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Abstract In this study the fatigue strength of fillet welded tube-to-plate joints failing at the weld root and subjected to multi-axial stress states is investigated. The fatigue test data is collected from the literature and it is assessed together with the experimental data generated in this study. Finite element analysis is used to analyze the stress state at the weld root. The fatigue strength estimation capabilities of local stress based methods such as the Principal Stress Hypothesis (PSH), von Mises Stress hypothesis (vMH), Modified Wöhler Curve Method (MWCM), and Effective Equivalent Stress Hypothesis (EESH) are compared. The applicability of modified Gough Pollard Equation (GPE) in local stress system is also assessed. It is observed that most of the proposed local stress assessment methods can estimate the fatigue strength of fillet welds subjected to multiaxial stress states with constant principal stress direction, e.g. proportional loading. In case of load histories which produce varying principal stress directions with respect to time, e.g. non-proportional loading, better estimation capability is shown by MWCM and EESH. In most of the cases of varying principal stress direction load histories, vMH and PSH fail to estimate the fatigue strength. The fatigue strength of specimens tested with combined loading is reduced in comparison to the fatigue strength of specimens tested with only internal pressure and only bending loading. Out-of-phase loading does not affect the fatigue strength significantly for the specimens in this study. However; a decrease in fatigue strength is observed for the test data for out-of-phase loading collected from the literature.

Keywords: fatigue strength; tube-to-plate joint; welded joints; local stress based approaches; multi-axial stress state.

Nomenclature

FAT	Characteristic fatigue class in MPa corresponding to $2x10^6$ cycles at failure with a survival probability of 95% and a confidence limit of 75%
$FAT_{50\%}$	Fatigue strength corresponding to $2x10^6$ cycles at failure with a survival probability of 50% and a confidence limit of 75%
R	Stress ratio, minimum stress/maximum stress
R_p	Stress ratio due to internal pressure loading,minimum axial stress/maximum axial stress