Humber Bridge A-frame rocker bearings replacement

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Summary

The Humber Bridge was opened in 1981 and carries the A15 dual carriageway over the Humber estuary, UK. From opening until 1997, it was the longest single span suspension bridge in the world with a main span of 1410 m. The deck is discontinuous at the towers where pairs of A-frame rocker bearings control the vertical and lateral position of the deck and provide a torsional reaction to the deck box. Extensive wear to the pin bearings of the main-span A-frame rockers was apparent, hampering their performance. Six refurbishment / replacement options were considered prior to selection of replacement of the A-frames by pendels and a wind shoe. The pendels will be connected to the deck box and tower portal beam at their ends using spherical bearing housed pins offering future durability and maintenance advantages. The wind shoe cantilevers from the deck box end, horizontal reaction provided by opposed hydraulically preloaded sliding bearings.

Keywords: Humber Bridge; bearings; suspension bridge.

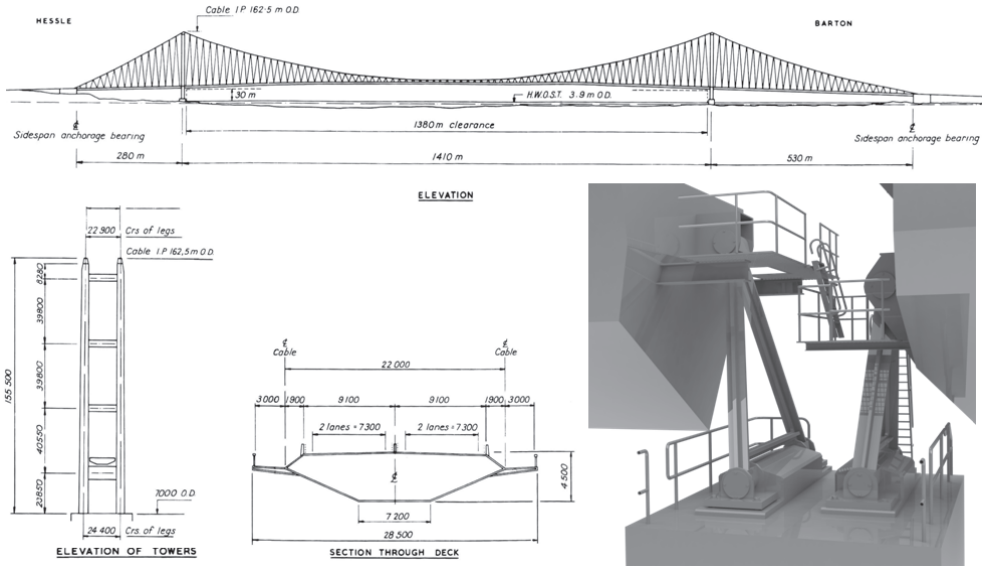

Fig. 1: The Humber Bridge. Bottom right, main span (to the left) and side span (to the right) A-frame rocker bearing.

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1. Introduction and A-frame behaviour

From the routine bridge management regime, the adequacy of capacity and performance of the main span A-frames has been questioned. The accumulated longitudinal displacement of the main span is estimated as 4.5 km/year. This has led to wear of the bearing pins and / or casings. Detailed understanding of the behaviour of the A-frames was developed demonstrating the key role these bearings play in providing torsional restraint to the deck box.

2. Design

Six options were developed [1]. From a detailed appraisal study and assessing of each option against nine criteria, a single option was selected – replacement of the A-frames with rocking pendels to take vertical loads and a wind shoe to take horizontal loads (Fig. 2).

The Eurocode's load model 1 (used for the effects of a mixture of car and normal lorries and specified by the UK National Annex for loaded lengths up to 1500 m) was shown to generate load effects in excess of both the original design loading and current bridge traffic. Project specific adjustment factors were used. Wind loading effects were significant, notably dynamic effects. Pendel ULS axial design loads were -16 MN (compression), +12 MN (tension).

The pendels are an "I" section of welded plates. The limited room available for the pendel bearing casings led to the use of a high structural steel grade, S690QL1(-60) to BS EN 10025-6. The bearings at each end of the pendel are spherical mounted pins more commonly encountered within the realms of mechanical engineering. Increased wear resistance, better accommodation of lack-of-fit and easier future replacement are envisaged. New steel frames connect the pendel at its top and bottom to the deck box and tower portal beam by preloaded steel bars. The steel wind shoe bears onto opposed hydraulically preloaded bearings. The preloaded bearings are split into fundamental replaceable components of a hydraulic accumulator, cylinder and sliding spherical bearing. Local strengthening within the deck box by reinforced concrete acting compositely with the existing steel and steel plates bolted to external surfaces are proposed. Temporary pendels connect the deck box adjacent to the tower legs support the bridge under lane closures whilst the A-frames are replaced.

3. Discussion and conclusion

The works proposed are some of the most significant structural works undertaken on the bridge since opening. The pendel with wind shoe replacement option is felt to be an efficient proposal, limiting disruption during construction and facilitating easier future maintenance and replacement. Tender for the detailed design is taking place during October and November 2012. The anticipated tender cost is £4m. Construction should commence in early 2013. Following procurement of bearings and fabrication, work on site will be focussed around spring / summer 2013 and completed autumn 2013.

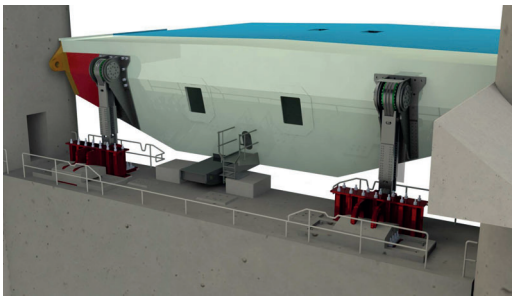

Fig. 2: Proposed arrangement – A-frames replaced by pendel and wind shoe.

4. References

[1] HORNBY S.R., COLLINS J., HILL P., and COOPER J., "Humber bridge A-frame refurbishment/replacement", *IABMAS 2012*, CRC Press, 2012, pp. 3170-3177.