IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Modelling damage initiation and propagation in postbuckling and bonded composite aerostructures with geometrical discontinuities

Project number: IMURA0071

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Research Academy theme/s

Advanced computational engineering, simulation and manufacture.

The research problem

Advanced composite materials continue to find increased use in the development of new lightweight aerostructures. This technology will play a major role in realising Governmental aims of substantial reductions in fuel consumption and Nitrous Oxide emissions. For example, the European Union plans to cut 50% in aircraft fuel consumption and 80% in Nitrous Oxide emissions by 2020 [1].

Current industry practice in the design of composite aerostructures is effectively demonstrated in Figure 1. Figure 1(a) outlines the current design scenario expressed diagrammatically by an equilibrium curve of applied loading versus the corresponding end-shortening of a representative composite structural component. It is noted that such components may be designed to buckle slightly below the limit load but that no damage is allowed to develop between the limit and ultimate design loads. This results in a structure with a high reserve strength. Figure 1(b) is an aspirational scenario where the structure is more likely to operate in a postbuckled tate and the onset of damage is permitted between the limit and ultimate design loads. The ultimate load is also very close to the collapse load of the component. A high-level of confidence needs to be achieved by industry to design such structures. Central to this aim, is the development of robust and reliable predictive tools to simulate damage initiation

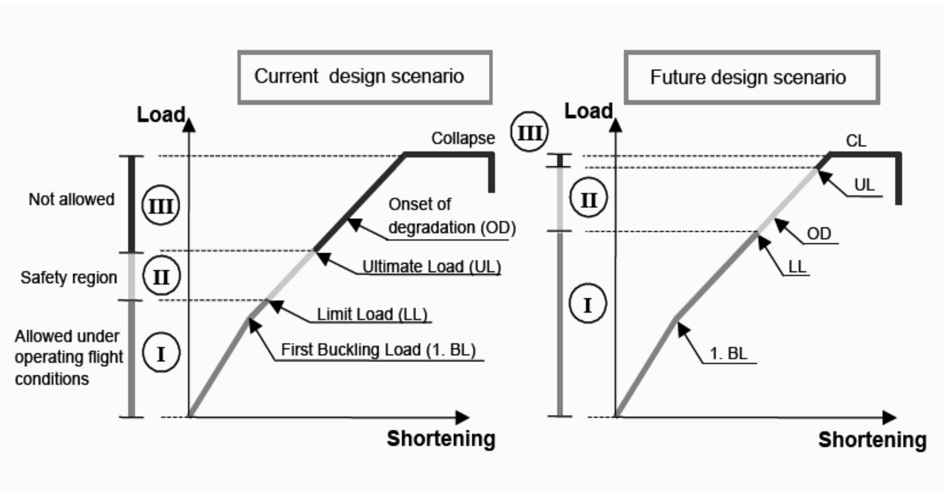

Figure 1: Composites design philosophy; (a) current and (b) future design scenarios. [courtesy of DLR].

and propagation under various loading conditions. Figure 2 shows damage initiating at the skin-stiffener interface of a compressively loaded postbuckling composite pane.

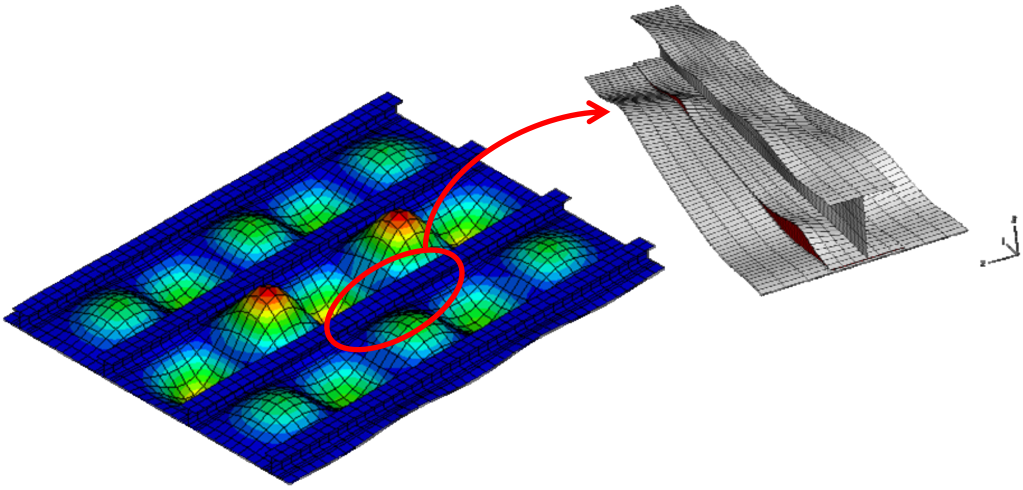

Figure 2: A postbuckling stiffened composite panel showing localised skin-stiffener separation.

Project aims

A physically-based composites damage model has been developed for ABAQUS/Implicit [2]. This model will be adapted for ABAQUS/Explicit which is more robust in dealing with highly non-linear behaviour and more suited for modelling impact damage.

A number if representative geometric discontinuities will be modelled and their response under static and impact loading will be assessed. The models will be validated using existing experimental databases.

These aims will combine to enable the creation of a virtual testing environment for airframe manufacturers where some of the costly physical testing, undertaken during the design process, will be replaced by simulation.

Expected outcomes

A robust and reliable modelling methodology will be developed for the analysis of representative postbuckling aerostructures which may contain structural discontinuities such as stiffener runouts or cutouts. This work will also suggest design improvements to critical regions.

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?

The development of a reliable predictive tool for the analysis of postbuckling aerostructues will equip industry with the confidence to design significantly lighter airframes. This, in turn, will contribute to reducing environmental impact.

References

[1] Group of Personalities, “*European Aeronautics: A Vision for 2020*,” Office for Official Publications of the European Communities, Belgium (2001).

[2] Apruzzese., Falzon, B.G., “*Numerical analysis of complex failure mechanisms in composite structures*, “ Proceedings of ICCM-16, 8-13 July, Kyoto, Japan (2007).