Parametric Study of Seismic Gap Between Two Adjacent Structures By Using Etab

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Abstract- *A parametric study on buildings pounding response as well as proper seismic hazard mitigation practice for adjacent buildings is carried out. Therefore, the needs to improve seismic performance of the built environment through the development of performance-oriented procedures have been developed. This work aims at studying seismic gap between adjacent buildings by linear dynamic analysis in ETABS. A parametric study is conducted to investigate the minimum seismic pounding gap between two adjacent structures by response Spectrum analysis for medium soil and Earthquake recorded excitation are used for input in the dynamic analysis on different models. Pounding produces acceleration and shear at various story levels that are greater than those obtained from the no pounding case, while the peak drift depends on the input excitation characteristics.*

Keywords- Adjacent building, Dynamic analysis, Energy dissipation, Medium soil, Seismic pounding.

I. INTRODUCTION

Pounding is one of the main causes of severe building damages in earthquake. The non-structural damage involves pounding or movement across separation joints between adjacent structures. Structures designed to resist moderate and frequently occurring earthquakes must have sufficient stiffness and strength to control deflection and to prevent damage .However, it is inappropriate to design a structure to remain elastic under severe earthquake because of economic constraints. The inherent damping of yielding structural elements can be advantageously utilized to lower the strength requirements, leading to a more economical design. This yielding provides ductility or toughness of structure against sudden brittle type structural failure. Since stiffness and ductility are generally to opposing properties, it is desirable to devise a structural system that combines these properties in most effective manner without excessive increase in cost. Pounding between closely spaced building structures can be a serious hazard in seismically active areas. Investigations of past and recent earthquakes damage have illustrated several instances of pounding damage .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.

The main objective and scope are to evaluate the effects of structural pounding on the global response of building structures; to determine the minimum seismic gap between buildings and provide engineers with practical analytical tools for predicting pounding response and damage. This model is used for studying the response of structural system under the condition of structural pounding during earthquakes for medium soil condition at seismic zone IV.

A. Objective of Study:-

To compute the minimum seismic gap between buildings for rigid floor diaphragm idealizations by analysis using ETABS.

1. Generation of three dimensional models of buildings for rigid floor diaphragm idealization to analyze dynamic analysis (i.e. response spectrum analysis) using ETABS.
2. Performing linear dynamic analysis of rigid floor diaphragm idealization for medium soil at Zone IV.
3. Analyzing the displacement of buildings for Ten Storey and Fifteen Storey building cases to permit movement, in order to avoid pounding due to earthquake by Linear Dynamic Analysis.
4. Comparison of the results between Ten Storey and Fifteen Storey building cases.
5. Selection of the suitable type of the structural protective measures.

B. 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 shown in fig.1 a.

(2) Adjacent buildings with the same floor levels but with different heights shown in fig.1b

(3) Adjacent structures with different total height and with different floor levels shown in fig.1c

(4) Structures are situated in a row shown in fig.1d

(5) Adjacent units of the same buildings which are connected by one or more bridges or through expansion joints.

(6) Structures having different dynamic characteristics, which are separated by a distance small enough so that pounding can occurs

(7) Pounding occurred at the unsupported part (e.g. mid-height) of column or wall resulting in severe pounding damage.

(8) The majority of buildings were constructed according to the earlier code that was vague on separation distance.

(9) Possible settlement and rocking of the structures located on soft soils lead to large lateral deflections which results in pounding.

(10) Buildings having irregular lateral load resisting systems in plan rotate during an earthquake, and due to the torsional rotations, pounding occurs near the building periphery against the adjacent buildings shown in fig.1e

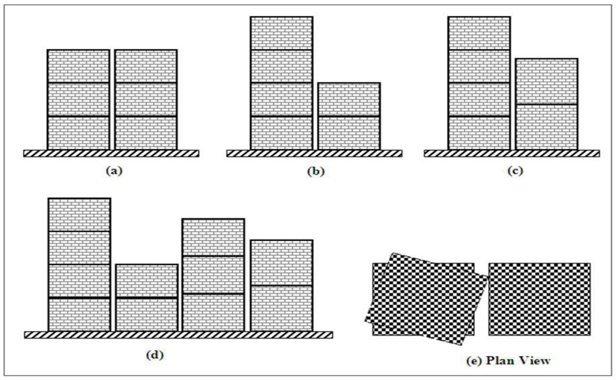


Fig. 1 Representation of different places where pounding occurs

II .DETAILS OF THE MODELS

The models which have been adopted for study are asymmetric ten storey and fifteen storey buildings having minimum separation gap between them.

Two models have been considered for the purpose of the study.

1. Ten and Fifteen storey adjacent buildings.

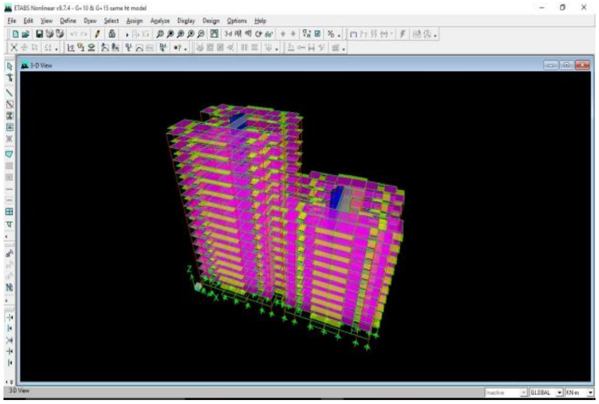


Fig.2 3D View -Ten and Fifteen storey adjacent buildings created in ETABS.

2. Ten storey adjacent buildings.

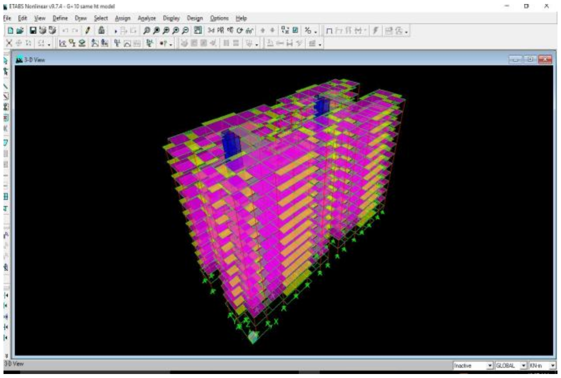


Fig.3 3D View -Ten storey adjacent buildings created in ETABS

A. Defining the material properties, structural components and modeling the structure

Beam, column and slab specifications are as follows:-

Table 1. Beam, column and slab specifications:

COLUMN SIZES FOR MODEL 1	250x800,300x1000,300x1300, 300x1000,250x600,250x1000, 300x1500,400x1300.
FOR MODEL 2	200x750,200x1000,200x1200, 300x1000.
Beams	200 x 700 mm
Slab one way	125mm thickness
Slab two way	150mm thickness
Lobby	150mm way
Sunk	150mm

B. Concrete

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

Recommended grades for the different members is as follows:

Footing /Raft	M25
Columns/lift	M30
Beams/Slabs	M25

Any other structural member will be in general designed is M25.

C. Reinforcement

The reinforcement shall be high strength deformed steel bars with yield strength of 500 N/mm2 confirming to IS1786.

III. ASSIGNING LOADS

Structures and structural elements will be designed by Limit State Method. In structural design, account is taken of the dead, imposed and wind loads and forces such as those caused by earthquake etc, where applicable. After having modelled the structural components, all possible load cases are assigned. These are as follows:

A. Dead Loads

The dead loads are calculated on the basis of unit weights of materials given in IS 875 (Part I).

The dead loads on the structure include the self weight of beams, columns, slabs, walls and other permanent members. The self weight of beams and columns (frame members) and slabs (area sections) is automatically considered by the program itself.

The wall loads have been calculated and assigned as uniformly distributed loads on the beams.

Wall load = unit weight of brickwork x thickness of wall x height of wall.
Unit weight of brickwork = 20kN/cum
Thickness of Brick wall = 0.150m
Wall load of Brick wall = 20 x 0.150 x 2.25 = 6.75KN/m (wall height = 2.25m).

B. Impose Loads:-

Imposed loads are assumed in accordance with IS 875 part II, The Impose loads have been assigned as uniform area loads on the slab elements as per IS 1893 (Part I) 2002

As per Table 8, Percentage of Impose load to be considered in Seismic weight calculation, IS 1893 (Part I) 2002, since the live load class is up to 3 KN/m^2, 25% of the impose load has been considered.

C. Wind Loads:-

Wind load for design of structures shall be based on the design wind speed arrived from IS: 875 (Part III).

The parameters for calculation of design wind speed as per IS: 875 (Part III)-1987.

Basic wind speed, Vb = 47m/s
Risk Coefficient, K1 = 1
(If design life of structure taken as 50 yrs.)

Terrain, Height, Structure size factor, K2 = to suit the height of the structure for terrain category-4 & class B is 1.10.

Topography factor, K3= 1.0
Design Wind Speed Vz=47m/s
Design Wind Pressure Pz = 0.6x (55) 2= 1815 N/m2

The external & internal pressure coefficients shall be as per respective clauses of IS: 875 (Part III).

IV. ANALYSIS OF THE STRUCTURE

The response spectrum analysis procedures have been carried out for determining the various structural parameters of the model. Here we are mainly concerned with the behavior of the structure under the effect of Pounding such as earthquakes and the displacement of the structure.

A. Response spectrum analysis in ETABS:-

The step by step procedure is as follows

1) Defining earthquake loads under the load type ‘quake’ and naming it appropriately.
2) Defining response spectrum function as per IS 1893 (Part I) 2002. The values of Sa/g Vs. T assign in the program.
3) Modifying the quake analysis case with the appropriate analysis case type, applied loads and scale factors.
4) Running the analysis.

1. Lateral load calculations

From Modal analysis fundamental time period of the structure have been found to be

a) Model 1

Mode 1—2.7714 sec
Mode 2—2.5934 sec

b) Model 2

Mode 1—2.5844 sec
Mode 2—2.2795 sec

The base shear has been calculated by running the response spectrum analysis.

2. Seismic Weight of the Building

The Seismic Weight of the whole building is the sum of the seismic weights of all the floors.

a) For model 1

DL= 1.160X 10^5 KN
SDL = 8.152X10^4 KN
LL = 2.796X10^4KN
Total seismic weight = DL+SDL+0.25 LL
=22.548X10^4 KN

b) For model 2

DL = 9.484X 10^4 KN
SDL = 5.864X10^4 KN
LL= 2.264X10^4
Total seismic weight = DL+SDL+0.25 LL
= 15.914X10^4 KN

B . Analysis of Ten and Fifteen storey adjacent buildings (Model 1)

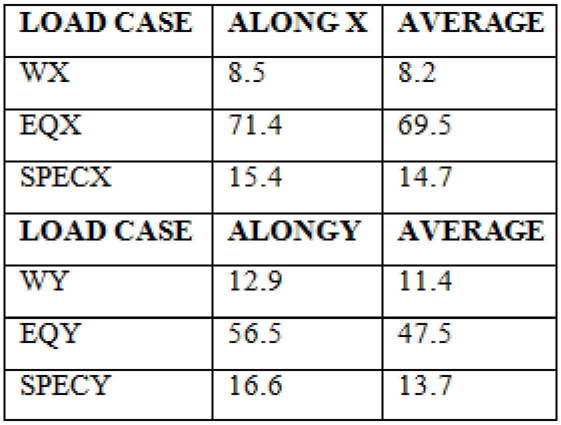
Analyzing the Model 1 in ETABS Results are as follows.

Table 2.Mass Participation Ratio for Model 1
(Static and dynamic ratios are in percent)

TYPE	NAME	STATIC	DYNAMIC
Load	DEAD	0.2551	0.0000
Load	LIVE	0.4661	0.0000
Load	WX	99.9943	96.6173
Load	WY	99.9681	94.3568
Load	EQX	99.9994	99.9284
Load	EQY	99.9990	99.8870
Load	SDL	0.3845	0.0000
Accel	UX	99.9656	92.3931
Accel	UY	99.9402	90.5040
Accel	UZ	0.0000	0.0000
Accel	RX	99.9996	99.9388
Accel	RY	99.9997	99.9477
Accel	RZ	187.3621	90.8506

From the above table no. of modes to be used in the analysis should be such that the sum of total model mass consider is at greater than 90% as per IS 1893(Part I)-2002 clause no.7.8.4.2.

Table 3. Storey maximum and average lateral displacement along x and y direction in mm.



LOAD CASE	ALONG X	AVERAGE
WX	8.5	8.2
EQX	71.4	69.5
SPECX	15.4	14.7
LOAD CASE	**ALONGY**	**AVERAGE**
WY	12.9	11.4
EQY	56.5	47.5
SPECY	16.6	13.7

I have taken maximum value of earthquake forces along x direction=71.4mm

Therefore,
Permissible displacement as per IS875 =
H/500 = 99mm

Hence safe.

C. Analysis of ten storey adjacent buildings (Model 2)

Analyzing the model 2 in ETABS Results are as follows.

Table 4. Mass Participation Ratio for Model 2
(Static and dynamic ratios are in percent)

TYPE	NAME	STATIC	DYNAMIC
Load	DEAD	0.3653	0.0000
Load	LIVE	0.6757	0.0000
Load	WX	99.9960	96.9031
Load	WY	99.9956	96.9405
Load	EQX	100.0000	99.9873
Load	EQY	99.9999	99.9772
Load	SDL	0.3650	0.0000
Accel	UX	99.9918	96.9779
Accel	UY	99.9934	97.5361
Accel	UZ	0.0000	0.0000
Accel	RX	100.0000	99.9853
Accel	RY	99.9999	99.9745
Accel	RZ	97.5762	97.6196

From the above table no. of modes to be used in the analysis should be such that the sum of total model mass consider is at greater than 90% as per IS 1893(Part I)-2002 clause no.7.8.4.2.

Table 5. Storey maximum and average lateral displacement along x and y direction in mm.

LOAD CASE	ALONG X	AVERAGE
WX	2.9	2.8
EQX	58.7	56.6
SPECX	12.6	11.5
LOAD CASE	**ALONGY**	**AVERAGE**
WY	4.9	4.5
EQY	25.8	23.8
SPECY	11.0	9.7

I have taken maximum value of earthquake forces along x direction=58.7mm

Therefore,
Permissible displacement as per IS875= H/500 = 69mm.

Hence safe.

FOR MODEL 1

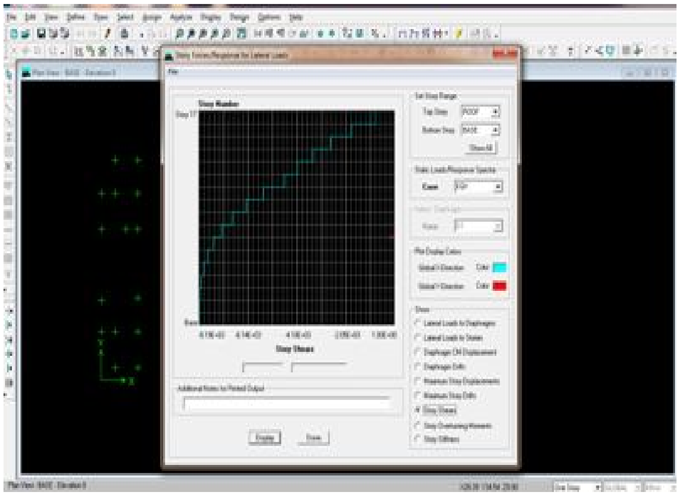


Fig.4 Storey Shear for quake force along x-Direction.

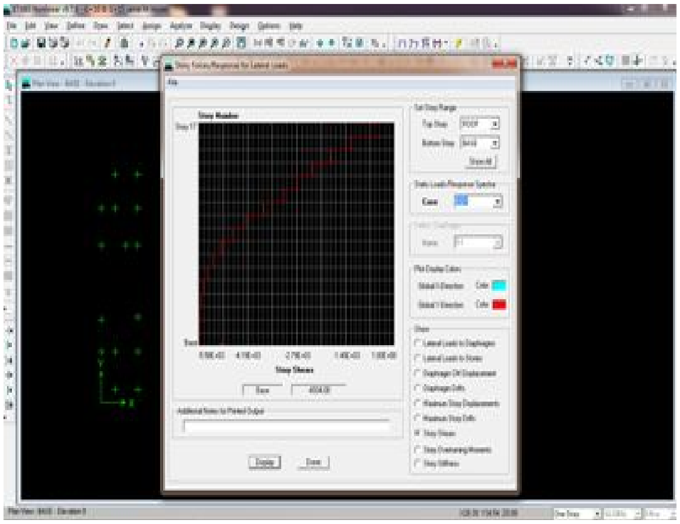


Fig.5 Storey Shear for quake force along Y-Direction.

FOR MODEL 2

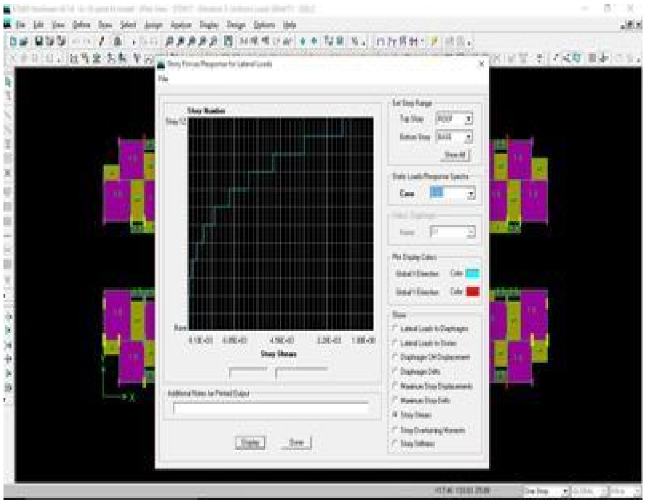


Fig.6 Storey Shear for quake force along x-Direction

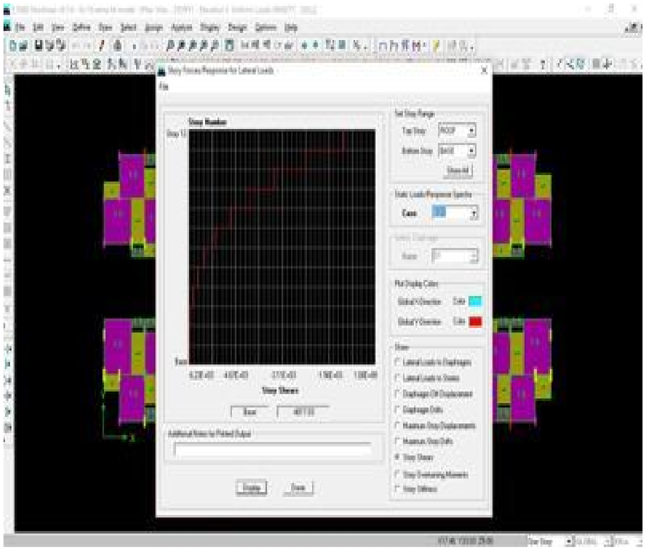


Fig.7 Storey Shear for quake force along Y-Direction.

V. CONCLUSION

1. In the pounding case constructing the separated buildings is the best way of preventing structural pounding. However if adjacent buildings must be constructed for any reason, these structures must be separated with gaps as given in IS 1893 (Part I): 2002.
2. Model mass participation ratio for adjacent fifteen storey and Ten & Fifteen storey adjacent buildings comes out to be 97.61% and 90.8506% respectively, which are greater than 90% as per clause 7.8.4.2 IS 1893 (Part I) : 2002.
3. Minimum seismic gap can be provided 0.010m (i.e. 10mm) per storey is sufficient in both the cases for no seismic pounding between buildings.

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