Innovative Practices in Large-span Prestressed Concrete Beam Construction for Housing Projects

Abstract: Large-span prestressed concrete beam is a structural form widely used in modern buildings, and the rationality of its construction technology is directly related to the engineering quality and safety. Article on the analysis of large span prestressed concrete beam construction points, on the basis of new template support system application, steel connection, high performance concrete mix ratio design, intelligent tension system application of key construction technology, and discusses the BIM technology application, prefabricated construction, green construction process optimization and innovation. The results show that the construction technology of large-span prestressed concrete beam is feasible and effective, which can provide a reference for similar projects.

Key words: Concrete Beam, Housing Projects, buildings, construction technology

Introduction

Large-span prestressed concrete beam can effectively increase the space span of the building, expand the use function of the building, improve the quality of the space, so it is widely used in modern buildings. The prestressed concrete beam is an innovative composite structure that offer high load capacity and stiffness and exceptional anti-crack performance, making it a leading trend in composite structures [10]. However, the construction is difficult, and there are high technical requirements for formwork support system, reinforcement engineering, concrete engineering, prestressed tension technology, etc [6,7]. It is necessary to deeply study the key construction technology, optimize the construction technology, and innovate the construction method, so as to ensure the quality of the project and improve the construction efficiency. This article focuses on improving construction efficiency.

2. Construction points of long-span prestressed concrete beam

The article discusses a vital problem in modern construction engineering, focusing on the challenges and improvements in the building of large-span prestressed concrete beams. Its emphasis on innovative construction technology, optimization of construction procedures, and sustainability combines well with the present global focus on efficiency and green construction. The insights presented can serve as a significant reference for professionals and researchers working in structural engineering.

2.1 Formwork works and support system

Formwork is the key of concrete construction, which is particularly important for long-span prestressed concrete beam. First of all, the section size and linear shape of the beam body should be strictly controlled to ensure that the flatness of the bottom mold meets the standard requirements, the height difference of the bottom mold should be controlled within ± 2mm, and the height difference of the two adjacent templates should not exceed 1mm. Secondly, the bracket system needs to be accurately calculated and specially designed, and reviewed by a third party. The step distance of the support pole should be 1.0m, the horizontal pole step distance should be 1.5m, and the layout distance of the vertical and horizontal scissors support should be 2.0m. The support foundation should be set on a solid foundation, with sleepers to ensure that the support does not sink [8,9]. At the same time, the support shall be set with adjustable mechanism to facilitate tuning during construction. During the construction process, dynamic monitoring should be strengthened and timely adjusted to prevent beam deformation. When the beam span is greater than 24m, the deformation of the support system should be specially calculated[1]。

2.2 Rebar engineering

Prestressed steel beam and non-prestressed steel reinforcement are generally used for long-span prestressed concrete beams. Prestressed steel bundle should be low loose, high strength steel strand, non-prestressed steel can be hot rolled or cold rolled ribbed steel. The stirrup should be φ 8mm@50mm, the non-anchorage area should be φ 8mm@100mm, and the limb length should be 80mm. The diameter of the upper and lower longitudinal reinforcement of the beam web shall be 12mm, and the spacing shall be 200mm [9]. When the beam height exceeds 1.2m, the vertical reinforcement of the web can be arranged by φ 10mm@200mm. The minimum diameter of longitudinal stressed reinforcement is 16mm and the spacing is 200~300mm. The lower longitudinal reinforcement should be arranged along the full length of the beam, and the upper longitudinal reinforcement can use additional tendons according to the force needs. Rebar connection should be preferred by mechanical connection or welding form, and lap joints should be staggered. The steel frame shall be lifted as a whole to improve efficiency and ensure quality. The thickness of the protective layer of the steel bar shall meet the design and specification requirements, and reliable positioning and support measures shall be taken to avoid the displacement and deformation of the steel bar in the pouring[2].

2.3 Concrete works

Large-span prestressed concrete beam has high requirements on concrete performance, usually requiring high strength and high performance concrete. The mix ratio of concrete needs to be optimized through the test, select raw materials with excellent performance, and strict control of water consumption, slump, gas content and other indicators. The beam concrete should be poured continuously. If the construction joint needs to be retained, the joint surface should be treated and the grouting pipe should be embedded. Concrete pouring shall be carried out in layers. The thickness of each layer shall be controlled below 500mm[3].

2.4 Prestressed tensioning process

Prestressed tension is the key content of large span concrete beam construction, and tension technology has an important influence on the quality of beam. Prestressed system is divided into two systems: cohesive system and unbonded system. The construction process of a cohesive system is relatively complex, but it is more favorable for crack control. When the bonding system is adopted, high strength steel strand should be selected as φs15.2mm, φs15.7mm or φs21.8mm, and the ultimate strength standard value is not lower than 1860MPa; When the non-bonded system is used, high strength wire such as φ 25mm, φ 27mm and φ 30mm can be used, and the standard value of ultimate strength is not lower than 1570MPa. The tension end anchor should be made of high quality clip and high strength pad, effectively uniform prestress. The tension should be graded loading, the primary tension should not exceed 25% of the design tension, the secondary tension should not exceed 75% of the designed value, and the interval between the secondary tension and the primary tension should not be less than 1h. During the tension process, the tension and elongation value should be accurately monitored, and then the grouting pressure should be sealed in time. The rear tension beam body can be anchored in the end flange plate, but secondary tension is required to compensate for the elastic compression and creep loss of concrete[4]。

3. Key construction technology

3.1 Application of the new formwork support system

The traditional steel pipe bracket erection method is time-consuming and easily causes concrete surface damage; the new aluminum alloy formwork support system can realize fast loading and unloading and significantly improve construction efficiency. The new formwork support system is assembled from light aluminum alloy profiles, which can be bolted to quickly build various formwork support frames. It has strong bearing capacity, good stiffness, convenient loading and unloading, can be used, and is more economical and environmentally friendly. The key nodes adopt factory customized standard components, and the site assembly is simple and fast, which can effectively ensure the construction quality. The system has been applied in many major projects in China and has achieved good results.

3.2 Rebar connection

Reinforcement engineering is an important part of concrete construction, and the reinforcement connection method has a great influence on the construction efficiency and cost. The traditional steel bar binding lap method is very time-consuming and laborious. The new sleeve extrusion connection technology can realize the fast and reliable connection of steel bars.

This method uses the connection sleeve, through the special hydraulic machinery, the steel bar is inserted into the two ends of the sleeve, extrusion deformation, forming a permanent connection, its strength can reach the tensile limit strength of the steel bar. The technology is simple and fast, and one person and one machine can operate efficiently. The time of connecting a single joint is not more than 2min, which significantly reduces the on-site workload and improves the labor production efficiency. The sleeve connection does not need to be welded, which can avoid the thermal influence of steel bars, the connection performance is stable and reliable, and save a lot of steel bars, in line with the concept of green construction[5].

3.3 Mix ratio design of high-performance concrete

Large-span prestressed concrete beam has high requirements for concrete strength, durability and other performance indicators, ordinary concrete is often difficult to meet the requirements, need to use high performance concrete. The design of high performance concrete mix ratio should be optimized on the basis of ordinary concrete mix ratio, mixed with excellent admixture, water reducing agent, etc., and increase the amount of cement, reduce the water-cement ratio, control the sand grading, improve the workability, in order to obtain better strength and durability. Through the reasonable blending of silicon ash and fly ash, the compaction and impermeability of concrete can be further enhanced. In order to ensure the construction performance, the slow coagulation type admixture can be added to extend the setting time, and take into account the slump. The mix ratio of high performance concrete should be optimized through special tests, the best raw materials and dosage should be selected, and the quality control should be strengthened to ensure the consistency and stability of production and supply.

3.4 Application of intelligent tension-drawing system

The key to the construction of prestressed concrete beam is to accurately control the tension and elongation. Traditional manual operation inevitably causes errors and fluctuations. Using intelligent tension system can realize high precision and fully automatic construction. The intelligent tensioning system is controlled by programmable logic controller (Programmable Logic Controller, PLC), integrating oil pump, pressure sensor, displacement sensor and other equipment, which can collect and feedback tensioning data in real time, and automatically adjust according to the set parameters. The system also has functions such as data recording and report analysis, which can realize the digital management and quality traceability of the whole process of tension. The application of the system can ensure that the tension error is controlled within ± 2% of the design value, the elongation error is controlled within ± 6% of the theoretical value, the construction quality and accuracy are effectively improved, and the labor efficiency can be significantly improved and the labor cost can be saved.

4. Construction technology optimization and innovation

4.1BIM technology application

The main application points of BIM technology are as follows: (1) using parametric design technology, Establish a model including the beam body geometry size, material properties, load condition and other parameters, Automatically generate and optimize multiple sets of design solutions, To improve the design efficiency and quality; (2) Adopt intelligent reinforcement technology, According to the design scheme and the specification requirements, Automatically generate the reinforcement configuration scheme in the BIM, And output the feeding list and processing details, Guide the reinforcement construction; (3) Application of stent intelligent computing technology, According to the beam body information and the construction specifications, intelligently arrange the supports in the BIM and optimize the specifications and spacing of components, Ensure that the bracket system is safe, reliable, economical and efficient; (4) Using the virtual construction simulation technology, Three-dimensional dynamic simulations of the key construction processes on the BIM platform, Optimize the construction process and process, Reasonable arrangement of resource input, Guide the site construction, Improve the level of construction management. The application of BIM technology can significantly improve the construction efficiency of prestressed concrete beam, ensure the construction quality and safety, and promote the development of construction engineering to the digital and intelligent direction.

4.2 Prefabricated construction

Prefabricated construction is an advanced construction method, in line with the trend of industrialization and information development. The prefabricated construction transfers the traditional site operation to the factory to realize the factory for the factory production of construction parts and parts, which can optimize the allocation of resources, reduce material loss and improve labor production efficiency. For long-span prestressed concrete beams, the paper innovatively proposes the whole prefabricated intelligent construction method of large-span prestressed concrete beams on the basis of analyzing the advancement of prefabricated buildings. Through the modular design of the beam body, the beam body is divided into several sections, prefabricated in the factory to make full use of the mechanized production line to realize standardized and fine manufacturing, so as to significantly improve the concrete performance and surface quality of the beam body. The segment components are transported to the site by transport vehicles, and the construction technology of "overall lifting + sliding in place" is adopted to realize the rapid assembly with the column, wall and other components, and the overall assembly is realized through the sleeve grouting connection. In the assembly process, the component bolt connection, the prestressed reinforcement and the continuous longitudinal reinforcement field connection all adopt the robot welding method, which realizes the mechanization and automation of the whole construction process, and improves the construction efficiency and quality. This construction method significantly reduces wet operations on site, improves the utilization rate of turnover materials, reduces personnel demand, and is more economical.

4.3 Green construction

Green construction is the inevitable requirement of the sustainable development of the construction industry. The construction of large-span prestressed concrete beam should fully implement the concept of green construction, pay attention to energy saving, material saving, water saving and land saving, and control the adverse impact of the construction process on the environment. In the construction organization and planning, resource conservation and environmental protection factors should be systematically considered, the construction scheme should be optimized, energy-saving and environmental protection materials should be selected, and clean production mode should be implemented to reduce noise and dust. For materials such as steel bars and formwork, factory processing methods should be adopted as far as possible to reduce on-site cutting and welding operations. Waste wood and steel should be collected by classification and submitted for recycling by professional institutions. For concrete curing, the waste water and reclaimed water should be used first, and the construction wastewater should be reused or discharged according to the standard after treatment. For large mechanical equipment, energy-saving type number should be selected, and LED lamps should be used for engineering lighting. Actively apply solar energy, ground source heat pump and other renewable energy, promote prefabricated construction, reduce the site wet operation. Strengthen the education and training of construction personnel, enhance the awareness of green construction, and implement environmental responsibility to each post.

5. Conclusion

Large-span prestressed concrete beam is the key structural form in modern buildings. The systematic study of its construction technology is of great significance to ensure the project quality, improve the construction efficiency and promote the transformation and upgrading of the construction industry. On the basis of analyzing the key construction points, this paper focuses on the key construction technology, and puts forward the construction technology optimization and innovation path. The adoption of advanced concepts and methods such as BIM technology application, prefabricated construction and green construction represents the future development direction of construction engineering. We should further strengthen the linkage of "industry, university, research and application", strengthen the transformation of scientific and technological achievements, improve the technical standards and specifications, and effectively promote the high-quality development of long-span prestressed concrete beam.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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