

Effect of Concrete Creep on the displacement of single tower single cable plane Extradosed Cable-stayed Bridge

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Abstract. Extradosed Cable-stayed Bridge is both cable-stayed Bridge and Continuous rigid frame bridge mechanics feature, Beam is the main force components, cable is supplement. This article combined with a single tower and single cable plane Extradosed cable-stayed bridge in Yunnan, use different creep calculation models and analysis deflection caused by creep effects. The results showing that deflection caused by creep effect is smaller than the same span continuous rigid frame bridge, the value is about 2cm. On the other hand the deflection is increasing with ambient humidity decreases, therefore in the dry environment the calculation model is relatively large in the pre-camber. In the choice of RC creep model is significant in the dry areas.

1. Introduction

The Extradosed cable-stayed bridge between the continuous rigid frame bridge and the cable-stayed bridge, Both continuous rigid frame Bridges and cable-stayed Bridges of the mechanical characteristics, Force is based on the beam and the cable is auxiliary.

The beam height is about 1/2 times of the same span bridge, main girder deflection caused by creep effect is not obvious, but if the continuous rigid frame bridge, the main girder load sharing ratio is higher, tend to continuous rigid frame bridge, deflection problems still can not be ignored.

The way to solve the deflection problem: construction process of strict monitoring and set up certain camber, all need to calculate the creep effect in the late, but numerous creep calculation theory, calculation result difference is bigger, There is no specific calculation method for the Extradosed cable-stayed bridge, often leads to a large deviation between the predicted and actual values, Leading to distortion of the operation phase out of control. It is very important to predict the creep effect on the main girder more accurately. In this paper, six creep calculation models are used, Combination with engineering examples to predict the main girder deflection caused by creep.

2. Overview of the project

Taking the first concrete extradosed cable-stayed bridge opened to traffic in Yunnan province as an example (the elevation is shown in Figure 1), with Midas Civil for modeling calculation. The Sifang bridge road grade is grade III of urban trunk road, two-way 4 lanes, the design speed is 30km/h; road design load-II, crowd load is 3.5kN/m²; bridge width is 27.0m.



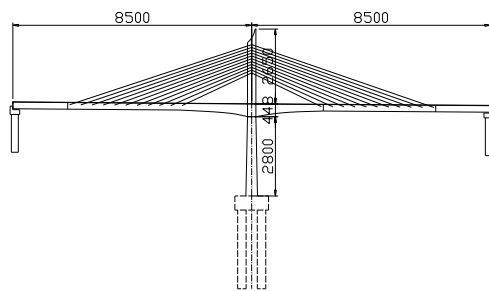


Figure. 1 Elevation drawing of Cable-stayed Bridge

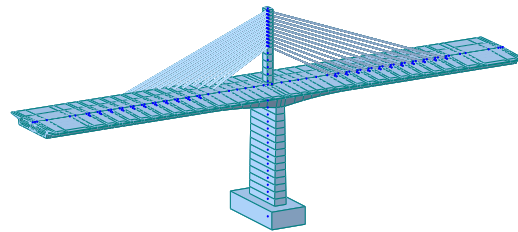


Figure. 2 The structural calculation model

The main beam adopts single box three-compartment large cantilever variable cross-section PC continuous box girder, as shown in figure2. The main tower with a rectangular section of reinforced concrete single column, long is 3m, 2m wide, Tower height is 26.5m. The stay-cables are arranged on the central dividing strip, 22 cables in the east and the west respectively. The longitudinal standard spacing is 4m on the main beam, and the transverse spacing is 1m. The material parameters of Sifang bridge are summarized in table1.

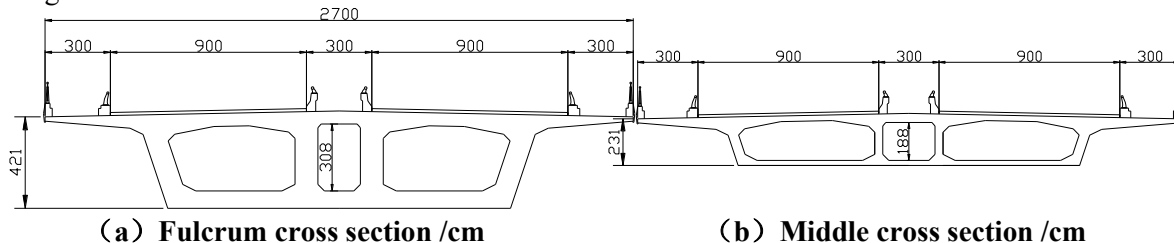


Figure. 3 Main Bridge PC Continuous Box Girder Layout

Table.1 The material parameter summary of calculation model

Material code	Unit type	Material type	Elastic Modulus (MPa)	Bulk density (kN/m ³)	Coefficient of linear expansion 1/°C
1	Bridge pier, main beam, main tower	Concrete 50	3.45E+04	26	1.00E-05
2	Stay Cables	High strength steel wire	1.95E+05	78.5	1.20E-05
3	Prestressed steel wire	High strength steel wire	1.95E+05	78.5	1.20E-05

3. Calculation Model

The Midas Civil structural analysis software is used to calculate and analyze the structure, according to Rod structure, analysis model is shown in figure 3. There are 146 units and 172 nodes in the whole bridge. The boundary conditions are as follows: the lower end of the tower is consolidated, the transition pier and auxiliary pier are simulated by the movable hinged support, and the lower end of the support unit of the cast in situ section is a fixed hinged support. There are totally 7 types of section, of which the section is automatically calculated by the program.

In view of the numerous computational models of creep, this paper uses the 85 China code and China 04 code, the European CEB-FIP78 model and the CEB-FIP90 model, the ACI209 model and the Japanese standard model to calculate and analyze. The creep calculation formulas of each model are shown in table 2.

Table.2 The formula of creep

Formula source	The formula of creep
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Standard of CEB-FIP 78 [4]	$\phi(t, \tau) = \beta_{\alpha}(\tau) + \phi_d \beta_d(t - \tau) + \phi_f [\beta_f(t) - \beta_f(\tau)]$
Standard of CEB-FIP 90 [8]	$\phi(t, \tau) = \phi_0 \beta_c(t, \tau) = \varphi_{RH} \beta_{fcm}(\tau) \beta_c(t, \tau)$
Standard of ACI209 [9]	$\phi(t, \tau) = \frac{(t - \tau)^{0.6}}{10 + (t - \tau)^{0.6}} \phi(u) \quad \phi(u) = 2.35 \beta_1 \beta_2 \beta_3 \beta_4 \beta_5 \beta_6$
Standard of Japan [10]	$\phi(t, t_0) = \phi_{d0} \cdot \beta_d(t - t_0) + \phi_{f0} [\beta_f(t) - \beta_f(t_0)]$

4. Calculation of displacement variation of main beam

This paper selected 10 calculated positions as shown in figure4, and the east 3 node with the largest deflection in the later period is taken as an example, and six kinds of creep models are adopted to calculate the displacement variation of the joints from the construction stage to the operation for 30 years.

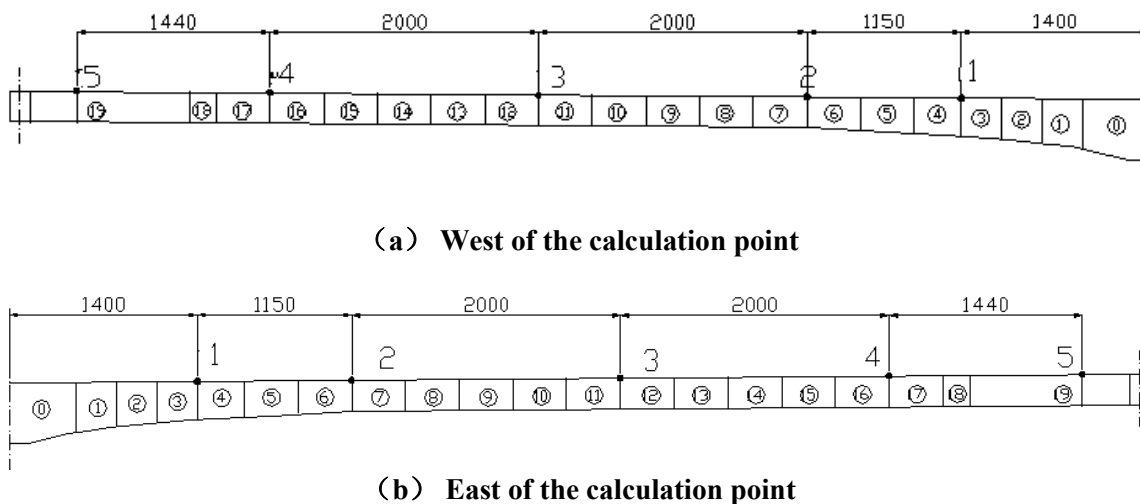


Fig. 4 The schematic diagram of displacement calculation points

Nine working conditions are selected for calculation. Condition1 is 5#formation, tensioned prestressed beams (no cable segment are completed), condition2 is 11#tensioned beams (6cables are completed), condition3 is 16# beam tension cable (cable construction completed), condition4 is the removal of the closure segment (hanger complete closure, condition5 is bridge completed (end of construction), condition6 is operating five years, condition7 is operating 10 years, condition8 is operation for 20 years, condition9 is operation for 30 years.

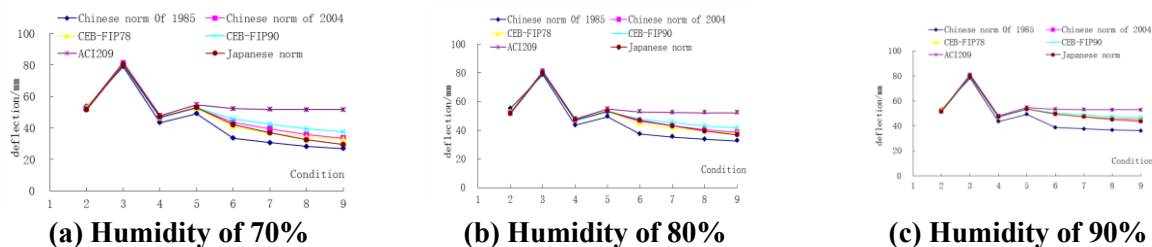


Figure. 5 The displacement development curve of east3 point

According to preliminary study found that environmental humidity is sensitive to the parameter calculation of creep, the location of bridge humidity is between 70%-90%. Therefore, taken into account in the calculation of humidity in three different conditions of deflection, there are 70%, 80%, and 90% respectively. The east 3 calculation point shows downward deflection trend in the whole operation stage (see figure5), the operation starts five years later, and then tends to be gentle, the

deflection measurements are relatively small. When the humidity is 70%, the Japanese standard model calculates the maximum deflection during operation, reaching 23.5mm.

5. Deflection Caused by Creep Effect

The bridge construction control of pre camber setting on operation phase is based on deflection calculation results. The setting of pre camber is reasonable to make the superstructure of the bridge go through the construction and repeatedly bend up or down. After the bridge has been operating for a certain period of time, the designed elevation curve is expected. In this paper, three cases of humidity 70%, 80% and 90% are calculated respectively.

When the humidity is 70%, the calculation results caused by creep are 30 years after the completed bridge operation, as shown in figure6. The choice of calculation model has influence on the calculation point of non-cable area 1~3 obviously, and the calculation results of each model are different, and the influence on the calculation points of 4 and 5 is smaller.

The deflection of the main girder calculated by Japanese standard is the largest, followed by China's 85 code, and the deflection of the girder calculated by American standard is the smallest. Therefore, there are different between the Japanese standard calculation results and the American Standard calculation results, the maximum difference is 20mm.

According to the calculation of humidity of 80%, the deflection caused by creep after 30 years of operation in the calculation points is shown in figure7. The overall calculation results show that the deflection is smaller than that of the humidity of 70%; the calculated deflection value of China 85 standard model is the largest, followed by the Japanese standard model, and the calculated result by the American Standard (ACI209 model) is the smallest; the results of China's current model 04 model are enveloped.

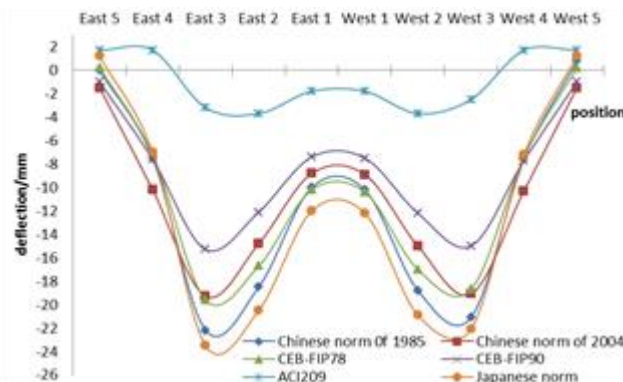


Fig. 6 The deflection calculation results (humidity of 70%)

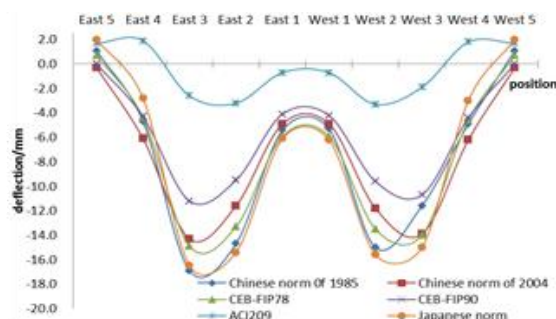


Fig. 7 The deflection calculation results (humidity of 80%)

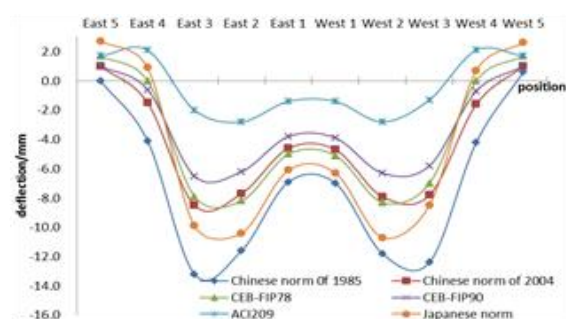


Fig. 8 The deflection calculation results (humidity of 80%)

The project is located in a relatively humid environment, the annual average humidity of 80%, summer humidity up to 90%, figure8 is 90% humidity, 30 years after the completion of the bridge

each point of calculation, deformation caused by creep. The results show that the deflection of the cable zone is small, and the deflection of the non-cable is larger. When the humidity is 90%, the deformation caused by the later creep is smaller than that of the humidity of 80%.

The calculation results under three kinds of environmental humidity show that the creep effect is smaller in humid environment. The results of six models are different, The Japanese standard model and the Chinese 85 standard model calculated the deflection values are larger, the American Standard (ACI209 model) of the overall calculation results are small, the current China's 04 standard model calculation result is enveloped.

6. Conclusion

The paragraph text follows on from the subsection heading but should not be in italic.

In this paper, the concrete creep calculation model recommended by Chinese, European, American and Japanese codes is combined with the author's previous research results, The deflection calculation of a single tower cable stayed bridge with single cable plane and a Extradosed cable-stayed bridge is carried out, and the following conclusions are obtained:

1) In the operation stage, the final deformation value caused by the creep effect of concrete is smaller, which is about 2cm. It can be seen that the later creep part is smaller than that of the same span continuous rigid frame bridge when the camber of the single-tower Extradosed Cable-stayed Bridge with single plane is set up.

2) The deflection caused by creep decreases with the increase of environmental humidity; If the humidity is large, the camber will be smaller, and the camber will be increased when the humidity is small.

3) By comparing the model analysis found that the current standard of 04 Chinese calculated envelope the most value in the middle is not visible, concrete creep effect in the Extradosed cable-stayed bridge is not clear, according to the 04 standard setting camber is the most conservative, the design can be appropriately improved.

4) The calculation difference of each model increases with the decrease of humidity, and the camber of each model is different in the drying environment. Therefore, the more dry area, the more important the choice of concrete creep calculation model.

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