Application Analysis Of Bridge Construction Monitoring And Monitoring Technology Based On BIM Technology

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Abstract: With the continuous development of the bridge construction industry, monitoring technology during bridge construction has become a research focus in the field of construction. Although relevant research is ongoing, the results of the research are not ideal. Based on BIM technology, the construction of a certain bridge was monitored by the forward calculation method and adaptive control method, and the structural stress and temperature of 10 measuring points during the bridge construction process were monitored. The actual measurement results show that the maximum stress of Y5 measuring point 31m away from the center line of the top of the bridge pier reaches 3947 MPa. The change trend of the measured stress and the theoretically calculated stress is basically the same, and the difference is controlled within the warning difference of ±2 MPa. The farther the measuring point is from the center line of the top of the pier, the lower the temperature. This shows that the application of BIM technology-based bridge construction monitoring technology in the bridge construction process can effectively monitor the structural stress and temperature of each measuring point.

1. Introduction

The production link of the construction industry usually lacks collaborative work, and the structure of bridge buildings is easily affected by various external factors, not only during the use of the bridge, but also during the bridge construction period [1-2]. The traditional construction monitoring technology gradually showed its drawbacks with its application in actual projects. At the same time, BIM technology has received widespread attention in all walks of life, combined with the current complex structure of bridge buildings and the current development status of technology and safety during construction, the analysis of the application of bridge construction monitoring technology is of great significance [3].

The research on BIM technology and bridge construction monitoring technology is the focus of everyone's attention, and there are many related studies. Akinade O O reviewed the existing literature to assess the limitations of existing CDW management tools, and conducted a qualitative focus group interview (FGI) to understand their expectations of using BIM for CDW management [4-5]. Ginzburg A considers the maturity level of BIM technology according to the Bew-Richards model implemented by BIM [6]. Weng-Fong C integrates BIM and WSN into a unique system, enabling the construction site to intuitively monitor the safety status through a color space interface, and automatically exclude any harmful gases [7]. Set up multiple wireless sensor nodes in the underground construction site to collect data on hazardous gas levels and environmental conditions (temperature and humidity) [8]. Wang Z B provided the influence formula of the mid-span position parameter of the reference line considering the influence of temperature, span and tower top elevation for the installation of the bridge main cable, and checked the stress cutting length of the boom using the forward calculation method [9-10].

The innovations of this paper are as follows: (1) Based on BIM technology, the construction of a bridge is monitored by combining the forward calculation method and the adaptive control method. (2) The farther the measuring point is from the center line of the top of the pier, the greater the structural stress. And the change trend of the measured structural stress and theoretically calculated stress is basically the same, and the difference is controlled within the warning difference. (3) Bridge construction monitoring technology based on BIM technology can effectively monitor the structural stress and temperature of each measuring point.

2. BIM Technology and Bridge Construction Monitoring Technology

2.1 Features of BIM Technology

Building Information Modeling (BIM) is based on relevant data in different stages of construction projects, and is applied in engineering around the information model and modeling process. Its characteristics can be summarized as the following points: First, the graphic elements of BIM design are specific objects corresponding to the building structure. Second, BIM uses a visual design, which can display the three-dimensional vision of the building structure. Third, BIM realizes collaborative work, including the collaboration of all stages of the project. Fourth, BIM technology is based on a unified relational database.

2.2 Bridge Construction Detection and Monitoring Technology

(1) Formal calculation method

The forward calculation method analyzes the deformation and force of the structure according to the actual construction loading sequence of the bridge structure, and can simulate the actual construction process of the bridge structure to obtain the displacement and force state of each construction stage.

(2) Adaptive control method

During bridge construction inspection, it is necessary to correct the parameter values in the calculation model according to the actual structural response during construction, and automatically adapt to the physical and mechanical laws of the structure. According to the adaptive control idea, the least square method is used to identify the parameters and analyze the error.

When the bridge construction reaches a certain stage, the measured deflection of the cantilever broken *n* stages of the constructed bridge segment is *T*. Assuming the original ideal state of the conjoined theoretical calculation deflection is β, the amount of error between the two is *Z*. The parameter error to be identified is χ, and the deflection error caused by each stage is δ. Then the residual calculation formula is shown in Formula 1:

$$\varepsilon = Z - \delta = Z - \phi\chi$$
$$Z = \phi\chi + \varepsilon \tag{1}$$

Among them, ϕ is a linear transformation matrix with an error of χ to δ.On this basis, the calculation formula of variance is shown in Formula 2:

$$W = \varepsilon^n \varepsilon = (Z - \delta)^n (Z - \delta) = (Z - \phi\chi)^n (Z - \phi\chi)$$
$$= Z^n Z - Z^n \phi\chi - \chi^n \phi Z + \chi^n \phi^n \phi\chi \tag{2}$$

When $\chi - (\phi^n \phi)^{-1} \phi^n Z = 0$, the equal sign in the above equation is true, and the variance reaches the minimum. Therefore, the least squares estimate of χ is shown in Formula 3:

$$\hat{\chi} = (\phi^n \phi)^{-1} \phi^n Z \tag{3}$$

In the elevation control of continuous bridge construction, ϕ can be calculated from the structural performance, the measured value *T* of the deflection is observed, *Z* is calculated, and the parameter error estimate is obtained, and the parameter is corrected according to the parameter error.

3. Experiments on Bridge Construction Monitoring Plan Based on BIM Technology

3.1 Monitoring Equipment

Choose a vibrating wire concrete strain gauge and a matching vibrating wire reader. All stress measuring points are equipped with temperature sensors for temperature monitoring. The resolution of temperature monitoring is less than or equal to 0.1°C.

3.2 Layout of Measuring Points

Using virtual construction technology based on BIM technology, combined with engineering experience, the measuring points of bridge construction monitoring are arranged, totaling 10 measuring points. The specific measuring point positions and corresponding strain gauge numbers and temperature sensor numbers are as follows:

Table 1. Layout and number of measuring points

Strain gauge number	Temperature sensor number	Channel number	Location description (distance from center line of pier top /m)
Y1	T1	1	-15.5
Y2	T2	2	-5
Y3	T3	3	5
Y4	T4	4	15.5
Y5	T5	5	31
Y6	T6	6	15.5
Y7	T7	7	5
Y8	T8	8	-5
Y9	T9	9	-15.5
Y10	T10	10	-31

As shown in Table 1, the strain gauge number and the temperature sensor number are based on the pipe number. The location of each strain gauge and temperature sensor is based on the distance from the top centerline of the respective pier.

4. Discussion on Application of Bridge Construction Monitoring Technology Based on BIM Technology

4.1 Stress Monitoring Results and Analysis

The construction period of the bridge is long, so it is necessary to select a pair of strain gauges and supporting reading instruments with good long-term performance, good stability and high accuracy. During bridge construction, the stress of each measuring point at the same time on a random day is monitored, and the results are as follows:

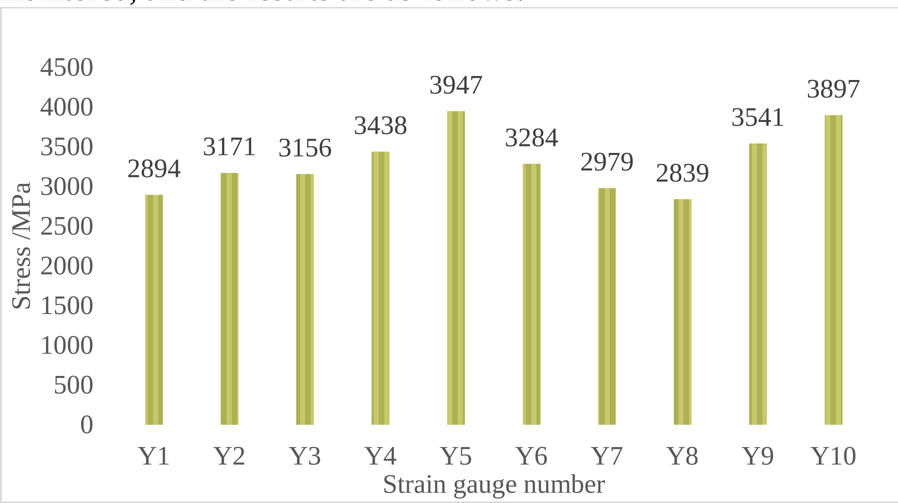

Figure 1. Strain force monitoring results of each measuring point

As shown in Figure 1, even if the monitoring is performed at the same time and on the same day, the stresses at different measuring points are still different. The magnitude of the stress has a certain relationship with the position of the measuring point. The largest stress is the Y5 measuring point, which is 31m away from the center line of the top of the bridge pier, and the stress reaches 3947 MPa. The smallest stress is the Y8 measuring point, which is 5m away from the centerline of the top of the bridge pier, and the stress is only 2839 MPa. This shows that the farther the measuring point is from the center line of the top of the pier, the greater the stress.

In order to judge whether the difference between the actual stress and the theoretical calculated stress state of the bridge at each measuring point meets the requirements, the difference between the actual measured stress and the theoretical stress is calculated, and the results are as follows:

Table 2. The stress difference of each measuring point

Strain gauge number	Measured stress /MPa	D-value	Warning value
Y1	2894	0.45	±2
Y2	3171	-0.21	±2
Y3	3156	0.88	±2
Y4	3438	-1.13	±2
Y5	3947	0.87	±2
Y6	3284	0.66	±2
Y7	2979	0.24	±2
Y8	2839	-0.39	±2
Y9	3541	1.48	±2
Y10	3897	1.05	±2

As shown in Table 2, the change trend of the measured stress and the theoretically calculated stress is basically the same, and the difference is controlled within the warning difference of ±2 MPa. The smallest difference is controlled at 0.21 MPa, which is the stress difference at the measuring point Y2. The maximum difference is controlled at 1.48 MPa, which is the stress difference at the measuring point Y9. It is possible to re-monitor or increase the monitoring intensity of the measuring points with large differences in a targeted manner, and set up more measuring points to reduce the error.

4.2 Temperature Monitoring Results and Analysis

The purpose of monitoring temperature is to compensate the temperature, eliminate the influence of temperature changes on the strain of the stress sensor, and at the same time control the temperature changes of the measuring points, and analyze the influence of temperature changes on the cantilever hanging basket construction line.

Put temperature sensors in all stress monitoring points to monitor the temperature of each measuring point at the same time on a random day during bridge construction. The results are as follows:

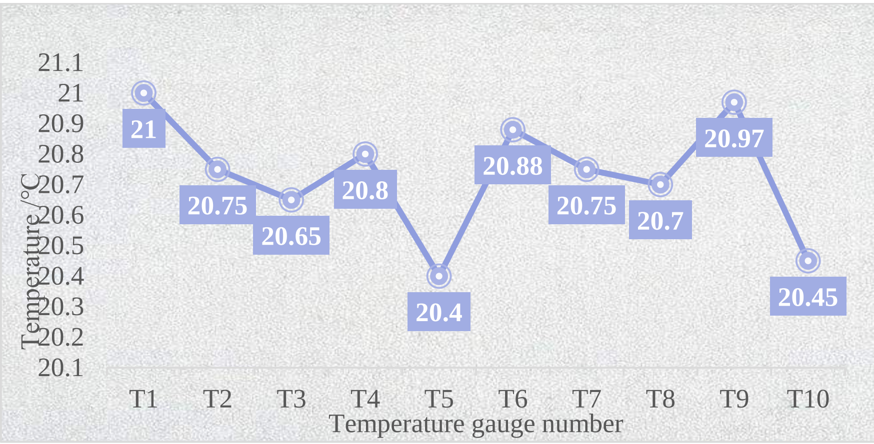

Figure 2. Temperature monitoring results of each measuring point

As shown in Figure 2, although the monitoring is performed at the same time on the same day, there are slight differences in temperature at each measuring point. There is also a certain relationship between temperature and the location of the measuring point. The lowest temperature measurement point is Y5, which is 20.4°C. The highest temperature measurement point is Y1, which is 21°C. The farther the measuring point is from the center line of the top of the pier, the lower the temperature.

Conclusions

Monitoring the structural stress and temperature during the construction of a certain bridge found that the change trend of the measured stress and the theoretical calculated stress is basically the same. This shows that the application of BIM technology-based bridge construction monitoring technology in the bridge construction process can effectively monitor structural stress and temperature.Due to limited time and knowledge, the number of measuring points set in this article is insufficient. In the next research work, the number of measuring points should be increased, and monitoring should be carried out in the early, middle and late stages of construction to ensure the validity of the monitoring data.

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