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Analysis and Design of Post Tention Concrete Slabs

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Abstract—*The advancement of pre-stressing innovation has one of the more vital upgrades in the fields of basic building and development. Alluding especially to post tensioning applications, it is for the most part perceived how it opens the likelihood to enhance economy, basic conduct and stylish angles in solid arrangements. As in present day days post tensioning has been most efficient technique when contrasted with the RCC works. The venture talks about the action of utilizing post tensioning in sections and bars in structures. This strategy is very utilized as a part of the development of shopping centers, theatres and multi-storey structures. Notwithstanding the straightforwardness of its essential ideas and understood points of interest, the application degree of post-tensioning arrangements can't be viewed as orchestrated in the diverse territories and basic applications. Truth be told, for different reasons, it gives the idea that the potential offered by pre-stressing is a long way from being abused, particularly in building structures field. By and large where post-tensioning would give a prevalent arrangement, it occurs after all that a more regular non-prestressed arrangement is frequently chosen. Post-tensioned chunks are a favored strategy for modern, business and private floor piece development. The undeniably broad utilization of this strategy is because of its points of interest and its temperament of simple application to a wide assortment of structure geometry and plan solutions. The utilization of post-tensioned story sections and strengthened solid centre dividers has turned out to be progressively prominent in tall structure development. Financial aspects of the post-tensioning section framework are examined including relative material substance, speed of development, and variables influencing the cost of post-tensioning. At last, a talk on the*

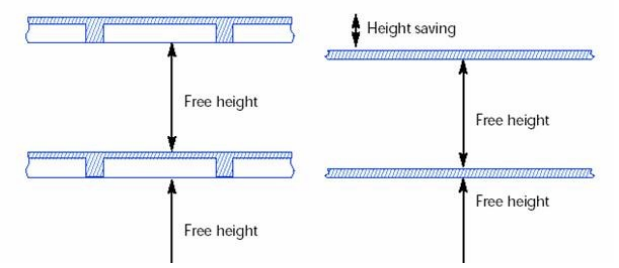
adaptability of post-tensioned building structures regarding future uses, new floor entrances and pulverization is exhibited.

Index Terms—Proportionate edge strategy, level section, stack adjusting technique, post-tensioned, RCC, seismic investigation, strud, staad-genius.

I INTRODUCTION

At the point when Eugene Freyssinet created and licensed the system of prestressing concrete in 1928 he minimal understood the applications to which his development would be placed in future years. Tremendous development in the utilization of prestressed concrete occurred after the Second World War with the material used to repair and remake connects in Europe. It is currently an acknowledged Civil Engineering development material.The A.C.I. Advisory group on Prestressed Concrete gives a standout amongst the most well-suited portrayals of post tensioned cement. `Prestressed Concrete will be concrete in which there have been presented inside powers of such extent and dissemination that the powers coming about because of given outer loadings are neutralized to an attractive degree'. In post-tensioning we get a few particular favorable circumstances: - a) Designers have the chance to give powers inside to the solid structure to neutralize and adjust loads maintained by the structure subsequently empowering outline streamlining. b) Designers can use the upside of the compressive quality of cement while dodging its innate shortcoming in strain. c) Post-tensioned solid joins and advances the present high quality cements furthermore, steel to bring about a down to earth and productive auxiliary framework. The principal post-tensioned structures were raised in the USA in the 1950's utilizing unbonded post tensioning. Some post-tensioned structures were worked in Europe very right off the bat however the genuine advancement occurred in Australia and the USA. Joint endeavors by prestressing organizations, analysts and configuration designs in these beginning times brought about principles and proposals which helped with advancing the across the board utilization of this type of development in Australia, the USA and all through

the Asian district. Broad research in these nations, and additionally in Europe all the more as of late, has significantly extended the learning accessible on such structures and now frames the reason for measures and codes of training in these countries.Since the acquaintance of post-tensioning with structures, a lot of experience has been picked up as to which kind of building has floors most suited to this technique for development



Traditional R.C.C. design PT slab design

Fig. 1. Height comparison of R.C.C. & PT slab design

II. Scope of the Present Study

The post-tensioning method is now a days increasing widely, due to its application. By using the post-tensioning method one can design the most economic and the safe design. But while using this method more precautions has to be made for the shear and the deflection criteria for the slabs. The design of the post-tension flat slab can be done by using load balancing and equivalent frame method. Among of both the equivalent frame method is widely used. In the load balancing method the 65 to 80% of the dead load is carried by the tendon itself. So that there is an upward deflection due to tendon profile resulting the reduction in overall deflection. In the present study the design of the post-tensioned flat slab is done by using both methods, load balancing method and equivalent frame method. As the shear and deflection check is the most important for the post-tensioned slabs the detail design for the shear and deflections (short term deflection and long term deflections due to creep and shrinkage) is carried out. The parametric study of the post-tensioned flat slab by varying the span by 0.5m interval is done and results of the different parameters such as thickness of slab, grade of concrete, loss due to stress, normal reinforcement, reinforcement for the shear, number of tendons, stressing force per tendon and deflection etc. are presented in the graphical form. Continuing to this 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 post-tensioned flat slab, post-tensioned beams and the R.C.C. slab, only R.C.C. flat slab and the R.C.C. slab and beams. After the design of these four cases the comparative study with respect to the economy is carried out.

III .Design Methodology

The design of post-tensioned slab is done by two methods, load balancing method and the equivalent frame method. The load balancing method introduced by T. Y. Lin is most suitable for the indeterminate structures rather than the determinate structures. In this method the 65 to 80% of dead load is balanced by the tendons so that the flexural member will not be subjected to bending stress under a given load conditions. On the other hand the equivalent frame method is widely use for the design of post-tensioned slabs. Here load balancing method and equivalent frame method are discussed in the following section.

A. Load-Balancing Method

The concept of load balancing is introduced for prestressed concrete structures, as per T.Y Lin et al [3] a third approach after the elastic stress and the ultimate strength method of design and analysis. It is first applied to simple beams and cantilevers and then to continuous beams and rigid frames. This load-balancing method represents the simplest approach to prestressed design and analysis, its advantage over the elastic stress and ultimate strength methods is not significant for statically determinate structures. When dealing with statically indeterminate systems including flat slabs and certain thin shells, load-balancing method offers tremendous advantage both in calculating and visualizing. According to load-balancing method, prestressing balances a certain portion of the gravity loads so that flexural members, such as slabs, beams, and girders, will not be subjected to bending stresses under a given load condition. Thus a structure carrying transverse loads is subjected only to axial stresses.

B. Equivalent Frame Method of Analysis

The equivalent frame method of analysis is known as the beam method. This method of analysis utilizes the

conventional elastic analysis assumption and models the slab or slab and columns, as a beam or as a frame, respectively. This is the most widely used and applied method of analysis for the post-tensioned flat plates.

According to Y. H. Luo, A. Durrani et al [4] the effect of vertical of lateral services and design loading on post-tensioned flat plates, bonded or unbonded, may be analyzed as for rigid frames in accordance with the provisions of the code (IS, ACI etc.). When the columns are relatively slender or not rigidly connected to the slab, their stiffness may be neglected and continuous beam analysis applied. As per A.C. Scordelis, Lin, T.Y, and R Itaya et al [5] the moment induced by prestressing may also be determined by a similar analysis of a rigid frame or continuous beam, using equivalent load or load balancing concept. However it should be kept in mind that the distribution of moments due to loads may differ considerably from the distribution of moments due to prestressing. Service loads produce very pronounced moments peaks at columns, whereas the moment curve produced by post-tensioning has a more gentle undulating variation of the same form as the tendon profile.

According to A .Pan, and J. P. Moehle [6] the effects of reversed tendon curvature at supports are generally neglected in applying the load balancing method to design of flat plates since the reverse curvature has only a minor influence on the elastic moments (in the order of 5 to 10 percent), and does not affect the ultimate moment capacity. It is necessary to consider reverse tendon curvature tort adequately evaluate the shear carried by the tendons inside the critical section.

IV. Parametric Study

For the purpose of parametric study of post-tensioned slab the slabs with and without drop varying from 7m to 12m at an interval of 0.5m are considered.

Load considered- Dead load –self weight Live load – 2 KN/m2 Superimposed dead load - 1 KN/m2Analysis and design is done by using following methods Load balancing method Equivalent frame method

For the application of design procedure a office building is consider as a case study. The plan of the office building (G+4) is considered. This building is designed by considering four cases with different floor systems. The different

floor systems used for these four cases are as follows.

For the above four cases the quantities of reinforcing steel, prestressing steel, concrete required for the slab, beam and

column is calculated and are presented in the tabular form. Along with this a total cost of the building per square meter is found and the comparison of all the four cases with respect to cost is given here.

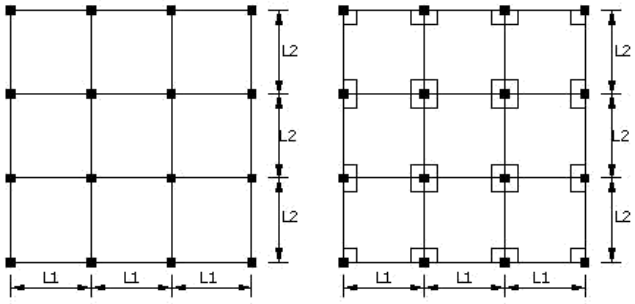


Fig. 2. Plan of slab with drop and without drop

Item	Concrete (m3)	Reinfor cing steel (Kg)	Prestressin g steel (Kg)	Form work	Rate per sqm
PT flat slab	507.52	31659	8400	2100	Rs. 2800/-
RC flat slab	549.69	85550	-----	2100	Rs. 3600/-
PT slab with RCC beam	641.33	42271	6720	2100	Rs. 3200/-
RCC slab with RCC beam	626.31	86701	----	2100	Rs. 3800/-

Table 1:Rate Analysis for the cases considered

VI. Results and Conclusion

The analysis, design and the estimation of the office building for the four different floor systems is done and finally the rate per square meter for the construction of this building is found out.

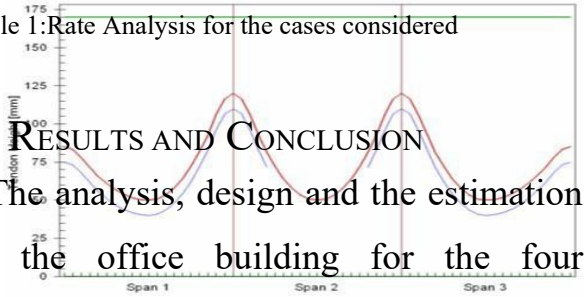


Fig. 3. Tendon profile for the slab without

V Estimating and Costing

From the analysis and design results of the office building the total estimation for the quantities for a typical floor is calculated. The quantities of concrete, reinforcing steel, prestressing steel and the formwork and their cost according to the current rate excluding the labour charges for all the four cases are given in the table I. The rate per square meter for

a typical floor (which includes slab, beam and column) of a building in each

case is according to the values calculated form the detail estimation.

(Rate of concrete=4400/-per m3, Rate of steel=50/-per kg, Rate of form work=400), Rate of prestressing steel=130/-per kg)

The fig .6 shows the variation of the rate per square meter for these four different cases.

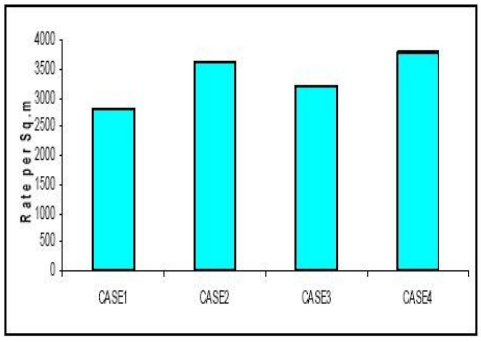


Fig. 5. Variation of rate for each floor system

The design and the estimation of the office building for the four different floor systems is done and finally the rate per square meter for the construction of this building is found out. The Fig. 6 shows the variation of the rate per square meter for these four different cases. The observation made from the above work is as follows:

From the economic point of view the post-tensioned flat slab is the most economical among all four floor systems and the reinforced concrete slab with reinforced concrete beam is the costlier one for this span.

slab and post- tensioned slab with reinforced concrete beam is 15 Kg/m2 and 20.15 Kg/m2 respectively.

The reinforcing steel is more in case of post-tensioned slab with reinforced concrete beams because the slab transfers the load on the beam and more loads is taken by the beams itself.

If we consider the post-tensioned flat slab and reinforced concrete flat slab, the thickness of reinforced concrete flat slab is 12.5% greater and its cost is 27% greater than the post-tensioned flat slab.

From both post-tensioned floor system building the post-tensioned flat slab is more economical than the post-tensioned slab with reinforced concrete beams.

The quantity of prestressing steel is 4 Kg/m2 for post-tensioned 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 is greater.

The reinforcing steel required for the post-tensioned flat

The reinforcing steel for the reinforced concrete flat slab is 41 Kg/m2 while for the reinforced concrete slab and beam it is 40 Kg/m2.

The amount of concrete required for a floor is more in case of post-tensioned slab with reinforced concrete beams

while it is least for the post-tensioned flat slab floor system.

The floor to floor height available in case of post-tensioned flat and reinforced concrete flat slab is 2.65m while in case of post-tensioned slab with reinforced concrete beams and reinforced concrete slab and beams is 2.4m.

If we consider the period of construction for a floor it is 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.

The wall load is considered on all over the floor (KN/m2) for the post-tensioned building While analysis. So there is flexibility to the user to construct a wall wherever required in case of post-tensioning.

VII. Seismic Analysis

According to A. J. Duran, S.T Mau, A.A Abouhashish [7] and Y. H Luo, A. Durrani, J. Conte [8] the Equivalent frame method for flat slab underestimates the negative moment and overestimate positive moments. A comparative study of pt and RCC flat plate is done considering the earthquake load using Equivalent frame method in accordance to [9],[10] and using struds software the conclusions drawn are as follows:

1. The moment calculated for Post-tensioned flat plate slab is 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.
2. Due to post-tensioning of flat plate slab there is no much effect on axial force but shear and moment on column increases.
3. The deflection at center of flat plate slab is controlled more effectively

by parabolic and Trapezoidal tendon than triangular tendon.

4. Modeling flat plate slab with diaphragm and without diaphragm in case of response spectrum there is no variation in axial force, shear force and moment as moment of inertia of slab is very high it acts as rigid.

5. 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.

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