Strengthening of Avonmouth Bridge

Hyder

Avonmouth Bridge is a twin steel box girder bridge carrying the M5 motorway between junctions 18 and 19 just west of Bristol. It is 1.4km long, with spans from 30m to 174m. The original structure was designed to BS 153 loading and opened to traffic in 1975. Since this time loading intensities have considerably increased and highway structures are now required to carry the design loading specified in BD 37/88.

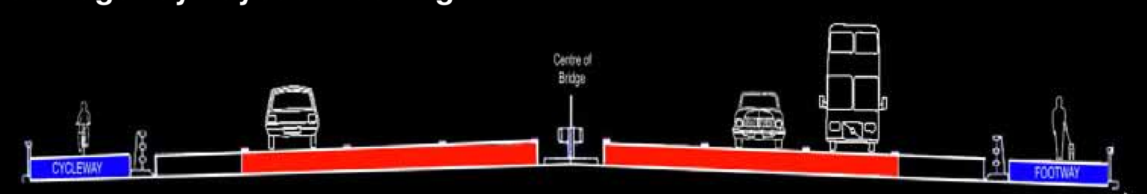
Under the ownership of the Highways Agency, strengthening of the bridge has been carried out between 1995 and 2000. The opportunity was taken to widen the carriageway from three to four running lanes in both directions.

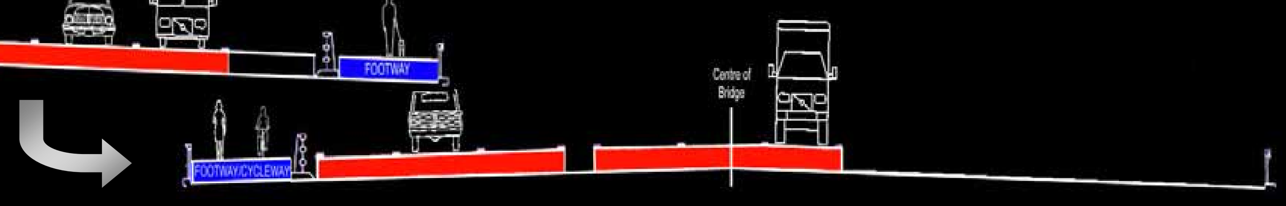
A major drawback of adding more steel to strengthen an existing structure is that the extra self weight significantly reduces the enhancement in strength, therefore a number of innovative approaches, were developed to counteract this effect. Specific elements of the approach are outlined below.

The result of these departures and innovative elements was a reduction in strengthening steelwork necessary from some 6000 tonnes to 3000 tonnes. Works will be complete in December 2000.

one

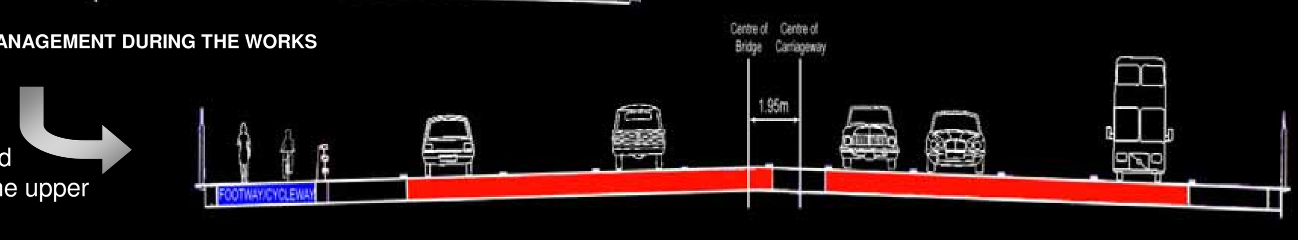
Carriageway Layout Widening





Widening of the carriageway was accommodated within the existing bridge deck by combining the footway and cycletrack on one side of the bridge, and by moving the street lighting columns from the central reserve onto extended cantilever beams.

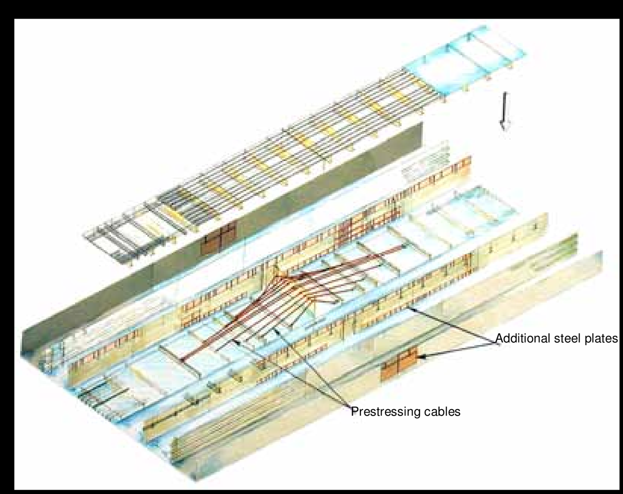
To minimise locked in live load, during the strengthening of the east box girder, traffic was moved to the west side of the bridge, and vice versa. A weigh-in-motion system was in continuous operation to record the maximum live load that could be locked in to any additional strengthening if all traffic came to a standstill. This was used to determine the upper limit of locked in stress with confidence.



two

Approach span strengthening

The prestressing system at the approach span piers consisted of a fan of Macalloy bars with horizontal bars at top flange level. This arrangement reduced the hogging moment at the piers and relieved shear in the webs, passing load directly into the diaphragm in an efficient manner without adding to the compression in the bottom flange.

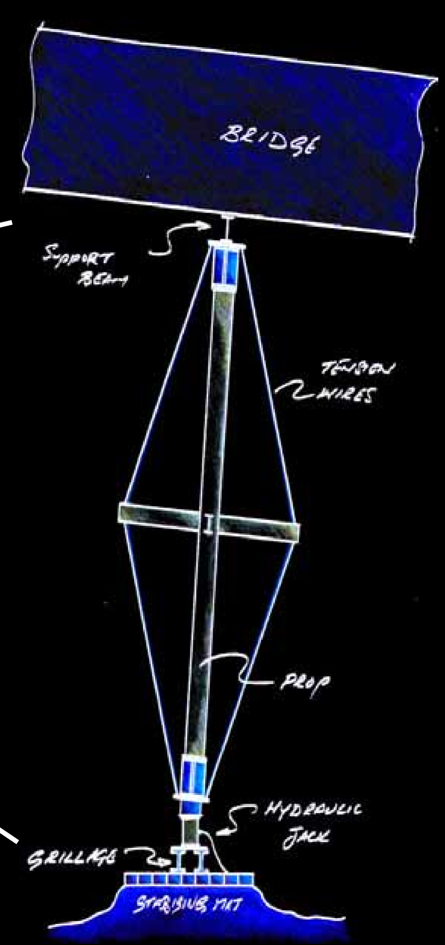


three

Temporary works during strengthening

The strengthening scheme was designed to maximise the composite action of the strengthening steelwork by making it carry original structural dead load where possible. Temporary trestles were positioned in the region being strengthened and jacked up to relieve dead load.

The surfacing was strategically removed prior to strengthening. Replacement of dead and superimposed dead load occurred after the strengthening, and therefore some of this load went into the new steel so relieving stress in the original bridge through better composite action.

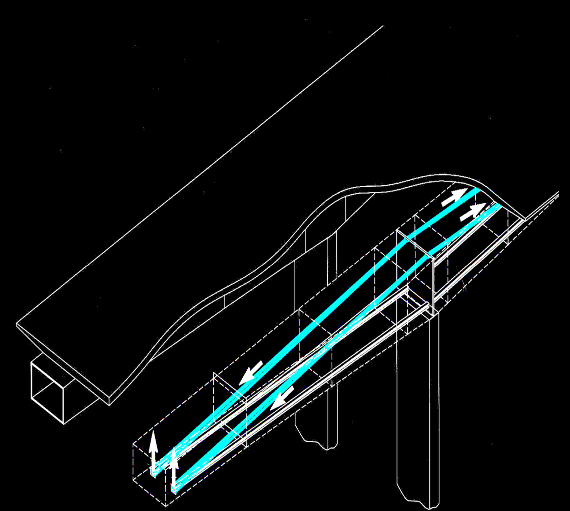


four

Strut and tie system inside main span boxes

Over the main river spans the box girder is much deeper, allowing space for an efficient strut and tie system. This consisted of steel circular hollow section struts laid on the bottom flange transverse stiffeners from the pier diaphragms to $^1/_3$ span.

Prestressing strands attached to the far ends of the tubes pass over saddles located near the tops of the diaphragms. This construction can be likened to building a cable-stayed structure inside the bridge. It was more efficient and more economic than traditional plating.



five

Departures from standard

The strengthening design has adopted a number of departures from standard. These include:

- all steelwork for the original construction came with test certificates, it was therefore possible in the analysis to determine the actual yield stresses for individual elements of the bridge.
- HB vehicles and abnormal indivisible loads are escorted over the bridge along the centreline of either box girder. This ensured that the lighter HA loading predominated in the design of cross girders and deck elements.
- by detailed inspection of the original surfacing and strict control on its future replacement, the load factor was reduced from 1.75 to 1.2 which represented a considerable weight saving in design.
- recordings of the thermal movements of the superstructure have been taken over a number of years. These were analysed and used to enable lower loadings to be applied to the substructure. Actual values of the coefficient of thermal expansion are significantly lower than values derived from the code.
- measurement of the steelwork fabrication tolerances such as plate flatness and stiffener straightness showed that the bridge had been fabricated to the tight tolerances set out in the “Interim Design and Workmanship Rules” that were current when it was built. This allowed higher stresses to be used for certain compression elements.

Client:	Highways Agency
Structural Engineer:	Hyder Special Structures
Main Contractor:	Costain Civil Engineering Limited
Steelwork Contractor:	Kværner Cleveland Bridge Limited

Hyder Consulting acknowledges the permission of the Highways Agency to present this poster for the Institution of Structural Engineers' Structural Awards 2001.