Researching on Control Device of Prestressing Wire Reinforcement

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Researching on Control Device of Prestressing Wire Reinforcement

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Abstract. This paper mainly introduces a device for controlling prestress and its related research methods, the advantage of this method is that the reinforcement process is easy to operate and control the prestress of wire rope accurately. The relationship between the stress and strain of the steel wire rope is monitored during the experiment, and the one-to-one relationship between the controllable position and the pretightening force of the steel wire rope is confirmed by the 5mm steel wire rope, and the results are analyzed theoretically by the measured elastic modulus. The results show that the method can effectively control the prestressing force, and the result provides a reference method for strengthening the concrete column with prestressed steel strand.

1. Introduction
According to the experience of earthquake damage in recent years at home and abroad, the design concept of "strong column and weak beam" is put forward. At present, the demand for improving the bearing capacity and ductility of the column has been gradually clear, combined with the actual situation of the existing building life in China, the reinforcement column technology has been widely used. At present, there are two kinds of reinforcement technology: Active and passive reinforcement; Passive reinforcement methods include: Enlarging section method, Concrete replacement method, Bonded steel structure strengthening method, Fiber reinforced plastic reinforcement method and so on. There is a common problem of stress hysteresis in these methods, which makes it necessary to have a certain degree of expansion cracks before the reinforcement materials play a role. The active reinforcement method, such as the external prestressing reinforcement method [1-3], to some extent, eliminates the problem of stress hysteresis, but there are still some problems. Guo Zixiong [4-5] et al carried out the experimental study on the axial compressive behavior of RC column strengthened with prestressed steel plate hoop, and the control of the prestress level is based on the average strain of 4 measuring points on the steel hoop. The method of reinforcing concrete column with wire winding is widely praised for its low cost, and it can improve the bearing capacity of the column, especially the ductility performance, especially in the case of only a small space. With the progress of the research on the reinforcement of reinforced concrete columns, the prestressed size monitoring [6-7] and the control have become a bottleneck in the further development of the wire.

2. Testing
The device is welded with the same size nut, and the nut sleeve can be matched with the bolt after welding. Bushing holes in the matching bolts to facilitate the rope through, the size of the apertures and bolts is determined by the actual use of wire ropes. The wire rope uses a 6 x 10 cord wire rope with a diameter of 5 mm, so the aperture is set to 12 mm.
The steel wire rope is wound to be reinforced, and both ends of the steel wire rope pass through the hole of the device and are reinforced by buckle. To ensure the reinforcement effect, the appropriate distance between buckle and bolt should be reserved, the reinforcement process continues to expand bolts, the reinforcement device is shown in Figure 1.

![Reinforcement Device Diagram](image)

**Figure 1.** Reinforcement Device Diagram

### 3. Prestress Testing

The tensile test was carried out by the servo test machine of the material laboratory of Xi'an University of Technology. Before the start of the test, the rope fixed at both ends in the test machine and found the rope tension value equal to the actual value of prestressing. Mark the initial position of the bolt and set the initial pull value. After the test began, the bolts were rotated by 60 degrees each time, record the tensile force of the sensor and the wire rope deformation value. The effective length of the wire rope (equivalent to the distance between the two ends of the test machine) is 0.8m. The specific device shown in Figure 2. Easy to calculate and compare the data, adjust the test machine to the initial tension value of 300N. In order to study the instability of the stretching process, make a set of wire rope tensile test. Measured obtaining the stress-strain curve shown in Figure 3:

![Tensile Testing](image)

![stress-strain curve](image)

**Figure 2.** Tensile Testing  **Figure 3.** stress-strain curve

The following data can be obtained from the test:
The actual measured elastic modulus of wire rope is 77.08 GPa. Strain is verified by resistance strain extensometer.

The ultimate tensile force of wire rope is close to 9300 N. And when the tension reaches 3000 N, the stress-strain curve gradually becomes straight, so the data has high accuracy.

Based on the above data, the suitable scheme is used to solve the problem of stress relaxation. Wire rope was tightened to 3000 N, until its tensile force gradually reduced to stable and then fine-tune to 300 N, in this way, the error due to factors such as the combination of the device can be eliminated. The average of the set of data is shown in Table 1. Combined with the Table 1, draw a curve as shown in figure 4.

As can be seen from the above figure 4, the deformation increment in the prestressing process is not uniform. The reason for this phenomenon is that during the tightening process, the nut sleeve ends have a friction effect on the wire rope, when the nut sleeve rotation, the friction is accumulated to a certain extent will be released, resulting in strain increment of uneven changes. And with the increasing stress of the wire rope, the wire rope on the nut pressure is also growing, resulting in increased static friction and the increased strain of the divergence situation. In spite of this instability, the change is relatively small relative to the tensile value, indicating that the prestressing control of the method is feasible. The corresponding relationship in the reinforcement process is not equal to the modulus of elasticity measured by the tensile test and is less than the value calculated by the stress-strain of the wire rope. The reason for the analysis is that the device makes the wire rope not as fully capable of material as the tensile test.

<table>
<thead>
<tr>
<th>Wire rope deformation value (mm)</th>
<th>Tensile force (N)</th>
<th>Wire rope deformation value (mm)</th>
<th>Tensile force (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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<tr>
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<td>1850</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 1. Wire Rope Deformation - Rally Value Data Sheet

![Figure 4. Wire rope deformation - tension curve](image)
4. Theoretical Analysis and Error Analysis

The stress-strain relationship of the wire rope conforms to the elastic deformation. The section of steel strand: This kind of specifications every six strands wire rope, 10 per share, the specifications of wire rope cross-sectional area was 6.8mm². Check from the specification table, the bolt thread spacing is a fixed value, so each rotation of a circle, the device expansion distance is fixed. However, according to the test results, the deformation of the wire rope is not equal to the bolt spacing, the actual result is that each rotation of the screw 60°, the deformation of the wire rope is 0.13mm. And rotate once, both ends at the same time shrink, so the deformation should be multiplied by 2.

In accordance with Chinese Code for Design of Concrete Structures (GB 50010-2010), the theoretical calculations are as follows[8-10]:

\[
\sigma = E \times \varepsilon
\]

\[
\frac{F}{S} = E \times \frac{\Delta L}{L}
\]

\[
\frac{\Delta F}{6.8 \text{mm}^2} = \frac{77.08 \text{GPa} \times 0.13 \text{mm} \times 2}{800 \text{mm}}
\]

\[
\Delta F = 170 \text{N}
\]

Because of the interference by the friction, we have made improvements to the actual device and polished a small angle in the steel wire rope face contact with the nut sleeve, also smear a small amount of lubricant in the course of the experiment, and the coefficient of the theoretical value of the amendment. Three steel wires with the same specifications and the same batch were selected as the experimental results, and compared with the theoretical calculation values. tension - wire rope deformation curve shown in Figure 5.

![Figure 5. Total curve of deformation and tensile force of wire rope](image)

As is clearly shown in the Figure 5, the tension value can be kept uniform, and the phenomenon that the prestress peak becomes larger, the improvement of the device can reduce the influence of friction on the experiment to a certain extent, but with the increase of the friction force, the friction between the corner and the device will inevitably increase, so we modify the theoretical value of friction coefficient \(\gamma = 0.93\) From the 30% of the ultimate tensile stress, the results are in good agreement with the actual values. The test data and error analysis are shown in the following table 2. After correction by coefficient, the error between theoretical value and actual value can be kept within ±8%. It is proved that this method can not only ensure the accurate value of prestress, but also can better correspond to the relationship between the rotation angle of bolt and the prestress value of steel wire rope.
5. Conclusion

This paper puts forward a convenient and feasible device used for wire rope reinforced concrete member pre-tightening force control. The feasibility of the device was verified by field test and theoretical calculation, and correction coefficient of friction was introduced to the theoretical calculation result has carried on the correction, through the revised coefficient, the error of the theoretical value and practical value to keep within the plus or minus 8%, Which provides the basis for the application of controllable preloading force for the reinforcement of concrete members. There is
still a lot of space to explore the steel wire rope reinforcement technology. In the future, with the development of the construction technology, the research of wire rope reinforcement technology will be of great value.

6. References