Industrial Member Report Summary – Key Findings for Industry

Effects of Biaxiality on Residual Stress Relief and Fracture in Welded Joints

TWI Core Research Programme

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Industrial need

TWI's database of full-scale fracture tests includes wide plate tests carried out on well characterised welded joints with and without use of a warm prestress (WPS). This work relates to a set of tests carried out at -70°C on surface cracked specimens using biaxial loading conditions for both the WPS (where applicable) and the final failure condition. Factors other than this (weld procedure, flaw size, materials properties etc) were matched as far as possible in order to ensure that WPS was the only significant variable between the tests. The main objectives were:

- To demonstrate the effect of WPS under different biaxiality conditions on welding residual stress.
- To calculate the effect of biaxiality on failure in terms of fracture assessment procedures.
- To analyse the effect of biaxiality on the relief of welding residual stresses during WPS, and compare these results with experimental measurements.
- To demonstrate the effect of using different reference stress/limit load solutions on failure assessment.

Key Findings

- Residual stresses transverse to the weld in an uncracked joint subjected to a simulated WPS were higher when biaxial loading was applied than under uniaxial loading conditions, ie there was less mechanical relief of residual stresses under biaxial conditions.
- The initial estimate of L_r was reduced by a factor of around 1.3 once a revised global limit load solution was used, and the effects of biaxiality had been taken into account.
- Refinement of the treatment of residual stress from a simple Level 1 approach to a Level 3 approach allowed a reduction in the value of K_r at failure by a factor of around two.
- All the results associated with failure of the biaxial wide plates lie outside the default failure assessment line so can be considered to support the fracture models in BS 7910 and R6.
- The Level 1 model for residual stress relaxation is a reasonable representation of the data obtained after WPS, especially if the appropriate plastic collapse model is used and weld strength mismatch and biaxiality are taken into account.
- The experimental data used to validate the BS 7910 plastic collapse equations, when analysed in terms of the R6 global collapse model produce several points on the 'unsafe' side of the boundary, ie the equations overpredict the observed failure load.

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