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# Seismic Analysis of Flat Slab Structure Using ETABS Software : A Review

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**ABSTRACT**

The behavior of reinforced concrete moment resisting frame structures in recent earthquakes all over the world has highlighted the consequences of poor performance of beam column joints. Large amount of research carried out to understand the complex mechanisms and safe behavior of beam column joints has gone into code recommendations. The design of reinforced concrete structures solely depends on various parameters like bending moment; shear force and stress induced in a particular member of a structure. Variation in the magnitude of these parameters may alter the entire design of a particular element. In this paper we are presenting review of literature related to analysis of structures considering diaphragm effect.

**Keywords:** Slab, Review, Analysis, Structure, Forces, Stresses.

## I. INTRODUCTION

Flat slab is a reinforced concrete slab supported directly by concrete columns without the use of beams. Flat slab is defined as a one sided or two-sided support system with sheer load of the slab being concentrated on the supporting columns and a square slab called 'drop panels'. Drop panels play a significant role here as they augment the overall capacity and sturdiness of the flooring system beneath the vertical loads thereby boosting cost effectiveness of the construction. Usually the height of drop panels is about two times the height of slab.

Flat Slabs are considered suitable for most of the construction and for asymmetrical column layouts like floors with curved shapes and ramps etc. The advantages of applying flat slabs are many like depth solution, flat soffit and flexibility in design layout. Even though building flat slabs can be an expensive affair but gives immense freedom to architects and engineers the luxury of designing. Benefits of using flat slabs are manifold not only in terms of prospective design and layout efficiency but are also helpful for the total construction process especially for easing off installation procedures and saving on construction time. If possible, try to do away with drop panels as much as possible and try to make the best use of the thickness of flat slabs. The reason is to permit the benefits of flat soffits for the floor surface to be maintained, to ensure drop panels are cast as part of the column.

In today's world the exploding population creating the disasters like land scarcity which leads us to the bringing some new construction technology and commercial structures. A normal building structure has number of beams in it. But while taking flat slabs no beams are casted separately. A structure is said to be more stable flat slab or say flat plate. These methods can be used provided the limitations specified therein are satisfied. The two design methods are i) The direct design method, ii) The equivalent frame method. In a developing country like India the benefits of pre-stressing and particularly of post-tensioning are yet to be recognized. The inherent hurdle is undoubtedly the higher initial investment that is required from the clients. This has to be overlooked considering the significant benefits of post-tensioning and the high benefit-aspect ratio that can be advantageously procured. In the present study an attempt is made to be compare the design and cost effectiveness of post-tensioned flat slab with respect to the reinforced concrete flat slab system. Pushover analysis is a popular performance based design method, so there are many studies conducted using this method. Time history analysis is a non linear dynamic analysis to obtain the dynamic response of the structure subjected to seismic loading. Most of these studies assumed that the lateral force distribution was an inverted triangular distribution, according to recommendation of codes only flexural plastic hinges were considered. It was also studied that mode shapes and the lateral distribution of base shear gives the same results. The following are some studies in brief:

## II. LITERATURE-REVIEW

**Kamal Amin Chebo et.al (2022)** research paper analyzed the behaviour of single span hollow core slab under successive impact load at three different locations: centre, edge, and near the support under a 600 kg free falling steel ball from a height of 14 m. The structural response of the slab in terms of damage assessment, acceleration response, damping, and impact force was investigated. A full scale experimental program consists of testing a single span hollow core slab. The specimen has 6000 mm × 1200 mm × 200 mm dimensions with a 100 mm cast in a place topping slab.

Results stated that concrete solid section behaves in a much better way than the hollow section in terms of structural damage and cracks generation. Filling material such as foam can be used to absorb a part of the energy induced in the body of the hollow core unit to mitigate the brittle fracture of the thin flanges, therefore enhancing the structural performance of the slab system. The presented damping ratio showed the vulnerability of the impact load location in the hollow core slab.

**Vanteddu Satwika and Mohit Jaiswal (2022)** in the research paper, the technique of post tensioning was used to strengthen a flat slab. RCC flat slabs was compared to post-tensioned flab slabs with different tendon profiles and tendons were available in two forms: distributed and banded. The models were built as per ACI 318-14 and these slab models were created using ETABS software, and the parameters were compared: thickness, supporting reactions, punching shear, and deflection when compared to traditional flat slabs.

The results indicate that post-tensioned flat slabs have a higher punching shear capacity even at shallower depths, resulting in more cost-effective sections. The provision of tendons also results in lower deflection.

Distributed tendons are more effective in obtaining lesser depths compared to the banded tendons. Support reactions was less in post-tensioned flat slab due to the reduction of dead weight, which results in less material requirement for construction. Hence cost of construction is reduced. Since the support reaction for PT slabs is lower, the components that take load from the slabs, such as columns and foundations, can be built for lower loads, resulting in smaller sections and reinforcement, lowering the overall construction cost. Punching shear strength of a flat slab can be increased by using post- tensioning technique and achieving more punching shear strength even at lesser depth. There by, overcoming one of the major problems in the design of flat slab. Downward deflections can be greatly reduced by the provision of post-tensioning tendons resulting in good serviceability. Provision of distributed tendons along with drop is the most effective way considering the overall performance of the flat slab.

**Dheekshith K and Prasad Naik (2021)** research paper compared the response of RCC slab building and hollow core slab under the seismic load conditions for a G+9 storey structure modelled using analytical application ETABS considering shear walls on the sides. As hollow core slabs cannot be directly modelled by ETABS, Secondary Beams were adopted with the same dimensions as Hollow Core Slabs. The hollow core slab were modelled using ANSYS( Analysis of Systems software). Three models were evaluated for each RCC building in Zones 3, 4, and 5 and for each common ceiling structure.

Results stated that storey displacement increased for hollow core slab compared to RCC structure. Hollow core slab building acceleration in Storey is lower relative to the RCC building in the X direction, while it was higher in the Y direction. The time span of hollow core slab is less compared to RCC construction, storey drift has decreased for hollow core slab construction. The base shear of hollow core slab construction is less due to the reduction in building weight compared to RCC building.

**Omar Ahmad (2021)** research paper presented comparative study between post-tensioned, and reinforced concrete flat slab to compare how much each slab cost. It describes that since the post-tension slabs are thinner and it provides fewer columns, so the amount of concrete required is less than the required amount in a flat slab. Special steel tendons that was used in post-tensioned slabs will be stretched by a hydraulic jack after the casting of concrete, and these tendons have an effect in reducing the reinforcement steel bars. Although tendons are used only in post-tension slabs, the amount of steel used in it is less

compared to flat slabs. Furthermore, the contractor work cost differs from doing the post-tensioned slab and flat slab. The study was done by comparing the amount of concrete, steel and the contractor work cost.

The results obtained from the comparative study between post-tension slabs and reinforcement concrete flat slabs indicated that post-tensioned slabs are cheaper.

**E. Michelini et.al (2020)** research paper conducted an experimental and numerical research on precast prestressed deep HCS subjected to flexure and shear. The work was structured

in two main phases as execution of 4 experimental tests on a 500 mm deep HCS (two in flexure and two in shear) and further, validation of the adopted numerical procedure,

which takes into account the material non-linearity by means of 2D-PARC model, through a detailed comparison with experimental results.

Conclusion stated that the adopted numerical procedure, based on fracture mechanics principles, represents a rational technique for analyzing cracking development and propagation in deep HCS.

**Vinod Shukla and Dr. Pankaj Singh (2020)** objective of the research was to compare depth of two- way slab, flat slab, grid slab and post tensioned slabs, compare material quantities of two- way slab, flat slab, grid slab and post tensioned slabs and the cost for various types of slabs such as two- way slab, flat slab, grid slab and post tensioned slabs. The two-way slab, flat slab and grid slab is designed according to IS 456: 2000 and post tension slab was designed according to IS1343-1987.

Results stated that grid slab requires less depth with 41mm and flat slab has high depth of slab with 365mm. Post tension slab requires less cement of 1800 kg and grid slab requires more cement with an amount of 7723 kg. Post tension slab requires less fine aggregates of 1.88 and grid slab requires a high amount of fine aggregates with 7.69. Solid slab requires less coarse aggregate of 3.72 and grid slab requires high amount of coarse aggregate with 15.38. Grid slab requires less steel of 53.26 kg and flat slab requires a high amount of steel with 1,243.306 kg. Considering the factors like depth of the slab, cement, fine aggregate, coarse aggregate and steel requirements, it was concluded that post tensioned slab requires less amount of Rs. 32,917/- for the construction and Flat slab requires high amount of Rs.1,24,106/-.

**Abhishek R. Pandharipande and N. J. Pathak (2019)** research paper aimed to investigate the practicality of hollow plastic balls in a reinforced concrete slab. The range of the research involves evaluating the flexural strength and behavior of light weight slab and conventional slab by analytical and experimental work. The slab specimen casted were of three types namely, conventional slab, B.D.S of 50 mm diameter and B.D.S of 100 mm diameter having dimensions of 750 mm X 500 mm X 150 mm. The testing of slab specimens was done on a universal testing machine by giving one point line loading. Finite element analysis on slab specimens is also done by using ANSYS WORKBENCH 16.0.

Results concluded that a Bubble deck slab of 50 mm and 100 mm diameter can be used in practice, as the deflection values of the particular slabs are within the permissible limit as stated in IS Code.

**Atif Zakaria et.al (2019)** research paper presented analysis of multistoried RCC buildings (4,6,8 Storey) considering building system as OMRF with ductile shear wall and adopting ribbed slab and grid (waffle) slab where the used analysis methods was Equivalent Static Method, Response Spectrum Analysis, and Time History Analysis as per IS: 1893-2002 part-I: Criteria for Earthquake resistant structure.

Results stated that Grid slab building has a better seismic response than ribbed slab building. When the total height of the structure increases the base shear, displacement, Storey shear and drift increases simultaneously. In OMRF building shear wall takes the immense percentage of the base shear and the storey shear. Approximately above 95% from the load would be withstood by shear walls.

**Soubhagya Ranjan Rath et.al (2019)** in the research paper, model of the Multi-storey tall structure has been created in ETABS as per architectural layout. Materials and concrete sections were defined including core walls and slabs and load cases and other parameters to the model was assigned. For the detailed slab analysis and design comparison, it has been imported to SAFE software. Assigning and checking for slab properties, load cases and design parameters for different types of slabs including Post tensioned tendons. The slab models were analysed and designed for further parametric comparison in case of PT flat slab, conventional and even for normal flat slab.

Results stated that PT flat slab system has greater flexibility than conventional system due to more quantity of story displacement in case of seismic analysis but in PT flat slab perimeter beams are provided to maintain the structure from earthquake load. Normal flat slab results in more magnitude of slab displacement than conventional slab but the post-tensioned flat slab results in 7%-10% lesser slab displacement than the conventional system. Flat slab and PT flat slab systems have an equal reaction force on columns and 28% lesser than the conventional system. Considering slab forces, PT flat slab results in almost 60% lesser force than compared to the normal conventional slab. Normal flat results even more force than a normal slab.

**Umamaheswara Rao Tallapalem et.al (2019)** in the research paper, the three types of Beam-columns connections such as Rigid connection ,semi-Rigid connection and Hinged connections were developed in G+20 High rise building. These High rise building were analysed with help of Time history analysis of High Seismic waves, Moderate Seismic waves and Low seismic waves so as to identify the behaviour of connections and the results of Top Displacements, story Drifts and Inter storey Drifts were compared for the different connections and different Seismic waves. The model was prepared using staad.pro software with three types of Precast joint connection such as Rigid Connection, Semi Rigid connection and Hinged connection.

Results stated that lower earthquakes maximum inter storey drift for hinged connections are nine times higher than the semirigid connections. It may lead to nine times higher assumptions than existing one. Rigid connections were 1.81 times lesser than the Semi-Rigid connection. It may lead to lower assumptions 1.81 times than existing one. Finally in Major Earthquake affected areas and Low Earthquake affected areas Hinged connections are assumed to Approximately 10 times higher consideration than Semi Rigid connections. For moderated earthquake affected areas rigid connections and Semi Rigid connections behave nearly the same.

**Jay Vekariya et.al (2018)** research paper presented analysis and design of the post-tensioned flat slab with drop panel and post tensioned voided slab using the ADAPT BUILDER 2015.

Results stated that self-weight of voided slab was less compared with solid slab, so by providing 35% voided portion into solid slab, deflection can be reduced up to 19%. 2. Punching shear was a major problem in the flat slab system by providing voided flat slab system punching shear reduction up to 23%. Numbers of tendons were less required for control deflection and stress in voided slab compared to Solid flat slab. By providing a voided slab 35%, the self-weight of slab reduced up to 13%.

**Jnanesh Reddy R K and Pradeep A R (2017)** research paper compared the cost effectiveness of Post-Tensioned flat slab systems with respect to reinforced concrete flat slab system. Both the systems was analyzed using RAPT and ETABS respectively which is based on the design methodology. The structure was modeled using the ETABS, and the model considered is having basement, ground and 4 floors with dimensions 38.13 m*28.85 m, with largest spans of 9.44 m*6.16 m (flat slab). The column dimensions are 750*750 mm. Grade of concrete considered is M30 and grade rebar is fe415 for columns, beams, and slabs. Slab is loaded for self weight, live load of 5 kn/m2 (as per IS 875 part 2).

Results stated that concrete needed for R.C.C Flat Slab construction with edge beams was 330 m3 and that for PT Slab with drop panels was 247 m3 . Cost of steel required for the R.C.C Flat Slab construction was Rs. 3915751 /- and the cost of steel & tendons required for PT Slab construction is Rs. 3445148 /- . Further the results indicated that Post Tensioned flat slabs are cheaper than the RCC slab systems.

**Kamal Padhiar et.al (2017)** in the research paper, two different floor post-tensioning floor systems was considered, they were flat slab and flat slab with drop panels. Four spans were considered for the equivalent frame system to evaluate structural parameters like concrete grade M35 to M50. Two different span to depth ratio used for flat plate slab and flat slab with drop panel. Dead load due to self weight of the structure, live load and post- tensioned load was considered for the analysis. Grade of concrete directly influencing the deflection &Non PT steel(conventional steel) of flat plate. With changing grade of concrete, effect of punching shear ratio, factored moment at mid span and PT quantity was investigated and the design was conducted using the computer analysis program ADAPT-PT.

Required quantity of PT steel in case of flat plate slab is 5-10% more than flat slab with drop panel for different span. But it is not increased by changing the grade of concrete for each span. In both types of geometry for the same span with increasing grade of concrete, the quantity of non PT steel is reduced by 5-10%. But for the same grade of concrete having the same span, the quantity of non PT steel in case of flat plate slab is 40-50% more than the flat slab with drop panel. Conclusion stated that that flat plate slab was suitable and economical up to 8.0 meter span. If necessity of span more than 8.0 meter and above up to 13 meter flat slab with drop panel gives economy.

**Mohammed Imran et.al (2017)** objective of the research paper was to investigate and compare seismic behaviour of RCC Flat slab and Post tensioned slab using the methodology of Linear time history analysis integral part of Etabs 2015 software in two different seismic zones i.e., Zone 2 and Zone 3 in India. Various types of Buildings with G+9, G+11, G+14, G+19 and G+24 storeys were considered with differences in geometrical properties and material properties. Results were to compare the behaviour of both structures for the parameters like lateral displacement, inter story drift, axial force and storey shear.

Results stated that the post tensioned flat slab was more effective under seismic loading compared to flat slab, but now a day's post tensioned slab is gaining popularity as it has the same specialities as of flat slab construction. It is quite common especially for commercial spaces; enhancing the weight reduction, speed, economical and importantly shorter construction time. To further improve the results of flat slab under seismic and temperature loads the thickness of slab and size of columns may increase.

**Prasad Bhamare et.al (2017)** research paper conducted a detailed study of various concepts of precast, went through a number of literature & found the facts associated with it. One building as a case and design the same building as a precast building and Traditional Cast in-situ building was considered. Cost analysis as well as feasibility check on basis of costing and duration was analyzed.

Research concluded that the precast concrete system was more economical than conventional cast in place method but still there are some conditions which we have to take care of while using precast, such as quantity of construction, Distance of site from manufacturing unit. Type of building etc. we have identified that for standard & Repetitive work precast is the best option to choose. In observation the most important thing to be observed in precast construction technique is the time effective it require less time to construct. It requires skilled worker and qualified contractor, Lower initial cost especially for large projects. The main limitation of precast is transportation from place of manufacturing to place of site where it is to be fixed.

**V. G. Mutalik Desai and Mohammad J. Shaikh (2016)** research paper presented analysis and behavior of Post-tensioned flat slab where the modeling and analysis of flat slab and PT flat slab was done using SAFE. For post-tensioning 12.7 dia and 9.5 dia 7 ply high tensile steel strands was used in analyzing the PT slab. Slab panel of 8m by 12m was modelled for different cases and respective properties are assigned. Slab was divided into column strip and middle strips. Drops were provided along column strip in flat slab and PT flat slab and results were compared with flat slab and PT flat slab with respect to deflection, punching, moment and stresses.

PT flat slab proves that PT flat slab could be a better option compared to flat slab, in respect of cost of project, stability and durability.

**Supriya T J and Praveen J V (2014)** research paper presented the behaviour of precast

hollow core slabs in high rise buildings. Five models of hollow core slab buildings of different member sizes is analyzed using equivalent static method and Response spectrum method for seismic zone IV. Structural system used for these buildings are taken as concrete special moment-resisting frame with ductile shear walls. Five different models of hollow core slab building with different member sizes have been performed. Static analysis has been carried out by equivalent static method and dynamic analysis has been carried out by response spectrum method as per recommendation of IS: 1893(Part 1):2002.

Results stated that base shear was less for hollow core slab building compared to solid slab building for different seismic zones. Storey drift is higher for hollow core slab building as compared solid slab building. Thus hollow core slab building consumes less material when compared to solid slab building. Therefore hollow core slab building is best compared to solid slab building.

**Renee A Lindsay et.al (2004)** in the research paper, a full scale precast concrete super-assemblage was constructed in the laboratory and tested in two stages. The first stage investigated existing construction and demonstrated major shortcomings in construction practice that would lead to very poor seismic performance. This paper presents the results from the second stage that investigates the efficiency of improved construction details on seismic performance. The improved details consist of a simple (pinned type) connection system that uses a low friction bearing strip and compressible material for the supporting beams together with a 750mm wide timber infill between the perimeter beams and the first precast floor unit.

Test results show a marked increase in performance between the new connection detail and the existing standard construction details, with relatively small amounts of damage to both the frame and flooring system at high lateral drift levels. The results show that interstorey drifts in excess of 3.0% can be sustained without loss of support of the floor units with the improved detailing The overall performance of the super-assembly is determined in terms of the hysteretic performance and the fragility implications in terms of the drift damage are classified.

**Ankit Purohit and Lovish Pamecha (2017)** the research paper presented analyzed the behavior, performance and response of G+12 story building on parameters of deflection, stresses, bending moment and shear force. The investigation considered four cases namely Soft soil with zone V, Medium soil with zone V, soft soil with zone II and medium soil with zone II. The objectives behind the research included developement, design and analyze model of the High rise structure in FEA software and comparison of results of earthquake load applied on the structure by FEA software in Zone II and Zone V for soft and medium soil cases. Comparison of results of earthquake load applied on the structure by FEA software in soft and hard soil type.

Results stated that the Deflection, Shear Force Bending Moment, Beam End Forces, Displacement, Beam Stresses Sectional Force and Bending Moment are noticed maximum in Zone V for all the four cases. In terms of soil analysis, it was found for both zone IV and zone V that the displacement in soft soil is greater than medium soil case. Shear force values are also greater in soft soil. Bending moment is noticed lesser in soft soil than medium soil for all cases.

**Arvindreddy and R.J.Fernandes (2015)** in this paper an analytical study is made to find response of different regular and irregular structures located in severe zone V. Analysis has been made by taking 15 storey building by static and dynamic methods using ETABS 2013 and IS code 1893-2002 (part1).

In this present work two types of structures considered are reinforced concrete regular and irregular 15 storey buildings and are analyzed by static and dynamic methods. For time history analysis past earthquake ground motion record is taken to study response of all the structures. Presently there are six models. One is of regular structure and remaining are irregular structural models. Linear Equivalent Static analysis is performed for regular buildings up to 90m height in zone I and II, Dynamic Analysis should be performed for regular and irregular buildings in zone IV and V. Dynamic Analysis can take the form of a dynamic Time History Analysis or a linear Response Spectrum Analysis. Behavior of structures will be found by comparing responses in the form of storey displacement for regular and irregular structures.

The results obtained from static analysis method showcased lesser storey displacement values as compared to response spectrum analysis. This variation was due to nonlinear distribution of force. In diaphragm irregularity, storey displacement and storey drift was found to be less as compared to regular structures in both static and response spectrum method. As per pushover curve, stiffness irregularity showcased nonlinear behavior at earlier stage as compared to all other structures. Therefore earthquake is more enhanced in stiffness irregularity structure. Time history analysis stated that for 15 storey stiffness irregularity shows least base force as compared to all other structures. Overall, conclusion derived from results stated structure built-in with stiffness irregularity will be on non-conservative side and as seen from time history analysis, as storey increases behavior of stiffness irregularity and diaphragm irregularity becomes reverse.

**Boskey Bahoria et. al (2010)** the research paper presented analysis, design and the estimation of the office building (G+4) for the four different floor systems namely Post-tensioned Flat Slab, RCC Flat Slab, post-tensioned slab with RCC beam and RCC slab with beam.

Results derived from economic point of view stated that the post-tensioned flat slab was the most economical among all four floor systems and the reinforced concrete slab with reinforced concrete beam was the costlier one for this span. While considering the post-tensioned flat slab and reinforced concrete flat slab, the thickness of reinforced concrete flat slab was 12.5% greater and its cost was 27% greater than the posttensioned flat slab. From both post-tensioned floor system building the posttensioned flat slab was more economical than the post-tensioned slab with reinforced concrete beams. The quantity of prestressing steel was 4 Kg/m2 for posttensioned flat slab and 3.2 Kg/m2 for post-tensioned slab with reinforced concrete beams i.e. the prestressing steel required for the post-tensioned flat slab was greater. The amount of concrete required for a floor is more in case of post-tensioned slab with reinforced concrete beams while it was least for the post-tensioned flat slab floor system. The floor to floor height available in case of posttensioned flat and reinforced concrete flat slab was 2.65m while in case of post-tensioned slab with reinforced concrete beams and reinforced concrete slab and beams was 2.4m. While considering the period of construction for a floor it was less in case of post-tensioned flat slab than the other three cases as the post-tensioning allows the earlier removal of the formwork. In case of post-tensioned slab with reinforced concrete beams the formwork of slab can be removed earlier but the formwork for the reinforced concrete beams cannot be removed earlier. While estimating the cost of the each building the labour charges are not considered, as the time period reduce the labour charges will reduce in case of post-tensioned flat slab.

**Boskey Vishal Bahoria and Dhananjay K. Parbat (2013)** the plan of the office building (G+4) was considered and structure was designed by considering four cases with different floor systems. The quantities of reinforcing steel, prestressing steel, concrete required for the slab, beam and column is calculated for the same and are presented in tabular form. Along with this total cost of the building per square meter is found and comparison of all the four cases with respect to cost was done.

Results stated that the moment calculated for Post-tensioned flat plate slab was less as compare to moment calculated for RCC flat plate slab by equivalent frame method because as depth of Post tensioned flat plate slab 30 to 35% less than RCC plate slab, due to which self weight of slab get reduced. Due to post-tensioning of flat plate slab there is no much effect on axial force but shear and moment on column increases. The deflection at center of flat plate slab was controlled more effectively by parabolic and Trapezoidal tendon than triangular tendon. Modeling flat plate slab with diaphragm and without diaphragm in case of response spectrum there was no variation in axial force, shear force and moment as moment of inertia of slab was very high it acts as rigid.

Conclusion stated that Post-tensioned design of flat plate slab allows nearly 70% reduction in steel and 30 % reduction in concrete as compared to Reinforced cement concrete flat plate slab.

**Jnanesh Reddy R K and Pradeep A R (2017)** the research paper aimed to compare the cost effectiveness of Post- Tensioned flat slab systems with respect to reinforced concrete flat slab system. Both the systems were analyzed using RAPT and ETABS respectively which is based on the design methodology.

Analysis of the structure (R.C.C Flat Slab).Design and detailing of R.C.C flat slab. Analysis of the structure (using PT Slab with drop panels). Design and detailing of PT Slab. Comparison of designs of PT Slab and R.C.C Flat Slab. Cost Analysis between PT Slab and R.C.C Flat Slab.

From the quantity estimations and costing it was observed that concrete needed for R.C.C Flat Slab construction with edge beams is 330 m3 and that for PT Slab with drop panels is 247 m3 . Cost of steel required for the R.C.C Flat Slab construction is Rs. 3915751 /- and the cost of steel & tendons required for PT Slab construction is Rs. 3445148 /- . When a concrete slab is stressed by the post-tensioning method, it means the steel is being tensioned and the concrete is being compressed. As a building material, concrete is very strong in compression but relatively weak in tension. Steel is very strong in tension. Putting a concrete slab into compression and the steel into tension. before any substantial service loads are applied puts both building materials into their strongest states. The result is a 'stiffer concrete slab' that actively is compressed and has more capacity to resist tensile forces. Therefore, the stiffness and strength of the structure using PT Slab will be more than the structure constructed using R.C.C Flat Slab. Results concluded that PT Slab was 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.

## Conclusion

The seismic behavior of multi-storied building frame during an earthquake motion depends upon the distribution of strength, mass and stiffness in both horizontal and vertical planes. All models are analyzed by using design and analysis software ETABS or SAP and designed as per IS 456:2000 and IS 1893:2002. Push over analysis is a non linear static analysis had been used to obtain the inelastic deformation capability of frame. Only non-linear dynamic analysis is more accurate than pushover analysis; where non-linear dynamic analysis is time taking to perform. In order to obtain dynamic response of the structure, Time history analysis is carried out. So we can conclude that pushover analysis is the appropriate method to use for performance based design to get the response of the structures. Boskey Bahoria gives the idea about the post tensioned flat slab building structure having four cases depending upon by varying the span length by 0.5 m interval and discuss the comparative study of four cases with respect to economy.U. Prawatwong makes a two models one with drop panel shows the connections between slab-column and another is without drop panel shows connection between interior columns with PT flat plate and bonded tendons having seismic performance on two three fifth scale pattern under constant gravity load to investigate the seismic performance. Jnanesh Reddy RK compares the cost effectiveness of the post-tensioned flat slab with respect to RCC flat slab by using RAPT and ETABS softwares giving the final statement that PT flat slab is more advisable than RCC flat slab because it reduced the dead load by reducing thickness of slab.

Summary stated that the drop panels and columns only give a directly support for slab in types of building. Due to direct support of drop panels and column of the building floor to floor height of building reduces so space available is more for our use. By comparing flat pt slab and conventional slab we get result as reinforcement is 15% more and cost also 30% more than that of pt flat slab. Reinforcement required more in post tensioning slab due to provision of the beam support more load so required more reinforcement. In post tensioning with reinforcement beam we can removed formwork earlier but in conventional case we can not remove formwork in earlier period. Quantity of concrete required more in PT slab with reinforced concrete beam for one floor is more than that of PT slab method.

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