Research on Application of Intelligent Prestressed Construction Technology Based on Computer Software Analysis

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Abstract. The important process of prestressing work is prestressing tension, which can directly affect the safety and durability of prestressed structure and frame. The role of prestressing tension is to ensure the quality of the bridge, which is related to the safety and durability of the bridge structure. This article mainly analyzes the intelligent tension technology, studies the specific application of the intelligent tension technology in construction, and does a little research on the future development of the intelligent tension technology. Practice has proved that the elongation value of the tension force of the intelligent tension system is accurate in operation, has good performance, high safety performance, simple operation and quality control.

Keywords: Intelligent Tensioning Technology, Prestressed Construction, Application

1. Introduction

Nowadays, the intelligent tensioning technology applied in prestressed construction mainly relies on computer equipment to complete the intelligent operation and promote the automatic operation of related equipment, which will require the use of local area network wireless network for intelligent tensioning equipment. Good connection with computer equipment, use the Internet as the carrier to exchange effective data and then realize the application of intelligent tensioning technology in prestressed construction [1-4]. The prestressed intelligent tensioning construction technology can promote related equipment in the construction process [5,6]. The automation will be able to reduce or avoid the adverse effects of human factors on the pre-stress construction process, so as to standardize the construction process and the tensioning technical process and ensure the quality of the pre-stress construction [7-11].

Prestressed technology is the most critical technology in civil engineering construction. The quality of prestressed construction is directly related to the safety and durability of prestressed structures or components. Since 2007, nearly 40 bridges in our country have collapsed, resulting in hundreds of casualties and huge economic losses. The reason is that in addition to design defects, overloading and overruns, poor management during operation and other factors, a very important point is construction. Caused by quality problems. Through the investigation and inspection of a large number of pre-stressed bridges, it is found that a considerable part of the hidden quality of pre-stressed bridges comes
from the non-standard construction of pre-stressed tension and the lack of effective quality control methods.

2. Overview of Smart Tension Technology

2.1. Disadvantages of traditional tensioning technology

Traditional pre-stressed tensioning equipment and construction methods are all manually operated, and their disadvantages are:

(1) The ZB4-500 (or ZB4-630) oil pump and YCW (or YDC) series jacks are the most commonly used in traditional tensioning construction. The accuracy of the supporting pressure gauge is generally 1.6 grades, and the minimum scale of the pressure gauge is 1MPa. The number can only be estimated manually. Due to the large vibration, the pressure gauge pointer swings and the data cannot be accurately read;

(2) The prestressing construction process is to manually operate the handwheel of the oil pump to control the flow rate. The speed of the load application varies greatly due to personal experience and habits, and the pressure holding time is canceled at will. Human factors are uncontrollable, making the prestressed tendons The tension is not synchronized, and the local deformation of the component is intensified;

(3) The regression equations of the jacks at both ends are different, the oil supply of the oil pump is inconsistent, and the manual cannot control the loading speed, which causes the elongation value to be too long or too short at one end;

(4) The elongation value of the steel strand is measured using a steel ruler or tape measure, and it cannot be accurately stretched to the initial stress stop point. Some projects do not measure the elongation value of the steel strand at all because of the rush to progress or the lack of quality supervision. But quickly apply the tensile force to the design value, which cannot achieve the dual control required by the relevant construction specifications, and the construction quality cannot be guaranteed at all;

(5) The tensioning record report is filled in manually, the tensioning data is easily artificially fraudulent, and the construction process and results cannot be traced;

(6) The way for owners, supervisors, and construction units to manage and control the key processes of tensioning is to go to the site to see the measurement, to see the tensioning process and results, and the tensioning time control of the entire line should require a lot of manpower and material resources;

(7) For the prestressed construction of prefabricated hollow slab beams, small box beams, cast-in-place continuous beams and large-span continuous rigid frame bridges, workers save trouble and adopt single-beam unilateral tensioning, which leads to excessive concentration of local stress on the structure and the side of the beam. Bending and cracking; especially large-span box girder and rigid frame bridges that need to be stretched multiple times, because jacks and tool anchors need to be reinstalled for each stroke, labor intensity and safety hazards are great;

(8) Excessive unwinding speed can easily lead to excessive loss of prestress, instantaneous unwinding, and large impact on the clip during retraction, which can easily cause safety accidents due to slippage and breakage.

2.2. The working principle of the smart tensioning system

The intelligent tensioning program control system is composed of a system host and front-end equipment. The front-end equipment of the operation will be composed of measurement and control circuits, oil pumps, jacks, and sensors. The system software interface has a high applicability in program control. It is convenient for the staff to operate, and the interface design of the system host needs to rely on front-line operators.

In the working principle of the pre-stressed intelligent tensioning system, jacks and tool anchors need to be installed at both ends of the beam body, and respectively connected with the pre-stressed
intelligent tensioning instrument. The signal line is connected, and the jack is connected with the prestressed intelligent tensioning instrument by tubing, and a limit plate setting needs to be added between the jack and the bridge. The prestressed intelligent tensioning system mainly uses the relevant stress as the index for system control, and the error between the elongation is the index for proofreading. During the prestressing construction process, the intelligent tensioning system will use sensor technology to carry out relevant data. Collect it and feed it back to the system host for processing in real time. In the oil pump station, the receiving system sends instructions according to the actual working conditions, and then can effectively adjust the working parameters of the variable frequency motor to ensure the effective control of the oil pump motor's speed, tension and loading speed. The system host issues related instructions according to the preset program before work to effectively control the mechanical operation of related equipment, and realize the automatic and intelligent prestressing construction process.

The calculation steps of smart tension force are as follows:

1. Establish a priority judgment matrix \( F = \{f_{ij}\}_{n \times n} \), this matrix is a fuzzy complementary matrix, and the values in the matrix adopt the two-element scaling method, which is represented by a scale of 0.1 to 0.9. This method can accurately describe any two This factor relates to the relative importance of a criterion.

\[
F = \begin{pmatrix}
f_{11} & f_{12} & \cdots & f_{1n} \\
f_{21} & f_{22} & \cdots & f_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
f_{n1} & f_{n2} & \cdots & f_{nn}
\end{pmatrix}
\]

2. Find the line sum and use the conversion formula

\[
r_i = \sum_{j=1}^{n} f_{ij} \quad \text{and use the conversion formula} \quad r_i = \frac{r_i - r_j}{2n} + 0.5
\]

The matrix \( F \) is transformed into a fuzzy consistency judgment matrix \( R = \{r_{ij}\}_{n \times n} \).

3. The square root method finds the ranking vector, as shown in formula (1).

\[
W^{(0)} = \{\omega_1, \omega_2, \cdots, \omega_n\}^T = \left[ \frac{\prod_{j=1}^{n} e_{1j}}{\sum_{i=1}^{n} \prod_{j=1}^{n} e_{ij}}, \frac{\prod_{j=1}^{n} e_{2j}}{\sum_{i=1}^{n} \prod_{j=1}^{n} e_{ij}}, \cdots, \frac{\prod_{j=1}^{n} e_{nj}}{\sum_{i=1}^{n} \prod_{j=1}^{n} e_{ij}} \right]^T
\]

4. Use the conversion formula \( e_{ij} = \frac{r_{ij}}{r_{ji}} \) to transform the complementary judgment matrix \( R = \{r_{ij}\}_{n \times n} \) into a reciprocal matrix \( E = \{e_{ij}\}_{n \times n} \).

2.3. Operation process of intelligent tensioning system for prestress construction

Before the construction of the prestressed intelligent tensioning technology, the relevant materials and appliances should be strictly inspected to ensure that they meet the specified standards, including the elastic modulus of the tunnel strength, steel strands, steel bars, anchors, connectors, jacks, and tensioning machines, etc. Detection of related accessories and equipment to ensure the smooth operation of the tensioning system.

After the relevant inspection work is completed, you can enter the program of the intelligent tensioning operation: after entering the main interface of the system operation, enter the engineering information into the system, and set the parameters of the beam type, the tension stage design control stress, and the elongation value. The first step is to perform software control operations to observe the numerical changes of the pressure value and the displacement value. If there is an abnormal situation, the operation needs to be suspended in time to check the abnormal factors. In the process of pre-
stressed tensioning technology, high attention should be paid to the equipment at both ends of the beam and slab. The working condition of the jack is to ensure the safety of the construction. After the tensioning construction of each hole is completed, the equipment automatically retracts the top and saves the valid data, and then enters the next tensioning link. The tensioning construction operation should be consistent with the previous construction steps. When the entire beam and slab tensioning construction is completed, the tension report can be produced and printed out. Finally, the software, motor, power supply, jack and tubing and other equipment can be shut down and disconnected in an orderly manner to ensure the reuse rate of the equipment.

2.4. Detailed design scheme of intelligent tensioning system
Due to the diversity of bridge structures, different structures and working conditions have different requirements for tensioning, so the basic design of the above-mentioned intelligent tensioning system is further studied and refined, and different programs are formed to meet different structures and different working conditions. Situation requirements. The configuration of two pumps and two tops is suitable for T-beam and single-ended tensioning. It is characterized by symmetrical tensioning at both ends of a single beam. Generally, the prestressed beam is short, and the designed control load can be achieved within one tensioning stroke. The aforementioned basic design can meet the tensioning requirements of this type of structure. The configuration scheme of two pumps and two tops is shown in Figure 1.

![Figure 1. Schematic diagram of the installation structure of the basic scheme of the intelligent tensioning system](image)

In the small box girder, continuous rigid frame girder and large-span cast-in-place box girder, they should be stretched symmetrically along the central axis. Sometimes, because of the large length of the prestressed beam, it takes two or more strokes to reach the design. To control the load, for this purpose, the above-mentioned basic scheme is further studied, and the scheme shown in Figure 2 is formed. The scheme is a two-pump four-pump configuration. The main and auxiliary pumping stations each have two sets of integrated valve groups, which drive two jacks respectively to achieve symmetrical tensioning of two prestressed tendons at the same time; long cables can be equipped with automatic tool anchors. After each stretch is completed, the jack and tool anchor can automatically return to the position without manual reinstallation, realizing the continuous stretching of the long cable.
2.5. The workflow of the smart tensioning system
With the above design scheme, the operator only needs to input the relevant parameters such as the tensile force at all levels and the holding time after the equipment is installed, and the whole tensile process can be automatically completed after the start. Automatic, fast and safe. The working process of automatic tensioning (take the configuration of two pumps and two tops as an example) is shown in Figure 2.

![Figure 2](image_url)

**Figure 2.** First-level tensioning work flow chart
During the operation of the smart tensioning system, the system host is equipped with a safety pre-warning operation, which will ensure the safe operation of the system and avoid hidden dangers such as over-tensioning. During the execution of the smart tensioning system, relevant data and curve graphics will be presented directly. On the host interface of the system, it can ensure that the tensioning construction process is combined with different construction requirements to make and print different output reports to realize the synchronization and real-time performance of the tensioning construction.

3. Practical application of intelligent tension technology in prestress construction
In a viaduct cast-in-place box girder project, the application of intelligent tensioning technology in the relevant prestress construction, the use of prestressed tensioning program-controlled equipment, and
the separation of the oil pump and the jack will facilitate the construction work. Combined with the specific survey data, the concrete strength of the cast-in-place beam is about 51.03MPa, and the tensile strength is 57.12MPa. When the elastic modulus is designed, it is calculated to be 4.02*104N/mm2, and the practical elastic modulus is 4.61 *104N/mm2, to meet the requirements of relevant design specifications.

In the first tension control stage of the entire tension construction, the tension stress of the steel strand is set to 15% σ con to avoid the error value of the elongation and to ensure that the forces of the steel strands in the same bundle are uniform. When the tensile stress of the steel strand exceeds this value, it will be in the load-holding stage and then automatically loosen the jack rope and record the elongation value of the cylinder and the amount of the tool clamp. The second tension control stage is to automatically control the boost speed. The stress value is limited to 30% σ con. When it is close to this value, the boost speed will be automatically slowed. When it reaches and exceeds 30% σ con, it will enter the holding load. The link is consistent with the work content at the end of the first tension control phase. In the third phase, the oil pump is automatically tensioned. This phase is based on the 100% σ con stress value, and the pressure rise speed is automatically slowed when it approaches. When it reaches 100% σ con, it is in the static stop loading stage and self-compensated. After the loading is completed, it is the same as the later operation content of the above two stages. The elongation value and the exposed amount are recorded. Enter the unloading and anchoring operation procedure.

4. The development prospects of pre-stressed intelligent tensioning construction technology
The pre-stress intelligent tensioning construction process is relatively simple in the construction process, and the related construction equipment needs to be controlled manually, but there is no interference of human factors and environmental factors during the tensioning construction process, which effectively guarantees the construction quality, and the design requirements and In terms of construction technical specifications, the tension stop point, loading rate, and holding time can be effectively controlled to reduce the loss of effective prestress, and intelligent tension technology is applied in the prestress construction process, and computer equipment is used to realize automatic operation and Monitoring, real-time control on measurement data, will provide favorable conditions for on-site construction quality control and specification rigor, and to a certain extent, it can avoid the risk of data fraud in the process of engineering construction.

Therefore, the application scope of intelligent tensioning technology in prestressed construction has room for expansion. It can effectively reduce the artificial strength in the prestressed construction process and enhance the skills of related staff to meet the requirements of modern prestressed construction. At present, The degree of research on intelligent tensioning technology in many large domestic units has been enhanced. This technology provides favorable conditions for ensuring the quality of prestressed tensioning construction with high precision and strong stability, and has broad market applications Development prospects.

5. Conclusion
The development of prestressed intelligent construction technology will further promote the standardization and standardization of prestressed construction, and promote the development of tension control accuracy during the construction process, and improve the quality of prestressed construction. With the rapid research of intelligent tensioning technology And the increasing maturity will be able to ensure the safety of domestic bridge construction and ensure the quality of construction, save construction costs, and effectively expand the field of domestic pre-stressed construction technology, and contribute to the acceleration of the modernization process.

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