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DESIGNING AND ANALYSING OF POST-TENSIONING SLAB AND COMPARATIVE STUDY OF PT SLAB AND CONVENTIONAL RCC FLAT SLAB IN FINANCIAL ASPECTS

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ABSTRACT
There are many types of slabs that used in structural buildings, eg. Flat slab, composite slab, pre-cast slab and post-tensioning slab. Every slab has its own advantages as well as disadvantages and where to be used according to a need of the project. Basically Flat slab and Post tensioning slab used for commercial structures like shopping malls, cinemas, schools, universities etc, it is not preferable in the structures where columns are placed in middle of these structures and at least there should be a long distance between the columns. Hence during the construction of these structures, long span are required. As we refer the structural members, for providing desired strength we have to provide extra reinforcement in slab and pour extra concrete to increase thickness of slab which also replicate in our economic status. The cost and strength should be taken into consideration while selecting the type of slab.

Keyword: slab, structure, post-tensioning slab, stresses, cost, construction, steel reinforcement, concrete, design.

Post-tensioning Slab

Concrete in which internal stresses of sufficient magnitude and distribution have been introduce to counterbalance the stresses coming from given external loading the desired degree. Pre-stress is knowingly introduced in RCC members by tensioning steel reinforcement. Post Tensioning is the form of pre-stressing where tendons are tensioned after the initial setting of concrete and the tendons are instantly fixed against it. This process can also be used in pre-cast and cast-in-place concrete.

RCC Flat Slab

In traditional construction methods are based on the principle that the slab is supported by beams and the beams are supported in columns. In the flat slab system, beams are avoided and the slab is directly supported in the columns. To counter this failure in slab we have to increase depth of slab, which results in increment of dead weight of slab. It not only makes construction cost high, but also the member supporting them which makes it uneconomical.

Scope of Study

In the designing process, the priority for economy and stress resistant is selecting the structural system that offer the lowest overall cost with high stress bearing capacity while meeting load and code requirements. The aim of the study is to present that post-tensioning is more economical and technically fit than the reinforced concrete flat slabs according to the quantity of steel reinforcement, concrete, tendons and the contractor cost. This study is so important because the role of civil engineer in the managing field is to save time, efforts and money, and all owners looking for less cost with high performance for their project.

LITERATURE REVIEW

The structure in which slab is directly supported by columns and column drop panels have been considering in many buildings. Also it has benefits of being a reduction in floor to floor height. Thin beams placed at regular intervals in perpendicular directions, thick slab used in the place of conventional slab. Considering the economic point of view, the post-tension slab is the most economical among all the systems.

OBJECTIVE OF WORK AND STRUCTURE DETAILING

- To design and compare post-tensioning slab with RCC flat slab.
- To determine the efficiency of post-tensioned slab in lowering the amount of thickness of slab, dead weight and deflection.
- To create cost effective solutions to overcome failure due to axial loads and to obtain thinner sections.
- To compare the designed post-tensioning slab with conventional flat slab in terms of economic aspects.

MATERIALS

CONCRETE

- Grade of concrete for beam & columns: M-35
- Strength of concrete at the time of stressing: 28 Mpa REBAR
- Grade of un-tensioned steel: Fe 500. PRESTRESSING STEEL
- HT Strand for pre stressing: 12.6mm dia, 7 ply Class II IS 14268 Low Rlxn
- Area of strand: 98.7mm2
- Modulus of Elasticity, E: 1.95E5 Mpa
- Breaking load: 183.5 KN Ultimate Tensile Strength: 1860 Mpa
- POST TENSIONING SYSTEM
- Post-tensioning system for slab: Flat bonded System
- Friction parameters (IS1343:2012): μ= 0.2
- k= 0.003/m
- Slip: 6mm (max)

Codes /References

- IS 1343 IS Code of Practice for Pre stressed Concrete – Edition 2012
- IS 456 IS Code of Practice for Plain and Reinforced Concrete
- BS 8110 Structural use of concrete - Part 1: Code of practice for design &construction

METHODOLOGY

Designing and Analyzing of Post Tensioning Slab for various Axial Loads

The Analysis & design of the Post-tensioned slab system is carried out using the software **ADAPT Floor Pro**. The complete floor slab system is modelled using finite element method along with the supporting systems and the post tensioning effects. The design is carried out considering various “design strips” configured in orthogonal directions after analysis of the complete floor system. The slab strips are checked for stresses for at Transfer & Service stages and for strength at Ultimate stages. Punching shear of the floor slab is checked for all column locations.

MATERIALS

CONCRETE MATERIAL PROPERTIES

ID	Label	F'c	Unit Weight	Type	Ec	Creep coefficient
		MPa	kg/m3		MPa	
1	Concrete 1	35	2500.00	Normal	29580	2.00

F'c = strength at 28 days
Ec = modulus of elasticity at 28 days

REINFORCEMENT (NON-PRESTRESSED) MATERIAL PROPERTIES

ID	Label	fy	fvy	Es
		MPa	MPa	MPa
1	Mild Steel 1	Fe500	415.00	200000

fy = yield stress of longitudinal reinforcement
fvy = yield stress of one-way shear reinforcement
Es = modulus of elasticity

PRESTRESSING MATERIAL PROPERTIES

ID	Label	fpu	fpy	Eps
		MPa	MPa	MPa
1	Prestressing 1	1860.00	1700.00	195000

Fpu = ultimate stress
Fpy = yield stress
Eps = modulus of elasticity

Deflections:

Short term Deflection (Instantaneous Deflection with service loads)

LOCATION-1

Maximum Short term Deflection = 6.62 mm
Span at this location = 8400mm
Deflection / Span Ratio = 6.62/8400 = 1/1268

LOCATION-2

Maximum Short term Deflection = 6.1 mm
Span at this location = 7700 mm
Deflection / Span Ratio = 6.1/7700 = 1/1262

Long term Deflection (Total Deflection including effects of temperature, creep & shrinkage considering cracking)

The long-term deflection contour considering cracking and the long term effects of creep & shrinkage is presented below

LOCATION-01;

Maximum Long term Deflection = 14.7 mm Span at this location = 8400mm

Deflection/Span Ratio = **14.7/8400 = 1 /571 - OK (< 1/250 – Clause 19.3.1a :IS 1343)**

Location - 2

Maximum Long term Deflection at this location = 10.9 mm Span = 7700mm

Deflection/Span Ratio = **10.9/7700 = 1 /706 - OK (< 1/250 – Clause 19.3.1a :IS 1343)**

Load Combination Strength

Label	Condition	Axis	Factored shear	Factored moment	Stress due to shear	Stress due to moment	Total stress	Allowable stress	Stress ratio
			kN	kN-m	MPa	MPa	MPa	MPa	
Column 8	Interior	rr	-1181.200	658.410	0.57	0.30	0.87	1.58	0.55
Column 8	Interior	ss	-1181.200	24.656	0.57	0.01	0.58	1.58	0.37
Column 9	Interior	rr	-1144.500	623.380	0.55	0.29	0.84	1.58	0.53
Column 9	Interior	ss	-1144.500	24.332	0.55	0.01	0.56	1.58	0.36
Column 10	Interior	rr	-1306.400	-389.000	0.63	0.18	0.81	1.58	0.51
Column 10	Interior	ss	-1306.400	18.582	0.63	0.01	0.64	1.58	0.40
Column 20	Interior	rr	-1338.500	-408.330	0.65	0.19	0.83	1.58	0.53
Column 20	Interior	ss	-1338.500	-19.942	0.65	0.01	0.66	1.58	0.41
Column 21	Interior	rr	-1350.100	-410.480	0.65	0.19	0.84	1.58	0.53
Column 21	Interior	ss	-1350.100	68.499	0.65	0.03	0.68	1.58	0.43
Column 24	Interior	rr	-1208.000	671.820	0.58	0.31	0.89	1.58	0.56
Column 24	Interior	ss	-1208.000	-39.216	0.58	0.02	0.60	1.58	0.38

Comparative Study between Post-Tensioning Slab and Conventional

RCC Flat Slab

The study had been done on a slab with the columns. The purpose of making the study on slab with columns is because that they are not the same in the different types of slabs. Figure shows the location of columns, the dimensions and the distances between the columns. The quantity and cost of steel and concrete will be calculated and the contractor work cost.

Upon designing the slab, the strength of concrete in the post-tensioned slab should be 30 MPa while it should be 25 MPa in a reinforced concrete flat slab. This difference in cost of the strength of concrete differs also in the cost of it in which the 30 MPa concrete strength is more expensive by approximately 350 rupees compared to the 25 MPa. The yield strength of the steel bars the same in both types of slabs which is 550 MPa.

Material Properties in Both Slabs

	Post-Tensioned Slab	RCC Flat Slab
Concrete Strength (MPa)	30	25
Steel Strength (MPa)	550	550

If the slab would be flat slab the thickness should be 225 mm while if the slab would be a post-tensioned slab the thickness should be 200 mm. The area of the slab had been calculated and it is 1352 m2. By multiplying the area with the thickness of the slab, it will give the total volume of the slab.

The Volume of Flat Slab and Post-Tensioned Slab

	Post-Tensioned Slab	**RCC Flat Slab**
Thickness (mm)	200	225
Area (m^2)	1352	1352
Volume (m^3)	270.4	304.2

The study had been done by calculating the quantities of concrete, steel reinforcement, and tendons in both slabs and then estimating their cost with an estimation of contractor work cost to know how much each slab cost and according to the cost the more economical slab will be used.

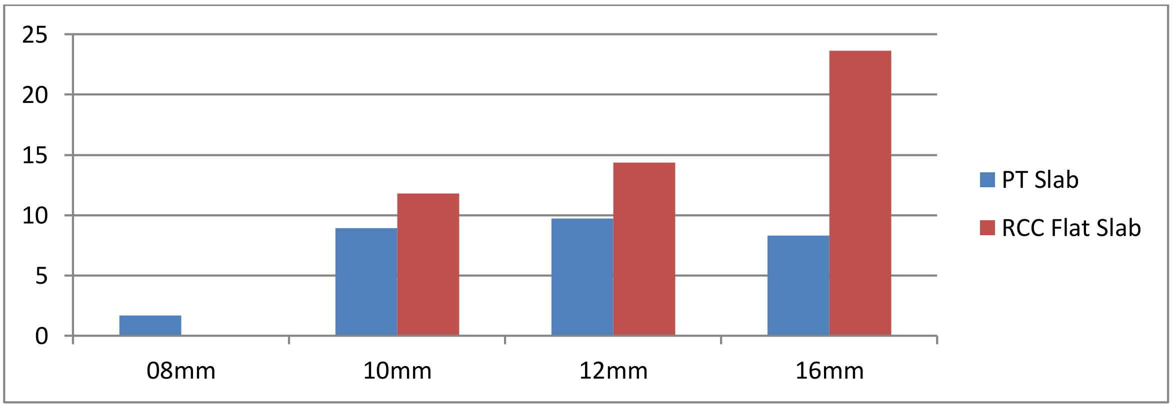
First of all the quantity of concrete had been compared in both slabs. In this project the number of columns in which slab is resting. So, the concrete poured in the columns are same in both the slabs.

Quantity and Cost of Concrete

Concrete		**Post-Tensioned Slab**	**Flat Slab**
Columns	**Number**	31	31
	Concrete(m^3)	63.07	63.07
Slab	**Concrete(m^3)**	366.90	387.73
Total (m^3)		429.97	450.80
Rate (Rs)		4140.08	4022.6
Total (Rs)		1780110.20	1813388.08

Quantity of Steel Reinforcement

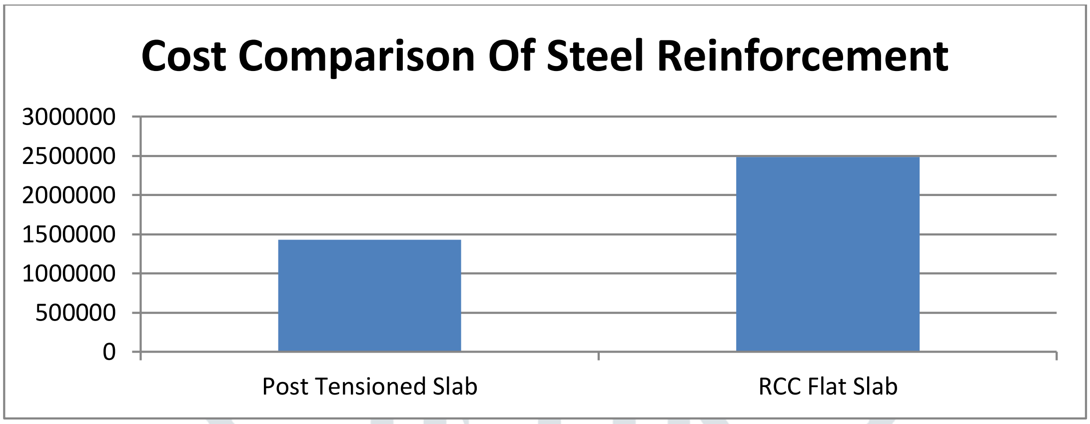
Steel Reinforcement	**Post-Tensioned Slab**	**Flat Slab**
08mm (MT)	1.676	-
10mm (MT)	8.905	11.781
12mm (MT)	9.721	14.372
16mm (MT)	8.319	23.631



Diameter Wise Comparison of Steel Reinforcement

Cost Comparison of Steel Reinforcement

	08mm	10mm	12mm	16mm	Total Cost
Post-Tensioned slab (Rs)	86122.94	444234.83	484941.81	415001.64	1430301.22
RCC Flat Slab(Rs)	-	587706.97	716961.60	1178856.07	2483524.64

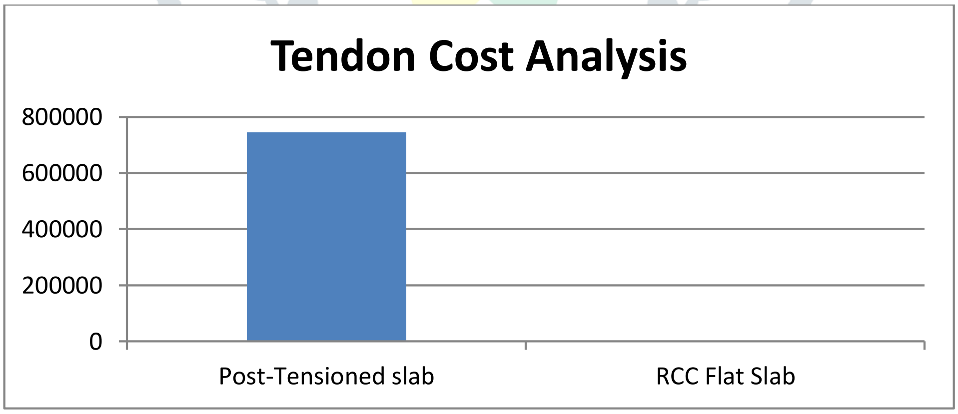


Comparison on Steel Reinforcement

In post-tensioned slab, there is additional amount of steel reinforcement (**Tendons**). With the help of these tendons we are doing stressing activity of slab. The post-tensioning company charge 55 rupees per square feet.

Cost of Tendons

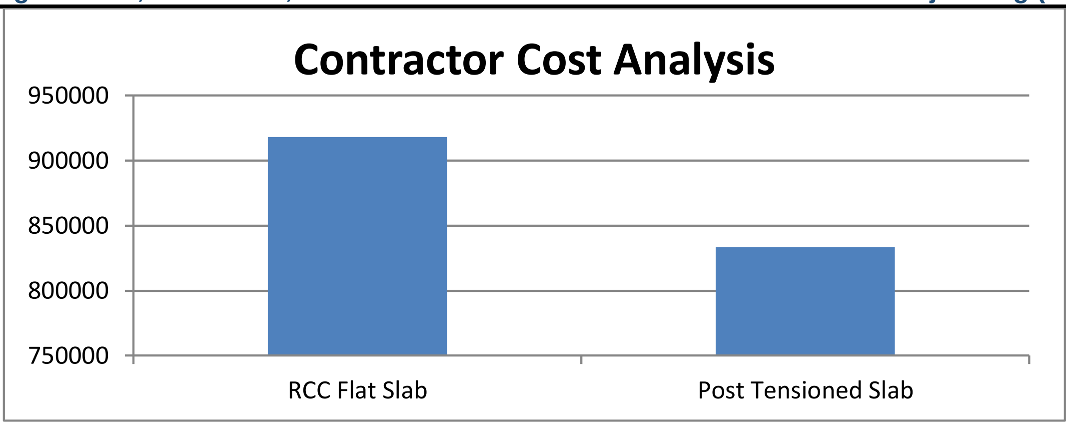
Tendons	Post-tensioned slab	RCC Flat slab
Price rate(Rs)	55	-
Total Price (Rs)	743600	-



Cost of Tendons

Cost of Contractor Work

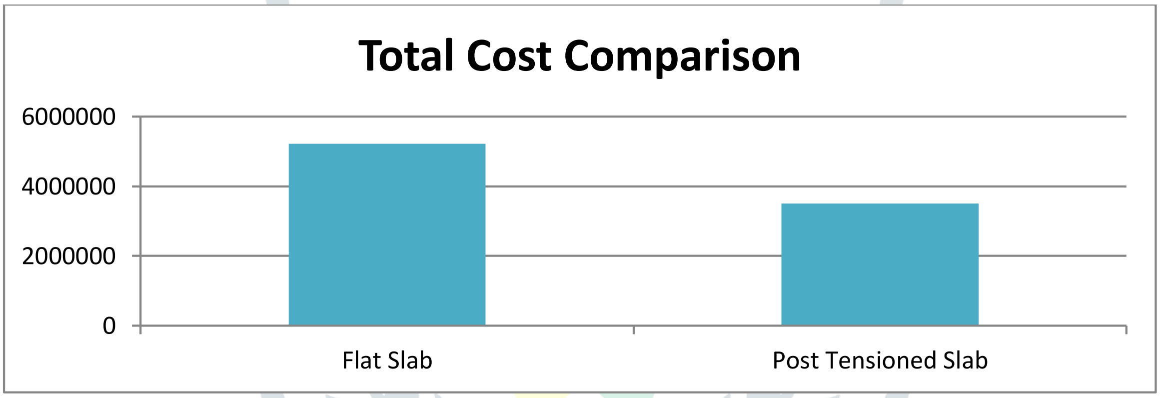
Contractor	Flat Slab	Post Tensioned Slab
Columns (m^3)	63.07	63.07
Slab (m^3)	304.2	270.4
Total (m^3)	367.27	333.47
Price rate (Rs)	2500	2500
Total Price (Rs)	918175	833675



Cost of Contractor Work

Total Cost in Both Slabs

Cost	Flat Slab	Post-Tensioned Slab
Concrete(Rs)	1813388.08	1780110.20
Steel(Rs)	2483524.64	1430301.22
Tendons (Rs)	-	743600
Contractor(Rs)	918175	833675
Total (Rs)	**5215087.72**	**3500686.42**



Total Cost in Both Slabs

Result and Discussion

Finite Element Analysis:

Finite element analysis, is utilizing the finite element method (FEM), is a product of the digital age, coming to the fore with the advent of digital computers in the 1950s. It follows on from matrix methods and finite difference methods of analysis, which had been developed and used long before this time. It is a computer-based analysis tool for simulating and analyzing engineering products and systems. FEA is an extremely potent engineering design utility, but it should be handled with safety measures. For example, it is possible to integrate a system with computer-aided design software, leading to a type of uninformed push-button analysis in the design process. Unfortunately, colossal errors can be made at the push of a button, as this warning makes clear.

The basic principles underlying the Finite Element Analysis are relatively simple. Consider a body or engineering component through which the distribution of a field variable, e.g. displacement or stress, is required. Examples could be a component under load, temperatures subject to a heat input, etc.

CONCLUSION AND FUTURE SCOPE

From the present study it was examined that PT slab stiffness is much efficient in comparison to conventional RCC Slab frame system in reducing moment, displacement, peak displacement and other various forces.

Following conclusions are observed in above analysis :

Axial Force: As results observed it is proved that PT slab shows more resistance and distributing property as compared to conventional RCC Flat Slab.

Shear Force: In terms of unbalance forces it can be said that unbalance forces are linear and PT slab has tendency to resist shear forces as compared to conventional RCC Flat Slab.

Displacement: In terms of displacement it can said that PT slab can resist 25% more displacement as compared to Conventional RCC Flat Slab.

Bending Moment: In terms of bending moment it is observed that PT Slab is more cost friendly and stable structure since ending moment observed is less.

Future Scope:

1. In this case Pt slab is considered in flat slab with drop panels whereas in future it can be consider without drop panels.
2. In this study flat slab is consider for comparative analysis whereas in future study one can opt waffle or ribbed slab.
3. In this study seismic analysis is done whereas in future one can perform wind loadanalysis.

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