A PARAMETRIC STUDY ON SEISMIC POUNDING BY CONSIDERING EFFECT OF GAP BETWEEN THE BUILDINGS

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***Abstract*: The present work it is aimed to investigate using ETABS software that, does pounding exists for a larger span buildings separated with the facilitation of expansion joints? The building is introduced with a joint gap model at mid section of the building model in x- direction, y- direction and along both x and y directions. Performance disquisition is carried for both Response Spectrum and Step Time analysis. The work outcomes describe the influence of expansion joints, infill masonry frames and masonry bracings on striking of buildings.**

Results obtained encounters that infill frames could perform in a better under pounding and also the expansion joint gap should be altered for each direction where the striking effect is enhanced. And the analysis method Step Time shows greater extent of results with the influence of joint gap when collated with Response Spectrum of Analysis.

***Keywords*: Seismic Pounding, Gap Model, Storey Displacements, Storey Drifts.**

I. INTRODUCTION

1.1 GENERAL

Pounding between any adjacent buildings could be worst damage as the buildings lie side by side with different dynamic properties that vibrates phase and separation distances/ system energy dissipation is nearly sufficient to meet the proposals on adjacent buildings. Seismic effect between adjacent buildings during the seismic events is very strong in common, despite the recommendations of the expulsion of design codes. Pounding significantly modifies the dynamic behavior of the entry on the ground, in terms of relative and absolute displacement accelerations; therefore, you must consider for a proper assessment of the seismic performance. The worst case is not aligned blocks (floor to column- pounding) since the impact of large slabs and rigid against average height columns can break them and then lead to structural-collapse; however, the collision between the blocks movement (floor-floor striker) is more common and can also be very threatening. This document aims to blows between RC slabs with buildings movement. Technicians (difficulty using sets of expansion) and economic (loss of land use) posses the system construction very sophisticated in many commuter belt cities is the major agitation in addressing seismic disruption. For the reasons explained, it is very widely acceptable: an attack is a adorable phenomenon to be avoided or rehab the fields on the ground acceleration values corresponding design will be in many cases the actions that are significantly higher than earthquake described by the design code recommendations used until present.

1.2 SEISMIC STRIKING EFFECT BETWEEN THE BUILDINGS

Striking force is one of the lead cause for majority of building damages in earthquake. The non-structural damage induces pounding/ lateral movement across the separation joints in between adjacently lying structures. Seismic striking in the seam alongside building occurs when

- During an action of ground motion
- During varying dynamic characters of structures
- When adjacent buildings vibrates out of phase

The separation joint is a small width between any two diverse building or often two appendages of the similar spontaneity that empowers the structures to relocate independent from of one another.

1.3 GAP ELEMENT

Gap is a common element that connects two nodes adjacent to model the contact. It is enabled when structures are and when they will turn away. A force of shock is generated when they arrive. Each service can be linear stiffness and damaging properties effective. The mass from the link or element support was located in the joints i and j and half of the mass attributed to three degrees of freedom in each of the elements of translational joints. Cannot believe the internal effects within the own element. Typically the effective value is the rigidity in a range of 102 to 104 times more than the rigidity in the elements connected.

1.4 INFILL FRAMES

A supporting wall three dimensional frame work structure which is generally made of steel or reinforced cement concrete that covers the perimeter of a building. Frames usually ensure the bearing function but the infill walls serve as a separator to interior and exterior space, which fills the boxes of outer frames. To bear its own weight it has a unique static function. The use of these walls provides an economical and durable solution. The behavior of infill walls influence on the

building response with increased effect of stiffness and also energy dissipation. For the better performance of infill's it should built in adherence with frame elements.

1.5 MASONRY BRACINGS

The diagonal element which is a compression member resists the compression forces is called Bracings. With the introduction of any lateral forces it offers stable nature with increased stiffness.

II. OBJECTIVES OF THE PRESENT STUDY

Structural pounding is very complex phenomenon which is involved in causing local damages to structures during earthquake. It is very essential to diquisite the seismic pounding out-turns between adjacent buildings. The principal aims of this present study are as follows:

1. To study whether the pounding forces arrives for same storied buildings with the introduction of gap element.
2. Comparison of effect of infill walls over wall with bracings (Struts) on displacement profiles to study the minimum seismic gap to be provided for such type of buildings by dynamic analysis.
3. Comparison of storey displacements and storey drifts for the building by analysis with Time history method and comparing it with response spectrum results.

III. METHODOLOGY

Various approaches of disparate convolutions have been advanced for the structural seismic analysis. The current study E-TABS software is used for the analysis which the various analyzing methods are involved. The main methods currently used for this analysis are:

- Linear Static Analysis (Seismic Co-efficient Analysis).
- Linear Dynamic Analysis (Response Spectrum Analysis).
- Non- Linear Dynamic Analysis (Step Time Analysis).

3.1 Modeling And Analysis for a Proposed Frame Structure

The main focus of this study is on the effect seismic pounding between adjacent buildings with same height (storey), different heights and with separation distance of 50mm by providing a gap model with a spring.

3.1.1 Selection of Buildings

In the present analysis it is considered to analyze 2 types of buildings with categorizing the buildings providing gap of 50mm along X-axis, Y-axis and X-Y axis of a single separation building with large bays. The details of the structures are shown below:
A nine storey building of 36mx36m is considered where the structure is passage separated and bare frame analysis, analysis with brick walls, infill frames and Braced frames at periphery are to be performed and results are compared.
The modeling is done for both types of frames and direction of joint provided by defining the properties of materials, members, load cases and load combinations.

Table 1: Proposed Beam sizes and Column sizes with a definite grade of concrete

Grade Of Concrete, f_{ck} N/mm^2	Beam Sizes (mm x mm)	Column Sizes (mm x mm)	Slab Depth (mm)
M30	230x450	230x450	150
M30 (mid compartment)	230x300	230x450	150

Table 2: Description of material properties

Grade of Concrete	M 30
Grade of Steel	Fe 415
Young's Modulus of Concrete, E_c	27386.12 N/mm^2
Young's Modulus of Steel, E_s	2x10^5 N/mm^2
Density of Reinforced Concrete	25 kN/m^3
Density of Brick Frames (infill)	20 kN/m^3
Thickness of infill wall	230 mm

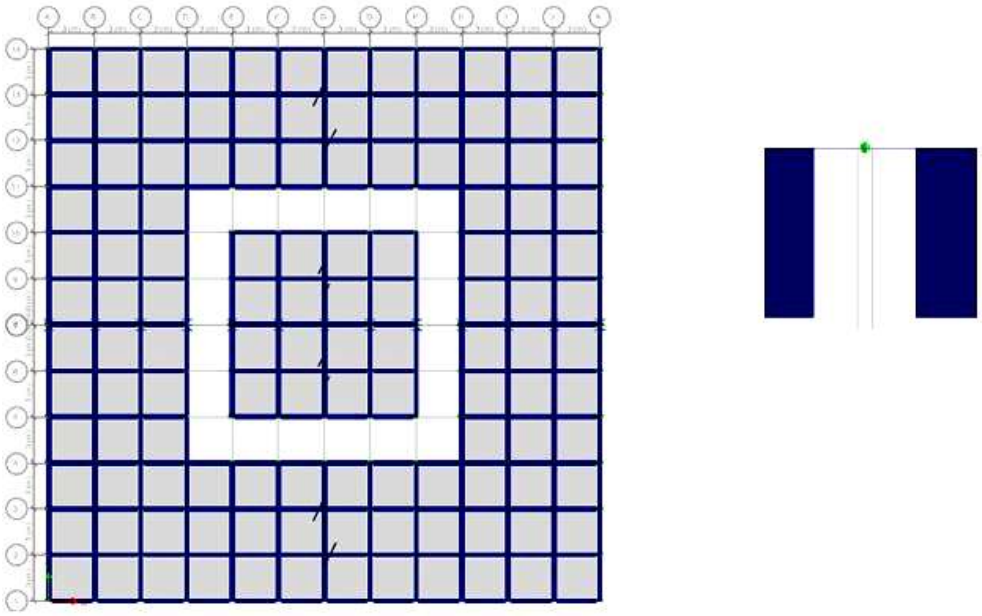

Figure 1: (a) Plan View of a Y- directional gap element building with bare frame
(b) Extruded View of Gap Model

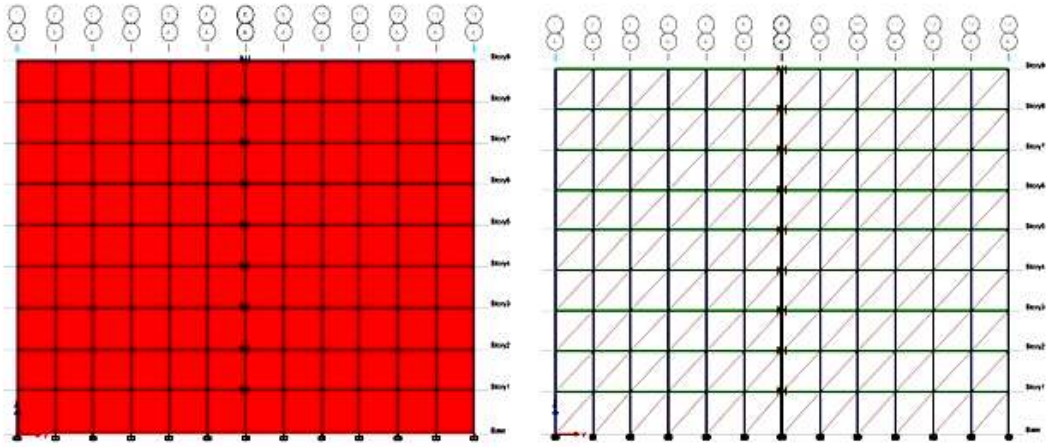

Figure 2: Elevated model of building with a infill frames and masonry bracing frames

For the above models with an expansion joint introduced along x-direction, y direction and x-y direction analysis is performed for both response spectrum and time history analysis.

Response Spectrum Analysis: The Response Spectrum analysis is carried for the Zone V region with medium type of soil and the design is as follows

Seismic Design as per IS: 1893: 2002
Data:
Zone Factor, Z=0.36 (for zone V)
Importance Factor, I = 1
Response Reduction Factor, R= 5
Soil Type= Type 2 Medium Soil
Calculations:
For medium soil sites,
Ta = 0.09*27/√36
Ta = 0.405 Sec.
Ah= (Sa/g)x(I/R) x(Z/2)
Ah = (0.36/2)*(1.0/5.0)*2.46
Ah = 0.088
V_b= 6737.13 kN.

Time History Analysis: In the present study Hollister earthquake attack in 1989, at California Time history input is collected and analysis is carried.

Location: Hollister, California
Date: October 17, 1989
Origin time: 5:04:15 pm
Duration: 8- 15 seconds
Magnitude: 6.9 Mw
Peak acceleration: 0.65g
Intensity: IX (Violent)

IV. RESULTS AND DISCUSSIONS

4.1 Storey Displacements

By the performance analysis of response spectrum method and time history method of analysis it is found that the infill frames and bracings have proved to provide performance under pounding forces. The following comparisons were done between response spectrum and time history method.

Table 3: Comparison of displacement profiles between Time History results with Response Spectrum Results.

Displacement in mm						
Time History			Response Spectrum Analysis			
X	y	xy	x	y	xy	Storey Height
306.90	269.96	254.28	59.70	25.70	26.40	27
278.38	257.19	233.62	57.70	24.70	25.30	24
246.20	235.81	212.31	54.30	23.10	23.60	21
211.03	210.00	185.16	49.40	20.80	21.30	18
172.30	187.90	169.27	43.20	18.10	18.40	15
163.85	158.19	139.45	36.00	14.80	15.10	12
142.70	121.40	95.89	27.80	11.20	11.40	9
93.50	80.01	69.96	19.00	7.40	7.50	6
42.10	37.58	28.64	9.70	3.40	3.80	3

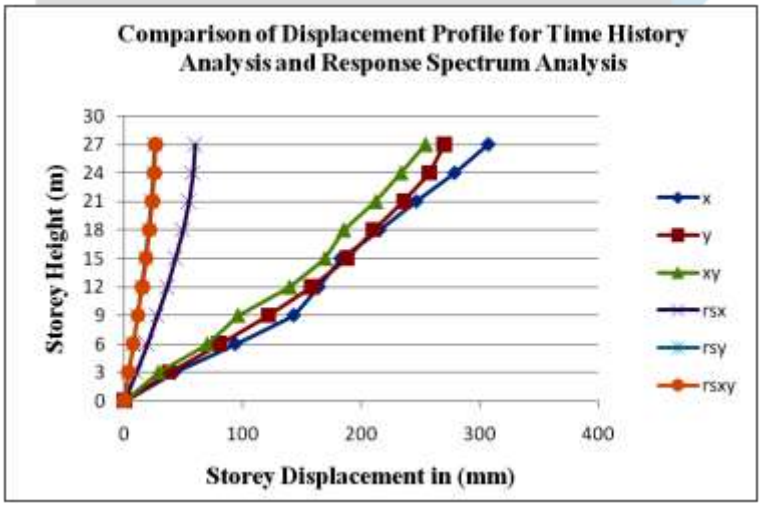

Figure 3: Displacement Profile Comparison of Response spectrum and Time History analysis

By contrasting the results it is clear that there is a drastic dissimilarities in displacement profile of time history where the value 306.90mm, 269.96 mm and 254.28 mm in time history and 59.70 mm, 25.70 mm and 26.40 mm for analysis through response spectrum procedure along x, y and xy directional elements.

4.2. Storey Drifts

Table 4: Storey drifts at different storey levels in comparison with Time history results for X- directional gap element

Storey Height (m)	Storey Drift For X Directional Gap Element		Storey Drift For Y Directional Gap Element		Storey Drift For XY Directional Gap Element	
	Time History Analysis	Response Spectrum Analysis	Time History Analysis	Response Spectrum Analysis	Time History Analysis	Response Spectrum Analysis
27	0.007850	0.00067	0.006634	0.00034	0.00629	0.00034
24	0.009326	0.00113	0.008110	0.00056	0.00776	0.000558
21	0.013390	0.00163	0.012174	0.00076	0.01182	0.000761
18	0.015910	0.00260	0.014694	0.00094	0.01434	0.000939
15	0.017450	0.00240	0.016234	0.00109	0.01588	0.001088
12	0.017500	0.00273	0.016284	0.00121	0.01593	0.001207
9	0.016400	0.00293	0.015184	0.00129	0.01483	0.001291
6	0.008133	0.00310	0.006917	0.00133	0.00657	0.001324
3	0.005533	0.00320	0.004317	0.00106	0.00397	0.001059
0	0	0	0	0	0	0

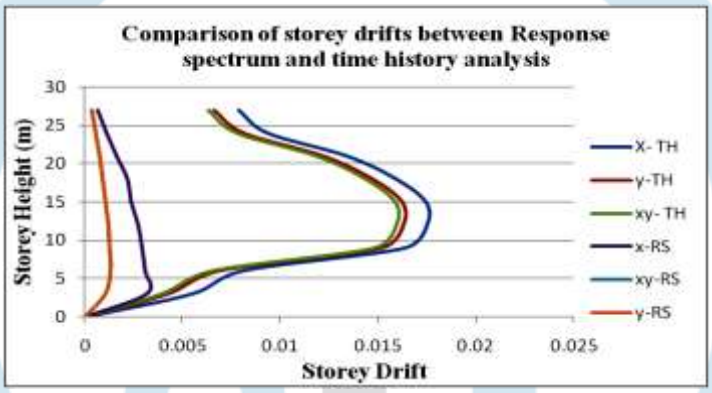

Figure 4: Graphical representation of comparison on storey drifts between response spectrum and time history method

With the values obtained from the analysis and by the above graph it is clear that the values of drift are out of phase in time history analysis when compared to response spectrum analysis. The limit of storey drift is h/250 where h is the height of the storey. The maximum drift observed is 0.0175 along x-direction, 0.01628 along y-direction and 0.01593 along x-y direction.

4.3 Storey Shear

Table 5: Storey Forces obtained from Response Spectrum Analysis

Direction of gap element	Storey Force (kN)		
	Bare frame	Infill frame	Brace frame
x	6834.34	8743.28	7678.81
y	6834.31	8743.19	7678.79
xy	6868.19	8778.60	7712.57

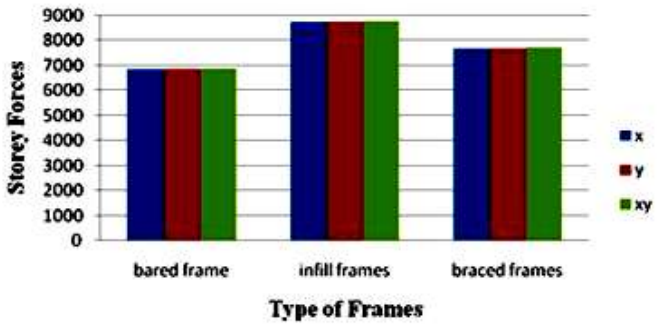

Figure 5: Graphical plot of storey forces with different frames

The graph represents the storey forces are maximum for infill frames with the values of 8743.28 kN, along x- direction, 8743.19 kN along y- directional and 8778.60 kN along x-y directional joint element model

Table3: Comparison of storey forces of bare frame between Response Spectrum and Time History Method

Direction of gap element	Storey Force (kN)	
	Response Spectrum Method	Time History Method
x	6834.32	180140.80
y	6834.34	180336.45
xy	6868.19	181712.62

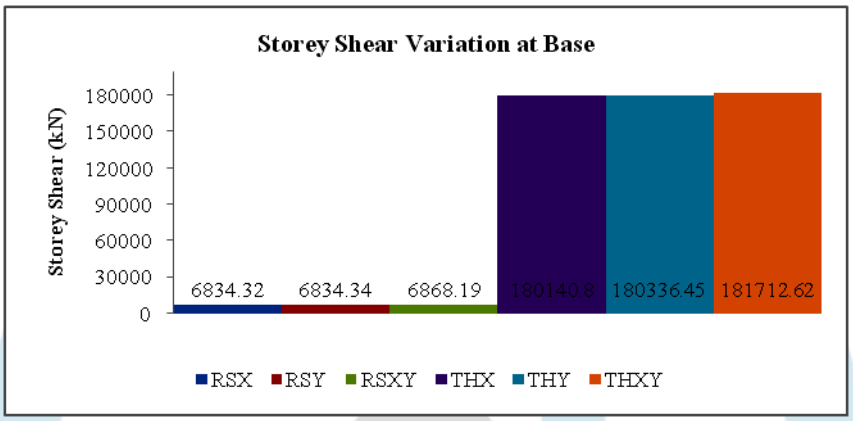

Figure 5:Graphical plot of storey shear at base variation between time history and response spectrum

V. CONCLUSION

When the analysis of pounding is carried for each type of frames at every direction of joint space many outcomes from the results were observed. By noting the observations the following conclusions were made,

1. With the introduction of infill frames the maximum displacements can be reduced up to 98.3% when compared to other frame systems in case of response spectrum such that pounding can be minimized for such an extent.
2. By the variation of displacement profiles the spacing should be increased with 74.8% along X and Y a directions and 74.21 % along X-Y direction. Where it is noted that the direction of expansion joint has no greater influence over the pounding in Response Spectrum method of analysis and the width of joint has major influence over it.
3. From time history analysis it is observed : the gap element has an larger influence over direction of gap space in which it is observed as to accommodate 56.69% lesser along x direction displacements when compared with other two directions. The maximum spacing accommodation to be provided is 320 mm.
4. Also in consideration of storey drifts there is a difference of 31.45% increase from the maximum permissible limit i.e, h/250 where it is convincing with maximum damage instance of California Earthquake.
5. It is very clear from the results of past history that larger space or joint width accommodation should be facilitated between the buildings at the regions where there is supplemental domination of earthquake's impact.
6. For rectangular columns the orientation of columns also influences highly in displacements of the buildings.

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