Scaffolding Support System Monitoring of Cantilever Structure Based on FBG

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ABSTRACT

Scaffolding support system of Shengjing Culture Art Center suffers from complex forces due to cantilever. Aware of the importance of early warning for structural disaster, FBG on-line sensing system has been adopted to monitor the key parts of the scaffolding for a long time. By self-developing embedded tube-encapsulated method and optimizing FBG sensing transmission line, the FBG sensor has good survival rate in the monitoring process. The monitoring results of scaffolding shows: the temperature change in the scaffolds is basically consistent with the environment; when cantilever beam is stripped, redistribution of internal force of cantilever beam causes wavelength shift of FBG strain sensor.

1 Engineering General Situation

Shengjing Culture Art Center is located in commercial core area of Shenyang Hunnan New District. The architecture of the center is made up of three auditoriums, including the comprehensive hall (1800 seats), the concert hall (1200 seats) and the multi-function hall (500 seats), as shown in Figure 1. The concert hall is a typical long-span cantilever structure. Due to complicated structure form, the bearing capacity and stability of the scaffolding in the construction process is worth more attention.

Shengjing Culture Art Center project mainly adopts full framing and buckled type scaffolding combined support system, including:

(1) The scaffolding under the main beam: horizontal steel pipe is φ48×3.0mm, 0.6m in pole spacing, 1.2m in step distance;

(2) The scaffolding under the secondary beam: horizontal steel pipe is φ48×3.0mm, 0.6m in pole spacing, 1.2m in step distance;

(3) Inclined bracing part: inclined bracing spacing is 2.4m;

(4) Scissors bracing part: double-layer horizontal scissors braceing set on the top

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and bottom with strengthening truss is set per 6m;

(5) Base part: plate area is 5000mm^2, 10mm in thickness.

Fig. 1 Architectural effect figures of Shengjing Culture Art Center

2 Monitoring Content

Shengjing Culture Art Center engineering monitoring object: 1$^{\#}$, 2$^{\#}$ scaffolding [1]-[4]poles position of prestressed cantilever beam in+23.200m level are as shown in Figure 2.

Strain monitoring continues throughout the prestressed concrete casting, steel strand tension and concrete formwork etc. the whole construction process. The construction conditions are as shown in Table 1.

Table 1 Construction conditions

Condition number	Date	Construction conditions
1	2012.11.03	Concrete casting of cantilever beam in +23.200m level ahead
2	2012.11.03	Concrete casting of cantilever beam in +23.200m level
3	2012.11.29	Prestressed steel strand tension of cantilever beam in +23.200m level
4	2012.12.18	Formwork, concrete casting, prestressed steel strand tension of cantilever beam in +25.600m level
5	2013.1.19	Formwork, concrete casting of cantilever slab
6	2013.3.19	Formwork, concrete casting, prestressed steel strand tension of column and roof supporting
7	2013.3.27	Form stripping of cantilever beam, slab, column in +25.600m level
8	2013.3.28	Form stripping of cantilever beam in+23.200m level
9	2013.3.30	Form stripping of cantilever beam in+23.200m level

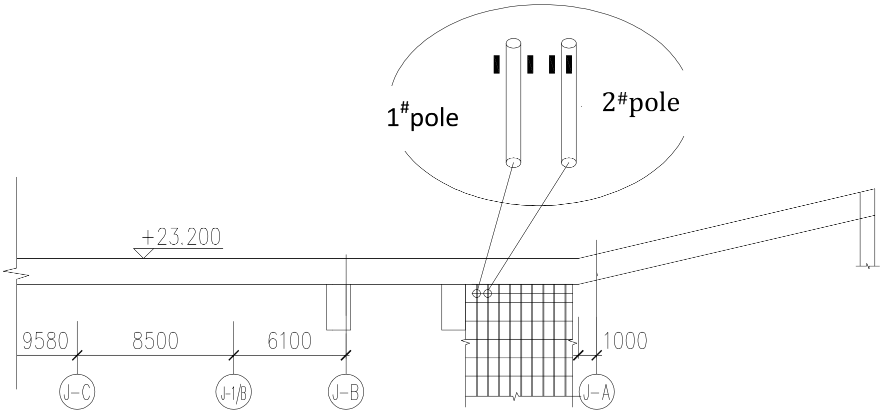

Fig. 2 FBG sensors of scaffolding in+23.200m level

Shengjing Culture Art Center engineering monitoring point：FBG[5]-[8] strain and temperature sensors are routed to monitor the strain variation of the pole cross section. 4# and 5# FBG sensors are set on 1# pole, and 1#、2#、3# FBG sensors set on 2#pole. Furthermore, 1# sensor is FBG temperature sensor, while others are FBG strain sensors. FBG sensors are pasted on the pole which has been polished and cleaned. In order to protect FBG sensor, 8 core armored cable is set, as shown in Figure 3,4.

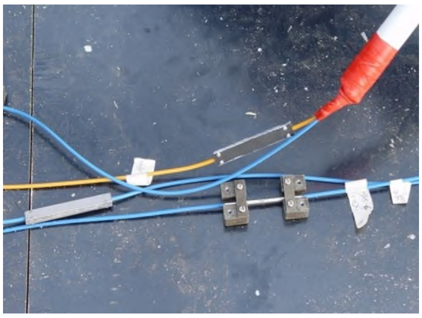

Fig. 3 FBG strain and temperature sensors

Fig. 4 Protection of FBG sensor in the scaffolding pole

3 Measurement Data Analysis

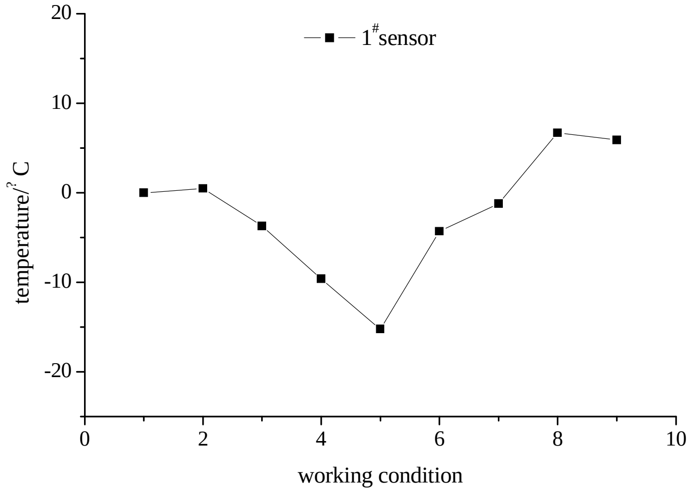

Fig. 5 FBG temperature sensor measurement data

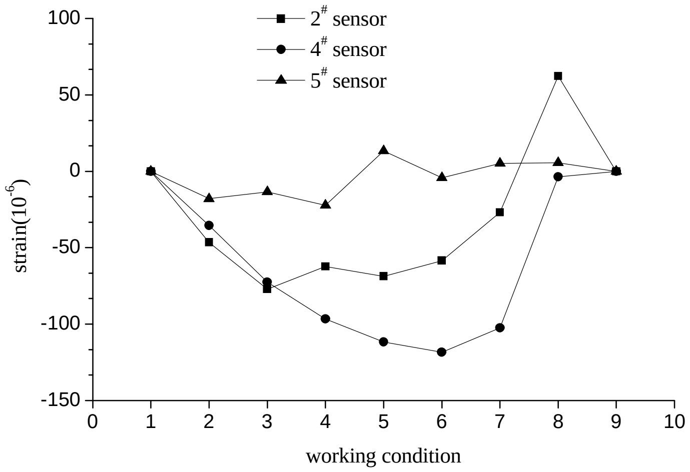

Fig. 6 FBG strain sensor measurement data

Fig. 5 is temperature change curve of FBG temperature sensor ($1^{\#}$ sensor). Temperature monitoring results show: the curve first decreases and then increases in the construction process of condition 1- 9. The minimum temperature is -15.2℃, in January 19th, the monitoring temperature consistent with ambient temperature. Meanwhile, it plays the role of temperature compensation, eliminating the effect of temperature change on wavelength shift of FBG strain sensor.

Fig. 6 is strain change curve of FBG temperature sensor ($2^{\#}$, $4^{\#}$and $5^{\#}$sensor), $3^{\#}$ sensor is damaged in the construction process. In the condition of cantilever beam concrete casting, as the vertical load increased, the cross section of scaffolding is compressed. The maximum compressive strain from $2^{\#}$ sensor monitoring is 46με. In the condition of prestressed steel strand tension in the cantilever beam, the compressive strain from $2^{\#}$ and $4^{\#}$ sensor monitoring increases to 75με, and $5^{\#}$ sensor monitoring remained unchanged. The maximum compressive strain from $4^{\#}$ sensor monitoring is 118με in the condition of formwork, concrete casting, prestressed steel strand tension in the column and roof. In the condition of stripping of cantilever beam, slab and column, the compressive strain from $2^{\#}$, $4^{\#}$ and $5^{\#}$ sensor monitoring gradually decreased due to redistribution of internal force in the cantilever beam. Especially in the condition of cantilever beam stripping in+23.200m level, the maximum tensile strain from $2^{\#}$ sensor monitoring is 62με.

In the whole process of Shengjing Culture Art Center engineering construction, the cross section strain of the scaffolding is changed as the load on the cantilever beam changes. The $1^{\#}$ and $2^{\#}$ pole of scaffolding in+23.200m level is basically in the state of compression. The compressive strain increased gradually until prestressed steel strand tension of column. The maximum compressive strain from $4^{\#}$ sensor monitoring is 118με. With the follow-up construction process, the compressive strain of the pole gradually decreases, even the pole being in tension, the maximum tensile strain from $2^{\#}$ sensor monitoring is 62με. It is concluded that: monitoring data is in a safe range.

4 Conclusions

Data reference for structural internal force reserve is provided, by using FBG sensors to carry out the whole construction process monitoring of prestressed cantilever beam supporting scaffolding. The conclusions can be drawn as follows:

(1) By adopting the method of double layer steel tube encapsulation, the calibration experiment and temperature compensation in real time has been carried out, so the monitoring data is accurate.

(2) Due to prestressing, $4^{\#}$ monitoring point compressive strain reaches maximum, 118 με. Monitoring data is in a safe range.

(3) Owing to the limit of data collected, the monitoring condition only stays in the construction stage. In order to reveal the change of load and resistance later, especially the influence of the binder curing process on the structure, it is necessary to make further research and analysis in the structure operation period.

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