4	110
G+4	Case 2	4F	73.9	140

Table 5.2: Maximum Displacement for 4 storey building considering all the cases

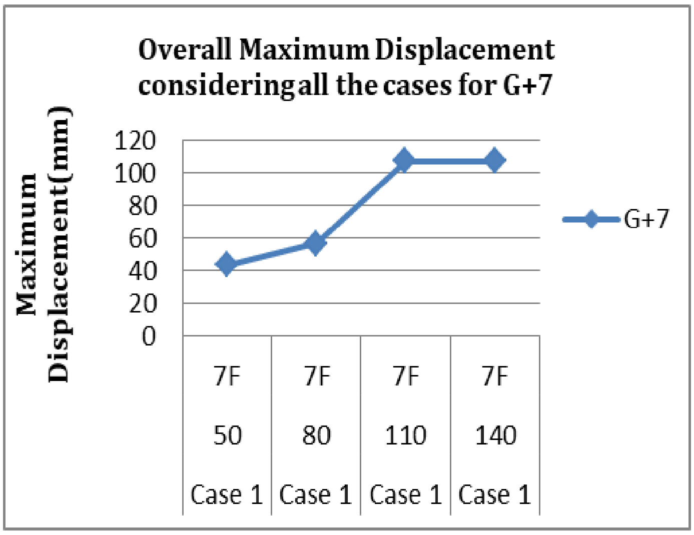

Fig 4: Maximum Displacement for 7 storey building considering all the cases

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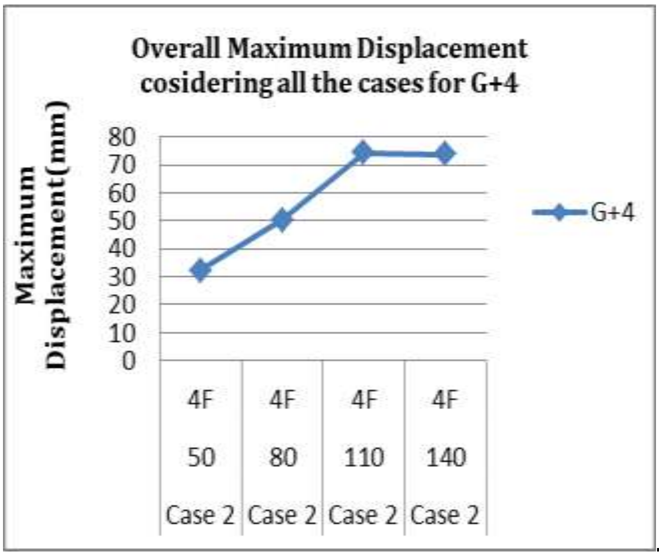

Fig 5: Maximum Displacement for 4 storey building considering all the cases

5.3 Maximum Storey drifts for 7 storey building considering all the cases

Building	Cases	Storey	Maximum Storey Drifts(mm)	Gap Element (mm)
G+7	Case 1	1F	0.002474	50
G+7	Case 1	1F	0.004729	80
G+7	Case 1	1F	0.005998	110
G+7	Case 1	1F	0.006004	140

Table 5.3: Maximum Storey Drifts for 7 storey building considering all the cases

5.4 Maximum Storey drifts for 4 storey building considering all the cases

Building	Cases	Storey	Maximum Storey Drifts(mm)	Gap Element (mm)
G+4	Case 2	1F	0.00275	50
G+4	Case 2	1F	0.004282	80
G+4	Case 2	1F	0.006379	110
G+4	Case 2	1F	0.00638	140

Table 5.4: Maximum Storey Drifts for 4 storey building considering all the cases

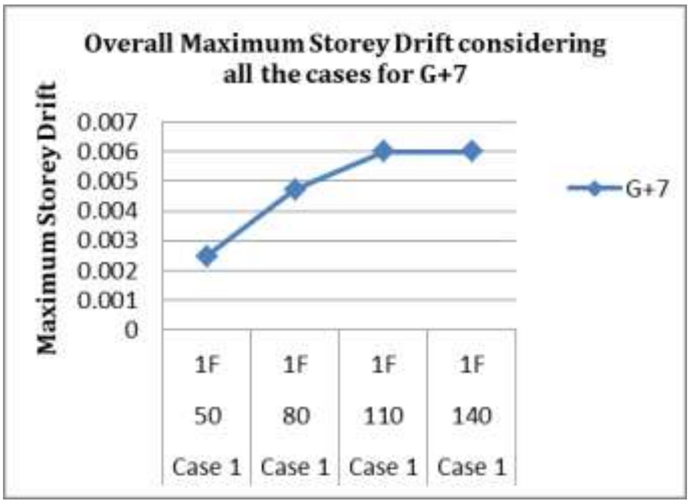

Fig 6: Maximum Storey drifts for 7 storey building considering all the cases

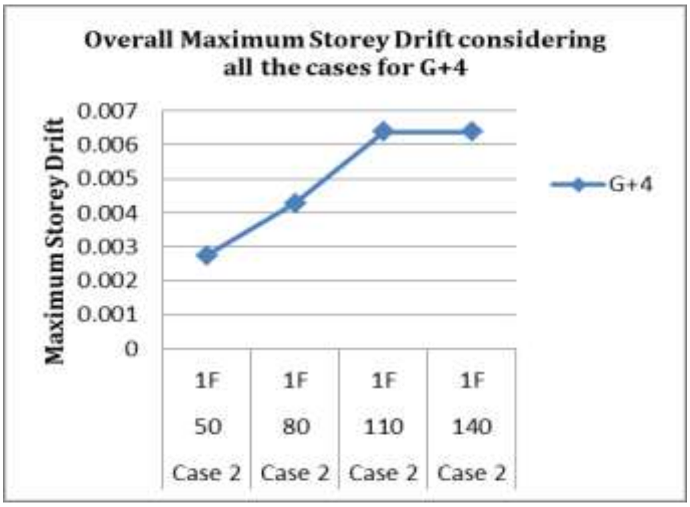

Fig7: Maximum Storey Drifts for 4 storey buildingconsidering all the cases

CONCLUSIONS

Based on analysis carried out on the seismic pounding effect in the buildings the following conclusions are:

1. The displacements are found to be increasing i.e. lesser amounts of displacements occurring at lower storeys and gradually increasing at higher storeys

2. The storey drifts are found to be increasing i.e. lesser amounts of displacements occurring at higher storeys and gradually increasing at lower and intermediate storeys

3. With the buildings provided with the gap element of 50, 80,110,140mm here the displacement as well as Storey drift is found to be gradually increasing for

50mm and 80mm gap element but with gap element of 110 and 140mm the displacement and the storey drift values are found to be constant i.e.., if the gap element size is further increased the displacement and the storey drift values becomes constant.

4. The displacement is found to be maximum at the higher storey i.e. seventh storey for Case 1 and fourth storey for Case 2 on comparison with all the cases respectively and further less at the bottom storeys.

5. The drift is found to be maximum at the lower storey i.e. first storey for Case 1 and fourth storey for Case 2 on comparison with all the cases respectively and further less at the higher storeys.

6. Thus gap element enables the building to vibrate within the expansion joint or the gap element value i.e. 50, 80,110and 140mm.and decreasing the effect of earthquake forces on the buildings.

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