

# **Shallow Crack Fracture Mechanics, Toughness Tests and Applications**

Cambridge, UK, 23–24 September 1992

Technical Director – Michael G Dawes

International Conference

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MECHANICS, TOUGHNESS TESTS  
AND APPLICATIONS**

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**Michael G Dawes, PhD, CEng, FWeldI**  
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## FOREWORD

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Fracture mechanics theory and practice has developed to the stage where there are now many widely recognised national standards for fracture mechanics toughness tests. These standards have been greatly influenced by the early development of the ASTM E399  $K_{Ic}$  test method, which involves test specimens having crack depth ( $a$ ) to specimen width ( $W$ ) ratios of about 0.5. However, within the last decade there has been an increasing awareness that the use of such deeply notched specimens may result in extreme under- or over-estimates of the true fracture toughness associated with shallow surface cracks in welded structures. Since this knowledge has serious implications for structural integrity and safety, it has stimulated work towards a better understanding of the factors that control fracture toughness, and also the new procedures that are necessary to extend the current standards for applications to shallow cracks in specific situations. This work was exemplified by the recent completion of a large TWI/Edison Welding Institute research project, which led to the idea for this conference.

Thus, the objective of this conference was to provide a timely and first international state-of-the-art review of shallow crack problems and tests, and their application to metal structures.

The conference comprised four sessions:

- Session A: Fundamentals
- Session B: Fracture toughness
- Session C: Applied conditions
- Session D: Fracture assessments

The first contribution to Session A, Paper 13, provides a general introduction to the conference and poses a series of questions that need to be answered. The answers are provided in the context of a brief post-conference overview. The subsequent papers in Session A cover the fundamentals of fracture characterising parameters, such as  $K$ , CTOD and  $J$ ; the quantification of geometric constraint using  $Q$  and  $T$  stress approaches; the application of these and other analytical and numerical approaches (including the well known Anderson and Dodds, and Beremin local approach) to cleavage and ductile crack extension; and a simple engineering approach for characterising shallow crack fracture toughness under explosive loading.

Session B includes papers on the development of shallow crack testing procedures; shallow crack test results for base metals and welded joints; considerations of weld yield strength overmatching, and fatigue precracking compared to EDM notching.

Session C contains papers on 2D and 3D finite element analysis of applied or driving force values of  $K$ , CTOD and  $J$  for base metals, welded laboratory test specimens and welded T-butt welds. Papers 2, 14 and 28 give proposed CTOD and  $J$  estimations formulae for deep and shallow crack SENB specimens. Paper 29 shows the influence of weld strength mismatch on crack tip constraint in SENB specimens. This session also includes a contribution (Paper 35) on the emission and reflection of surface (Rayleigh) waves following pop-in at the crack tip.

Session D covers fracture assessments for both ductile and brittle (cleavage) crack extension. The papers consider components as diverse as large through-thickness, surface and edge cracked laboratory specimens, cracked broad flanged beams and pipes in four-point bending, and a pipe elbow loaded in cantilever in-plane bending.

At this state-of-the-art of shallow crack mechanics tests and analyses, it is significant that none of the papers in Session D include fracture toughness data associated with the shallow crack SENB specimen designs that are featured so prominently in Sessions A, B and C. This may be seen as an indication of the relatively recent and rapid evolution of shallow crack test methods, which leads one to expect that further significant advances in this subject area will occur prior to the 2nd International Conference on Shallow Crack Fracture Mechanics Toughness Tests and Applications, which is planned tentatively for a venue in Europe in 1995.

The success of this conference was made possible by the authors, a body of experts that devoted their time and wisdom to reviewing the papers, the session chairmen, the Conference Organiser, Tony Gray, and his staff at TWI. All of these people are gratefully acknowledged.

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*Principal Fracture Consultant*  
*Engineering and Materials Group*  
*TWI*

# Shallow Crack Fracture Mechanics, Toughness Tests and Applications

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