The Institution of Structural Engineers

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2011/12 Undergraduate Research Grant Scheme – Executive Summary

Project title:
The structural performance of cable-supported structures during a fire

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University of Edinburgh

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Project summary:
Many large cable supported structures such as the Forth Road Bridge, the O2 Arena, the roof of Heathrow Terminal 5, and the London Eye use a type of conical steel termination with a resin socket to secure the cable as an anchorage. There is requirement for this investigation because there has been little previous research into the performance of these sockets at elevated temperatures. In the history of cable structures there has been little failure due to fire; however, the hazard is tangible even if the risk is low.

The results of this investigation (including Dynamic Mechanical Analysis and Axial Load testing), concluded that there is *a requirement for protection* of even moderately loaded anchorages as the sockets display *significant loss in performance* at temperatures above 150°C in the resin, while at temperatures over 290°C the resin degrades - and all strength is eventually lost. This translated to a gas temperature of around 300-360°C. Larger anchorages are expected to perform to higher gas temperatures; however, this requires further research before this trend can be confirmed.

Cables loaded above the design capacity will fail at significantly lower temperatures. This may be of effect if the load path in the tied structure is redistributed due to failure of adjacent members.

Generally, the *performance of the resin sockets was deemed unsatisfactory* in terms of failure temperature and serviceability states, regardless of their definition, even though performance may satisfy the design standards set out in the Eurocodes. A pull-out of just 5mm may be enough to cause alarm. Discoloration of the sockets after a fire may also be an issue. A pre-warning of imminent failure was when the cable pulled-out of roughly a third of the socket depth or 1.5 times the diameter of the cable. More research should be conducted into the strengths of cable anchorages at high temperatures and protection methods could be sought and investigated.

The performance of many major structures is likely to be dominated by the level of redundancy in the structure. On long-span suspension bridges, the distance between the hanger cables can be over 20 metres, therefore a vehicle fire adjacent to one of the hanger cables is only likely to affect that one hanger. A loss of one hanger cable would not lead to global structural failure. Thus, it should be down to the design engineer to decide whether or not there is specific requirement for thermal protection solutions.