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Analysis the Prestress Loss of Prestressd Concrete Continuous Girder Bridges in Cantilever Construction Stage

Pengtao JIA, Tingjie ZHANG
Department of Civil Engineering & Architecture, Chongqing Jiaotong University, Chongqing 400074, CHINA

Abstract: By using the finite element software Midas civil and the engineering of Bai La Zai first four-wire bridge to establishment of 3D entity model of prestressed concrete continuous girder bridges in cantilever construction stage. To find out the relationship between "the effective prestress loss" and "disease of beam body" on the cantilever construction stage of continuous girder bridge. From the aspects of "friction loss, loss of anchorage, loss of stress by the elastic of concrete and loss of stress caused by shrinkage and creep of concrete" to explore the loss of prestress on the cantilever construction stage. Provide suggestion for the design of prestressed concrete continuous beam bridge, the construction stage and prevention and treatment the disease at the stage of operation. What's more, the theoretical achievements not only give a way to control the extent of cracking and deflection but also to offer theoretical foundations for further research.

Keywords: Cantilever Construction; Elastic Compression; Prestress Loss

1. Introduction

Prestressed concrete box girder bridges (include continuous girder bridges and continuous rigid frame bridges) are widely used because of advantageous structural behavior and perfect shapes. In addition, prestressed concrete box girder bridges also has good seismic ability, carrying capacity strong, quick construction, easy maintenance and ease of cantilever construction and other structural characteristics, relatively fast in recent years has been the development of prestressed concrete bridge in the bridges constructed and those under construction (main span of 30 ~ 350 m) occupy an increasingly large proportion. However, in the past few years, excessive deflection at the mid span and cracks in the box girders have commonly appeared in some long-span prestressed concrete box girder bridges after a period of operation, reducing the serviceability and durability of the bridges. The causes of cracks and excessive deflection are still not clear.

As shown in literature [1-3], the girder downwarping mostly associated with the beam body cracking, cracking of the beam body accelerated the downwarping of middle unit, and both influence each other. The relationship between excessive deflection at the mid span and cracks in the box girders are as shown in fig.1. In addition, the beam body cracking not only cause the overall stiffness decreases but also lead to prestress loss, and influence the shrinkage and the creep of concrete, and change Section properties, and continue to exacerbate the generate and develop of cracks. So after the beam body cracking, the structure downwarping will increase.

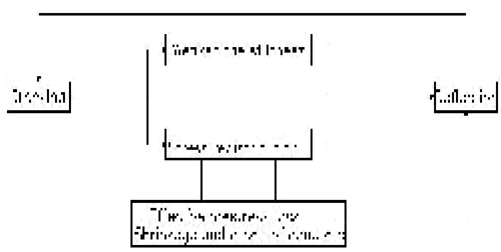

Figure 1. Relationship between cracking and deflection

Up to the present, the shortage of system investigation about cracking and deflection in domestic. Such as the shrinkage and creep of concrete, the prestress loss of prestressd concrete in construction stage, crack design and deformation calculation of box girder are both not mature enough in theory. These issue are bring technical difficulties to the long-span prestressed concrete box girder bridges in design, construction and operation.

This article through using the finite element software Midas civil and the engineering of Bai La Zai first four-wire bridges to establishment of 3D entity model of prestressed concrete continuous girder bridges in cantilever construction stage. To find out the relationship between "the effective prestress loss" and "disease of beam body" on the cantilever construction stage of continuous girder bridge. From the aspects of "friction loss, loss of anchorage, loss of stress by the elastic of concrete and loss of stress caused by shrinkage and creep of concrete“ to explore the loss of prestress on the cantilever construction stage.

2. Analysis in Theory

Prestressed concrete continuous girder bridge often adopts the hanging basket cantilever construction, that is using the hanging basket balanced pouring concrete beam on both sides of the pier column symmetry (the length of each segment is 2 ~ 5m), and when finished each segment, and after the strength of concrete achieving the required strength will be prestressed tensioning and anchoring. And then move forward the construction hanging basket, until the cantilever beam segment finished.

In china, the prestress loss of continuous girder bridge would happen in the period from the prestress steel rebar stretching in cantilever construction to service stage. And the prestress loss includes 6 types in the CODE FOR DESIGN OF REINFORCED CONCRETE AND PRESTRESSED CONCRETE HIGHWAY BRIDGES AND CULVERTS [S] (Beijing: China Communications Press,2004). However, this article is from the four aspects of this:

Firstly, the stress loss caused by friction between prestressed rebar and the wall of pipes. The friction loss refers to the phenomenon that when the post tension method is used to stress reinforcement the friction existing between the prestressed rebar and the surrounding wall of pipes, and the stress of the prestressed steel bar will reduce gradually with the increase of the distance from the tensioning end.

Secondly, loss of anchorage ---- the stress loss because of the deformed anchorage, the reinforcement shrinkage and the joint compression. When tendons are stretched and anchored, the anchorage device is deformed, gaps are pressed closer and the inward shrinkage of reinforcement happens.

Thirdly, loss of stress by the elastic compression of concrete. When the concrete was compressed by prestressing and deforms, there would appear the compression strain $\varepsilon p=\varepsilon c$ so as to cause the loss of stress, that is the loss of stress of concrete elastic compression.

Fourthly, loss of stress due to shrinkage and creep of concrete. The shrinkage and creep of concrete will both make the length of members shorter so as to cause the loss of stress. It should be noted that there exists the mutual impact among the concrete shrinkage and the loss of creeping stress and the loss of relaxation stress of rebar. Nowadays, the method of separately computing the single factor needs to be improved,

In view of the above reasons, to research the prestressed concrete continuous girder bridge in cantilever construction process due to friction loss, loss of anchorage, loss of stress by the elastic of concrete and loss of stress caused by shrinkage and creep of concrete is very necessary. And in order to find out the relationship between the effective prestress loss and disease of beam body on the cantilever construction stage of continuous girder bridge.

This article through using the finite element software Midas civil and the engineering of Bai La Zai first four-wire bridge to establishment of 3D entity model of prestressed concrete continuous girder bridges in cantilever construction stage. To explore the relationship between the elastic compression of concrete and the loss of prestress on the cantilever construction stage. Provide suggestion for the design of prestressed concrete continuous beam bridge, the construction stage and prevention and treatment the disease at the stage of operation. What's more, the theoretical achievements not only give a way to control the extent of cracking and deflection but also to offer theoretical foundations for further research.

3. Project Overview

Bai La Zai first four-wire bridge (between 0# pier and 3#pier) is three span prestressd concrete continuous girder bridge. And adopt the hanging basket cantilever construction to building the bridge. The arrange of the span is 32.75+48+32.75=113.5 m, the distance between the side of the pier-centerline and the end of the beam is 0.75 m, the main-pier is 2# and 3#, the panoramic of the continuous girder bridge is as shown in fig.2. The amount of the T beam which use hanging basket cantilever construction to pour concrete is 24 segment (apart from 0# and finished segment). In addition, the materials of prestressd concrete continuous girder bridge include the high-strength concrete and prestressed steel rebar. The requirement and characteristics of materials are presented as follows.

Firstly, Concrete: high strength, sufficient load-carrying capacity, and the strength of concrete should be over 50, quick hardening and early strength required for quick construction, small shrinkage and creep, large effective prestress and high efficiency.

Secondly, Prestressed reinforcement: high strength, sufficient load-carrying capacity, and little loss of prestress due to relaxation. And the diameter φ=15.2 mm, the small wire is produced by cold working after high-quality carbon steel is treated by method of medium lead bath quench. The elastic modulus is 195 Gpa.

What's more, the tension control stress of prestressed reinforcement is 1395 Mpa. The arrange of prestressed reinforcement is as showing in fig.3. The section of pier-top is 4.0 m high, the high of the section of middle-span is 2.7 m.

In the Figure 3, NOTES:

(1) N1-N6 The box girder roof prestressed steel beam

(2) N9 Mid span roof prestressed steel beam

(3) N10-N14 The box girder of prestressed steel beam

(4) N15-N18 The box girder bottom prestressed steel beam.

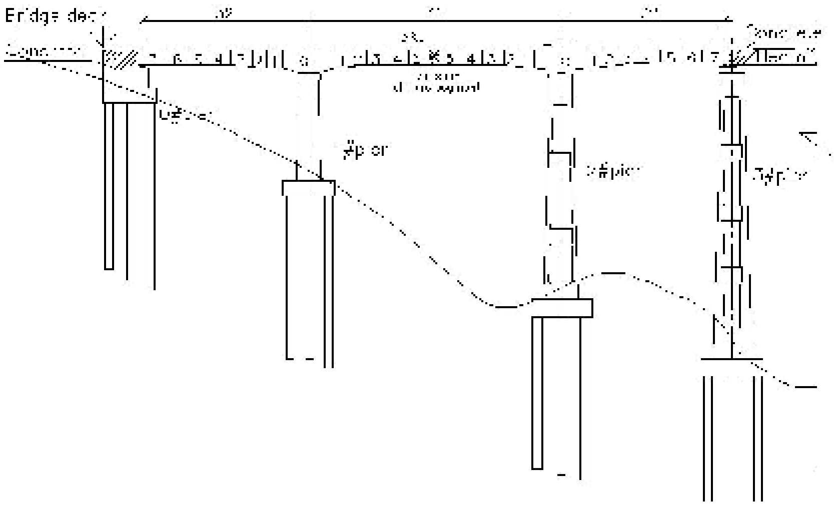

Figure 2. Continuous Girder Bridge Vertical View

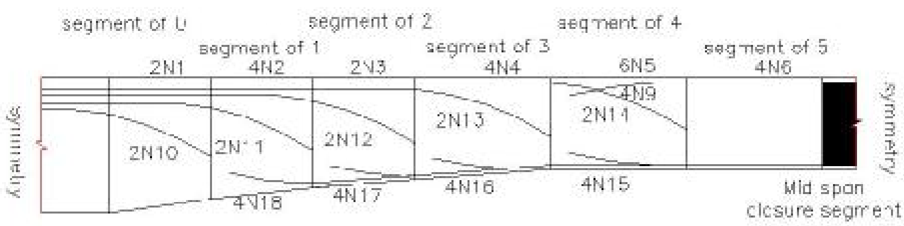

Figure 3. Concrete continuous girder bridgeprestressed steel beam layout

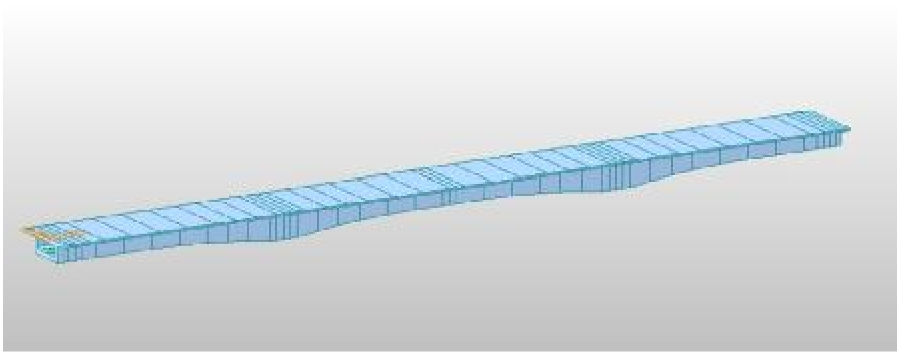

Figure 4. Midas Civil Calculation model

4. Computational Analysis

Through use the finite element software Midas civil, and also use the Midas civil beam elements which with tension compression, torsion, bending characteristics of the three-dimensional model. To computational and analysis the loss of prestress on the cantilever construction stage from four aspects, for prestressed concrete continuous beam bridge cantilever construction stage as shown in figure.4. At the same time, the cross-sectional area, the calculation model of steel beam properties, ultimate strength, pipe diameter and friction coefficient can be simulated in the Midas civil 3-D model.

At the end of computation analysis, to comparison the calculation results with the "CODE FOR DESIGN OF REINFORCED CONCRETE AND PRESTRESSED CONCRETE HIGHWAY BRIDGES AND CULVERTS" (JTG D62 2004), and find reasons for the effective prestress loss in the stage of prestressed concrete continuous beam bridge cantilever construction.

4.1. Result analysis

In view of Bai La Zai first four-wire bridge the symmetrical arrangement of longitudinal prestressed beam along the span closure section. And in 1# pier and 2# pier symmetrical cantilever construction stage of prestressed beam is also arranged symmetrically, and both ends of tension. So, we only need to analyze the value of the data of the prestress loss caused by 1# pier cantilever construction stage, and to research the relationship between the elastic compression of concrete and the loss of prestress on the

cantilever construction stage. To calculate the Midas civil continuous beam model, and get the prestress loss of prestressed reinforced construction stage, as shown in Table 1.

Table 1. The prestress loss of prestressed reinforced construction stage

Prestressed Reinforcement	Construction Stage	Control Prestress	Elastic Loss	Shrinkage and creep	Effective Prestress
N1	CS-0	1395.0	0.94	1.69	1392.37
	CS-1	1395.0	4.65	4.4	1385.95
	CS-2	1395.0	9.61	7.43	1377.96
	CS-3	1395.0	13.83	10.52	1370.65
	CS-4	1395.0	19.68	13.61	1361.71
	CS-5	1395.0	24.39	16.73	1353.88
N10	CS-0	1395.0	1.26	1.84	1391.9
	CS-1	1395.0	5.73	5.89	1383.38
	CS-2	1395.0	10.16	11.61	1373.23
	CS-3	1395.0	15.13	16.83	1363.04
	CS-4	1395.0	19.87	21.68	1353.45
	CS-5	1395.0	25.83	26.39	1342.78

It can be concluded from the above table, with the construction of prestressed concrete continuous girder bridge to promote, the transient prestress loss did not change, but because of concrete and elastic deformation caused by shrinkage and creep loss increases gradually, what's more, at the same time, relaxation of prestressing steel loss is also growing, and its development speed is faster.

5. Conclusions

For prestressed concrete continuous girder bridge, calculate the stress state of the structure of the construction phase is the premise to solve the condition of prestressed concrete continuous beam bridge web cracking and deflection of mid span. The prestress loss of prestressed concrete continuous beam bridge of 3D model calculation and analysis, focusing on the concrete elastic compression and shrinkage creep influence on prestress loss in construction stage.The results show that:

Firstly, for prestressed concrete continuous beam bridge, the accurate estimation of the size of the prestress loss and shrinkage and creep of concrete directly affects the bridge stiffness. Therefore, the prestress loss and shrinkage and creep of concrete has become the main reason for deflection of continuous prestressed concrete continuous beam bridge in the operation stage. The prestress loss of bridge deflection is more, more serious, and even cracks.

Secondly, underestimation of the relationship between the concrete shrinkage and creep and prestress loss, which is a prestressed concrete continuous girder bridge deflection under the constant cross in another reason. With the continuous prestressed concrete beam bridge cantilever construction stage of prestressed loss increased gradually. The influence of concrete creep on prestress loss and midspan deflection of mid span is gradually increasing.

All in all, through the example of the actual bridge structure analysis, it can be the reason of prestressed concrete continuous girder bridge operation of the late stage web cracking and deflection of the mid span of the construction stage is the prestress loss caused by excessive. Also, the prestress loss in construction stage have a certain impact on the box girder deflection and cracking in webs. So, through the analysis of this paper, the long-term deflection for prestressed concrete continuous girder bridge evaluation provides an effective reference, but also can provide a reference for similar projects.

References

[1] Ministry of Transport of P. R China. JTG D62 – 2004 Code for design of reinforced concrete and prestressed concrete highway bridges and culverts [S]. Beijing: China Communications Press, 2004

[2] McComac Jack C, Nelson James K. Design of reinforced concrete [M]. John Wiley & Sons, Inc, 2006

[3] Peter F Takacs Deformations in Concrete Cantilever Bridges: Observations and Theoretical Modeling. The Norwegian University of Science and Technology. Norway 2002

[4] Bazant. Z. P. Panula. L, Creep and Shrinkage Characlerization for Analyzing Prestressed Concrete Structures [S]. PCI Journal, 1980, 25(3): 86 – 122.

[5] Shi Ying, Zheng Jianqun Cracking Control of PC Continuous box Girder Bridges from the Design point of View [J]. Journal of Chongqing Jiaotong University, 2005, 24(4): 13 – 18

[6] Lü Zhitao, Pan Zuanfeng Issues in Design of Long-span Prestressed Concrete box Girder Bridges [J].China Civil Engineering Journal, 2010, 43(1): 70 – 76

[7] Wang Jian. Prediction of thermal effects, shrinkage and creep effects, and prestress losses in long-span PC box girder bridge [D]. Changsha Hunan University, 2007

[8] Peter F T. Deformation in concrete cantilever bridges observation and theoretical modeling [D]. Norway. The Norwayegian University of Science and Technology, 2002