Analysis on the Construction Process of Newly Built Prestressed Concrete Channel Girders Passing Through the Existing Liaison Line

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Abstract: When the new pre-stressed bridge project crosses the existing engineering routes for construction, the girder-making location affects the construction of Lanzhou subway and the opening of subway on schedule. Therefore, how to effectively shorten the construction cycle and reduce the impact on the construction of Lanzhou subway under the premise of ensuring construction safety and quality has become an urgent problem. In view of this problem, with the background of construction of new prestressed concrete channel girders under the existing liaison line, it is proposed to tension the prestressing bundles when the concrete strength and elastic modulus of the girders reach 75% of the design strength, and the study shows that: when the C55 concrete strength of the channel girders reaches 75%, it is safe to tension the prestressing tendons and feasible to push the construction of the girders laterally; this scheme can be realized through scientific and reasonable construction organization and process adjustment. Through scientific and reasonable construction organization and technological adjustment, this scheme can realize the harmonious coexistence of the newly built prestressed concrete channel girder and the construction of Lanzhou Metro, and at the same time ensure the construction progress and project quality. This program can not only shorten the construction period, but also ensure the construction safety and project quality. The results of the study have important reference value and practical significance for other similar projects.

Keywords: Prestressing; Concrete; Channel Girders; Construction Techniques

1. Introduction

The application of prestressing technology in bridge structure has a pivotal position, which has inspired the in-depth exploration and practical enthusiasm of the majority of scholars. Through unremitting efforts, the transformation of the performance of slowly bonded prestressed concrete beams to bonded prestressed concrete beams has been successfully realized, and this achievement marks a great progress of prestressing technology [1]. Meanwhile, scholars have conducted systematic studies on the effects of bending performance and flexural stiffness of prestressed concrete beams under cyclic loading, revealing their intrinsic laws [2]. In addition, the upper limit of the shear bearing capacity of prestressed concrete beams has also been thoroughly explored, providing a scientific basis for design [3].

In recent years, the research scope of prestressing technology has been extended to the whole process control of construction. From the careful preparation before construction, including the site layout, to the refinement of the girder reinforcement, the precise installation of strands and bellows, the stable support of formwork, the careful pouring of concrete, to the precise implementation of prestressing tensioning and the meticulous operation of orifice grouting, each step incorporates the concept of strict quality control [4]. This series of studies has laid a solid foundation for the quality construction of prestressed concrete bridges.

Subsequently, on the basis of prestressed technical bridges, the field of local prestressing was further developed [5-9], which not only improved the application of prestressed bridge construction technology, but also provided a solid theoretical support for its wide application in actual projects. At the same time, it has successfully solved many practical engineering problems [10-12], promoted the popularization and development of extracorporeal prestressing technology, and provided more flexible and diversified choices for the optimal design and construction of bridge structures.

With the acceleration of urbanization and the continuous improvement of transportation network, it is increasingly common for new bridge projects to cross the existing engineering routes. Such projects not only require new bridges to meet the needs of structural safety, durability and functionality, but also must minimize the impact on existing traffic routes and ensure the normal operation of existing routes during construction. Prestressed concrete bridges are widely used in modern bridge engineering for their excellent mechanical properties and durability. However, the traditional prestressing tensioning process usually requires the concrete strength and modulus of elasticity to reach 100% of the design strength, i.e., it is usually necessary to wait for a 28-day curing period before tensioning operations can be carried out. This time requirement often conflicts with the normal work demands of existing project routes, posing great challenges to construction organization and traffic management.

Taking the construction of a new prestressed concrete channel girder under the existing liaison line as an example, the location of the girder production seriously affects the construction of Lanzhou metro, which affects the opening of the metro on schedule. Therefore, how to effectively shorten the construction period and reduce the impact on the construction of Lanzhou metro under the premise of ensuring construction safety and quality has become an urgent problem.

Aiming at this problem, this study takes the construction of new prestressed concrete channel girders under the existing liaison line as the background, and proposes to carry out the tensioning of prestressing bundles in advance when the concrete strength and elastic modulus of the new prestressed concrete channel girders reach 75% of the design strength. This program aims at the scientific and reasonable construction organization and process adjustment, under the premise of affecting the construction of Lanzhou metro and ensuring the opening of the metro on schedule. Realize the harmonious coexistence of the new bridge and the existing line, and at the same time ensure the construction progress and project quality. Through the combination of theoretical analysis and field test, the application effect of the program in the actual project is verified to provide scientific basis and technical support for the construction of similar projects. In addition, this study will also explore the comprehensive impact of the program on the construction period, cost, safety and quality of the project, with a view to forming a complete and feasible set of construction methods, which will provide useful reference for similar projects.

2. Project Overview

Newly built prestressed concrete channel girder crossing the existing contact line (K5+372) project, of which the new prestressed concrete channel girder is 32m long, for the simply supported girder system. The total length of the girder is 32.6m, the width of the girder is 8.9m, the height of the girder is 3.7m, the height of the main girder spanning the girder is 3.2m, the height of the pivot girder is 3.7m; the width of the upper flange plate is 1.2m, the width of the girder top is 8.90m, and the width of the girder bottom is 8.1m.

3. Construction Process

The new prestressed concrete channel girder was prefabricated on the line side of the existing liaison line (K5+372), and the main girder was cast-in-place by setting up berth girder supports, as shown in Figure 1. When the prestressed concrete channel girders were precast, they were moved to the line design position. However, the girder making location affects the construction of Lanzhou subway, which affects the opening of the subway on schedule. To address this problem, this study proposes to advance the tensioning operation of prestressing bundles when the concrete strength and modulus of elasticity of the girders reach 75% of the design strength. Through scientific and reasonable construction organization and process adjustment, this scheme can realize the harmonious coexistence of the new prestressed concrete channel girders and the construction of

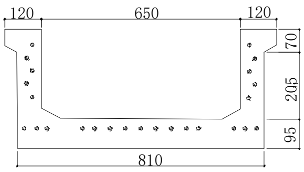
Lanzhou metro, and at the same time ensure the construction progress and project quality, and accelerate the construction progress and shorten the construction period.

Figure 1. Construction Site of Slotted Beam

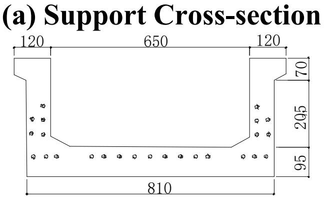
4. An Analytical Study on the State of Tension Prestressing of Channel Girders

In order to ensure that the concrete strength and modulus of elasticity of the newly constructed prestressed concrete channel girders proposed in this research program are in a safe state of channel girder tension prestressing when the concrete strength and modulus of elasticity of the girders reach 75% of the design strength. Verification and analysis of the state of tensile prestressing of channel girders are carried out. The main contents are as follows.

Newly built prestressed concrete channel girder concrete strength class C55, modulus of elasticity 3.55×104MPa, standard compressive strength 37.0MPa, standard compressive strength 3.30MPa, capacity weight used 26.5KN/m3. prestressing tendons used $15\varphi^{s}15.2mm$ high strength and low relaxation strand, standard tensile strength $f_{pk}=1860MP$, supporting group anchor anchorage ancho rage. Ordinary steel reinforcement adopts HPB300 and HRB400 steel reinforcement. The cross-section form and dimensions of the new prestressed concrete channel girder are shown in Figure 2.



(a) Support Cross-section



(b) Mid-span Section

Figure 2. Calculated Forms and Dimensions

According to the actual construction situation, the finite element model of the new prestressed concrete channel girder was constructed by using MIDAS finite element software. In this model, the action of prestressing load is simulated by defining the unbonded prestressing steel beam and its arrangement pattern, and the calculation results are shown in Figure 3. The stress distribution and changes of the channel girder in the prestressed tension state are analyzed.

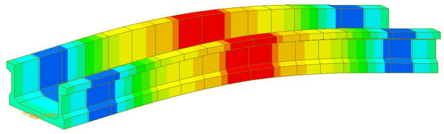


Figure 3. Finite Element Model of Newly Constructed Prestressed Concrete Channel Girder

4.1 Total Stress State of Main Girder Control Section Tensioning

The results of the analysis of the total stress state of the control section of the main girder have been compiled in Table 1. According to the data in Table 1, when the newly constructed prestressed concrete channel girder was under prestressing tension, all the stresses in all the sections were compressive stresses, and the maximum value of compressive stress was 9.291 MPa. In the position of the mid-span cross-section of the channel girder, the value of the total stress was also kept below 27.75 MPa. In addition, the local maximum compressive stress of the concrete under the anchor was 11.59 MPa, which was also below the safety limit of 27.75 MPa. Therefore, when the new prestressed concrete channel girders are made of C55 concrete and their strength reaches 75% of the design strength, it is safe and feasible to carry out the tensioning of prestressing tendons, which will not lead to cracking or compression cracking of the girders. This conclusion verifies the effectiveness and feasibility of this construction program.

4.2 Localized Stress State of Concrete Under Anchor

There is a 90mm diameter metal bellows pre-buried for hole formation, and equipped with M15-15 type group anchor anchors for anchoring. The construction adopts bidirectional tensioning at both ends, and the control stress under the anchor is set to

1283.4MPa during the tensioning process, while the double control of tensioning tonnage and elongation is adopted to ensure that the tensioning control force under the anchor reaches 2695.14kN and the control elongation is 102.5mm.The jacking operation of the channel beam adopts the sideways jacking method, and the moving process is smooth and slow without vertical vibration and vertical load, and the vertical load remains unchanged. The vertical load remains unchanged, and its stress state is the same as that of the prestressing tensioning stage. Therefore, it is practicable to carry out the lateral jacking construction of the girder after the concrete strength of the C55 channel girder reaches 75% of the design strength.

Table 1. Table of Maximum Stresses in the Control Section of the Main Girder

placement	top margin M_{ax}(MPa)		$0.75f_{ck}$	lower margin M_{ax}(MPa)		$0.75f_{ck}$
$l/4$	3.171	≦	27.75	9.291	≦	27.75
$l/2$	4.748	≦	27.75	8.226	≦	27.75

4.3 Analysis of the Stress State under the Working Condition of Main Girder Displacement

After calculation and analysis, the stress check results of the newly constructed prestressed concrete channel girder under the working condition are summarized in Table 2.Under the condition that the slurry material in the aperture has not yet solidified, the newly constructed prestressed concrete channel girder is in the state of full cross-section compression under the action of the combined load, and the maximal compressive stress in the cross-section at the mid-span position is 20.693 MPa.When the slurry material is completely solidified, the maximal working stress decreases to 11.37 MPa.The maximal working stress before the slurry material has not yet solidified is 11.37 MPa compared with the maximal stress at the mid-span position. The maximum working stress of the new prestressed concrete channel girder before the grouting material solidified exceeded 45% compared to the state after the grouting material fully solidified, but it was still lower than the safety limit value of 27.75 MPa. Considering that there has been a period of time from the pre-stressing tensioning to the restoration of the bridge line, the strength of the girder concrete has increased and the grouting material has already possessed a certain degree of strength, the maximum working stress of the new prestressed concrete channel girder in the mid-span section was 20.693 MPa. It is feasible to restore the line to traffic immediately after the bridge jacking is in place and the line on the bridge is restored.

In summary, this program effectively realizes the harmonious parallelism between the new prestressed concrete channel girders and the construction activities of Lanzhou Metro through the carefully planned construction organization design and innovative process adjustment strategy, under the premise of affecting the construction of Lanzhou Metro and ensuring that the Metro will be opened on schedule. Ensure that the construction is efficiently advanced, while also strictly guaranteeing the quality and safety of the project. This solution not only significantly shortens the project cycle, but also ensures the safety during the construction process and the final quality of the project, demonstrating a high degree of practicality and feasibility. In addition, the conclusions drawn from this study have important reference value and practical significance for guiding other similar projects, and can provide useful inspiration and reference for the construction management and technological innovation of similar projects.

Table 2. Maximum Stresses in Control Section of Main Girder

placement	top margin M_{ax}(MPa)		$0.75f_{ck}$	lower margin M_{ax}(MPa)		$0.75f_{ck}$
$l/4$	17.823	≦	27.75	13.311	≦	27.75
$l/2$	20.693	≦	27.75	14.762	≦	27.75

5. Conclusion

Through the research and analysis, the following conclusions are drawn:

(1) The maximum compressive stress of the control section of the newly constructed prestressed concrete channel girder is 9.291MPa during tensioning, and the maximum compressive stress of the concrete localized under the anchors is 11.59MPa, both

of which are lower than the specified limit value of 27.75MPa, and therefore satisfy the relevant requirements.

(2) The maximum stress of the newly constructed prestressed concrete channel girder in the shifted working condition reaches 20.693 MPa, and when the grouting material is completely solidified, the maximum working stress decreases to 11.37 MPa. Before the grouting material is not solidified, the maximum working stress is about 45% higher than that after solidification, but in spite of this, the value of the stress still remains below the safety limit value of 27.75 MPa.

This program without affecting the construction of the Lanzhou subway, to ensure the opening of the subway on schedule. This program not only significantly shortens the project cycle, but also ensures the safety in the construction process and the final quality of the project. Through the combination of theoretical analysis and on-site test method, the application effect of this program in the actual project is verified to provide scientific basis and technical support for the construction of similar projects.

However, this program still faces many challenges and unanswered questions. The primary concern is whether the mechanical properties of the newly constructed prestressed concrete channel girders meet expectations. Specifically, whether its concrete strength and modulus of elasticity can be moderately lower than 75% of the design strength while ensuring safety is a scientific question that needs to be explored in depth. In addition, exploring the possibility of incorporating specific additives or modifying materials into concrete with a view to significantly improving its early strength without compromising its long-term performance, thereby accelerating the construction schedule and effectively addressing similar engineering challenges, becomes an important direction for future research.

Further research should also cover the evaluation of the impact of these additives on concrete durability, crack resistance and other key physicochemical properties to ensure that the proposed solutions are not only efficient but also comprehensive and reliable. At the same time, the search for the most cost-effective and environmentally friendly combination of materials and technologies, taking into account the economic costs and environmental impacts, is important to promote the application of this solution in practical engineering. Therefore, the intersection of materials science, structural engineering and environmental science will be the key to solving this kind of problems and improving and enriching the content of this program in the future.

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