



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: **Experimental and Numerical Studies on Mixed Mode Fracture and Fatigue Using a New Specimen**
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SHORT ABSTRACT

Mixed mode fracture and fatigue failures are one of the most significant causes of failure in materials and structural components. In the present investigation, a simple and efficient specimen geometry and out-of-plane loading fixture that can be used with conventional uniaxial universal testing machines for conducting any combination of mixed mode (I/II/III) fracture and fatigue crack growth studies have been proposed. The proposed specimen is a single edge cracked circular (SECC) specimen which can be employed on both metallic and non-metallic materials under static and fatigue loads.

To examine the efficacy of the proposed SECC specimen and out-of-plane loading fixture, a large number of fracture experiments under quasi-static loading have been conducted on specimens made of PMMA material under two different mixed mode loading configurations, viz., mixed mode (I/II) and (I/III). Furthermore, the efficacy of the SECC specimen to perform mixed fatigue (I/II) fatigue crack growth studies using metallic materials has also been examined by conducting a series of fatigue experiments on two different materials, viz., Al 7075-T6 aluminium alloy and AISI 304 steel. Along with the aforementioned experimental studies, a large number of three-dimensional finite element analyses of the full loading assembly have been performed in ANSYS® to aid the present experimental results.

The present results of the mixed mode fracture experimental studies have been compared with widely used mixed mode fracture criteria, specifically in terms of fracture toughness, critical fracture load, crack kink angle, and crack twist angle, to support the effectiveness of the proposed specimen for fracture and fatigue studies. More than one specimen has been employed in all the present experiments to understand the repeatability and correctness of the adopted experimental procedures.

Another aspect of the present research work focuses on the prediction of crack length versus the number of loading cycles curve (or fatigue life curve) under mixed mode (I/II) loading conditions using modified Paris's law with different ΔK_{eq} models. Currently, these ΔK_{eq} models are essentially used for two purposes: firstly, correlating the mixed mode (I/II) fatigue crack growth rate (FCGR), and secondly, predicting the mixed mode fatigue life using numerical methods. Clearly, different ΔK_{eq} models can result in varied FCGR characteristics and different fatigue life predictions under mixed mode cyclic loading. Therefore, the performance evaluation and potential applications of various ΔK_{eq} models have been investigated using the proposed SECC specimen setup. Further, in the present work, for the first time, a novel ΔK_{eq} model based on the GMTS criterion has been proposed for correlating the mixed mode FCGR and predicting fatigue life. For this purpose, mixed mode (I/II) fatigue crack growth experiments have been carried out using the SECC specimen made of AISI 304 steel and Al 7075-T6 alloy under different loading angles.

Another important issue related to the numerical estimation of mixed mode (I/II) fatigue life while using various ΔK_{eq} models in the modified Paris law has also been addressed in detail in the present work. The current practice of estimating the fatigue life is to consider a ΔK_{eq} model and employ the mode I Paris' constants in the modified Paris law. Different sets of Paris' constants can be obtained directly from the mixed mode fatigue crack growth experiments, apart from the values obtained from mode I tests. Therefore, the influence of all these different types of Paris' constants in the prediction of fatigue life while using various ΔK_{eq} models has been studied in depth and presented with important observations.

The results of the present work clearly show that (a) the GMTS criterion has shown superior performance while predicting the crack kink angles and fracture locus, similar to some other criteria in mixed mode fracture tests; (b) for a given loading angle and a set of the Paris' constants, the performance of all the ΔK_{eq} models is nearly the same; (c) the results of life prediction using mixed mode Paris constants are in excellent agreement with the experimental mixed mode fatigue life for all the ΔK_{eq} models; (d) the results clearly show that the influence of the Paris' constants has significant effect on the prediction of the mixed mode life than the selection of a ΔK_{eq} model; (e) excellent repeatability of the static and fatigue experimental results have been noticed when more than one SECC specimen is employed, and finally (f) the results of the present investigation clearly demonstrate that the proposed specimen setup can be used to study the mixed mode (I/II), (I/III), and (I/II/III) behavior of linear elastic materials under static and fatigue loading.