One-page case history instrumentation and monitoring

Example 21 (2008) - Crack detection in a steel girder bridge

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BACKGROUND AND DESCRIPTION OF PROJECT
The bridge is a 70 year old 950 m long steel girder bridge, in Gothenburg Sweden. It consists of a concrete deck slab resting on nine continuous steel girders supported by more than 50 steel columns. It is the main communication line across the Göta river.

Fig.1. View of part of the bridge

The time in service for the bridge is approaching its design life of 80 years. A routine inspection in 1999 disclosed large cracks in the flanges of steel girders above the support columns. These were considered to be due to a combination of fatigue after many years of service and the low quality steel used in the bridge when it was constructed in 1936 to 1939.

Fig 2. Crack in the top flange of a girder

The cracks were repaired. The bridge will be replaced but not before 2020. Therefore, the Traffic Authority evaluated various technologies for integrity monitoring of the existing bridge in order to detect any unexpected structural behavior. The final choice was an early warning system based on optical fiber sensing technology.

DESCRIPTION OF THE EARLY WARNING SYSTEM

Monitoring technology
- The EWS utilizes a distributed optical fiber sensing technology based on the Brillouin scattering effect.
- The sensing fibers monitor 5 of the most heavily loaded girders over the entire length of the bridge.
- In addition a distributed temperature sensing fiber is installed for temperature compensation.

Primary monitoring and analysis functions
- Detection and localization of new cracks in the girders
- Monitor strains at all measurement points every 2 hours
- Detect unusual short-term and long-term strain changes

Fig. 3. Coil of the optical fiber sensing tape

The distributed strain sensing element consists of a polyimide coated glass fiber integrated within a strip of glass fiber reinforced thermoplastic composite tape. These are bonded to the steel girders using appropriate adhesive and covered with aluminum tape for physical and chemical protection. The optical fiber needed for temperature measurements was simply clamped to the structure.

The measurements are performed with a distance sampling interval of 0.1 m along the 5 instrumented girders making the total number of monitoring points more than 50000 for strain and another 50000 for temperature. In case of crack detection, detection of unusual strain variations with time, detection of strain above preset threshold levels or detection of system malfunctions, warning messages are sent to responsible entities in the form of e-mail and SMS for further study or emergency and preventative actions.

Site acceptance tests were carried out to verify satisfactory function of the fiber optic monitoring system in accordance with specifications. These tests were completed in autumn 2008. The system will be kept in operation until a new bridge is completed, sometime after 2020.

Fig. 4. Thirty day record of strain for 2 points 10 cm apart.

REFERENCE: Myroll et al. (2009)