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Seismic Behaviour of Flat Slab Systems

Pradip S. Lande[1], Aniket B. Raut[2]

[1]*Associate Professor, Applied Mechanics Department*
Government College of Engineering, Amravati Maharashtra, India
[2]*PG Student, Applied Mechanics Department*
Government College of Engineering, Amravati, Maharashtra, India

Abstract: **The flat plate system has been adopted in many buildings construction taking advantage of the reduced floor height to meet the economical and architectural demands. Flat-slab RC buildings exhibit several advantages over conventional beam column building. However, the structural effectiveness of flat-slab construction is hindered by its alleged inferior performance under earthquake loading. Although flat-slab systems are widely used in earthquake prone regions of the world, unfortunately, earthquake experience has proved that this form of construction is vulnerable to more damage and failure, when not designed and detailed properly. Therefore careful analysis of flat slab building is important.**

In the present study a parametric investigation was carried out in order to identify the seismic response of systems a) flat slab building b) flat slab with perimetric beams c) flat slab with shear walls d) flat slab with drop panel. e) Conventional building the aforementioned hypothetical systems were studied for two different storey heights located in zone v. and analyzed by using ETABS Nonlinear version 9.7.3. Linear dynamic analysis i.e. response spectrum analysis is performed on the system to get the seismic behaviour.

Keywords: **Flat slab, perimetric beam, shear wall, response spectrum analysis,**

1. INTRODUCTION

The flat-slab system is a special structural form of reinforced concrete construction that possesses major advantages over the conventional beam column frame. The flat slab system provides easier formwork, architectural flexibility, unobstructed space, lower building height and shorter construction time. There are some serious issues that require examination with the flat-slab construction system. One of the issues which were observed is the potentially large transverse displacements because of the absence of deep beams and/or shear walls, resulting in low transverse stiffness. This cause excessive deformation which in turn cause damage of non-structural members even when subjected to earthquakes of moderate intensity. Another issue is the brittle punching failure due to the transfer of shear forces and unbalanced moments between slabs and columns. When subjected to earthquake action, the unbalanced moments can produce high shear stresses in the slab. Flat-slab systems are also susceptible to significant reduction in stiffness resulting from the cracking that occurs from construction loads, service gravity loads, temperature and shrinkage effects and lateral loads. Therefore, it was recommended that in regions of high seismic hazard, flat-slab systems should only be used as the vertical load carrying system in structures braced by frames or shear walls responsible for the lateral capacity of the structure.

2. LITERATURE REVIEW

The literature shows the considerable working and study on a flat slab building and its behaviour under the seismic excitation. Several experimental and numerical analyses were performed on the flat slab building structures by various authors. These works are reviewed keeping in view the methodology, principles and various aspects and behaviour of flat slab building under the earthquake forces. Some of related works are discussed below.

Ms. Kiran Parmar , Prof. Mazhar Dhankot (2013), deals with the comparison between three dual lateral load resisting systems in the multistory buildings. A. E. Hassaballa, M. A. Ismaeil *et.al performed the* pushover analysis on the four story building using SAP2000 software (Ver.14) and equivalent static method according to UBC 97. Sharad P. Desai and Swapnil B. Cholekar carried out the analysis in STAAD Pro V8i software. Results of conventional building, flat slab with drop and flat slab without drop for different heights with and without masonry infill wall are considered in the analysis. K S Sable et.al (2012)[6] this paper investigates the comparison of conventional reinforced concrete building system i.e. slab, beam & column to the flat slab building. Ema COELHO, Paulo CANDEIAS *et.al* (2004)[8] carried out an experimental program at the ELSA Laboratory, with the aim of assessing the seismic behaviour of flat-slab structures. The program consisted in pseudo-dynamic tests on a full-scale three storey RC flat-slab building structure, representative of flat-slab buildings in European seismic regions.

From the literature survey it can be conclude that the seismic performance of flat slab building is complicated as it depends upon the seismic zone, plan dimension, storey height etc. hence a careful analysis of flat slab building is needed. Most of the author perform a seismic analysis on flat slab building and compare with it a conventional building to get the comparative behaviour of flat slab building.

3. MODELLING

For the dynamic analysis of buildings ETABS version 9.7.3 computer program is used for the analysis purpose. The program is specialized for the linear static and dynamic analysis of multi-story structures. It has a Wide range of structural modeling capabilities, including the ability to model shear walls, Columns and beams it can handle static wind and vertical loads, modal analysis as Well as seismic spectral and time history analysis, three dimensional modeling of buildings is a standard feature of the program. A three dimensional mathematical model was prepared for each of the two buildings under consideration. All shear Walls, columns, beams and structural slabs were included in the model of each building. The reinforced concrete structural elements were assumed to be uncracked, and the steel reinforcements were ignored, which is the customary way of modeling reinforced concrete buildings

3.1 Computational Model

For determining the seismic performance of flat slab building two different height hypothetical structure (G+6 and G+12) are considered and five models is analyzed *viz.* flat slab building, flat slab with shear wall, flat slab with drop panel and conventional beam column building. The model must ideally represent the mass distribution, strength, stiffness and deformability. Material properties and Modeling of the structural elements used in the Present study is discussed below.

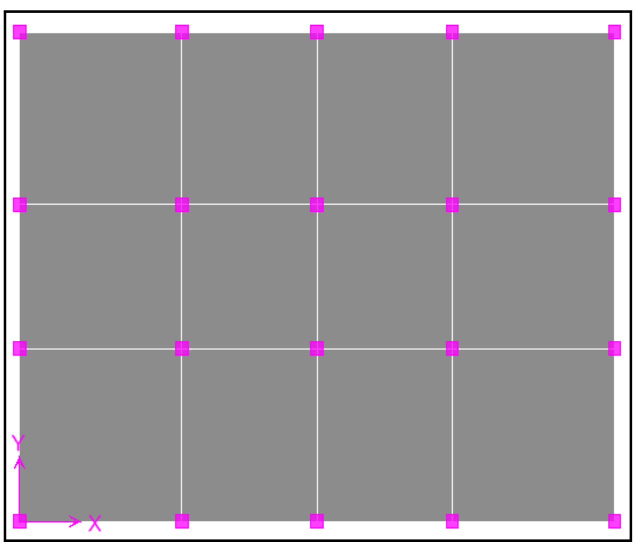

Fig. 1. plan of flat slab building

3.2 Material Properties

M-25 grade of concrete and Fe-415 grade of reinforcing steel are used for all the frame models used in this study. Elastic material properties of these materials are taken as per Indian Standard IS 456: 2000. The short-term modulus of elasticity (E_c) of concrete is taken as.

$$E_C = 5000\sqrt{f_{ck}}$$

f_{ck} is the characteristic compressive strength of concrete cube in MPa at 28-day (25 MPa in this case). For the steel rebar, yield stress (f_y) and modulus of elasticity (Es) is taken as per IS 456 (2000).

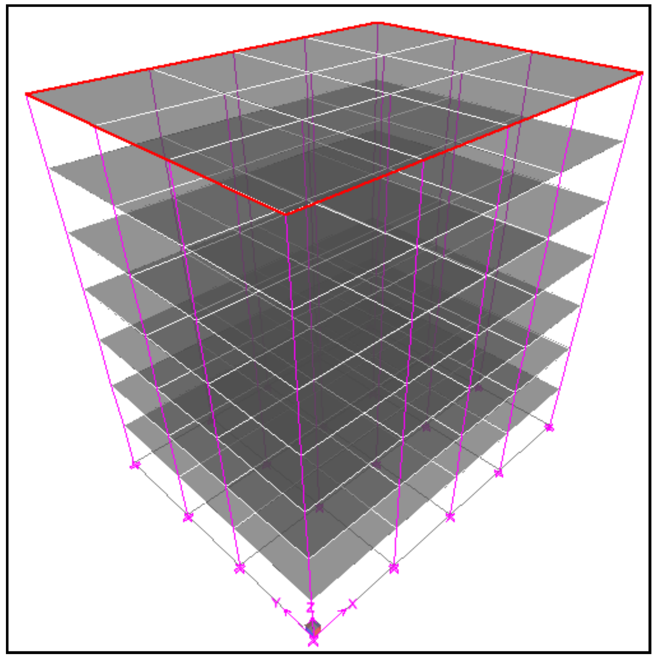

Fig. 2. 3D view of flat slab building in ETABS

Structural element sizes:-

For G+6 building

Column size 450 x 450 mm.

Beam size 230 x 400 mm.

Thickness of flat slab 150 mm.

Thickness of convectional two way slab 120 mm.

Thickness of shear wall 150 mm

Thickness of wall 230 mm

Thickness of interior wall 115 mm

For G+12 building

Column size 650 x 650 mm.

Beam size 230 x 500 mm.

Thickness of flat slab 150 mm.
Thickness of convectional two way slab 120 mm.
Thickness of shear wall 150 mm
Thickness of wall 230 mm
Thickness of interior wall 115 mm

1. Live load
   Live load of 4 kN/m^2 is considered on the building.
   Earthquake force data
2. Earthquake load for the building has been calculated as per IS-1893-2002:
   i. Zone (Z) = V
   ii. Response Reduction Factor (RF) = 5
   iii. Importance Factor (I) = 1
   iv. Rock and soil site factor (SS) = 2
   v. Type of Structures = 1
   vi. Damping Ratio (DM) = 0.05

4. RESULTS AND DISCUSSION

The linear dynamic analysis *i.e.* response spectrum analysis is carried out on the aforementioned building on two different height of buildings i.e. G+6 and G+12 storey buildings. And the response is compared in terms of displacement, storey drift and acceleration. The results of response spectrum analysis are shown in below figures.

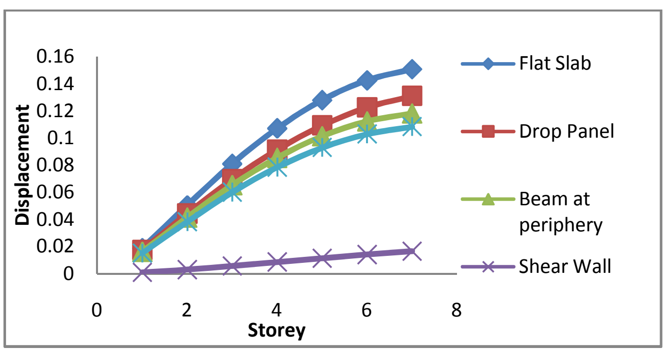

Fig. 3. storey verses displacement (G+6)

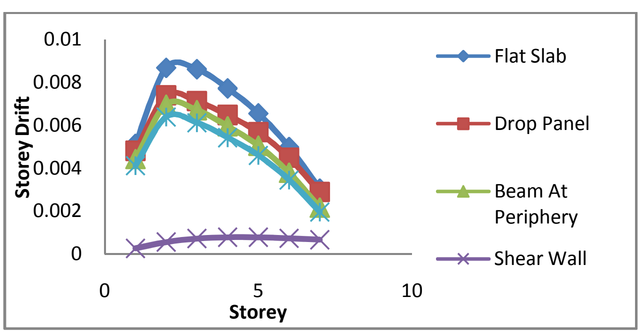

Fig. 4. storey verses storey drift (G+6)

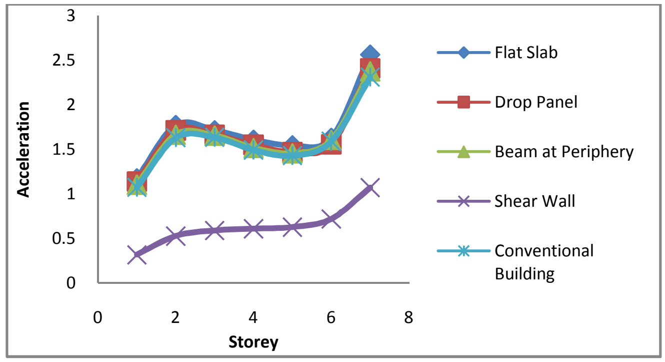

Fig. 5. storey verses acceleration (G+6)

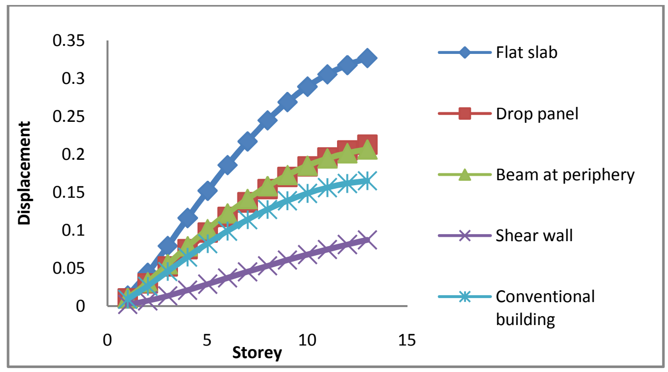

Fig. 6. storey verses displacement (G+12)

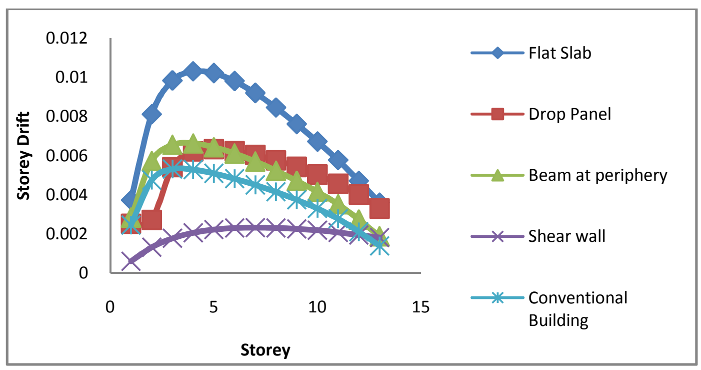

Fig. 7. storey verses storey drift (G+12)

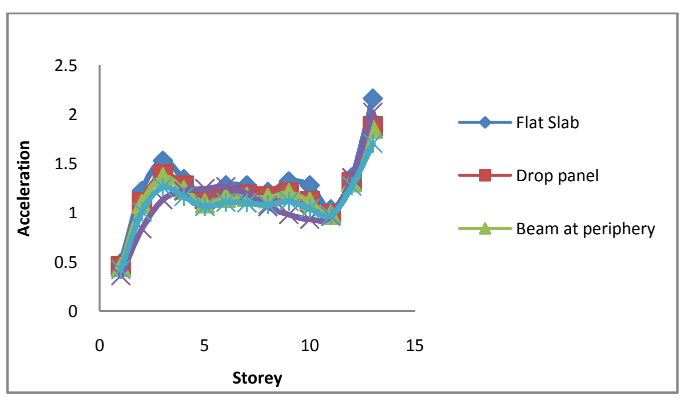

Fig. 8. storey verses acceleration (G+12)

From the response spectrum analysis it is found the maximum displacement for flat slab and the maximum storey drift also found for flab slab. Min displacement found for flat slab with shear wall. Flat slab displacement is found 28% more than of conventional building for G+ 6. And 49.49% for G+12 building. Therefore it is advisable for tall building to use the shear wall.

5. CONCLUSIONS

This paper presents a summary of the study, for conventional R.C.C building and flat slab building with and without shear wall, flat slab with drop panel and building with beam at periphery for seismic zone v. The effect of seismic load has been studied for these five types of buildings. On the basis of the results following conclusions have been drawn:

1. The storey displacement is found maximum for the flat slab building as compared to conventional RC building and flat slab with shear wall the maximum displacement of the flat slab building is due to the absence of lateral load resisting system.
2. The maximum storey drift found for G+6 building having a flat slab (As compared to its maximum limit i.e. 0.04% of height)
3. For all the cases considered drift values follow a parabolic path along storey height with maximum value lying somewhere near the middle storey.
4. It is found that flat slab structures exhibit higher flexibility compared to traditional frame structures. In order to limit deformation demands under the seismic excitations, combination with other stiffer structural systems as shear-walls is advisable.
5. the maximum storey drift also found for flab slab. Min displacement found for flat slab with shear wall. Flat slab displacement is found 28% more than of conventional building for G+ 6. And 49.49% for G+12 building. Therefore it is advisable for tall building to use the shear wall.

REFERENCES

[1] A. E. Hassaballa , M. A. Ismaeil , A. N. Alzead, Fathelrahman M. Adam, “Pushover Analysis of Existing 4 Storey RC Flat Slab Building”, *International Journal of Sciences: Basic and Applied Research (IJSBAR)(2014) Volume 16, No 2, pp 242-257*

[2] Sharad P. Desai , Swapnil B. Cholekar “Seismic Behaviour Of Flat Slab Framed Structure With And Without Masonry Infill Wall”, *International Journal of Engineering Research & Technology (IJERT)* Vol. 2 Issue 7, July – 2013 ISSN: 2278-0181

[3] Prof. K S Sable, Er. V A Ghodechor, Prof. S B Kandekar, “Comparative Study of Seismic Behavior of Multistory Flat Slab and Conventional Reinforced Concrete Framed Structures”, International Journal of Computer Technology and Electronics Engineering (IJCTEE) Volume 2, Issue 3, June 2012

[4] Ema COELHO, Paulo CANDEIAS, Giorgios ANAMATEROS, Raul ZAHARIA, Fabio TAUCER, Artur V. PINTO, “ASSESSMENT OF THE SEISMIC BEHAVIOUR OF RC FLAT SLAB UILDING STRUCTURES”, *13th World Conference on Earthquake Engineering Vancouver, B.C., Canada* August 1-6, 2004 Paper No. 2630

[5] Ms. Kiran parmar , prof. Mazhar dhankot, “Comparative study between dual systems For lateral load resistance in buildings of variable heights*”, journal of information, knowledge and research in computer engineering”*, ISSN: 0975 – 6760 NOV 12 TO OCT 13 volume – 02.

[6] CSI Analysis Reference Manual for SAP2000®, ETABS®, and SAFE™.

[7] I.S. 1893-1984, Indian Standard Code of Practice for Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces. *Bureau of Indian Standard*, New Delhi.

[8] I.S. 875-1987, Indian Standard Code of Practice for Structural Safety of Buildings: Loading Standards (other than Earthquake) *Bureau of Indian Standard*, New Delhi