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Comparitive Study of Different Seismic Analysis in Case of Pounding

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ABSTRACT

Seismic pounding between two adjacent structures is a phenomenon which is observed during earthquakes which may cause structural damages as well as architectural damages. Pounding is defined as the collision between two buildings or different parts of the same building to serve damage or sometimes complete collapse. Actually, the separation distance of many buildings is fails to accommodate their relative motions, so building vibrating out of phase and collapse. Among the possible structural damages the seismic induced pounding has been commonly observed phenomenon. This project entitled "A Comparative Study of Different Seismic Analysis in case of pounding" aims at studying the seismic gap between the buildings by static and dynamic analysis in ETABS Non-Linear software and also giving a comparison between them. A parametric study is conducted to investigate the minimum seismic pounding gap between two adjacent structures by response Spectrum analysis for medium soil and El-Centro Earthquake recorded excitation are used for input in the dynamic analysis on different models. By analyzing the two structures using Equivalent Static, Response Spectrum and Time History Analysis, according to SRSS method the minimum separation gap between two adjacent buildings to avoid pounding is 0.0380m, 0.0275m and 0.138m respectively. As a result of comparison between the three methods of analysis it is observed that the maximum displacements obtained by the dynamic analysis are higher than the static analysis.

Keywords— Seismic Pounding, ETABS, EI Centro.

I. INTRODUCTION

The dynamic characteristic of adjacent structures leads to an out-of-phase oscillation of the structures when subjected to an external excitation. If the separation gap between structures is insufficient to accommodate the lateral displacements due to this out-of-phase oscillation impacts will occur. Many incidents of seismic pounding have been reported to date. The magnitudes of the impact forces and the location of the impacts along the heights of the structures depend on the magnitude of the existing separation gap, the extent of difference between the dynamic properties of the impacting structures and the characteristics of the excitation. For these reasons, it has been widely accepted that pounding is an undesirable phenomenon that should be prevented or mitigated zones in connection with the corresponding design ground acceleration values will lead in many cases to earthquake actions which are remarkably higher than defined by the design codes used up to now. The most simplest and effective way for avoiding pounding and reducing damage due to pounding is to provide enough separation gap between the structures, but it is sometimes difficult to be implemented due to detailing problem and when cost of land is high. An alternative to the seismic separation gap provision in the structure design is to minimize the effect of pounding through decreasing lateral motion.

1.2 CAUSES OF POUNDING

Structural pounding damage in structures can arise from the following :

1. Adjacent buildings with the same heights and the same floor levels.
2. Adjacent buildings with the same floor levels but with different heights.
3. Adjacent units of the same buildings which are connected by one or more bridges or through expansion joints.
4. Structures having different dynamic characteristics, which are separated by a distance small enough so that pounding can occur.
5. Pounding occurred at the unsupported part of column or wall resulting in severe pounding damage.
6. The majority of buildings were constructed according to the earlier code that was vague on separation distance.

1.3 REQUIRED SEPARATION GAP

Seismic pounding occurs when the separation distance between adjacent buildings is not large enough to accommodate the relative motion during earthquake events. Seismic codes and regulations worldwide specify minimum separation distances to be provided between adjacent buildings, to preclude pounding, which is obviously equal to the relative displacement demand of the two potentially colliding structural systems. For instance, according to the 2000 edition of the International building code and in many seismic design codes and regulations worldwide, minimum separation distances (Lopez Garcia 2004) are given by Absolute sum (ABS) or Square Root of Sum of Squares (SRSS) as follows:

$S = U_a + U_b$ (ABS)

$S = \sqrt{U_a^2 + U_b^2}$ (SRSS)

Where *S*= separation distance and U_a, U_b=peak displacement response of adjacent structures A and B, respectively.

Bureau of Indian Standards clearly gives in its code IS 4326 that a Separation Section is to be provided between buildings. Separation Section is defined as a gap of specified width between adjacent buildings or parts of the same building, either left uncovered or covered suitably to permit movement in order to avoid hammering due to earthquake. Further it states that for buildings of height greater than 40 meters, it will be desirable to carry out model or dynamic analysis of the structures in order to compute the drift at each storey, and the gap width between the adjoining structures shall not be less than the sum of their dynamic deflections at any level. Minimum width of separation gaps as mentioned in 5.1of IS 4326, shall be as specified in Table 1.

Table 1 Minimum separation gap mentioned in IS 4326

S. No	Type of Construction	Gap Width/Storey, in mm for Design Seismic Coefficient αh =0.12
1	Box system or frames with shear walls	15.0
2	Moment resistant reinforced concrete frame	20.0
3	Moment resistant steel frame	30.0

1.4 METHODS OF SEISMIC ANALYSIS

Various methods have been developed for the seismic analysis of the structures. The three main techniques used in this study are as a follows

1. Equivalent Static Analysis.
2. Response Spectrum Analysis.
3. Time History Analysis

1.4.1 Equivalent Static Analysis

All design against seismic loads must consider the dynamic nature of the load. However, for simple regular structures, analysis by equivalent linear static methods is often sufficient. This is permitted in most codes of practice for regular, low- to medium-rise buildings. It begins with an estimation of base shear load and its distribution on each story calculated by using formulas given in the code. Equivalent static analysis can therefore work well for low to medium-rise buildings without significant coupled lateral-torsional modes, in which only the first mode in each direction is considered. Tall buildings (over, say, 75 m), where second and higher modes can be important, or buildings with torsional effects, are much less suitable for the method, and require more complex methods to be used in these circumstances.

1.4.2 Response Spectrum

Response spectrum method of analysis shall be performed using the design spectrum specified in Clause 6.4.2 or by a site specific design, spectrum mentioned in Clause 6.4.6 of IS 1893 (2002). This method gives the complete time history response of joint displacements and member forces. It involves the calculation of only the maximum values of the displacements and member forces. Computer analysis can be used to determine these modes for a structure. A response is taken from the design spectrum from each mode, based on the modal frequency and the modal mass, and they are then combined to provide an estimate of the total response of the structure. In this we have to calculate the magnitude of forces in all directions i.e. X, Y & Z and then see the effects on the building. Combination methods include the following:

- absolute - peak values are added together
- square root of the sum of the squares (SRSS)
- complete quadratic combination (CQC)

1.4.3 Time History Analysis

It is an analysis of the dynamic response of the structure at each increment of time, when its base is subjected to a specific ground motion time history. The recorded ground motions database from past natural events can be reliable source for time histories. Recorded ground motions are randomly selected from analogous magnitude; distance and soil condition category are the three main parameters in time history generation.. This analysis is considered to be more realistic compared to response spectrum analysis and it is most useful for very long or very tall structures (flexible structures).

II. MODELLING AND ANALYSIS OF THE STRUCTURE

In order to determine the seismic gap between two building with rigid floor diaphragms using static and dynamic analysis. The details of the two buildings are shown in the next section. ETABS Nonlinear software is used to create the 3D model and to run all the analysis. Basic or advanced systems under static or dynamic conditions may be evaluated using ETABS. The results produced by the programs should be in a form directly usable by the engineer. General-purpose computer programs produce results in a general form that may need additional processing before they are usable in structural design.

2.1 DETAILS OF THE MODELS

The models adopted for this study are ten storey(G+10) and eight storey (G+8) buildings which are assumed to be adjacent and the buildings are designed according to IS 456 : 2000 in ETABS Non- Linear software. Both the structures consists of square columns of sizes 600mm x 600mm for ten storey structure and 450mm x 450mm for eight storey structure. Beam sizes for the both the structures are 500mm x 400mm and 350mm x 250mm respectively. The floor slabs are taken as 150mm thick with rigid floor diaphragms. The height of each storey for both the buildings are taken as 3.2m height. For both the buildings the end conditions are taken as fixed. Both the internal and external wall loads are calculated and assigned on both buildings. Seismic parameters are assigned according to IS 1893(Part1:2002) taking zone factor 0.36.

2.2 ANALYSIS OF THE STRUCTURE

Namely three types of analysis procedures have been carried out for determining the various structural parameters of the model generated in ETABS Non Linear software. In this study we are mainly concerned with the behavior of the structure under the effect of ground motion and dynamic excitations such as earthquakes and the displacement of the structure in the inelastic range. For simple regular structures, analysis by equivalent linear static methods is often sufficient which begins with an estimate of peak earthquake load calculated as a function of the parameters given in the code. Equivalent static analysis can, therefore, work well for low- to medium-rise buildings without significant coupled lateral–torsional modes, in which only the first mode in each direction is of significance.

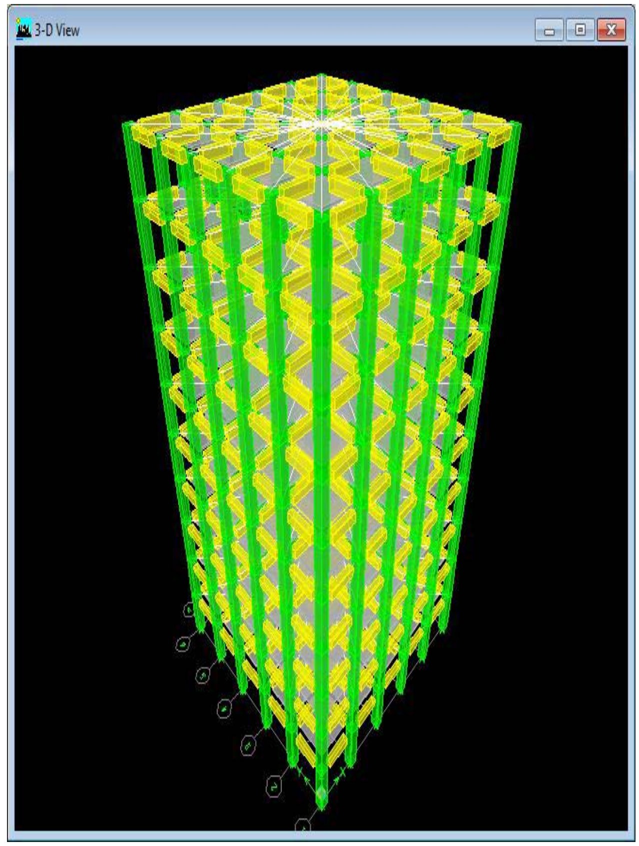

Fig 1 : 3-D view of the ten storey building (G+10) created in ETABS Non Linear software.

Response-spectrum analysis determines the statistically likely response of a structure to seismic loading. This linear type of analysis uses response-spectrum ground acceleration records based on the seismic load and site conditions, rather than time-history ground motion records. this method is extremely efficient and takes into account the dynamical behavior of the structure. In this method the building is considered as a flexible structure with lumped masses concentrated at floor levels, with each mass having one degree of freedom that of lateral displacement in the direction under consideration. In this study the analysis is carried out by using IS 1893 spectra. Time-history analysis captures the step-by-step response of structures to seismic ground motion. EI Centro,1940 data file is taken in this study to determine the structural response in each increment of time.

III. RESULTS AND DISCUSSIONS

Results from equivalent static analysis are observed for the displacements and storey drifts. Using response spectrum analysis the results are observed for the natural frequencies, storey drifts and displacements at each storey to determine the seismic pounding gap between the two adjacent structures. For the time history analysis EI-

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Centro earthquake data is taken and the results are observed to compare floor responses of both the structures. As per the codal provisions FEMA : 273-1997 and SRSS method, the safe separation distance between two adjacent buildings will be $S = \sqrt{(U_a^2 + U_b^2)}$

1. In Equivalent Static Analysis considering the maximum displacements, the minimum separation gap to avoid pounding should be $\sqrt{0.0375^2 + 0.0242^2} = 0.0380m$.
2. From the obtained displacements in Response spectrum Analysis the safe separation gap which has to provide is $\sqrt{0.027^2 + 0.023^2} = 0.0275m$.
3. For the displacements of Time History Analysis the safe separation gap is $\sqrt{0.1228^2 + 0.1262^2} = 0.138m$.

3.1 COMPARISON OF RESULTS

The maximum displacements of the two structures for all the methods of analysis had been compared in case of pounding. It is observed that with the increasing height of the buildings the difference between the displacements is gradually increased by considering the maximum displacement of each storey. As a matter of fact time history analysis represent the maximum response of structure during earthquake ground motion. It is seen that from the below graphs the storey displacement obtained by response spectrum analysis and static analysis are close to each other. From the diagrams below, it is observed that, in first five stories, the difference between the results obtained with different methods is insignificant. With increasing the height of building, the difference between the displacements (calculated by those methods) is gradually increased, by considering the maximum displacement of each storey. It is clear that the time history analysis gives higher values for maximum displacements of all the stories in both the buildings rather than other methods of analysis. As a result of comparison between the three methods of analysis it is observed that the maximum displacements obtained by the dynamic analysis are higher than the static analysis. The below graphs shows the comparison of maximum displacements taken from ETABS of both ten storey (G + 10) and eight storey (G + 8) structures for all the three analysis.

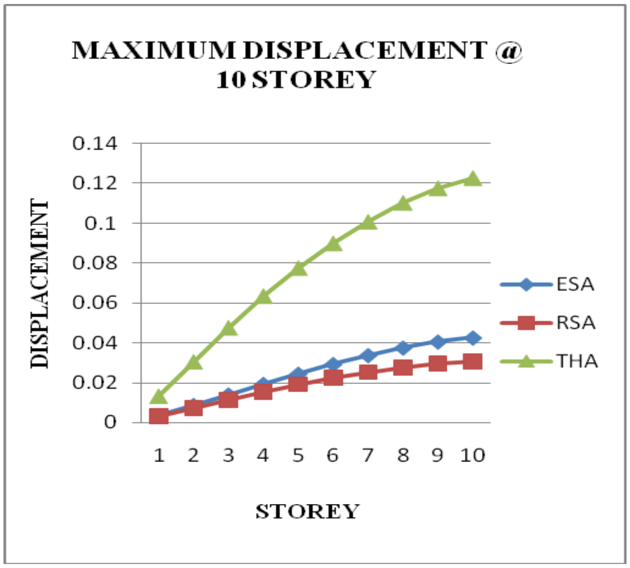

Fig 2 : Comparative Graph for all the three analysis @ 10 storey

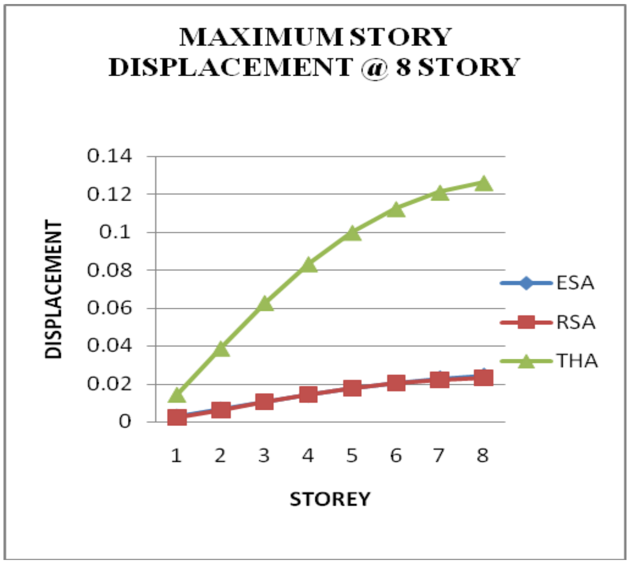

Fig 3 : Comparative Graph for all the Three Analysis @ 8 storey

IV. CONCLUSION

The major conclusions regarding the pounding effect between the two adjacent buildings are summarized as follows :

1. By analyzing the two structures using Equivalent Static, Response Spectrum and Time History Analysis it was concluded that the minimum separation gap to avoid pounding is 0.0380m, 0.0275m and 0.138m respectively.
2. As a result of comparison between the three methods of analysis it is observed that the maximum displacements

obtained by the dynamic analysis are higher than the static analysis.
3.Static Analysis is not sufficient for high rise buildings and it is necessary to provide Dynamic Analysis. For important structures Time History Analysis should be performed as it predicts the structural response more accurately compared to other methods.
4.During pounding the smaller building experiences more damage as compared to the larger building.
5. As pounding force decreases for greater separation, hence it reduces damage to the neighboring building.

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