Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Volume 12, Issue 12, December 2023

Comparative Study on Different Configuration of Reinforced Concrete and Post Tensioned Slab System

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***Abstract*— The importance of high-rise buildings in the present scenario is increasing and floor system plays an important role in overall cost and service of the building. Post- tensioning system (PT) is probably the latest discovery in man's ongoing search for new materials and methods of construction. In India, RC Structures are commonly used for residential as well as commercial buildings. In recent times RC Structures has been partially or fully replaced by PT structural elements. In RC beams, depth of beam increases with increase in Span, because of deflection limitation. Depth of beam can be reduced by pre-stressed section, especially for longer span. It is now a well-established method of construction as the technology is fully available.**

In the present study a typical slab system is considered with both RC and PT configurations. Different combinations of RC slab System (RSB), Post Tensioned slab and Beam (PSB), Post Tensioned slab with RC Beam (PSRB), Post Tensioned Beam with RC Slab(PBRS), Post Tensioned Slab(PS) and Post Tensioned Slab with Drop Panel(PSD) are considered. The results obtained are Shear force, Bending moment, Deflection and Stress distribution. All the results are tabulated, and conclusions are drawn. The estimation of cost is carried out for all the Structural systems considered.

I.INTRODUCTION

The post-tensioned slab system represents a paradigm shift in the realm of structural engineering, introducing a revolutionary approach to reinforcing concrete structures. At its core, this innovative construction technique involves the strategic placement of high-strength steel tendons within a concrete slab, post-curing, to actively counteract tensile forces and enhance overall structural performance. The distinctive feature of post-tensioning lies in its timing—unlike conventional reinforcement methods where steel bars are incorporated before pouring concrete, post-tensioning inserts tensioned tendons after the concrete has set. This process transforms the slab into a robust and flexible structural element capable of spanning greater distances with reduced thickness. One of the primary advantages of post-tensioned slabs is their increased span capability. By introducing high-strength tendons after the concrete has cured, these slabs can achieve longer spans between supports compared to traditional reinforced concrete slabs. This characteristic not only allows for more open and adaptable architectural designs but also reduces the need for additional columns or load-bearing walls within a structure. The result is aesthetically pleasing, spacious interiors that capitalize on the structural efficiency of the post-tensioned system.

Material efficiency is another key benefit of post-tensioning. The system enables the use of thinner concrete sections without compromising structural integrity, leading to reduced material usage. This not only contributes to cost savings but also aligns with sustainability goals by minimizing the environmental impact of construction. The active compression applied by the tensioned tendons enhances the concrete's ability to resist tensile forces, thereby controlling and limiting cracking. This crack control is vital for the durability of structures, reducing maintenance requirements and ensuring a longer service life. The efficiency of post-tensioning extends to construction timelines. With the ability to span larger distances using fewer supports, this system accelerates the building process, making it an attractive option for projects with tight schedules. The speed of construction can be particularly advantageous in urban environments were minimizing disruption and completing projects promptly are critical considerations.

Designing a post-tensioned slab requires a meticulous approach, considering factors such as loading conditions, support locations, and desired spans. Engineers leverage specialized software and expertise to analyze and optimize the layout of post-tensioning tendons, ensuring the most efficient distribution of forces within the structure. The careful consideration of factors like durability, serviceability, and constructability is essential to create a successful and resilient design. The applications of post-tensioned slab systems span a wide range of structures, from residential and commercial buildings to bridges and infrastructure projects. The versatility of the system, coupled with its ability to address various design and construction challenges, makes it a preferred choice for projects of varying scales and complexities. As technology continues to advance, the post-tensioned slab system is expected to evolve further, with ongoing research and development aimed at refining its applications and exploring new possibilities in structural engineering.

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II.PROJECT DEFINITION

The construction industry continually seeks innovative and efficient methods to optimize structural integrity while maintaining cost-effectiveness. Traditional concrete structures often face challenges due to their low tensile strength, requiring extensive reinforcement and steel quantities to ensure adequate structural support. Pre-stressed concrete emerges as a robust solution to overcome these limitations, providing enhanced strength and durability. Pre-stressed concrete systems are analyzed and designed using various software one among them in this study we are using ADAPT-Floor Pro software which gives solution specifically tailored for the structural analysis, design, and optimization of concrete floor systems. ADAPT-Floor Pro offers an elevated level of sophistication and functionality, empowering engineers and architects with a comprehensive platform for creating, modeling, and simulating complex floor structures with a focus on precision, efficiency, and safety.

DEFINITION OF MODELS CONSIDERED FOR ANALYSIS

The different types of Floors systems considered in this study are as follows

1.RC slab System (RSB)
2.Post Tensioned slab and Beam (PSB)
3.Post Tensioned slab with RC Beam (PSRB)
4.Post Tensioned Beam with RC Slab (PBRS)
5.Post Tensioned Slab (PS)
6.Post Tensioned Slab with Drop Panel (PSD)

In this present study the parameters considered for design and analysis for all the floor system are Live Load-4kN/mm^2, Floor Finish-2kN/mm^2, Grade of concrete: M-40, Reinforcing steel-Fe415,Tendons Reinforcing steel-Fe460, Slab Thickness: 200mm

A.RC SLAB SYSTEM(RSB):Reinforced Concrete (RC) slab systems are fundamental components in building construction, forming horizontal surfaces that provide support, functionality, and space within structures. These slabs can vary in their design and construction methods, offering different strengths and capabilities suitable for various architectural and engineering needs. In this present study the beam dimension considered is shown in the Table-1

Table-1: RC Slab System

Structural Member				
Sl. No.	Description	unit	Dimension	
1	Beam	mm	600	750

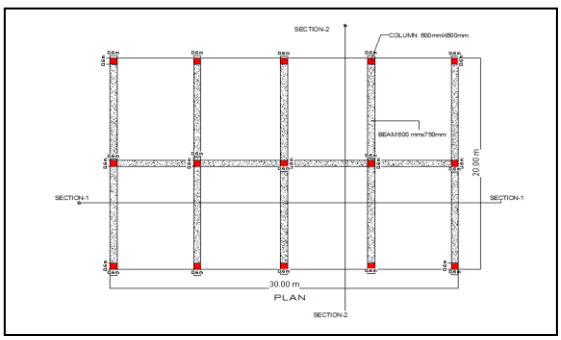

Fig.1: Plan of the model-RSB

B.POST TENSIONED SLAB AND BEAM(PSB): A combination of post-tensioned slabs and beams represents an advanced and efficient structural system commonly used in building construction, particularly in larger structures, to enhance load-bearing capacity, reduce structural depth, and improve overall structural performance. The combination of post-tensioned slabs and beams offers a sophisticated and efficient structural system that optimizes strength, load-bearing capacity, and design flexibility. It's often utilized in various construction projects, particularly where longer spans, reduced structural depth, and open architectural spaces are desired. Proper planning, skilled labor, and quality control during construction are crucial to ensure the success and durability of structures utilizing this innovative construction method. In this present study the beam dimension considered is shown in the

Table-2: Post Tensioned Slab and Beam

Structural Members				
Sl. No.	Description	unit	Dimension	
1	Beam	mm	450	600

F

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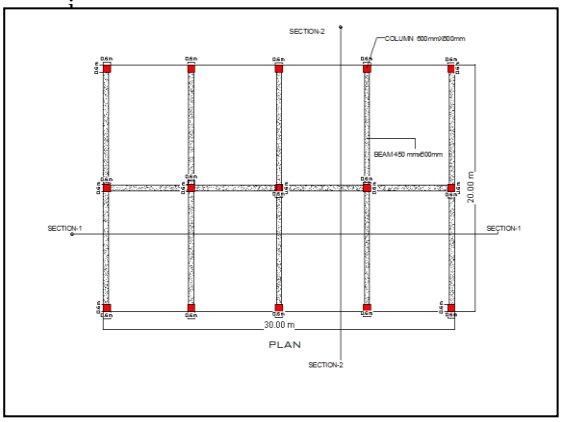

Fig.2: Plan of the model-PSB

C. POST TENSIONED SLAB AND RC BEAM (PSRB): Post-tensioned slabs in combination with reinforced concrete (RC) beams represent a composite structural system that leverages the strengths of both construction methods to create efficient and robust building elements. This hybrid approach combines the advantages of post-tensioning in slabs with the reinforced concrete beams to optimize structural performance and design flexibility. The combination of post-tensioned slabs with reinforced concrete beams represents an innovative structural system that effectively combines the benefits of both methods. This composite approach is commonly employed in various building projects, including high-rise structures, commercial buildings, and infrastructure, where a balance between efficient design, strength, and cost-effectiveness is desired. Proper planning, skilled labor, and attention to detail during construction are vital to ensure the success and long-term performance of structures using this hybrid construction method. In this present study the beam dimension considered is shown in the Table-3

International Journal of Engineering Research & Technology (IJERT)
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Table-3: Post Tensioned Slab and RC Beam

Structural Members				
Sl. No.	Description	unit	Dimension	
1	Beam	mm	450	500

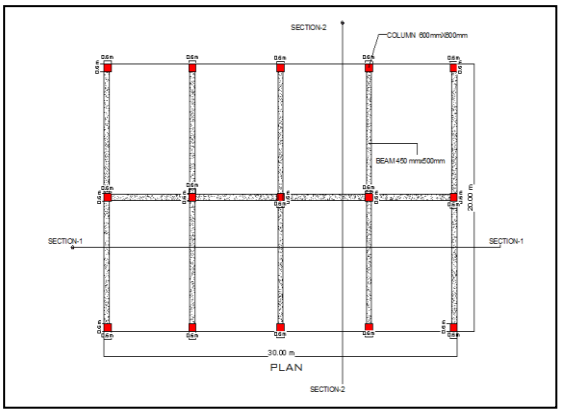

Fig.3: Plan of the model-PSRB

D.POST TENSIONED BEAM WITH RC SLAB(PBRS):Post-tensioned beams with reinforced concrete (RC) slabs form a hybrid structural system that combines the advantages of both construction methods. In this system, post-tensioned beams are used in conjunction with conventionally reinforced concrete slabs to create a robust, flexible, and efficient structural design. The integration of post-tensioned beams with reinforced concrete slabs offers a strong and efficient structural system that optimizes load-bearing capacity and design flexibility. It is commonly utilized in various construction projects where increased strength, longer spans, and architectural adaptability are essential. Expertise in design, construction practices, and quality control are critical to ensure the success and longevity of structures employing this innovative construction method. In this present study the beam dimension considered is shown in the Table-4

Table-4: Post Tensioned Beam With RC Slab

Structural Members				
Sl. No.	Description	unit	Dimension	
1	Beam	mm	450	500

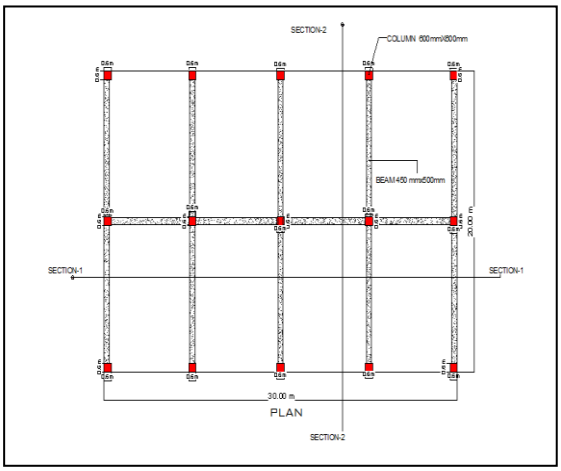

Fig.4: Plan of the model- PBRS

E. POST TENSIONED SLAB (PS): A post-tensioned slab is a structural system used in building construction that employs high-strength steel tendons or cables to enhance the load-bearing capacity and performance of concrete slabs. The post-tensioning method involves the installation of steel tendons after the concrete has been cast, providing a more efficient and versatile alternative to conventional reinforced concrete slabs. Post-tensioned slabs have become an integral part of modern construction due to their superior load-bearing capacity, reduced structural depth, and increased design flexibility. Their ability to minimize cracking and deflection while allowing for more open and adaptable architectural spaces makes them a popular choice in diverse construction projects. Proper design, installation, and quality control during construction are essential for ensuring the long-term performance and durability of structures featuring post-tensioned slabs.

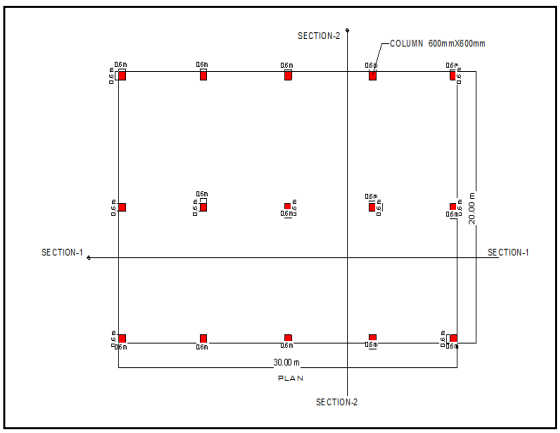

Fig.5: Plan of the model-PS

E.POST TENSIONED SLAB WITH DROP PANEL (PSD):A post-tensioned slab with drop panels is a structural system commonly used in building construction, particularly for high-rise buildings. This system combines the benefits of post-tensioning with the inclusion of drop panels to reinforce specific areas of the slab where additional strength is needed. Post-tensioned slabs with drop panels offer an efficient and optimized structural system by combining the benefits of post-tensioning with additional localized reinforcement. They are frequently utilized in high-rise buildings and other structures where load distribution, reduced deflection, and efficient load transfer are essential for the integrity and stability of the building. Expert design, construction practices, and quality control are essential to ensure the success and longevity of structures employing this system

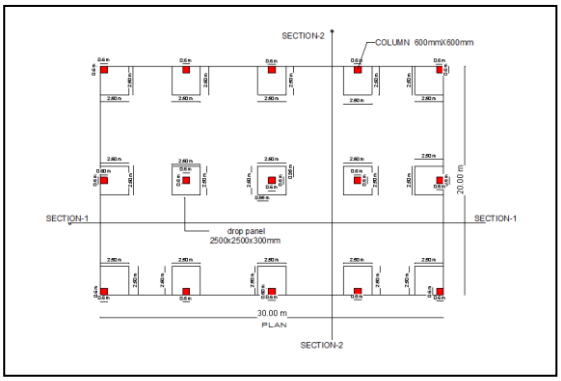

Fig.3.12: Plan of the model-PSD

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
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IV.FE ANALYSIS

Analysis and Design of RC and PT slab systems are carried out using FE based ADAPT software. Procedure to carryout analysis and design of slab system is as follows.

- Create a structural model.
- Generate a structural model, either by importing from a third-party program, or creating your
- Own structural model using the tools of ADAPT-Modeler.
- Defining of material properties, Load cases, Tendons and cable profiles.
- Analysis model and section generation.
- Results.

V.RESULTS AND DISCUSSION

The Analysis and Design of different types of RC and PT slab systems are carried out using ADAPT software and the results obtained are Shear Force, bending moment, Deflection and Stress distribution.

A.SHEAR FORCE OF DIFFERENT FLOOR SYSTEMS:

The shear force results of different floor system are presented in the Table-5 and the fig:7 shows the variation of deflection for the different floor systems

Table-5: Comparison of Shear Force Results

Sl. No.	Floor System	Shear force(kN)
1.	RC slab System(RSB)	373.07
2.	Post Tensioned slab and Beam(PSB)	299.02
3.	Post Tensioned slab with RC Beam (PSRB)	402.04
4.	Post Tensioned Beam with RC Slab(PBRS)	318.80
5.	Post Tensioned Slab(PS)	767.84
6.	Post Tensioned Slab with Drop Panel(PSD)	288.72

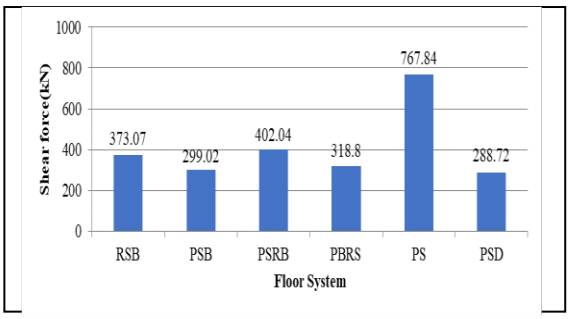

Fig.7: Shear Force Results

B.BENDING MOMENT OF DIFFERENT FLOOR SYSTEMS:

The Bending Moment results of different floor system are presented in the Table-6 and the fig:8 shows the variation of deflection for the different floor systems.

Table-6: Comparison of Bending Moment Results

Sl. No.	Floor System	Bending Moment (kN-m)
1.	RC slab System(RSB)	433.45
2.	Post Tensioned slab and Beam(PSB)	260.72
3.	Post Tensioned slab with RC Beam (PSRB)	210.95
4.	Post Tensioned Beam with RC Slab(PBRS)	146.47
5.	Post Tensioned Slab(PS)	674.94
6.	Post Tensioned Slab with Drop Panel(PSD)	97.04

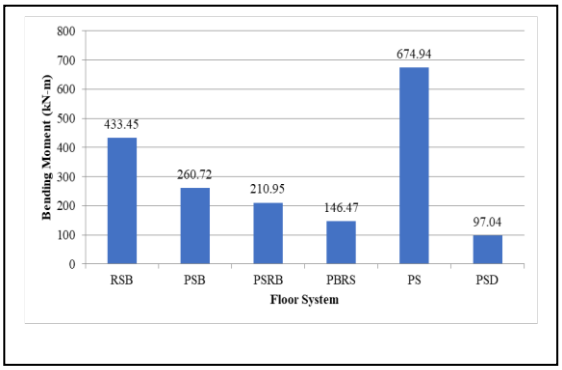

Fig.8: Bending Moment Results

C.DEFLECTION OF DIFFERENT FLOOR SYSTEMS

The Deflection results of different floor system are presented in the Table-7 and the fig:9 shows the variation of deflection for the different floor system.

Table-7: Comparison of Deflection Results

Sl. No.	Floor System	Deflection(mm)
1.	RC slab System(RSB)	0.37
2.	Post Tensioned slab and Beam(PSB)	0.30
3.	Post Tensioned slab with RC Beam (PSRB)	0.27
4.	Post Tensioned Beam with RC Slab(PBRS)	1.57
5.	Post Tensioned Slab(PS)	0.21
6.	Post Tensioned Slab with Drop Panel(PSD)	0.24

Published by :
http://www.ijert.org

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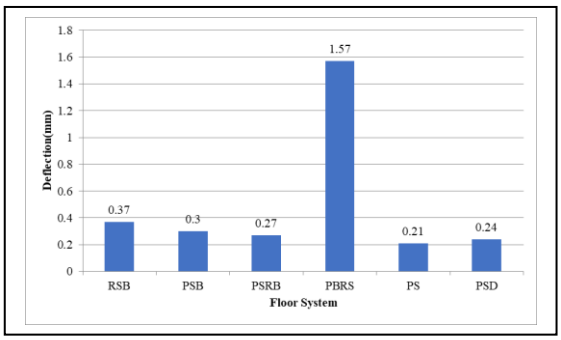

Fig.9: Deflection Results

D.STRESSES OF DIFFERENT FLOOR SYSTEMS:

The Stress results for different floor system are presented in the Table-8 and the fig:10 shows the variation of stress for the different floor systems.

Table-8: Comparison of Stress Results

Sl. No.	Floor System	Stress (N/mm2)	As per IS Code
1.	RC slab System(RSB)	-	As per IS 1343-2012 – Max stresses for grouted post-tensioned tendons of M40 is 5 N/mm2
2.	Post Tensioned slab and Beam(PSB)	2.42	
3.	Post Tensioned slab with RC Beam (PSRB)	2.59	
4.	Post Tensioned Beam with RC Slab(PBRS)	4.52	
5.	Post Tensioned Slab(PS)	4.54	
6.	Post Tensioned Slab with Drop Panel(PSD)	4.56	

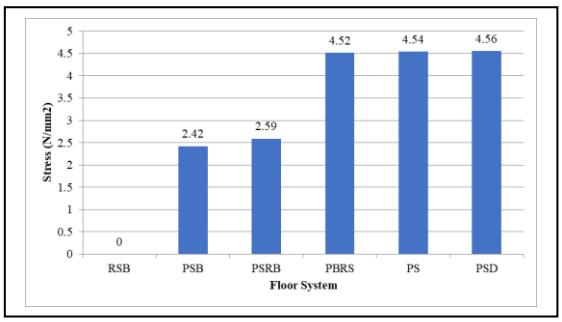

Fig.10: Stress Results

E.ESTIMATION OF COST FOR DIFFERENT SLAB SYSTEMS:

The estimation and costing of different floor systems is done and the rate per square meter is found and are presented in the Table-9 and the fig:11 shows the variation of the rate per square meter for the different floor systems.

Table-9: Estimation of Cost for the different slab systems

Sl. No.	Floor systems	Concrete (m3)	Reinforcing steel(kg)	Pre-stressing steel (kg)	Total cost(Rs)	Rate per sqm
1.	RC slab System (RSB)	179	21567	-	22,75,740	3,793
2.	Post Tensioned slab and Beam (PSB)	155	8890	1474	16,07,558	2,679
3.	Post Tensioned slab with RC Beam (PSRB)	149	11483	1017	16,62,411	2,771
4.	Post Tensioned Beam with RC Slab (PBRS)	149	18974	817	20,81,873	3,470
5.	Post Tensioned Slab(PS)	120	6594	2097	13,70,190	2,284
6.	Post Tensioned Slab with Drop Panel (PSD)	129	6877	160	11,48,159	1,914

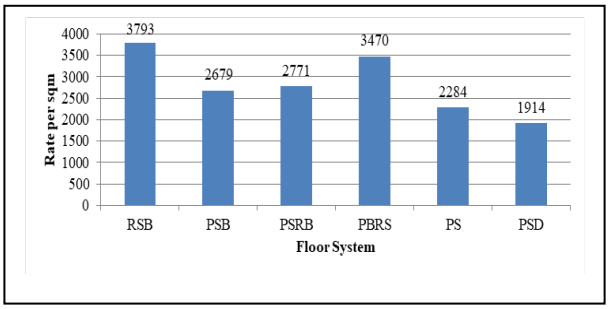

Fig.11: Estimation of Cost for different slab systems

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Volume 12, Issue 12, December 2023

VI.CONCLUSIONS

The Analysis and Design of different types of RC and PT slab systems is carried out and the conclusions are drawn from the results obtained by Shear Force, Bending moment, Deflection and Stress distribution are as follows

- The Post-Tensioned slab with drop panel is economical among all floor systems and it is going to reduce cost by 43.49% that of RC slab system.
- Shear Force diagram of different floor systems shows post-tensioned slab with Drop panel has least Shear Force among all others slab systems.
- The shear force value of RC slab system is 51.41% lesser than the maximum shear force value of Post Tensioned slab.
- Bending moment diagram of different floor systems shows post-tensioned slab with drop panel has least bending moment among all others slab systems.
- The Bending moment value of RC slab system is 35.77% lesser than the maximum Bending moment value of Post Tensioned slab.
- Deflection of different floor systems shows post-tensioned slab has least deflection among all others slab systems.
- The deflection value of RC slab system is 76.43% lesser than the maximum deflection value of Post Tensioned Beam with RC Slab.
- The maximum stresses for grouted post-tensioned tendons of M-40 grade of Post-Tensioned Slab and Beam is 2.42 N/mm2which is less compared to all other slab systems.
- The rate per sqm value of RC slab system is 49.55% higher than the rate per sqm value of Post Tensioned Slab with Drop Panel.

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