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A Review Paper on Investigation into the Effect of Pounding on High Rise Structure

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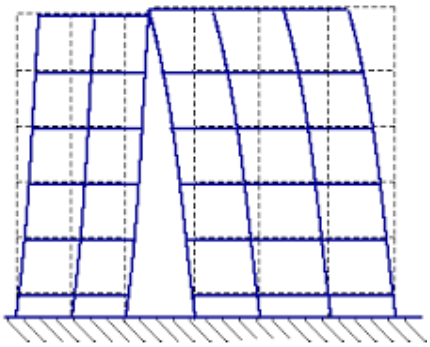
Abstract: **-- It has been widely seen that when an earthquake occurs it causes large and intense shaking of the ground. So the building or the structure of any shape, size or of any height will experience the motion at its base. The level of damage caused by an earthquake on a structure depends on the intensity of release of strain energy and the duration of shaking. The amplitudes are largest with respect to the large earthquake and the duration of shaking generally increases with the size of an earthquake. When two adjacent building vibrates out of phase the collision occurs due to the insufficient separation or gap this phenomenon is known as pounding of the building. This paper includes the study of pounding between adjacent buildings with same or different properties. Lump mass system is considered using MDOF system. In this time history analysis is carried out using past earthquake of Imperial Valley.**

I. INTRODUCTION

Investigation of past studies had illustrated the damages caused due to earthquake. Earthquake is a sudden shaking of earths surface due to the release of strain energy in large amount, due to this sudden shaking buildings or structures experiences initial force due to which partial or collapse or fully collapse condition occur. But when the buildings are adjacent to each other and due to insufficient separation the collision takes place which results more damage in the structure. The phenomenon where building displaces out of phase and collides with each other, this is known as pounding of building. But the level of damage caused by earthquake on a structure depends on the amplitude and the duration of shaking. The amplitudes are largest with respect to the large earthquake and the duration of shaking generally increases with the size of earthquake.

As per Indian standard 1893:2002 the structure is said to be sway when the lateral displacement is more than the 0.004 times the height of structure above the ground. This displacement causes the high torsion and moment in the structure. The effect due to lateral displacement becomes more critical when the two structures are placed adjacent to each other without providing insufficient gap. The effect experienced by both the structure is known as pounding effect.



The powerful 2001 Bhuj earthquake has been most dominating earthquake in the last five decades in India. Reinforced concrete building suffered the heaviest damage during the earthquake because of poor design and construction practices and pounding of adjacent structure was evident at Ajodhya apartment in Ahmadabad with significant damages.

TYPES OF POUNDING

1. Floor to column pounding:

This type of pounding occurs in some adjacent buildings in which the floor levels are not in the same heights. Therefore when shaking with different phases occurs, the floor of one building hits the column of another, and causes serious damages which can lead to fracture of the columns of storey. This type is the most dangerous impact

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that can result in sudden destruction of the building. The separation of two building is kept according to IS 4326.

2. Adjacent buildings with greatly differing mass:
Since adjacent buildings may differ in the structural system of floors and in their application, they have different mass which causes different phase oscillations, since the lighter building tolerates more intensive response.

3. Buildings with significantly differing total heights:
When two structures with different heights are adjacent, because of different dynamic properties, the short structure hits the adjacent one, which results in floor shearing in higher levels of impact part.

4. End buildings of a row when all the buildings have similar properties:
This type of impact is usually seen in buildings, which are built completely the same. In this type of impact, some similar buildings that oscillate similarly, in strong earthquake, hit the last building in the series and causes serious displacement in the pounded building. Existence of same shape of the vibration in some building and height momentum lead to last building has intensive responses.

FACTORS AFFECTING POUNDING

1. Soil conditions
2. Building heights and relative difference between heights
3. Separation between adjacent buildings
4. Lateral load resisting structural system.
5. The peak ground acceleration of the earthquake at location of building.
6. The material of construction.
7. Type of induced vibrations.
8. Damping mechanism.
9. The lateral eccentricity and twisting motion ,if any

II. LITERATURE REVIEW

Amruta Sadan and Tapashetti(2014):
In this journal author analyzed a three dimensional reinforced concrete moment resisting frame buildings with open ground floor in SAP2000 to observe pounding and also Time History Analysis is carried out taking data of Elcentro. Author also said that since gap between the buildings cannot be increased to accommodate the relative movement of both the buildings, the relative displacement can be reduced by providing additional stiffness i.e. By bracings, shear wall and by combined action, to accommodate out of phase movement under provided gap and also Shear walls are provided to reduce the lateral displacements in the buildings, here they have replaced masonry wall with RC wall. They also provided information that to improve seismic response FVD is provided as a diagonal brace as it substantially increases the damping within the structure and also provides additional stiffness and strength and energy dissipation capacity during strong winds and moderate earthquakes.

M.A. Somwanshiand M.A. Bhokare,2017): This study considers the simple case of collision between two buildings with floors at the same height. They also stated that If by increasing the distance of the two buildings still pounding occurs, this increase of distance increases the responses and by using impact absorbing material, the acceleration response of structures was reduced which can be very important, especially for non-structural elements also Connecting the structures at a floor level reduced the responses. In this author has focused on lighten the seismic pounding effects between buildings and measures to reduce this effect. . The viscous damper and elastic spring can reduce the structural response. They have also described that elastic spring itself can limit the pounding force. By connecting the structures at a floor level reduced the response of adjacent structure. Connecting the two buildings at more than a level did not improve very much the responses of the structures.

Puneeth Kumar and S Karuna,(2015):
In this study to observe pounding between adjacent buildings, separated by an expansion joint were subjected to gravity and dynamic loading and were analyzed by using Sap2000. After analyzing they resulted that displacement of buildings with bracings is reduced 50% than buildings when compared with bare frame and also was the same case with shear wall.In this author concluded that during strong earthquakes, adjacent buildings without proper separation gap are affected by pounding. When author comparing all the cases of study, adjacent buildings with same floor level, different floor level and set back, out of phase movement was greater than expansion joint which created impact force adjacent

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buildings, with different dynamic properties, vibrated out of phase leading to pounding damage. The maximum response (displacement) was more in taller buildings than the shorter one. They also concluded that Buildings with shear wall are more effective than with bracings.

M. Abdel-Mooty and H. Al-Atrpy (2009): In this paper author studied the factors affecting seismic pounding of adjacent buildings were identified and critically examined. The formulation and modeling of pounding phenomenon was introduced. Parametric study on seismic pounding phenomenon was conducted to examine the effects of various factors on seismic pounding. They calculated Pounding forces by using software SAP 2000 where nonlinear gap elements between the adjacent building floors were used to calculate pounding forces. They concluded that variation in the stiffness of the gap element has negligible effect on the calculated pounding forces but the size of the gap significantly affect the calculated forces and their frequency of occurrence. They also concluded that pounding forces depends very much on the characteristics of the earthquake records and the dynamic characteristics of the adjacent buildings. They stated that effect of earthquake record is not limited to just the value of force; it affects the frequency of hits and also Pounding forces increases as the difference in the structural systems in the adjacent buildings increases. They said that largest pounding forces occur when there is a difference in height of the adjacent buildings due to the whiplash effect. Highest values of pounding forces occur near the top of the building. In generally pounding forces decreases as the separation distance increases. However, very small separation distance may prevent the build-up of momentum of the moving masses thus reducing the impact forces. They observed that the number of pounding hits consistently decreases as the separation distance increases.

M phanikumarand J D Chaitanya Kumar (2015):
In this thesis the factors affecting seismic pounding of adjacent buildings were identified and c examined. Parametric study on seismic pounding phenomenon was conducted to examine the effects of various factors on seismic pounding. They calculated Pounding forces acting on structure by using commercial software packages like ETABS, where nonlinear gap elements between the adjacent building floors are used to calculate pounding forces. Based on the observations from the analysis results, they concluded that Compared to the linear dynamic analysis the storey displacements of the two adjacent buildings increased 90 to 95% with non-linear dynamic analysis. They also mentioned that there is no pounding between two adjacent buildings when it is analyzed by linear dynamic analysis because the displacement are very small, but there is a pounding effect when it is analyzed by non-linear dynamic analysis because the displacements increased largely. They concluded that it is necessary to carry out non-linear dynamic analysis to know the actual response of the structure. The displacements of the buildings decreasing gradually by introducing shear walls over brick infill walls at suitable locations. From this we can say that the minimum seismic gap can be reduced by introducing shear walls when the separation distance available is less. In this the pounding forces are decreasing by 10 to 15% between two adjacent buildings as the separation distance is increasing with a variation of 10 mm gradually. So, it can be said that the pounding effect can be decreased with increasing separation distance. They said that pounding forces are also decreases gradually between two adjacent buildings by introducing shear walls at suitable locations compared to fully brick infill walls. So, that pounding effect can be mitigated by introducing shear walls over brick infill walls.

III. CONCLUSION

From the above literatures it can be concluded that the building with lighter mass are prone to the most intensive response. When the mass and stiffness of both buildings are same they oscillate in the same phase and so there is no overlap, hence no pounding but if the stiffness is kept same and masses are changed then pounding is observed.

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