Design and Analysis of Reinforced Concrete Flat Slab with MMC layer

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Abstract - *An abstract summarizes, in one paragraph (usually), the major review delves into the structural significance and applications of slab systems, with a particular focus on the efficiency and versatility of flat slabs. Flat slabs, characterized by their simplicity and direct load transfer to columns without intermediate beams, have become a pivotal choice in contemporary construction. The absence of beams not only contributes to a sleek and open interior aesthetic but also streamlines the construction process, reducing costs and timelines. This review examines the structural integrity of flat slabs, exploring their adaptability to various architectural designs and the seamless distribution of loads. Additionally, it investigates the practical advantages of flat slabs, such as their ability to accommodate diverse loadings and facilitate creative floor plan layouts. By shedding light on the evolving technologies and materials associated with flat slab construction, this review aims to provide a comprehensive understanding of the strengths and potential considerations associated with this widely employed structural system.*

Key Words: *Flat slab, review, stability*

1.INTRODUCTION

A flat slab is a commonly used structural element in building construction. It is highly appreciated for its user-friendly nature, cost-effectiveness, and versatility in accommodating various design concepts. This innovative floor system eliminates the need for beams between columns, resulting in a contemporary and spacious ambiance. Flat slabs are composed of a solid, even slab that is directly supported by columns. They evenly distribute loads, enhancing structural strength and providing flexibility in layout and design. This building approach is extensively used in a diverse range of commercial, residential, and institutional structures because to its cost-effectiveness and straightforwardness of construction. Due to its inherent versatility and effectiveness, flat slabs are now the favoured option for contemporary projects that need a harmonious blend of structural performance and aesthetics. Flat slabs are often used in construction projects because to their pragmatic benefits, which are closely linked to their aesthetic and structural advantages. The absence of beams in the construction process simplifies it, resulting in reduced costs for manpower and materials. Flat slabs are a pragmatic choice for projects with time constraints due to their streamlined methodology, which concurrently reduces building schedules. In addition, the ability to customize floor plans promotes creative architectural concepts, allowing architects to optimize space use and enhance the overall functionality of a structure. The adaptability of flat slabs to withstand various types of loads, such as heavy machines or dynamic pressures, highlights their reliability in a wide variety of uses. Flat slabs are evolving to meet the evolving requirements of modern architectural and engineering methods due to advancements in construction technology and materials. As a result, this structural system remains a fundamental component in the construction industry, embodying a harmonious blend of effectiveness, shape, and purpose.

2. LITERATURE REVIEW

In literature [1] The objective of this research initiative is to evaluate the cost-effectiveness of post-tensioned flat slab systems relative to flat slab systems made of reinforced concrete. Both systems are assessed utilising ETABS and RAPT, which are tailored to their distinct design methodologies.

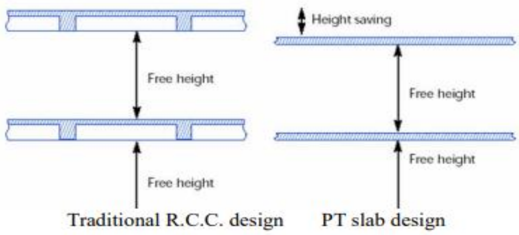

Figure 1: Height comparison of R.C.C. & PT slab design

The use of PT slabs provides numerous additional benefits. As a consequence of the diminished slab thickness in contrast to a reinforced concrete flat slab, the structural integrity may be improved, thereby facilitating greater distance visibility of its vertical dimension. Thus, it is more advantageous to utilise post-tensioned (PT) slabs rather than reinforced concrete (RCC) flat slabs when constructing commercial structures (figure 1). By reducing the inactive burden during construction, PT Slab contributes to the development of a lighter structure.

In literature [2] The aim of this study is to conduct an exhaustive analysis of the prevalence of slab/plate construction in India and assess the efficacy of slab/plate building design methodologies in accordance with the American Concrete Institute ACI-318 and Indian Standard 456:2000.

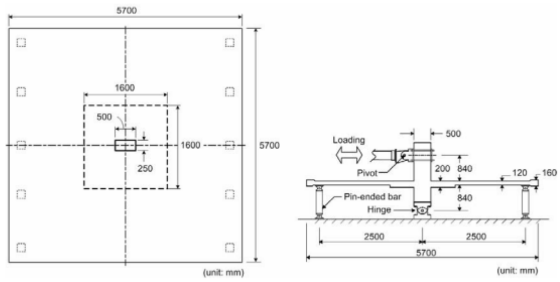

Figure 2: Interior slab–column connection specimen [2]

Post-tensioning should be avoided when designing and constructing flat plates or slabs with spans of up to ten meters (figure 2); instead, conventional reinforced concrete (RCC) is advised. There are a number of design flaws in conventional RCC flat plates and slabs constructed in India in accordance with Indian standards that require immediate correction.

In literature [3] Through the utilisation of the SAFE and ETABS software applications, this research intends to design a post-tensioned structure. The primary aim of this programme is to methodically devise designs for multi-story structures that adhere to the architectural principles established by the Indian Standard. The primary objective of this undertaking is to construct edifices that possess the capacity to withstand seismic and atmospheric loads. The column and beam were specified with minimal dimensions of C500*500 and B300*500, respectively. The seismic investigation was performed utilising the ETABS software. Post-tensioning is utilized in the construction of the structure, which increases its cost-effectiveness.

In literature [4] The behaviour and analysis of post-tensioned flat slabs are the subject of this thesis. The SAFE software is employed to perform modelling and analysis of post-tensioned (PT) flat slabs as well as flat slabs. Comparative analysis is conducted on the deflection, striking, moment, and stresses of the flat slab and the PT flat slab. Based on the current case study, the subsequent deductions can be drawn. In Case I, the PT flat slab deviates by approximately 80% to 90%. In Case II, it deviates by 65% to 75%. In Case III, it deviates by 55% to 65%. In Case I and Case III, the piercing shear capacity ratio falls within the permissible limits. Nevertheless, in Case II, it surpasses the acceptable limits. When considering PT planar slabs, the frequency of positive and negative moments is diminished. In particular, the reductions are as follows: 75% to 85% in Case I, 60% to 70% in Case II, and 50% to 60% in Case III.

Figure 3: Aesthetic appearance of flat slab floor [4]

The acceptable thresholds of tension for PT flat slabs conform to the parameters outlined in IS: 1343-1980. Upon comparing the flat slab to Case I–A, Case II–B, and Case II–C, which pertain to the PT flat slab, it becomes apparent that the latter alternatives demonstrate superior performance with respect to moment, deflection, striking, and stresses. PT flat slabs are pragmatic and cost-effective in every circumstance compared to flat slabs. In Case II-A, the cost differential was insignificant. Comparative to preceding cases, Case II-B is more economically efficient. Assuming Case III of the PT flat slab, a reduction in slab and drop thickness results in cost savings between 7 and 8.5 percent.

In literature [5] The objective of this paper is to present the use of flat plate/slab construction in India. The slab placement in building structure is shown in figure 5.The applications in buildings followed by a comparative description of flat plate/slab structure designs based on Indian Standard 456:2000 and American Concrete Institute ACI-318 codes. In practical it was observed that the PT structure doesn't reduce thickness of slab and also doesn't reduce in the cost of structure.

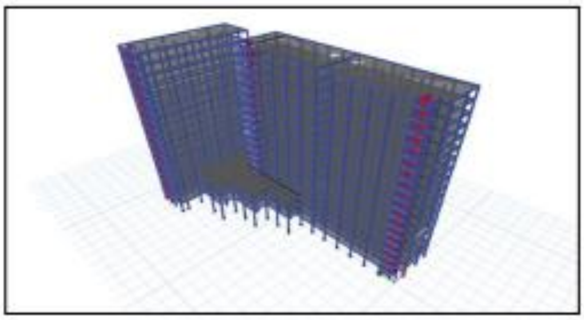

Figure 4: Aesthetic appearance of flat slab floor [5]

Due to issues related with pt construction in India and its higher cost, conventional RCC should be the preferred choice for spans up to 10 meters. Design of conventional RCC flat plate/slab in India, utilizing Indian codes, has many shortcomings, which will be addressed and revised soon.

In literature [6] The primary aim of this study is to conduct an exhaustive examination of the response and behaviour of post-tensioned flat slabs in the face of seismic activity, in addition to drawing comparisons to the behaviour exhibited by conventional flat slabs (figure 5). The behaviour and analysis of post-tensioned flat slabs are the subject of this thesis. SAFE is utilized for the analysis and modelling of post-tensioned flat slabs and flat slabs.

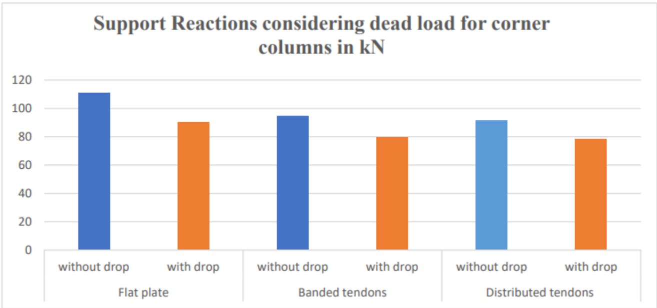

Figure 5: Comparison of support reactions of corner columns

The secondary moment generated by a solitary elongated wire causes significant changes in the moments of the strips in both orientations. There is a substantial impact of hyper-static moments on construction. The function of hyper-static periods in the construction process is crucial. It is difficult to modify eccentricity in a flat plate because of the narrow slab's surface. It remains conceivable, nonetheless, to calculate the force necessary to produce additional moments. While post-tensioning flat plate slabs does not significantly affect the axial force, it does increase the moment and shear on columns.

In literature [7] The present study offers a thorough clarification of the methodology and design process pertaining to flat slab structures as specified in the 456:2000 standard. The advantage of the flat slab architecture is greater than that of the beam slab structure. This slab provides improved structural efficacy and decreased construction expenses when compared to the use of beam slabs. The specifications for slab thickness, panel breadth, drop selection criteria, and reinforcing information are detailed on this page.

In literature [8] This study examined six unique conventional RC frame and flat slab constructions, comprising G+3, G+8, and G+12 story buildings. Seismic zone IV was utilized to investigate and evaluate the performance of the flat slab as well as the susceptibility of the solely frame and strictly flat slab models under various load conditions. The software E-Tabs is utilized to conduct the analysis (flat slab model is shown in figure 6). The number of instances on the uppermost floor increases, then declines after the second level. A transformation occurs in the columns' characteristics as the height of a structure increases.

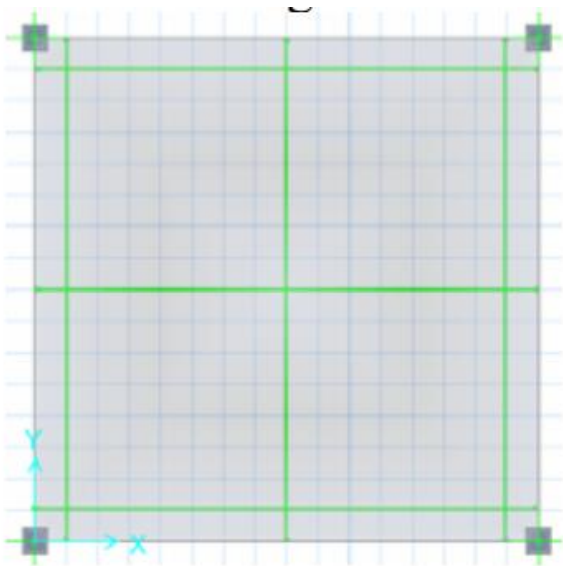

Figure 6: PT flat slab 2D model [8]

In all conceivable scenarios, the columns are constructed to withstand the combined forces of earthquakes and inert loads. The load combination that presents the greatest risk is 1.5 times the sum of the negative and positive values of the earthquake load and the inactive load. The magnitudes of column moments in flat plate structures are significantly greater than those observed in conventional reinforced concrete (RCC) buildings. Depending on the storey, the column moments in flat plates differ by a range of 10 to 20 percent from those in conventional R.C.C. frames. The maximum base fractures occur at the plinth level for columns of all types. The magnitude of force applied to the base diminishes below the plinth as the vertical dimension of the structure enhances. Significantly, the base shear will increase in tandem with the height. The base shear of a flat plate structure is diminished when compared to that of a traditional RCC design. An 8 to 13 percent difference exists between the two values. For all column types, the greatest lateral displacement takes place at the terrace level. An escalation in the degree of lateral movement is observed as the narrative unfolds. A substantial increase in horizontal displacement will accompany a rise in altitude. RCC structures frequently demonstrate diminished lateral displacement in comparison to flat plate constructions. The range of the discrepancy between the two values is 57% to 28%. The length of the natural time period extends in tandem with the number of storeys. A comparison is made between the construction durations of typical Reinforced Concrete Construction (RCC) buildings and flat slab structures, and the latter demonstrates a significantly reduced time frame. The percentage difference between the two values varies between 14 and 33 percent.

In literature [9] The primary aim of this article is to compare grid slabs, flat slabs with drops, and flat slabs without drops in order to determine which is the most cost-effective. The construction site under consideration is located in Nexus Point, Nagpur, in close proximity to VIDHAN-BHAVAN and the NMC offices. With a length of 31.38 meters and a width of 27.22 meters, the monolith comprises a total surface area of 854.16 square meters. M35 grade concrete and Fe 415 steel were incorporated into the design.

3. CONCLUSIONS

The collective analysis from the presented literature reveals a comprehensive overview of the comparison between post-tensioned (PT) flat slab systems and traditional reinforced concrete flat slab systems. The studies consistently highlight the cost-effectiveness and structural benefits associated with PT flat slabs, emphasizing their superiority in terms of reduced thickness, enhanced aesthetic appeal, and overall economic efficiency. Notably, the reduction in dead load contributes to creating lighter structures, aligning with contemporary architectural trends. The studies employing software tools like RAPT, ETABS, and SAFE underscore the precision and reliability of PT flat slab designs, showcasing their ability to meet seismic and wind resistance requirements. Furthermore, comparisons in terms of deflection, punching, moment, and stresses consistently favor PT flat slabs, affirming their economic viability across various cases. However, some literature provides a contrasting view, suggesting that, in practical scenarios in India, PT structures may not necessarily reduce slab thickness or overall construction costs. As the debate unfolds, these studies collectively contribute valuable insights, shedding light on the complexities, advantages, and areas for improvement within the domain of flat slab construction. Metal matrix composites (MMCs) offer an intriguing avenue for enhancing the performance of flat slab structures, but their integration into such designs presents a notable research gap. While MMCs have demonstrated impressive mechanical properties, including high strength-to-weight ratios and improved fatigue resistance compared to conventional materials, their application in flat slab structural analysis remains relatively unexplored. One key research gap lies in understanding the behavior of MMCs within the context of flat slab systems, particularly regarding load distribution, deflection characteristics, and failure mechanisms. Traditional flat slab designs often rely on reinforced concrete or steel for structural integrity, with limited exploration of MMCs' potential benefits. Therefore, investigating how MMCs interact with other materials and how they affect the overall performance of flat slab structures is crucial. there is a lack of comprehensive experimental data and analytical models specifically tailored to assess the suitability of MMCs in flat slab applications. Existing studies primarily focus on MMCs in aerospace or automotive industries, where loading conditions and structural requirements differ significantly from those encountered in building construction. Consequently, there is a need for research that addresses the unique challenges and considerations associated with implementing MMCs in flat slab designs. the practical aspects of manufacturing, cost-effectiveness, and sustainability of MMCs in flat slab construction remain relatively unexplored. While MMCs offer promising mechanical properties, their production processes, such as powder metallurgy or liquid-phase infiltration, may introduce challenges in scalability and cost competitiveness compared to conventional materials. Additionally, the environmental impact of MMC production and disposal requires careful examination to ensure their long-term viability as sustainable construction materials.

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