Size effect on the fatigue of High Frequency Mechanical Impact treated welds

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Abstract

Fatigue strength improvement of welds by High Frequency Mechanical Impact (HFMI) treatment may enable resource efficient structural design. In civil engineering structures like bridges, plate thicknesses up to 40-50 mm are common. The majority of fatigue test data available on the enhancement of welded details using HFMI treatment are however obtained from relatively thin plates. In this study, an overview of existing fatigue test data with HFMI treatment is presented and evaluated with regard to size effect. A thickness and attachment length dependency of fatigue strength of transverse attachment details was observed and an attachment length dependency for longitudinal attachment details. Based on the gathered data, a fatigue strength-to-thickness relation could not be observed for butt welds and longitudinal attachments.

Keywords: fatigue enhancement; post weld treatment; HFMI; thickness effect; size effect.

1 Introduction

Civil engineering structures such as bridges suffer highly from fatigue of welded joints. In bridge applications plate thicknesses up to 40-50 mm are common. In more rare cases even flange thicknesses over 80 mm exist. Post weld improvement techniques such as High Frequency Mechanical Impact (HFMI) treatment may offer a cost efficient way to reduce the fatigue sensitivity of bridges. The HFMI treatment is a newer variant of hammer and needle peening. It exerts higher frequency impacts than the predecessors resulting in smaller spacing between the indentations. In addition, it is quieter and more comfortable to use by the operator. The main mechanisms of improvement are similar; tensile welding residual stresses are substituted by compressive residual stresses in the order of magnitude of the yield strength and the transition from base to weld material is smoothened.

Although many studies have been performed to investigate the degree of improvement achieved by HFMI and proposed guidelines have been developed [1], few studies have been performed on the size effect. In this paper, an overview of existing fatigue tests with HFMI treatment has been made and the gathered stress vs. number of cycles to failure has been evaluated with regard to size effect. The size effect deals with both effects of thickness and length of attachment [2].

2 Size effect

It is well known that the fatigue strength of welded steel joints decreases as the thickness of the load carrying plate increases. This has been extensively studied and reviews are given in [2][3][4] for as-welded and to some extent also for toe ground details. The decrease of the fatigue strength due to thickness effect is associated with three different factors, referred to as geometrical, statistical and technological factors [5].

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