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Feasibility Study on the Design of the Superstructure of Yuyang Bridge Based on Midas Civil

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Abstract: This study primarily utilizes the Midas Civil bridge modeling and analysis software. Initially, the bridge dimensions are designed based on the project overview and relevant specifications. The software is then used to model and analyze the overall bridge structure, applying boundary conditions and various loads, followed by load combinations. The number of prestressed steel bars is estimated based on the internal forces of the bridge model. The CDN software is employed to perform PSC (Prestressed Concrete) checks on the bridge structure. The software's various check results comply with the specifications for the bridge structure's strength, stiffness, and stability requirements.

Keywords: Midas Civil; Cantilever Casting; Prestressed; Box Girder.

1. Introduction

In recent years, bridge engineering has developed rapidly, and the application of long-span structures in high-speed railways has become very widespread [1]. In railway engineering, to meet the requirements of high-speed railways for smoothness, economy, and aesthetics, a new bridge type has emerged—the long-span prestressed concrete continuous beam-arch bridge. This bridge type consists of a prestressed concrete continuous beam, arch ribs, and hangers, forming a flexible arch and rigid beam composite structure [2-3], typically with three spans in one unit. Such bridges often use the cantilever construction method for the main beam, followed by the construction of the arch ribs and then the tensioning of the hangers [4]. At the same time, to ensure the safety and reliability of the bridge structure, conducting a feasibility analysis of the bridge design is essential and effective. Otherwise, when resonance or excessive vibration amplitudes occur, the bridge structure may fail, seriously threatening people's property and personal safety.

2. Project Overview

The designed bridge has a deck width of 13.0 meters and a main beam length of 320 meters. The main beam has two working sections: the mid-span section (beam height of 3.89 meters, web thickness of 0.4 meters) and the support section (beam height of 8.5 meters, web thickness of 0.7 meters), with variable sections from the support to the mid-span and from the mid-span to the support. C60 concrete is used for the main beam. The main beam cross-sectional dimensions are shown in Figure 1, and the geometric properties of the cross-sections are listed in Table 1.

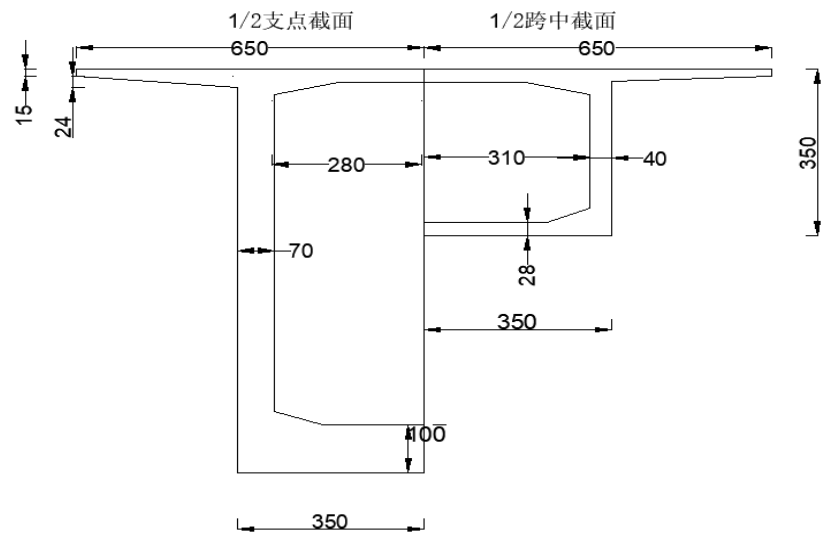

Figure 1. Cross-sectional view at the support and mid-span (unit: cm)

Table 1. Calculation Results of Section Geometric Properties

Section Location	Cross-sectional Area A (m^2)	Moment of Inertia I (m^4	Neutral Axis Height from Beam Bottom (m)
Mid-span Section	3.588	79.57	2.153
Support Section	5.993	169.56	3.726

3. Main Beam Effect Calculation

3.1. Load Cases and Load Combinations

When calculating the internal forces during the normal use stage, the Midas Civil software can be directly used. During the calculation, various unfavorable live load arrangements need to be considered. For the loading and unloading bridge loads on the track, the "moving vehicle load" method in Midas Civil can be used, allowing the software to automatically draw the internal force influence lines and determine the most unfavorable positions. The various load cases and load combinations in the model are shown in Table 2.

Table 2. Internal Force Values for Frequent Combinations in the Serviceability Limit State

Position	Control Section	Frequent Combination (all)	
		Shear Force (kN)	Bending Moment (kN·m)
I[2]	Temporary, Permanent Support	-6529.9	-23679.2
I[7]	Transition Point	-1514.2	-22067.5
I[8]	Transition Point	-1196.8	13408.0
I[24]	L/4	11649.4	-22931.7
I[49]	Transition Point	-1806.1	35486.6
I[50]	Transition Point	-1372.0	32757.2
I[52]	L/2	817.8	33933.7

4. Main Beam Service Stage Verification

4.1. Service Stage Normal Section Crack Resistance Verification

According to the formula 7.1.5-1 in the "Bridge Specifications." Maximum compressive stress in the compression zone of concrete:

Uncracked Member:

$$\sigma_{kc} + \sigma_{pt} \leq 0.5 f_{ck}$$

|Cracked Member:

$$\sigma_{cc} \leq 0.5 f_{ck}$$

For Class A prestressed concrete members, the following requirements must be met under frequent effects:

$$\sigma_{st} - \sigma_{pc} \leq 0.7 f_{tk}$$

For Class A prestressed concrete members, the following requirements must be met under quasi-permanent effects:

$$\sigma_{lt} - \sigma_{pc} \leq 0$$

During the normal use stage, the envelope diagrams for the normal section crack resistance verification of Class A prestressed concrete members in Civil Designer are shown in Figures 2 and 3.

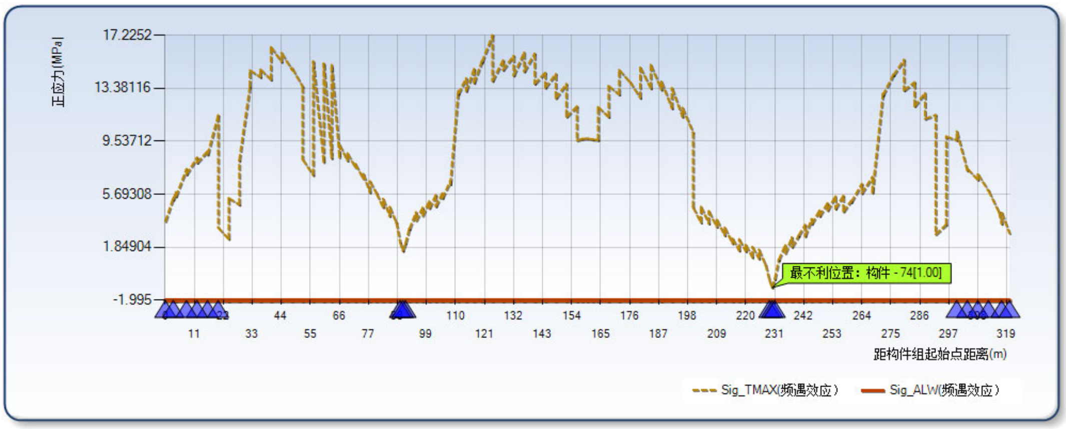

Figure 2. Envelope Diagram for Normal Section Crack Resistance Verification (Frequent - Top)

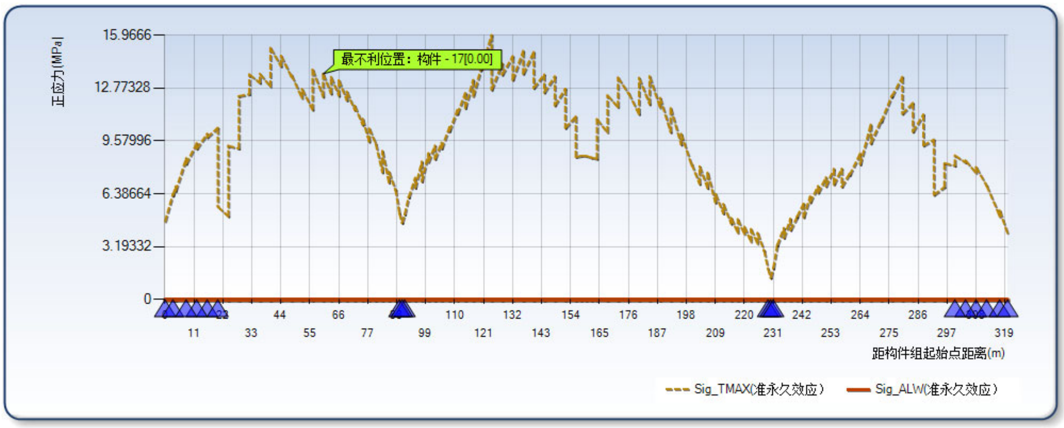

Figure 3. Envelope Diagram for Normal Section Crack Resistance Verification (Quasi-Permanent - Top)

The normal section crack resistance verification during the normal use stage should be conducted according to Article 6.3.1 of the JTG 3362-2018 specification. The verification for member 42 of Yuyang Bridge at position 0.000 is as follows:

Under frequent combination:

$\sigma_{st} = 8.177$ Mpa(compression) ; $\sigma_{pc} = -0.839$ Mpa(tension)

$$\sigma_{max} = \sigma_{st} + \sigma_{pc} = -7.33\text{Mpa(compression)}$$

$$\sigma_{alw} = -0.7 \times f_{tk} = 0.7 \times 2.850$$

$$= -1.995 \text{ Mpa(tension)}$$

$$\sigma_{max} \geq \sigma_{alw}$$

The member of Yuyang Bridge satisfies the normal section crack resistance verification under frequent combination.

Under quasi-permanent combination:

$$\sigma_{lt} = 7.459\text{Mpa(compression)};\ \sigma_{pc}$$

$$= -0.844 \text{ Mpa(tension)}$$

$$\sigma_{max} = \sigma_{lt} + \sigma_{pc} = 6.615\text{Mpa(compression))}$$

$$\sigma_{alw} = 0 \text{ Mpa (compression)）}$$

$$\sigma_{max} \geq \sigma_{alw}$$

Under quasi-permanent combination, the normal section tensile stress verification is OK. The verification process for other members of Yuyang Bridge is similar to that of member 42.

5. Conclusion

This study utilizes Midas Civil software for structural calculations and verifies the results using Civil Designer. The calculations show that while ensuring accuracy, using Midas Civil for structural calculations involves fewer units, a simple modeling method, accurate and intuitive results, and easy data extraction. Additionally, it allows for internal force calculations under various load combinations, facilitating comparisons between different results. Midas Civil has good human-computer interaction performance, making post-processing convenient, intuitive, and easy to master.

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