

**First Canadian Highway Bridge  
Prestressed by Carbon Fibre Strands  
and Monitored by Optical Fibre Sensors**

by

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Accepting the challenge of the future in the field of civil engineering, the City of Calgary constructed the first concrete highway bridge using six precast concrete girders prestressed by two different types of carbon fibre reinforced plastic (FRP) strands. The FRP reinforcements were used in an attempt to overcome the corrosion problems of concrete structures associated with steel, which reduces the serviceability life of bridges, especially in Canada, due to the use of de-icer applications.

The bridge is a two span continuous skew type, 22.83 and 19.23 m, located at Centre Street/Beddington trail in Calgary, Alberta, Canada, as shown in Figure (1). The bridge was constructed by Graham Construction Ltd. The bridge consists of a total of 13 bulb-tee section precast, prestressed concrete girders in each span, produced by Con-Force Structures Ltd, Canada, in their Calgary plant. Mr. Leon Grant, P.Eng., of Con-Force, was responsible for all the construction details needed to adapt the system into Canadian Standards, and he facilitated the use of the same prestressing bed used for steel strands. Messrs. Chris Wade and Amit Guha-Thakurta were the two engineers who overlooked the design and construction of the bridge on behalf of the City of Calgary, in consultation with Dr. G. Tadros of Strait Crossing Inc. of Calgary, Alberta. The two types of FRP strands used were carbon fibre composite cables (CFCC) 15.2 m in diameter, produced by Tokyo Rope, Japan; and two 8 mm diameter Leadline rods produced by Mitsubishi Kasei. CFCC and Leadline strands were used to prestress four and two girders, respectively. Typical precast concrete girder is shown in Figure (2). Continuity of

the two spans was achieved by post-tensioned steel tendons extended along the entire length of the bridge. Special structural details were implemented to provide safety precautions for the unlikely event of possible problems.

To adapt the system to the Canadian practice for prestressing, steel couplers were used to couple the CFCC and Leadline strands to conventional steel strands as shown in Figure (3). Detailed information on the construction is given in Reference (1).

Fibre optical Bragg grating strain and temperature sensors were used to monitor the behaviour of the concrete girders during construction and under serviceability loading conditions. The sensors were developed by Dr. R. Measures and his colleagues, Dr. T. Alavie and Dr. R. Maaskant at the University of Toronto Institute for Aerospace Studies.

Before construction of the bridge, an experimental program was conducted at the Structural Engineering and Construction R & D Facility of the University of Manitoba. The experimental program was conducted by Mr. A. Abdelrahman and Dr. S. Rizkalla of the University of Manitoba. The program included testing a 1:3.3 scaled model of the bridge girder prestressed by the same type, size and anchorage of the two different types of strands used for the bridge girders. The tests included static and cyclic loading using the testing facilities of the University of Manitoba shown in Figure (4). Detailed information on the experimental program is given in Reference (2).

This project provided an essential milestone for the acceptance, continued development and adoption of advanced composite materials and smart structures technology by the Canadian construction industry. Use of this technology could be the solution for one of the most significant problems related to deterioration of concrete structures due to corrosion. Use of advanced optical fibre sensors has also proven to be an excellent and reliable system to monitor

the behaviour; alerting engineers for any possible distress and providing valuable data for future strengthening in response to the continuous demand of increasing traffic loads. Dr. Measures, Dr. Rizkalla and Dr. A. Mufti of the Technical University of Nova Scotia are currently working on extending the sensor's range of applications, improving installation procedures and reducing the cost of these sensors. The work will attempt to develop an integrated optoelectronic chip technology to improve reliability, consistency and useability of the system.

### REFERENCES

1. Rizkalla, S.H., G. Tadros, "First Smart Bridge in Canada," submitted to *ACI Concrete International*, December 1993.
2. Abdelrahman, A.A., G. Tadros and S.H. Rizkalla, "Test Model for the first Canadian Smart Highway Bridge", submitted to *ACI Structures Journal*, November 1993.