Seismic Pounding Analysis between Adjacent Buildings to Achieve More Safety towards Earthquakes

Bottu.Shiva Kumar[1], 2vallepu Vishnu Vardhan
ASSOC. PROF[2]
ANASUYADEVI INST. OF TECH & SCIENCES (5Q)[12]

Abstract: **Insufficient separation distance between adjacent buildings during strong earthquakes would probably result into striking of the buildings and subsequently create an excessive dynamic force called pounding. It produces undesirable forces resulting in large displacements, local damage and possible failure of the entire structure. Among the possible structural damages, seismic induced pounding has been commonly observed in several earthquakes. This project aims at studying seismic pounding effect between adjacent buildings by linear and nonlinear dynamic analysis using ETABS (Non Linear) computer program. A detailed parametric study is carried out to investigate the effect of various parameters on the structural pounding by Response Spectrum (Linear Dynamic) Analysis for medium soil at zone Vand Time History (Non-Linear Dynamic) Analysis for Bhuj earthquake recorded excitation on different models with varying separation distances. Pounding produces acceleration and shear at various storey levels that are greater than those obtained from the no pounding case, while the peak drift depends on the input excitation characteristics. Also, increasing gap width is likely to be effective when the separation is sufficiently wide practically to eliminate contact. Finally the resultsare observed to study the effect of structural displacementsand pounding forces between two adjacent buildings.**

Keywords: **Seismic pounding, separation distance, seismic gap, adjacent buildings, storey displacements, pounding force.**

I. INTRODUCTION

Pounding of adjacent buildings could have worse damage as adjacent buildings with different dynamic characteristics which vibrate out of phase and there is insufficient separation distance or energy dissipation system to accommodate the relative motions of adjacent buildings. A large separation is controversial from both technical (difficulty in using expansion joint) and economical (loss of land usage) views. The highly congested building system in many metropolitan cities constitutes a major concern for seismic pounding damage. 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 pounding mitigation and reducing damage due to pounding is to provide enough separation but it is sometimes difficult to be implemented due to detailing problem and high cost of land. An alternative to the seismic separation gap provision in the structure design is to minimize the effect of pounding through decreasing lateral motion which can be achieved by joining adjacent structures at critical locations so that their motion could be in-phase with one another or by increasing the pounding buildings damping capacity by means of passive structural control of energy dissipation system or by seismic retrofitting. According to the 2000 edition of the

II. STRUCTURAL MODELING

The models, which have been adopted for study, are asymmetric ten storey and fifteen storey buildings having the 50mm separation gap between them. Two models have been considered for the purpose of the study.

Model 1: Fifteen storey adjacent buildings.
Model 2: Ten and Fifteen storey adjacent buildings.

III. METHODS OF SEISMIC ANALYSIS

The finite element analysis software's ETABS and SAP2000 Nonlinear is utilized to create 3D model and run all analyses. The software is able to predict the geometric nonlinear behaviour of space frames under static or dynamic loadings, taking into account both geometric nonlinearity and material inelasticity. The software accepts static loads (either forces or displacements) as well as dynamic (accelerations) actions and has the ability to perform Eigen values, nonlinear static pushover and nonlinear dynamic analyses.

IV. RESULTS AND DISCUSSIONS

ETABS and SAP2000 are used to compute the response of ten and fifteen storey buildings for rigid floor diaphragm Linear Dynamic (response spectrum) analysis. Results from Response Spectrum analysis are observed for the natural frequencies and modal mass participation ratios and Displacements of the joints to determine the seismic pounding gap between adjacent structures of two models.

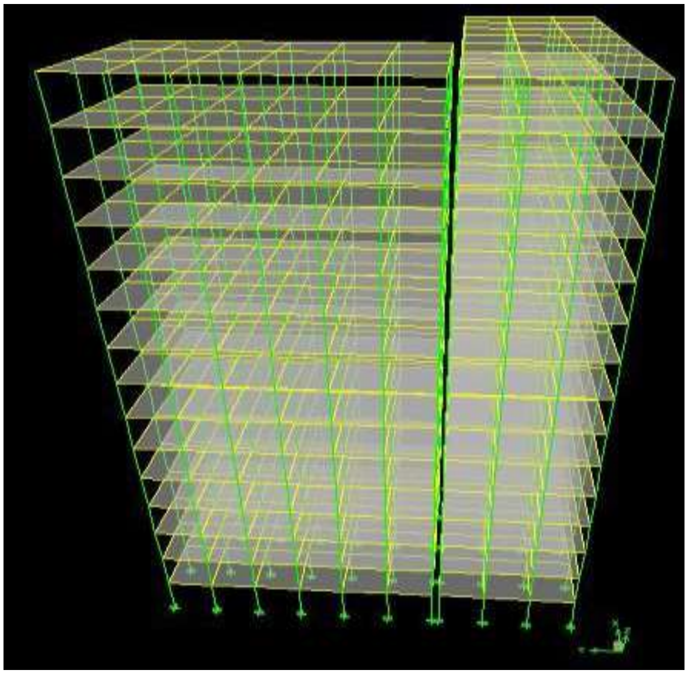

Fig.1 View of Ten and Fifteen storey adjacent buildings created in ETABS

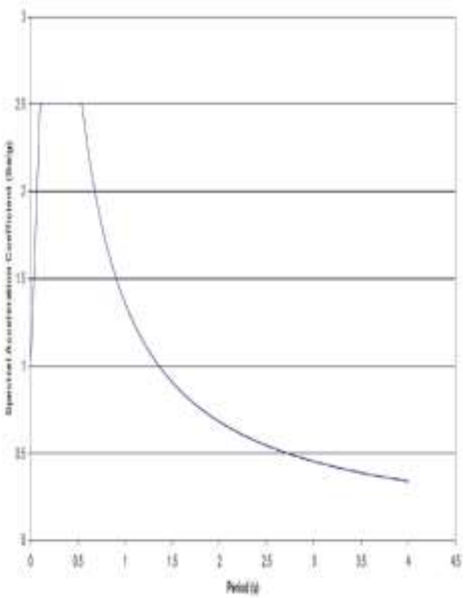

Fig.2 Defining response spectrum function (Sa/g) Vs. Period in ETABS

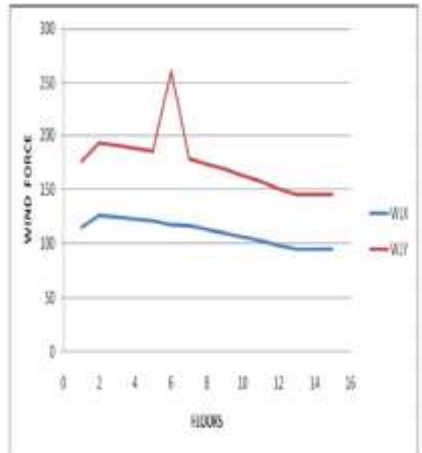

Fig.3 Wind forces along X & Y directions

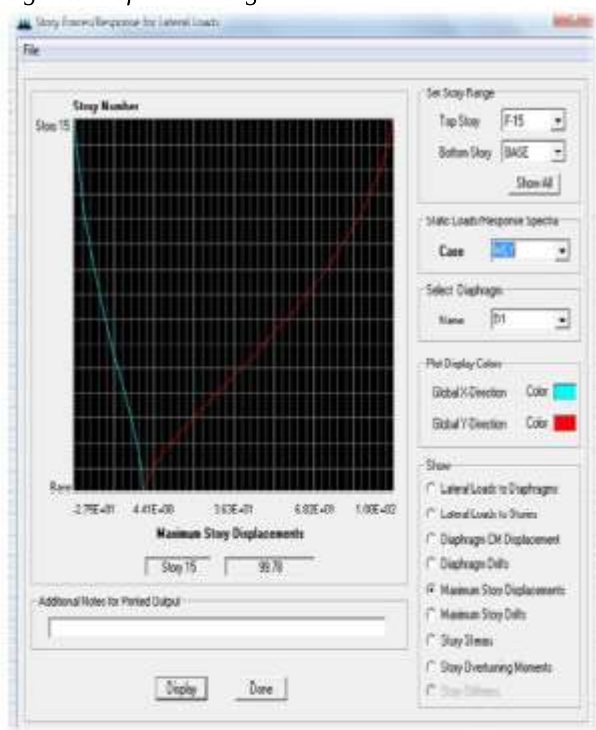

Fig.4 Maximum storey displacement for Wind force along Y-direction (Model 1)

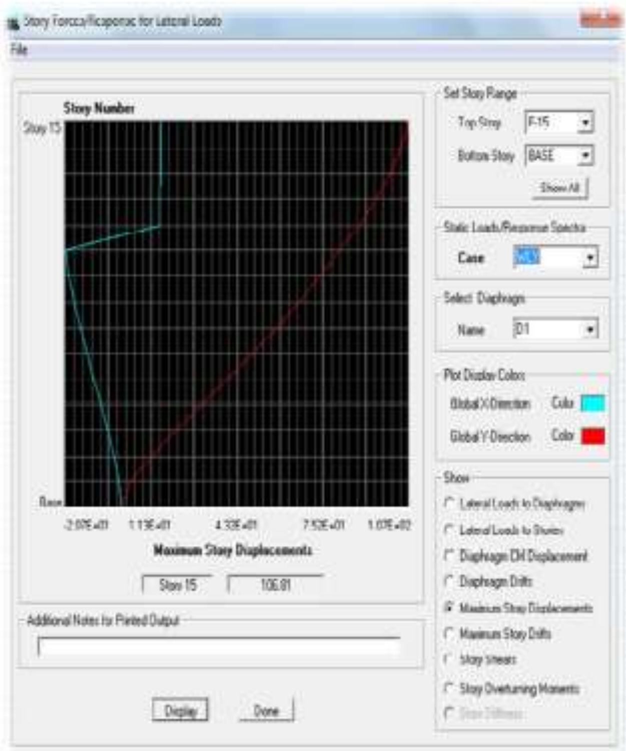

Fig.5 Maximum storey displacement for Wind force along Y-direction (Model 2)

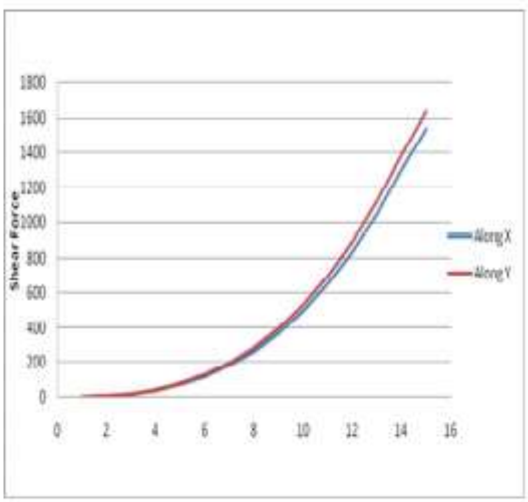

Fig.6 Storey shear along X & Y directions

V. CONCLUSION

Considering equal floor levels between adjacent buildings the maximum displacement in adjacent fifteen storey buildings is 99.76 mm, which exceeds the provided seismic gap. Also for adjacent Ten & Fifteen storey adjacent buildings it is 106.81mm which is much more than the 50mm seismic gap provided, hence there is seismic pounding between adjacent buildings. Therefore, it was found that minimum seismic gap could be provided 0.010m (i.e. 10mm) per storey is sufficient in both the cases for no seismic pounding between buildings. Form the calculations of damping ratios for adjacent fifteen storey buildings is 8.274% and for adjacent Ten and Fifteen storey adjacent buildings is 7.958%. As we have already incorporated 5% inherent damping in the response spectrum analysis, so the excess damping results in the pounding between adjacent buildings.

REFERENCES

[1] A.V. Bhaskararao, *'Seismic Response of Adjacent Buildings Connected with Dampers'* ,13th World Conference on Earthquake Engineering, Vancouver, B.C., Canada, August 1-6, 2004,Paper No. 3143.

[2] A.V. Bhaskararao, '*Seismic analysis of structures connected with friction dampers*', Department of Civil Engineering, IIT Bombay, Powai, Mumbai, India

[3] 3. Alireza M.Goltabar, '*Study of Impact between Adjacent Structures during of Earthquake and their Effective Parameters*', American J. of Engineering and Applied Sciences 1 (3): 210-218, 2008

[4] Anagnostopoulos S A., '*Pounding of Buildings in Series during Earthquakes*', Earthquake Engineering and Structural Dynamics, Vol.16, pp. 443-456, 1988.

[5] Anagnostopoulos, S. A. and Spiliopoulos, K.V. (1992), '*An investigation of earthquake induced pounding between adjacent buildings*', Earthquake Engineering and Structural Dynamics, Vol. 21, pp. 289-302.

[6] *Arash Rezavani, A.S. Moghadam, 'Using Shaking Table to Study Different Methods of Reduceing Effects of Buildings Pounding During Earthquake', Paper No. 698, 13th World Conference on Earthquake Engineering, Vancouver, B.C., Canada, August 1-6- 2004.*

[7] *Bruce D. Westermo., 'The Dynamics of Interstructural Connection to Prevent Pounding', Earthquake Engineering and Structural Dynamics, Vol.18, pp. 687-699, 1989.*

[8] Chenna Rajaram, '*A Study of Pounding Between Adjacent Structures*', A thesis submitted for the Degree of MS, Earthquake Research Center, International Institute of Information Technology, Hyderabad, April 2011.

[9] Christina J Athanassiadou, George G Penelis and Andreas J Kappos, '*Seismic Response of Adjacent Buildings with Similar or Different Dynamic Characteristics'*, Earthquake Spectra, Vol.10, No.2, pp. 293-317, 1994.

[10] C.L. Ng, Y.L. Xu, '*Experimental Study on Seismic Response Mitigation of Complex Structure using Passive Friction Damper*'.

[11] D. Lopez Gracia, *'Discussion on: Critical Building Separation Distance in Reducing Pounding Risk Under Earthquake Excitation',* Structural Safety, 27 (2005) 393–396.

[12] Diego Lopez Garcia., *'Separation between Adjacent Nonlinear Structures for Prevention of Seismic Pounding',* Proceedings on 13th World Conference on Earthquake Engineering, 2004.

Ersin Aydin, Baki Ozturk and Latif Yesil, '*Application of Viscous Dampers for Prevention of Pounding effect in Adjacent Buildings*', 14th Conference, ECEE, 2010.

