

# Fibre reinforced polymer composites in structural engineering

Dr Toby Mottram, Reader in the School of Engineering at Warwick University and member of the Institution's Research Panel, explains how the emergence of fibre reinforced polymer (FRP) composites in structural engineering practice has led to a co-ordination of R&D

Since the 1990s there has been rapid growth in the application of advanced FRP composites in construction around the world, in terms of both research activities and practical implementations. FRPs are used as structural shapes and systems, in reinforced and prestressed concrete, and as high stiffness-to-weight materials for the repair and strengthening of existing structures<sup>1</sup>. Novel applications on foot and road bridges are also on the increase<sup>2,3</sup>. An advanced FRP composite comprises a polymer-based matrix reinforced by continuous fibres of carbon, aramid or glass. To produce its structural form, the processing methods are those of pultrusion, resin transfer moulding, and filament winding. Products made by the pultrusion process currently dominate the market place<sup>1</sup>.

The use of carbon FRPs for structural applications was first studied at the Swiss Federal Testing Laboratories (EMPA). In 1991, the Ibach Bridge, Lucerne, Switzerland was the first public structure to be strengthened with bonded carbon FRP strips<sup>4</sup>. This, and others early projects used the external reinforcement to repair a defective structure, to allow for increases in the applied load, or to allow modification of the structure for changes in use. As these examples proved commercially successful, and, after the initial hesitant reaction to change, the technique of post-strengthening with FRPs is now well established<sup>5,6</sup>; and now other FRP techniques have started to gain a foothold<sup>2,3</sup>.

The construction industry continues to offer considerable scope for the development of improved technologies and components, the materials and systems which make up buildings and works. nCRISP encourages research and innovation in this broad area ([www.crisp-uk.org.uk](http://www.crisp-uk.org.uk)). Its Industry Activists' Group has identified as two priority issues the new construction technologies and techniques and off-site production and



**Pultruded FRP 50m mast supported by aramid guys** (photo: courtesy Alan Dick & Co Ltd)

**Below left: Strengthening beams in a building with carbon fibre to increase load bearing capacity.** (Photo: courtesy NGCC)

**Below right: The composite pedestrian bridge in Lleida, Spain, is with its free span of 38m the longest of its kind in Europe. The bridge is made of structural profiles from Fiberline Composites** (photo: courtesy Fiberline Composites)

customisation. FRP composites undoubtedly have the potential to provide the solution to these priority issues<sup>1-7</sup>. Indeed, many have hailed FRP composites as a new generation of construction materials following steel and concrete.

Against this backdrop, there has been a strategic requirement for Network groups to co-ordinate the R&D that has led to many notable prototype structures<sup>4</sup> and the publication of manuals for the practice<sup>5,6</sup>. The Engineering and Physical Sciences Research Council has for a number of years supported UK networks as a mechanism to create new



interdisciplinary research communities. The aim of such networking is to transfer ideas, experimental techniques, models and technological and scientific insights and to promote mobility between academe and industry. In January 2000 the EPSRC network on *Advanced Polymeric Composites for Structural Applications in Construction* (CoSACNet) was created. Its objectives were to:

- examine problems facing industry in current applications of polymer composite materials in civil structural applications;
- provide an educational resource for training engineers in industry through the use of Continuous Professional Development courses;
- provide a forum for discussion of general scientific and technical issues associated with composite materials in application through regular meetings, online discussion forums and conferences (ACIC 2004 [/www.surrey.ac.uk/eng/research/ems/csr/conference.htm](http://www.surrey.ac.uk/eng/research/ems/csr/conference.htm))
- disseminate information gained by Network activities to the wider structural engineering community;
- establish mechanisms for interaction between academia and industry in identifying potential research areas.

CoSACNet was active for 3 years and the network's web site at

[www.cosacnet.soton.ac.uk/](http://www.cosacnet.soton.ac.uk/) gives details on the leading participants and specific deliverables.

The EPSRC network ran in parallel with the industry-based Network Group for Composites in Construction (NGCC), which is managed by staff at the Building Research Establishment (BRE). The role of NGCC is to:

- promote and develop best practice in the application of FRP composites in construction through their safe and responsible use and management;
- be recognised by the construction and FRP composite communities as the leading focus for co-ordinating activities relating to composites in construction;
- to provide a first class service to members, customers and industry.

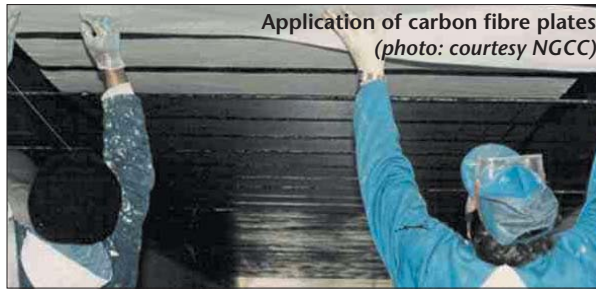
Following the absorption of CoSACNet into the R&D task group of NGCC the links between industry and academia are



to be maintained and improved. NGCC now has five regional groups to address the specific needs of local industry and support local organisations. The groups in Scotland, Wales, Northern Ireland, North East England, and North West England strengthen the links between FRP composite suppliers and end-users across the UK. The NGCC web site: [www.ngcc.org.uk/index.jsp](http://www.ngcc.org.uk/index.jsp) provides further details of the network's activities and membership benefits.

To provide a medium for the publication of full-length papers of values and interest to structural engineers the *ASCE Journal of Composites for Construction (JCC)* was first published in 1997. It publishes original research papers, review papers<sup>1</sup>, and case studies dealing with the use of FRP composites in construction. Of special interest are the papers that bridge the gap between fundamental research and design of large structural systems and their construction process<sup>7</sup>. The four issues comprising volume 1 each contained four full-length papers. A current issue comprising 10 papers is a measure of the success of JCC.

To co-ordinate R&D activities worldwide, The International Institute for FRP in Construction (IIFC) was established in March 2003 with members starting to join in January 2004. The aim of the Institute is to advance the understanding and the application of FRP



composites in our civil infrastructure, in the service of the engineering profession and society. Its website address is [www.iifc-hq.org/](http://www.iifc-hq.org/). As laid down in its by-laws, the activities of IIFC shall include:

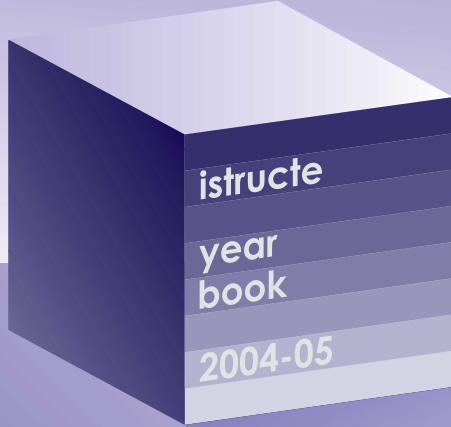
- the organisation and sponsorship of international conferences, symposiums, workshops, short courses and seminars, including a biennial official conference (CICE 2004) <http://www.adelaide.edu.au/cice2004/>;
- the publication of an official newsletter and other relevant materials;
- the establishment of working groups in selected areas to develop state-of-the-art reports and design recommendations;
- the development of curriculums and course materials to meet educational needs at different levels.

In a short period of 13 years the field has seen progress from witnessing the first application of FRP composites in structural engineering<sup>2</sup> to accepting


certain techniques in common practice<sup>1,3,4</sup>. The creation and growth of activities which co-ordinate R&D both at national and international level has played a significant role in the transformation from theory to practice. Readers who have an interest in the future of FRP composites in structural engineering practice are encouraged to use NGCC and IIFC activities to track current and future R&D.

## REFERENCES

1. Bakis, C. E., Bank, L. C., Brown, V., Cosenza, E., Davalos, J., Lesko, J. J., Machida, A., Rizkalla, S., and Triantafillou, T.: 'FRP composites in construction state-of-the-art review,' 150th anniversary paper, *J. Compos. Constr.*, ASCE, 6/2, 2002, p 73-87
2. Firth, I. P. T.: 'A tale of two bridges: The Lockmeadow and Halgavor bridges', *The Structural Engineer*, 80/5, 2002, p 26-32.
3. Keller, T.: 'Use of fibre reinforced polymers in bridge construction,' *Structural Engineering Documents 7*, Intl. Association for Bridges and Structural Engineering (IABSE-AIPC-IVBH), Zurich, 2003.
4. Meier, U. and Deuring, M.: 'The application of fibre composites in bridge repair,' *Strasse und Verkehr*, 77/9, 1991, p 534-535
5. 'Design guidance for strengthening concrete structures using fibre composite materials,' *Tech. Rep. No. 55*, The Concrete Society, Crowthorne, 2000
6. Cadei, J. M. C., Stratford, T. J., Hollaway, L. C., and Duckett, W. G., 'Strengthening of metallic structures using externally bonded fibre reinforced polymers,' *RP645, CIRIA 645*, CIRIA, London, 2004
7. Reising, R. M. W., Shahrooz, B. M., Hunt, V. J., Neumann, A. R., Helmicki, A. J. and Hastak, M.: 'Close look at construction issues and performance of four fiber-reinforced polymer composite bridge decks', *J. Compos. Constr.*, ASCE, 8/1, 2004, p 33-42



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