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Effect of weld toe geometry on fatigue life of lap fillet welded ultra-high strength steel joints

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Abstract

The effect of arc weld toe geometry on pulsating bending fatigue performance was studied using as-welded and toe machined welded joints of an ultra-high strength steel with a tensile strength grade of 980 MPa. Weld toe machining significantly improved the fatigue strength of the welded joints even when the radius of the machined toe was 0.5 mm, although this is smaller than the minimum size described in the document, International Institute of Welding (IIW) Recommendations on Post Weld Improvement of Steel and Aluminium Structures, which applies to welded joints of steel with plate thicknesses from 6 mm to 50 mm. The fatigue cracks of the as-welded joints initiated along the bottom of the ripple pattern in the weld metal near the weld toe. A fatigue life prediction based on the fracture mechanics approach for the as-welded and the toe machined joints suggested that consideration of the microscopic geometry of the weld ripple pattern is important for improving the accuracy of fatigue life predictions of as-welded joints.

Keywords: Weld toe, Welded joints, Life prediction, Stress intensity factors, Carbon steel

Nomenclature

N	number of cycles to failure
$\Delta\sigma_n$	nominal stress range
a_0	intercept of the S-N line
a_1	slope of the S-N line
a	crack depth
c	surface crack half-length
a/c	crack aspect ratio
m	Paris-Erdogan equation exponent
C	fatigue crack growth constant
ΔK_s	stress intensity factor range at the deepest point when a surface crack reaches the first grain boundary (a semi-circular surface crack is presumed)
$\tilde{\omega}_s$	size of the overlapping region of the tensile plastic zone at the maximum load and the compressive plastic zone at the minimum load when a shear crack reaches the first grain