FRP

International

Fiber Reinforced Plastics

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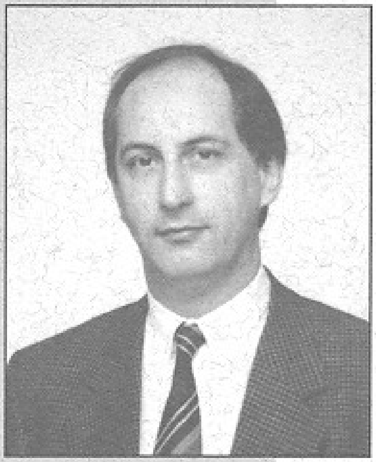
Guest Author – Dr. Luc Taerwe

Dr. Taerwe is a professor of structural concrete and applied statistics at the University of Ghent. His research interests are in the field of FRP reinforcements, fibre reinforced concrete, high strength concrete, early age properties and behaviour of concrete. In 1988, he was the recipient of RILEM's Robert L'Hermite Award and in 1991 he received the IABSE Prize.



Guest Author:
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Dr. Taerwe was involved in some of the earliest research on FRP reinforcement for prestressing concrete structural members. This research involved using the first generation of GFRP bars developed by the German companies STRAUBAG (later SICOM) and BAYER. The test included a 20 m long concrete beam, post-tensioned with a cable consisting of 19 GFRP bars and loaded up to failure as shown in Figure (1). Currently, Dr. Taerwe is engaged in a BRITE/EURAM Program on the use of non-metallic reinforcement for concrete structures. Tests have been performed to determine transfer length and the relaxation of AFRP bars (type Arapree). The research also included an experimental program to investigate the structural behaviour of concrete slabs pretensioned by AFRP. The tests are currently being performed on one-way slabs reinforced with FRP grids.

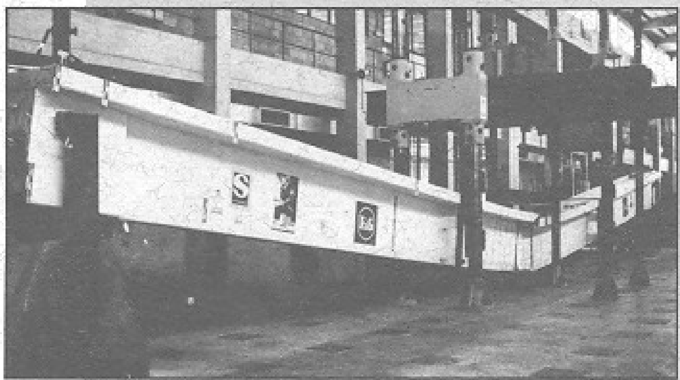

Figure 1. STRAUBAG - 20 metre long beam after failure

Dr. Taerwe is a member of ACI Committee 440 for FRP Reinforcement and Joint ACI/ASCE Committee 423 on Prestressed Concrete. He is the chairman of the "Second International Symposium on Non-Metallic

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(FRP) Reinforcement for Concrete Structures (FRPRCS-2)," which will be held in Ghent from 23 to 25 August 1995. The first symposium took place in Vancouver in March 1993 where proceedings were published as ACI Special Publication No. 138. The Symposium in Ghent is sponsored by CEB, RILEM, ACI, CSCE and the Belgian Concrete Society. The call for papers resulted in over 90 abstracts from 18 different countries. Sessions will include: material development and properties, structural behaviour of concrete members, repair and strengthening, applications, design rules and regulations. The Symposium will provide an international forum for all those who are working with, or are interested in FRP reinforcement.

Editor's Comments

Ghent is a very attractive location from a touristic point of view and well- known for its historical centre with many medieval buildings. It is also very close to Bruges and Brussels. All readers of FRP International are cordially invited to attend the Symposium!

Composite Structures

Advanced Composite Cable-Stayed Bridge

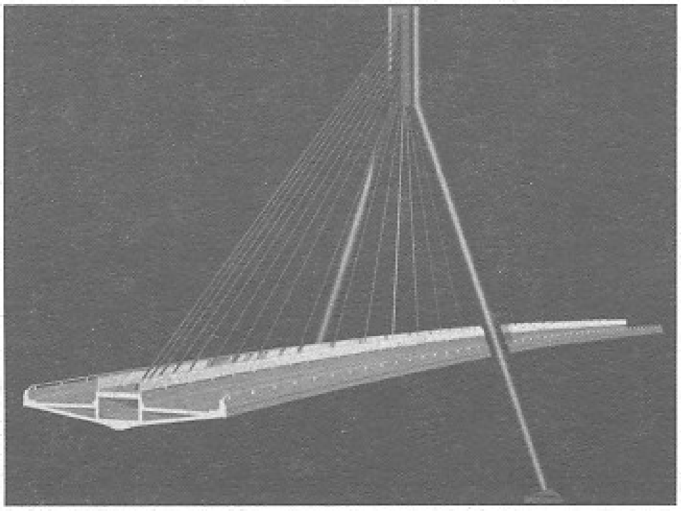

Figure 2. Proposed world's first cable-stayed bridge

A consortium of companies from across America is working to build the world's first cable-stayed bridge built entirely of advanced composite materials (Fig. 2). The bridge will be built over Interstate Highway 5 in Southern California. The Advanced Composites for Technology Transfer/Bridge Infrastructure Renewal Consortium (ACTT/BIR) is moving quickly thanks to a 21 million dollar grant from the Advanced Research Projects Agency (ARPA) of the Department of Defense. The Federal Highway Administration (FHWA) has also given the project 1.5 million dollars.

The ACTT/BIR Consortium is administered by The University of California at San Diego (UCSD) where the Charles Lee Powell Structural Laboratories are the largest full-scale testing laboratories in the nation. UCSD is joined by several large and small companies endeavouring to turn defense technology into civilian use. DuPont is providing aramid and fabrication. J. Mueller International is working with the bridge designers. Trans-Science Corporation is supplying the computational mechanics of composites. Lockheed Missiles and Space Company is working on composite fabrication, Bechtel will be working with design and construction and XXsys Technologies will implant sensors. Shell Chemical Company will supply resins. Finally, Fluor Daniel, Inc. and Morrison Knudsen, Inc. will oversee the construction of the bridge.

The Federal Highway Administration, the California Department of Transportation, and the Delaware Department of Transportation are supporting the bridge and infrastructure renewal project.

While the ARPA award was announced in October of 1993, it wasn't until June of 1994 that the funds were in-house and available. The ACTT/BIR Consortium is using the ARPA grant and the FHWA award to demonstrate that a class of advance composite materials and fabrication technologies from the defense industry can be converted and applied to solve a number of critical civil infrastructure problems concerning bridges. The project will also introduce a cost effective way of using composites in building new structures and repairing old ones.

The advanced composite bridge will be developed in three eighteen-month phases. The first and current phase will utilize composites for repair and retrofit of existing bridges. Phase I also focuses on technologies related to replacing existing bridges and building new bridges using composites. Phase II targets field applications, construction strategies, and commercialization of the Phase I discoveries. Phase III is devoted to the fabrication and construction of a complete bridge system and the implementation of a large bridge rehabilitation project.

The Consortium has already succeeded in developing concepts for the strengthening of damaged or substandard concrete bridge columns and concrete bridge decks. In the case of columns, a strategy of retrofitting with carbon fibre jackets was adopted (Fig. 3). Large-scale testing reveals that carbon jackets are structurally as effective as a comparable steel jacket system, less costly, and can be applied 10 to 15 times faster. The importance of retrofitting bridge

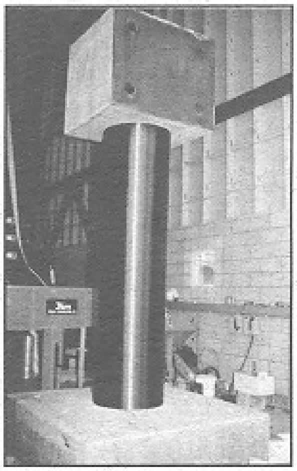

Figure 3. Strengthening of damaged and substandard concrete bridge columns

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columns quickly cannot be overstated. If the column retrofits of the bridges involved in last year's Northridge Earthquake could have been completed prior to January 1994, six out of the seven major structural failures that occurred during the earthquake might have been prevented (Fig. 4)!

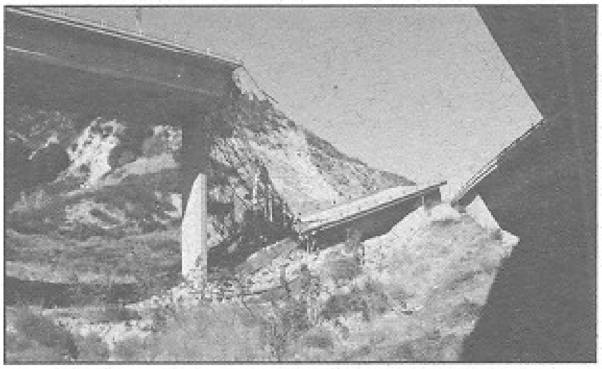

Figure 4. Bridge failure during Northridge Earthquake in California

In the case of bridge decks, the Consortium has developed a carbon overlay system (Fig. 5) that has proven, in large-scale tests, to be effective for the repair and retrofit of concrete bridge decks. The same method can be used for repair and retrofit of substandard concrete and masonry buildings (Fig. 6). Carbon overlays used to repair buildings is predicted to be a cost-effective solution for the approximately 40 percent of US buildings where seismic upgrading is necessary.

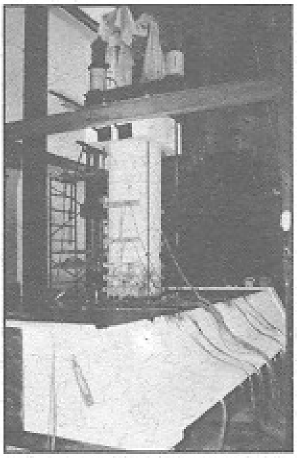

Figure 5. Carbon overlay system for repair and retrofit concrete bridge decks

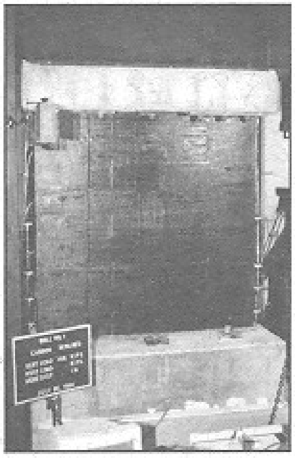

Figure 6. Overlay system for repair and retrofit concrete and masonry bridges

In addition to repairs, a composite bridge deck system has been developed that can serve as a replacement deck or a new deck. A composite bridge deck has the capacity of a reinforced concrete deck but weighs one-tenth as much. The reduced mass of a composite deck makes it so light that a bridge deck could be replaced as cost effectively as retrofitting a bridge's columns.

More than two hundred thousand bridges in America need retrofit or repair. United States carbon suppliers view the use of composites in the civil sector as a multibillion dollar industry. Subsets of the ACTT/BIR Consortium are already in the process of forming joint ventures to commercialize these new composite products. One group is focusing on column wrapping. Another is gearing toward the manufacture of bridge decks. A third group is targeting its efforts toward retrofitting and repairing buildings.

After extensive large-scale testing, the first field demonstrations of a carbon jacketing system for bridge column retrofit will take place this month. The bridge column that will be wrapped with composites are located in critical sections of the I-10 freeway in Los Angeles. Additional demonstrations will occur at the I-5 and I-5 interchange in San Diego. Full commercialization of the carbon jacket retrofitting system is expected by this year.

For further information call Wanda Levine at (619) 534-6373, E-mail — ARPA@UCSD.EDU

• Rehabilitation of Foulk Road Bridge #26 (Wilmington, Delaware) Using Advanced Composite Materials: First Full-Scale Use of CFRP Sheets for Bridge Rehabilitation in US

A research effort led by University of Delaware professors Michael Chajes and Dennis Mertz, along with doctoral candidate William Finch, Jr., has resulted in the first full-scale application of carbon fibre reinforced plastics (CFRP) for bridge rehabilitation in the nation. Advanced composite materials such as CFRP hold great promise for cost-effective rehabilitation of deficient structures due to their high strength-to-strength ratio and resistance to corrosion. In addition, because composite materials are easily applied, their use minimizes traffic disruption and can lead to a significant savings in construction costs.

Several prestressed, adjacent concrete box-beam bridges in the state of Delaware have developed longitudinal cracking on the bottom soffit of the beams. As a result, a two-phase research effort was initiated by faculty in the Civil Engineering Department at the University of Delaware, in conjunction with the Delaware Department of Transportation through the Delaware Transportation Institute. The first phase involved identifying the causes of the cracking, and the second phase dealt with developing a suitable method for repair.

Initial investigation into the problem identified the cause of cracking as a lack of transverse reinforcement on the bottom face of the precast, prestressed beams, built prior to 1973. Cracking occurred as a result of

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transverse tensile stresses developed by either corrosion and subsequent expansion of the prestressing strands and/or stresses developed due to freeze-thaw action of water trapped in the beam voids. The lack of transverse reinforcing in the beam soffit allowed the tensile stresses to develop unchecked.

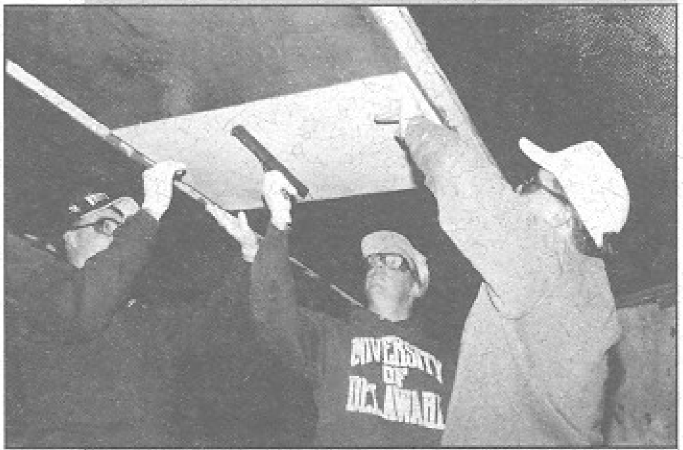

Figure 7. Rehabilitation of Foulk Bridge #26 Wilmington, Delaware

The second phase of the project involved a field demonstration in which composite materials, supplied by the Tonen Corporation, were externally bonded to Foulk Road Bridge #26 as shown in Fig. (7). The bridge, built in 1965, exhibited the typical longitudinal cracks resulting from a lack of transverse reinforcement. The superstructure is made up of 24 simple-span box-beams, each 53'8" long. Each beam is 3' wide, 2'3" deep, and has a wall thickness of approximately 5". Six of the beams were retrofitted using two types of Tonen's unidirectional CFRP Forca tow sheets. The sheets, having tensile strengths ranging from 427 to 505 ksi and tensile moduli ranging from 33,000 to 54,000 ksi, were bonded to the beams with the fibres oriented transversely to the beam's length. The applied CFRP sheets have a tensile capacity similar to #4 rebars spaced 12" on centre (the amount of transverse reinforcement used in beams built after 1973).

The field installation was performed during a one-week period in mid-October 1994. Monitoring of the retrofit will continue over the next several years to evaluate the effectiveness and durability of composite materials. It is estimated that this type of rehabilitation could be conducted for approximately 10% of the cost of replacing the bridge.

For more information, contact Dr. Michael Chajes, or William Finch, Jr., P.E., University of Delaware, Department of Civil Engineering, Newark, DE 19716; (302) 831-6056.

DRBA Commissioners Approve Prototype Composite Bridge

(Newcastle, DE) The Delaware River and Bay Authority Commission agreed to build a prototype bridge using fibre-reinforced resins, replacing the traditional concrete and steel. This test could pave the way for larger "composite" spans.

The Authority will enter into an agreement with Hardcore DuPont Composites, LLC, working with Figg Engineering Group, to design and build the structure. This landmark project will cost the Authority $311,051 with Hardcore contributing another $117,000. In addition, federally-backed research and development monies will be used for the project.

This prototype bridge will be over 70 feet long and 16 feet wide. It will be manufactured through a modified vacuum assisted resin transfer moulding process, which can repeatedly produce products with consistent and reliable properties. This process has already been used by the Authority to produce six prototype composite fenders at the Cape May-Lewes Ferry and strong, lightweight hatch covers and doors to replace heavier steel counterparts on the Delaware Memorial Bridge. Composites are also being used in a variety of other applications in the rail, marine, energy and transportation industries.

The Authority will benefit from the use of this new technology in several respects. Use of composites have lower life cycle costs due to their longevity and resistance to corrosion. Composites are also lighter in weight than their steel and concrete counterparts, therefore construction time and costs can be reduced. Additionally, the technology has an environmentally friendly nature and the end products can be made more pleasing to the eye.

Because the composite technology is in its developmental stages, its initial cost is somewhat higher than conventional steel and concrete structures. However, as composites gain acceptance and their production increases, the initial cost of structural systems will become more competitive.

For further information, please contact James Salmon, telephone (302) 571-6409.

ACC Club Members Complete 50 Projects with FRPS

The member companies of the ACC Club of Japan have now completed a total of fifty projects using FRPs. An outline of the ACC Club was included in the Fall 1993 issue of FRP International. Founded in November 1991, it is an association of general contracting and prestressing companies and materials manufacturers involved with FRPs.

The fifty projects completed include 21 highly durable bridges, 10 structures in contact with seawater or fresh water, 6 non-magnetic or non-conducting structures, 4 ground anchors, 4 buildings, and 5 underground structures. Most of these cases employ FRPs because of their non-corrosive properties, but, in some structures, FRPs are used for their non-magnetic qualities or their light weight.

The ACC Club is marking the completion of 50 projects with FRPs by publishing a catalogue of the completed structures. For most of these, photographs, plans, etc., of the structures during construction and after completion are included. Explanations of the materials used, and of the characteristics of FRPs, are also included (text in Japanese).

For more information regarding the FRP structures catalogue, please contact Tatsuhiko Iwasaki, ACC Club Secretariat, A.M. Engineering, K.K., Koga Building, 2-3-14 Muromachi Nihonbashi, Chuo-ku, Tokyo. Telephone: 81-3-3231-0690, Fax: 81-3-3242-7584.

• ACM Bridges Help Preserve Environment

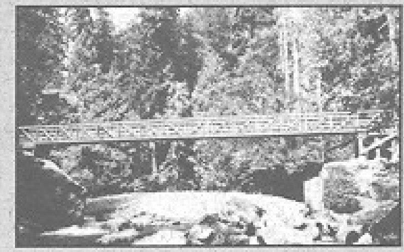

Figure 8. 80 feet prestressed-truss bridge erected in Olympic National Park, WA, USA

A 24 metre (80 feet) prestressed-truss bridge using pultruded isopolyester composite sections was used to comply with the environmental restriction imposed on rebuilding a bridge along a popular hiking trail in Olympic National Park, WA, USA.

At this location, steel bridge replacement was not feasible because it would require a helicopter lift which threatened the nesting area of the marbled murrelet. The bird is listed as endangered by the US Fish and Wildlife Service. The helicopters were not allowed to fly within 400 metres vertically or horizontally. The other restrictions require rebuilding without using heavy equipment or native materials such as trees.

The bridge is designed by structural engineer and architect G. Eric Johansen, and sculptor Roy Wilson, partners of E.T. Techtonics Inc., Philadelphia, PA. The prestressed-truss bridge, shown in Figure 8 results in the lowest installed cost because of its light weight, high strength, and easy installation. The bridge was assembled using hand tools, without scaffolding or heavy equipment. No special skills were needed. Pultruded FRP shapes were supplied by Creative Pultrusions of Alum Bank, PA.

For further information, contact Eric Johansen; Fax: (215) 925-8237.

New Products

• Laminated Composite Reinforcement (LCR) for Concrete Structures

A non-metallic, fibre/epoxy reinforcement bar has been developed at Cornell University by Dr. Petru Petrina. The bar is made from a composite laminated panel made in three layers, a core layer and two cover layers, and transverse ribs. The combination and proportion of layers and ribs causes the bar to behave inelastically at high stresses. Under tension, the bar expands between the ribs, increasing the bond strength when the LCR bar is embedded in concrete.

The LCR is made by creating a sheet or a panel of core material comprised of a number of layers of prepreg material or a few layers of a thick unidirectional lamina, producing a unidirectional composite. Between the core laminate and the side layers (made of a few thin plies), there are periodic transverse ribs on both sides of the core, with fibres perpendicular to those in the core as shown in Figure 9. The composite panels are cured in a vacuum bag and heated to fuse the layers. The finished panels are cut parallel to the core fibres to the desired width, producing rectangular cross-sections.

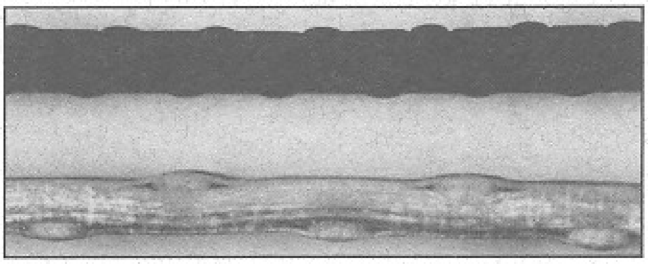

Figure 9. Laminated Composite Reinforcement (LCR) developed at Cornell University

The tensile strength of the LCR is about 3 to 4 times that of Grade 60 steel, and about the same as that of the seven-wire steel pretensioning strand, of 1724 MPa (250 ksi). Pull-out tests show that the combination of frictional bond and bar/ribs interlock produces a high bond strength. Preliminary test results of model beams reinforced with LCR bars made of fibreglass prepreg show excellent flexural strength and crack distribution, but much larger deflections than beams reinforced with steel.

The LCR bars can be joined in the field by using a typical bond anchorage system comprised of a cylindrical sleeve filled with anchorage mortar. The lateral expansion of the bar induces normal stresses at the concrete/bar interface that has significantly increased the bond strength. The average bond strength developed by LCR bars is about 27.5 MPa (4000 psi), which is about twice the average bond strength developed by the best commercially available Fiber Reinforced Plastic

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tendons fabricated by pultrusion.

The LCR bar is relatively simple to manufacture, exhibits nonlinear ductile behaviour, has a relatively high bond strength, and requires only a simple sleeve-type anchorage to develop its ultimate strength.

Based on the technical merit and commercial potential of LCR, Cornell Research Foundation (CRF) Cornell's patents and technology marketing arm, has submitted for patent protection on the technology. CRF is actively seeking strategic partners to commercialize LCR through a licensing arrangement.

For more technicals, contact Dr. Petru Petrina, Fax (607) 255-2011.

• FIRP Panel Reinforced Glued Laminated Wood Beams

Figure 10. Cross-section of beam reinforced with carbon reinforced plastic sheets

Western Wood Structures, Inc. and Fiber Technologies, Inc. have combined to introduce one of the most effective new structural wood products to enter the structural wood composite marketplace: High Strength Fiber-Reinforced Glulams or FiRP Glulams.

The FiRP Glulam is a composite of wood, plastic, and high strength synthetic fibres. The high strength fibres are oriented in a thin plastic matrix laminated into the Glulam beam using standard gluing procedures as shown in Figure (10). A non-structural cover board is often added to the bottom of the beam for appearance and to protect the FiRP Reinforcement.

Since most of the tensile forces are carried by the FiRP Reinforcement, the design capacity of the beam is greatly increased allowing longer spans and greater loads for a given Glulam member. FiRP Glulams can now be manufactured to be 2-3 times stronger for a given size. The FiRP Reinforcement is so strong that a 0.07" thick layer is equal in strength to six 1-1/2" high grade Douglas fir laminations. Only small amounts of reinforcement are required, thereby having little or no visual impact.

Because equivalent FiRP Glulams are smaller, additional savings are achieved from lower freight costs, lower treating costs, and less expensive job-site assembly, including lifting equipment costs. The reduced cross section for a given load for a FiRP Glulam leads to significant "dead weight" reduction, an important factor in construction of long span structures.

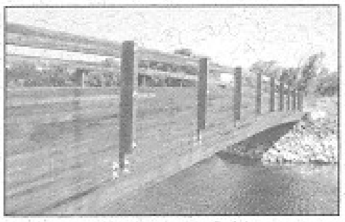

Figure 11. Taylor Lake Bridge, The Dalles, Oregon

FiRP Glulam systems for roofs, bridges and many other uses may be the lowest cost option when compared to other wood products and, in many cases, concrete or steel as shown in Figure (11). In many situations when the total cost of the FiRP Glulam system is considered, the savings may reach 20 to 25%. FiRP Glulams are the best, most economical option for structural needs.

Research

• FRP in Masonry Rehabilitation

A report on the rehabilitation of masonry structures using non-metallic fibre composite reinforcement has been completed by the Department of Civil Engineering, University of Toronto. The study explores potential applications of advanced composite materials in masonry rehabilitation as a means of eliminating or reducing the extent of cracking in such structures caused either by foundation problems or by mechanical load actions. The work builds on existing knowledge regarding conventional rehabilitation technology and on past experience from structural applications of advanced composite materials, with particular reference to the use of fibre-reinforced plastic (FRP) reinforcement in rehabilitation of buildings and bridges. The most relevant masonry rehabilitation techniques are outlined in the study, with emphasis on those that are deemed suitable for use with non-metallic FRP reinforcing products. The main mechanical characteristics of FRP materials are reviewed, including FRP laminates (sheets), reinforcing rods and grids, and prestressing elements. The objective of this review is to highlight those properties and characteristics that would primarily influence or benefit the implementation of these materials in masonry rehabilitation. Results of related research studies and applications relevant to the objectives of this work are also outlined. Finally, draft guidelines for application of FRP materials in selected methods for masonry rehabilitation have been given. The study shows that the FRP materials are a feasible alternative to steel in masonry rehabilitation, provided that the underlying design concepts are no longer linked to a ductile post-yield failure, though large deformability demands may still be adequately accommodated.

For further information, please contact
Dr. S. J. Pantazopoulou, Phone (416) 978-4608,
FAX (416) 978-6813.

New Rust-Free Concrete Culverts

A research project is in progress at the University of Windsor, to evaluate the use of glass fibre reinforced plastic (GFRP) in the construction of concrete culverts, and to develop a procedure for their design. This should lead to cost-effective underground structures with non-corrodible reinforcement and reduced wall thickness.

Concrete slabs reinforced with GFRP show early developments of cracks, yet they continue to carry the load and reach a failure load equal to or higher than that of identical slabs with steel reinforcement. However, the bending rigidity of the GFRP slabs is considerably lower than steel reinforced ones, and this characteristic is advantageous for the performance of culverts since their behaviour is governed by their interaction with the soil. Herein, the reduced bending rigidity leads to considerable reduction in the induced bending moment and shear forces.

The project addresses the problem of durability of reinforced concrete culverts and takes advantage of the flexibility of the GFRP reinforced concrete walls due to the soil-structure interaction. The relatively higher cost of GFRP in comparison with steel reinforcements is offset by the reduction in thickness of the concrete wall.

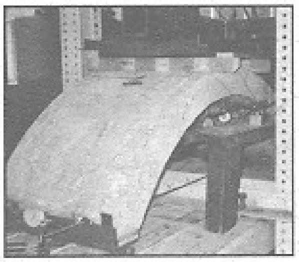

Figure 12. New rust-free concrete culverts

Figure (12) shows a test conducted on a segment of an 8 foot diameter conduit wall.

For further information, please contact Dr. G. Abdel-Sayeed, Phone (519) 253-4232 (ext 2550), FAX (510) 973-7062.

The Council of Great Lakes Governors Polymer Composite Initiative

The Council of Great Lakes Governors from the Great Lakes States — New York, Pennsylvania, Ohio, Indiana, Michigan, Illinois, Wisconsin and Minnesota — is supporting a regional initiative on the use of polymer composites for primary structural applications. The first project to be undertaken is in the rehabilitation of civil structures using polymer composite materials, specifically, column wrapping and carbon plate strengthening. The project will be coordinated through the transportation departments of the Great Lakes States in that they will choose and undertake demonstration projects and a R&D program which will be coordinated among all states. The group expects to have all the states involved and networking on a coordinated program to maximize technology transfer and usage.

The Great Lakes States possess some unique and important characteristics. They are a huge economic unit; they have a huge manufacturing and polymer composites industry; they have large infrastructure repair needs; and they have in common, severe environmental and climactic conditions.

The program is being developed by a steering committee working out of the Council of Great Lakes Governors office in Chicago. Discussions are underway with FHWA to support this regional consortium. The partnership will include the state DOTs, FHWA, infrastructure and other industry, and academia.

The Council of Great Lakes Governors Polymer Composite Initiative organized a session at the SPI Composite Institute in Cincinnati on January 30 to February 1, 1995, and had a booth at their Expo.

The group invites participation, cooperation and support from interested parties, particularly from industry, the Federal Government and representatives of the Great Lakes States.

For further information, please contact John Hemman, Phone (216) 687-2401 or Fax (810) 421-8252.

Awards

The Composites Institute announced the winners of its Best Paper Awards at its 50th Annual Conference and Expo '95. In the category of FRP, the following awards were given:

Best Design Paper — *Design Procedure for Predicting Creep and Recovery of Pultruded Composites*, Ayman S. Mosallam, The George Washington University, Richard E. Chambers, Chambers Engineering, P.C.

Best Applications Paper — *Aramid RP Strands as Prestressing Tendons in a Precast Concrete Bridge*, James G. Gallt, Palmer Engineering, Issam E. Harik, University of Kentucky.

Best Infrastructure Paper — *Experimental Behavior of a Reinforced Plastic Vehicle Bridge*, M.A. Erki, P. Yantha, Department of Civil Engineering — Royal Military College of Canada, M.F. Green, Department of Civil Engineering, Queen's University, G.E. Johansen and R. Wilson, E.T. Techtonics Incorporated, D. Maurer, Creative Pultrusions, Inc.

Theses

Heere, R., 1994, *Evaluation of Shotcrete Repairs on B.C. Dams.* M.A.Sc., Thesis, University of British Columbia, Vancouver, British Columbia. Supervisor: N. Banthia.

Bellavance, Eric, 1995, *A Study of Grouted Anchorages Reinforced with Composite Material Rods.* M.A.Sc. University of Sherbrooke, Sherbrooke, Quebec. Supervisor: B. Benmokrane.

Pizhong, Qiao, *Analytical Studies of Concrete Double-Tee Bridge System Prestressed with FRP Materials,* Florida Atlantic University, Boca Raton, FL 33431, August 1993.

Rong, Qu, *Theoretical Analysis of Reinforced and Prestressed Concrete Bridge Members Strengthened with CFRP Laminates,* Florida Atlantic University, Boca Raton, FL 33431, December 1994.

Conferences

"Journées Européens des composites" Conference and Exhibition (JEC) CNIT Paris-la-Defense, Paris, France. **26-28 April 1995.** Contact Centre de Promotion des Composites, FAX: +33 (1) 4763-5739.

40th International SAMPE Symposium and Exhibition, Anaheim Convention Centre and Anaheim Hilton Hotel, CA. **8-11 May 1995.** Contact Dr. Gerald Bailey, FAX: (619) 464-9902.

Tenth ASCE Engineering Mechanics Conference, University of Colorado, Boulder CO, USA, **21-24 May 1995** - Session on Non-Metallic Reinforcement for Concrete Structures. Contact: Dr. Richard N. White, School of Civil and Environmental Eng'g. Cornell University, Ithaca, NY FAX: (607) 255-4828.

The First Israeli Workshop on Composite Materials for Civil Engineering Construction, National Building Research Institute of Israel, Technion — Israel Institute of Technology, Haifa, Israel, **29 May 1995.** Organized by the National Building Research Institute and The Society for the Advancement of Materials and Process Engineering (SAMPE) Israel Chapter. For more information please contact Dr. Lawrence C. Bank (Workshop Chairman). FAX: 972-4-324534, Email Bank@cua.edu.

Second International Symposium on Non-Metallic (FRP) Reinforcement for Concrete Structures, Universiteit Ghent, Belgium, **23-25 August 1995**. Contact: Dr. Luc Taerwe, Universiteit Ghent, Dept of Structural Eng'g. Technologiepark-Zwijnaarde 9, B-9052 Ghent, Belgium, FAX: +32 (9) 264-5845, E-mail: Ltaerwe@mecanic.rug.ac.be

IABSE - Extending the Lifespan of Structures, San Francisco, CA, USA, **23-25 August 1995.** Contact: IABSE Secretariat, ETH-Hönggerberg, CH-8093 Zurich, Switzerland, FAX: +41(1) 371-2131.

4th International Bridge Engineering Conference, St. Francis Hotel, San Francisco, CA. Sponsored by TRB & NRC. **28-30 August 1995.** Contact C. Ballinger, FAX: (703) 938-1252

9th International Conference on Mechanics of Composite Materials, Riga, Latvia, Sweden, **17-20 October 1995.** Contact: Secretariat, FAX: +46 (31) 772-2296.

The World of FRP in Corrosion and Construction 9th International Technical Conference & Exhibition, Caesar's Palace, Las Vegas, **18-21 September, 1995.** Contact SPI Western Composites Institute, FAX (310) 420-9156.

ACI 95 Fall Convention, Montreal, Bonaventure Hilton & Radisson Gouverneurs, Quebec, Canada, **5-10 November 1995.**

Second Symposium on High Temperature And Environmental Effects On Polymeric Composites, sponsored by ASTM Committee D-30, Norfolk, Virginia, **14-16 November 1995.** Contact Dr. A. Zureick, FAX: (404) 894-0211.

International Conference on Fibre Reinforced Structural Plastics in Civil Engineering. Indian Institute of Technology, Madras, India. **18-20 December 1995.**

The 75th Annual Transportation Research Board Meeting. Washington, DC. **7-11 January 1996.** Abstracts for Synthetic Fiber Reinforced Concrete in Transportation Applications session are due by August 1, 1995. Contact Clifford MacDonald, FAX (612) 736-7496.

The First International Conference on Composites in Infrastructure (ICCI '96) Tucson, Arizona, USA. **15-17 January 1996**. Contact Prof. M. Ehsani, University of Arizona, FAX: (602) 621-1443; Dr. Saadatmanesh, FAX: (602) 621-2148. E-mail: baltes@bigdog.engr.arizona.edu.

2nd International Conference on the Use of Advanced Composite Materials for Bridges and Structures, Montreal, Quebec, Canada, **11-14 August 1996.** Deadlines: Sept 15, 1995 for 300 word abstract. Contact: Dr. S. Rizkalla, Faculty of Engineering, University of Manitoba, Winnipeg, MB R3T 5V6 FAX: (204) 261-5465.

Third FRP International Symposium on Non-Metallic (FRP) Reinforcement for Concrete Structures, Tokyo, Japan, **Summer 1997.** Deadlines: t.b.a. Contact: Dr. T. Uomoto, Institute of Industrial Science, University of Tokyo, 22-1 Roppongi, 7-Chome, Minato-ku, Tokyo 106, Japan.

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