Strengthening and Widening of Tamar Bridge

Tamar Suspension Bridge carries the A38 across the River Tamar just north of Plymouth. Opened in 1961, the 335m main span was then the longest in the UK and the structure is now the fourth longest suspension bridge after Humber, Forth and Severn. The original structure was designed to BS 153 loading and opened to traffic in 1961. Since this time loadings have considerably increased and highway structures are now required to carry the design loading specified in BD 37.

Under the ownership of the Tamar Bridge and Torpoint Ferry Joint Committee strengthening of the bridge has been carried out between 1999 and 2002.
The committee is comprised of members from Cornwall County Council and Plymouth City Council.

If strengthening work had not gone ahead, a 17 tonne weight restriction would have been imposed, due to deficiencies in both the concrete deck and the steel truss. Such a low weight limit on this vital transport link would have had serious consequences for commerce in South East Cornwall.

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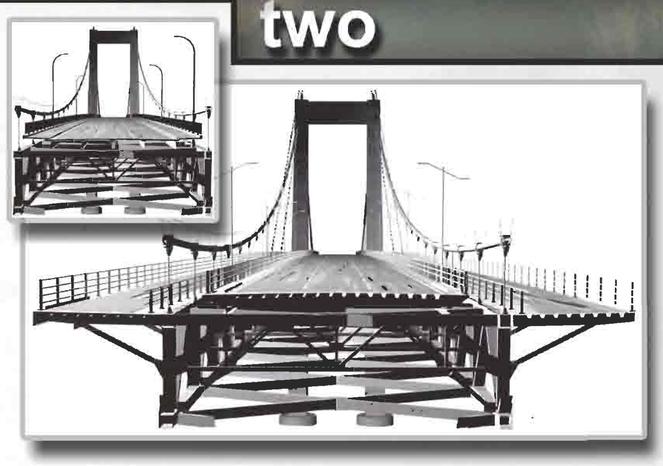

Structural Innovation

The main elements of the scheme comprised replacement of the existing concrete deck by a lightweight steel deck, steel plating added to the truss and strengthening of the existing cable structure with new cable stays.

The addition of the cantilever lanes prior to the removal of the concrete deck would increase the suspended weight to 11,000 tonnes. It was for this reason that 18 additional cables were fitted – four inclined cables per tower leg and two running beneath the main span bottom chords of the truss. This also allowed the rising of the final main span profile.

This ingenious use of additional cables permitted the addition of the new lanes prior to replacing the concrete deck, thus allowing the bridge to remain open to 40,000 vehicles per day throughout the project. These new cables carried the extra weight of the new cantilevers and now, on completion, they assist in carrying the heavy traffic loads.

This was the first time, anywhere in the world, that a suspension bridge has been strengthened in this way whilst maintaining traffic flows.

In Harmony with the Environment and Sustainable

Several options were considered, the overriding goal being to maintain the flow of traffic across the Tamar whilst the concrete deck was replaced. The obvious solution was to construct a second temporary bridge. To avoid the major additional cost of removing a temporary bridge, this concept was extended to make the second bridge permanent, but dedicated after completion of the works to the use of pedestrians, cycles and buses.

To reduce the costs of substructure and highway works an alternative option considered was to temporarily widen the existing bridge, with lanes cantilevered from the top-chord of the truss. This would require extra strengthening to the steel truss in addition to that required to strengthen to a 45 tonne weight limit. This truss strengthening could be significantly reduced by the addition of cable stays.

This option was further developed to the final solution, which reuses these temporary works as additional lanes. This solution was the economic and innovative one. The accompanying social, environmental and cost benefits of the adopted solution as against a second bridge were immense.

As part of the preparation for the Private Bill necessary for the works, an Environmental Impact Assessment was carried out in 1996 and an Environmental Statement submitted to Parliament. This covered all aspects of the works, its impact on the estuary and the immediate interest on each side of the Tamar. The study confirmed only minimal environmental impact but all possible measures were taken throughout the planning and construction to ensure that the works did not have a negative impact on the area.

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Traffic Amelioration

The addition of sections of new deck as cantilevers, approximately 6m wide either side of the bridge, will provide the two additional lanes, one dedicated for use by local eastbound traffic with bus priority, the other for segregated pedestrian and cyclist use.

Where local Plymouth bound traffic slipped onto the A38 at Saltash an accident black spot existed – the third worst accident zone in Cornwall. The slip road now leads straight onto the new, cantilevered lane, so merging of eastbound traffic now happens at the Plymouth tolling area where traffic is slower and there is more space.

In addition to priority access to the northern cantilevered lane, buses now have a dedicated lane bypassing the toll booths, giving a priority crossing into Pemros Road. Automatic barriers were installed at the booths to make this manoeuvre safe.

Appropriate Use of Materials

Another important design decision was to reconsider the interaction between deck and truss. The original concrete deck was not sufficiently connected to the truss – it carried the traffic but was a burdensome load. In the new design the lightweight steel deck acts compositely with the truss thereby enhancing its strength. This important feature greatly reduced the amount of steel plating required to strengthen the truss.

Remarkably, the final five lane suspended deck is only 25 tonnes heavier than the old three lane bridge. In all 2800 tonnes of structural steel have been added to the bridge and 125 tonnes of new cables, bringing the total suspended weight to 7900 tonnes.

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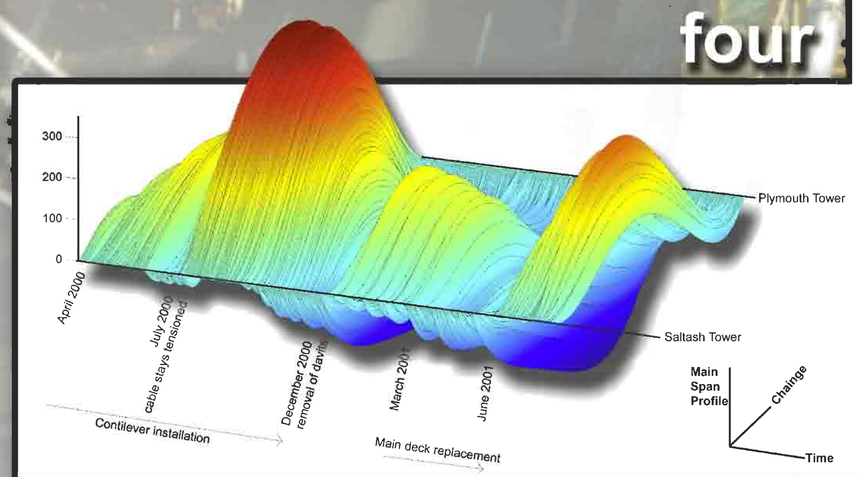

Structural Monitoring

The loads produced by the traffic can cause the main span typically to deflect by as much as 300mm. It was important therefore that the actual deflection was known during the welding operations on the new deck panels to prevent stresses being locked into the new structure.

To provide this, and other information, the 'health' of the bridge needed continuous monitoring using a host of electronic information. A liquid level sensing system monitored the deck, theodolites measured tower separation whilst strain gauges checked on the cables and anchor bars.

five

Working in Partnership

Assisted by the adoption of the Engineering and Construction form of contract, a Project Team was formed from the Joint Authorities, Cornwall County Council and Plymouth City Council; the Consultant, Hyder; and the Contractor, Cleveland Bridge.

The Project Team worked together for a year before construction commenced to develop the design and ensure a high level of buildability. On site all four parties shared a single office and administrative system. Decision were most commonly reached by the team working in an open plan office environment, where all parties had unrestricted access to information.

The Project has been recognised by the Movement for Innovation as an M4I Demonstration Project for its innovative practices.

Hyder

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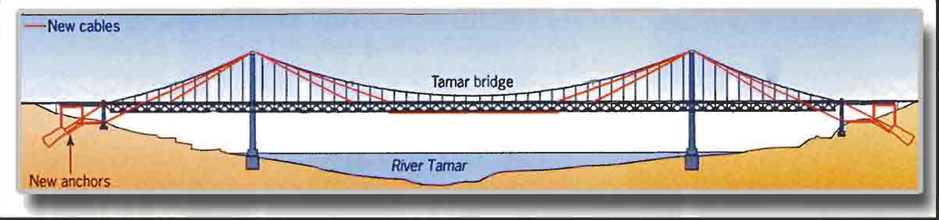

Client: Tamar Bridge and Torpoint Ferry Joint Committee
Structural Engineer: Hyder Consulting Ltd.
Main Contractor: Cleveland Bridge (UK) Ltd.

Hyder Consulting acknowledges the permission of the Tamar Bridge and Torpoint Ferry Joint Committee to present this poster for the Institution of Structural Engineers' Structural Awards 2003.