IITB-Monash Research Academy

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Multiscale Modelling of Composite Laminates using Meshless Methods

Project number: IMURA0070

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Research Academy theme/s

Advanced computational engineering, simulation and manufacture.

The research problem

The development of sophisticated numerical tools for composite damage modelling has become a priority research area in aerostructures. This has been partly motivated by the need to reduce the high development costs currently incurred in the development of new generation passenger and military transport aircraft which make extensive use of carbon-fibre material in their primary structure. One way of achieving this is to replace some of the experimental testing, required for certification, by simulation. This can only be achieved if industry can reliably predict the complex damage mechanisms which may occur in such structures. Indeed, this shortcoming is still yielding designs which are highly conservative and the material's full potential has yet to be fully exploited.

The finite element method has been widely adopted for the modelling of in-plane damage and delamination (cracking) and a high level of sophistication in composite damage modelling has been achieved using continuum damage mechanics and fracture mechanics [1,2]. Nonetheless, there are still problems with mesh-size dependency, mesh distortion when mesh adaptivity is required and numerical stability.

A number of these problems are mitigated using a meshless approach whereby node connectivity, leading to the formation of elements, is removed. In essence, the structural domain is represented by a 'cloud' of nodes, each with an associated weighted shape function. Various meshless methods have been proposed [3] and the strategy that will be adopted for this research is based on the Element-Free Galerkin (EFG) method first utilised by Belytchko [4,5]. Figure 1 shows the mutliscale approach that will be adopted whereby a damage modelling capability, using EFG, is developed at the microscale level and the resulting constitutive behaviour utlised by finite element models of the structure at the meso- and macroscale level. The development of a robust meshless-based tool for composite damage modelling would represent a major step forward towards the effective and reliable virtual testing of composite aerostructures.

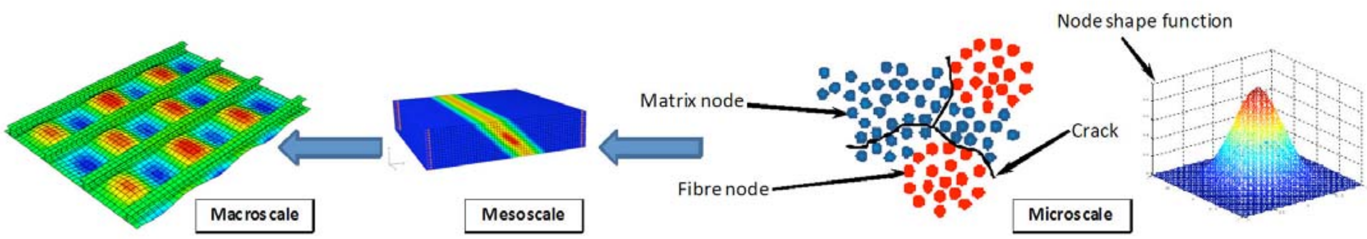

Figure 1: Multiscale modelling using Meshless and Finite Element methods

Project aims

The primary aim of this project is the development of an Element-Free Galerkin method for modelling damage in composite material at the microscale level. Considerable challenges also present themselves in adopting a multiscale approach and an effective methodology will be developed to accomplish this.

Expected outcomes

It is expected that numerical code will be developed for the damage modelling of composite material and a methodology implemented for utilising this information in meso- and macroscale finite element models. This capability will be validated against a number of experimental results on test coupons and stiffened panels.

Which of the above Theme does this project address?

This project will contribute towards the theme of ‘Advanced computational engineering, simulation and manufacture’.

How will the project address the Goals of the above Themes?

It is generally recognised that the means to reduce development costs in the design and analysis of a new product is through the use of simulation and numerical modelling. A highly-sophisticated and reliable method of damage prediction in composites is sought by industry to allow it to reduce its experimental testing programmes by utilising more simulation in the development cycle. This project will make a contribution towards realising this aim.

References

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[5] Belytchko, T., Lu, Y.Y., Gu, L., “Fracture *Element-free Galerkin methods*,” International Journal for Numerical Methods in Engineering, 37 (1994), 229 – 256.