Analysis and Comparative Study of Unbonded Post-tensioned Cast-In-Place Parking Floor on the Effects of Tendon Layout using Safe

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Abstract— *In recent years post-tensioned floors are commonly used for parking purposes in residential and commercial high rise buildings. This paper includes result on a study of un-bonded post tensioned cast-in-place parking floor subjected to various arrangements of tendon layout based on FEM analysis. Modelling and analysis of post-tensioned flat plate is done by using SAFE software. Equivalent loads based on cable profiles are applied to the flat plate according to the tendon layout. Design moments, service moments, hyper-static moments, short term deflection, long term deflection, and punching shear are compared for the various tendon layouts at service and ultimate limit state.*

Keywords— ***Post-Tensioned flat plate, SAFE, Tendons***.

I. INTRODUCTION

In recent days post-tensioned parking floor is common in residential and commercial high rise buildings. Usage of post tensioned floors provide beneficial advantages over reinforced concrete floors in terms of reduction in thickness of slab, construction speed, rapid fixing services and also offers superior structural performance and other advantages. Here we used load balancing techniques for the design of PT flat plate, and this method is mainly dependent on tendon arrangements. This paper shows the comparative study and behavior of PT flat plate by the effects of tendon layout at service and ultimate limit state.

II. POST-TENSIONED FLAT PLATE

Post-tensioning concrete slabs is a method in which tendons are stressed after the concrete is poured around it. Post-tensioned concrete slab is a method for overcoming concretes natural weak in tension. In Post- tensioned floors, compressive stress is already introduced in it, before the slab is put in to service, because of the nature of the stress, the top part of the slab will be in tension and bottom part will be in compression. In PT slabs stresses gets nullified with load acting and it makes the slab in which stresses opposite to loads are introduced. Now the opposite stresses in PT slabs are introduced using high tensile steel strands which can take more load than reinforced concrete slabs.

2.1 Post-tensioning is of two types,

2.1.1 Bonded post-tensioning system

Bonded post-tensioning system are those in which pre-stressing steel strand is bonded to the concrete after it is tensioned by injecting cement grout inside of a duct in which the tendon is placed. This method mainly prevents corrosion of tendons.

2.1.2 Unbonded post-tensioning system:

Unbonded post-tensioning system are those in which pre-stressing steel strand is preventing from bonding to the concrete and thus free to move relative to the concrete. The force is transferred to the concrete by the mechanical assembly only.

2.2 Advantages of Post-tensioning

- Simple form work
- Speedier construction
- Steel quantity is reduced
- Larger span
- Reduced cracks in slab

- Freezing and thawing is higher than RC slab systems
- Improved deflection criteria
- Superior and economical design
- Reduced moments and stresses than compare to RC slab systems

III. MODELING AND ANALYSIS

SAFE-2D Post-tensioned flat plate models shown in Fig.1.

Case I: Banded and Distributed tendon layout

Case II: Distributed and Distributed tendon layout

Case III: Banded and Banded layout

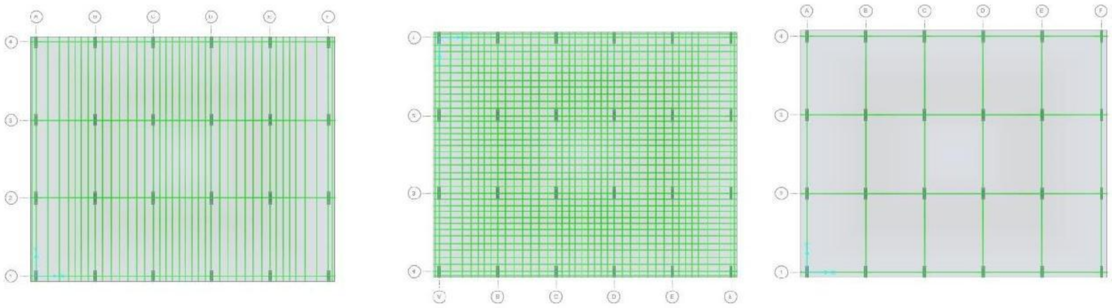

FIG.1: PT FLAT PLATE 2D MODEL FOR CASE I, II, & III

3.1 Model Description

PT flat plate modeled in SAFE V12 Floor slab having dimension of size 41.2m x 25.2m center to center. Model is analyzed for uniform LL of 3.125 kN/m2. Detailed descriptions of PT flat plate for different cases have been mentioned in the below tables.

IV. RESULTS AND ANALYSIS

From the results the following observations are made:

- **Service moments:** By considering all the three cases of tendon layout case 1 i.e, Banded and distributed tendons gives less elastic moment values than case 2 and case 3. It means banded and distributed tendons can improve the flexural capacity of a member at service limit state. Banded tendons are more effective in reducing punching failure, whereas distributed tendons are effective in reducing punching failure of a member. Banded/distributed tendons are more effective in reducing flexure of a member at service limit state.

- **Design moments:** By considering all the three cases of tendon layout case 2 i.e, distributed and distributed tendons gives less design moment values than case 1 and case 3. It means the tendons are closely placed here in both directions. Hence the load capacity of the member increased here than compare to case 1 and case 3, as I said earlier distributed tendons are more effective in reducing flexure of a member in case 2 tendons are running in both the directions, hence load capacity of a member is increased than compare to other two cases at ultimate limit state.

- **Hyper-static moments:** By considering all the three cases of tendon layout, case 2 i.e, Distributed and distributed tendons gives less secondary moment values than case 1 and case 3. It means the tendons are closely placed here in both directions. Hence the load capacity of the member increased here than compare to case 1 and case 3.

- **Short term deflection:** By considering all the three cases of tendon layout, case 1 i.e. Banded and distributed tendons gives less immediate deflection values than case 2 and case 3 and it is shown in Fig.2

- **Long term deflection:** By considering all the three cases of tendon layout, case 1 i.e. Banded and distributed tendons gives less deflection values than case 2 and case 3 and it is shown in Fig.3. Total/final deflection values in all the 3 cases are within the permissible limit hence our design is safe.

- **Punching shear:** Here punching values in all 3 cases at some points it is exceeding than permissible limit hence for our design shear reinforcement is required at that points. By considering all the three cases of tendon layout, case 3 i.e, Banded and banded tendons punching shear capacity ratio values are better than case 1 and case 2, this is because banded tendons runs along both the directions and they are more effective in reducing punching failure than distributed tendons.

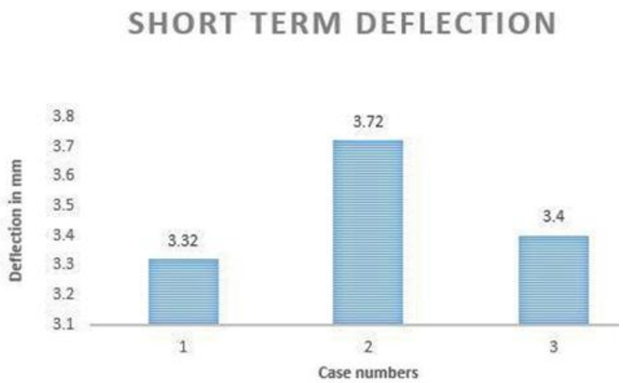

FIG.2: SHORT TERM DEFLECTION IN mm

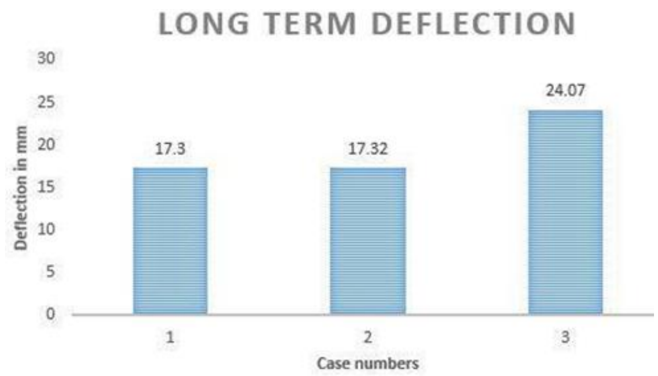

FIG.3: LONG TERM DEFLECTION IN mm

TABLE 1
DESCRIPTION FLAT PLATE MODEL

CASE	GRADE (MPA)	SLAB THICKNESS(mm)	LONG SPAN (m)	SHORT SPAN (m)
I	40	200	8	8
II	40	200	8	8
III	40	200	8	8

TABLE 2
ANALYSIS RESULTS OF POST-TENSIONED FLAT PLATE MODELS

	Critical Service Moment in kN-m	Critical Design Moment in kN-m	Critical Hyper-static Moment in kN-m
CASE I	(+M)108.41	(+Mu)258.52	(Max)125.76
	(-M)91.02	(-Mu)341.62	(Min)-2.95
	(+M)130.64	(+Mu)249.77	(Max)108.30
CASE II	(-M)96.29	(-Mu)341.62	(Min)-26.03
	(+M)105.11	(+Mu)259.76	(Max)137.74
	(-M)113.68	(-Mu)340.89	(Min)-32.91
	CASE I	CASE II	CASE III
	3.32	3.72	3.40
DEFLECTION (mm)	17.30	17.32	24.07

TABLE 3
ANALYSIS RESULTS OF POST-TENSIONED FLAT PLATE MODELS

PUNCHING	1.34	1.42	1.20	1.20	1.42	1.34
SHEAR CAPACITY	0.94	1.44	1.23	1.23	1.44	0.94
RATIO	0.94	1.44	1.23	1.23	1.44	0.94
VALUES OF CASE I	1.34	1.42	1.20	1.20	1.42	1.34
PUNCHING SHEAR	1.40	1.44	1.25	1.25	1.44	1.40
CAPACITY	0.99	1.37	1.21	1.21	1.37	0.99
RATIO	0.99	1.36	1.19	1.19	1.36	0.99
VALUES OF CASE II	1.41	1.44	1.26	1.26	1.44	1.41
PUNCHING SHEAR	1.27	1.32	1.13	1.13	1.32	1.27
CAPACITY	0.92	1.44	1.24	1.24	1.44	0.92
RATIO	0.92	1.44	1.24	1.24	1.44	0.92
VALUES OF CASE III	1.27	1.32	1.13	1.13	1.32	1.27

V. CONCLUSION

- Moment distributions across the slab panels may vary significantly between different tendon layouts, resulting in different signs at critical sections at service limit states.
- Moment distributions across the slab panels are almost similar between different tendon layouts, at ultimate limit states.
- Load carrying capacity of a case 1 FEM model is more than compare to case 2 and case 3 at service limit state.
- Load carrying capacity of a case 2 FEM model is more than compare to case 1 and case 3 at ultimate limit state.
- Load carrying capacity of a case 2 FEM model is more than compare to case 1 and case 3 to withstand hyper -static moments (secondary moments).
- Total deflection including effect of temperature, creep and shrinkage, the deflection values are within the permissible limit for all the 3 cases. But, case 1 gives fewer values than compare to case 2 and case 3.
- The punching shear capacity ratio values in case 3 are better than compare to case 1 and case 2, at some points it is exceeding than permissible limit at that point shear reinforcement is required.
- Overall by seeing the results obtained from analysis, case 2 (distributed and distributed tendons) behaving good at ultimate limit state than case 2 and case 3. Here strength and serviceability considerably increased; hence I am concluding case 1 is better option for constructing un-bonded post-tensioned parking floor slabs.

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