

Performance Evaluation of Long-Span Post-Tensioned Slab for Commercial Building using ETABS and ADAPT PT 2D/3D

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Abstract - The rapid growth of commercial infrastructure has increased the demand for long-span, columnfree floor systems that provide architectural flexibility and efficient space utilization. Conventional reinforced concrete (RCC) slabs become structurally inefficient and uneconomical for spans exceeding 8 m due to excessive self-weight, higher deflection, and cracking under service loads. Post-tensioned (PT) slab systems offer a superior alternative by introducing prestressing forces that counteract tensile stresses, resulting in improved serviceability, reduced slab thickness, and material optimization.

This research presents a performance evaluation of a long-span post-tensioned slab for a commercial building using ETABS and ADAPT PT 2D/3D software. A slab of size 10 m x 12m is modeled and analyzed under identical loading and boundary conditions as per IS 456:2000, IS 1343:2012, and ACI 318-19 provisions. The study compares bending moment distribution, deflection behavior, stress profiles, tendon optimization, and time-dependent effects such as creep, shrinkage, and prestress losses. This results in improved structural efficiency and reduced material usage.

The results obtained from both software show close agreement, with variations within 10%. ADAPT PT provides more accurate estimation of long-term effects and tendon optimization, while ETABS offers efficient global structural analysis. The post-tensioned slab system achieved approximately 15–20% reduction in material consumption and improved serviceability compared to conventional RCC slabs. The study concludes that post-tensioned slabs are a reliable, economical, and sustainable solution for long-span commercial buildings when analyzed using integrated software-based approaches.

Keywords:- Post-Tensioned Slab, Long-Span Floors, ETABS, ADAPT PT 2D/3D, Commercial Buildings, Serviceability.

1. INTRODUCTION

Modern commercial buildings demand large, open, and column-free spaces to meet functional and architectural requirements. Such layouts require long-span floor systems that can efficiently carry loads while maintaining serviceability. Conventional reinforced concrete (RCC) slabs, although widely used, become uneconomical for spans

greater than 8 m due to increased slab thickness, higher self-weight, excessive deflection, and cracking.

Post-tensioned (PT) slab systems have emerged as an effective solution for long-span applications. In PT slabs, high-strength steel tendons are tensioned after concrete hardening, inducing compressive stresses that counteract tensile stresses due to external loads. This results in reduced deflection, better crack control, and improved structural efficiency. PT slabs also enable thinner sections, reduced material consumption, and faster construction.

With advancements in structural analysis software, tools such as ETABS and ADAPT PT 2D/3D are extensively used for the analysis and design of PT slabs. However, these tools adopt different modeling assumptions and computational approaches. Therefore, a comparative evaluation of their results is essential to assess reliability and accuracy. This study focuses on the performance evaluation of a long-span PT slab using both ETABS and ADAPT PT 2D/3D under Indian and international design standards. In this study, a long-span PT slab system is analyzed using ETABS and ADAPT PT software.

2. LITERATURE REVIEW

Previous studies have shown that post-tensioned slabs provide better performance compared to conventional slabs in terms of deflection control and crack resistance. Researchers have reported a reduction in deflection by 30–50% and material savings up to 20%. ETABS is widely used for global structural analysis, whereas ADAPT PT provides detailed design of prestressed systems considering prestress losses, creep, and shrinkage effects. However, limited studies are available comparing both software in the Indian context.

3. POST-TENSIONING

Prestressed concrete is a type of concrete in which internal compressive stresses are introduced to counteract the tensile stresses developed due to external loads. Post-tensioning is one of the methods of prestressing in which high-strength steel tendons are tensioned after the concrete has attained sufficient strength.

In post-tensioned slabs, tendons are placed inside ducts and stressed using hydraulic jacks. The applied prestressing force induces compression in the concrete, which helps in reducing

tensile stresses and controlling cracking. This results in improved structural performance and enhanced durability of the slab system.

The tendon profile is generally parabolic in shape, which helps in balancing the applied loads effectively. This load balancing concept reduces bending moments and deflection in the slab, especially for long-span applications. Post-tensioning also allows for reduced slab thickness, which decreases the overall dead load of the structure.

Additionally, post-tensioned slabs provide better control over serviceability parameters such as deflection and crack width. The system is highly suitable for commercial buildings where large column-free spaces are required. Due to these advantages, post-tensioning has become a preferred choice for modern construction practices.

4. MODEL DETAILS

The structure considered in the present study is a G+6 commercial building designed to evaluate the performance of a long-span post-tensioned slab system. The building is modeled to represent practical commercial construction where large column-free spaces are required. For detailed post-tensioning design, ADAPT PT 2D/3D software is used. The tendon layout, prestressing force, and prestress losses such as creep, shrinkage, and relaxation are considered in the analysis.

The slab system has plan dimensions of 10 m × 12 m, which falls under long-span category. In addition to the main slab area, a cantilever projection of 4 m is provided, which introduces critical negative bending moments and deflection challenges. The inclusion of cantilever makes the analysis more realistic and complex.

The details of the structural model considered in the study are as follows:

- Type of Structure: - **G+6 Commercial Building**
- Slab System: - **Post-Tensioned Slab**
- Slab Dimensions: - **10 m × 12 m**
- Cantilever Length: - **4 m**
- Type of Analysis: - **Static Analysis**

4.1. Material Properties:-

- Grade of Concrete:- **M40**
- Grade of Prestressing Steel:- **1860 MPa**

4.2. Modeling Details:-

- Software Used for Analysis:- **ETABS**
- Software Used for PT Design:- **ADAPT PT 2D/3D**
- Slab Modeling:- **Shell Elements**
- Tendon Profile:- **Parabolic**
- Prestressing Direction:- **Both Directions**

4.3. Design Considerations:

- Long-span slab behavior considered
- Cantilever effect included in analysis
- Prestress losses (creep, shrinkage, relaxation) considered
- Design carried out as per relevant IS codes

4.4. Loading Details

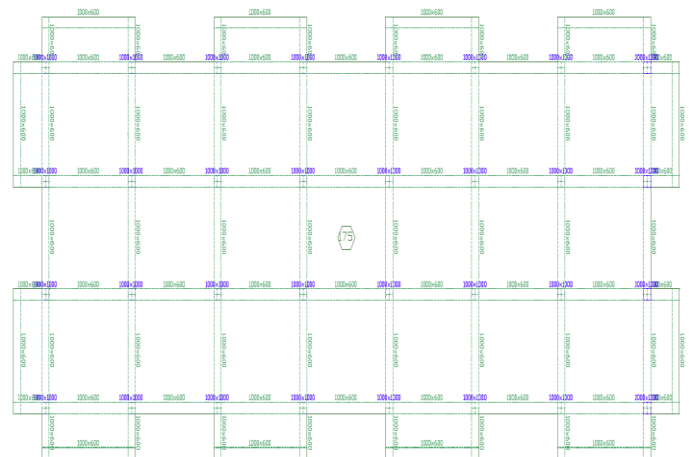
Dead Load = 2 kN/m²
Live Load = 5 kN/m²

Loads are applied uniformly over the slab, and load combinations are considered as per IS 875.

5. WORKING WITH ADAPT PT (CALCULATIONS & RESULTS)

5.1 Input Parameters

- Span of Slab = **10 m × 12 m**
- Cantilever Length = **4 m**
- Concrete Grade = **M40**
- Prestressing Steel = **1860 MPa**
- Dead Load = **2 kN/m²**
- Live Load = **5 kN/m²**



5.2 Prestressing Force Calculation

- Initial Prestressing Force (P) = **1800 kN**
- Jacking Stress = **1400 MPa**
- Number of Tendons = **4 to 12 (per strip)**

5.3 Prestress Losses

- Elastic Shortening Loss = **3 – 5 %**
- Creep Loss = **6 – 8 %**
- Shrinkage Loss = **4 – 6 %**
- Relaxation Loss = **2 – 3 %**

Total Loss = **15 – 20 %**

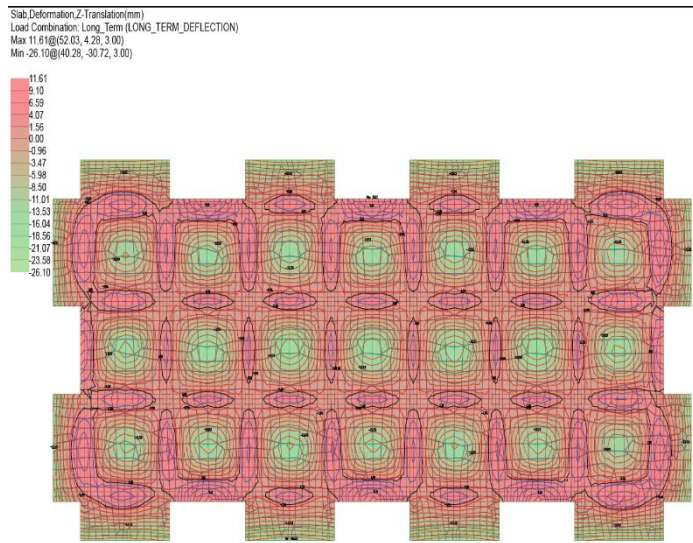
5.4 Bending Moment Results

- Maximum Positive Moment = **+928 kNm**
- Maximum Negative Moment = **-450 kNm**
- Cantilever Moment = **-1099 kNm**

5.5. Deflection Results

- Short-Term Deflection = **13.08 mm**
- Long-Term Deflection = **26.10 mm**

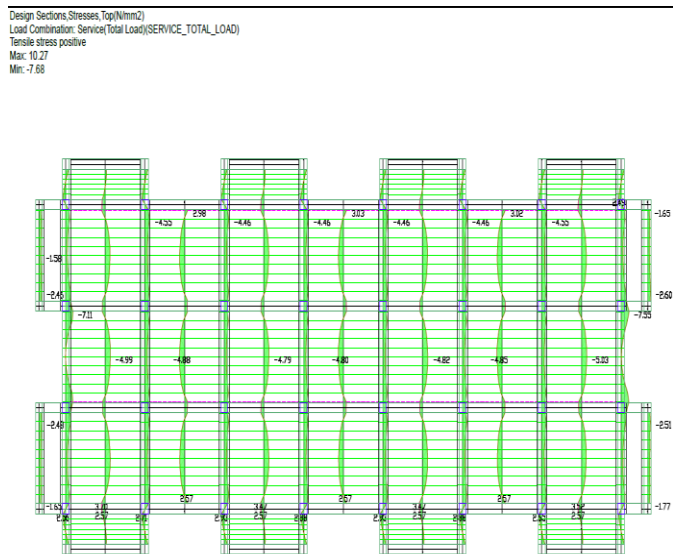
Permissible Deflection = $\text{Span}/250$



5.6 Stress Results

- Top Fiber Stress = **10.27 MPa (Compression)**
- Bottom Fiber Stress = **2.25 MPa (Tension)**

✓ Within permissible limits



5.7 Observations

- Deflection is within allowable limit
- Prestressing reduces tensile stress
- Cantilever region shows maximum effect
- Overall performance is satisfactory

6. WORKING WITH ETABS (CALCULATIONS & RESULTS)

6.1 Modeling Details

- Software Used = **ETABS**
- Slab Element Type = **Shell Element**
- Analysis Type = **Linear Static Analysis**
- Load Application = **Uniformly Distributed Load**
- Load Combinations = **As per IS 875**

6.2 Bending Moment Results

- Maximum Positive Moment = **+1489 kNm**
- Maximum Negative Moment = **-1056 kNm**
- Cantilever Moment = **-1834 kNm**

6.3 Deflection Results

- Maximum Deflection = **38.60 mm**

Permissible Deflection = $\text{Span} / 250 = 40 \text{ mm}$

✓ Status: **SAFE (within permissible limits)**

6.4 Observations

- Bending moments are higher compared to PT slab results
- Deflection is within permissible limits but higher than ADAPT
- Cantilever region shows maximum deflection and moment
- ETABS provides overall structural behavior of slab system

7. COMPARISON OF ETABS AND ADAPT PT RESULTS

PARAMETER	ETABS RESULTS	ADAPT PT RESULTS	REMARKS
Maximum Positive Moment	+1489 kNm	+928 kNm	Significantly reduced due to prestressing
Maximum Negative Moment	-1056 kNm	-450 kNm	Better control in PT slab
Cantilever Moment	-1834 kNm	-1099 kNm	Critical but optimized in PT
Deflection	38.60 mm	26.10 mm	Lower in PT slab
Permissible Deflection	40 mm	40 mm	Within limits
Top Fiber Stress	14.86 MPa	10.27 MPa	Compression within safe limits
Bottom Fiber Stress	5.48 MPa	2.25 MPa	Tension minimized

8. RESULTS AND DISCUSSION

The analysis of the long-span slab using ETABS and ADAPT PT 2D/3D indicates a significant improvement in structural performance due to prestressing. The bending moment values are reduced from +1489 kNm in ETABS to +928 kNm in ADAPT for positive moment, and from -1056 kNm to -450 kNm for negative moment. The cantilever region is observed as the most critical zone with maximum negative moments in both analyses.

The deflection obtained from ETABS is 38.60 mm, which is within the permissible limit of 40 mm, whereas ADAPT PT shows a lower long-term deflection of 26.10 mm. The stress results indicate improved performance in ADAPT, where compressive stresses are maintained in the top fiber and tensile stresses are minimized at the bottom. Overall, the PT slab system demonstrates better efficiency in terms of moment reduction, deflection control, and serviceability.

9. CONCLUSION

- The post-tensioned slab system proves to be highly effective for long-span commercial buildings. It provides improved structural performance compared to conventional RCC slabs.
- Prestressing significantly reduces both positive and negative bending moments in the slab. This leads to better load distribution and enhanced structural efficiency.
- Deflection values obtained are well within permissible limits as per design codes. This ensures satisfactory serviceability of the slab system.
- Stress distribution is effectively controlled with compression in top fiber and reduced tension at bottom. This minimizes cracking and improves durability of the structure.
- The cantilever portion is identified as the most critical region in the slab system. However, it performs safely under the applied loading conditions.
- Comparative analysis shows that ADAPT PT provides more refined and accurate results than ETABS. This is due to the consideration of prestressing effects and time-dependent losses.

10. REFERENCES

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