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REVUE EUROPEENNE D ETUDES · EUROPEAN JOURNAL OF MILITARY STUDIES
Social Science Journal

The Investigation of Pre-stressing Systems includes all Structural Materials

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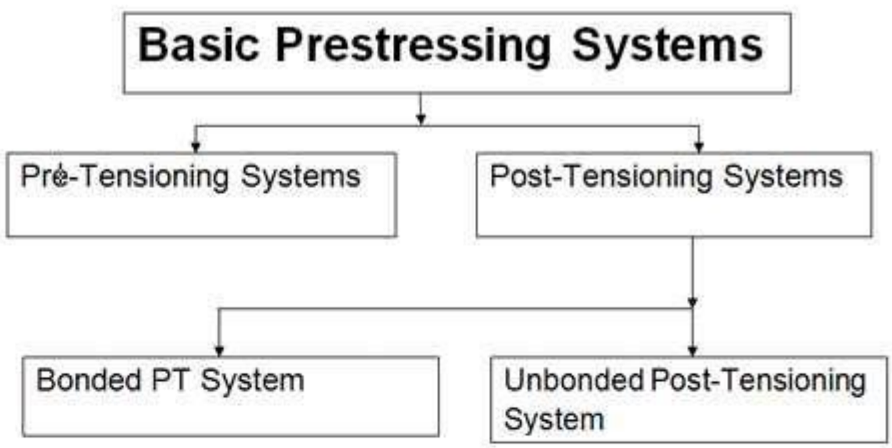
Abstract:
The individual not only provided elegant answers to the issues at hand, but also demonstrated the methodology for constructing these solutions. In contemporary times, there is a growing architectural demand for slender structures with long spans. Reinforced concrete (RCC) alone is insufficient to meet these architectural requirements. While RCC may fulfill architectural requirements for certain span lengths, it becomes cost-prohibitive for longer spans. Therefore, there is a need for research to determine the most economical structure for post-tensioning, particularly in high labor cost countries where external scaffolding is to be avoided. For low-rise structures, it is advisable to utilize precast concrete as much as possible and incorporate vertical pre-stressing in addition to horizontal pre-stressing to enhance resistance against lateral loads. The use of pre-stressing in contemporary constructions has significantly expanded the possibilities for designing shapes that were previously deemed economically unviable, impractical, or too bulky to withstand loads. The use of curvilinear shapes in architecture has given rise to a novel lexicon that, in earlier periods, would have been seen as unfeasible. The utilization of pre-stressing has been identified as a viable method for attaining water-resistant flat roof surfaces, even in the absence of conventional bituminous waterproofing. This is due to the continuous compression exerted on the concrete, which effectively prevents the occurrence of cracks that may otherwise result in long-term water infiltration.

Keywords: Pre-stressing Systems Pre-Tensioning Systems Post-Tensioning Systems 1.0 Introduction:

Principal design objectives for structural engineers include safety, functionality, cost-effectiveness, and compliance with current regulatory requirements. When making a decision on a structural construction system, it is crucial for engineers and architects to possess a comprehensive understanding of the suitable utilisation of post-tensioned concrete and the potential consequences that may arise. In the contemporary construction industry, the utilisation of meticulously examined and meticulously constructed concrete structures, composed of top-tier components, may provide an exceptional amalgamation of longevity, acoustic management, and fire protection, which are essential requisites in the present-day architectural sphere. Concrete is often chosen as a more economically viable material compared to steel, taking into account several market considerations such as pricing alternatives, material supply, lower floor to-floor heights, and the availability of developer finance. Fiber-reinforced concrete is a kind of concrete that has been intentionally subjected to internal stresses of certain size and distribution. These internal stresses are designed to counterbalance the stresses caused by external loads to a suitable extent. The fundamental distinction between a prestressed concrete structure and a standard reinforced concrete structure is in the implementation of an initial load on the former before its use. The application of an initial load, often known as "prestress," is necessary in order for the structure to effectively mitigate the stresses that occur over its operational lifespan. The use of prestressing to a building is not limited to a singular occurrence. The notion of prestressing predates its use in concrete structures.

2.0 BASIC PRESTRESSING SYSTEM

The pre-tensioning system is mostly used in precast structural elements such as railway sleepers, among others. The post-tensioning system is often used for various site applications such as bridge girders, beam flat slabs, and others. Traditionally, the bonded post-tensioning system was utilised, but in recent times, the unbounded post-tensioning system has gained popularity. My area of expertise is in the field of post-tensioning systems. I am now doing research on the economic viability of implementing the PT system.



3.0 LITERATURE REVIEW

The inception of pre-stressed concrete materialised in the year 1888. Durable and sustainable bridges are of significant importance in the current field of engineering technology, as they contribute significantly to the socio-economic growth of a country. The cost-effectiveness, minimal maintenance requirements, and extended lifespan of pre-stressed concrete bridges have been widely acknowledged by owners and designers for a considerable period of time. The aforementioned trend is evident in the progressive expansion of the market presence of pre-stressed concrete, which has seen a remarkable surge from a negligible share in 1950 to a substantial majority of over 55 percent at now. The rate of expansion in bridge construction is now experiencing significant acceleration, including both short-span and long-span bridges. Previously, the construction of long-span bridges was mostly dominated by the use of structural steel. It is often observed that bridge designers are taken aback by the fact that precast, pre-stressed concrete bridges often exhibit lower initial costs compared to other bridge designs. Additionally, when considering the savings in maintenance, precast bridges provide a very economical solution. The use of a precast pre-stressed bridge system has two primary benefits: cost-effectiveness and reduced construction downtime. Pre-stressing refers to the practise of applying an initial load to a structure in order to allow the structure to effectively resist the stresses that occur over its operational lifespan.

According to Rajamoori Arun Kumar et al. (1), bridges play a crucial role in facilitating road connectivity, serving as vital infrastructure components in both urban and rural regions. The advent of modern technologies has led to the replacement of traditional bridges with more cost-effective structural systems. One of the proposed options is the implementation of a T-Beam structural prestressed concrete (PSC) system. The PSC T-beam is widely accepted in motorway and bridge systems because to its structural efficiency, stability, serviceability, cost-effectiveness in construction, and visually appealing aesthetics. The design of PSC beams becomes more intricate as the structure itself becomes more complex, necessitating the use of specialized techniques and procedures. When comparing the PSC T-beam to the RCC T-beam, it can be seen that the geometry of the RCC T-beam is simpler and less complex in terms of construction. Bridge design is a complex and significant aspect of structural engineering. In the realm of bridge design, the factors of span length and live load consistently have significant importance. Several things have an impact on the conception stage of design. The impact of live load on different spans exhibits variability. In shorter spans, the governing factor is the track load, but in wider spans, the governing factor is the wheel load. The selection of a structural system for a certain span is consistently a subject of investigation and analysis. The selection of structural systems is influenced by several factors, including considerations of economic viability and the level of complexity involved in the building process. The selection of a 24-meter span is a crucial feature in this research, since it encompasses two significant factors. Within a span of 24 metres, according to codal rules, it is permissible to choose a structural system such as a prestressed concrete T-beam. The present research focuses on the analysis of structural systems suitable for a span of 24 metres, with particular attention given to the detail design process. The analysis is conducted in accordance with the loadings specified by the Indian Road Congress (IRC) and the relevant provisions outlined in the Indian Standard (IS) code books. The choice of an economy and construction of a structural system is contingent upon the outcome. The following list enumerates the main factors as follows:

1. The bending moments and shear force experienced by a prestressed concrete (PSC) T-beam girder are lower compared to those experienced by a reinforced concrete (RCC) T-beam girder in a bridge structure. Designers have the option of deciding on a lighter section for a prestressed concrete (PSC) T-beam girder compared to a reinforced concrete (RCC) T-girder for a 24-meter span.
2. The exact moment of resistance of steel has been determined and it has been found that the PSC T-Beam Girder exhibits more capacity than the other option for both spans of 24 m and spans above 24 m.

3. The shear force resistance of a prestressed concrete (PSC) T-beam girder is greater than that of a reinforced concrete (RCC) T-girder over a span of 24 metres.
4. In the framework of a bridge project, it can be seen that the PSC T-Beam Girder exhibits a lower quantity of steel and a reduced cost of concrete compared to the RCC T-Beam Girder.
5. The deflection of a prestressed concrete (PSC) T-beam girder is lower compared to that of a reinforced concrete (RCC) T-beam girder bridge.
6. The durability of PSC T-beam girders surpasses that of RCC T-beam girder bridges.

The RCC building approach, as discussed by Rahman et al. [2], has undoubtedly emerged as a very transformative method in contemporary construction practices. The amalgamation of concrete's notable compressive strength with the remarkable tensile strength and elasticity of steel has yielded a composite material that exhibits durability, cost-effectiveness, and robustness. Furthermore, the implementation of any novel technology necessitates a comprehensive testing process. It is worth noting that concrete exhibits weakness in terms of its tensile strength. However, the primary attribute of concrete that we use is its exceptional compressive strength. The issue pertaining to serviceability in reinforced concrete (R.C.C.) constructions has stimulated significant cognitive engagement. The resolution was discovered by the use of pre-stressing techniques. Similar to conventional reinforced concrete, pre-stressed concrete is comprised of a combination of concrete that is capable of withstanding compressive forces and reinforcing materials that bear tensile forces. The use of pre-stressing has become imperative in several applications as a means to maximize the compressive strength of reinforced concrete and effectively manage the occurrence of cracking and deflection. The objective of this study is to develop a design for a Flat Slab of Reinforced Concrete (R.C.C.) and a pre-stressed concrete variant, followed by a comparative analysis of the obtained findings. The objective of this study is to provide a conclusive determination about the comparative superiority of different procedures. The following table presents the cost in rupees for various spans of both Reinforced Concrete (R.C.C.) Flat Slabs using M:30 grade concrete and Pre-stressed Concrete Flat Slabs using M:30 and higher grade concretes. Based on the findings of the experimental investigation, it can be inferred that reinforced concrete (RCC) flat slabs demonstrate economic viability for spans up to 9 metres. However, for spans beyond this threshold, pre-stressed concrete flat slabs emerge as a more favourable alternative. The cost advantage of pre-stressed concrete exhibits a rising trend in percentage terms as the span increases. In addition, the use of pre-stressed concrete flat slabs has the advantage of reduced thickness, hence providing more headroom and mitigating seismic effects. The enhanced durability of pre-stressed concrete constructions has been well acknowledged.

Table 1: Cost Comparison of Flat Slab

Spa(nm)	Concrete Grade	Estimated cast of prestressedconcrete Flat Slab (RS)	Estimate cast of RCC Flat Slab for M30 Grade Only (RS)	% Defference on the basic of higher value (%)
6	M30 M40 M50	10,41,832,55 11,49,725,88 12,93,028,59	7,97,417,39	23.43
7	M30 M40 M50	15,47,927,56 14,89,880,00 16,76,070,00	12,75,258,64	17.58
8	M30 M40 M50	20,05,632,48 21,57,895,70 21,76,305,96	19,34,492,04	3.48
9	M30 M40 M50	27,28,601,36 29,64,421,83 42,92,180,92	26,87,130,49	0
10	M30 M40 M50	37,36,27,85 40,66,529,37 42,92,180,92	39,76,100,49	-6.04
11	M30 M40 M50	43,88,401,82 44,99,979,70 48,48,999,00	52,58,04,4.6	-16.54
12	M30 M40 M50	56,04,387,18 57,64,089,07 60,83,029,00	76,17,202,13	-26.42

In the field of RCC structures, Ankit Sahu et al. (3) have observed that these types of structures are widely used in both residential and commercial buildings. Post-tensioned pre-stressed beams are not often used in construction sites, particularly for structures with shorter spans. Two decades ago, there was a significant issue about the availability of skilled workers for pre-stressing operations. However, nowadays there exists a plethora of firms that provide services for these tasks. In reinforced concrete beams, the depth of the beam is seen to grow proportionally with an increase in the span length. This phenomenon is mostly attributed to the need for deflection restriction. The depth of a beam may be decreased in a pre-stressed section, resulting in cost savings for longer span pre-stressed beams. This research is conducted to determine the percentage cost differential between the two approaches in relation to span. In the last two decades, the use of pre-stressing in India was not prevalent, resulting in reinforced concrete (R.C.C.) beams being more cost-effective, even for spans of 25 metres. The rationale for this practise is that the mix design for high strength concrete was historically established on a basis of 500kg/m3 (equivalent to 10 bags of cement per cubic metre), as allowed by the IS: 456-1978 standard. The cost of high-grade concrete has decreased due to contemporary mix design approaches that adhere to a limit of 8 bags of cement per cubic metre, aiming to minimise shrinkage and creep.

Moreover, there has been a significant reduction in the price disparity between HYSD bars and high tensile steel used for pre-stressing, which has decreased from over 100% to a range of 25-30%. The same applies to fixtures and accessories that are related to pre-stressing. In the past, the aforementioned items were characterised by high costs; however, they have since become more accessible due to increased demand, which has led to producers benefiting from economies of scale. In this study, Mundhada et al. (4) discuss the economic aspects of continuous reinforced concrete (R.C.C.) beams in comparison to continuous pre-stressed concrete beams. This study covers the design and estimation of continuous reinforced concrete (R.C.C.) beams and continuous pre-stressed concrete beams with varying spans. In the contemporary era characterised by rapid air travel, we possess a wide array of building methodologies readily available for use. Examples of different types of structures include steel structures, reinforced concrete (R.C.C.) structures, core and hull structures (which combine steel and R.C.C. construction), ferro cement structures, and prestressed concrete structures. Occasionally, the presence of several options might result in a state of perplexity. The optimal approach involves carefully considering the specific conditions and nature of the building in order to choose the most suitable construction type. The objective of this study is to develop designs for medium span continuous reinforced concrete (R.C.C.) beams, as well as continuous pre-stressed concrete beams, and thereafter conduct a comparative analysis of the outcomes. The use of MS Excel for programming purposes is often employed in the design of beams.

The objective is to arrive at a conclusive determination on the comparative superiority of the two procedures. The findings indicate that, for short spans, a continuous reinforced concrete (R.C.C.) beam is more cost-effective than a continuous pre-stressed concrete beam. However, for greater spans, the opposite holds true. Pradeep Nath Mathur and colleagues. The user's text is already academic and does not need to be rewritten. The technique of pre-stressed concrete differs significantly from that of reinforced concrete (RCC). There are two kinds of pre-stressing system devices: pre-tensioning and post-tensioning. The establishment of an anchoring system in concrete structural elements is facilitated by the use of prestressing for pre and post-tensioning device mechanisms. In contemporary practise, the technique of pre-stressing electricity involves the use of low voltage and high current for the purpose of anchoring a concrete part. Additionally, sulphur is employed in conjunction with this anchoring device. The application of a coating as a duct material prior to the casting of a concrete part. The melting of sulphur occurs inside the structure due to the heat created during the process of delivering power. The construction has the potential to be stabilised by securing nuts at both ends.

Various gadgets have a significant impact on the field of civil engineering. The study of pre-stressed concrete encompasses several processes that greatly contribute to our understanding of the working system's mechanism. Anchoring devices are available as tools for performing these processes on structures. It is well-established that structures constructed using pre-stressed concrete exhibit enhanced reliability, strength, and reduced size when compared to reinforced concrete structures. Therefore, it can be concluded that the use of anchoring devices may enhance the structural integrity of concrete constructions. Additionally, pre-stressed beams have the capacity to withstand greater loads compared to reinforced concrete (RCC) beams. This technique is a cost-effective approach for securing the beam in place.

4.0 Conclusion

Based on the aforementioned analysis, it can be inferred that

Pre-stressed concrete is a more cost-effective option for constructing big spans compared to reinforced concrete (RCC) construction. However, it tends to be rather costly for smaller spans.

The PT system is designed to eliminate shrinkage cracks and provide waterproofing capabilities.

In some applications, the use of a Post-Tensioning (PT) system is deemed necessary due to architectural specifications that call for increased cantilever projection and the usage of thin members.

In conducting a comprehensive examination of the literature, it is evident that there is a dearth of research focused on the economic aspects of studying different cross-sections of beams or girders.

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