Critical Structural Health Monitoring of Hammersmith Flyover

On the 23rd December 2011 Hammersmith Flyover was infamously closed due to the detection of significant damage to the post tension cables, with significant media coverage. The story however started many years earlier.

Built in the 1961, Hammersmith Flyover is a precast, post tensioned segment concrete box girder over 622m long with 17 spans carrying 4 lanes of traffic into London. After 2000, post tension special inspection had identified some deterioration and a strain gauge monitoring system was installed to identified to detect deterioration.

After spurious results from the strain gauge monitoring, TfL revised their strategy, and looked to use innovative long term Acoustic Emission monitoring to confirm the location and extent of deterioration of the post tension cables by detecting wire break. An internal automated total station system was to measure sagging to detect the onset of failure. Additionally, extensive strain and movement monitoring of piers and bearings was requested to establish the performance of the flyovers bearings that unusually were located at the base of the pier.

After an initial survey of the structure which defined the optimised sensor layout (and cost), Mistras were awarded in 2009 the structural monitoring of Hammersmith Flyover by Amey as part of TfL’s northern frame work contract (LOHAC). Over 8 weeks Mistras designed and installed the Acoustic Emission (AE) and structural health monitoring system, working in challenging confined space conditions.

After successfully passing commissioning with mapping of signal transmission, TfL carried out a blind wire break, by cutting an exposed wire. This was successfully detected and located using our embedded wire break neural network fully validating the Mistras system.

Over the next 18 months, nearly 400 wire breaks were detected and processed automatically by the monitoring system onsite, uploaded to a bespoke and secure customer website along with other structural health results. This information provided short term reassurance of safety, and clear evidence of an integrity issue, allowing ranked spans wire break severity.

This triggered TfL’s preparation process for further investigations, contingency planning and advanced warning to senior management.
These initial wire break results lead the Amey investigation team to specific locations (+/-100mm from each tendons datum). This targeted destructive investigation at key hot spots revealed increasingly concerning results, including fully severed tendons, prompting the closure of the Flyover on 23rd December 2011.

During the Phase 1 strengthening of the most damaged spans in early 2012 by Amey, the initial AE monitoring system was extended to the 6.5 west side spans. This and strengthening were successfully completed before the start of the London Olympics allowing the reopening of the structure.

Monitoring of the un strengthened spans continued until and throughout Phase 2 strengthening in 2015 providing continuous feedback about deterioration rate. This deterioration rate coupled with accurate PTSI information allowed the date prediction of each individual span failure, enabling prioritisation of span repair.

During Phase 2 Strengthening by Costain, Mistras adapted the structural health monitoring system to provide addition crack monitoring and segment separation gauges added along the viaduct. Data was provided in near real time to the Costain team as part of their temporary works.

Once the HFO strengthening was completed in 2016, the AE monitoring was decommissioned leaving behind a new long term structural health monitoring system to measure the new bearing performance, flooding detection and segment separation at key locations.

Services in this turnkey project included:

- Confined space management and rescue for the works
- Design, supply and integration of <800 wire break and AE sensor monitoring system
- Installation and commissioning of all sensors
- Software programming and data processing
- Long term monitoring support, data analysis and reporting

In addition to the above Mistras provided non-destructive testing of welds, vibration monitoring, rebar detection and sizing with ferroscan, concrete coring, confined space rescue and management.

Since this project, Mistras has used this post tension wire and strand monitoring technology on many structures for Highways England and councils in the UK plus post tension structures across Europe, Scandinavia and the USA.