

## FATIGUE DESIGN OF WELDED TUBULAR STEEL BRIDGE DETAILS

Renato Natal Jorge<sup>1</sup>, António Augusto Fernandes<sup>1</sup>, P.T. de Castro<sup>1</sup>, Nuno Eduardo Santos<sup>2</sup>, Ricardo Fonseca<sup>2</sup>, António Campos e Matos<sup>2</sup>

<sup>1</sup>IDMEC, Faculty of Engineering, University of Porto  
Rua Dr. Roberto Frias, 4200-465, Porto, Portugal  
[rnatal@fe.up.pt](mailto:rnatal@fe.up.pt)

<sup>22</sup>GEG-Gabinete de Estruturas e Geotecnia, Lda.  
, Rua da Alegria, 1930-1º, 4200-020, Porto, Portugal

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Fatigue and fracture are at the root of more than 80% of the failures in steel structures. Brittle and ductile failures subsequent to fatigue cracking occurs in bridges, mainly because specific details have a lower fatigue resistance than foreseen at design stage.

Once the design of a bridge structure is finished, there is little room for improvement of the fatigue life, during the fabrication process. Thus to obtain an optimal cost design, the total costs should be considered, including not only the fabrication costs but also costs associated to inspection during construction and in-service inspection, assuming that the consequential costs due to structural collapse are not acceptable.

It is well documented that the costs due to changes of design parameters carried out at the beginning of a project are a fraction of the costs incurred if defects are detected during fabrication or if fatigue and /or fracture develop in-service. Thus fatigue reliability evaluation is of crucial importance for the design and management of steel bridges.

Fatigue failures typically begin at high stress concentration locations at weld terminations of specific structural details such as stiffeners, reinforcements, attachments, secondary brackets, due to the presence of secondary stresses or out of plane bending, and less frequently by the presence of large internal defects in the welded joints.

Steel bridge design can involve very complex structures specially when aesthetic factors rather than functionality dictates the design of the bridge. The work being reported covers the design of such a bridge. The case study refers to an urban bridge built in Porto, over the VCI ring road. As part of the Euro 2004 program, the bridge was one of the major constructions built to link a new road connection to Bessa Soccer Stadium.

With a single span of 75 meters and a 45° crossing angle over VCI road, the bridge was fabricated with welded steel circular hollow sections, except for the cross beams made from HEB range.

The bridge is formed by two main Warren tri-dimensional beams, on each side, varying in height from 5,70 to 9,15 meters, and connected only in the lower level by the cross beams with 11,5 meters span.

The concept design uses very complex nodes with up to eight intersecting members, thus creating very complex stress fields and high stress concentration spots. The structure was designed in compliance with Portuguese regulations and Eurocode 3. Due to the complexity of the details, the simplified methodologies of codes such as Eurocode 3 or BS5400 could not be used directly in the fatigue design and more refined 3D Finite Element Method had to be used to calculate the structural hot spot stress range at the weld toe. Two critical nodes were selected for analysis and two models were studied using shell elements.

The linear surface extrapolation procedure based on the stresses along the free surface of the structure was used. The limitations of the classical S-N fatigue analysis used in current codes of practice and in particular the uncertainty in the characterisation of the loading on the bridge structure, caused by the vehicular passage, aggravated in Portugal by the inexistence of WIM (weight in motion ) vehicle data, are discussed .