# Polymer Composites as Construction Materials

## Application Summary Sheet 4

**Title: Bridges**

**Target Audience:** Civil and Structural Engineers, Bridge Designers.

**Keywords:** Bridges, decks.

**Overview of application / summary:**

Fibre reinforced polymer material (FRPs) offer bridge designers the advantages of high stiffness-to-weight and high strength-to-weight ratios when compared to conventional construction materials such as steel and reinforced concrete. FRP can be pre-formed into complete structural units, reducing construction time. In addition, FRP's have excellent corrosion resistance particularly against de-icing salts.

There has been considerable recent development worldwide in the use of FRP's for bridge building, resulting in numerous successful examples of both pedestrian and highway bridges worldwide:

**Aberfeldy Footbridge**

This is the world's first and also longest advanced composite footbridge, which was erected in 1992 and crosses the River Tay in Scotland. Maunsell worked closely with Dundee University whose final-year bridge engineering students provided the bridge erection team. The bridge is a cable-stayed structure with a main span of 63m and two back spans of 25m. It is stayed from two 18m-high 'A' shaped GRP pylons using Parafil cables (Kevlar aramid fibres sheathed in a protective low density polyethylene). The bridge deck was fabricated from the Advanced Composite Construction System (ACCS). A unique method of erection of towers, cables and deck was used which needed no site cranage. This was made possible by the lightweight components. The bridge was completed by the addition of GRP handrailing and a wear-resistant deck finish. The minimal foundations and rapid site assembly meant that the solution was very cost effective for the client. With an original design live load capacity of 3.5 $kN/m^2$ , the bridge has since been

strengthened to accommodate golf carts and had ballast added to improve its dynamic performance.

## Tom's Creek Bridge, Blacksburg, Virginia

The bridge reconstruction project utilised Strongwell's FRP hybrid 8" x 6" double-web beam with carbon fiber reinforcement in the flanges to increase the beam's stiffness, together with internal flange stiffeners. The bridge was upgraded in 1997 from a 10-ton to 20-ton capacity after the rusted, severely deteriorated steel beams were replaced. Total construction time for steel beam removal and replacement with the composite beams and a timber deck was less than five days (website: http://www.strongwell.com)

## Bonds Mill Lift Bridge

The worlds first advanced composite road bridge. The 8.2m span bridge deck is manufactured from Maunsell Structural Plastics' Advanced Composites Construction System (ACCS). There are a series of pultruded GRP sections running longitudinally which are bonded together using an epoxy resin to form a cellular box girder with six main cells which are filled with epoxy foam. The deck is a 'double ply' of ACCS skins with cells running in two orthogonal directions. The total weight of the ACCS deck and surfacing is 4.5 tonnes for 35m$^2$ of deck area giving a live to dead load ratio of 13.5.

## Review of alternative/existing technology, potential market and future developments, synergy with traditional materials:

Bridges are one of the highest forms of civil engineering - few other structures command the same combination of functionality and visual impact. Although major projects both in the UK and abroad have been quite regular events over the past decades (eg Humber Bridge, Second Severn Crossing) in recent years there has been something of a renaissance in the art of medium span bridge design, particularly of footbridges. One catalyst for this has been the 27 bridges funded by the Millennium Commission with notable examples being The River Lune, Shanks, Lowry and Gateshead Millennium Bridges. A common feature to all of these is slenderness and use of steel (either stainless or non-corroding Cor-Ten). To a certain extent the cost of materials

and complexity of design has taken a back seat to aesthetics and innovation, the most extreme example being the Arup/Lord Foster "Blade of Light" across the Thames.

For vehicle carrying bridges in the UK, particularly across motorways, reinforced concrete or steel is the norm. FRP materials may have particular applications in deck replacement (see *Bridge Decks* application sheet) where corrosion resistance and speed of installation are important, also in bridge enclosure systems providing environmental protection (see *Bridge Enclosure Systems*). One highly specialist application for FRP has been air-transportable military bridges. For short span road bridges and footbridges one major competitor to FRP is timber. In countries such as Canada, North America, Norway, Sweden and Denmark there have been major programmes developing the use of timber as a renewable resource for footbridges and medium span vehicle bridges. Particular developments have been the stress laminated timber deck and composite concrete/timber deck (also featuring the use non-ferrous FRP reinforcement), and carbon fibre strengthening of glulam and other engineered wood (see *Strengthening*).

## Impact of Application

### Financial:

Higher material costs, although outweighed by faster erection time and lower disruption.

**Environmental:** Alternative to steel and concrete

### Engineering:

Speed of erection (road closures, disruption)
Lightweight - ease of transportation and handling
Lightweight - possibility of smaller scale foundations and other supports
Low thermal expansion
Good fatigue performance
Corrosion resistance
Low corrosion
Non conductive (eg railways)

## Where to get further information

### Websites:

Plastic Bridges Website - a list of numerous links
http://www.csa.com/hottopics/bridge/websites.html

COBRAE
http://www.nedland.nl/cobrae.html

Further Bridge Examples and Case Studies
http://www.ngcc.org.uk/

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