Structures
Research Theme

Stephen Hallett

bristol.ac.uk/composites
Our research into the mechanical performance of composites encompasses novel numerical methods, novel structural configurations, advanced analysis techniques, multi-functionality and data rich experimentation.

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Highlights from 2016/17

• Composites UTC supported by Rolls-Royce 10 year anniversary
  • Started in the structures area but now diversified into materials and manufacturing too
  • Finite element modelling tools are now being deployed by Rolls-Royce on component design
  • Research into novel through-thickness reinforcement (TTR) and new TTR manufacturing methods now being trialed by Rolls-Royce

• Wind Blade Research Hub launched
  • Research partnership between Offshore Renewable Energy Catapult and University of Bristol

• EU H2020 Shape Adaptive Blades for Rotorcraft Efficiency (SABRE) project launched (€6M)

• >25 Journal papers published in 2017
Shape Adaptive Blades for Rotorcraft Efficiency

Objective:
Reduce fuel burn, CO₂ and NOx emissions by 5 – 10%.

Aims to develop ground-breaking new helicopter blade morphing technologies.

Technologies developed will be applicable to other industries, such as fixed wing aircraft and wind turbines.

Led by Dr. Ben Woods and coordinated by the University of Bristol.

Horizon 2020
€6M budget

6 partners from 4 EU countries

3.5 year duration

University of BRISTOL
Bristol Composites Institute (ACCIS)
Effect of Defects 1/2

- We are studying a range of defects to understand and predict their failure
- Manufacture of controlled level of defects in a lab environment
  - Ply waviness
  - AFP Gaps and Overlaps
  - Voids
- Careful monitoring of failure modes and mechanisms and knockdown from pristine strength

(Image credits: Mike Jones, Iryna Tretiak)
Effect of Defects 2/2

- Advanced numerical models have been developed to accurately predict failure
  - Quasi-static tension and compression
  - Multi-axial loading
  - Fatigue

- Initial work has been to generate virtual allowables to aid the design and certification process

- Recent work has developed multi-scale analysis capability for full-scale components

- Now linking to manufacturing simulation to predict origin of defects

(Image credits: Supratik Mukhopadhyay, Jonathan Belnoue, Oliver Nixon-Pearson)
Hybrid Structures

• Novel concepts for metal-fibre hybrid structures are being realised by combining manufacture and performance simulation.

• The full potential of such structures is yet to be unlocked:
  • Combining the best of CFRP (specific properties, fatigue) and metal alloys (isotropy, plasticity).
  • Promoting direct load transfer between fibres and metal.
  • Making the most of advanced manufacture, e.g. additive layer manufacture + precision braiding and filament winding.

(Image credits: Dr Ric XC Sun, Jordan Jones)
Ultra-efficient wound trusses

• A patented new manufacturing process that combines the “best of everything”
  • The excellent material properties of composites
  • The superlative structural efficiency of trusses
  • The low cost of a continuous winding process

Analysis shows the potential for wound trusses to be an order of magnitude more efficient than carbon fibre tubes

New automated truss winder designed and built here at UoB (Chris Hunt)
Exploiting Non-linearity

a) Multi-functional applications,

- e.g. Morphing structures

b) New concepts

\[ P_e (N) \]

\[ w_e (mm) \]

- Multi-stage morphing via intermediate snaps

- Morphing structures

- Initial airflow

- Airflow speed increases

- Inlet closes

- Airflow speed decreases

- Passive or actuated snap-back

- Snaps shut

- Airflow

- Air inlets

- Alberto Pirrera

- Paul Weaver
Non-linear structures
(Experimental Methods)

- Novel experimental methods for nonlinear, postbuckled structures
- Allows more possible deformation shapes to be measured
- Enables model validation, required for engineering applications
Composite Lattices Systems

- Couple stiffness anisotropy and geometric effects.
- Tailoring for bespoke response characteristics.
- Active lattices for morphing (thermal actuation).
- Potential for adaptive, multi-stable, space filling surfaces.

Prototype thermal actuator [Tom Watts]

Tuned snap actuation at critical temperature
Summary and Outlook

• A significant number of projects ranging from blue-sky research to engineering applications
  • See quick-fire and posters for more technical details
• >£12M funding in active grants
• 35 PhD students and 28 Staff Researchers
• Working with many industrial partners
• Further opportunities for new projects and technology transfer