The Research on Force Condition Checking Calculation of the Girder in Construction with Bridge Girder Erection Machine

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Abstract. In this paper, combined with the construction of a highway bridge across the railway Beijing-Guangzhou, discusses how to check the process of the construction with bridge girder erection machine. The contents of the bridge construction which need to be calculated are checked according to the characteristics of the structure and construction machine, and the stress state of the structure in construction is gotten, which can provide the theory support for the girder construction.

Introduction

With the constant improvement of railway and highway transportation system in China, railway and highway mileage have been raised sharply, and the transport networks have become increasingly complex in China. In the transportation route planning, there will be more and more intersection between the roads and railways, as the artery of national economy, to ensure the railway in normal operation is priority than other things. So the research on force condition checking calculation of the girder in construction with bridge girder erection machine is very important to ensure the safety of the railways. This paper introduces the research work on force condition checking calculation of the girder in construction with bridge girder erection machine which based on the girder construction of the bridge of an expressway across the Beijing-Guangzhou railway [1-6].

The Structure of Bridge Girder Erection Machine

The bridge girder erection machine of type GT40/130 was used in the erection of the bridge girder. The transverse coupling systems and diagonal bridging should be installed in the front, middle and back between the two Longitudinal beams of bridge girder erection machine to ensure stability and firm. The structure is shown in Fig.1.
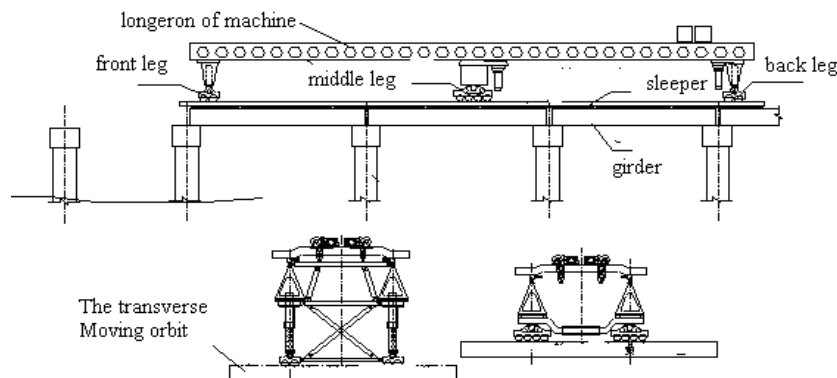

Fig. 1 The Structure of the Bridge Girder Erection Machine

The Contents of Checking Calculation of the Girder in Construction

First of all, a theoretical calculation of girder construction system for theoretical data should be carried out. According to the characteristics of the project and the structure of the bridge machine, the following contents in construction which are need checked are identified:

①Load-carrying capability of the girder should be checked calculated in construction

②Load-carrying capability of the pier should be checked calculated in construction

③The safety check calculation of crossing a span in the cantilever gesture should be checked

④The safety check calculation of the lateral movement orbit in the construction of side span beam should be checked

The Checking Calculation on the Load-carrying Capability of the Girder

In the construction stage, the simply supported girders will bear loads settled by the bridge girder erection machine, so in this condition the load-carrying capability of the simply supported girder should be checked in order to meet the requires of the construction. This condition is shown in Fig.2

There are two kinds of loads should be taken into account: concentrated load and uniformly distributed load.

1) Under the action of concentrated load

All the girders are simply supported in construction stage, when the loads of bridge girder erection machine located in the middle of the 35m span is the most unfavorable condition.

$$P=295.29kN \tag{1}$$

Tab. 1 Beam Stress Table under the Concentrated Load

Bending moment M (kN.m)		Stress (MPa)		
Position	Bending moment of section	Position	Top of section	Bottom of section
Middle of span	2478.2	Middle of span	9.23	-0.92

2) Under the action of uniformly distributed load.

The edge beams are expressed as uniformly distributed load, which located at the middle span of 35m girders and the side span of 22m girders.

$$P(side\ girder)＝1020kN \tag{2}$$

$$q=1020/ (4×35) =7.5kN/m \tag{3}$$

Tab. 2 Beam Stress Table under Uniformly Distributed Load

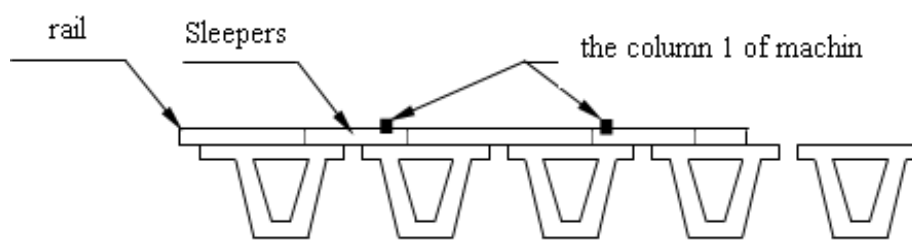| Bending moment M(kN.m)		Stress (MPa)		
Position	Bending moment of section	Position	Top of section	Bottom of section
Middle of span	1385.01	Middle of span	7.51	1.83

Fig. 2 The Diagram when Bridge Crane over Hole

The calculation result shows that the load-carrying capability of the girder can meet the requirements of the erection construction. But it is important to note that load of bridge girder erection machine should be settled by the four pieces of beams to ensure that the load of each beam does not exceed 1/3 of the total weight.

The Checking Calculation on the Load-carrying Capability of the Pier

It does not need to carry on the checking calculation if beam erection on double column piers. But pier will be in a state of eccentric compression if beam erection on single column pier. The most adverse state of eccentric compression is in the erection condition of 3 and 1 piece of girder. The calculation was carried on and the result shows that the load-carrying capability of the pier can meet the requirements of the construction.

The Safety Check Calculation of Crossing a Span in the Cantilever Gesture

1) The weight of different parts:
W1—the weight of front leg, 4.2/2=2.1t =21kN
W2—the weight of transverse guide beam, 4.9+1.5×2+6=13.9t =139kN
q—uniformly distributed load, 5kN/m
Q—the weight of beam, 100/2=50t =500kN
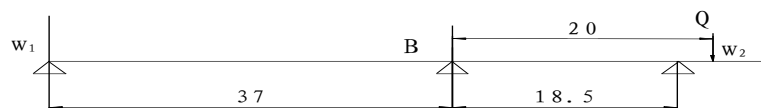
Fig. 3 Force Diagram when Bridge Crane over Hole

2) Overturning moment:

$$M_q =W1×37+ql2 /2=2.5×37+0.5×38.52/2=463tm = 4630kN.m \tag{4}$$

3) Equilibrium moment:
When RB=0,

$$M_p =18.5×W2 /2+ql2/3+ (Q+ W2 /2) ×20 \tag{5}$$

$$=18.5×6.95+0.5×26.52/2+56.95×20=1443tm =14430kN.m$$

4) Stability factor:

$$n=M_p /M_q=14430/4630=3.1>1.3 \tag{6}$$

The Safety Check Calculation of the Lateral Movement Orbit in the Construction of Side Span Beam

1) The cantilever size of lateral movement orbit on the position of front and middle strong point:
The distance between centers of concrete beam and column is 900mm, the wheel center 800mm.
Front strong point: the distance between mat stone and the edge of capping beam: 500mm; the cantilever of walk road wheel 800mm.
Middle strong point: the width of web: 1800mm; the cantilever of walk road wheel: 400mm
2) Moment of inertia of orbital:
Front strong point: W=1471.6cm3
Middle strong point: W=1073.4 cm3
3) The force on the position of front and middle strong point:
The weight of bridge girder erection machine: 1000kN, the force in Front Strong point: 300kN, the force in middle Strong point: 700kN

Front Strong point: 690kN (single column), 345kN (single wheel); middle Strong point: 101kN (single column); 505kN (single wheel)

4) The bending moment of the cantilever in the position of Front and middle Strong point

Front Strong point: M=345×0.8 =276kN·m;

Middle Strong point: M=505×0.4 =202kN·m

5) Stress:

Material allowable stress: [σ] =210MPa

$$\text{Front Strong point: } \sigma = 27.6 \times 10^4 / 1471.6 = 187.6 \text{ MPa} < 210\text{MPa} \tag{7}$$

$$\text{Middle Strong point: } \sigma = 20.2 \times 10^4 / 1073.4 = 188.2 \text{ MPa} < 210\text{MPa} \tag{8}$$

Summary

In this paper, the checking content of girder erection is introduced by combing with the checked calculation of actual project, and through calculation and test, the conclusion is as follows:

①Load-carrying capability of the girder is checked calculated in construction

②Load-carrying capability of the pier is checked calculated in construction

③The safety calculation for crossing a span in the cantilever gesture should be checked.

④The safety calculation for the lateral movement orbit in the construction of side span beam should be checked.

The checked results show that the index can conform to the requirements of the girder construction. The work will provide a valuable reference for other girder construction with bridge girder erection machine.

Acknowledgement

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