Strengthening of Avonmouth Bridge

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 2000 tonnes. Works will be complete in December 2000.

Carriageway Layout Widening

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 weight-in-motion system was in continuous operation to record the instantaneous loadings 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.

Widening of the carriageway was accommodated within the existing bridge box by moving the central reserve onto extended cantilever beams. Moving the street lighting columns from the central reserve onto extended cantilever beams.

Approach span strengthening

The strengthening scheme was designed to maximise the composite action of the strengthening steelwork by using a carry chord at the end of the strut and tie system. This carry chord is more efficient and more economic than traditional plating. It was more efficient and more economic to building a cable-stayed structure inside the original bridge through better composite action.

Strengthening of Approach Span

Truss and tie system inside main span boxes

Over the main span, the top flange is much deeper, allowing space for an efficient truss and tie system. The compressed strut carries horizontal section stress load on the bottom flange transverse diaphragms from the prestressed diagonals.

Prestressing strands attached to the fan of Macalloy bars with horizontal arrangement reduced the hogging moment at the piers and relieved stress in the beam, passing load directly into the diaphragm in an efficient manner without adding to the compression in the bottom flange.

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.
- H11 vehicles and abnormal indivisible loads are now carried by the structure. This ensured that the design dead load exceeded in service yield stresses in all elements.
- Strut and tie action was 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.
- The prestressing system at the mid span piers consisted of a fan of Macalloy bars with horizontal bars at the top flange level. This arrangement reduced the hogging moment at the piers and relieved stress in the beam, passing load directly into the diaphragm in an efficient manner without adding to the compression in the bottom flange.

The surfacing was strategically removed prior to strengthening. Replacement of dead and permanent dead load occurred after the strengthening and therefore some of this load could then be used to support, slightly, the existing bridge through better composite action.

TRAFFIC MANAGEMENT DURING THE WORKS

Temporary works during strengthening

The surfacing was strategically removed prior to strengthening. Replacement of dead and permanent dead load occurred after the strengthening and therefore some of this load could then be used to support, slightly, the existing bridge through better composite action.

DEPARTURES FROM STANDARD

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- H11 vehicles and abnormal indivisible loads are now carried by the structure. This ensured that the design dead load exceeded in service yield stresses in all elements.
- Horizontal prestressing strands were 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.
- The prestressing system at the mid span piers consisted of a fan of Macalloy bars with horizontal bars at the top flange level. This arrangement reduced the hogging moment at the piers and relieved stress in the beam, passing load directly into the diaphragm in an efficient manner without adding to the compression in the bottom flange.

New service loading intensities have considerably increased since the design of the original bridge. As a result of this change, the original yield stresses for certain elements of the structure have been exceeded.

Client: Hyder

Structural Engineer: Hyder Special Structures

Main Contractor: Costain Civil Engineering Limited

Steelwork Contractor: Kramer Cleveland Bridge Limited

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