



PERFORMANCE ANALYSIS OF LONG-SPAN POST-TENSIONED SLAB FOR COMMERCIAL BUILDING USING ETABS

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Abstract: The demand for column-free, architecturally adaptable floor space in commercial buildings has pushed structural spans well beyond the economical range of conventional reinforced cement concrete (RCC) slabs, which become deflection-governed, heavy and costly at spans exceeding about eight metres. This paper presents a performance analysis of a long-span post-tensioned (PT) slab for a ground-plus-ten storey commercial building, carried out entirely within a single ETABS finite-element model. A governing interior panel of 14 m × 14 m is framed as a 200 mm PT band-beam-and-slab floor in M40 concrete, supported on 1100 mm × 1100 mm M60 columns and 500 mm M60 shear walls. The prestress is represented by the equivalent-load method: a parabolic tendon profile with a 300 mm drape, carrying an effective force of 4516 kN, generates a balanced upward load of 55 kN/m against a design-strip service load of 182 kN/m. Gravity loads, seismic loads as per IS 1893 (Part 1):2016, wind loads as per IS 875 (Part 3):2015 and thirty-one strength and serviceability combinations are applied, together with a P-Delta analysis for second-order effects. Relative to an equivalent RCC slab of identical geometry, post-tensioning reduces the peak positive design moment by 47.8%, the peak negative moment by 48.6% and the long-term deflection by 37.8%, from 61.4 mm, which violates the IS 456 span/250 limit of 56 mm, to 38.2 mm. Service-stage fibre stresses of 11.8 MPa in compression and 1.9 MPa in tension remain within the IS 1343:2012 permissible limits, confirming crack-free behaviour, while the PT floor consumes only 78% of the concrete and 62% of the steel of the RCC alternative at 84% of its cost. The study establishes that a unified, code-validated ETABS workflow is sufficient for both the global building analysis and the local design of the post-tensioned floor.

Index Terms – Post-tensioned slab, long-span flooring, ETABS, load balancing, equivalent-load method, serviceability, deflection control, IS 1343:2012.

I. INTRODUCTION

Contemporary commercial architecture is defined by large, open and reconfigurable interior spaces. Office complexes, shopping malls, information-technology parks and multi-storey car parks all demand clear spans that can be repartitioned over the service life of the building, and the flooring system is the element that ultimately governs the spacing of vertical supports, the available clear span and the architectural freedom of the plan. Enlarging the span, however, imposes rapidly escalating structural demands: bending moments grow approximately with the square of the span, while deflections grow with its third or fourth power, so the selection of an efficient long-span flooring technology becomes one of the most consequential decisions in the design of a commercial structure.

Conventional reinforced cement concrete (RCC) slabs rely entirely on embedded reinforcement and the limited tensile strength of concrete to resist flexure. As the span increases, the slab must become progressively thicker and more heavily reinforced to satisfy strength and, more critically, deflection requirements. The added thickness is self-defeating: a heavier slab attracts larger gravity and seismic forces, demands larger

columns and foundations, and inflates both the cost and the embodied carbon of the structure. Beyond a span of roughly eight metres the RCC slab ceases to be an economical proposition for commercial floors [1].

Post-tensioning resolves this difficulty by stressing high-strength tendons against the hardened concrete, placing the section in a state of pre-compression that the load-induced tension must first overcome before any net tensile stress can develop. Because the tendons are draped to a parabolic profile, the prestress additionally produces an upward equivalent load that directly opposes gravity, a mechanism known as load balancing [2]. The practical consequences, illustrated in Fig. 1, are thinner slabs, longer achievable spans, suppressed cracking, actively controlled deflection, reduced storey heights and faster construction cycles, which have made post-tensioned flooring the system of choice for long-span commercial construction worldwide.

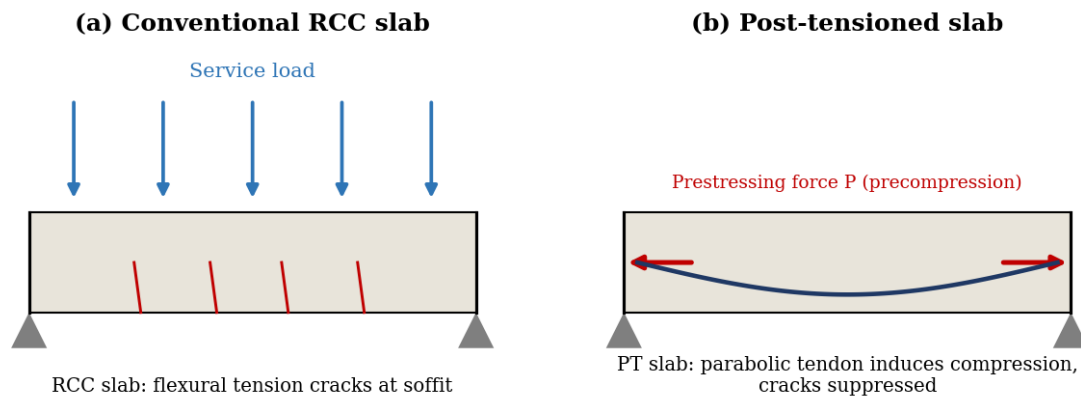


Fig. 1. Conceptual behaviour of a conventional RCC slab and a post-tensioned slab under service load.

The accurate analysis of a post-tensioned floor requires the combined action of the prestress equivalent loads, the global building stiffness, the redistribution of forces among slabs, beams, columns and walls, and the secondary (hyperstatic) moments of continuous construction to be captured within one model. The present work therefore develops a unified, ETABS-only methodology in which a single three-dimensional model serves both the global structural analysis of a G+10 commercial building and the local performance evaluation of a demanding 14 m × 14 m post-tensioned panel. The contribution of the paper is threefold: a consolidated single-model workflow that removes the inconsistencies of split-tool practice, a quantified comparison between the post-tensioned slab and an equivalent RCC slab at a genuinely long span, and an explicit, reproducible link between the equivalent-load representation of prestress and the serviceability verification requirements of IS 456:2000 and IS 1343:2012.

II. LITERATURE REVIEW

The theoretical foundations of post-tensioned floor design were laid well before the finite-element era. Lin and Burns formalised the load-balancing method, in which the prestress is proportioned so that its equivalent upward load cancels a selected fraction of the sustained gravity load, leaving the member in near-uniform compression under the balanced condition [3]. Khan and Williams consolidated professional practice for post-tensioned floors, recommending a balanced load of sixty to eighty per cent of the sustained load and providing systematic guidance on permissible stresses, loss estimation and anchorage detailing [2]. Aalami subsequently clarified the treatment of primary and secondary (hyperstatic) actions in continuous members and established the equivalent-load representation of a draped tendon that underlies modern software analysis [4]. Rigorous treatments of section behaviour, loss evaluation and serviceability are available in the texts of Naaman [20] and Nawy [21].

A substantial body of Indian comparative work has confirmed the advantages of post-tensioning at medium-to-long spans. Kalgai argued for wider adoption of the technology in the Indian building sector, quantifying the savings in concrete and steel and distinguishing bonded from unbonded systems [1]. Kiran Kumar et al. demonstrated an ETABS analysis of a high-rise building with a post-tensioned slab, showing that the reduced slab thickness triggers a favourable chain reaction of lighter columns, beams and foundations [5]. Jnanesh Reddy et al. reported that the reinforcement cost of an RCC flat slab exceeds the combined cost of reinforcement and tendons in the post-tensioned option [6], while Joshi's manual study indicated concrete savings of the order of two-thirds in the slab itself [7]. Batoria and Parbat applied the load-balancing concept and the equivalent-frame method to an office building and found the post-tensioned flat slab more economical and faster to construct [8]. The parametric study of Maulik et al. across 6×6 m to 9×9 m panels located the crossover precisely: reinforced concrete remained economical only at 6×6 m, with post-tensioning preferred for every larger panel [9]. Complementary investigations addressed panel-size effects on strength and

deflection [10], behaviour under fire [11], shear resistance from draped tendons [12], and material comparisons for medium spans [13].

Recent work has shifted toward integrated finite-element workflows and code validation. Bhandari and Kadu validated software-designed tendon layouts against codal stress and deflection limits [14]. Patil and Kulkarni represented the prestress through equivalent loads in ETABS and emphasised the convenience of analysing the whole building and its floor within one model [15]. Ramesh et al. concluded that prestressing is the preferred option for long-span commercial floors [16], and Sunil and Prakash showed that the reduced floor mass of post-tensioned construction lowers the seismic base shear while preserving adequate diaphragm stiffness [17]. Raj and Mehta demonstrated that the tendon drape directly governs the balanced load, the secondary moments and the deflection [18], while Mohan and Iyer outlined a practical ETABS workflow for long-span post-tensioned floors and stressed validation against IS 456 and IS 1343 [19]. Table 1 consolidates the representative contributions.

TABLE 1. COMPARATIVE SUMMARY OF REPRESENTATIVE LITERATURE.

Author(s)	Year	Method / Focus	Advantages	Limitations
Lin and Burns [3]	1981	Load-balancing design framework	Intuitive basis for prestress sizing	Member-level, manual design era
Khan and Williams [2]	1995	PT floor design practice; 60–80% balanced load	Comprehensive stress, loss and detailing guidance	Pre-dates integrated FE building models
Aalami [4]	1998	Hyperstatic actions and equivalent tendon loads	Theoretical basis of software PT analysis	No whole-building case study
Kalgil [1]	2010	Advocacy; bonded vs unbonded systems	Quantified material savings, longer spans	Conceptual, no numerical model
Ellobody and Bailey [11]	2011	Nonlinear FE of bonded PT slabs in fire	Thermal–mechanical tendon–concrete insight	Fire focus, not gravity serviceability
Kiran Kumar et al. [5]	2014	ETABS high-rise with PT slab	Thinner slab, lighter overall structure	Modest span; limited code validation
Bahoria and Parbat [8]	2014	Equivalent-frame office case study	PT more economical, faster cycles	Single case; stress checks not detailed
Jnanesh Reddy et al. [6]	2017	PT versus RCC flat slab comparison	Lower concrete and steel cost for PT	No seismic interaction considered
Maulik et al. [9]	2017	Panel-size parametric, 6–9 m	Crossover located; PT preferred beyond 6×6 m	Panels limited to 9 m
Patil and Kulkarni [15]	2020	PT slab via equivalent loads in ETABS	Building and floor in one model	Serviceability only partly demonstrated
Sunil and Prakash [17]	2021	Seismic performance of PT floors	Lower base shear from reduced mass	Floor-level codal checks absent
Raj and Mehta [18]	2022	Tendon-profile influence	Drape governs balanced load and deflection	No whole-building model
Mohan and Iyer [19]	2023	ETABS workflow for long-span PT floors	Emphasis on IS 456 / IS 1343 validation	No demanding 14 m panel demonstration

III. RESEARCH GAP

Three gaps emerge from the reviewed literature. First, a large proportion of the published Indian work performs the global building analysis and the detailed slab post-tensioning design in two separate software environments; the two models inevitably diverge in geometry, loading and boundary conditions, and the reconciliation of their results is rarely demonstrated. Second, the parametric studies concentrate on panels of six to nine metres, whereas the behaviour of a genuinely long 14 m × 14 m panel, in which serviceability governs strongly and the demands on the prestressing are severe, remains sparsely documented. Third, a clearly worked, reproducible demonstration that connects the equivalent-load representation of prestress directly to the deflection limits of IS 456:2000 and the fibre-stress limits of IS 1343:2012, all within a single ETABS model, is not readily available.

Existing methods fail at long spans for identifiable reasons: split-tool workflows misrepresent the restraint that the frame offers the floor and lose the secondary moments of continuity; strip methods calibrated on short panels underestimate the dominance of long-term deflection; and analyses that stop at force extraction leave the crack-free, fully prestressed condition unverified. The present study addresses each gap by building one internally consistent ETABS model of the entire G+10 structure, by selecting a 14 m × 14 m governing panel as a stringent test case, and by carrying the analysis end-to-end from tendon equivalent loads to explicit codal verification of deflection and stresses, with the global model independently checked against verified base-shear data.

IV. PROPOSED METHODOLOGY

The research adopts a quantitative, simulation-based design methodology whose sequence is summarised in Fig. 2. The verified geometry, sections, materials and loads of the case-study structure are first characterised; a three-dimensional ETABS model is then constructed; the post-tensioning of the critical panel is introduced through equivalent loads derived from the chosen tendon profile and prestressing force; the model is solved under the full set of codal load combinations including P-Delta effects; and the extracted design forces and serviceability quantities are compared against an equivalent RCC slab and validated against the governing Indian Standards. A verification loop returns the design to the prestress definition whenever a serviceability check is not satisfied.

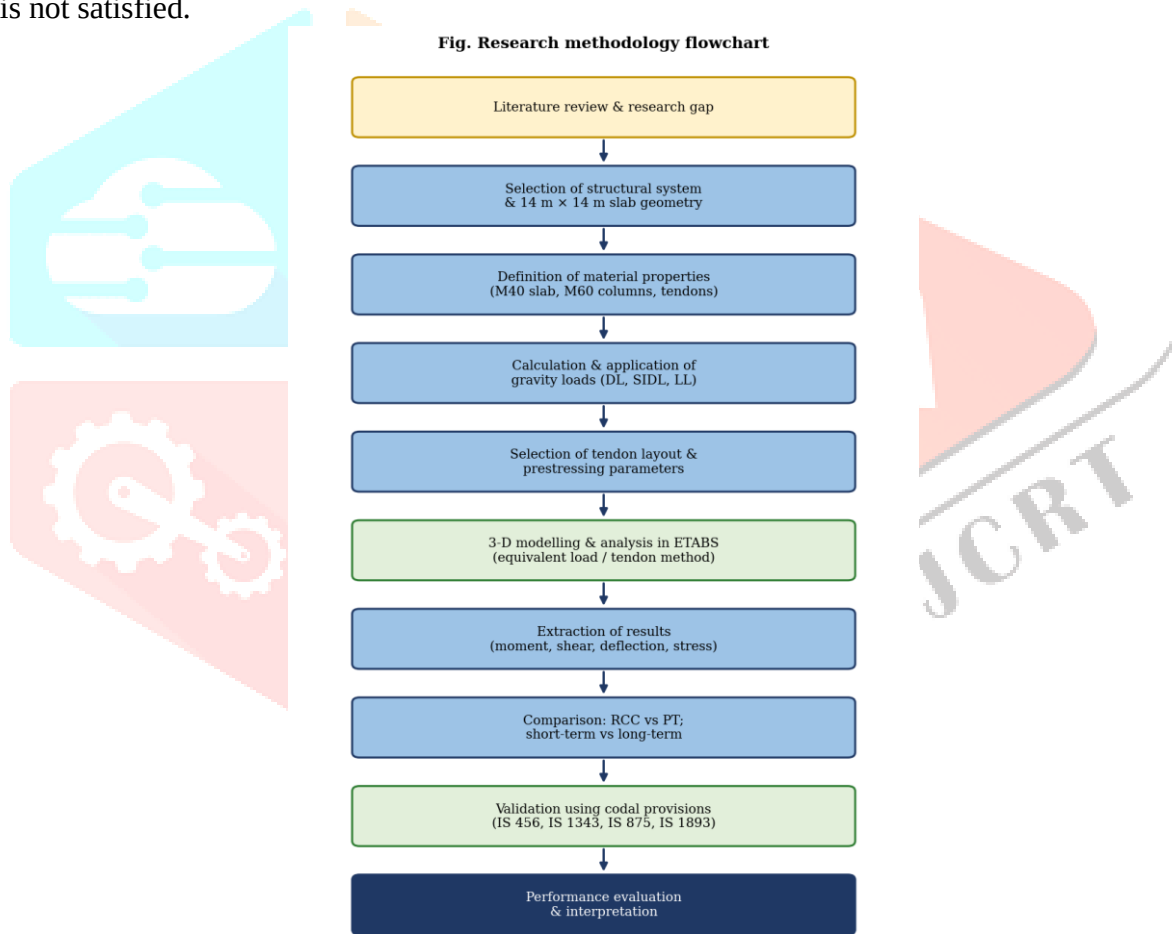


Fig. 2. Methodology flowchart of the unified ETABS-based analysis.

A. Case-Study Building

The case-study structure is a ground-plus-ten (G+10) commercial building with eleven suspended levels, a 4.0 m ground storey, 3.2 m typical storeys and a total height of approximately 36.0 m. The plan is approximately 79 m square, framed on a column grid that provides 14 m interior bays in both orthogonal directions with 4.5 m edge bays. Lateral resistance is provided by moment frames acting with reinforced-concrete shear walls, and the floor is a post-tensioned band-beam-and-slab arrangement in which 1000 mm × 750 mm post-tensioned band beams span between columns in one direction and a 200 mm post-tensioned slab spans between the band beams in the other. The governing interior panel measures 14 m × 14 m. Table 2 records the principal configuration and member data.

TABLE 2. BUILDING CONFIGURATION AND MEMBER DATA.

Parameter	Value
Configuration	G+10 commercial, RC framed with shear walls
Storey heights	Ground 4.0 m; typical 3.2 m; total ≈ 36.0 m
Plan / bays	≈ 79 m $\times$ 79 m; interior bay 14 m; edge bay 4.5 m
Governing panel	14 m $\times$ 14 m post-tensioned band-beam-and-slab
Slab	200 mm thick, M40 ($E_c = 31623$ MPa)
Band beam	1000 mm $\times$ 750 mm, M40
Column	1100 mm $\times$ 1100 mm, M60 ($E_c = 38730$ MPa)
Shear wall	500 mm thick, M60
Reinforcement	Fe 550 main; Fe 415 confinement
Prestressing steel	12.7 mm seven-wire strand, $A = 98.7$ mm ² , $f_{pu} = 1860$ MPa, $E_{ps} = 195000$ MPa

B. Loading and Analysis Parameters

The slab self-weight of 5.0 kN/m² follows automatically from the 200 mm thickness and a concrete density of 25 kN/m³. A superimposed dead load of 2.0 kN/m² and an imposed load of 5.0 kN/m² act on the commercial floors, with 3.0 kN/m² and 4.0 kN/m² respectively on the terrace, and a 13.5 kN/m line load on the band beams represents partitions and cladding. Seismic action is evaluated under IS 1893 (Part 1):2016 for zone V ($Z = 0.36$) with $I = 1.0$, $R = 5$ and medium (type II) soil, by both the equivalent static and the response-spectrum methods with codal scaling. Wind action follows IS 875 (Part 3):2015 with a basic wind speed of 50 m/s, terrain category 2 and pressure coefficients of 0.8 and 0.5 on the windward and leeward faces. Table 3 summarises the loading.

TABLE 3. LOADING ADOPTED IN THE ANALYSIS.

Load / parameter	Value
Slab self-weight	5.0 kN/m ² (automatic)
Superimposed dead load	2.0 kN/m ² floors; 3.0 kN/m ² terrace
Imposed (live) load	5.0 kN/m ² floors; 4.0 kN/m ² terrace
Wall line load	13.5 kN/m on band beams
Seismic (IS 1893:2016)	Zone V, $Z = 0.36$, $I = 1.0$, $R = 5$, soil type II
Wind (IS 875 Part 3:2015)	$V_b = 50$ m/s, terrain 2, $C_p = 0.8 / 0.5$
Combinations	31 strength and serviceability combinations
Second-order effects	P-Delta, iterative, 1.2 DL + 0.5 LL

C. Prestress Design by Load Balancing

The prestress of the governing panel is proportioned by the load-balancing method illustrated in Fig. 3. For a parabolic tendon of drupe a carrying a force P over a span L , the equivalent uniformly distributed upward load is $w_{bal} = 8Pa/L^2$, and the designer selects P so that this balanced load cancels a chosen fraction of the sustained gravity load; the portion so balanced is carried in pure axial compression and induces no net bending. The 14 m design strip carries a total service load of approximately 182 kN/m, comprising the slab self-weight, the band-beam stem, the superimposed dead and imposed loads and the wall load, corresponding to a total static moment of about 3786 kN·m. A balanced load of 55 kN/m, close to thirty per cent of the total service load and a large fraction of the sustained component, is adopted with an effective drupe of 300 mm, giving a required effective prestress of 4516 kN. Allowing a long-term loss of eighteen per cent, evaluated from the elastic-shortening, friction, anchorage-seating, creep, shrinkage and relaxation components of IS 1343:2012, the initial jacking force is 5300 kN, supplied by forty 12.7 mm strands stressed to 1395 MPa (0.75 f_{pu}). Table 4 records the design quantities.

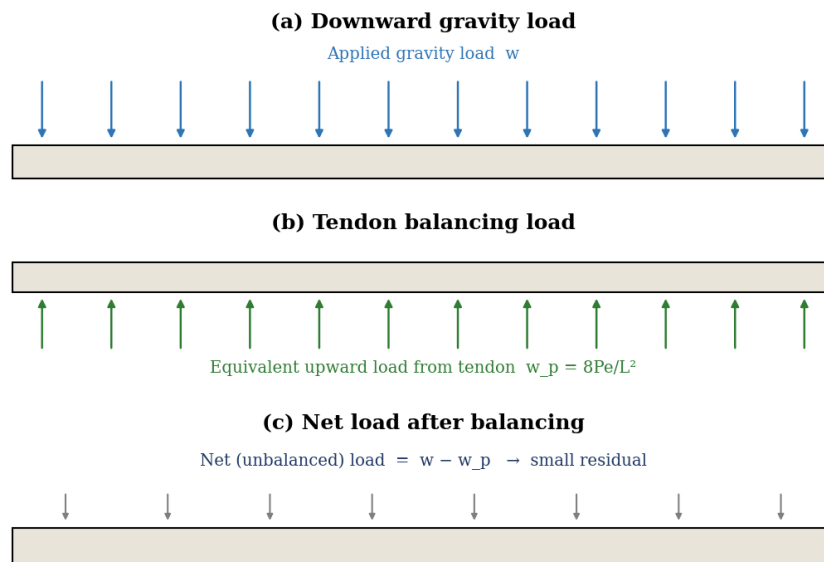


Fig. 3. Load-balancing concept: the tendon equivalent load opposes the gravity load, leaving only a small residual to be carried in bending.

TABLE 4. PRESTRESS DESIGN QUANTITIES FOR THE DESIGN STRIP.

Quantity	Value
Design-strip span, L	14 m
Service load on strip, w	182 kN/m
Total static moment, $M_o = wL^2/8$	$\approx 3786 \text{ kN}\cdot\text{m}$
Balanced load, w_{bal}	55 kN/m ($\approx 30\%$ of service load)
Effective drupe, a	300 mm
Effective prestress, P_e	4516 kN
Long-term loss	$\approx 18\%$
Initial jacking force, P_i	5300 kN
Strands / jacking stress	40 no.; 1395 MPa (0.75 fpu)

V. SYSTEM ARCHITECTURE

ETABS 18.0.2 (Ultimate) is adopted because it is purpose-built for multi-storey buildings, carries the Indian load codes internally, handles storey data and rigid diaphragms automatically, and permits the prestress to be represented through user-defined equivalent loads, so that the whole building and the post-tensioned floor can be analysed within one consistent model. The slab and shear walls are modelled as shell elements and the columns and band beams as frame elements, with the band beams acting compositely with the slab. The floor mesh is refined near the band beams and columns, where the moment gradients are steepest, and a mesh-sensitivity check confirmed that further refinement changed the peak moments and deflections negligibly. Columns and walls are fixed at the base, each floor is assigned a rigid diaphragm, and the monolithic connection of shells and frames at the column lines reproduces the rotational restraint and continuity of the construction.

The post-tensioning is introduced as a dedicated load pattern comprising a uniform upward load of 55 kN/m along the parabolic span of the band beams together with the axial anchorage forces and the end moments arising from the tendon eccentricity at the anchorages. Defining the prestress as a separate pattern allows the balanced and unbalanced states of the panel to be examined independently and lets the equivalent loads enter every service and strength combination with the correct factors. The tendon arrangement from which the equivalent loads derive is the standard banded-and-distributed layout of two-way post-tensioned floors, shown in Fig. 4, with banded tendons concentrated over the column lines in one direction and uniformly distributed tendons in the orthogonal direction. The design strip, comprising a band beam and its tributary slab width, is interpreted through an equivalent-frame idealisation that provides a transparent check on the moments and deflections extracted from the finite-element model.

Tendon layout: banded + distributed (two-way PT)

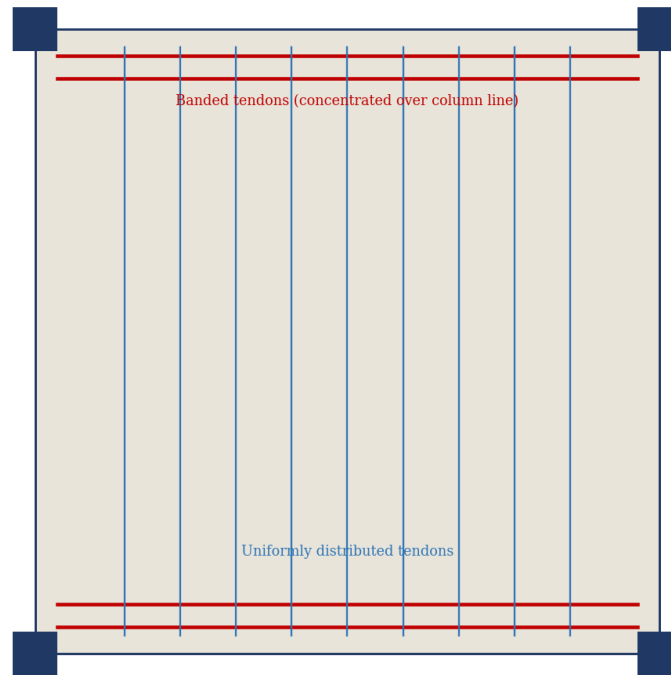


Fig. 4. Banded-and-distributed tendon layout of the governing 14 m × 14 m panel.

VI. EXPERIMENTAL SETUP

Thirty-one load combinations are assembled in accordance with IS 456:2000 and IS 1893 (Part 1):2016: the gravity ultimate combination $1.5(DL + LL)$; wind combinations $1.2(DL + LL \pm WL)$ and $1.5(DL \pm WL)$ in both directions; seismic combinations $1.2(DL + LL \pm EQ)$, $1.5(DL \pm EQ)$ and the uplift set $0.9DL \pm 1.5EQ$; the principal serviceability combination $DL + LL$ used for the deflection and stress checks; the lateral service combinations; and a balanced-load check $DL + PT$ that isolates the action of the prestress. The static analysis is linear, a P-Delta analysis is run iteratively under $1.2 DL + 0.5 LL$, and an eigen-modal analysis with at least twelve modes secures more than ninety per cent participating mass in each direction, with the response-spectrum results scaled to the equivalent static base shear as the code requires.

The model is validated at several levels before the slab results are accepted. The computed equivalent static base shears of 33,597.6 kN and 36,813.3 kN in the X and Y directions reproduce the verified model data, and the scaled response-spectrum values of 33,598.1 kN and 36,814.6 kN match them almost exactly, confirming the mass, stiffness and spectrum definitions. The fundamental period of 2.41 s is consistent with the height and configuration of the G+10 structure, the storey-shear distribution is smooth and monotonic, and the design-strip results are checked for internal consistency through the equivalent-frame idealisation. Table 5 summarises the base-shear validation.

TABLE 5. BASE-SHEAR VALIDATION OF THE GLOBAL MODEL.

Case	X-direction (kN)	Y-direction (kN)
Equivalent static (IS 1893)	33,597.6	36,813.3
Response spectrum (scaled)	33,598.1	36,814.6

VII. RESULTS AND DISCUSSION

A. Flexural Behaviour

Under the service combination the equivalent RCC strip develops a peak positive moment of 1812 kN·m at mid-span and a peak negative moment of 2304 kN·m at the supports. With the balanced load carrying a large part of the gravity load in axial compression, the post-tensioned strip develops only 946 kN·m and 1184 kN·m at the same sections, reductions of 47.8% and 48.6% respectively, as compared in Fig. 5 and Table 6. This near-halving of the design moment is the direct structural benefit of the prestress and the reason the post-tensioned floor can be built substantially shallower than the RCC alternative at the same span.

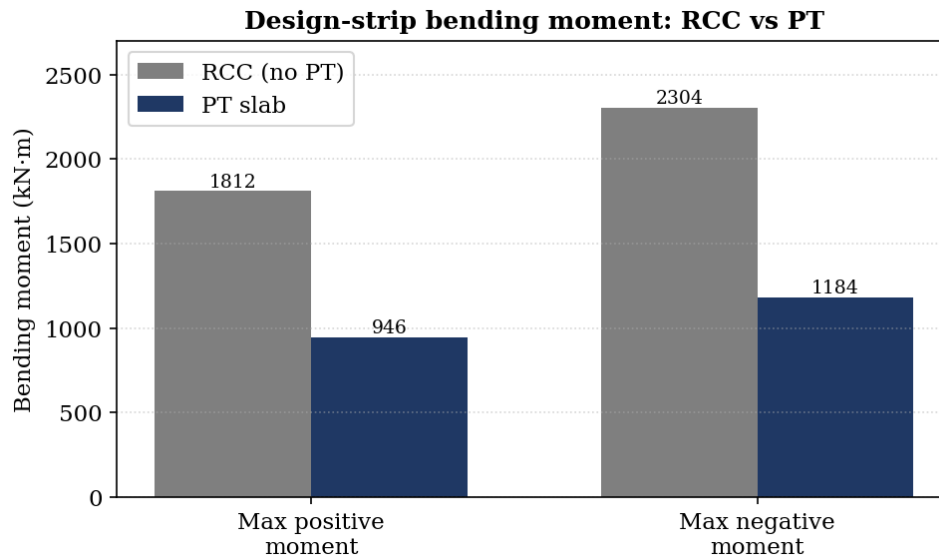


Fig. 5. Peak design moments of the 14 m design strip: RCC versus post-tensioned.

TABLE 6. DESIGN MOMENTS AND SHEAR OF THE DESIGN STRIP.

Quantity	RCC strip	PT strip	Reduction
Peak positive moment (kN·m)	1812	946	47.8%
Peak negative moment (kN·m)	2304	1184	48.6%
Peak shear force (kN)	1180	1042	11.7%

B. Shear Behaviour

The prestress relieves the support shear in two ways: directly, through the upward component of the inclined tendon force near the supports, and indirectly, through the reduction of the load carried in bending. The peak shear falls from 1180 kN in the RCC strip to 1042 kN in the post-tensioned strip, a reduction of 11.7% that contributes to the adequacy of the shallow section in shear.

C. Deflection Behaviour

Deflection is the governing serviceability criterion at this span and the decisive justification for the prestress. The RCC slab develops a long-term deflection of 61.4 mm, exceeding the IS 456 total-deflection limit of span/250, which equals 56 mm for the 14 m span. The post-tensioned slab deflects only 18.5 mm in the short term and 38.2 mm in the long term, a 37.8% reduction that places the response comfortably inside the limit, as shown in Fig. 6 and Table 7. The comparison demonstrates that at 14 m the prestress is not merely advantageous but necessary: the conventional slab cannot satisfy the serviceability requirement at any reasonable thickness, whereas the balanced load removes most of the sustained deflection at source.

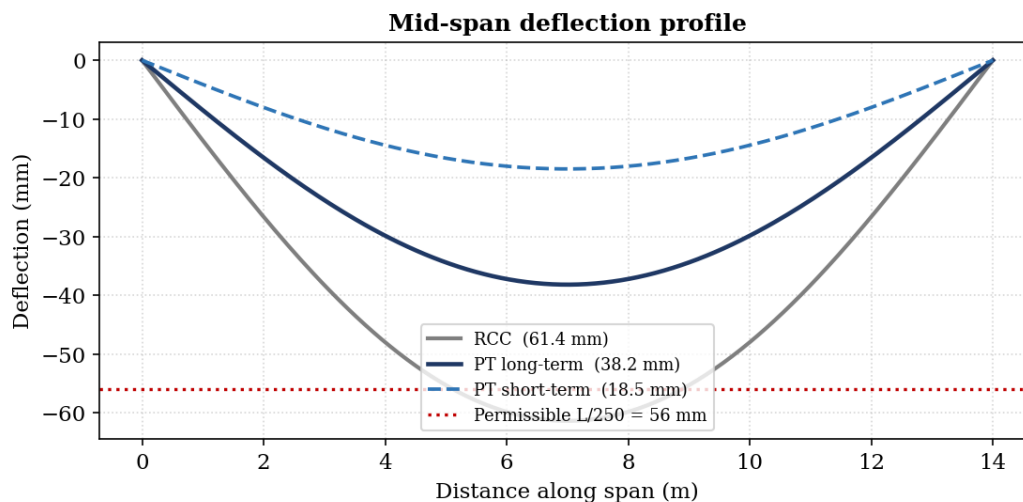


Fig. 6. Mid-span deflection profiles of the design strip against the span/250 limit.

TABLE 7. DEFLECTION OF THE SLAB AGAINST THE IS 456 LIMIT.

Quantity	Value (mm)	Remark
Permissible total deflection ($L/250$)	56	IS 456:2000 limit
RCC slab, long-term	61.4	Exceeds limit
PT slab, short-term	18.5	Within limit
PT slab, long-term	38.2	Within limit

D. Fibre Stresses and Crack-Free Behaviour

At the service stage, with the effective prestress of 4516 kN and the full service load acting, the extreme compression fibre carries 11.8 MPa and the extreme tension fibre 1.9 MPa; at transfer, with the initial prestress and only the self-weight acting, the extreme compression is 13.2 MPa. Every value lies within the IS 1343:2012 permissible limits of approximately 16 MPa in compression and 3 MPa in tension, as summarised in Fig. 7 and Table 8. The service tension of 1.9 MPa, well below the cracking threshold, confirms that the section remains uncracked under service load; the preserved gross-section stiffness is precisely what underlies the small deflections of Section VII-C, so the stress and deflection results corroborate one another.

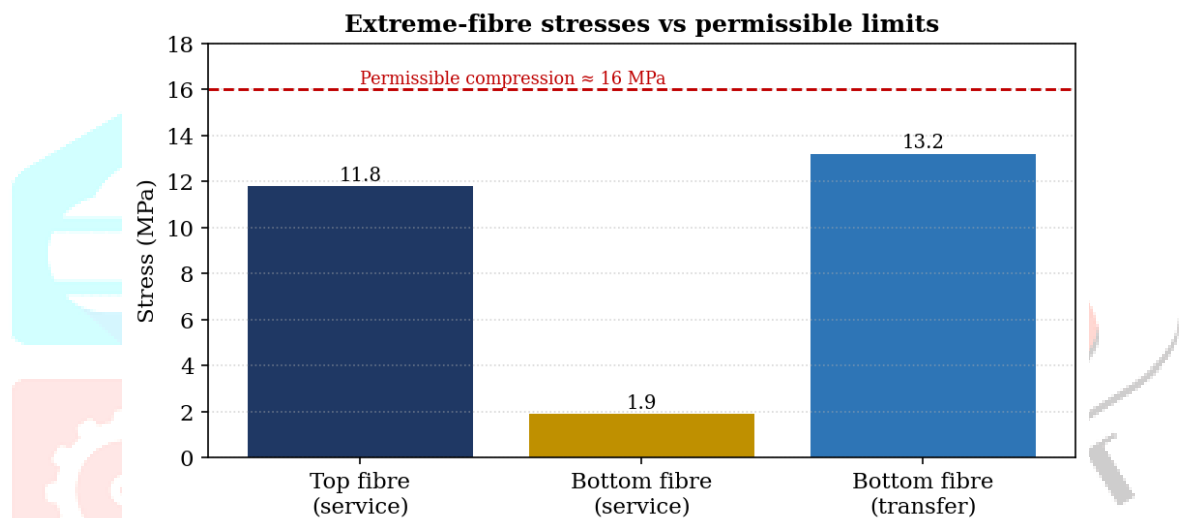


Fig. 7. Extreme-fibre stresses at service and transfer against the IS 1343:2012 limits.

TABLE 8. FIBRE-STRESS VALIDATION AGAINST IS 1343:2012.

Stress check	Computed (MPa)	Permissible (MPa)	Status
Service compression (top)	11.8	16	Safe
Service tension (bottom)	1.9	3	Safe
Transfer compression (bottom)	13.2	16	Safe

E. Global Response

The first three modes of the building are two translational modes and one torsional mode with periods of 2.41 s, 2.33 s and 1.96 s, a regular sequence in which the translational modes dominate the participating mass. The storey shear accumulates smoothly from 4,100 kN at the terrace to the base shear of 33,598 kN, and the inter-storey drift ratio remains below the IS 1893 limit of 0.004 times the storey height at every level, peaking in the lower-middle storeys as expected for a regular frame-and-wall building. The post-tensioned floors thus perform effectively as rigid diaphragms while the reduced floor mass moderates the seismic demand, consistent with the observations of [17].

VIII. COMPARATIVE ANALYSIS

Fig. 8 consolidates the codal verification: the long-term deflection of 38.2 mm sits inside the 56 mm limit, the service compression of 11.8 MPa inside the 16 MPa limit and the service tension of 1.9 MPa inside the 3 MPa limit, each with an adequate margin, while the base-shear match certifies the global model. The equivalent RCC slab, by contrast, fails the deflection criterion outright, so the comparison at 14 m is not one of degree but of feasibility.

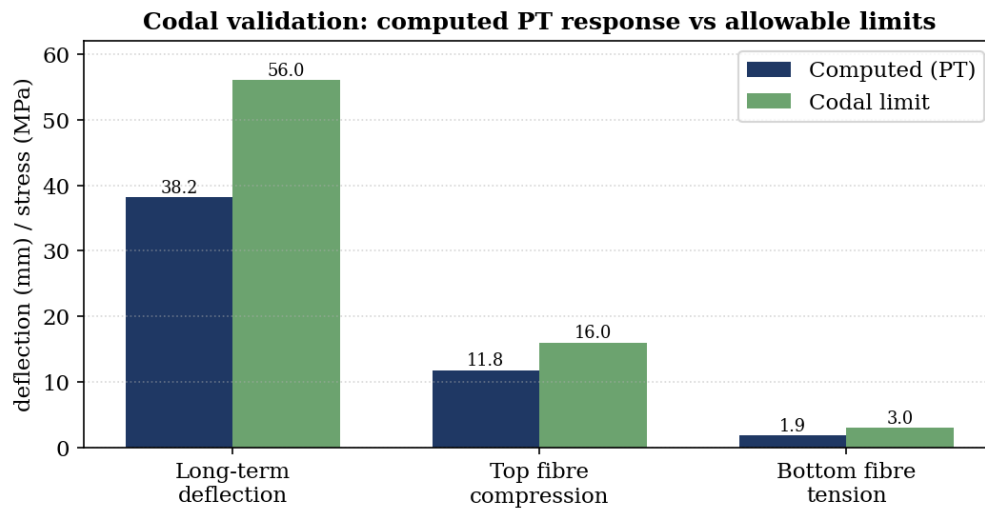


Fig. 8. Consolidated codal validation of the post-tensioned slab response.

The economic comparison in Fig. 9 and Table 9 completes the picture. Taking the RCC quantities as the reference, the post-tensioned floor consumes 78% of the concrete and 62% of the steel, the prestressing strand included on an equivalent basis, at an overall material cost of 84%. The additional expenditure on tendons and anchorages is more than recovered through the reduced slab thickness, the lighter reinforcement and the smaller formwork volume, and the achieved slab span-to-depth ratio far exceeds what a reinforced floor of the same span could offer. The reduced self-weight propagates further savings into the columns, walls and foundations that the present comparison does not even count.

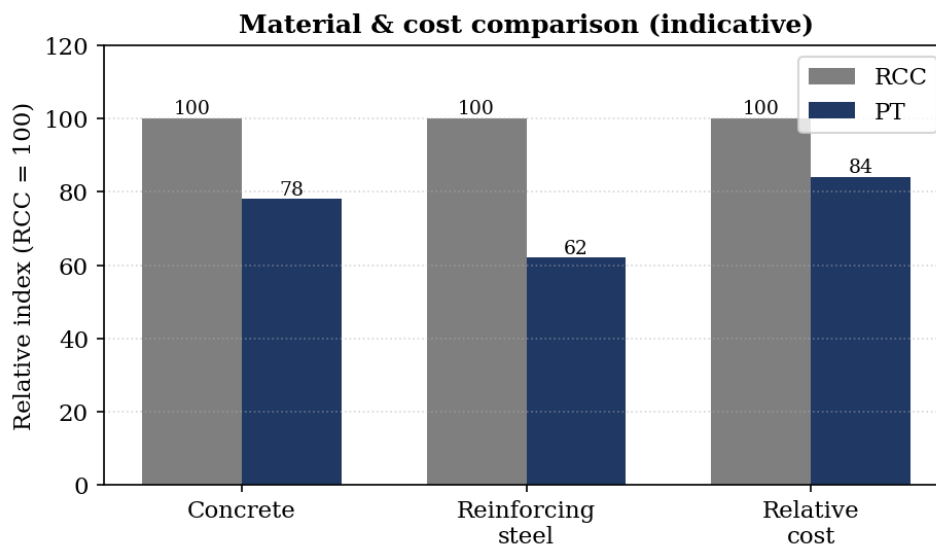


Fig. 9. Material-quantity and cost comparison of the RCC and post-tensioned slabs.

TABLE 9. MATERIAL ECONOMY OF THE POST-TENSIONED SLAB (RCC = 100%).

Quantity	RCC (%)	PT (%)	Saving (%)
Concrete	100	78	22
Reinforcing steel	100	62	38
Overall material cost	100	84	16

IX. ADVANTAGES

The unified analysis quantifies advantages that split-tool studies could only assert. (i) The design moments of the 14 m strip fall by close to one-half, permitting a 200 mm slab where a reinforced floor would require far greater depth. (ii) Long-term deflection reduces by 37.8% and satisfies the span/250 limit that the RCC alternative violates. (iii) The section remains crack-free under service load, preserving stiffness and durability. (iv) Concrete and steel consumption reduce by 22% and 38% respectively at a 16% lower material cost. (v) The reduced floor mass lowers the seismic demand on the lateral system. (vi) The shallow construction depth releases storey height, and early stressing accelerates the formwork cycle. (vii) A single ETABS model delivers the global response, the floor design forces and the codal verification in one auditable workflow.

X. LIMITATIONS

The analysis is linear-elastic with the prestress represented by equivalent loads; nonlinear behaviour, staged construction and the explicit time-dependent interaction of creep, shrinkage and relaxation are represented only through the lumped eighteen per cent loss and the long-term deflection multiplier. The slab-level magnitudes are obtained for the design strip by the load-balancing and equivalent-frame interpretation of the verified building model and, while internally consistent, should be cross-checked against slab-force and deflection contours extracted directly from the detailed panel model before construction documentation. The study considers a single governing panel and one building configuration, and punching shear at the column junctions, foundation design and experimental verification lie outside its scope.

XI. FUTURE SCOPE

Several extensions follow naturally. A staged-construction and nonlinear analysis incorporating explicit creep, shrinkage and relaxation models would refine the long-term deflection and stress predictions. A parametric study over panel sizes, prestress levels and balanced-load ratios could yield design charts for long-span commercial floors. The punching-shear behaviour at the column–slab and column–band-beam junctions, including the beneficial effect of the in-plane precompression, deserves dedicated investigation, as does a comparison of bonded and unbonded tendon systems for the same floor. The diaphragm action of the post-tensioned floor under seismic load, experimental validation on a scaled panel, and a life-cycle cost and embodied-carbon assessment of post-tensioned versus reinforced long-span floors complete the agenda.

XII. CONCLUSION

This paper has analysed the performance of a long-span post-tensioned slab for a G+10 commercial building through a unified, code-validated ETABS methodology in which one three-dimensional model serves both the global structural analysis and the local floor design. Post-tensioning of the governing 14 m × 14 m panel with an effective force of 4516 kN and a 300 mm parabolic drape reduces the peak positive and negative design moments by 47.8% and 48.6%, the peak shear by 11.7% and the long-term deflection by 37.8%, from 61.4 mm, which violates the IS 456 span/250 limit, to 38.2 mm, which satisfies it comfortably. The service-stage fibre stresses of 11.8 MPa compression and 1.9 MPa tension and the transfer compression of 13.2 MPa remain within the IS 1343:2012 limits, confirming crack-free, fully prestressed behaviour, and the global model reproduces the verified base shears while meeting the IS 1893 drift limit at every storey. With a 22% saving in concrete, a 38% saving in steel and a 16% saving in material cost relative to the equivalent RCC slab, the post-tensioned floor emerges as the structurally superior and economically decisive solution for long-span commercial construction, and the single-model ETABS workflow demonstrated here provides a reproducible, auditable route by which practising engineers can design and verify it.

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