Pounding Analysis Between Adjacent Building As Per Indian Standard Code

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Abstract- *The aim of this paper is to analyze the safe seismic pounding gap between adjacent high rise buildings. In metropolitan areas structures are constructed very close to each other or sometime just adjacently connected to each other since land cost is too high and deficiency of land as well. But problem arise when shaking of ground occur due to earthquake, these structure with different characteristics do not have safe distance between them to show their displacement independently. Hence cause adverse damage to each other with their different structural members. Since, loses of lives & properties are very much depends upon safety of structures. Therefore pounding gap is one of the important aspect concerning to safety of structures. In this paper, safe seismic gap between two adjacent buildings have calculated using ETABS as per Indian Standard Codes.*

Keywords- Seismic Pounding, Adjacent Building, Structural Damage, ETABS Analysis.

I. INTRODUCTION

Seismic pounding may be defined as the collision of two adjacent building which are vibrating out of phase during earthquake. The Pounding of adjacent buildings would have worse damage to an adjacent buildings with different dynamic characteristics like displacement, acceleration,etc which vibrate out of phase (means deflection curve crest of one building coincide with deflection curve trough of another building) and if there was insufficient gap or energy dissipation system so as to move independently then it could cause severe damage. Previous seismic codes didn't gave perfect guidelines to for pounding consideration point of view, because of this and due to economic considerations including maximum land usage requirements, especially in the high dense populated areas like metro cities, there are lot of buildings which are constructed very close to each other hence they may suffer pounding damage in future earthquakes. Hence providing large separation is controversial from both point of view i.e, technical point "difficulty in using expansion joint" and economic point of view "loss of land usage". An earthquake release large amount of seismic energy which hit the foundation and thus the superstructure vibrate in wave form. Hence two adjacent building will vibrate in wave form but if they were in contact with each other or very close to each other then there structural component will collide each other. Also if they were out of phase then consequences will be worst. And the areas of congested building system are highly prone to pounding damage since there were luckiness of availability of land. Consequently, it has been generally acknowledged that beating is an unwanted marvel that ought to be forestalled or relieved zones regarding the comparing configuration ground increasing speed esteems will lead as a rule to seismic tremor activities which are astoundingly higher than characterized by the structure codes utilized something like at this point. The most easiest and successful route for beating alleviation and diminishing harm because of beating is to give enough division yet it is once in a while hard to be actualized because of enumerating issue and significant expense of land.

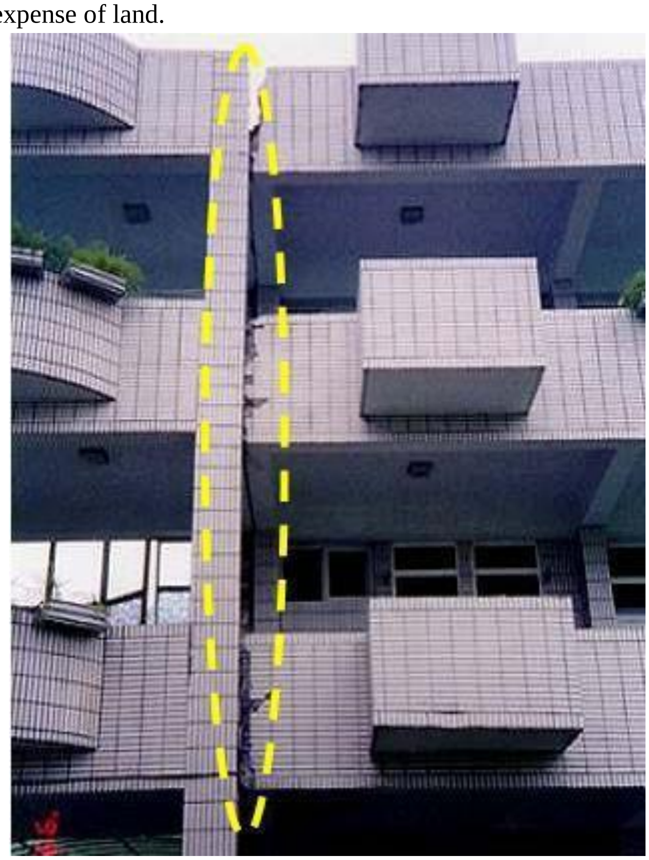

Fig-1 :Pounding of Adjacent Buildings

II. CAUSES OF POUNDING

Possible reasons of forming structural pounding may be as follow:

Main reason of structural pounding is having insufficient gap or distance between two structures so as they can't be move independently during earthquake. Along with this condition many different causes may found as follow:

1. If foundation rest on soft soil and during earthquake may would led to slight settlement which cause deflection or may titling the structure, if it was not provided by sufficient gap then cause pounding.
2. Buildings subjected to torsion having irregular lateral loading systems will rotate in plan during an earthquake, and due to it, pounding may occurs near the building periphery & may damage to adjacent building.

Hence, basically to overcome pounding effect we have to analyze the structure using various method and cross verify it by our Indian Standards code norms.

III. POUNDING MIGITATIONS AS PER IS CODE

Recommendation as per IS 1893:2016 Part1

- Separation between adjoining structures should be R times the sum of displacements of individual structures. Calculated as per design base shear where R is response reduction factor (Clause 7.11.1)
- When floor level of adjacent building are at same level then separation distance shall be calculated by $R_1\Delta_1 + R_2\Delta_2$. Where R &$\Delta$ are the respective response reduction factor & displacement of building calculated.

As per IS 1893-2016 P1,
Seismic gap width should be,
$Seismic\ Gap = (\Delta_1 + \Delta_2) \times R$
Where, Δ_1, Δ_2 are storey displacement

IV. METHODOLOGY

To observe the pounding, two reinforced concrete moment resisting buildings ie G+15 & G+10 are analyzed using ETABS. All column are rectangular with fixed base & beam to Beam connection are also taken as fixed. Typical plan of both structures are kept same are shown as below:

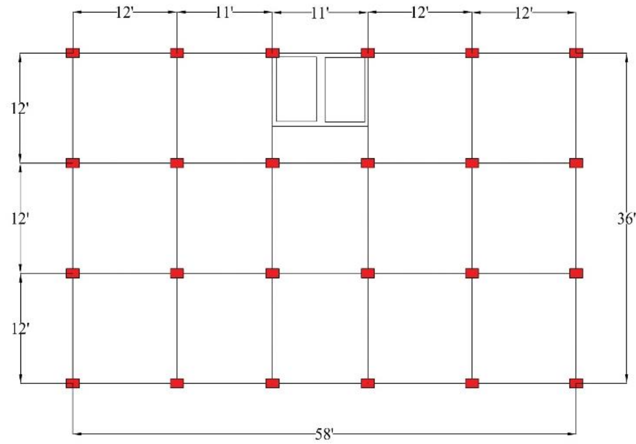

Fig-2 :Typical Plan of Adjacent Buildings

Specifications Of Building

Sr No	Description	Specification	
1	Number of Story	G+15	G+10
2	Ground Height	1.5m	1.5m
3	Storey Height (Floor to Floor)	3m	3 m
4.	Total Height	46.5	31.5
5	Column Size	450 X 300 mm	450 X 300 mm
6	Beam Size	450 X 300 mm	450 X 300 mm
7	Slab thickness	150 mm	150 mm
8	Wall thickness	250 mm	250 mm

The concrete shall be in grades designated as per Table 2 IS 456-2000.

Recommended grades for the different members is as follows:

Columns/lift	M25
Beams	M20
Slab	M20

Nominal cover of 25 mm is used for slab & beam whereas 40 mm is used for column & lift as per. High strength yield deformed bar is used ie Fe 500.

Now, self-weight of all structural member are automatically taken into account by ETABS itself. Additional dead load of screeding mortar is taken 0.52 KN/m^2 as a Floor Finish. Live load is considered to be 3 KN/m^2 on floors as per IS 875 P 2.

Wall load on outer side wall is

∴ Wall Load = Wall thickness × (Floor to Floor Ht – Depth of Beam) × Unit Weight of Brick.

Wall Load = 0.25 × (3-0.45) × 18 = 4.12292 kN/m^2 = 11.475 kN/m^2 .

For partionwall , Load = 11.475/2 = 5.7375 kN/m^2 .

Basic Data of both Model Adopted, from IS 1893 – 2016,

Z = 0.24 considering zone factor IV. (Delhi)
I = 1.2 considering residential building.
R = 5 Special RCMOF
Soil Type : II
5% damping ratio.
Basic Wind Speed = 47 m/s.

As per IS 1893 – 2016, (clause 6.4.3, 7.6 & 7.7.1) Equivalent static method is only applicable for the structures having time period less than 0.4 & having height less than 15m. Since here our both models have natural time period more than 0.4s & also height greater than 15 m. So as per IS 1893, we have to analyze the structure using dynamic analysis method. Dynamic analysis can per performed in three ways as followed,

1. Response Spectrum Method
2. Modal Time History Method
3. Time History Method

Here, response spectrum analysis procedures have been carried out for determining the various structural parameters of the models. All these data had been inserted in ETABS software so as to find maximum displacement of buildings.

V. RESULT & DISSCUSSIONS

After passing all the concrete frame checked the results are as follows:

Maximum Displacement Results

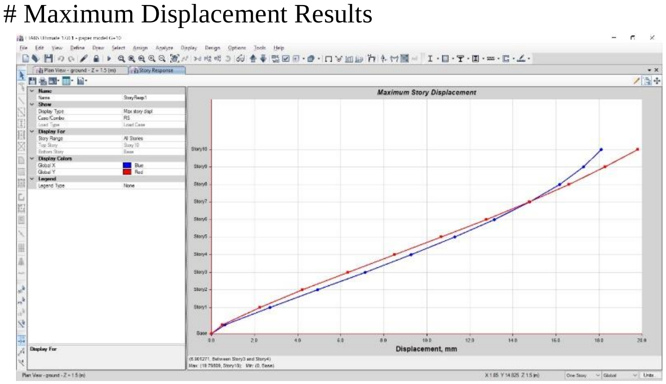

Fig-3 : G+10 storey displacement

Maximum displacement occur at topstoreyie in x direction is 18.1 mm, in y direction is 19.8 mm.

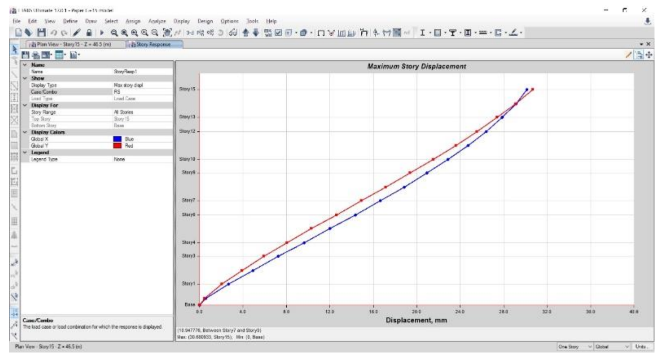

Fig-4 : G+15storey displacement

Maximum displacement occur at top storeyie in x direction is 30.13 mm, in y direction is 30.69 mm.

From above graph plot the maximum displacement of G+15

VI. SEISMIC GAP CALCULATIONS

Since G+15 & G+10 building had to be constructed adjacently in X direction hence I had considered max value of displacement of each model in x direction.

From above results obtained,
Max displacement of G+10 in X direction = 18.1 mm
Max displacement of G+15 in X direction = 30.13 mm
R = 5.0 considering special RC moment resistant frame (SMRF)

As per clause 7.11.3 Separation between adjacent units (IS 1893-2016 part 1)

Two adjacent buildings, or two adjacent units of the same building with separation joints in between shall be separated by a distance equal to the amount R times the sum of the calculated storey displacement Δ_1, Δ_2 calculated as per 7.11.1.

$$Seismic\ Gap = (\Delta_1 + \Delta_2) \times R$$
$$Seismic\ Gap = (18.1 + 30.13) \times 5 = 241.15\ mm$$

The minimum Seismic gap between two adjacent structures ie G+15 & G+10 building is provided to be≈ 245 mm.

VII. CONCLUSION

The study of the creation and analysis of the models by linear dynamic analysis (i.e. response spectrum analysis) for medium soil condition has been carried out on those models to observe displacement at the joints of structure. The models have been studied are a) G+15 storey buildings, b) G+10storey buildings. Based on the observations from the analysis results, the following conclusion can be drawn.

1. In the pounding case constructing the separated buildings is the best way of preventing structural pounding. Storey maximum and average lateral displacement for G+15 storey buildings comes out to be **30.13** mm as well as storey maximum and average lateral displacement for G+12 buildings comes out to be **30.69**mm so it is clear that in both cases results are less than as per IS 456 2000, clause 20.5.
2. The minimum Seismic gap between two adjacent structures ie fifteen storey building & twelve storey building is found to be 245 mm.

Hence from the above conclusion it is clearly seems that there is need to increase the stiffness of the buildings by providing shear walls or placing them at right angles to the divided line between two adjacent buildings, so that they can be used as bumper elements in the case of pounding, otherwise additional energy dissipation devices such as elastomeric pad, viscous fluid dampers, tuned liquid dampers which increases damping ratio are good solutions for this cases.

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