



Predictive Modelling of Damage in Marine Composite Structures

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INTRODUCTION

An improved understanding of the detailed response to shock loading of large structures made from fibre composite materials is critical if their use is to be made more widespread. Numerical and experimental models in this study were aimed at developing a simple yet effective way of modelling the behaviour and damage of thick composite plates under impact.

Construction of a half scale Corvette ready for testing.

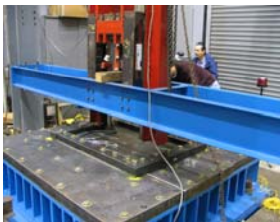


OBJECTIVES

- Conduct impact tests on both large and small scale panels made from E – Glass Woven Roving and a vinyl ester resin.
- Set up a simple analytical model to compare with the global response obtained from the experiments.
- Develop numerical models to capture main damage mechanisms of Delamination, matrix cracking and fibre breakage.

Impact test facilities

Impact test facilities used are shown below. The large rig in blue was at a naval research facility and capable of taking panels up to 1.3 metres square and applying a drop weight up to 682 Kg's! A hemispherical tup of 200 mm diameter was adopted. The smaller facility was based at the Naval Academy where panels of 230 by 180 mm were tested with maximum drop weights of 25 Kg's. Velocities up to 7 m/s were studied.



Typical Damage to Large and Small Scale Panels



Large scale

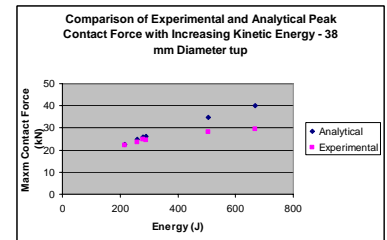
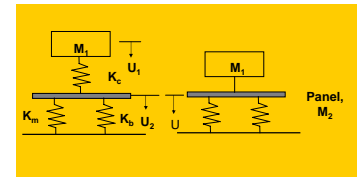
Small scale

Small scale plate cut through the centre – showing delamination



Simple Analytical Model

A simple analytical model based on equating the kinetic energy of the impacting mass to the energy absorbed by the panel in deforming and denting was established to capture the simple physics of the problem. The bending and membrane stiffness of the plate is replaced by springs together with the varying contact force.

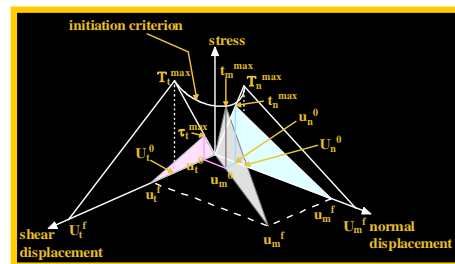


3D Damage Modelling

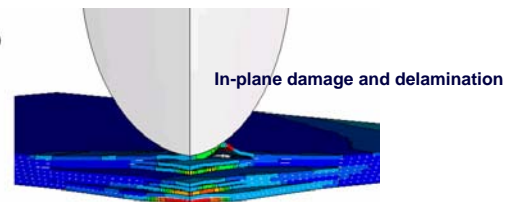
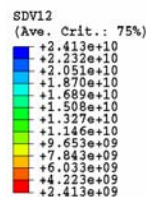
Here an existing 2d damage model has been modified and applied alongside an out-of-plane damage model at the ply and inter-ply level (delamination).

3d damage initiation is defined with an equivalent strain function and damage propagation is based on damage mechanics principles. Once damage has initiated, the progressive degradation is defined with damage parameters obtained from cyclic loading tests and standard tensile/compressive tests.

Delamination is modelled using a 3d linear traction separation 'cohesive zone model' at the inter-ply level.

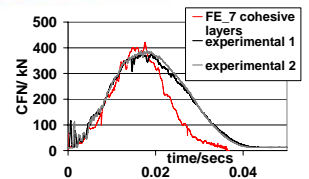


Linear, coupled cohesive zone model



In-plane damage and delamination

Contact force prediction for large plate impact, 72.2kJ



CONCLUSION

The 3d damage model provides a simple and successful tool for modelling the effects of a dynamic load on the contact force and out-of-plane displacement. It also provides a visual representation of the extent of damage incurred in the form of modulus reduction resulting from matrix cracking, fibre damage and delamination.