ABSTRACT

The present study is concerned with methods of testing and structural assessment for fracture resistance of a structural steel in those situations where linear elastic fracture mechanics are inapplicable due to the thickness or operational temperature of interest.

A literature review of the current status of elastic plastic fracture mechanics was carried out, and this was divided into two parts: analysis of elastic plastic fracture toughness characterizing parameters, and techniques for their use in practical assessment of the integrity of structures.

Measurements of fracture toughness using the crack opening displacement concept were carried out on specimens of various bend geometries, in order to identify the dependence of these measurements on the value of crack length and crack length/specimen width a/W ratio. It was concluded that at lower shelf temperatures results are insensitive to a/W, but at higher temperatures, fracture toughness increases with decreasing value of a/W. Measurements of fracture toughness using the J-integral concept displayed the same behaviour, and a relationship J-δ depending on the material's value of σ_Y is suggested. A relationship between the effects of thickness and crack length as means of achieving constrained through thickness deformation at fracture was derived. Extrapolating the available experimental data, it is suggested that very deep cracks will enable the attainment of low levels of through thickness strain, using smaller specimens than those required by LEFM specifications.

A study of methods for the experimental determination of J-integral values and of fracture toughness using the J-integral was carried out, and recommendations concerning this subject were established. In particular the commonly used approximate expression for the estimation of J based on the energy input up to the point of interest was shown to give unsafe estimates of J for deeply cracked three point bend test pieces.

Assessment of the upper shelf fracture behaviour of a structural steel requires the determination of elastic plastic resistance curves. The geometry dependence of R-curves was studied, and experimental techniques to measure the crack growth resistance were developed.