



Multi-Scale Modelling of Materials and Structures



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Multi-Scale Modelling of Materials and Structures at the University of Edinburgh

The Institute for Materials and Processes brings together world class researchers to advance engineering applications of materials, fluids and processes, and to provide a high quality and creative research environment which can be harnessed by our industrial partners. Experimental, computational and theoretical methods are used to shed light on the underlying engineering science.

The Institute for Infrastructure and Environment has expertise in applying engineering materials in a wide range of structural applications, and the two Research Institutes are co-located at the University's King's Buildings site, and work closely together.

Materials research areas include:

- Materials Design and Characterisation
- Multi-scale Modelling from Atoms to Processes
- Composite Materials Manufacture and Processing
- Fire Testing of Materials and Structures
- Dynamic, Impact and Ballistic Performance of Advanced Materials
- Mechanical Testing from Fibres to Large Structures

The Composites and Structural Engineering Groups' research is focused on polymer composites used in aerospace, off-shore and on-shore wind, marine tidal energy systems, automotive and oil and gas applications. Advanced research, consultancy and design code development is undertaken for all types of structures and materials, including:

Structural Mechanics

Structural stability and buckling, inelastic analysis, fatigue, plates and shells, numerical simulation, finite element modelling and analysis. Advanced mechanical testing and design of fibre reinforced composites.

Structural Applications of Composite Materials

Advanced composite materials (e.g. carbon and glass fibre, FRP, textile reinforced mortars) for aerospace, renewable energy (e.g. tidal and wind turbines) and automotive, for strengthening/rehabilitation of damaged or deficient structural elements, and for new construction applications: FRP reinforcement of concrete, all-FRP structures, and polymer composite structures for renewable energy; polymer adhesive joints; structures made of hybrid and innovative materials.

Fire Effects on Structures and Materials

Structural analysis and design accounting for thermal/mechanical fire effects on materials and structures; experimental and computational work; multi-scale approach: from micro scale to full structural frames.

Dynamic Loading on Structures

Impact dynamics, blast loading, armour and protection systems (metals, concrete, composites, cellular materials), earthquake analysis and design, structural robustness against extreme conditions.

Energy Infrastructure

Analysis and integrity of critical components (tanks, vessels, piping, pipelines), offshore structures and pipelines, offshore platforms for renewable energy, condition assessment of "aging infrastructure".

Steel Structures

Cold-formed thin-walled members (tubular, open-section, perforated), advanced steel materials (stainless steel, high-strength steel), steel materials at elevated temperatures and post-fire condition, tubular structures and welded connections.

Particular areas of research specialisation include:

- Innovative composites for marine renewable energy applications (tidal and wind energy blades)
- Advanced composites and emerging structural engineering materials
- Structures in fire and at elevated temperatures
- Strengthening and repair of infrastructure
- Silos and thin-walled structures
- Dynamic effects in structures and materials
- Structural health monitoring non-destructive testing
- Sensing of Damage in Composites
- Pipeline design for oil & gas and offshore
- Processing of thermoset and thermoplastic composites
- Biomechanical applications of structural engineering

Our Facilities:

The University of Edinburgh has substantial facilities for physical testing, computational analysis and processing of a wide range of materials and structures. Testing ranges from simple coupon strength tests, to large-scale bespoke tests of structural elements under complicated loads.

Materials Testing Laboratory

The new (2017) material testing laboratory houses static and dynamic test machines (50KN-300KN) aimed at specialised mechanical testing of advanced composite materials, complete with environmental chamber (-70°C to 300°C), non-contact video extensometry and Digital Image Correlation. Mechanical testing is supported by materials characterisation equipment (DSC, DMTA), optical and scanning electron microscopy.

New Structural Composites Research Facility

This innovative £1.8m Research Facility, the first of its kind in the world, will become operational in 2018 and will be dedicated to the test and assessment of the mechanical performance of large structures under simulated fatigue loading.

The facility will enable faster fatigue or cyclic load testing of large structures and will initially be focussed on fibre-reinforced composite material structures. It will use a brand new, ultra-efficient digital displacement regenerative pumping hydraulic system to enable structures to be tested 10 times faster than possible with existing hydraulic systems. This will enable accelerated research into fundamental engineering options for new materials technology and quicker evaluation leading to more rapid certification and deployment to market. Meaningful full scale benchmarking of composite performance at scale will be possible for the first time and it will drive forward research into fatigue failure.

The Structures Laboratory

This facility enables structures testing equipment from small coupons to full-scale structures, and allows structural testing on material samples. It is a high headroom lab for testing large and unusual structural assemblies. The strong floor and reaction frame systems give great versatility in the types of test that are carried out here, there is a state of the art Instron actuator system for applying two independent loads under precise computer control. The lab is equipped with furnaces and ovens for structural testing under heat and fire. An instrumented drop-weight impact osites and other materials.

Materials Processing Laboratory

This laboratory is dedicated to the novel processing of fibre reinforced polymer composites, including thermoplastic and thermosetting polymers, using powder processing, liquid moulding, press moulding, in-situ polymerisation of thermoplastics and novel prepregging facilities.