PARAMETRIC STUDY ON SEISMIC POUNDING EFFECT IN BUILDING SYSTEM

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Abstract - *Seismic pounding between adjacent buildings can cause severe damage to the structures under earthquakes, when owing to their different dynamic characteristics. The buildings vibrate out of   phase and at rest separation is deficient to accommodate their relative motions. Such buildings are usually separated by expansion joint which is insufficient to provide the lateral movements of the buildings during earthquakes. Sometimes getting of required safe separations is not possible in metropolitan areas due to high land value and limited availability of land space. There are many buildings which are constructed very nearly to one another in Metropolitan cities, because everyone wants to construct up to their property line due to high cost of land. If building separations is found to be deficient to prevent pounding, then there should be some secure and cost effective methods to prevent structural pounding between adjacent buildings. This study covers the prevention techniques of pounding between adjacent buildings due to earthquakes, here we considered earthquake zone II and V. Use of shear walls by ETABS 9.7.4 Version Software Package, with proper placement are proposed as possible prevention techniques for pounding between adjacent buildings.*

Key Words: Seismic pounding, equivalent static analysis, response spectrum analysis, displacement, storey drift, shear wall.

1. INTRODUCTION

Introduction of previous and recent earthquakes harms have shown that structures are tend to serious injuries and collapse during normal or strong earthquakes. An earthquake of magnitude 6 is capable of damaging of buildings, bridges, industries, port facilities causes economic loss. Several earthquakes can be seen in Egypt in past and recent times. The annual average earthquake in Egypt and its places nearby 5.5 to 7.3.

Its results in pounding between buildings which are narrow spaced, which causes severe damage, Investigation have shown that pounding damage was observed in Mexico (1985), Canada(1988), kobe(1995), kocaeli(1999) of earthquakes can be seen. Pounding was seen at sites over 90km from epicenter. It indicates severe damage that may be occurring in future near epicenter pounding damage of adjacent buildings causes due to vibration which is having different dynamic characteristics. It occurs highly in areas where population density is high, where buildings are

closely placed. Due to economical land use it has been built closely. Pounding effect can be reduced easily by constructing the buildings by providing the required spacing and minimizing the structural design. Adjoining buildings can be united at few locations to decrease lateral motion, which can make time motion in phase with other. Seismic retrofitting and energy dissipation method can also be used effectively to increase resistant power of pounding buildings.

The aim of the study is to find a mathematical model and method to formulate nearby buildings pounding crisis, depending classical impact theory. The main purpose is to calculate the effects of structural pounding on the worldwide response of construction structures securely by giving engineers the realistic logical tools for predicting damages and reactions.

Two adjoining multi storey buildings are considered to represent the structure for pounding problems. Retrofitting technique can be adopted to increase the potential of the week zones in the post-elastic range.

ETABS 9.7.4 is used for static, dynamic analysis and design program for 3-D structures. The function has ability to solve various difficulties from 2-D trusses to complex 3-D structures. Formation and alteration of models, execution of the study, checking and optimization of the design are done through this single interface, graphical displays of outcome, including displacements are produced.

2. SEISMIC POUNDING EFFECT

Pounding is an important cause of rigorous building damages in earthquake. The non-structural damage involves pounding or movement across separation joints between neighboring structures.

The seismic pounding between two adjacent buildings occur:

♦ During an earthquake

♦ Different dynamic characteristics

♦ Adjacent buildings shake out of stage

♦ At-rest separation is insufficient

Prevention Measures to Avoid Pounding:

The prevention measures to avoid the seismic pounding between the adjacent buildings here considered are

1. RC Shear Wall
2. Steel Cross Bracings
3. Dampers

In this study considering only the RC Shear wall to prevent the pounding effect in two adjacent buildings.

2.1 RC Shear Wall

The universal, and possibly the most successful, method for strengthening reinforced concrete frame structures consists of the installation of RC shear walls, as shown in figure. These walls are usually either of reinforced concrete or of reinforced masonry construction. New RC shear walls must be installed at corners of two adjacent the buildings. Cautious detailing and material selection are required to ensure an effective connection between the new and existing structure.

3. BUILDING MODELLING

For this study, a 12-story building and 8 storey building with a 3.2-meters height for each story, regular in plan was modeled. These buildings were designed in compliance to the Indian Code of Practice for Seismic Resistant Design of Buildings .The buildings were assumed to be fixed at the base. The buildings were modeled using software ETABS. Models were studied in zone 2 and zone 5 comparisons of lateral displacement, storey drift, all structural models under consideration.

•**Model 1**: Pounding combination 1(same ground profile)

•**Model 2**: Pounding combination 2(same ground profile)

•**Model 3**: Pounding combination 3(same ground profile)

•**Model 4**: Pounding combination 4(variation in ground)

•**Model 5**: Pounding combination 5(variation in ground)

•**Model 6**: Pounding combination 6(variation in ground)

4. BUILDING PARAMETERS

12 STOREY BUILDING	8 STOREY BUILDING
M30 Grade concrete, Fe500 steel	M25 Grade concrete, Fe500 steel
Column size 450x450mm	Column size 350x450mm
Beam size 300x500mm	Beam size 200x600mm

Slab thickness is 150mm	Slab thickness is 125mm
Floor height is 3.2m	Floor height is 3.2m
5m spacing c/c column distance	5m spacing c/c column distance
Floor finish is 2kn/m²	Floor finish is 2kn/m²
Live load is 3kn/m²	Live load is 3kn/m²

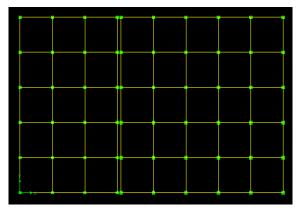**4.1Building plans**

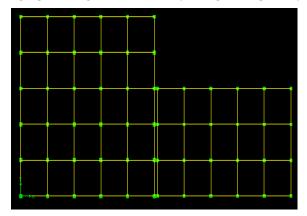Fig.1 pounding combination 1(same ground profile)

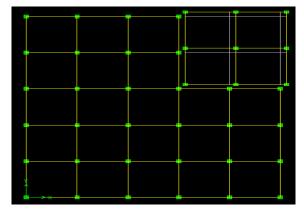Fig.2 pounding combination 2(same ground profile)

Fig.3 pounding combination 3(same ground profile)

The pounding combination 1, 2 and 3 are in same ground profile. The pounding combination 4, 5 and 6 are in one floor height difference in ground profile.
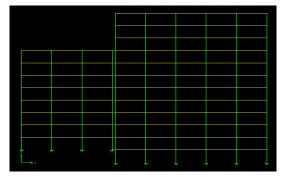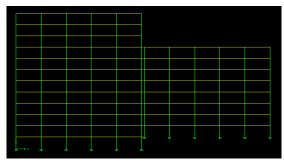

Fig.4 Pounding combination 4(variation in ground)

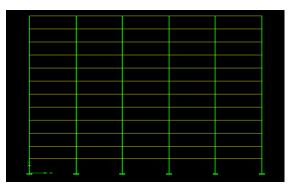

Fig.5 Pounding combination 5(variation in ground)

Fig.6 Pounding combination 6(variation in ground)
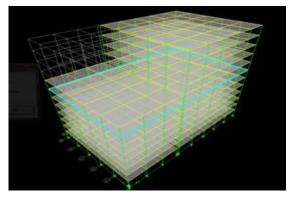
4.2 3-D Models of the buildings

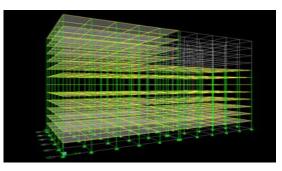Fig.7 3-D view of pounding combination 1
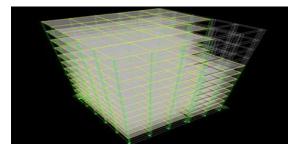

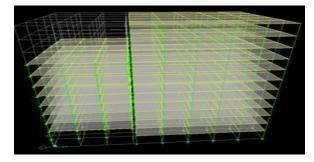Fig.8 3-D view of pounding combination 2

Fig.9 3-D view of pounding combination 3

Fig.10 3-D view of pounding combination 4

Fig.11 3-D view of pounding combination 5

Fig.12 3-D view of pounding combination 6

5. LOAD CONSIDERATION

1 Dead load:

The self weight of the structure (dead load) obtained from the Indian code IS 875 (section 1)-1987, table 1. In this project unit weight of the project is considered as 25 KN/ m³ and 30KN/m³. The self-weight of the basic segments are according to the accompanying.

2 Imposed load:

The imposed load are also called as live load, live load is nothing but variable or moving loads. It is mainly due to the occupants, furniture, temporary stores…etc. Except dead load all other loads considered as imposed loads. Live load is taken from the table 1 of IS 875(part 2) - 1987.

  Live load =3 KN/m²

3 Seismic Load:

Assume that the considered structure is located in Zone-II TO Zone-V according to the code of practice IS 1893–2002. The element will be taken from the Table 2. Importance factor for the same structure will be taken as 1 according to IS 1893 –2002 of table6.

Seismic design is done in accordance with IS: 1893:2002. This RC framed building is located in all Seismic Zones. The parameters to be used for analysis and design are given below as per IS: 1893. (Part I)

DETAILS	ZONE 2	ZONE 5
R	3	3
I	1	1
Z	0.10	0.36
Sa/g	Type2	Type2

6. RESULT AND DISCUSSION

6.1 Equilateral static analysis

6.1.1 Zone II

In 12 storey buildings, the maximum displacement is 47.1mm in the POUNDING COMBINATION 3 and the minimum displacement is 31.41mm in POUNDING COMBINATION 6.

In 8 storey buildings, the maximum displacement is 35.41mm in the POUNDING COMBINATION 4 and the minimum displacement is 4.58mm in POUNDING COMBINATION 3.

In 12 storey buildings, the storey drift is most extreme in the POUNDING COMBINATION 3 and the minimum storey drift is in POUNDING COMBINATION 6.

In 8 storey buildings, the storey drift is most extreme in the POUNDING COMBINATION 4 and the minimum storey drift is in POUNDING COMBINATION 3. The second highest storey drift is occurs in POUNDING COMBINATION 1.
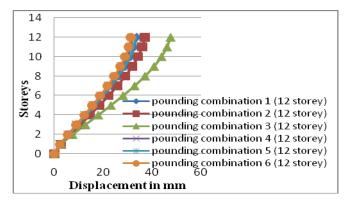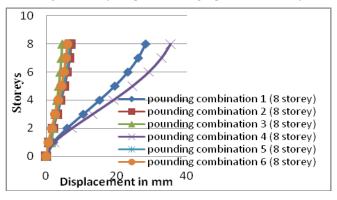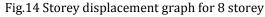

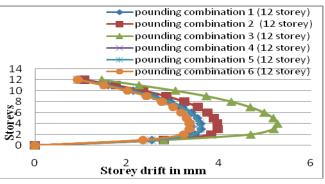Fig.13 Storey displacement graph for 12 storey

Fig.14 Storey displacement graph for 8 storey
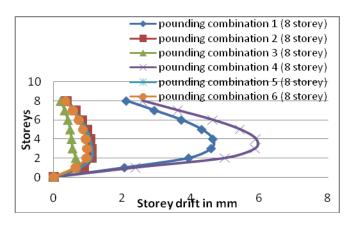

Fig.15 Storey drift graph for 12 storey

Fig.16 Storey drift graph for 8 storey

6.1.2 Zone V

In 12 storey buildings, the maximum displacement is 171.49mm in the POUNDING COMBINATION 3 and the minimum displacement is 113.30mm in POUNDING COMBINATION 6.

In 8 storey buildings, the maximum displacement is 127.48mm in the POUNDING COMBINATION 4 and the minimum displacement is 16.52mm in POUNDING COMBINATION 3.
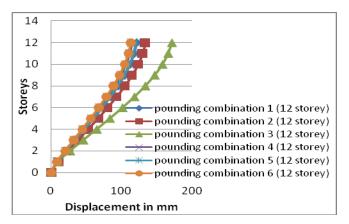

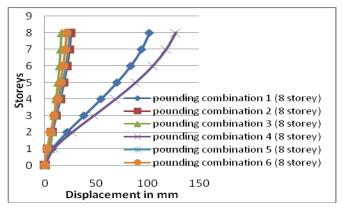Fig.17 Storey displacement graph for 12 storey

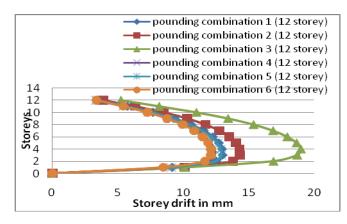Fig.18 Storey displacement graph for 8 storey

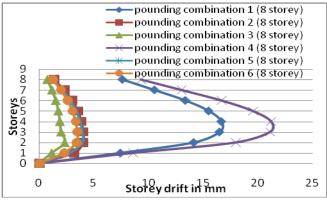Fig.19 Storey drift graph for 12 storey

Fig.20 Storey drift graph for 8 storey

6.2 Response spectrum analysis

6.2.1 Zone II

In 12 storey buildings, the maximum displacement is 31.72mm in the POUNDING COMBINATION 3 and the minimum displacement is 20.9mm in POUNDING COMBINATION 6.

In 8 storey buildings, the maximum displacement is 27.84mm in the POUNDING COMBINATION 4 and the minimum displacement is 11.81mm in POUNDING COMBINATION 3.
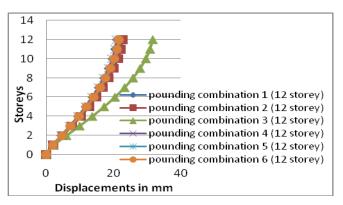

Fig.21 Storey displacement graph for 12 storey

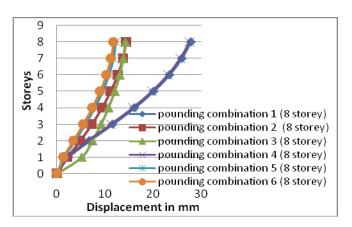Fig.22 Storey displacement graph for 8 storey

Fig.25 Storey displacement graph for 12 storey

Fig.23 Storey drift graph for 12 storey

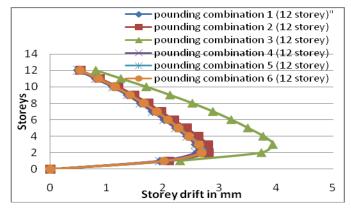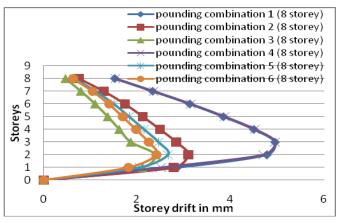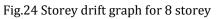
Fig.26 Storey displacement graph for 8 storey

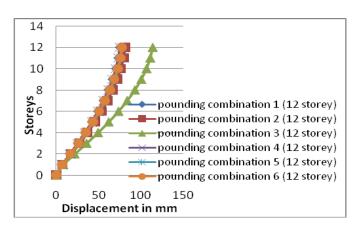Fig.24 Storey drift graph for 8 storey

6.2.2 Zone V

In 12 storey buildings, the maximum displacement is 114.24mm in the POUNDING COMBINATION 3 and the minimum displacement is 75.28mm in POUNDING COMBINATION 6.

In 8 storey buildings, the maximum displacement is 100.24mm in the POUNDING COMBINATION 4 and the minimum displacement is 42.54mm in POUNDING COMBINATION 3.
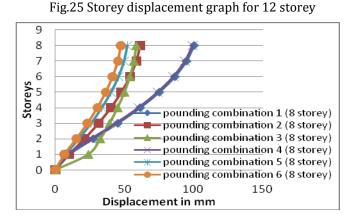

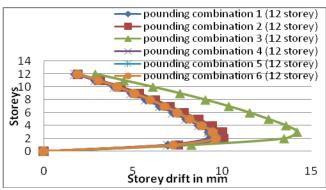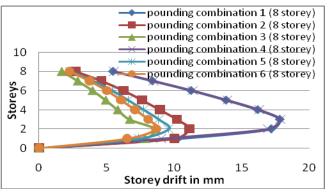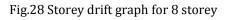Fig.27 Storey drift graph for 12 storey

Fig.28 Storey drift graph for 8 storey

6.3 Provide the shear wall to avoid pounding effect

In this study provide the RC Shear wall at corners of the two adjacent buildings. Shear walls provide the corners of buildings to reduce the displacement of the buildings. Provide the shear wall to avoid the pounding effect in two adjacent buildings. Provide the shear wall at all pounding combinations only Zone V cases.

6.3.1 Equilateral static analysis

In 12 storey buildings, the maximum displacement is 79.63mm in the POUNDING COMBINATION 2 and the minimum displacement is 52.24mm in POUNDING COMBINATION 6.

In 8 storey buildings, the maximum displacement is 11.09mm in the POUNDING COMBINATION 4 and the minimum displacement is 8.25mm in POUNDING COMBINATION 3.

Fig.29 Storey displacement graph for 12 storey

Fig.30 Storey displacement graph for 8 storey

6.3.2 Response spectrum analysis

In 12 storey buildings, the maximum displacement is 22.44mm in the POUNDING COMBINATION 2 and the minimum displacement is 16.97mm in POUNDING COMBINATION 6.

In 8 storey buildings, the maximum displacement is 11.09mm in the POUNDING COMBINATION 4 and the minimum displacement is 8.25mm in POUNDING COMBINATION 3.
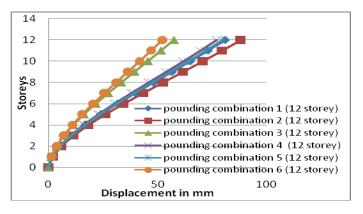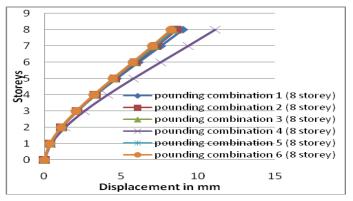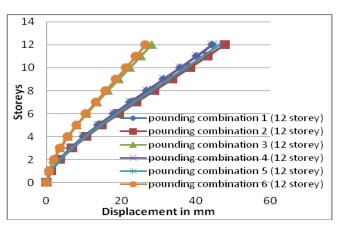

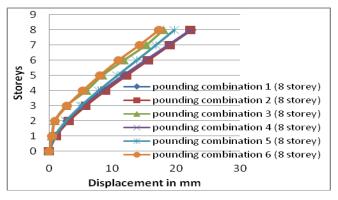Fig.31 Storey displacement graph for 12 storey

Fig.32 Storey displacement graph for 8 storey

7. CONCLUSION

Based on analysis carried out on the seismic pounding effect in the buildings the Following conclusions are:
♦ It is found that the displacement and storey drift are great in the POUNDING COMBINATION 3 and the minimum displacement is in POUNDING COMBINATION 6 for 12 storey building whereas the displacement is most extreme in the POUNDING COMBINATION 4 and the minimum displacement is in POUNDING COMBINATION 3 for 8 storey building for both zone II and V from equivalent static analysis without any special moment resisting systems.

♦ It is observed that the displacement and storey drift is most extreme in the POUNDING COMBINATION 1 and 4. The minimum displacement and storey drift in POUNDING COMBINATION 6 for 12 storey. Storey drift is maximum in the POUNDING COMBINATION 3 and minimum displacement is found in all other POUNDING COMBINATIONS for 8 storey for both zone II and V from response spectrum analysis without any resisting systems.

♦ It is noticed that the displacement is most extreme in the POUNDING COMBINATION 2 and the minimum displacement is in POUNDING COMBINATION 6 for 12 storey and the displacement is most extreme in the POUNDING COMBINATION 4. The minimum displacement is in all other POUNDING COMBINATIONS for 8 storey for zone V for building with shear wall.

♦ It is found that by providing the shear wall at the corners the pounding effect is reduced significantly both in terms of displacement and storey drift.

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