Application Summary Sheet 26

Title: Dowel Bars

Target Audience: Civil Engineers, Local Government Authorities, Construction companies, Highway Engineers

Keywords: Non-corroding, joints, load transfer, pavement joining, reinforcement, durability, highways, composite materials, Non-ferrous reinforcement

Overview of application / summary:

In the US, many road surfaces are constructed of concrete slabs, which are joined with steel dowel bars. Dowel bars are installed across the joints in adjacent concrete slabs in order to retain vertical movement between them when a load passes over. Loads are transferred through the dowel bar from one section to another. Corrosion in these steel joining components is becoming a major financial and operational concern to the Transport Authorities. Because the dowels are positioned at the edge of the slab, they are exposed to drainage of road salts and moisture, which are highly corrosive to steel. Research has shown that steel dowel bars can fail due to corrosion in as little as 7 to 15 years whereas the concrete slab can perform for 35 to 40 years. Fatigue is another contributor to premature failure of the dowel bars. Fatigue loads arise from constant vehicular and pedestrian traffic, amplifying the magnitude of dynamic loads and accelerating failure mechanisms.

The proven corrosion resistance of FRP composites in this type of environment made them a viable alternative, only the initial cost was an inhibitor to their use. FRP dowel bars were therefore put into service to exploit their superior corrosion and fatigue resistance, with the aim of matching the full service life of the slab to prevent intermediate replacement.

The performance of the FRP bars over several long-term test programmes was highly successful. It was found that elimination in corrosion damage to the bars extended road life with substantial cost savings accruing to the owner from reduced repair or replacement costs. These financial benefits have lead to widespread uptake in the US. Other benefits include a smoother ride, less disruption due to maintenance, and the availability of a proportion of road maintenance funds for other public services.

Although the majority of road surfaces in the UK are tarmac, slabbed pavements are a potential application once the engineering and long-term financial benefits are realised from US case studies.

Impact of application

Engineering:

- The inherent corrosion resistance of FRP dowel bars increases service life to match or exceed that of the concrete slab. Maintenance/replacement programmes for slabbed areas can be planned more accurately.
- Composite dowel bars exhibit superior performance under fatigue loading, further enhancing the service life.
- The inherent corrosion resistance maintains a smooth surface throughout the service life of the dowel, which is critical to permit the slabs around them to expand and contract with temperature fluctuation.
- The bars do not have to be stored when on-site as there is no risk of weathering.

Financial:

- Although higher in initial cost in comparison to steel, it is the potential through life financial savings for road and pavement owners that have lead to the uptake in use of composite dowel bars:

- Longer life expectancy will increase replacement intervals, thus reducing replacement and associated disruption costs over a long period.
- Maintenance, repair and associated traffic management costs will also be notably reduced.
- Transportation costs of the product are lower if shipped in volume due to the low weight. The larger the scheme the more cost effective composite bars become.
- No requirement for surface coating of the bars prior to installation.
- Less likelihood of claim against a Local Authority arising from injuries sustained from accidents with mis-aligned pavement slabs.

Environmental:

- FRP composite bars do not leach chemicals into the surrounding environment.
- The dowels will not deteriorate and damage the surrounding pavements preventing unsightly staining/crumbling and resulting in longer life for the structure.

Social

- Smoother ride on slabbed roads arising from the greater constraint of vertical movement between slabs.
- Less likelihood of accidental injury due to mis-aligned slabs.

- Long term cost effectiveness will make additional public money available for other services.
- Safer construction and installation processes.

Robustness of research

In 1983, The Market Development Alliance (MDA) for composite materials based in the US sponsored a major research programme on composite dowel bars with the purpose of evaluating the bars for retention of original properties when exposed to severe conditions. Two types of bar were to be compared - epoxy coated steel and all FRP composite. These were installed at the same time on two heavily travelled roads in Ohio State. Fifteen years later in 1998 the bars were excavated and the properties tested against the originals. From the results it was concluded that the FRP dowel bars were virtually unaffected during their in-situ service and exposure to the alkaline environment of the concrete. In comparison, the epoxy coated steel bars showed significant corrosion and delamination.

This research highlighted the massive potential engineering and financial benefits of FRP dowel bars to the US authorities and several other pilot projects were initiated around the country. The positive results have led the formulation of test specifications by the American Association of State Highway and Transportation Officials (AASHTO). The Civil Engineering Research Foundation (CERF) in the US is also funding research programmes.

Future developments

- The development of test and performance standards for composite dowel bars. Initially US standards, eventually British and European standards will emerge.
- The use of composite dowel bars on UK pavements once the long term performance and financial benefits are realised from ongoing US demonstration projects.
- The cost FRP bars will fall in line with steel as pultrusion manufacturing processes become more widespread and efficient. Authorities will then not be perturbed by initial cost.

Where to get further information

Companies

Creative Pultrusions, Inc. (US)	www.creativepultrusions.com
Hughes Bros, Inc.	www.hughesbros.com
FibreForce Ltd (UK)	www.fibreforce.co.uk
Eurocrete Ltd (UK)	email: eurocrete.trend@cwcom.net

Research Organisations

Market Development Alliance of the FRP Composites Industry
www.mdacomposites.org
Civil Engineering Research Foundation
www.cerf.org
Federal Highway Administration (FHWA) (US)
www.fhwa.dot.gov/
American Association of State Highway and Transportation Officials (AASHTO)
www.aashto.org/

Articles

Fiber-reinforced Polymer (FRP) Composite Dowel Bars...a 15-year Durability Study
Market Development Alliance Dowel Bar Team.
www.mdacomposites.org/Dowel_bar_Team.htm

In-Road Service Proves Dowel Bars
Composites Technology, July/August 1999. A review of the Ohio project and resulting report.

Websites

www.pultruder.com
"Corrosion Resistant Composite Dowel Bars Serve to Transfer Vehicle Loads in Nation's Highways"