QUB- Mechanical and Aerospace Engineering PhD Project 2019-2020

Uncertainty quantification in modelling damage in composites arising from manufacturing variability

Project description:

The increased use of carbon-fibre reinforced polymer (CFRP) material in the latest generation of wide-body passenger aircraft has necessitated considerable effort to ensure satisfactory damage tolerance. Such structures are far from optimum, owing to the extent of physical testing currently required in the certification programme, which has consequently limited the design space that can be explored. The development of reliable and robust computational tools, to model the complex phenomenon of composite damage, has the potential to reduce the extent of physical testing by replacing some of this testing with simulation. To date, numerous proposed models developed for the simulation of composite damage, have depended on considerable 'calibration' of the input data which limits their predictive capability. More recently, Prof Falzon's research group have proposed a sophisticated material model and an associated suite of ply-level tests to extract intrinsic material properties, for the reliable prediction of the energy-absorbing capacity of thermoset and thermoplastic composites. Excellent correlation has been achieved when validated with a number of test specimens without the need to calibrate any of the input parameters (i.e. the intrinsic material properties).

Reliable and robust predictive computational tools are essential for the aspiration aim of conducting a certain level of certification by simulation. To this end, the concept of 'Simulation Governance' has recently been proposed which outlines procedures for ensuring and enhancing the reliability of predictions based on numerical simulation. Essentially this governance structure is based on a systematic means of developing a model which can be updated as more information (e.g. through verification/validation or additional material characterisation tests) becomes available. Such a structure also requires uncertainty quantification to inform the model formulation. In fact Simulation Governance aims to reduce this uncertainty which is further categorised as either 'Epistemic', which deals with uncertainties associated with the physics which the model is trying to capture, and 'Aleatoric' which arise as a consequence of uncertainty which inevitably occurs in the acquisition of any data set required in the determination of intrinsic material properties. These two forms of uncertainty are often difficult to distinguish.

Aims and Objectives:

The aim of this research project is to introduce uncertainty quantification, in the damage model, which arises as a result of unavoidable manufacturing variability during the processing of carbon fibre composite structures. This can take many forms across scales; variations in fibre distribution/fibre volume fraction or voids/defects at the microscale, fibre waviness which may occur at the mesoscale and potential defects or deviations from an expected baseline, at the macroscale. This research will explore how such uncertainties influence the damage tolerance of composite structures.

Key skills required for the post:
Candidate should demonstrate knowledge/experience/skills in at least one of the following areas:

- Fibre reinforced composites
- Numerical modelling (primarily finite element analysis)
- Fracture and/or damage mechanics
- Stochastic analysis (desirable)

Key transferable skills that will be developed during the PhD:
These will include an ability to effectively communicate research outcomes to academic peers and industry, independent analytical thinking and problem solving, time management, and leadership.

Lead supervisor:	Prof Brian G. Falzon CEng, FRAeS b.falzon@qub.ac.uk
Other supervisors:	Dr Zahur Ullah z.ullah@qub.ac.uk
Funding mechanism:	UK only.
Application closing date:	Until suitable candidate appointed.
Guaranteed stipend	£15,009 tax free.

PhD students in the School may have the opportunity to apply to be demonstrators on undergraduate modules. Compensation for this can amount to in excess of £2,400 per year.

Queens University Belfast is a diverse and international institution which is strongly committed to equality and diversity, and to selection on merit. Currently women are under-represented in research positions in the School and accordingly applications from women are particularly welcome.