CHEMICAL ENGINEERING TRANSACTIONS
VOL. 46, 2015
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet
Guest Editors: Peiyu Ren, Yancang Li, Huiping Song

ISBN 978-88-95608-37-2; **ISSN** 2283-9216
DOI: 10.3303/CET1546138

Analysis of the Creep after the Prestressed Concrete Continuous Bridge Finished with Different Construction Period

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Prestressed concrete continuous girder bridge often adopt the method of cantilever pouring. Due to the technical force of construction team, the construction level, the construction period and the influence of related factors, its segmental construction cycle will be difference, thus affecting the creep effect. In this paper, accordance with the construction process of two railway continuous beam bridge, through the analysis of finite element modeling discusses the influence of creep effect which cause by the construction cycle of the cantilever construction of continuous girder bridge, some conclusions have referential values for continuous beam construction.

1. Introduction

For cantilever construction of prestressed concrete continuous girder bridge(FAN Li-chu, 1988),it need a complicated process into a bridge, the construction process and construction stage become more especial for large-span bridge, and the influence of various factors during the period of construction will make the internal force and deformation of each stage change and deviate from the design value with concrete pouring process, thus bring the influence in different degrees on the bridge linetype..

To find out the segmental construction period influence on creep after the bridge finished and ensure the bridge has a good operating conditions, combined with 48 m + 80 m + 48 m and 72 m + 128 m + 72 m two railway construction process of prestressed concrete continuous girder bridge, with finite element software for simulation, The paper will explore the segmental construction period influence on creep effect when the bridge finished.

2. Analysis principle

Creep(HUI Rong-yan *et al*,1988) is the slow deformation of a material over considerable length of time at constant stress or load . Cause of creep is mainly the viscous flow of gel and slip, creep increase quickly in the early of loading. The creep of prestressed concrete structures increased the prestress loss greatly, it is extremely unfavorable for the structure.

In the Railway Bridge and Culvert Design Code(1999) , concrete creep coefficient calculation formula is as follows:

$$\varphi(t,\tau)=\beta(\tau)+0.4\beta_{\mathrm{d}}(t-\tau)+\phi_f\left[\beta_f(t)-\beta_f(\tau)\right]$$
$$\beta_a(\tau)=0.8\left[1-\frac{f\tau}{f_\infty}\right] \tag{1}$$
$$\varphi_f=\varphi_{f1}\bullet\varphi_{f2}$$

$\varphi(t,\tau)$ - creep coefficient;

$\beta\mathrm{d}(t,\tau)$ -Delayed elastic strain;

$\frac{f\tau}{f_\infty}$ - The ratio of The strength f_τ when the concrete age is τ and the concrete's final strength f_∞

φ_f - Flow Plastic coefficient;

φ_{f1} - The coefficient depends on the surrounding environment;

φ_{f2} - The coefficient depends on the thickness h of theory;

$\beta_f(t), \beta_f(\tau)$ - delay plastic strain growth. According to the concrete ages, related to the thickness of h

$\beta\mathrm{d}(t,\tau)$, $\frac{f\tau}{f_\infty}$, φ_f, φ_{f1}, φ_{f2}, $\beta_f(t)$, $\beta_f(\tau)$ Can be obtained by the corresponding form the Code (1999)

Period of the construction segment is the main influence of concrete loading age, in theory, the longer the loading age, the more compact the structure, strength is higher, the corresponding creep will be smaller.

3. The finite element analysis

3.1 The general situation of the engineering

Choosing two double line railway continuous beam bridge, its main girder cross section are single box single room variable cross-section box girder, the span are 48+80+48m and 72 +128+72 m, the edge of the bottom changes according to the quadratic parabola, concrete beam uses C50 concrete.

For 48+80+48m continuous girder bridge ,the web slope is 1:5, total length of the bridge is 177.3m, side support center to the beam end is 0.65 m, its facade, the division of cross section structure and construction segments as shown in figure 1 (a).

For 72+128+72m continuous girder bridge, total length of the bridge is 273.6 m, side support center to the beam end is 0.8 m; Thickness of the top plate is 54cm except the beam end, thickness of base plate is 48 to 225cm, and 160 cm in the end fulcrum. Main girder of the upper structure and construction segments is shown in figure 1 (b).

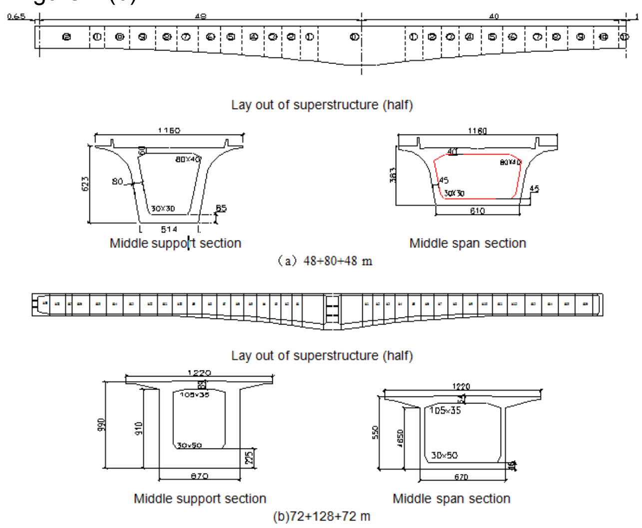


Figure 1: Main girder structure

3.2 Finite element model

The influence of the construction phase to the calculation result is a key consideration in the process of modeling. Simplified model considering the load as follows: the self-weight, cradle load, concrete wet weight, pressure weight, jacking force, prestressed load and secondary dead load, etc. The paper use finite element analysis software Doctor Bradge to analysis. The beam unit are used to simulate main girder and piers, the 48+80+48 m whole bridge is divided into 63 beam element, 64 nodes. The calculation model and division of node units as shown in figure 2(a), the 72m+128m+72m whole bridge is divided into 93 beam element, 94 nodes. The calculation model and division of node units as shown in figure 2 (b),

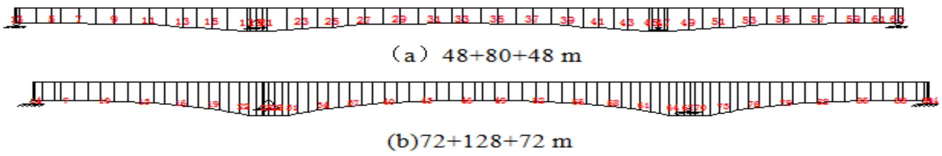


Figure 2: Finite element analysis model

3.3 Analysis program

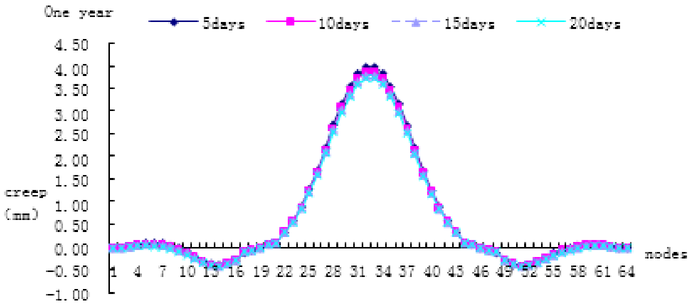
Changing the construction period of each segment, use five days to simulate grab the situation of the shortest time limit for a project construction period, 20 days to simulate the force majeure factors as the longest time limit, assume that each segment of the construction period, respectively, for five days, ten days, 15 and 20 days. Respectively analysis the two continuous girder bridge each segmental construction cycle, the influence of creep effect.

4. The Segmental construction period of a bridge influence 0n creep effect after the bridge finished

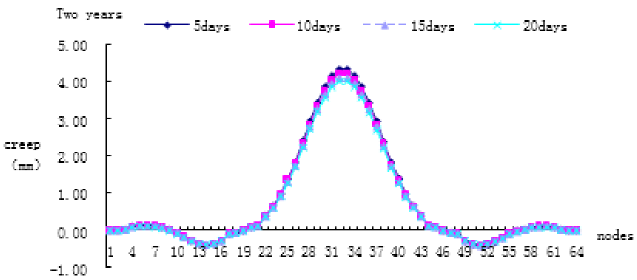
When the segmental construction cycle is different, respectively analysis the the creep effect of the tow continuous beams after the bridge finished for one year, two years and three years, ε represents the creep effect value ,the unit is: mm, Σ represents the cumulative displacement, the unit is: mm, ω represents the ratio creep effect and the cumulative displacement, the unit is: %. Each stage of the geometric model and creep effect as shown in figure 3 to figure 4, creep effect, the cumulative effect, and the ratio are shown in table 1-2.

4.1 48+80+48m Prestressed concrete continuous girder bridge

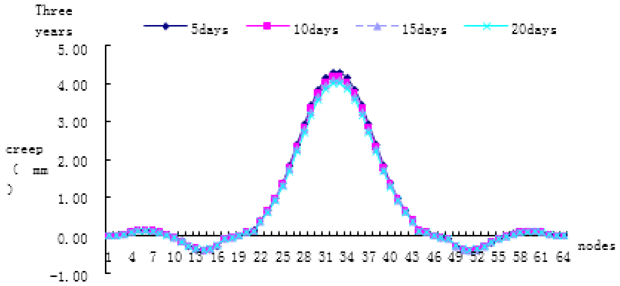
For 48+80+48m continuous beam, when the segmental construction cycle is 5 days, 10 days, 15 days and 20 days, creep effect after the bridge finished within three years as shown in figure 3, creep effect, the cumulative effect and the ratio of middle span nodes are shown in table 1.



(a) one year after the bridge finished



(b) two years after the bridge finished



(c) three years after the bridge finished

Figure 3: 48+80+48 m creep effect comparison after the bridge finished when the segment construction cycles is different

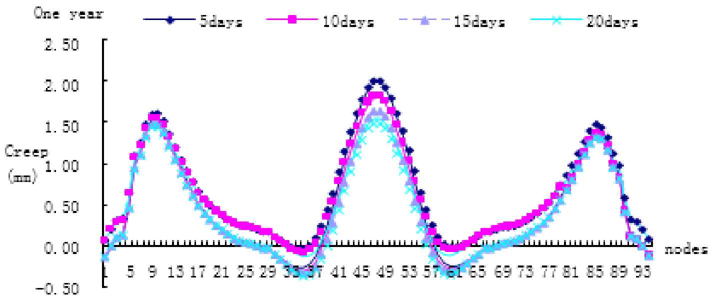
Table 1: Creep effect, the cumulative effect and the ratio of middle span nodes

Segment cycles	One year			Tow years			Three years		
	ε	Σ	ω	ε	Σ	ω	ε	Σ	ω
5days	3.966	-1.771	-223.941	4.316	1.470	293.605	3.694	4.218	87.577
10days	3.865	-1.565	-246.965	4.202	1.591	264.111	3.600	4.270	84.309
15days	3.786	-1.383	-273.753	4.104	1.701	241.270	3.519	4.320	81.458
20days	3.713	-1.123	-330.632	4.009	1.891	212.004	3.438	4.450	77.258

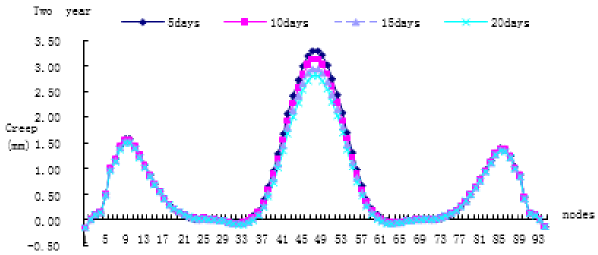
As can be seen from the chart and table, creep effect mainly influence the middle span, not obvious on the side span, near the middle support partial node downwarping.
From the figure 3 , in the midspan cross, the maximum creep were 3.966 mm and 3.713 mm, 3.865 mm and 3.786 mm in the first year when the bridge finished, reduced 2.5%, 2.0%, 1.9% with the extension of time; near the middle support ,part of the node in a negative displacement, the absolute maximum are 0.404 mm, 0.402 mm and 0.402 mm. in the side span across, the largest creep were 0.081mm, 0.064mm, 0.051mm, 0.037mm, Visible with the extension of construction period, the side span creep effect has been reduced, and it is far less than the middle span
In the second year after the bridge finished, the maximum creep were 4.316 mm and 4.202 mm,4.104 mm and 4.009mm, reduced 2.6%, 2.3%, 2.3% with the extension of time; Similar to the first year.
In the third year after the bridge finished, the maximum creep were 3.694 mm and 3.600 mm,3.519 mm and 3.438mm, reduced 2.5%, 2.3%, 2.3% ;in the side span across, the creep is not changing much.
The cumulative effect of all nodes in the first year is negative, in the second year, the third year, it is positive. with the extension of construction period, in the first year the proportion absolute value is increasing, but falling in the second and third year.

4.2 72m+128m+72m Prestressed concrete continuous girder bridge

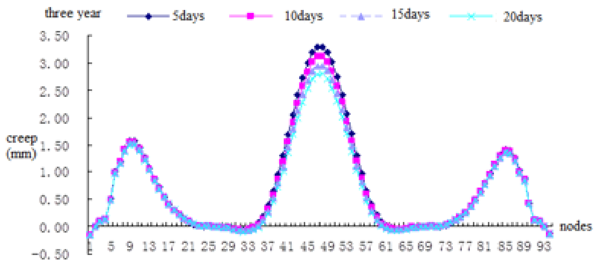
For 48+80+48m continuous beam, when the segmental construction cycle changes the creep effect after the bridge finished within three years as shown in figure 4, creep effect, the cumulative effect and the ratio of middle span nodes are shown in table 2.



(a) one year after the bridge finished



(b) two years after the bridge finished



(c) three years after the bridge finished

Figure 4: 72+128+72 m creep effect comparison after the bridge finished when the segment construction cycles is different

Table 2: Creep effect, the cumulative effect and the ratio of middle span nodes

Segment cycles	One year			Tow years			Three years		
	ε	$\sum$	ω	ε	$\sum$	ω	ε	$\sum$	ω
5days	2.000	-12.100	-16.529	3.290	-11.390	-28.885	3.018	-10.660	-28.311
10days	1.805	-11.720	-15.401	3.105	-11.110	-27.948	2.896	-10.430	-27.766
15days	1.637	-11.330	-14.448	2.942	-10.800	-27.241	2.779	-10.170	-27.325
20days	1.497	-11.140	-13.438	2.795	-10.670	-26.195	2.665	-10.080	-26.438

From the table above, the creep effect of the middle and side span mainly manifest as arched for prestressed concrete continuous girder bridge, the extent to different construction period has obvious regularity.
From figure 4, the maximum creep in the midspan cross were 2.000 mm, 1.805 mm and 1.637 mm and 1.497 mm ,with the extension of time it reduces by 9.8%, 9.3%, 8.5%; near the middle support , part of the nodes are in a negative displacement, the absolute maximum extend over time increase 13.8%, 11.8% and 8.2%.
In the second year, when the cantilever construction pouring and curing time is 5 days, 10 days, 15 days, 20 days, the maximum creep effect are 3.290 mm, 3.105 mm, 2.942 mm and 2.795 mm, with the extension of time it reduces by 5.6%, 5.3%, 5.0%, Compared with the first years the damping becomes narrow; The creep effect of midspan near the support become positive; Creep in the side span changes not obvious.
In the third year, from figure 4, the largest creep are: 3.018 mm, 2.896 mm and 2.779 mm and 2.665 mm, with the extension of time it reduces by 4%, 3.3% and 4.1%; Creep effect in the side span has a little change.
With the extension of construction period, the ratio are decreasing, the creep ratio of the midspan is not more than 30% in three years; but in the side span the creep ratio over than 50%, it shows that the creep effect influence much on the side span; Near the middle support, the ratio of nodes that have negative deflection is largest the first year, decreasing in the second and third years, and the change range from -2.007% to -7.321%.

5. Conclusions

(1) By changing segment casting construction period, the pouring and curing time is 5 days, 10 days, 15 days and 20 days, the analysis results shows that for 48 +80+48m continuous beam arch camber phenomenon mainly concentrated in the midspan , The ratio of the largest creep value and the length is 1/18500, side span arch phenomenon is not obvious, and there are part of the beam section near the support in the downwarping

state; For 72 +128+72m continuous beam arch camber phenomenon concentrated in the middle and side span, The ratio of the largest creep value and the length is 1/39000; that shows that when the span increases, the midspan creep effect weakened.

(2) Different construction period within three years the influence of the creep effect deformation are mainly concentrated in the middle span, the impact on the side span is not obvious; for 48+80+48m continuous beam, the variation range of the maximum creep effect is 1.9% ~ 2.5%, for 72+128+72m continuous beam, the maximum creep effect differ 10% in the first years, about 4% in the second year, the third year about 4%; Showing that when the span increases the effect of construction cycle reinforces.

(3) After the bridge finished, creep effect value has improved compared with the the first year, but it reduces in the third year, creep development trend does not change with the length of span.

(4) The ratio decreases with the extension of construction period. For 48+80+48m continuous beam, the creep effect many times of the the cumulative effect in the first year, the second and third year more than half of the cumulative effect; for 72+128 +72m, midspan nodes in the three years the creep effect absolute value is not more than 30% of the total cumulative effect, showing the creep effect of small span continuous beam bridge has a greater influence on the linear and the long-span affected less.

(5) Creep effects is good for linear to some extent, because creep will offset gravity and live load deflection, but it also cause excessive driving comfort if the arch camber is big, so the creep effect should be controlled in a reasonable range, for different span continuous beam, control construction cycle is an economic, reasonable and convenient way of controling the linear.

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