The Design of the Refurbishment of the M8 White Cart Viaduct, Glasgow

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Summary

The M8 White Cart Viaduct was designed and constructed in accordance with the Department of Transport (DOT) and British Standards of the time, and was opened to traffic in 1968. It is one of the most important major bridges in Scotland, carrying more than 90,000 vehicles a day. However, following an unfavourable assessment of the bridge in 1998, the Scottish Office Development Department (SODD), now Transport Scotland (TS), and Scott Wilson Scotland Limited (since acquired by URS) were engaged to develop a phased refurbishment strategy to upgrade the bridge. The proposals included the replacement of the parapets, replacement of the expansion joints and strengthening of the steel box girders. This paper describes the design of the phased refurbishment works, particularly the steel box girder strengthening including the replacement of the vulnerable half-joints.

Keywords: Bridges, steel box girder, assessment, strengthening, half-joints, parapets.

1. Introduction

The White Cart Viaduct, constructed between 1966 and 1968, for a cost of £1,8 million (Euros 2,250 million) carries the M8 Motorway over the White Cart Water immediately to the south of Glasgow Airport, Scotland. The bridge is of great strategic importance, carrying more than 90,000 vehicles a day. It is also the principal access route to Glasgow Airport. The viaduct is over 820 metres long

and has 23 spans, comprising a central suspended span supported on half-joints, haunched cantilever and anchor spans and continuous approach spans. The deck is formed from twin fabricated steel box girders acting compositely with a reinforced concrete deck slab. The alignment is curved in both plan and elevation and at its highest point the bridge is some 23 metres above the river. The overall width of the deck is 28,956 metres, accommodating the dual three-lane motorway, central reserve and verges.

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In 2001, URS was commissioned by TS to undertake the inspection and assessment of the viaduct. The assessment concluded that some elements of the steel box girders were significantly overstressed and the parapets, joints and lighting columns needed to be replaced.

2. The refurbishment strategy

Therefore TS further commissioned URS to develop immediate measures for the interim management of the bridge, followed by the design of the refurbishment works, which were to be undertaken in agreed phases, as follows:

Phase 1: Upgrade the parapet and replace the lighting columns.
Phase 2: Replace the movement joints and waterproof and resurface the deck.
Phase 3: Strengthen the box girders.
Phase 4: Apply a new paint protection system and repair the substructures.

Phase 1 and Phase 2 were successfully completed in 2006 and 2007 respectively. Phase 4 is due to commence in 2015.

Phase 3 was by far the largest and most complex stage of the programme, comprising a further assessment of the bridge for Special Vehicles, followed by the strengthening of the steel box girders. The strengthening included the replacement of the half-joints, provision of additional ring frame and cross frame bracing, provision of additional plates and stiffeners for the box webs, flanges and diaphragms, provision of additional access holes in the boxes and installation of additional shear connectors.

The half-joints were to have a significant influence on the temporary management of the structure and the design of the strengthening at this location, as the “cruciform” plates were formed from a very unusual and vulnerable laminate of mild steel “fused” to a relatively thin stainless steel facing.

3. Conclusions

The design of the strengthening for an existing bridge is often more difficult than the design of a new structure due to restricted access, site fabrication, the conflict between the existing design and the current code requirements, the inherent details and the strength, shape and integrity of the original construction. The project to strengthen the M8 White Cart Viaduct was no exception, and was further complicated by the need to maintain traffic flow on the bridge at all times.

The half-joint strengthening was the most challenging aspect of the design. Several options were considered in detail, the final choice being a full continuity splice, which was not the obvious or favourite option at the beginning of the study.

As a result of the successful refurbishment programme, the operation and maintenance of the viaduct have been greatly improved, it now complies with the requirements of the current Standards and the vulnerable half-joints have been negated.