ABSTRACT

Mutlu, Ovunc. Ph.D., Purdue University, May 2005. Progressive failure along frictional surfaces. Major Professor: Antonio Bobet

Slip initiation and propagation along non-homogeneous frictional surfaces are investigated by loading in biaxial compression specimens made of acrylic and gypsum. The specimens used in the tests are composed of three or two individual blocks with perfectly mated contact surfaces. The contact surfaces have on their upper half a frictional strength smaller than on their lower half. This creates a "weak" surface on the upper half and a "strong" surface on the lower half. Different tests are performed by changing the frictional characteristics (e.g. cohesion and friction) of the strong surface. The experiments are conducted by applying first a normal stress across the frictional surface and then increasing the shear stress until final debonding and slip along the strong surface occur. Slip starts on the weak area and, as the shear stress is increased, propagates towards the strong area. Full slip along the weak area introduces a sharp transition between the area of the discontinuity that has slipped and the area that has not. This transition induces a large concentration of stresses which can be treated within the framework of fracture mechanics as a mode II frictional crack. With further loading rupture occurs through the strong area as an unstable process that coincides with failure. The results show that the critical energy release rate G_{IIC} is a good indicator of the rupture. However G_{IIC} is not a material property. It depends on the normal stress applied, on the frictional characteristics of the interface, and on the critical slip required for the transition from peak to residual. A slip initiation model is proposed based on experimental observations and on fracture mechanics theory. The new model is incorporated into the finite element method code ABAQUS. Predictions with the model compare very well with experiments.