XFEM Modeling of Mixed-Mode Cracks in Thin Aluminum Panels

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Abstract: The Extended Finite Element Method (XFEM) capabilities of Abaqus V6.9-EF1 could have a significant impact on finite element modeling of failure for the U. S. Army. The Army has many areas where fracture is important from failure of components, to penetration, to warhead development. To assess the value of XFEM under static loading, comparisons were made with experimental data of notched panels. The panels had different angles of notches. The crack growth direction and applied forces for crack growth were compared to experiments using ABAQUS. The applied force at failure was within 5% of experimental values. The predicted crack growth direction was accurate. Since much of the Army's work involves dynamic explicit analysis, the XFEM technique may only find limited use until it is extended into the ABAQUS Explicit program.

Keywords: fatigue, failure, fracture, XFEM, 6061-T6 aluminum, crack, notch, mixed-mode

INTRODUCTION

Several center notched panels were tested to determine the applied force at crack growth and the direction of crack growth. In earlier studies, cohesive zone models were used to predict the mixed mode fracture results [1]. The previous analysis used cohesive elements parallel to and perpendicular to crack growth. Cohesive zone properties were derived from experimental KR versus crack growth curves. Critical crack tip opening displacements were incorporated into the cohesive elements. The resulting applied stress predictions were within 8% of experimental results.

This paper describes analysis of the same panels using the XFEM capabilities in ABAQUS V6.9-EF1 [2]. The full Kr verses crack growth curves were not used. Fracture toughness was used to determine a critical energy criteria and a critical displacement criteria. Both results are presented. The current method is simpler to model since cohesive elements are not required and the direction of crack growth does not need to be specified. Experimental parameters are limited to fracture toughness, yield strength, Young's modulus, and Poisson's ratio. Some issues with numerical convergence had to be