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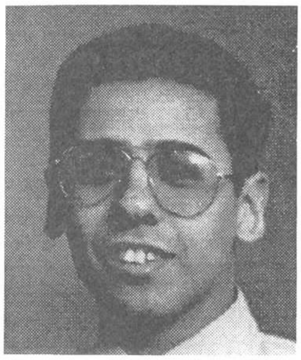

Summary

This paper discusses a comprehensive system used to monitor a highway bridge in Canada reinforced with fibre reinforced polymer (FRP). Taylor Bridge, the longest smart bridge in North America, includes four girders, the deck slab and the barrier wall reinforced using carbon and glass FRP materials. The Taylor Bridge is remotely monitored using fibre optic sensors embedded in the girders, the deck slab and the barrier wall to provide continuous information on the structural performance of the bridge. The signals obtained from the optical sensors are transmitted through a telephone line, allowing an office-based engineer to monitor the stresses and strains via a computer anywhere in the world. The paper discusses the expert system program used to reduce the data collected from the bridge into engineering information which can be used to assess the performance of the FRP material and the behaviour of the bridge. Design philosophies and construction techniques used for the bridge to handle these new materials are also presented.

Bridge Description and Design Philosophy

Due to a lack of codes and standards on the use of fibre reinforced polymer (FRP) as reinforcement and prestressing materials for concrete bridges, an experimental program included testing of a large scale model of a bridge girder totally reinforced with carbon FRP and a full scale portion of the deck slab at the University of Manitoba. The results were used to design the Taylor Bridge which opened to traffic in October 1997. To obtain continuous information on the behaviour of the bridge and the performance of FRP as reinforcement and prestressing tendons, the bridge is monitored to provide essential data for long-term behaviour durability. The Taylor Bridge is considered to be the world's largest highway bridge reinforced by FRP and monitored using fibre optic sensors. The 165.1m-long bridge consists of 40 prestressed concrete AASTO type girders. Four girders of the Taylor Bridge were prestressed by two different types of carbon fibre reinforced polymer (CFRP) material using straight and draped tendons. The girders were also reinforced by CFRP stirrups protruded from the AASHTO type girders to act in composite action with the bridge deck. A portion of the deck slab is reinforced by CFRP reinforcement. Glass fibre reinforced polymer (GFRP) was also used to reinforce the barrier wall. The barrier wall is connected to the deck slab with double headed stainless steel bars.

Monitoring of Taylor Bridge

FBG sensors were used to monitor the strains in the CFRP reinforcement of the girders and the deck slab of Taylor Bridge and in the GFRP reinforcement of the barrier wall. Selective girders reinforced by conventional steel reinforcement were also instrumented using FBG sensors. The FBG sensors used in the Taylor Bridge were fabricated by ElectroPhotonics Corporation, Toronto, Canada, and had a full range of 10,000 microstrain. The FBG sensors produced by ElectroPhotonics Corporation were used in concrete structural models and calibrated in several tests at the W. R. McQuade Laboratory at the University of Manitoba.

Preliminary results recorded by ISIS Canada researchers at the University of Manitoba are reported in this paper. The collected sensors' data addresses the following stages:

a-Construction stage
b-Load testing of the bridge
c-Long-term behaviour due to the temperature effect

Conclusion

A sophisticated network of fibre grating sensors has been successfully deployed in the Taylor Bridge, Headingley, Manitoba. The optical sensing system is used to remotely monitor the bridge structure, giving the bridge engineer a warning signal if abnormal conditions should occur. This project provides an example for the practical issues of design and implementation of such a system for long-term structural monitoring. The FBG sensors' data are processed using an interactive software package, specially implemented for this purpose. Preliminary data collected from the bridge shows that such a monitoring system can prove to be a very effective tool for the bridge engineer. Monitoring of the Taylor Bridge provides essential data related to the short-term and long-term performance of FRP material used to reinforce the bridge members. In summary, the monitoring system can provide a profile of the bridge, with detailed information on its structural behaviour, as well as the applied loads and environmental effects.