Construction simulation analysis of 120m continuous rigid frame bridge based on Midas Civil

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Abstract. In this paper, a three-dimensional finite element model of a continuous rigid frame bridge with a main span of 120m is established by the simulation and analysis of Midas Civil software. The deflection and stress of the main beam in each construction stage of continuous beam bridge are simulated and analyzed, which provides a reliable technical guarantee for the safe construction of the bridge.

1. Introduction
The main beam stress and line shape of the long span continuous rigid frame bridge are greatly affected by beam weight, Pre-stress, temperature, shrinkage and creep of concrete, and the construction process is complicated. All parameters in the construction process of structure deformation and stress (such as beam weight, structural stiffness, temperature field, effective Pre-stress, etc.) are exist error with the calculated values. These errors will interfere with the realization of the bridge design target in varying degrees. Therefore, large span bridge construction needs detailed and effective construction stage simulation analysis

A Pre-stressed concrete continuous rigid frame bridge with superstructure 69m + 120m + 69m is taken as the background, Its bottom structure pier adopts double thin-wall pier, and the bridge facade layout is shown in Figure 1. Design speed: 60km/h, the width of bridge is 14m, and the design load is grade —I highway. Seismic intensity: seven degrees, the basic design acceleration of design is 0.15 g.

![Figure 1. Bridge facade layout](image_url)
2. Construction program

1) Construction of the No. 0 beam section of the main bridge box girder. After the pier construction is completed, the construction of No. 0 beam section can be carried out. In order to ensure the quality of concrete pouring, the vertical structure can be layered pouring because the concrete square quantity of the 0 beam section is large and the pipe and steel bar are dense. The difference of concrete ages should be as small as possible. After the 0 section of the beam is completed, Pre-stressing is carried out and the next step is to install the rhombus basket.

2) Cantilever beam construction of the main box girder (beam section shown in Fig.2). The method of symmetrical cantilever construction is adopted in the No.1-14 box girder beam. The construction section of the cantilever beam is required to be completed, no matter in the stage of pouring, moving basket or dismantling, the construction of symmetrical balance should be strictly maintained. After the concrete placement of each beam is completed and the 90% design strength is reached, the longitudinal Pre-stressed steel bundles are tensioned first, and then the transverse and vertical Pre-stressed steel bundles are stretched.

3) Construction of cast-in-place section at the side of the main bridge. Side span on the support bracket completed once. The support should be pre-pressed to ensure safety and eliminate inelastic deformation, and according to the measured elastic deformation and construction monitoring requirements to establishment the horizontal and vertical camber.

4) Construction of the closure section of the main bridge box girder. The closure order, the closing temperature and the process of the box girder must be strictly controlled. The construction of the closing section should be arranged at the lowest temperature of the day as far as possible.

Order of side span: Dismantling the edge of the basket before closure the side span. Setting the weights on the side span of the cantilever and installing the stiffening skeleton. Pouring the concrete of closure section and unload the weight at the same time. Pre-stressed steel bundles are tensioned at the top and bottom floor after the strength of concrete reaches 90%. Remove the temporary constraint on the side span and the main pier.

3. Structural model

The Midas Civil analysis program is used in the monitoring and simulation calculation. The structural calculation is analyzed according to the spatial member structure, which is composed of the pier, the main beam and the bearing platform. Discrete graphs of structural model is shown in Figure 3. The total bridge consists of 167 units and 174 nodes. Where: the unit 1 to 83 is the main beam unit (space beam unit); the unit 101 to 180 is the pier unit (space beam element), and the unit 201 to the unit 204 is the cap unit (space beam unit).

The boundary conditions in the analysis are as follows: the two ends of the main beam are consolidated, the consolidation piers and auxiliary piers at the bottom of the cap are simulated by the movable hinge support.

There are 7 types of sections (variable section is automatically calculated by the program), and the material type is Group 2. The specific parameters are shown in Table 1 and Table 2.

| number | 1  | 2  | 3  | 4  | 5  | 6  | 7  |
|--------|----|----|----|----|----|----|----|
| location | Main pier section | Cap section | Root section of middle fulcrum | Middle fulcrum section | Section of closure segment | Left end fulcrum section | Right end fulcrum section |

Figure 2. Beam division map
| Material number | Unit type       | Material type | Elastic modulus (MPa) | Bulk density (kN/m³) | Thermal expansion coefficient 1/°C |
|-----------------|----------------|---------------|----------------------|----------------------|----------------------------------|
| 1               | Main beam      | C55           | 3.55E+04             | 25                   | 1.00E-05                         |
| 2               | Main piers and caps | C40     | 3.25E+04             | 25                   | 1.00E-05                         |

According to the design drawings and construction organization design, the whole bridge construction is divided into 58 calculation stages to simulate and the period is 264 days. The cantilever construction stage of the main bridge box girder is the key and difficult point of the whole bridge construction. Each section of the beam can be decomposed into 4 construction steps: forward basket, adjusting the elevation of vertical die, pouring concrete and tensioning Pre-stress.

The material characteristics of the main beam unit have been entered into γ=26kN/m³, The respective calculation area has been input in the cross section characteristic, so the constant load weight calculation is automatically counted.

4. Monitor the main calculation results

The structure will be impacted when the vehicle running on the bridge, the magnifying coefficient is used to simulate the structure. However, due to vehicle and bridge coupled vibration, Bridge irregularities, the impact analysis of vehicles is very complex. Based on a simplified assumption, the vehicle bridge coupling can be simplified.

4.1 Pre-camber

The design elevation of each section of the beam is calculated based on the design drawings. Consider the uncertainty of the late shrinkage and creep, residual amount of L×north/1000 by experience. The pre-camber setting of the full bridge is shown in Figure 3.

Calculation of the bridge pre-camber = (Maximum displacement of vehicle live load + maximum pedestrian load displacement)/2-Later creep displacement(30years);

The actual Pre-camber = Smooth Curve Fitting[- (min (Calculation of the bridge pre camber degree)-2×120000/1000) *Calculation of the bridge camber degree/min (Calculation of the bridge camber degree)];

Finished bridge liner=design elevation + finished bridge camber degree;

Camber degree of construction=The cumulative displacement of each node before the completion of the bridge.

**Table 2. Material parameter summary of calculation model**

| Material number | Unit type       | Material type | Elastic modulus (MPa) | Bulk density (kN/m³) | Thermal expansion coefficient 1/°C |
|-----------------|----------------|---------------|----------------------|----------------------|----------------------------------|
| 1               | Main beam      | C55           | 3.55E+04             | 25                   | 1.00E-05                         |
| 2               | Main piers and caps | C40     | 3.25E+04             | 25                   | 1.00E-05                         |

**Figure 3.** camber setting of hole bridge(unit:mm)
4.2 Stress calculation
In order to ensure the stress of the main girder in every stage of the continuous rigid frame bridge in control, the stress check is carried out for the main beam segments in the construction process, as shown in Figure 4.

(1) 1# Stress in the upper edge of main beam

(2) 1# Stress in the lower edge of main beam

(3) 5# Stress in the upper edge of main beam

(4) 5# Stress in the lower edge of main beam

(5) 9# Stress in the upper edge of main beam

(6) 9# Stress in the lower edge of main beam

(7) 13# Stress in the upper edge of main beam

(8) 13# Stress in the lower edge of main beam

(9) 14# Stress in the upper edge of main beam

(10) 14# Stress in the lower edge of main beam
4.3 Mode and frequency
20 order mode shape of vibration is calculated in this paper. The results of the first-four order natural frequencies and modes of vibration are shown in Fig. 5.

(1) first order mode shape/f=0.503 HZ
(2) second order mode shape/f=0.937 HZ
(3) third order mode shape/f=1.375 HZ
(4) fourth order mode shape/f=1.537 HZ

Figure 5. Mode shape and frequencies of each order

5. Conclusion
For large span bridges, the simulation calculation of construction is particularly important. After adjusting the parameters, the real-time calculation of construction monitoring is carried out by the
actual construction parameters. The actual value of the construction monitoring target is produced, which is used for the determination and error analysis of the installation elevation in the next stage.

On the basis of monitoring and calculation, according to the results of real-time monitoring of construction monitoring after completion of all phases of construction, the engineering monitoring unit of the project will submit the data of installation elevation, axis deviation and allowable error to the supervision unit before the next construction process. It makes the construction of the bridge orderly and provides a reliable technical support for the safe construction of the bridge.

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