

## **Abstract**

The main objective of the present investigation was to develop a method to predict the strength and failure modes of mechanically fastened joints in composite laminates.

The experimental observations concerning the effects of several parameters on the joint strength and the advantages and weaknesses of the methods used to determine stress distributions and to predict strength were described in a literature survey. Due to the three-dimensional stress state at the hole boundary, and due to the effects of factors such as clamping pressure on the joint strength, the development of a three-dimensional finite element model was proposed. Since the localised damage occurring before final failure was found to be crucial in determining the joint strength, the use of progressive damage models was considered essential.

Having discovered only a limited amount of experimental work concerning the identification of damage mechanisms occurring in bolted joints, an experimental investigation was performed. The processes of damage accumulation and final failure were identified using X-radiography and micrographs. Based on the results obtained, the use of a progressive damage model was further justified.

A three-dimensional finite element model of a laminate loaded by a bolt was developed. Damage progression was simulated using a three-dimensional failure criterion and by extending to three dimensions a previously developed progressive damage model. Good agreement between numerical and experimental results was achieved. The model was also able to simulate the catastrophic characteristics of tensile and shear failures.

Spline approximations for the through-thickness stresses and a delamination onset criterion were applied to assess the effects of stacking sequence and through-thickness constraints on delamination onset loads. The results obtained partially explained previous experimental observations. An analysis into the effects of metallic inserts bonded into the laminate hole was performed, highlighting the requirement of stronger adhesives to fully exploit the benefits associated with the use of inserts. The effects of the type of fit and of frictional contacts on stress distributions and on the joint strength were also investigated, and the results obtained gave insight into the effects of opting for a given design on the joint performance.