The Application of FBG Sensing in Monitoring Hulanhe Bridge in Heilong Jiang Province

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1. Project Introduction

Hulanhe bridge, a major thoroughfare spanning across the Hulan river in Heilong Jiang province in northeast China, was fully commissioned in March 2002. To withstand torrent current and rapid sedimentation, the 420-meter bridge was constructed incorporating concrete and steel rebar. Its longest suspended section is 42 meters. Due to complicated construction factors, long suspension section, heavy traffic, and large seasonal temperature differential, continuous long-term structural health monitoring of the bridge is critical.

Fiber Bragg Gratings (FBG) sensors have been deployed in many engineering applications in the international arena, ranging from bridges, aerospace vehicles, composite materials, concrete, high-voltage transmission lines, to bio-chemistry. Although domestic research and development in FBG sensors have made significant progress, there is yet a comprehensive report on their engineering applications. In a province-wide effort to motivate the use of FBG sensors in bridge engineering, the Heilong Jiang Department of Transportation, with the support of Heilong Jiang Road and Bridge Company, established a FBG application program in the Harbin Institute of Technology (HIT) with the specific objective to develop bridge monitoring testbeds.

2. Engineering Application

During the construction phase from May to October, 2001, the HIT group instrumented 15 FBG sensors to the 42-meter suspended section to monitor stress and structural health during construction and after bridge commission under live traffic load. After determining the representative stress locations, we chose to install 5 FBG strain sensors on the rebar in the 2nd and 5th bridge segments, as illustrated in Fig.1. During the bridge surfacing phase, we installed 7 FBG strain sensors and 3 FBG temperature sensors on the rebar as illustrated in Fig.2. For comparison, we also installed standard electrical strain gauges at corresponding locations.

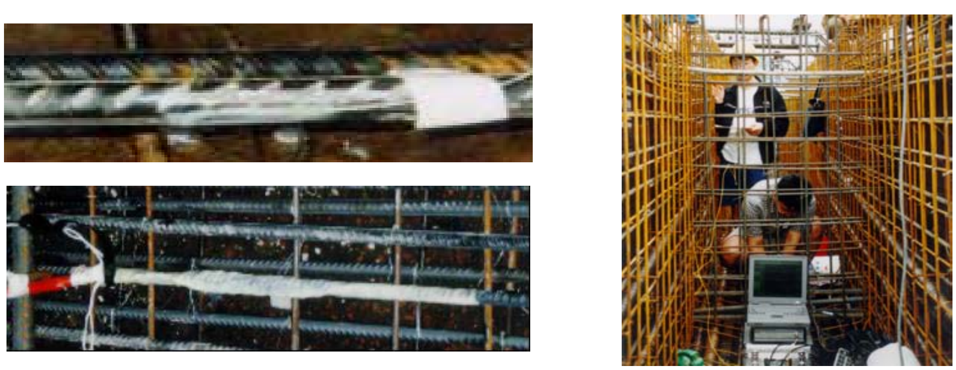


Fig.1. FBG sensor installation in bridge rebar segments.

Fig.2. FBG sensor installation on bridge surface.

The concrete was allowed to cure for 10 days. Several sensors were destroyed during construction. The remaining FBG sensors all performed well. Only one surviving electrical strain gauge had stable measurement readout. We compared the data from the FBG and electrical strain gauges by subjecting the bridge to varying stress conditions. The resulting measurements for sensor strain (με) versus bridge stress parameter plotted in Figs.3 and 4 demonstrate reliable FBG sensor measurements that correspond well with the forcing parameter; on the other hand, the electrical strain does not correlate as well.

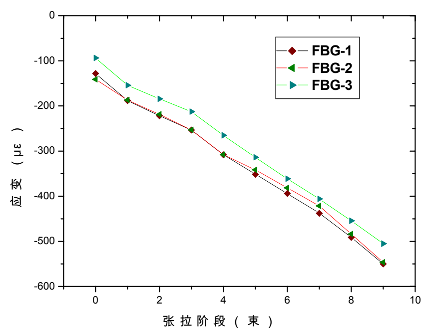


Fig.3. FBG strain versus bridge stress parameter

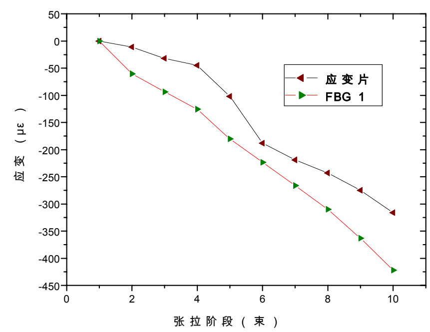
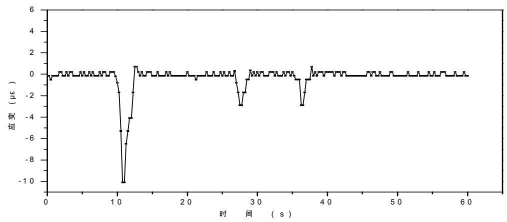


Fig.4. Comparison of strain measurements between corresponding FBG and electrical strain gauges.

In May 2002 the bridge was commission for live traffic. The FBG sensors continue to show reliable measurement, while only 1 electrical strain gauge on the bridge surface survived. Samples of the FBG strain and temperature measurements during bridge operation are shown in Figs. 5 and 6.

Fig.5. Measurement service on Hulanhe bridge (left), and FBG sensor display on Micron Optics FBG sensor interrogation system (right).



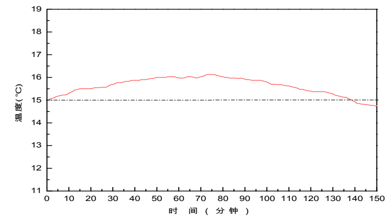


Fig.6. FBG strain sensor response in microstrain vs. seconds under traffic (left), and FBG temperature response (C) over time (minutes) (right).

3. Main Conclusion

This project was successfully carried out to install and measure FBG sensors on Hulanhe bridge in Heilong Jiang province during its construction, testing, and operational phases. Practical issues related to sensor installation, protection, and strategic positioning were taken into consideration. The results demonstrate : (1) the FBG sensors have superior stability and durability compared to the traditional electrical strain gauges, (2) FBG sensing can be an effective tool for monitor structural conditions during construction, (3) FBG sensing can provide effective measurements on long-term stress and temperature changes, and is a very useful structural health monitoring tool.