Buckling of complex, steel structures: City of Manchester Stadium, Barcelona Bullring, BA London Eye, 2012 London Olympic Stadium, Aviva Stadium, Infinity Footbridge

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Summary

The paper presents studies on buckling of complex, unusual, innovative and iconic built steel structures for which the author has been responsible. The work on City of Manchester Stadium focuses on pin-ended cable-stayed masts up to 40m long carrying 12 MN. Masts at Barcelona Bullring were of similar size, but of more complexity: being formed into portals providing overall stability to a 200m diameter roof. The work done on the BA London Eye was highly innovative and complex looking at the buckling of the 150m diameter bicycle wheel structure. The roof of the London Stadium has some similarities to the bicycle wheel of BA London Eye, but is restrained out of plane and thus more resilient with no global buckling modes. The stadium is one of a number undertaken by Buro Happold including the award-winning Aviva Stadium. The final project is Infinity Footbridge for which the author led the early buckling studies.

Keywords: Buckling, stadium, footbridge, analysis, Steel, non-linear, eigenvalues, innovation, Bullring;

1. Introduction

There are many papers or books that describe theoretical formulae for element buckling and/or tabulate effective lengths for elements. There are also numbers of papers that describe the recent development of theoretical approaches in codes to buckling of complex structures. However, this paper, it is hoped, presents an interesting, perhaps unique, case of assembling case studies of approaches adopted in assuring designs of some of the most complex iconic steel structures of recent times.

The paper begins with a unique simple explanation of how the approach to buckling of complex structures differs from that of simple code element design because the former examines how vulnerability to buckling derives increases deflections and bending stresses whereas the latter derives assumed reduced permissible axial stresses. The paper follows with a simple practical summary of the key techniques employed in approaching buckling of complex structures, namely eigenvalue analysis and full non-linear analysis.

The paper then presents a series of case studies of iconic structures in which buckling analysis played a key part. For each case study, despite the scales and complexities of the overall structures, it is shown how appraisal of buckling followed some key basic principles, namely of likely

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