Structural Health Monitoring of the Hammersmith Flyover

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Summary

A variety of monitoring equipment has been installed on the Hammersmith Flyover in London in an attempt to provide more information about the state of deterioration of this key piece of infrastructure. This paper presents an analysis of some of the data obtained, to determine whether useful conclusions about the structural condition of the bridge can be drawn and to evaluate the effectiveness of these monitoring systems.

While some useful conclusions about the condition of the bridge can be drawn there is much data which is of very limited use. Theoretical predictions can be used to demonstrate why some sensors will not provide useful information. Lessons learnt from this project can be applied to the design of future monitoring systems to prevent unnecessary sensors being installed.

Keywords: Structural Health Monitoring; Bridge; Hammersmith Flyover.

1. Introduction

Structural Health Monitoring systems are growing in popularity due to their capability to provide infrastructure managers with data to supplement inspection regimes and aid maintenance decisions. However, surprisingly little work has yet been published in which readings from such systems are related back to the actual performance of the structure being monitored. Without this crucial step the majority of data collected are of very little practical use.

This paper aims to evaluate the effectiveness of a monitoring system installed on a prestressed concrete viaduct in London, UK through consideration of a selection of the obtained data.

2. The Hammersmith Flyover

The Hammersmith Flyover (Figure 1) was constructed in the early 1960s and is a 622m long, 16 span, post-tensioned prestressed concrete segmental bridge supported on central columns. Unusually it has only a single expansion joint in a span towards the centre, roller bearings at the base of each pier and is restrained against longitudinal movement at each abutment.

There are now a number of concerns about the structural condition of the Hammersmith Flyover. Inspections revealed that many wires in the prestressing tendons had snapped and others were severely corroded. There were also concerns that deterioration of the bridge's roller bearings could be restricting the temperature expansion of the structure, inducing extra bending stresses in the deck sections.

A variety of monitoring equipment was installed on the flyover: Displacement gauges were installed at the base of each pier to measure longitudinal movement of the bearings. Strain gauges and inclinometers were attached at three different heights on the piers to monitor their movements. Finally, temperature sensors were installed at a variety of locations along the structure.

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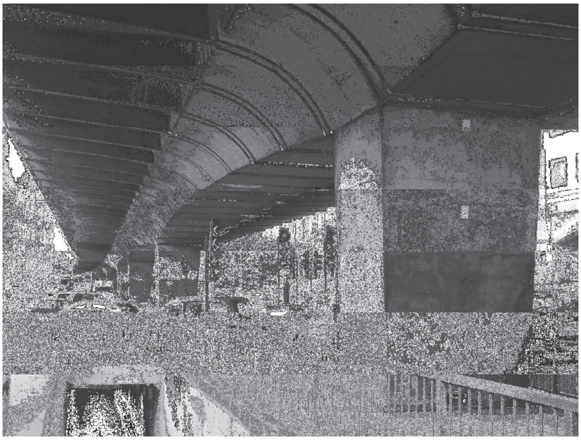

Figure 1: The Hammersmith Flyover

3. Data Interpretation

A plane frame beam model of the flyover was used to predict the values of the parameters expected to be measured by each sensor under a variety of different loadcases. The analysis was repeated after restricting the longitudinal movement of one of the bearings, to determine which parameters were sensitive to damage. Displacement readings were found to be predominantly caused by temperature changes. The temperature of the structure can easily be measured by the installed system. This suggests that plotting displacement against temperature should show a good correlation if all parts of the bridge are behaving as they should. Data from the majority of the displacement gauges did show a good correlation. However two piers were found to have a restricted range of movement suggesting some bearing deterioration had taken place.

In contrast the inclination of the piers was found to be primarily due to traffic loading with a low sensitivity to bearing damage. As traffic loading cannot be measured by this system, no useful information could be derived from the inclination data.

4. Conclusion

Data from the Structural Health Monitoring system has established that a number of the Hammersmith Flyover's bearings are not allowing free movement of the piers that they are supporting. This movement restriction could cause thermal expansion of the structure to induce extra bending stresses in the deck of 2-3MPa. These stresses could cause tensions to be induced in the bottom of the deck section at midspan. This has the potential to cause cracking of the concrete, potentially further increasing the rate of corrosion of the reinforcement and prestressing steel.

There is, however, much data which is very limited in use. The main reason for this is that data interpretation was not considered during the design of the monitoring system. Instead, sensors were installed to measure seemingly sensible parameters. It is clearly important that data interpretation is considered during the design of monitoring systems, rather than as a separate exercise after the system is installed. Modelling of the structure can be used to predict which sensors will provide useful information. If this had been done before installing the system it would have become apparent that some sensors would not provide useful information and so could have been omitted.