Analysis and Disposal about A Proof Prestressed Tensioning Accident

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Abstract
A four-story RC frame’s proof was with flexural member of pre-stressed concrete. When the post-tensioned pre-stressing construction method was used in project, the accident would happen due to pressing damage of local concrete. The strength of early-stage concrete was considered as main cause of accident in this paper. Many kinds of theory were used to calculate detailedly for the strength of early-stage concrete. The results were compared through different situations. The disposal measure was put forward by the conclusion. The method was proved to be available by the follow-up construction.

Keywords
Proof; Pre-stress; Strength of Early-stage Concrete; Accident; Compressive Strength

General Situation of Engineering and Accident
A project for the four story reinforced concrete frame structure was shown as Fig. 1. Thinking of the four floor layout design requiring large space, large span cantilever beam of 12.5 m was used for local design of the roof. The post tensioned pre-stressed construction technology was also taken into account. The commercial concrete of C40 was adopted in this large beam. Schematic diagrams of the actual situation and the pre-stressed reinforcement were shown as Fig. 2. The main girder’s construction about concrete structure of roof was completed in October 8, 2013. The work of post tensioned pre-stressed construction started from October 21. The period of tensioned pre-stressed construction was 13 days. The section of beam for tensioning was shown as Fig. 3, which was symmetric and had 8 holes. The tensile force of each hole for design was 120 tons and the value of total 8 holes was 960 tons. Each hole had 7 steel wires, which shared 17.14 tons tension. The design was used a seven holes anchorage. When stretching went back to sixth hole for jacking oil, the crack of concrete for side beam happened. Fig. 3 and Fig. 4 showed the local crushing damage of concrete for cantilever beam. The measured concrete strength representative value was 28.4 Mpa for the concrete core sampling of 5 days later.
**Problem Analysis**

According to the requirements of post tensioning pre-stressed construction, the concrete strength for pre-stressed reinforced should meet the design strength of more than 75 percent, which was above 30 Mpa. The testing concrete strength of 18th was 28.4 Mpa in this accident, which was below 30 Mpa. According to analyzing the law of strength growth for early age concrete, the strength of concrete of 13th day was below 28.4 Mpa, which was the key point for working. The calculation analysis of early age concrete strength from many ways was the focal point in this paper, which would help get the reasonable value for concrete strength of 13th day. Furthermore, the reason of accident was done for simple analysis from the early age loading, construction deviation, etc.

**The Traditional Formula Method**

It is well known that the overall strength of concrete is increased with the increasing age. But during the first 7~14 days, the strength had the rapid development. The linear relation between concrete age and strength was given as following:

\[ f_a = f_{28} \cdot \frac{\lg n}{\lg 28} \]  

(1)

Calculating from this formula of concrete, the strength of 13th day and 18th day were respectively 30.80Mpa and 34.7Mpa. The influencing factor was set as 0.88 if we considered the effect of concrete actual structure and curing conditions of specimen. The strength of 13th day and 18th day can be given as 27.1Mpa and 30.54Mpa.

**Test Estimation Method**

The compressive strength test of early age was done for concrete of the strength grade of C20~C60. There were 183 commercial concrete cube specimens for three batch and the early ages were respectively 3 days, 7 days, 14 days, 28 days and 60 days. The average strength of concrete for early age and coefficient of variation were deduced from the basic formula of

\[ \sigma = \lambda \cdot f_c \]  

(2)

According to the formula the standard value of axial compressive strength of concrete can be calculated as:

\[ f_{ct} = f_{ck} - 1.645 \cdot \sigma_c \]  

(3)

The relationship between axial compressive strength and cubic compressive strength can be got as:

\[ f_{ck} = 0.88f_{ck} \alpha_1 \alpha_2 \]  

(4)

\( \alpha_1 \) and \( \alpha_2 \) can be got according to reference.

We can get from formula(4):

\[ f_{ck} = f_{ck} \cdot 0.88 \alpha_1 \alpha_2 \]  

(5)

Then we can get the cube compressive strength of concrete for 13 days and 18 days as:

percent, 95.5 percent and 192.8 percent. From estimation of average value of C40 concrete, the strength of concrete was 31.92Mpa for 7 days and the other was 40Mpa for 14 days. At the same time considering the influencing factor of 0.88, the corresponding strength was amended to be 28.09 Mpa and 35.2 Mpa. Obviously, these results and the measured data had large deviation.

**Maturity Method**

Maturity method is the most common method at home and abroad to calculate the early strength of concrete. But it is also limited for using in the intensity range and the regression coefficient calculation. Based on analyzing the existing research results and the test data from the literature, the formula for standard value of concrete compressive strength was as follows:

\[ f_{28} = f_{28} \cdot [1 + a \ln(t / 28)] \]  

(2)

\( f_{28} \) —The standard value of concrete compressive strength for t days (t≤28) , Mpa;

\( f_{28} \) —The standard value of concrete compressive strength for 28 days, Mpa.

According to reference, \( a = 0.28 \), the standard value of concrete compressive strength for corresponding days was calculated as follows:

\[ f_{28}(13) = f_{28}(28) \cdot [1 + a \ln(13 / 28)] = 31.41 \text{ Mpa} \]

\[ f_{28}(18) = f_{28}(28) \cdot [1 + a \ln(18 / 28)] = 35.05 \text{ Mpa} \]
Fitting Formula Method

The tests of concrete strength of early age were also done by Xiong Wei from the Tianjing University. They got the fitting formula in natural curing conditions as follows:

\[ f_{c_u}^{13} = f_{c_d}^{13} / 0.88\alpha_1\alpha_2 = 24.81 \text{ MPa} \]

\[ f_{c_u}^{18} = f_{c_d}^{18} / 0.88\alpha_1\alpha_2 = 27.29 \text{ MPa} \]

By comparison of the results of these above methods, it can be concluded that the concrete strength of 18 days in natural curing conditions from axial compressive strength of inverse method and the fitting formula method is close to the actual strength of concrete in the project accident. The concrete strength of 13 days from the two formula were respectively 24.81 Mpa and 25.07 Mpa, which was very close to 25 Mpa. We can conclude that the concrete strength of 13 days was 25 Mpa, meaning that the concrete loading strength was 62 percent of design. In addition, the traditional formula method was more close to the measured data. Maturity method was close to the results of test estimation method. But the deviation from them was big with this project. Moreover, since the early age concrete strength increases rapidly, the damage will happen to concrete due to the load of construction and pre-stressed construction of concrete during early age, which will cause negative influence for concrete strength growth. The research showed that the more the early age is, the heavier the load is. The reduction got the maximum for 28 days of concrete age.

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\[ y = 7.1361\ln(x) + 6.7662 \]  \hspace{0.5cm} (6)

We can get from the above formula as:

\[ y_{13} = 25.07 \text{ MPa}; \quad y_{18} = 27.39 \text{ MPa}. \]

The Accident Treatment Measures and Suggestions

A strengthening solution was proposed by a design institute, recommended using the local replacement method to remedy. The task of construction was done by a construction unit to assume. The key problem was to relax the super tension high-pre-stressed steel strand stress condition. Considering the risk is too big for the artificial chiseling compacted concrete, because it is possible to damage the steel strand for non-fixed point through again tension. The oxyacetlene high-temperature burning method was decided to use after repeated demonstration. This method decided to use oxyacetlene high-temperature burning for steel strand anchorage, which will make it melt and separate from the clamping piece. Thus the steel strand anchorage would rebound to relax. The process shows that the method is feasible and practical. Each piece will only need 30 minutes to complete. And the rebound of steel strand is controllable, as shown as Fig. 6.

The processing results of this project show that it is feasible to use oxyacetlene high-temperature combustion for relaxing over high stress steel strand in the practical engineering. But there still have some problems needing further study. The first one is about research for the more reasonable anchorage to be reversible uninstall, which will make it easier to handle in similar accidents. The second one is to make sure there are or not effect from oxyacetlene high-
temperature burning on the strength of pre-stressed steel strand. If it has effect, we should get the influence law. The last one is that we should make sure the effect standard of strength and pre-stress loss due to repeated tension.

REFERENCES

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