International Conference on Recent Innovations in Science, Technology, Management and Environment
Indian Federation of United Nations Associations, New Delhi (India) (ICRISTME-16)
19th June 2016, www.conferenceworld.in ISBN: 978-81-931039-1-3

# EFFECT OF GAP BETWEEN BUILDING ON SEISMIC POUNDING FORCE

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## ABSTRACT

*The construction industry is growing very fast across the globe as such the demand for the space is increasing day by day. It is often in metropolitan cities that buildings are build very close to each other due to lack of space and this leads to phenomenon called "Pounding". The pounding means a collision of adjacent building to each other due to insufficient space between the buildings. The pounding is a dynamic property and depends on many factors.*

*In this papereffect of GAP between the building on pounding force is studied in detailed. The modeling and analysis of building is done by using ETABS analysis package. The gaps between the buildings are modeled by using compression only "GAP" element which consists of specified gap and a spring with proper stiffness. The nonlinear modal time history analysis is performed for three different ground motion characteristics and parameters such as displacement, pounding force and base shear etc are compared and presented.*

## I. INTRODUCTION

The pounding means a collision of adjacent building to each other due to insufficient space between the buildings. The two building or a part of the same building is separated by a gap called as expansion gap or seismic gap. If the sufficient gap is provided for the building to cater the seismic displacement demand the gap is categorized as "Seismic Joint". If gap is provided only to cater the expansion and contraction of building that gap is called as "Expansion Joint". It is always desirable to have seismic joint between two adjacent building or a part of the same building but due to some unavoidable circumstances this may not be possible for all buildings and this leads to seismic pounding.

Pounding of building is a dynamic phenomenon and depends on the many factors such as mass of building, height of building etc. The pound is more critical when the floor height of two adjacent building is unequal because the impact will be at the middle of columns. In this paper the efforts are made to study the effect of gap between building on pounding force.

## II. METHODOLOGY

Two adjacent buildings G+12 and G+7 are considered for the study. The gap between the buildings is considered from 50mm to 140mm with the difference of 30mm each. Following four mathematical models are prepared and time history analysis is performed on the building.

Model M1: Two adjacent buildings at different levels with 50mm gap between them

Model M2: Two adjacent buildings at different levels with 80mm gap between them

Model M3: Two adjacent buildings at different levels with 110mm gap between them

Model M4: Two adjacent buildings at different levels with 140mm gap between them

Model M5: Two adjacent buildings at different levels with 170mm gap between them

Model M6: Two adjacent buildings at different levels with 200mm gap between them

Model M7: Two adjacent buildings at different levels with 230mm gap between them

Model M8: Two adjacent buildings at different levels with 260mm gap between them

The building gap is modeled by using nonlinear link element with GAP properties. The stiffness of GAP element does not affect the analysis results however it is found from the available literature that the Gap element should be approximately 20 times stiffer than the lateral storey stiffness of stiffer building. The shorter building is considered as stiffer building and stiffness of GAP element may be worked out based on the stiffness of shorter building. These buildings are then join by GAP element to form the base models as described above. Nonlinear modal time history analysis is performed on the above five models. For the modal analysis Ritzs vector are used. The various parameters such as pounding force at each level, link deformation etc are compared and presented.

## III. MODELLING AND ANALYSIS

For deciding the sizes of various members the preliminary analysis are carried out on each of the building frame by equivalent static and response spectra dynamic analysis. Each of the building is considered independently for this analysis as

1) G+12 with bare frame system 2) G+7 with bare frame system

The various load combinations for strength and serviceability used for the design of members are listed below.

1) 1.5 (DL + LL + RLL)
2) 1.2 (DL + LL + RLL + EQX)
3) 1.2 (DL + LL + RLL - EQX)
4) 1.2(DL+ LL + RLL + EQY)
5) 1.2(DL + LL + RLL – EQY)
6) 1.5(DL+ EQX)
7) 1.5 (DL - EQX)
8) 1.5 (DL + EQY)
9) 1.5 (DL - EQY)
10) 0.9DL + 1.5EQY
11) 0.9DL - 1.5EQY
12) 0.9DL + 1.5EQX
13) 0.9DL - 1.5EQX

The seismic data used for the analysis is shown in TableI.The design results are not shown here however the optimum sizes of the members are shown in Table II

**Table I Data used for analysis**

| | |
|---|---|
| Response reduction factor | 5 |
| Importance factor | 1.5 |
| Soil condition | Medium |
| External wall | 230mm |
| Internal wall | 115mm |
| Thickness of shear wall | 200mm |
| Unit weight of Brick masonry | 18 KN/$m^3$ |
| Unit weight of RC | 25KN/$m^3$ |
| Thickness of slab | 150mm |
| Floor to floor height | 3.2m |
| Grade of steel | Fe 415 |
| Grade of concrete | M 30 |
| Floor finish | 1.875 KN/$m^2$ |
| Live load | 3.0 KN/$m^2$ |
| Height of parapet wall | 1m |
| Type of frame | SMRF |

**Table II Optimum sizes of members (ETABS design Output)**

<table>
<tr><th>Building Description</th><th>Storey</th><th>Sizes of beams (mm)</th><th>Size of columns</th><th>Size of brace</th></tr>
<tr><td rowspan="3">G+12 with bare frame</td><td>1,2,3</td><td>300 x 450</td><td>600 x 600</td><td>NA</td></tr>
<tr><td>3 to 9</td><td>300 x 450</td><td>500 x 500</td><td>NA</td></tr>
<tr><td>9 to 14</td><td>300 x 450</td><td>400 x 400</td><td>NA</td></tr>
<tr><td rowspan="2">G+7 with bare frame</td><td>1,2,3</td><td>300 x 450</td><td>500 x 500</td><td>NA</td></tr>
<tr><td>4 to 9</td><td>300 x 450</td><td>400 x 400</td><td>NA</td></tr>
</table>

The above sizes are worked for the gravity load and a lateral load (Seismic load) and for all design load combinations as per IS 456:2000 for strength and serviceability. The equivalent static earthquake load is calculated based on IS 1893:2002 for the approximate fundamental natural time period of building considering stiffness contribution of infill walls.

The shorter building is considered as stiffer building and stiffness of GAP element is worked out based on the stiffness of shorter building. The calculated stiffness of GAP elements at each level are shown in Table II .Total load applied is 40KN at roof level. The mathematical model of building is shown in Fig.1

**Table III Stiffness of GAP Element**

| Sr. No | Model | Level | Displacement (mm) | Calculated Stiffness of GAP Element(KN/m) |
|---|---|---|---|---|
| 1 | Bare Frame | 9 | 1 | 800 x10 $^{3}$ |
| | | 8 | 0.9 | 888.88 x10 $^{3}$ |
| | | 7 | 0.8 | 1.00 x10 $^{6}$ |
| | | 6 | 0.6 | 1.333 x10 $^{6}$ |
| | | 5 | 0.5 | 1.6 x10 $^{6}$ |
| | | 4 | 0.4 | 2 x10 $^{6}$ |
| | | 3 | 0.2 | 4 x10 $^{6}$ |
| | | 2 | 0.2 | 4 x10 $^{6}$ |
| | | 1 | 0.1 | 8 x10 $^{6}$ |

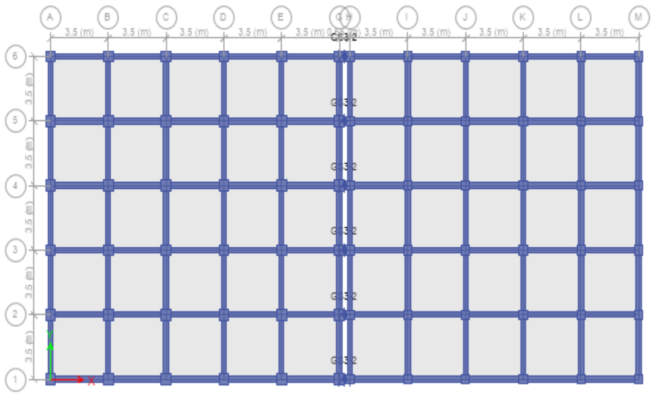
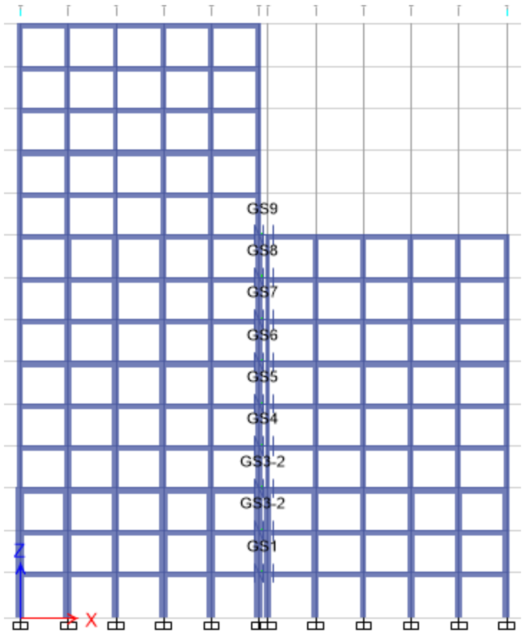
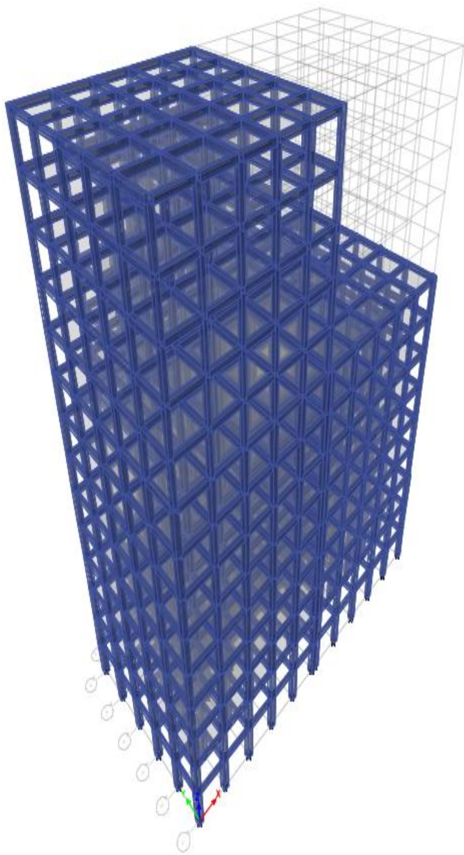


**Fig1 Typical plan of building**




**(a) Elevation**



**(b) Render View**

**Fig 2 Building Mathematical Model**

**Table IV Details of time history data**

| | |
|---|---|
| Earthquake | Imperial Valley |
| Date & time | 15/10/1979 |
| Station | Anderson Road |
| Hypocentral distance | 27.47 Km |
| Earthquakecomponunt | N 75 E |
| Peak acceleration | 349.18 cm/s/s |
| No of acceleration data points recorded | 1957 |
| Unit | cm/$s^2$ |
| Time interval | 0.02 sec |
| Magnitude | 6.6 |
| Scale factor for ETAB | 10 |

## IV. RESULTS AND DISCUSSION

The results obtained from the analysis are presented

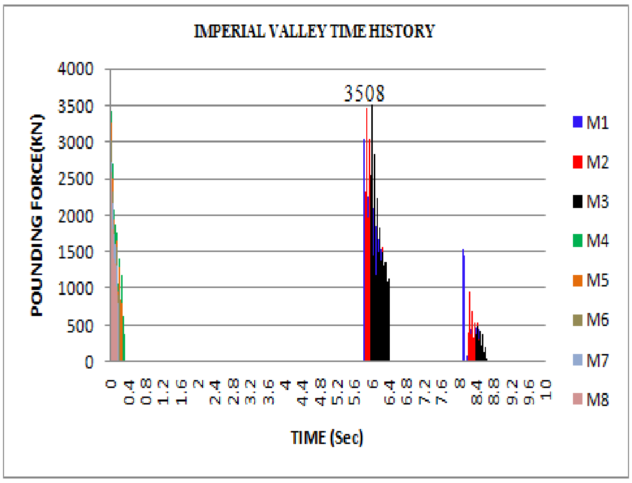



**Fig3 Time history of pounding force at Roof Level**

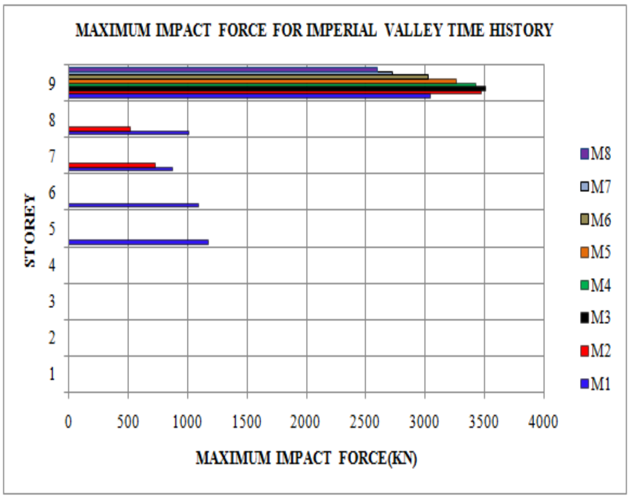



**Fig 4 Storey wise maximum impact force**

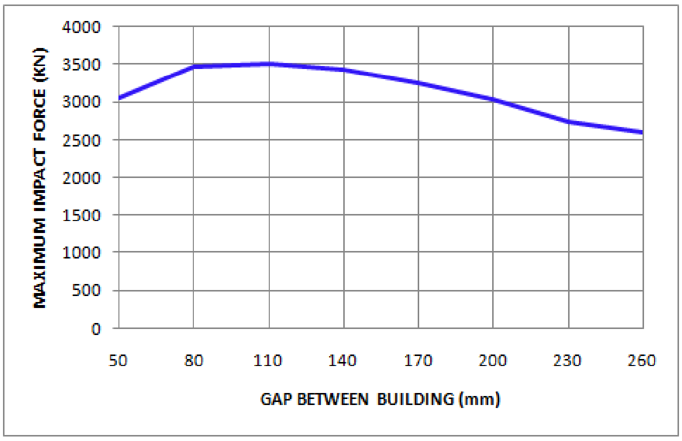



**Fig 4 Variation of maximum impact force**

As observed from the results impact force was found to be maximum for model M3 where the gap between the buildingis 110mm.The impact force increases up to a gap of 110mm and there after it decreases. The link deformation history at roof level was shown below.

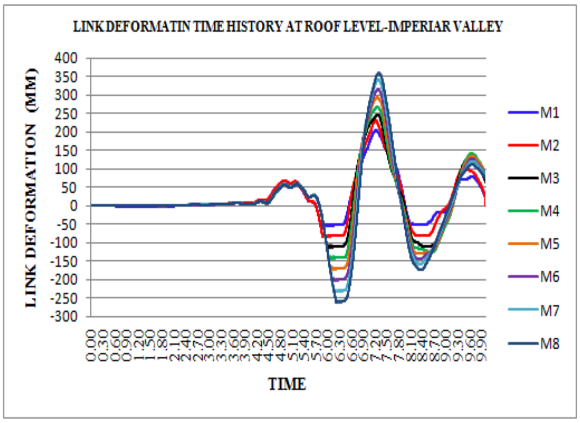



**Fig 5 Link Deformation Time History for Imperial Valley (Link ID K10)**

As observed from link deformation history demonstrate the working of link element used in modeling. The maximum negative displacement is the compression in the gap element which is restricted to 260mm and over this displacement is converted to the link force which is the actual impact force.

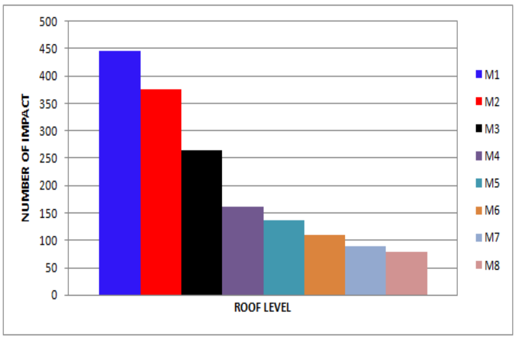



**Fig 6 Number of Impacts at roof level for different gap between building.**

From the results obtained it is clear that gap There is around 5% decrease in impact force can be achieved by increasing the gap between the building by 30mm. The number of impact also decreases as the gap increases.

## V. CONCLUSIONS

The gap between the buildings plays an important role as far as pounding is concern. Primarily the maximum impact force increases as gap increases and then after it goes on decreasing. The impact force was increases up to a gap of 110 mm and then impact force was found to be decreasing. There is approximately 5% reduction in impact force was observed for every 30mm increase in gap in building. There is 26% reduction in impact force was observed when gap between the building increases from110mm to 260mm. The number of impact at roof level goes on decreasing as gap increases. The 368 number of impacts was reduced as the gap increases from 50mm to 260mm. There is maximum of 36.8% reduction in number of impact can be achieve as gap increases from 50mm to 140mm.

## REFERENCES

[1]. M. Papadrakakis,t c. Apostolopoulou,z a. Zacharopoulos/ and s. Bitzarakis on “three-dimensional simulation of structural poundingduring earthquakes”
[2]. Praveen k. Malhotra on “dynamics of seismic pounding at expansion joints concrete bridges”
[3]. Bruce f. Maison and kazuhikokasai, on “analysis for type of structural pounding”
[4]. Kazuhiko kasai , anu r. Jagiasi,z and van jeng on “inelastic vibration phase theory for seismic pounding mitigation”
[5]. B. Madani a, f.behnamfara,n, h.tajmirriahi on “dynamic response of structures subjected to pounding and structure–soil–structure interaction”
[6]. Petroskomodromos on “simulation of the earthquake-induced pounding of seismically isolated buildings”
[7]. Jenghsianglin a, chengchiangweng b on “spectral analysis on pounding probability of adjacent buildings”
[8]. Robert jankowski on “pounding force response spectrum under earthquake.excitation”