QUB-CSC Scholarship PhD Project Proposal
2018-2019

Development of highly crashworthy lightweight structures utilising auxetic composite lattices

Project Description:

The development of transportation structures entails a considerable degree of effort in ensuring adequate crashworthiness for the protection of passengers. In essence, this requires the ability of a structure to absorb kinetic energy, prevent large decelerating forces from being transmitted to the passengers and minimize overall deformation to permit evacuation.

The ubiquitous use of lightweight composite materials in transportation structures has created a formidable challenge in ensuring the same level of crashworthiness as their metallic counterpart. Different approaches towards the development of more efficient materials has led to an interest in auxetic structures. Auxetic refers to a negative Poisson's ratio which is a meta-material property. Consequently, when a compressive load is applied to an auxetic, the material will contract in the direction orthogonal to the applied load, creating a denser region. This densification makes auxetics suited to severe loading conditions such as crushing (Fig 1). This research programme will examine their effectiveness in the design of lightweight crashworthy structures.

Non-auxetic Auxetic

Figure 1: Impact resistance of non-auxetic and auxetic materials [1]

In order to decrease design cycle times and ensure that safe design standards are met, virtual tests are usually performed by numerical simulation. The virtual crush and crash test data are subsequently used as part of the development of a new design. These numerical simulations produce results without building a physical model, and can be performed relatively quickly and inexpensively. This permits optimization of the design before an actual prototype of the vehicle has to be built.

The aim of this project is to provide a step change in the safety of lightweight transportation structures in crash events. A highly novel approach will be investigated which exploits the unique features of auxetic materials by developing auxetic composite lattices for thin-walled energy-absorbing structural components.

Moreover, the project will involve sophisticated experiments and advanced numerical modeling of different crashworthy structures. One approach will explore the use of thin-walled closed sections, such as a tube, filled with an auxetic composite macro lattice produced via 3D printing.

[1] Evans, K. E. and Alderson, A. (2000), Auxetic Materials: Functional Materials and Structures from Lateral Thinking!. Adv. Mater., 12: 617–628. doi:10.1002/(SICI)1521-4095(200005)12:9<617::AID-ADMA617>3.0.CO;2-3

Key Skills Required for the post:

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

- Structural analysis and testing
- Numerical modelling (primarily finite element analysis)

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.

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