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Research Article

Prestressed concrete continuous rigid frame bridge closure segments jacking force calculation and analysis

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Abstract: Prestressed concrete continuous rigid frame bridge in the completion of system transformation, the late creep and shrinkage of concrete combined with cooling effect between the two pier girder has a tendency to shorten, Forced to cross the pillar top displacement direction, the bottom of the pier top and pier produce bigger bending moment, Is limited by fibre concrete girders at the same time, the tensile stress inside the structure, the structural damage. Therefore, after the final closure for the side span, across different before the final closure of the cantilever end on a horizontal thrust, make the bridge produces a deviation to resist the displacement, is beneficial to late bridge stress, increase the safety of the structure. This article is based on a continuous rigid frame bridge under construction in chongqing construction present situation, in accordance with the requirements of design drawings, by establishing a finite element model, Calculation and analysis to determine which span closure jacking force value, Provide a theoretical basis to guide the construction.
Keywords: Continuous rigid frame bridge; Closure segments; jacking force; The finite element

INTRODUCTION

The bridge superstructure (62 + 116 + 62) m for prestressed concrete continuous rigid frame system, In box girder base beam 7 m high, across and end beam is 2.8 m high, high beam according to 1.8 parabola changes; Cross section for the single box single room straight box girder web, to 12 m wide box girder roof, floor 6.6 m wide, cantilever length is 2.7 m; 0 # beam section thickness of the roof and floor is 100 cm, the thickness of the web is 100 cm; Other thickness of roof beams to 28 cm, 100 cm from the base of the cantilever plate thickness according to the parabola changes from 1.8 parts of 30 cm across. The 1 # beam segment to 8 # web 70 cm thick section beam, 10 # beam segment to 15 # web 50 cm thick section beam, 9 # beam segment for the web transition section, box girder by 3% transverse slope inclined roof, satisfies the requirement of bridge deck transverse slope.

The upper structure every "T" Consists of 0 # beam segment and 14 double beam segments, Among them, 0 # beam segment, a total of 12 m long, cast-in-situ construction on the pier top bracket, 1 # ~ 10 # beam segment length of 3.5 m, 11 # ~ 14 # beam segment length of 4 m; Edge across different closure segments and the closure segments length are 2.0 m; Bridge to the curve, the radius of 1000 m; The whole bridge along the big range direction set longitudinal slope of 2.581%.

The pier top displacement and the relationship between the thrust

Such as structural finite element model (as shown in figure 1), in the largest cantilever construction cases(before the midspan closure), Give the cantilever end position longitudinal horizontal force P, to eliminate the pier top horizontal displacement.

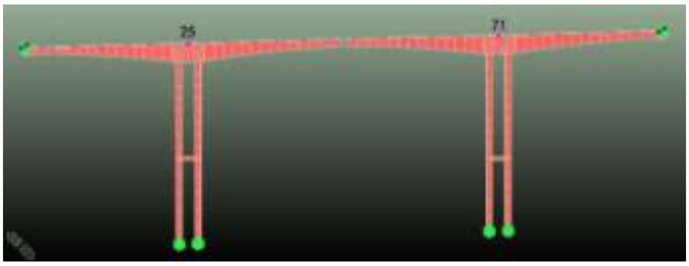

Fig-1: A bridge finite element model

At the largest cantilever end respectively applying 0 KN, 100 KN and 200 KN, 300 KN of thrust, Two 0 # beam segment center node (25 #, 71 # node)horizontal displacement are shown in table 1.

Table-1: Different under the action of jacking force, the level of the corresponding node displacement (mm) (the final closure temperature difference of 0° C)

Node number / Jacking force	25#	71#
0KN	4.10	-2.89
100KN	-0.01	1.04
200KN	-4.26	5.11
300KN	-8.60	9.26

Can be seen from table 1, The node displacement size and pushing force change is a linear relationship, Per 100 kn of thrust, 25 # nodes of horizontal displacement is 4.2 mm, the horizontal displacement of 71 # node is 4.1 mm. With the relationship between the node displacement and jacking force, can carry out jacking force optimization calculation and the analysis of the influence of temperature[1-3].

CALCULATION OF THE THRUST

The effects of shrinkage and creep effect for jacking force

In determining the bridge in operation after a period of time due to shrinkage and creep effects the actual amount pusher, we need to consider the following two factors:

- The theoretical value of jacking force is a long-term shrinkage and creep effect caused by the longitudinal horizontal displacement, Structure finite element model is to simulate the ideal state of bridge structure, But the actual Bridges in side span and bearing position of displacement will be affected by the friction resistance.
- From the bridge construction complete to creep and shrinkage will take a long time, If pushing 100% shrinkage and creep effect value in advance, This bridge in operation stage, will produce a reverse big displacement, the displacement is caused by jacking force, And combined with the role of live load, bridge piers will produce great negative bending moment, are more likely to cause cracking. In addition, the double thin-wall piers is commonly flexible piers, design would allow a certain amount of longitudinal displacement.

According to engineering experience, generally only need to push in advance 60% of the actual shrinkage and creep value. Considering the bridge after ten years of operating, 0 # beam segment center node displacement are shown in table 2.

Table-2: Bridge after ten years of operation, the corresponding node horizontal displacement (mm) (not pushing, closure temperature difference of 0° C)

Node number	Ten years accumulated displacement value	60% of the cumulative displacement value for ten years
25#	21.87	13.12
71#	-20.54	12.32

Under the effect of jacking force Pi, the amount of horizontal displacement of each node can be calculated by type (1):

$\delta_i = \delta_{1\text{-}i} \times P_i$ (1)

$\delta_i = 60\% * \delta_{10}$ (2)

namely $P_i = \delta_i / \delta_{1\text{-}i}$ (3)

In the equations: δ_i represents the horizontal displacement of each node generated by Pushing; $\delta_{1\text{-}i}$ represents the unit of all nodes under the influence of jacking force horizontal displacement; P_i represents the jacking force; δ_{10} representative nodes because of the bridge operation ten years accumulated horizontal displacement.

Through the table 1 and table 2 and the formula (3), can be calculated:

$P_{25}=\delta_{25}/\delta_{1\text{-}25}=-21.87\times0.6/0.042=-313KN$;

$P71=\delta_{71}/\delta_{1\text{-}71}=20.54\times0.6/0.041=301KN$;

In order to facilitate the construction, In front of the midspan fold, on two cantilever end position of jacking force, Across the closure segments of jacking force of the two should be equal. namely $|P_{25}| = P_{71}$. Thus pushing force $P=(|P_{25}|+P_{71})/2=307KN$。

The influence of temperature on the jacking force

In the real conditions, the actual closure and design closure temperature often have certain difference, Because the bridge after the final closure, Temperature rise is good for the structure, The influence of temperature lowering the structure is bad, So try to choose the final closure at low temperature. To analyze after the final closure at the design temperature, cooling effect on the structure, calculated the 10 cooling value of 0 # beam segment center horizontal displacement of the nodes, the results are shown in table 3.

Table-3: After the final closure temperature is reduced, horizontal displacement of node (mm)

Node number / Cool the temperature difference	25#	71#
0	0	0
-1	0.58	-0.59
-2	1.16	-1.18
-3	1.74	-1.78
-4	2.32	-2.37
-5	2.90	-2.96
-6	3.49	-3.55
-7	4.07	-4.14
-8	4.65	-4.74
-9	5.23	-5.33
-10	5.81	-5.92

From table 3 can be seen, Temperature has a linear proportional relationship with the horizontal displacement of the nodes, So if the final closure temperature and the design temperature is not equal, will make the horizontal displacement of each node, it must be put ahead of jacking force, to eliminate the effect of the final closure temperature difference. Closure deformation produced by the final closure temperature difference, it is necessary to optimize the jacking force is:

$P_{i\Delta T} = \Delta T \times \delta_{i\Delta T} \div \delta_{1-i}$ （4）

In the equations:

$P_{i\Delta T}$ represents the because of the final closure temperature needed to adjust the jacking force of all nodes (kN)

ΔT represents the difference between the design closure temperature and real closure temperature (°C)

$\delta_{i\Delta T}$ represents the heating or cooling 1°C a horizontal displacement of each node (mm) (structure temperature decrease in contrast to the effect of temperature)

δ_{1-i} represents the unit horizontal jacking force under the action of the horizontal displacement of the node

From table 3 and the formula (4):

$P_{25\Delta T} = \Delta T \times \delta_{25\Delta T} \div \delta_{1-25} = 0.58 \times \Delta T / 0.042 = 13.8\Delta T$

$P_{71\Delta T} = \Delta T \times \delta_{71\Delta T} \div \delta_{1-71} = 0.59 \times \Delta T / 0.041 = 14.4\Delta T$

For the convenience of construction, in the two cross closure segments of jacking force should be equal, Namely

$|P_{25\Delta T}| = |P_{71\Delta T}|, P_{\Delta T} = (P25\Delta T + P71\Delta T)/2 = 14.1\Delta T.$

The final closure jacking force calculation in the end

Comprehensive considering the system transformation, concrete shrinkage and creep, the final closure temperature and other influence factors. The Jacking force final computation formula is: Pi-Jacking force = $P_i \pm P_{i\Delta T}$ （5）

In accordance with the design drawings, design fold temperature is 18 °C, The bridge closure time tentatively scheduled for July and August. According to the actual final closure temperature, jacking force by shown in the table below:

The actual temperature（°C）	The final closure temperature difference（°C）	Effect of temperature difference（kN）	Jacking force（kN）
24	6	85	392
25	7	99	406
26	8	113	420
27	9	127	434
28	10	141	448
29	11	155	462
30	12	169	476
31	13	183	490

CONCLUSION

Through the above the final closure for the prestressed concrete continuous rigid frame bridge jacking force setting method theory of analysis and engineering examples in the implementation and verification, Illustrates the calculation of the thrust value of reasonable analysis method is scientific and accuracy, For similar bridge jacking force calculation and analysis has certain reference significance.

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