A REVIEW ON EVALUATION OF SEISMIC POUNDING EFFECT

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***Abstract*: Many efforts are performed to evaluate the seismic pounding using software and manual methods. Pounding is the worst case at which the buildings could be damaged the most when one building strikes another. The analysis results provided the extent of adverse effect which is mainly caused due o insufficient spacing or separation gap between the buildings which in some live instances made the structural collapse. The methods of evaluation of pounding using various software's with previous time history records, assigning of minimum separation joint, mitigation techniques to avoid the effect of pounding are suggested in the following literature reviews.**

***Keywords*: Pounding, GAP element, Kelvin-Voight elements model, Hertz- Hertz damp contact element model.**

I. LITERATURE REVIEW

Jagruti Patil et.al (2016) : The modeling and analysis of construction is using the analysis software ETABS. The differences between the buildings are modeled by introducing compression only "GAP" element between the buildings that consists of space specified and a spring to possess precise rigidity. The whole time modal analysis is accomplished for three different soil movement properties and parameters such as movement, beating the strength and the basis for cutting etc are compared and discussed. The paper focuses on the expansion gap model provided between two buildings to facilitate sufficient movement without any collision between the buildings. Two adjacent buildings varying number of floors G+12 and G+7 is considered for study with the seismic gap of differing width from 50mm to 260mm. The optimum sizes of the frame are provided.
Beam sizes: 300x450 mm of M30 grade**,**
Column sizes: 600x600mm size for 1st,2nd and 3rd floors, 500x500mm column for higher level floors of grade M30.

Eight models were considered with the gap between the buildings initiating from 50mm, 80mm, 110mm, 140mm, 170mm, 200mm, 230mm, 260mm and the models are analyzed using ETABS software for the non-linear link elements. It is observed that there is approximately 5% reduction in seismic impact force for every 30mm increase in gap from a difference of 30mm to 110mm. From 110 to 260mm gap there is 26% reduction in impact force for each increment in gap between the buildings and the maximum of 36.8% reduction in number of impact is observed from the study.

Sathish T. B et.al, (2016): The study covers some of the techniques to be adopted for the prevention of pounding between adjacent buildings in metropolitan areas where the specific separation cannot be provided. For the earthquake zone II and V analysis is carried out. It is suggested from the results that with the proper positionings of shear walls in the buildings there can be possible prevention of pounding between the buildings.

Kasaiah A et.al (2015): Analytical study of seismic pounding effect between adjacent buildings by linear and nonlinear dynamic analysis using ETABS (Non Linear) computer program. A study is conducted to a parametric investigation on the various attributes on the structural pounding by Responses Spectrum analysis for medium type of soil at zone 5 and Time History Analysis for Bhuj earthquakes are recorded stimulation on different models with different separation distances. Higher acceleration's and shear were developed at the assorted storey levels in pounding cases when compared to those obtained from an instance no striking forces, meanwhile the pivoted peak drifts on data stimulated characteristics. And also, the amplified joint or gap width effects likely when the separation is sufficient which is practically to inhibit the liaison between the structures. In this study two adjacent structures are considered in two cases one is two adjacently lying 15-storey buildings and two adjacent 9 and 15 storey buildings. The analysis is carried and by the results obtained it is concluded that the pounding effect is minimum in adjacent 15 storied buildings when compared to a adjacent 9 and a 15 storey buildings. The results encountered from non linear dynamic analysis gives actual repose of the structure when compared to linear dynamic analysis.

Raghunandhan M H et.al,(2015): In this paper time step analysis is used with E-Tabs software for the analysis of adjacent miltistoreyed buildings of G+9 and G+14 storey are performed. The provisions such as, separation distance, placing the shear walls, lateral bracings and variations of storey height s are considered for analysis. The responses like lateral storey displacements and storey forces are arrived for both fixed base and base isolated conditions.

A.B Shirole (2015): Alongside buildings during a seismic force action may knock against each other, undertaking their disparate dynamic behaviour, the buildings oscillates out of phase and the agreeable separation distance between the buildings is insufficient for the accommodation of their relative motions. Seismic striking can be a reason severe destruction to the structures.

In the term seismic pounding can be intercepted by allocating necessitated code specified intervals offers less risk, sometimes getting of safe separations in need is not possible in the commuter belt areas by cause of buildings are assembled very nearer due to high land costs, scarcity of land tracts, the obligation for concentrated facilities under single area and often neglecting the likely hood in case seismic pounding of nearby buildings during the design time. If structural spacing in belt commuting regions or cities is identified to be in limited to prevent the effect, then there will be some secured and cost operative furnishing methods in order to recover structural pounding. This execution suggests the recovery measures of striking of nearly adjoining buildings due to strong ground motion. Use of shear core walls, bracing systems and friction dampers are suggested as possible recovery techniques.

Software Verifications Csi (2014): A comparison is made to study the analysis on seismic pounding using two software's ETABS and SAP-2000. The El- Centro 1940 earthquake record is used for the analysis of seven storey two bayed frame linked by a gap element with four storey's one bay frame. Variations in the displacements of column lines 3 and 4 and link force at storey level 4 are found. Evidences are proved in both software analysis that the force is generated in the link element when the column lines moves in a phase and the specified initial opening is greater than separation or if they vibrate out of phase. The maximum lateral displacement of 5.551mm is found in both software analysis results.

Francisco López et.al (2014): A parametrical numerical study about the consequences of pounding between adjoining short-to-mid heights RC framed buildings with aligned slabs. Two 3 and 5-storey buildings are selected to represent the most common instances. The buildings are designed for a high seismicity region; their structure consists of square columns, rectangular deep beams and flat slabs. The study consists of analyzing the dynamic response of the colliding buildings to a number of representative strong seismic inputs. Pounding is described by a Kelvin-Voight linear gap element model. The Nonlinear behavior of the buildings structure is simulated with frame finite element models; nonlinearities are concentrated in plastic hinges whose moment-curvature is depicted by fiber models. It is observed that pounding amplifies inward story drifts for protruding floors of tallest building and outward storey drifts in less massive and flexible buildings. Outward absolute accelerations are amplified in the left and right buildings mainly at the colliding levels. The results obtained for all seismic inputs were similar and the pounding is less influenced by the damping of gap models.

Prof. A. B . Kawade et.al,(2013): Using the developed software, a large set of numerical evaluations and parametric analyses are performed, in order to investigate earthquake-induced striking of both fixed supported buildings and seismically isolated buildings. The parametric analyses will be performed by automatically varying a certain parameter, within a user-specified range of values, so as to assess its influence on the seismic response of the buildings, while taking into account pounding incidences. The results of the conducted experiments and parametric studies provided useful information regarding the effects of poundings on the seismic response of buildings.

N.U. Mate et.al(2012): A comparative study on various linear and non linear excitation models are considered for pounding analysis linear elastic structures of SDOF and MODF are utilized in order to simples the problem. The various connecting element models are defined such as linear element model, Kelvin-Voight elements model, Hertz- Hertz damp contact element model.To generate some qualitative results on the basis of characteristic of the structures under seismic pounding. A spring dashpot is assigned between the building models to predict the impact response. Finite element based software package tool MATLAB and SAP 2000 NL by importing different factual ground motions for the step time past analysis.

The outcomes of the study indicates that every contact element models predire the response of pounding for the closely spaced structures up to a reasonable limit. The results are influenced by the seismic behavior and the fundamental period correlations between the buildings.

Filiatrault et.al, (2012): The Shake table tests are performed on 3 and 8 storey single –bay unit steel frame model structures to study the colloiding effect between them. The height difference between the buildings is 2.5m i.e. 3 storied building has 1.5m floor height and 8 storey building frame has 4m height and both the plans have floor dimensions of 0.8 m x 0.8 m. Two frames are made to rest on a rigid foundation which is represented by a fully welded 150 x 150 x 19 mm^3 base plate which are welded to each column of the frames. Time step analysis was conducted for 10 seconds to the 1940's most disastrous earthquake record El-Centro as the input data values for testing o shake table. The pounding responses for differing earthquake intensities and initial separation gaps were measured. The comparison of predictions and experimental results were studied squealing from two prevailing analysis program. Modeling using gap elements of elastic behaviour in the 2 programs SLAM-2 and PC-ANSR are used to induce accurate displacements and impact force outcomes. In SLAM-2 program the technique of modal superposition is a basic solution strategy. In PC-ASNR program elastic gap element has been implemented for the time step analysis code which is a non linear analysis.

Diego Lopez Garcia (2004): The paper describes the four existing methods to calculate the critical space between adjacent nonlinear structures evaluated using Monte-Carlo excitations, where seismic stimulations is characterized as a non-stationary random process. Double differentiation combination rule is involved an all the 4 methods but different approaches are followed to calculate the correlation co-efficient **r**. **r** is obtained through numerical stimulated solutions where it is a new method adopted for finding the parameter because all other four methods gave unsatisfactory outputs in the sense where they are not efficient in providing consistent conservative estimates for all possible values of admissible parameters. The numerical values are found using the formulas as given,

$$S=X_{REL}=\sqrt{(Xa^2+Xb^2-2pXaXb}$$

r is a correlation coefficient and it is given by,

$$r=\frac{8\sqrt{\xi a\xi b}\left(\xi a+\xi b\frac{Ta}{Tb}\right)\left(\frac{Ta}{Tb}\right)^{1.5}}{\left[1-\left(\frac{Ta}{Tb}\right)^2\right]^2+4\xi a\xi b\left[1+\left(\frac{Ta}{Tb}\right)^2\right]\left(\frac{Ta}{Tb}\right)+4\left(\xi a^2+\xi b^2\right)\left(\frac{Ta}{Tb}\right)^2}$$

T_A and T_B are time period's of natural frequency of structures A and B respectively

x_A and x_B are the damping ratios of A and B.

Susendar Muthu Kumar et.al (2004): The efficiency of various models which includes stereo mechanical and a contact force[1] based linear element of springs, Kelvin and hertz modelis introduced for pounding excitation with non linear damping. Parametric studies were done using 2- degrees of freedom linear oscillators indicates the stereomechanical system displacements.For a given restitution coefficient with different adopted methodologies the Kelvin and Hertz damp model are same.For aucconting energy dissipation impact models are beat suited for pounding excitation where it is concluded the Hertz damp model as an effective contact force- based approach.

J.Azevedo et.al,(1996): The paper suggests the design criteria adopted for the buildings under pounding. Many structural damages are recorded due to the collapse of buildings during the seismic attacks in the region of Mexico (1985), Northridge (1994) and Kobe (1995). By the study of structural ability to withstand the seismic forces it is accounted that the adjacently constructed buildings with insufficient spacing resulted for unrepairable structural damage and collpse due to the collision of buildings resulted by a force called pounding force.Conclusions stated that minimum gap is nessarily provided between the buildings in order to avoid the negative impacts of the effect. Another part describes that standlone buildings with different geometrical properties causes non- rehabiliated damage on the structures during earthquake.

II. CONCLUSION

From the above literature outcomes it is observed that the effect of pounding on structures depends on the various factors. The following conclusions are made from the above studies,

1. From the above study the outcomes suggested that the non linear dynamic analysis is in good complement with the live illustrations of seismic pounding damages when compared with linear dynamic analysis.
2. From the various evaluation the mitigation measures or techniques such as adopting shear core walls at proper positions in the buildings, use of infill frames, friction dampers and bracings could effectively reduce the adverse pounding damages of the structures in metropolitan studies where it is not possible to facilitate the buildings with sufficient gap.
3. Different software's are used to perform seismic analysis to know the impact of striking between the separate wings of structures in which output from any software is agreeing with each other.
4. The buildings built in a row or the standalone buildings gave worse effect due to pounding by the above review.

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