Assessment of the residual stress distribution of a welded stiffener-to-deck plate connection of an orthotropic steel deck using hole-drilling

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Abstract

Manufacturing processes such as welding operations cause residual stresses which are present in most civil structures. They create plastic deformations without any external loads and therefore are often overlooked during design. Nevertheless, residual stresses can have profound influences on the fatigue life. This is also true for orthotropic steel decks. Unfortunately, for these bridges, little is known about the real distribution of residual stresses due to welding. Therefore, a semi-destructive experimental test setup is developed: hole-drilling. It became clear that near the weld region, the overall conclusions confirm the widely assumed tensile yield stresses. Further away from the weld region, the residual stresses decrease to almost zero. In conclusion, with the hole-drilling technique, it is possible to achieve a clear pattern of the existing residual stresses near welded locations without really damaging the structure. This knowledge can highly improve future fatigue calculations.

Keywords: residual stress; orthotropic steel deck; hole-drilling; weld; semi-destructive.

1 Introduction

Residual stresses are introduced unintentionally by almost every manufacturing process, such as rolling, forming, milling, welding, etc. Sometimes they are even intentionally introduced by the use of a surface treatment such as shot-peening in order to compensate for other types of residual stresses. The effect of residual stress can be either beneficial or detrimental, depending on the magnitude, sign and distribution of the introduced stresses. The presence of tensile residual stress is especially harmful due to its contribution to fatigue failure. The opposite is true for compressive residual stresses being present [1, 2]. Due to the fact that residual stress creates plastic deformations without any external load, it is ignored when evaluating fatigue failure using Eurocode 3 [3], because the stress variations only are considered. A possible solution for this omission is the use of Linear Elastic Fracture Mechanics (LEFM). This fatigue assessment method allows adding an initial stress state to the stress variations due to an external load [2]. However, in most cases more research concerning the actual magnitude and distribution of the residual stresses in steel structures is needed.

This is especially true for Orthotropic Steel Decks (OSDs) which suffer from important fatigue problems due to the extensive use of welded connections (Figure 1). These bridge decks consist of a grillage of closed trapezoidal longitudinal stiffeners and transverse webs welded to a deck plate. They are widely used in long span bridges since they are extremely light weighted when

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