

Short Lecture Course:

Failure Analysis & Fractography of Composites

Monday 29 February 2016

Lecturer: Dr Emile S Greenhalgh FIMMM CEng

Venue: Room 254, Roderic Hill Building, Imperial College London, UK

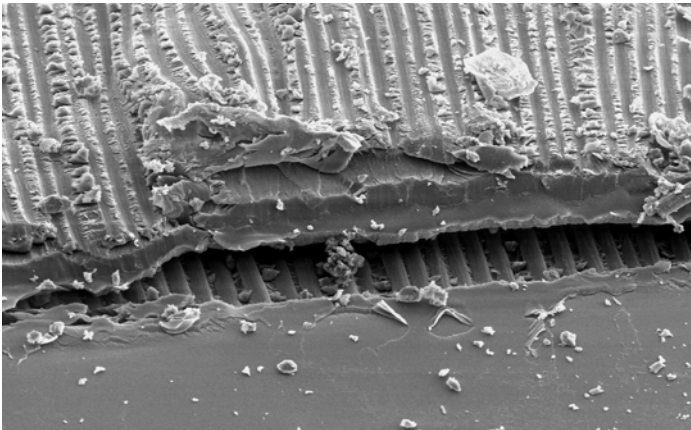


Course Aims

Composite failure analysis and fractography is a growing discipline and has proved to be invaluable for studying fibre reinforced polymer composites. By interpreting the fracture surface morphology, the source and sequence of fracture can be determined. Failure analysis is a powerful research tool for solving real engineering problems and can deliver significant cost savings to component development.

The aims of the course are:

- Familiarisation of the procedures for failure analysis of composites
- Identification of the morphology of the different fracture modes
- Application of the basic methodology to the investigation of failed components

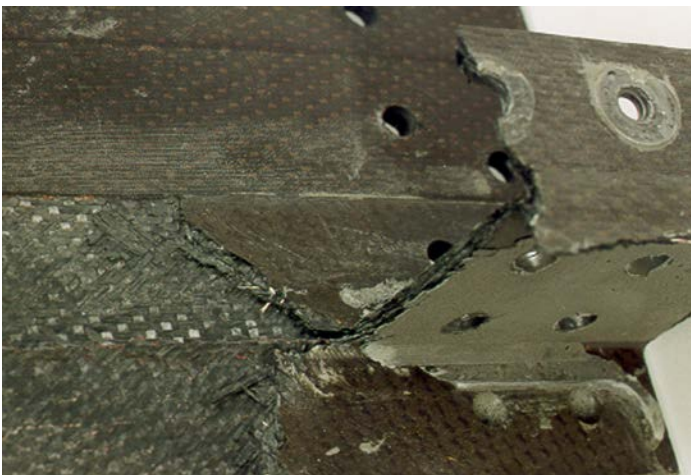


Course structure

The course will last for 7 hours of lectures, delivered over one day, with the course text provided to the delegates.

Who should attend?

The course should appeal to delegates with a basic knowledge of composites, together with a modest understanding laminate analysis. It will be suitable for delegates who are interested in applying fractographic methods, or wishing to expand their expertise in this field, or for more senior personnel who have responsibility for such practitioners.



Date Monday 29 February	Programme 09:00 Methodology and Tools for Failure Analysis (1.5 hour) 10:30 Fibre Dominated Failures (1 hour) 11:30 Delamination Dominated Failures (1 hour) 12:30 Fatigue Failures (30 minutes) 13:00 Lunch 14:00 Influence of Fibre Architecture (1 hour) 15:00 Defects and Damage (1 hour) 16:00 Case Studies (1 hour)
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Syllabus details - The following lecture topics will be given:

Methodology & Tools for Failure Analysis	Overview of health & safety issues. General procedures for failure analysis. Initial visual examination and NDE. Methods for photographing fracture surfaces. Dissection. Verification of materials & construction. Optical & scanning electron microscopy. Sequencing cracks. Reporting.
Fibre Dominated Failures	Morphologies associated with unidirectional laminates under tension, compression, flexure and in-plane shear. Intralaminar fracture. Tension, compression and flexure in cross-ply laminates. Tension, compression and flexure in multidirectional laminates.
Delamination Dominated Failures	Generic fracture morphologies of matrix resins. Pure modes of fracture in unidirectional laminates; mode I & mode II. Features characteristic of mixed-mode (I/II) delamination. Delamination at multi-directional ply interfaces. Delamination under mode III & mixed II/III.
Fatigue Failures	Basic fatigue morphologies of bulk polymers. Failures associated with interlaminar and intralaminar fatigue. Fracture morphologies associated with translaminar fatigue.
Influence of Fibre Architecture	Features particular to short-fibre composites. Fracture morphologies in filament wound materials. Morphologies of fabrics; woven and NCFs. Fractography of through-thickness reinforced materials (stitched and z-pinned laminates). Fractography of 3D composites.
Defects and Damage	Defects associated with constituents (fibres and matrix) and the fibre/matrix interface. Lamina scale defects; manufacturing and in-service environmental degradation. Morphologies associated with in-service damage, such as that induced by impact.
Case Studies	Failures due to overloading or design deficiencies. Failures due to material and manufacturing defects. Failures due to in-service factors.

About the Lecturer

Dr Emile Greenhalgh *CEng FIMMM* is a Reader at the Composites Centre at Imperial College London. Between 1987 and 2003, Dr Greenhalgh worked at RAE (now QinetiQ) in Farnborough in the Composite Structures Section, conducting research on a broad range of aspects of polymer composites and has published over one hundred reports and papers in this field.

He was trained by David Purslow, one of the founders of fractographic analysis of composites, and subsequently further developed the field of fractography, focusing on delamination and damage tolerance. He has developed new methods for identifying crack growth directions and failure modes in compression and delamination failure.

Throughout his career he has used fractographic analysis to underpin his research findings. He has initiated a European working group on composites fractography, conducted numerous failure investigations and his expertise has led involvement in high profile component failures (e.g. Formula One crashes) and as an expert witness in litigation cases. Through this work, he is one of the leading world experts on failure analysis of composites, and has given courses on fractography to organisations such as AAIB, NASA and Rolls Royce. In 2009 he published a book on [Failure Analysis and Fractography of Polymer Composites](#).