3-D FRACTURE ANALYSIS OF COMPOSITES BY DEM

S. Mohammadi, D.R.J. Owen, D. Peric

Department of Civil Engineering, University of Wales Swansea
Singleton Park, Swansea SA2 8PP, U.K.

ABSTRACT

Due to a wide use of laminated composites for aircraft and other structures, and the influence that impact damage may have in reducing the mechanical properties and life of these structures, the impact loading of laminated composite structures has been a very active area of research. One of the major problems that affects the design and performance of composite materials is their vulnerability to transverse impact which may cause substantial internal damage of the component due to matrix cracking, fibre failure and delamination.

The traditional approach to the simulation of stress distributions in arbitrary shaped components is by finite element techniques. However, this method (FEM) is rooted in the concepts of continuum mechanics and is not suited to general fracture propagation problems. In contrast, the discrete element method (DEM) is specifically designed to solve problems that exhibit strong discontinuities in material and geometric behaviour. In this study, a three dimensional combined finite/discrete element algorithm is developed to simulate delamination and material fracture in laminated composites subjected to impact loadings.

In this method of modelling of composites, the possible fractured region is modelled using a discrete element mesh, and the rest of the structure is modelled by a finite element mesh. A combined mesh enables us to prevent unnecessary contact detection and interaction calculations which comprise a major part of the analysis time. Each group of similar plies is modelled by one discrete element. Each discrete element will be discretized by a finite element mesh and might have material or geometric nonlinearities. The interlaminar behaviour of discrete elements is governed by bonding laws which include contact and friction interactions for the post delamination phase. Once two layers are delaminated, the corresponding interface will still be capable of further contact and friction interaction.

In conclusion, the combined finite/discrete element method has been found to be an effective approach for three dimensional fracture analysis of composites. This method, with some modifications, could be also used in modelling of masonry and reinforced concrete structures subjected to explosive and impact loading conditions,in which a progressive fracturing phenomenon is predictable.