Comparative analysis of RCC and PT Slabs underneath Lateral Loading: A Structural study using ETABS

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Abstract-. ETABS software is used to analyze the structural response of reinforced concrete (RCC) and post-tensioned (PT) slabs under lateral loading. This study investigates RCC and PT slabs' behavior by using finite element analysis to determine bending moments, shear forces, and storey drift. Prestrassed slabs display lower bending moments and shear forces than RCC slabs, demonstrating the effectiveness of prestressing in reducing structural requirements. A reduction in storey drift also indicates improved resistance to lateral deformations in PT slabs. In terms of structural performance and cost-effectiveness, PT slabs offer potential benefits for constructing layouts and construction, making them an attractive choice.

Keyword-: Concrete, flat slab structures, ETABS, Fibber reinforced concrete.

1 Introduction

Existing gradual collapse architecture building regulations include risk-based subjective scales and quantitative requirements. In order to evaluate the structural resilience of cement flat slab buildings, mathematical theories like Crucial Stress Crack Theories (CSCT) are employed. This research evaluates column punching under abrupt pillar removal situations employing the Ductility-Centered Robustness Evaluation created at Imperial College London. It also applies to devices using flat floors, showing that tying pressures necessitate connection punching beforehand. It is also demonstrated that integrity reinforcement benefits greatly from numerical modeling of post-punching [1]. In all of India's seismic zones, the dissertation examines the behavior and performance of a G+5 industrial multi-storey

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framework using smooth and standard slabs, concentrating on variables such as base shear, story drift, axial force, and displacement. A four millimeters variance in story movement and 5% higher shear and radial pressures per story for slab-like buildings than for traditional buildings are shown by the study, suggesting that these structures are suitable for different seismic zones [2].

In order to reduce bending moment and shear stresses, flat slabs are slabs without beams resting directly on supports. They transmit weight to the base and columns immediately. Column heads are extended and slab thickness is raised to sustain big loads. A plain ceiling, improved architectural look, less fire risk, improved light dispersion, simpler construction, and less expensive form work are all benefits of this design. Flat slab design is done uniquely across the country, with regulations like example IS 456-2000 and ACI 318-08 offering recommendations. With moments distributed as column strip and centered strip instances, finite element analysis and the Comparable Frame Technique are employed. An inner panel measuring 6.6 by 5.6 meters was created [3]. Significant corrosion-related degradation was the reason for the costly fix of the forty-year-old La Chandeliered parking structure in Québec, Canada. The city made the decision to install new, GFRP-barred slabs in place of the ones that were flat. A consulting agency created two designs; however, after doing a cost research, the municipality decided on the GFRP bars. The design, construction, and performance of GFRP-reinforced concrete flat slabs under actual service loads and circumstances during a 3.5-year period are examined in this study. It confirms that an initial higher GFRP cost does not always translate into a higher overall cost by providing a comparative cost comparison of steel-RC and GFRP-RC systems [4].

In multi-story structures subjected to structural loads and ISO 834 fire conditions, the study examines the resistance to fire of concrete flat slabs. It will need more trials to assess the effectiveness of the updated boundary conditions, which mirror real-world circumstances and reflect the impact of membrane movement on punching shear behavior. Given that heat transmission and distortion recovery were recorded, the test showed a much longer fireproofing endurance under limited support environments, suggesting that these parameters improve punch shear resistance [5]. Column-supported flat slabs (CSS), one type of high-strength architectural component, are using more and more fibber reinforced concrete (FR). With this technique, building times may be shortened and resources can be optimized without sacrificing structural integrity. Its usage in CSS is constrained, nevertheless. A research with an industrial focus compares the operation methods and expenses of CSS using Frs. and typical RC techniques [6]. This research examines the necessity of flex reinforcing and the time-saving benefits of using fibbers in place of steel bars for reinforcement. To determine productivity rates and specifics, databases and conversations with in site building professionals are used [7-9]. The findings indicate that while construction time and time-dependent costs have decreased, direct costs for fibber and hybrid systems have increased. The use of FR for CSS by architects and building managers is aided by this research [10]. Recommendations for the partial or complete replacement of steel reinforcing bars have arisen from the growing usage of fibber concrete reinforced (FRC) for structural applications. The impact of the fib MC-2010 FRC post-cracking strength categorization on physical reaction, for example, is a contributing factor why adoption is still not unified. Real-scale experiments were used to validate the implementation of a non-linear finite element model. For the purpose of improving construction methods with fiber-reinforced concretes; the fib investigation used the model in a real-scale test [11]. The best flexure solution was found using the structural reliability index, taking into account different post-cracking strength class &fibber types [12]. In a study in [13] the punching behavior of reinforced high strength concrete (SCH) flat slabs, this work draws attention to the paucity of experimental studies conducted on SCH slabs [14-17]. Under monotonic vertical stress, the study examines the reasonable usage of HSC by testing four samples with SCH along with one with Osgood striking power was achieved by using just a small amount of HSC in the slabs-column connecting zone; this punching strength was almost identical to that of a slab which had been fully cast in HSC. Australia produces 30 million tons of completed building products yearly, with 56% of that amount coming from concrete and 6% from steel. This indicates that the country is consuming more construction materials. In order to maximize the amount of embodied energy, this study looks at the environmental impact of concrete foundation systems with a particular emphasis upon Low Emission Building (ZEB).An analysis of Australian regulations and standards comparing several slab systems—such as beam & slab, flat slab, and flat plates—for constructions reveals worse energy efficiency [18].

The research in [19] examines contemporary reliability analysis methods for assessing flat slab security requirements. Using three methods—the Mean-Value First Order Second Moment Technique (MVFOSM), the First Order Second Period Technique (FOSM), and Monte-Carlo simulations using Importance Samples (MC-IS)—it examines punched shear barrier design options with shear strengthening. To gauge safety standards, reliability indices are employed. The punched shear strength with reinforcement from shear reliability indices for slab with shear reinforcement are assessed in this work and compared to a target safety level of 3.8. The necessary security standard is achieved by the EN 1992-1-1 regulations, according to the results. For design equation probability, the study recommends utilizing MC-IS and FOSM; nevertheless, MVFOSM might not be appropriate for complete safety [20-22]. The punching strength of foundations and rectangular slabs with and without shear reinforcement has been thoroughly investigated by researchers in [23]. They propose that the ideas of concrete and steel may be used to characterize strength. Nevertheless, the quantity of reinforcement for shear affects how these contributions are systematically evaluated. The evolution of the concrete and steel contributions in shear-reinforced flat slabs is examined in this article, which also offers a technique for calculating and assessing both and contrasts it with guidelines for design in the Euro code [24-27].

Software is a rapid and effective tool which may be utilized to analyze and design structures in the context of earthquakes. By utilizing ETABS software to assess the impacts of wind and earthquake pressures on these structures and guaranteeing that at least 50% of the floor area is utilized for commercial activities, the study in [28] focuses on assessing and constructing business structures with various slab arrangements. Based on IS 456-2000 code book, IS 875-part 5 (2015) code book, wind speed of 55 m/s, and seismic zone 5, the evaluation and design of a structure utilizing M30 grade concrete along with Fe-500 steel is conducted. Comparing the findings to various slab arrangements, they show that a structure with a grid-like slab remains stable and cost-effective. In tall building design, lateral stiffness plays a critical role in preventing collapse caused by gravity loads and second-order P-Delta effects. Compared to traditional slab structures, flat slab buildings are less stiff; nevertheless, maximal rigidity happens when drop is supplied [29]. One-way slabs, two-way slabs, and two-way flat plate reinforcing slabs are examples of transference of load devices with their greatest shear and negative moment capacities, mutual rectangular plates are an especially cost-effective option for formwork and reinforcing thickness. Drop-supported slabs have a higher shear and positive momentary strength than waffle flat slabs, which call for specialized labor and form work. Research takes sandy soil region into consideration [30-32]. Slender, support-free slabs were vital for contemporary structural structures. There has been years of effective use of post-tensioned slabs with unbounded tendons around the world. Recently, prepossessed slabs were developed and built in Poland with span and thinness above prescribed limits. These slabs deflect far from the limit value, even though they are bigger and thinner than is advised. In this study, a huge span slab is described [33]. Though current research focuses on BIM for point cloud assignment, which may be incorrect in situations of as-built structural changes or lack of information, the usage of terrain laser scanning devices (TLSs) on construction areas is growing. With the goal of minimizing outliers, a unique approach to robust flat and nonlinear features segmentation as well as classification is put forward computationally stage-free approach for extracting flat-slab floor and ceiling points is given, and it works well with polluted datasets. The applicability of the strategy is evaluated on a construction site with 150 million lines and a laboratory with thirty million points [34-35].

2 Methodology

This study shows a comparison between two structures with same loading and properties condition with the effect of slab stiffness considering general RCC slab structure and PT slab Structure to check variations in both in a Tall G+15 RCC building considering seismic zone V with hard soil type Under the seismic effect as per IS 1893(part I) -2016 non-linear analysis.
This study is structured into ten sequential steps. First, a comprehensive literature survey is conducted to gather insights from past research on post-tensioning (PT) techniques, structural analysis methods, and the impact of diaphragms on structures. Next, the selected geometry is modelled, with a plan area of 300 m^2 and a symmetrical frame, utilizing ETABS for structural modelling and SAFE software for modelling the PT slab. Following this, PT slabs are assigned using the analysis tool SAFE, and anchors are allocated to secure the post-tensioning tendons. Subsequently, the PT slab with tendons is generated in a flat slab configuration. Support conditions are then assigned, followed by the allocation of load conditions. The structure is analyzed using ETABS to assess its response to applied loads. Stress diagrams and contours of the loading conditions are generated to visualize the structural behaviour. Finally, the structure is thoroughly analyzed to evaluate its performance under various loading scenarios.

3 Analysis Using Etabs

Csi ETABS & SAFE is a multipurpose program for analyzing the different forms of structures. The following three activities was performed to achieve that goal
1. Modelling of the structure using ETABS
2. Assigning PT slab using SAFE.
3. Analyzing Structure for lateral loads.

Cases considered in this comparative analysis are as follows:

3.1 Case I: RCC conventional Frame with slab

For modeling an RCC traditional frame with a slab in ETABS, define beams and columns for the frame factors, assign segment properties to them, and create shell elements for the slab. Appropriately applying material properties, loadings, and boundary situations ensures correct structural analysis and design of the incorporated system.

Modelling RCC slab structures in ETABS includes developing a finite element model, defining material characteristics, assigning segment properties to slab elements, and making use of appropriate loads and boundary conditions to simulate real-world behavior and observe structural overall performance as shown in Fig .1.

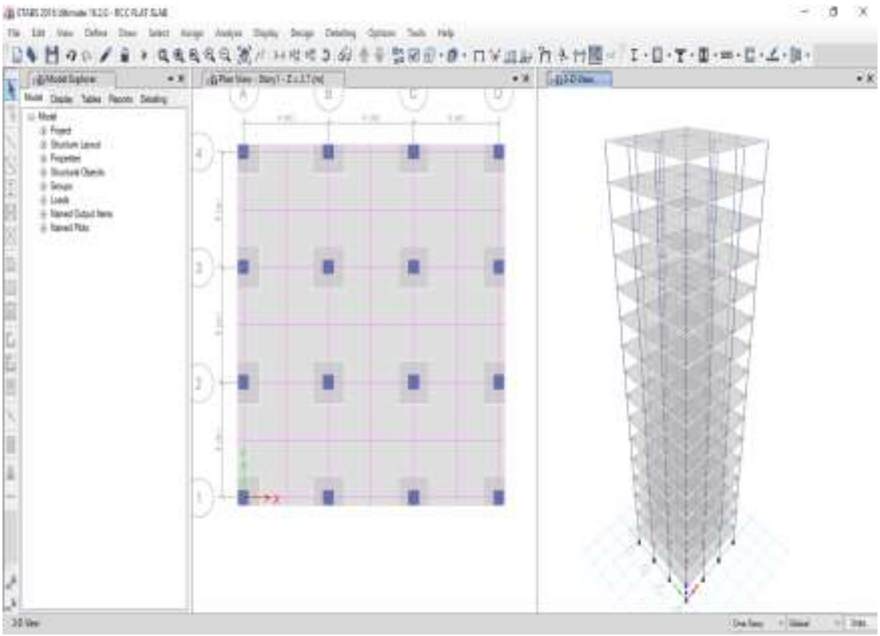

Fig. 1: RCC Slab Structure

3.2 Case II: PT Flat Slab Structure with drop panels

Modeling a post-tensioned (PT) flat slab structure with drop panels in ETABS involves incorporating the post-tensioning tendons inside the slab elements, defining the properties of the post-tensioning substances, appropriately representing the geometry and properties of the drop panels, and observing the structural behavior beneath diverse loading conditions to make certain efficient layout and performance.

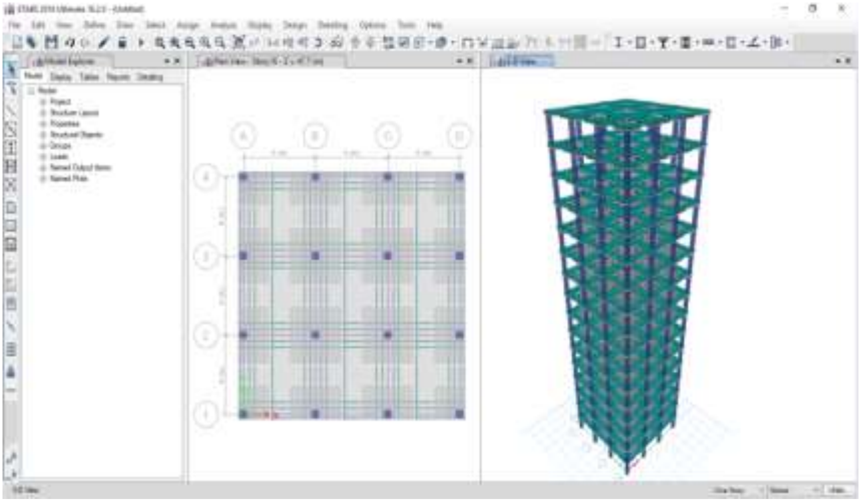

Fig. 2: PT slab structure

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Fig. 2 illustrates a post-tensioned (PT) slab structure modeled in ETABS, presenting incorporated post-tensioning tendons within slab factors, correctly representing the geometry and properties of the slab to investigate structural behavior considering prestressing outcomes.

4 Results and Discussion

This is a computer-based evaluation tool used for simulating and observing engineering products and structures. FEA is an effective engineering design application however requires cautious utilization. as an example, integrating it with computer-aided design software program can result in simplistic push-button analysis in the design process, probably resulting in substantial errors, as this warning highlights.

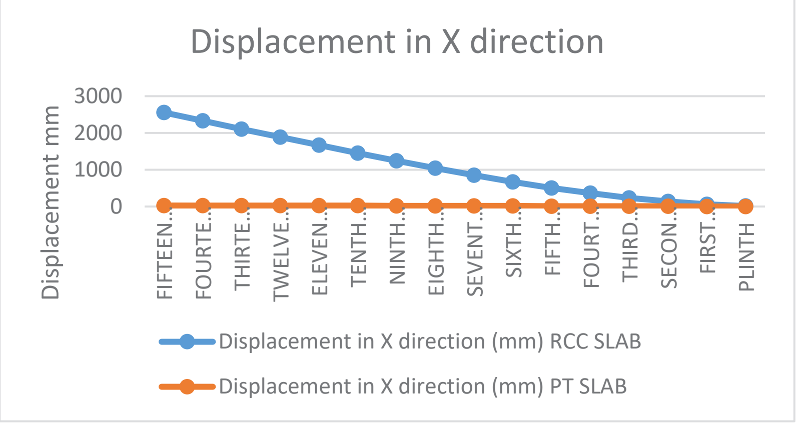

Fig. 3: Displacement in X direction

Fig. 3 depicts the displacement within the X direction, showcasing how much the structure's factors have moved horizontally under the implemented loads or boundary situations. This visualization facilitates engineers recognize how the structure responds to outside forces and become aware of ability areas of concern or immoderate deformation.

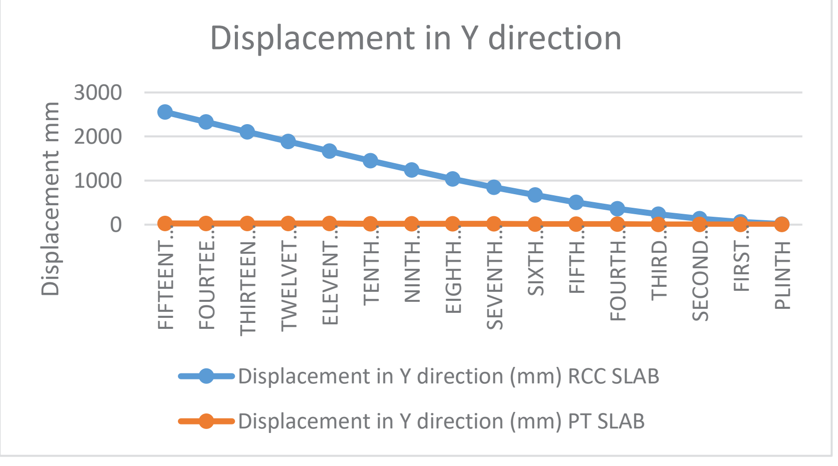

Fig. 4: Displacement in Y direction

Fig. 4 illustrates the displacement in the Y direction, indicating the vertical movement of structural factors because of implemented loads or boundary conditions. This visualization aids in assessing the structural response to vertical forces and identifying areas of huge deformation or stress.

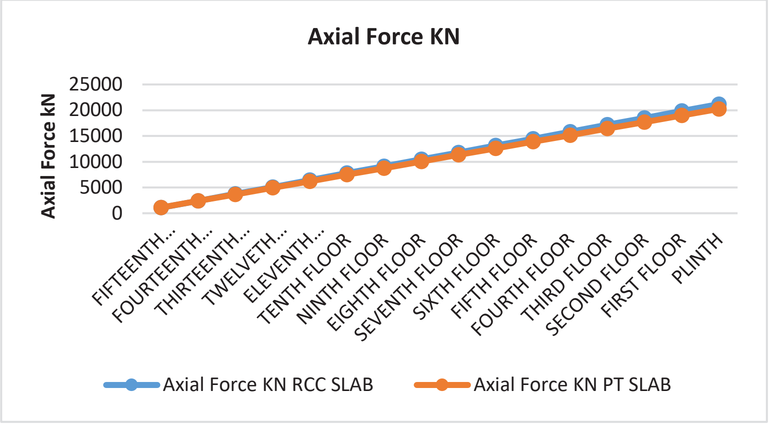

Fig. 5: Axial Force in KN

Fig. 5 provides the distribution of axial forces in kilonewtons (KN) throughout the structural components, offering insights into the magnitude and direction of inner forces alongside each member's length. This visualization serves to evaluate the load-bearing capacity and structural integrity of the factors within diverse loading scenarios.

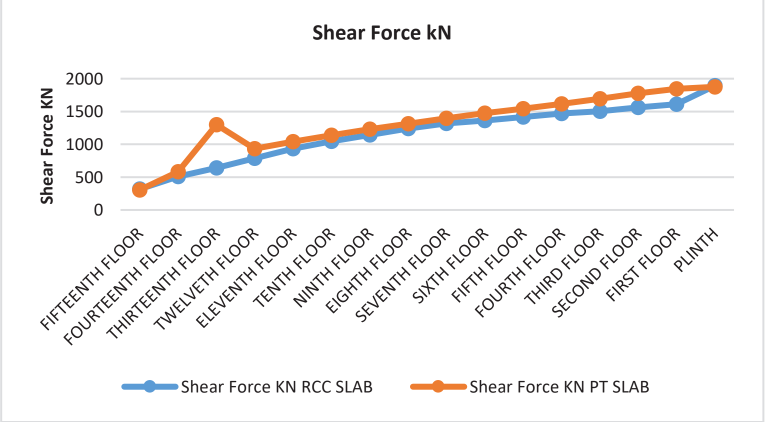

Fig. 6: Shear Force in KN

In Fig. 6, the shear force distribution in kilonewtons (KN) throughout the structural factors is depicted, imparting a detailed illustration of the magnitude and direction of internal forces appearing perpendicular to the length of each member. This visualization aids in comparing the structural balance and capability to withstand lateral loads.

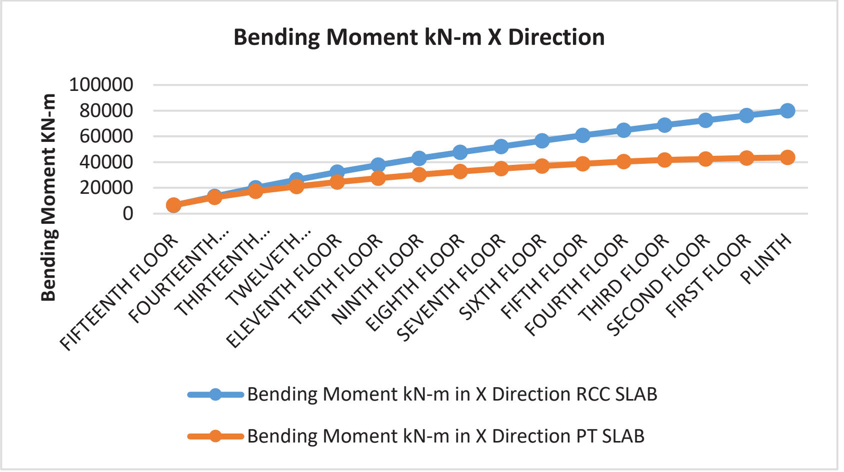

Fig. 7: Bending Moment in X Direction

For an RCC slab, Fig. 7 could imply the bending moments experienced by means of the slab elements within the X direction, supporting engineers recognize how the slab responds to implemented loads including gravity loads or lateral forces. For a PT-slab, Fig. 7 could additionally display the bending moments inside the X direction but would moreover recall the consequences of prestressing tendons on the slab's behavior.

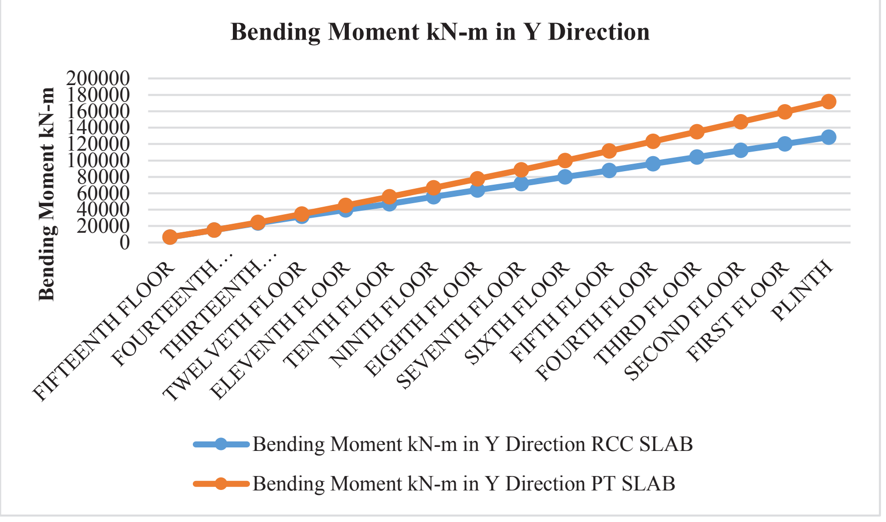

Fig.8: Bending Moment in Y Direction

Fig. 8 represents the bending moments inside the Y direction, providing perception into how structural elements experience bending forces perpendicular to their length. This visualization is critical for expertise the flexural behavior of each RCC and PT slabs, assisting within the evaluation of structural stability and the potential for bending failure.

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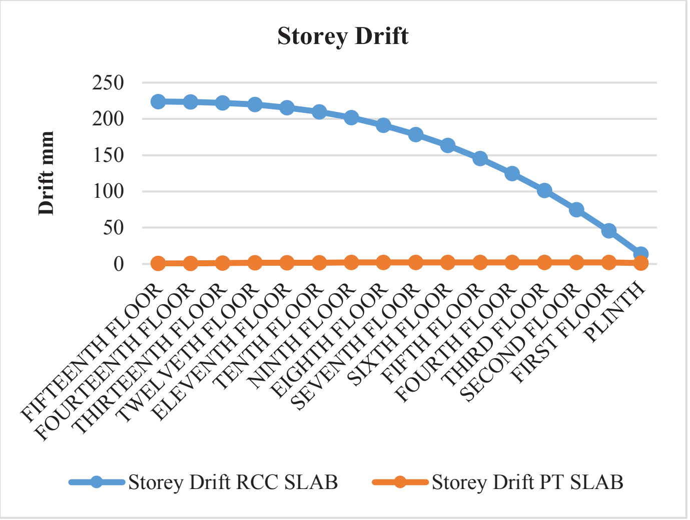

Fig. 9: Storey Drift

Fig. 9 presents the storey drift, showcasing the relative displacement among storeys of buildings subjected to lateral loads. This visualization is vital for assessing structural balance and deformation below seismic or wind forces for each RCC and PT slabs. Engineers can use information storey drift to ensure that buildings are structurally sound and protected, and to guide layout selections to meet overall performance and compliance criteria.

5 Conclusion

Under lateral loading conditions, post-tensioned slabs outperform reinforced concrete slabs (RCC) due to their superior overall performance. In terms of structural performance and stability, PT slabs exhibit reduced bending moments, shear forces, and storey drift. PT slabs seem to offer huge advantages in terms of material optimization and construction financial system, while ensuring adequate structural stability. In addition to highlighting the benefits of incorporating post-tensioning technique into structural designs, the results of this study provide valuable insight for engineers and architects in selecting slab structures for construction projects.

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