Review Paper on Seismic Design Assessment of RCC and Post-Tensioned Flat Slabs in ETAB

Shubham Deogade[1] Deepak Irukullawar[2]
[1]M. Tech. Student [2]Assistant Professor
[1,2]Department of Structural and Construction Engineering
[1,2]Ballarpur Institute of Technology, Maharashtra, India

Abstract— There are two methods of structural design working stress and limit state method or Resistance Factor Design (LRFD). The fundamental revision is that WSM is an elastic design method and LRFD is a plastic design method. Between 1900 and 1910 the elastic theory of structures was at last applied to RCC. A German chief engineer formulated the theory of "deformed bars for good bonding with concrete and verified that the amount of steel (8 % of the area)" slow elastic failure of the steel when the unexpected brittle failure of the concrete under accidental overloading. The reinforcement in a slab is usually placed in two directions perpendicular to one another. The reinforcement must resist the bending moments and the torsional moment. The post-tensioning method is now a day's increasing widely, due to its application. By using the post-tensioning method one can design the most economical and safe design. In this study, RCC flat slabs are compared to post-tensioned flat slabs with a constant plan, elevation, Member sizes, Spacing of columns as well as the grade of concrete and reinforcements. These two G+10 multistoried Buildings having flat slabs models are modeled in ETABS. Finally, we will compare both buildings in terms of forces, moments, and displacements in tabular as well as graphical representations.

Keywords: Flat Slab, Post Tension, RCC, ETABS, G+10 Multistoried Building

I. INTRODUCTION

Capacity Design is a design process in which it is decided which objects within a structural system will be permitted to yield (ductile components) and which objects will remain elastic (brittle components). Once ductile and brittle systems are decided upon, design proceeds according to the following guidelines: - (I) Ductile components are designed with sufficient deformation capacity such that they may satisfy displacement-based demand-capacity ratio. And (II) Brittle components are designed to achieve sufficient strength levels such that they may satisfy the strength-based demand-capacity ratio.

A. Load Transfer in Slabs

Slabs are generally designed on the assumption that they consists of a number of beams of breadth 'one meter'. The forces transfer from slab to beams occur either in one way or in two ways. The total system completely counts on the geometrical dimensions of the slab. Slabs may be supported by columns only, in this case two way action will prevail. If the ratio Long side / short side < 2 it is considered as 2-way slab, and if Longer side to shorter side greater than 2 then it is considered as 1-way slab. The load transfer mechanism from floor slab to supporting elements for one way slab and two way slab are shown in Fig.

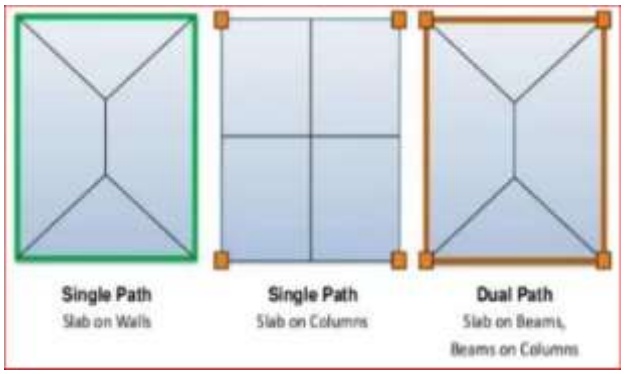

Fig. 1: Transfer of Loads from Slab to Supporting Members

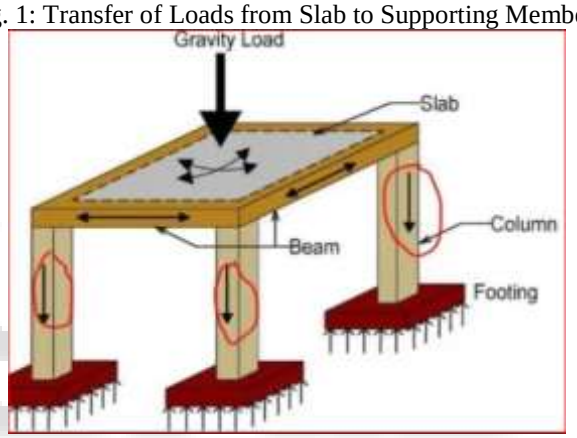

Fig. 2: Load Transfer Mechanism

B. Flat Slab

A flat slab is a two-way reinforced concrete slab that usually does not have beams and girders, and the loads are transferred directly to the supporting concrete columns. The flat slab includes either drop panels or column capitals at columns to resist heavier loads and thus permit longer spans.

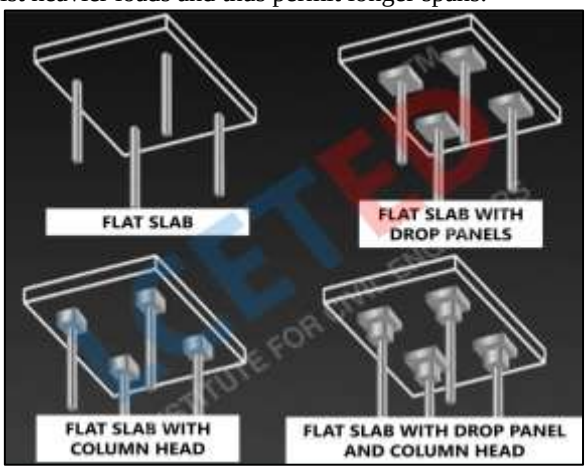

Fig. 3: Flat slab
http://www.dailycivil.com/wp

C. Post-Tensioning

As the floor system plays a vital role in the whole budget of a building, a post-tensioned floor system is invented which reduces the time for the construction and finally the cost of the structure. Post tension slab is a combination of conventional slab reinforcement and additional protruding high-strength steel tendons, which are consequently subjected to tension after the concrete has set. This hybridizations helps achieve the formation of a much thinner slab with a longer span devoid of any column-free spaces. The use of post-tensioning allows thinner concrete sections, longer spans between supports, stiffer walls to resist lateral loads and stiffer foundations to resist the effects of shrinking and swelling soils. We know concrete tolerates 'compressive' strength i.e. happily bears its own weight within a structure. Introduction of 'live' loads the concrete tends to deflect or sag which leads to cracking, thus weakening the structure. Concrete is weak under tensile strength. That's why steel reinforcing bars – 'rebar' – are frequently implanted in the concrete to limit the width of cracks. However, rebar offers only passive reinforcement i.e. rebar don't bear any load or force until the concrete has already cracked. So, Post Tensioning method should adopt generally in construction.

II. Scope of the Present Study

The present study is limited to Normal RCC and Post-Tensioning {PT} multi - storied flat slab buildings having Moment resisting frames.

1) Infill stiffness is not considered in the present study. Its related mass and weight is also neglected in the study.
2) The buildings from G+10 with constant aspect ratios are considered.
3) Both the buildings are assumed to have a constant area in plan.
4) Z- Direction indicates height of structure whereas plan of building lies in X-Y plane.
5) Both the buildings are assumed to have larger plan dimension in X direction.
6) Soil-structure interaction effects are not considered in the present study.
7) Column ends are assumed to be fixed at the foundation.

III. Objectives of the Study

Objectives for the project work are as follows:

1) Design and analysis of multistoried Post–tensioned and RCC flat slab structure under seismic zone III.
2) To compare the E-Tabs results for the following parameters- forces, moments, and displacements.
3) To study of cost effectiveness of Post-Tensioned flat slab systems with respect to reinforced concrete flat slab system.

IV. Design Methodology

Etabs using modal superposition or direct-integration methods, and both can be linear or nonlinear. The nonlinear modal method, also called FNA for Fast Nonlinear Analysis, is extremely efficient and accurate for a wide class of problems.

A. Modal superposition

The natural frequencies and mode shapes of a structure can be used to characterize its dynamic response to loads in the linear regime. The deformation of the structure can be calculated from a combination of the mode shapes of the structure using the modal superposition technique. Each mode shape is multiplied by a scale factor. The vector of displacements in the model, u, is defined as

$$u = \sum_{i=1}^{\infty} \propto i \; X \; \emptyset i$$

Where

$\propto i$ = the modal displacement and

$\emptyset i$ = the generalized coordinate of mode i. This technique is valid only for simulations with small displacements, linear elastic materials, and no contact conditions—in other words, linear problems.

Mode shapes describe the configurations into which a structure will naturally displace. Mode shapes of low-order mathematical expression tend to provide the greatest contribution to structural response. A structure with N degrees of freedom will have N corresponding mode shapes. Each mode shape is an independent and normalized displacement pattern which may be amplified and superimposed to create a resultant displacement pattern.

V. Literature Review

The literature review is carried out in following major areas. These are:

1) Research papers on response of buildings (regular or irregular configuration) under seismic loading and Literature based on behavior of structure under Seismic condition.
2) Importance of Indian seismic design codes and their introduction in brief
3) Discussion about Building configuration.

1) "Comparative Design of RCC & Post-tensioned flat slabs" BOSKEY et.al December 2010, in the present study the design of the post-tensioned flat slab is done by using two methods, load balancing method and equivalent frame method. The post-tensioned flat slab by varying the span by 0.5m interval is done. A design of post-tensioned beam is also done. For the study of post-tensioned slab and beams a case study of a multistory office building (G+4) is taken and it is designed by four cases. The analysis, design and the estimation of the office building for the four different floor systems is done. The study shows the variation of the rate per square meter for these four different cases.
2) "Seismic Performance of Post–Tensioned Interior Slab-Column Connections with and without drop" U. PRAWATWONG et.al, October 12-17, 2008
This paper presents an experimental study on the seismic performance of two three-fifth scale post-tensioned (PT) interior slab-column connection models, one without drop panel and another one with drop panel. Both models were tested under a constant gravity load. Displacement-controlled cyclic loading routine with monotonically increasing drift levels until failure was adopted to

investigate the seismic performance. No pinching phenomenon was observed in the hysteretic loops of both specimens. The specimen with drop panel experienced saturation of peak load from about 2.5% to 6.0% drifts, indicating flexural yielding took place before punching failure. The specimen with drop panel was able to reach 6.0% drift, whereas the one without drop panel could only undergo 2.0% drift. The test results suggest that the gravity shear ratio (Vg/V0) is the major variable which governs the drift capacity and ductility.

3) "Comparative Study of Post Tensioned and RCC Flat Slab in Multistory Commercial Building" JNANESH REDDY et.al. June-2017; In the present study an attempt is made to compare the cost effectiveness of Post-Tensioned flat slab systems with respect to reinforced concrete flat slab system. Both the systems are analyzed using RAPT and ETABS respectively which is based on the design methodology. There are many other benefits of using PT slab. As the thickness of the slab is much lesser than the R.C.C flat slab, aesthetic look of the building may get enhanced leading to a clear height for a longer distance. Hence, using a PT Slab is more advisable for a commercial building than using a R.C.C Flat Slab. Construction of a structure using PT Slab also leads to a lighter structure as the Dead Load gets reduced.
4) "Design Considerations for Reinforced Concrete Flat Slab Floor System" HARSHAL DESHPANDE et.al December-2014; The purpose of this paper is to present the use of flat plate/slab construction in India followed by a review of design methods for flat plate/slab structure designs based on Indian Standard 456:2000[1] and American Concrete Institute ACI-318[2]codes. Flat plate/slab can be designed and built either by conventional RCC or post-tensioning, conventional RCC design should be the preferred choice for spans up to 10 meters. Design of conventional RCC flat plate/slab in India, utilizing Indian codes, has many shortcomings, which have to be addressed and revised soon.
5) "Post-Tensioned Building Analysis and Design" RAHUL SINGH et.al, March 2018, in this paper, the emphasis is to design a post-tensioned building using ETABS and SAFE. The main purpose of this software is to design multi-storied building in a systematic process which will be in accordance with Indian Standard design codes. This project deals with provision of earthquake and wind resistance structure. Minimum sizes of column and beam provided was C500*500 and B300*500. Seismic analysis was done by using ETABS software. As building is post tensioned one, it proves to be economical.
6) "Analysis of Post-Tensioned Flat Slab by using SAFE" S. MALVADE et.al March-2017, the main objective of this paper is to give a review on the response and behavioral properties of Post tensioned flat slab during earthquake and compare with normal flat slab. A study on analysis and behavior Of Post-tensioned flat slab is been done in this thesis. Modeling and analysis of flat slab and PT flat slab is done using SAFE. Stretching one cable produces secondary moment and hence strip moments in both direction changes drastically. Hyper static moments are affecting during the construction stage. In stage wise construction hyper static moments play important role. In the flat plate varying eccentricity is not very much possible due to small thickness of slab but force can be worked out for new moments. Due to post-tensioning of flat plates slab there is no much effect on axial force but shear and moment on column increases.
7) "Study of Flat Slab", K.N.MATE et.al 2015, this study present a complete detail procedure of analysis and design of flat slab structure with is 456:2000. Flat slab gives the advantage over beam slab structure. This slab increases efficiency of structure and requires less construction cost as compared to beam slab construction. This paper gives the guideline for selection of drop, panel width, slab thickness and gives the reinforcement details.
8) "Comparative Analysis of Flat Slab and Post-Tensioned Flat Slab Using SAFE" Mohammad J. Shaikh et.al 2016, analysis and behavior of Post-tensioned flat slab is been done in this thesis. Modeling and analysis of flat slab and PT flat slab is done using SAFE. For post-tensioning 12.7 dia and 9.5 dia 7 ply high tensile steel strands are used in analyzing the PT slab. Slab panel of 8m by 12m is modeled for different cases and respective properties are assigned. Slab is divided into column strip and middle strips. Drops are provided along column strip in flat slab and PT flat slab. Results are compared with flat slab and PT flat slab with respect to deflection, punching, moment and stresses. The quantities of reinforcing steel, post-tensioning steel, concrete required for the slab is calculated for the same and cost per square meter are presented in graphical form. Overall study on PT flat slab proves that PT flat slab could be a better option compared to flat slab, in respect of cost of project.
9) "Comparative Study on Analysis and Designing of Post Tensioned Flat Slab vs. Conventional Slab" Soubhagya Ranjan Rath, May 2019, result shows that PT Flat slab system have more store displacement than normal conventional system as it is more flexible in case of seismic load. On the other hand, the PT flat slab systems do not require internal beams i.e. beam column frame structures. As slab in this system only supported by the column capitals or drop panels. Only perimeter beams are provided in this type of system. So basically the quantity for beam steel and concrete also decreases as compared to conventional system.
Considering the area of sections in both types of slab systems, result shows 50% increase in sectional area which leads to increase in concrete and steel quantity. It result costlier than PT flat system.
10) "Comparative Analysis of Conventional Slab Flat Slab and Post Tensioning Slab" Vishal Gupta et.al, 2018, in the present study main focus on economic analysis between conventional and post tensioning slab. This paper introduces economical comparison between different type of slab and different type of construction technique. The analysis and design is verified all Indian stranded codal provision in manual calculations as well as a power full computer software SAP2000. As per the economical aspect among conventional and post tensioning floor system the post-tensioned flat slab is the most economical. And the Conventional two-way slab

with reinforced concrete beam is most uneconomical span.

VI. METHODOLOGY

1) Literature survey.
2) Assuming the dimensions of the RCC and post-tensioned flat slab for G+10 building.
3) Assume for sizes and numbers of column required for the flat slab.
4) Study of IS code 1893:2016 for seismic design of building.
5) Calculation of loads act on flat slab.
6) Calculation of steel reinforcement required for flat slab.
7) Analysis and design of RCC flat slab for seismic zone III.
8) Analysis and design of post-tensioned flat slab for seismic zone III.
9) Comparison of parameters like force, moment and displacement graphically.
10) Conclusion.

REFERENCES

[1] "Design of RCC & Post-tensioned flat slabs" Bosky Bahoria1, Prof. R. S. Deotale2 and D K Parbat3, 2010; International Conference on Current Trends in Technology, NUICONE
[2] "Analysis and design of flat slab" G.R Chahvan1 and S.N Tande2 IJLTE 2016
[3] "Flat Slab Construction in India" S.S. Patil1 and A. Sigi2, International Journal of Engineering and Innovative Technology (IJEIT) Volume 3, Issue 10, April 2014
[4] "Analysis of Post-Tensioned Flat Slab by using SAFE" S. Malvade1 and P.J. Salunke2; International Journal of Scientific Engineering and Applied Science (IJSEAS) – Volume-3, Issue-3, March 2017, ISSN: 2395-3470, www.ijseas.com.
[5] "Seismic performance of post–tensioned interior Slab-column connections with and without drop panel" U. Prawatwong1, C.H. Tandian2 and P. Warnitchai3; the 14th World Conference on Earthquake Engineering October 12-17, 2008, Beijing, China
[6] Design Considerations for Reinforced Concrete Flat Slab Floor System, Harshal Deshpande, Radhika Joshi , Prashant Bangar, International Journal of Scientific & Engineering Research, Volume 5, Issue 12, page-59, ISSN 2229-5518, December-2014.
[7] Comparative Analysis of Flat Slab and Post-Tensioned Flat Slab Using SAFE, V. G. Mutalik Desai1, Mohammad J. Shaikh2, International Advanced Research Journal in Science, Engineering and Technology (IARJSET) ISSN (Online) 2393-8021 ISSN (Print) 2394-1588, Certified Vol. 3, Issue 8, August 2016.
[8] Use of flat slabs in multistory commercial building situated in high seismic zone, Navyashree K1, Sahana T.S2, IJRET: International Journal of Research in Engineering and Technology eissn: 2319-1163 | pissn: 2321-7308. Volume: 03 Issue: 08 | Aug-2014.
[9] "Study of Flat Slab", K.N.Mate1, P. S. Patil2, International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 volume 4 Issue 6, June 2015.
[10] "Post-Tensioned Building Analysis and Design – A Case Study" Rahul Singh1 , Amarjeet Chauhan1 , Yash Chonkar1 , Apurva Rati1 , Arbaz Kazi 2 International Advanced Research Journal in Science, Engineering and Technology ISO 3297:2007 Certified Vol. 5, Issue 3, March 2018.
[11] "Analysis And Design Of Flat Slab By Using Etabs Software" B.Anjaneyulu1, K Jaya Prakash2 International Journal of Science Engineering and Advance Technology, IJSEAT, Vol. 4, Issue 2.
[12] "Seismic Analysis of Flat Slab by using ETABS" S. Dhana Sree, E. Arunakanthi International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-9 Issue-3, January 2020.
[13] "A Review on Seismic Assessment of Post Tensioned Flat Slab" Shriraj S. Malvade P. J. Salunke IJSTE - International Journal of Science Technology & Engineering | Volume 2 | Issue 12 | June 2016
[14] "Comparative Study on Analysis and Designing of Post Tensioned Flat Slab vs. Conventional Slab" Soubhagya Ranjan Rath, International Journal of Research in Advent Technology, Vol.7, No.5, May 2019 E-ISSN: 2321-9637 Available online at www.ijrat.org
[15] Comparative Analysis of Conventional Slab, Flat Slab and Post Tensioning Slab Vishal Gupta1 Rohit Sahu2 Dr. Pankaj Singh3, IJSRD - International Journal for Scientific Research & Development| Vol. 6, Issue 03, 2018 | ISSN (online): 2321-0613

