Inspection of welded joints: reliability of ultrasonic inspection and inspection intervals

Christian CREMONA
Deputy Head
Technical Centre for Bridge Engineering (CTOA),
Technical Department for Transport, Roads and Bridges (SETRA)
Sourdun, France
christian.cremona@developpement-durable.gouv.fr

After 15 years of research activities on structural reliability applied to bridge assessment and maintenance, Dr. C. Cremona joined in 2009 the Direction for Research and Innovation of the Ministry for Ecology, Sustainable Development, Transport and Housing as head of the Civil Engineering and Construction Group. Since may 2011, he has been appointed as deputy head of the technical centre for bridge engineering in SETRA.

Summary

The objective of a non destructive control is to improve the reliability of a component (in the case of steel bridges, of a welded joint) by facilitating the detection of flaws reducing its strength. Due to the different uncertainties intrinsic to the control process, a probabilistic characterization of the reliability of a non destructive control is therefore fundamental for deciding pertinent maintenance actions. For this purpose, a classical approach consists in characterizing a control by a specific curve, called probability of detection, fitted on measurements. The French research project MIKTI has fixed as objective to analyze the reliability of several non destructive techniques applied for inspecting welded joints in bridges by means of a large series of fatigue and inspection tests. In this paper, ultrasonic controls are presented, showing their efficiency to detect small cracks in joints. Applied to standard welded joints, this helps to calibrate curves providing maximal inspection intervals between two inspections, under the assumption that no crack is detected after the first inspection.

Keywords: Welded joints, non destructive controls, ultrasonic controls, probabilities of detection, fracture mechanics, inspection intervals

1. Introduction

Welding is the most widespread technique for assembling steel components. Welding joints nevertheless constitute the most critical zones from a structural performance perspective. A review of documented deficiencies in the literature indicates that flaws predominantly tend to initiate in joints. The process of welding steel elements actually leads to modifications in both micro-structural and mechanical properties, the introduction of residual stresses, an increase in applied stresses, and the occurrence of welding imperfections. Depending on the set of operating and environmental conditions, one or more of these phenomena may cause failure through a variety of mechanisms. Within welded joints, fatigue cracks are by far the most common kind of failure mechanisms. Tremendous efforts have been deployed over the past twenty years to investigate the fatigue phenomenon, as introduced in Eurocode 3 [1]. The fatigue process involves uncertainties that underscore the role of inspections as a necessary both to introduce a fatigue damage model using efficiently this information and to establish a set of acceptance rules based on measurements of detected flaws or cracks. The combination of fracture mechanics (introduced to characterize cracking evolution over time) with a probabilistic analysis (to account for the variability among parameters used to characterize the phenomenon) provides the appropriate tools for evaluating the fatigue performance following that direction [2-5].
Non-destructive inspection techniques are designed to detect flaws or cracks early on, making it possible to recalibrate the fatigue prediction model. The inspection intervals should be short enough that the cracks that were not detectable at the preceding inspections do not have time to propagate to

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