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Comparative study of Post-tension system in flat plate and flat slab

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Abstract:

The use of post-tensioned concepts floors in buildings has been consistently growing in recent years. The greatest use of his type of construction has been in the USA, and in California it is the primary choice for concrete floors. Post-tensioned floors have already have been in use countries like Australia, Hong Kong, Singapore and Europe. Their use in the UK is now growing rapidly.As there is increase in urban population which has led to an increase in demand for liveable space, resulting in increasing cost. Due to increase in demand for efficient floor systems.As this thesis work is on comparative study of two different post tensioned slabs, one flat slab with drop and other without drop which is flat plate slab. Initially analysis is carried out in manual designing of slab using British code and then later modelling has been carried out in FEM software. In model all the properties of material and sections are defined first and then with the help of grid the frame with slab model is prepared.

Keywords **—Post-tension, Deflection, punching shear etc.**

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I .INTRODUCTION

As there is increase in urban population which has led to an increase in demand for liveable space, resulting in increasing cost. Due to increase in demand for efficient floor systems. These typical framing system in conventional RC buildings is a beam-slab system, but the use of flat-slab and flat-plate systems is becoming popular. However, as demand for large column-free areas has demanded the use of post-tensioned slab systems.Typical applications include parking structures and high-rise buildings, foundation systems, bridge and, tanks and silos, industrial pavements, dam structures and atomic waste containment structures.

Post-tensioned concrete one of the variants of prestressed concrete where tensioning of tendons is done after the immediate concrete structure has been casted. The tendons are encapsulated within a protective sleeve not placed in direct contact with the concrete, but duct which is either cast into the concrete structure or placed adjacent to it. At each ends of a tendons anchoring assembly are firmly fixed to the nearby concrete. Once the concrete has been casted and set, then tendons are stressed by pulling the tendon ends through the anchorages while pressing against the concrete.

A.Support of study

An office floors with a typical grid size of 10.8x8 m in a multi-story structure was considered for design withflat-plate, flat-slab andbeam-slab systems. In all cases, both Reinforced Concrete system and post-tensioned systems were used for the contrast of structural performance and along with cost and safety. The slab systems were designed using three different codes of practice: British Standard (BS),AmericanConcrete Institute (ACI) standards and Indian Standard (IS). From the cost analysis, it is observations that the post-tensioned flat-slab system delivers better cost reductionof approximately20% and 16.5% in the case of BS and IS standards, respectively. In the case of ACI standards, the post-tensioned and RC flatslabsystems yield17.7% and 12.5% cost reduction, respectively.

Posttension system is an effective construction method for structures with longer spans, severe loadings, and cost-effectiveness considerations. As this investigation develops a inclusive understanding on how various reinforcement ratios and compressive strengths of concretecontribute to deflection of post-tensioned two-way slabs system. This study confirmed the consideration effect of post-tensioning to decrease the deflection and reinforcement ratioin a two-way slab. Similarly, a wide range of differences in design of acomparable section of post-tensioned concrete slab was observed by using different codes of practice. The rigorous effect of the concretestrength on the post-tensioning designed slabs, especially in the lower ranges of compressive strength, was evident during the numericalanalysis.

II.METHODOLOGY AND ANALYSIS OF SLABS

As this thesis work is on comparative study of two different post tensioned slabs, one flat slab with drop and other without drop which is flat plate slab. Initially analysis is carried out in manual designing of slab using British code and then later modelling has been carried out in FEM software. In model all the properties of material and sections are defined first and then with the help of grid the frame with slab model is prepared.

After frame modelling in FEM software there are two ways to lay the design strips and tendon layout. As the software itself can calculate and auto distribute of the tendon profiles according to user defined. During modelling main tendons are laid with zero width spacing and auto resisting the self-weight of slab and in parabolic pattern. As in case of distributed tendons profile shall be the same with but in reverse parabolic pattern.

After completing model with tendons check for tendon is done as in its properties box number of strands, total prestress after all losses and at transfer losses is shown, so that the tendons do not have any excess numbers of strands and also to co-relating with manual results. As model is checked completely which should be error free from overlapping & disconnected joints. Before going for analysis, the load case, pattern and combination are computed according to codes provision, as analysis for mode cases is not necessary and as our area of interest lies restricted to slab only. As after completion ofanalysis model results are validated and similarly same procedure is carried out for other slab.In post-tensioned floors both the precompression and theupward load in the span act to reduce the tensile stresses in the concrete.However, the level of prestressing is not usually enough to prevent all tensilecracking under full design live loading at Serviceability Limit Slate. Underreduced live load much of the cracking will not be visible.

The action of post tensioning causes the floor to, shorten, deflect bend and rotate. If any of these effects are restrained, as secondary effects of prestress are set up. As slated above, if the level of prestress does not exceed approximately 2N/mm2, the secondary effects due to the restraint to shortening are usually neglected.

A. Loads and Material property

TABLE I - MATERIAL PROPERTIES - SUMMARY

Name	Type	E MPa	Unit Weight kN/m³	Design Strengths
HYSD415	Rebar	200000	76.9729	Fy=415 MPa, Fu=485 MPa
M35	Concrete	29580.4	24.9926	Fc=35 MPa
Tendon	Tendon	196500.6	76.9729	Fu=1861.58 MPa

TABLE II- FRAME SECTIONS - SUMMARY

Name	Material	Shape
C 300 X 300	M35	Concrete Rectangular
C 500 X 500	M35	Concrete Rectangular

TABLE III - SHELL LOADS - UNIFORM

Story	Label	Load Pattern	Direction	Load kN/m²
Story1	F1	Dead	Gravity	8.6 or 11.25
Story1	F1	Live	Gravity	4

TABLE IV - LOAD CASES - SUMMARY

Name	Type
Dead	Linear Static
Live	Linear Static
PT-FINAL	Linear Static

Name	Type
PT-TRANSFER	Linear Static
PT-FINAL-HP	Hyperstatic

TABLE V - LOAD COMBINATIONS

Name	Load Case/Combo	Scale Factor	Type
Load case 1	Dead	1.5	Linear Add
Load case 2	Dead	1.5	Linear Add
	Live	1.5	
Load case 3	Dead	1.5	Linear Add
	PT-FINAL-HP	1	
Load case 4	Dead	1.5	Linear Add
	Live	1.5	
	PT-FINAL-HP	1	
Load case 5	Dead	1	Linear Add
	PT-TRANSFER	1	
Load case 6	Dead	1	Linear Add
	PT-FINAL	1	
Load case 7	Dead	1	Linear Add
	Live	1	
	PT-FINAL	1	

III.COMPARISION OF SLABS

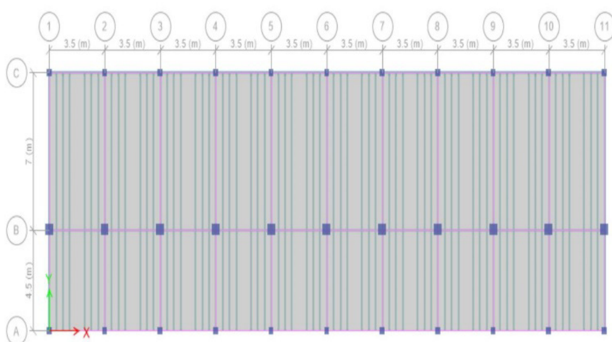

Fig .1 – plan view of flat plate slab.

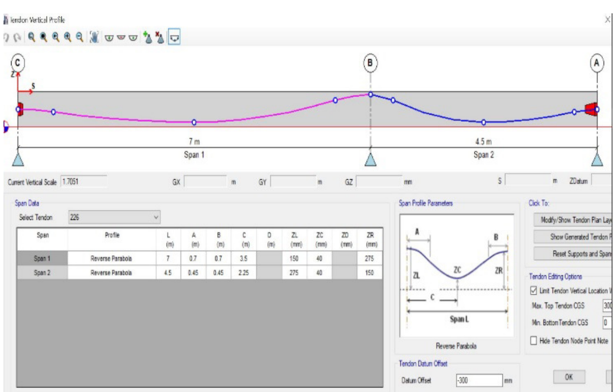

Fig .2 – Tendons profile in transvers direction from C-A

Fig .3 – Tendon profile in longitudinal direction 1-11

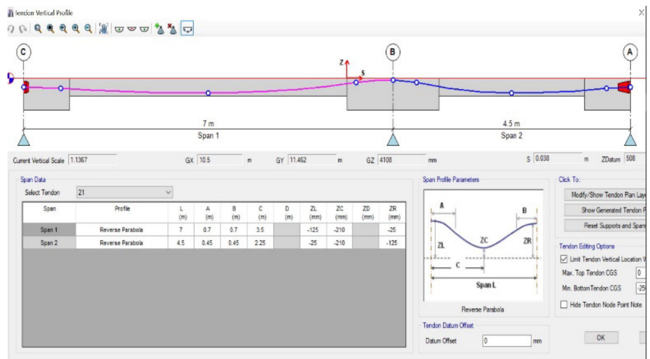

Fig .4 – Transverse direction profile of tendon in flat slab

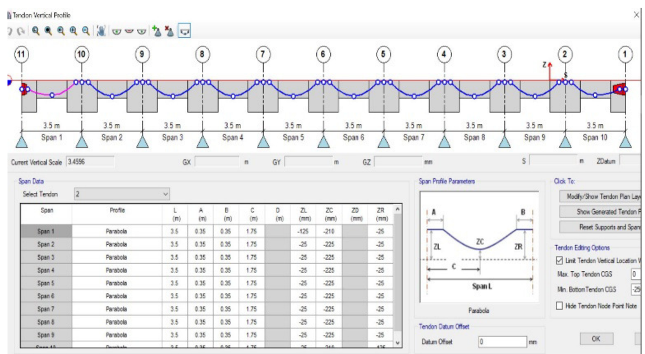

Fig .5 – Longitudinal direction profile of tendons in flat slab.

For Etabs modelling number of stories is considered is G+1 as this story number does not account for slab comparison in this case as load analysis for seismic has not be done. As only for dead, live and prestress load case from BS 8110-1997 part -1is considered. Deflection and Punching shear are calculated and theoretical and analytical are compared and checked for validation.

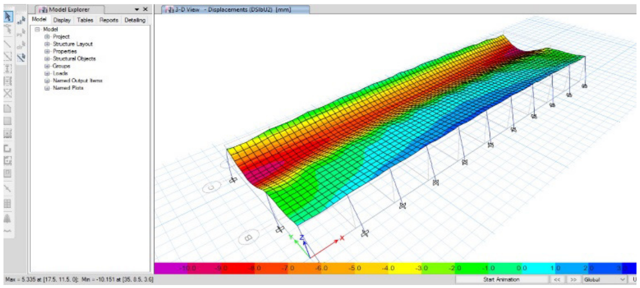

Fig .6 – Vertical displacement of slab

As the above figure has shown the range of vertical displacement or deflection for load case -4, which has maximum deflection. As per BS 8110-1997 part-1 the deflection allowable is ratio of span/250 or must be less than 20mm. As in this slab it passes through the deflection criteria.

Fig .7 – Punching shear ratio

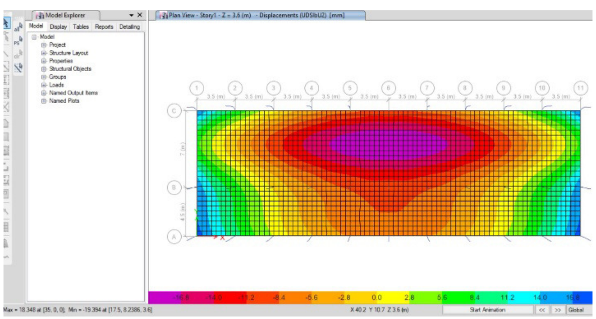

Fig .8 – vertical displacement of flat slab

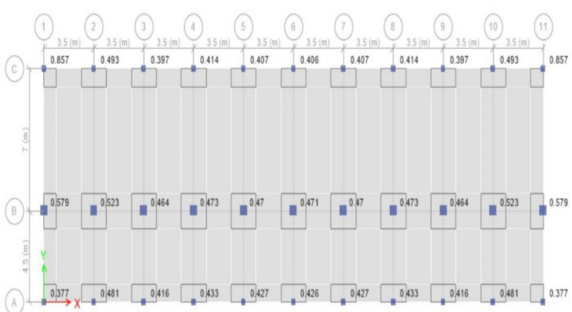

Fig .9 – Punching shear ratio of flat slab

IV.RESULTS AND CONCLUSION

In this paper both slabs are compared to understand difference in selected parameter. As both the slabs have common design procedure but varies in so many aspects like number of tendons, slab thickness, prestress in tendons at transfer and at service. In ETABs modelling also have similar procedure for designing the slab. As our observation was to study serviceability limits of both the slabs, which are in generally study with Reinforced concrete structures. As modelling, analysis and design checks are carried out using British code BS 8110-1997 part-1and BS 8110-1985 part2.

In this dissertation the parameter which are only compared between slabs are vertical deflection and punching shear. As flat plate slab and flat slab both provide beam free space and also aesthetical purpose, in such cases loads of slab are directly transferred to column. Which leads to slab becoming more vulnerable to progressive collapse in high rise buildings for which main governing part is punching shear. Hence in this study comparison also shown that which is slab better with respect to parameters.

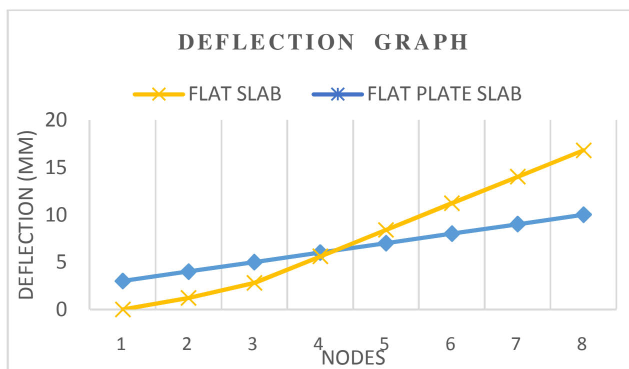

Fig .10 – Deflection graph for slabs

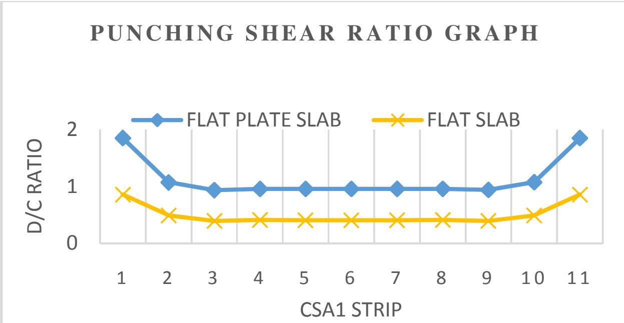

Fig .11 – Punching shear ratio for CSA1 strip columns.

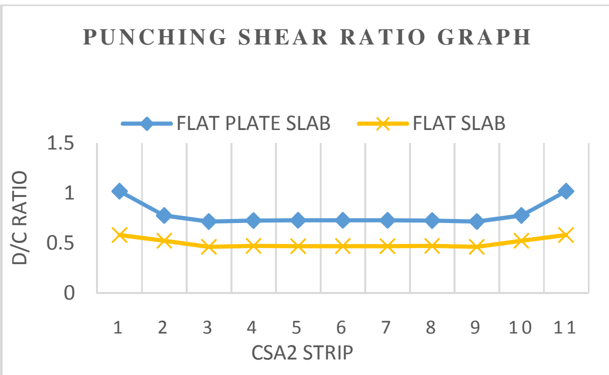

Fig .12 – Punching shear ratio for CSA2 strip columns.

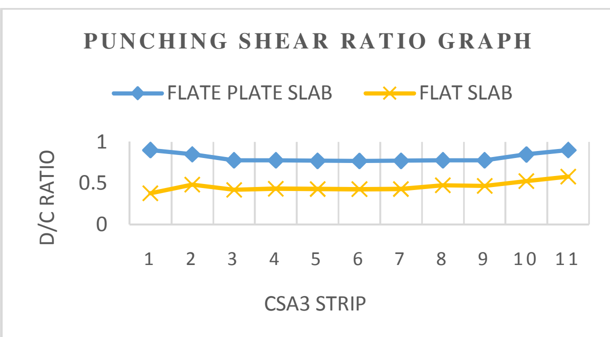

Fig .13– Punching shear ratio for CSA3 strip columns.

A.Conclusion and discussion

As the above parametric study shows the difference in slabs, which could be simply helpful to understand behavior of slabs under post-tensioning. Hence below are the conclusion drawn for post-tensioned flat plate slab and flat slab.

1.In case of deflection study for post-tensioned slabs, flat slab has more deflection compared to flat plate slab. This is due depth of slab is greater for flat plate slab than flat slab.

2.The deflection is under limit state of serviceability criteria for which span by depth ratio for flat plate slab is less than flat slab.

3.As in another parametric study which is punching shear ratio or demand per capacity (D/C ratio) ratio with respect to strips shows that flat slab with post-tensioning system offers better resistance to punching failure.

4.It is also observed that in comparative study punching effects are less for flat slab than flat plate slab with post -tension system.

5.This study shows that punching effect in post-tensioned flat slab has averagely reduced to 54% in comparison to flat plate slab with post-tensioning.

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