West Gate Bridge Strengthening Project - The Development of Novel Stiffened Panel Solutions

Chris MURPHY
Associate
Flint & Neill
London, UK
c.murphy@flintneill.com

Chris Murphy, born 1972, graduated in 1994 with a Masters degree from the University of Leeds, UK

Emad GAD
Professor
Swinburne University of Technology, Australia
EGad@swin.edu.au

Professor Emad Gad, born 1970. graduated with a Civil Engineering degree from Monash University in 1993 and a PhD from Melbourne University in 1997

Robert PERCY
Associate
Flint & Neill
London, UK
r.percy@flintneill.com

Robert Percy, born 1965, graduated with a Civil Engineering degree from the University of Southampton, UK in 1987

Summary

This paper describes the structural assessment work carried out by the West Gate Bridge Strengthening Alliance ("WGBSA") on the West Gate main cable-stayed bridge in devising the necessary strengthening measures for stiffened panels whilst minimizing the need to remove red-lead paint. As a consequence of this work, questions have been raised as to the safety of various stiffener buckling clauses in UK assessment code BD 56[1],[2] and BS 5400 Part 3[3]. The authors discuss the answers to these questions that were able to be addressed within the time-frame of the West Gate strengthening project. Additional issues which require future research are documented at the end of the paper.

Keywords: Cable stayed bridges; box girder bridges; steel bridge strengthening; stiffened panels, torsional buckling, bulb flat stiffeners, non-linear finite element modelling.

1. Introduction

The West Gate main cable stayed bridge comprises a five span continuous steel box girder, with the cable elements supporting the central 336m span over the river Yarra. As part of the recent strengthening project to increase the capacity of the West Gate bridge from 8 to 10 lanes, a full structural assessment of the steel box girder was carried out by the West Gate Bridge Strengthening Alliance ("WGBSA"). Further details of the project background are contained in a separate paper[8].

2. Initial Assessment Findings

The complex history of the bridge had resulted in many different configurations of stiffened panels requiring assessment. Box sections undamaged in the 1970 collapse were predominately strengthened prior to the 1978 opening by welding in additional angles between the existing bulb flat stiffeners. On the other hand the completely re-fabricated boxes of the collapsed span possessed stiffened panels formed entirely from angle stiffeners welded to steel plate.

In the initial assessment, the capacities of the West Gate stiffened panels were derived using the codified procedures of UK assessment codes BA 56/96 and BD 56/96[1]. An important parameter in estimating the ultimate strength of a stiffened compression panel formed from 'open-stiffener' sections (such as angles or bulb flats) is the local buckling stress of the stiffener outstand. In predicting this parameter, much benefit was gained by using Flint & Neill's 'Revised Appendix S[4]' as a less conservative alternative to either the Appendix C or Appendix S procedures in BA / BD 56/96 - the procedures normally used to estimate the local buckling stress of open stiffeners.

However, discrepancies occurred between the limiting stiffener outstand stresses predicted by Revised Appendix S and other clauses in BD 56 at bottom flange locations where the stiffeners were closely spaced. The post-collapse measure of welding additional angles between the original bulb flats in these locations had resulted in longitudinal stiffeners spaced close enough to invoke certain shape limit clauses in BD 56/96 Section 9.3. Such clauses imply that, if the centres of the longitudinal stiffeners are close enough together, it is safe to assume that the local buckling stress of the open-stiffener outstand is equal to the yield stress of the stiffener - i.e. local buckling does not

https://doi.org/10.2749/222137912805111267