FRP International

Fiber Reinforced Plastics

Autumn, 1996 Volume IV, Issue 4

Society Profile – ACI

The American Concrete Institute (ACI International)

In 1905, concerned concrete enthusiasts set out with a mission to develop a means for making concrete safe, usable, and durable. The result of their determination was the formation of the American Concrete Institute (ACI International).

Chartered as a technical society, the not-for-profit ACI International emerged with a goal of guiding and assisting its members and the general public by disseminating information on concrete. Indeed, ACI International's motto describes this interaction flawlessly: "Progress through Knowledge."

ACI prides itself as a consensus organization, one that gathers, correlates and disseminates information precisely. ACI is the premiere source of knowledge on concrete design and construction. This is no surprise to the 20,000 ACI members from North America and 100 other countries, the 3,000 participants in over 100 ACI Committees, members of 83 ACI national and international chapters, the 30,000 individuals who have received ACI Certification, and the thousands who attend ACI conventions and seminars annually.

ACI members are professional experts in the field of concrete design and construction. They represent engineering and architectural services, contractors and material producers, and government and higher education. ACI International members may take part in the development of design codes, standards, and practices that affect construction worldwide. By participating in one or more **technical committees,** a member helps write codes, standards, and reports that are the most widely accepted concrete construction documents in use today.

ACI International offers the world's most complete source of technical literature on concrete:

Concrete International. ACI International's world renown monthly magazine offering timely and practical 'how-to' reports on concrete design and construction.

ACI Structural Journal and ACI Materials Journal. These bi-monthlies address the latest developments on research and technology.

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In This Issue

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More than 400 **technical documents.** Included are publications such as ACI 318 **Building Code Requirements for Structural Concrete;** the 5-part ACI **Manual of Concrete Practice** known as the "encyclopedia of the concrete world".

ACI International's wide selection of educational seminars, two annual conventions and growing chapter programs are activities designed to help professionals.

ACI Committee 440 - FRP Reinforcement

At the Spring 1991 Convention in Boston, Massachusetts, USA, an exploratory meeting was held with the intent to form a new technical committee with the mission of studying and reporting on research, development and uses of fiber reinforced plastic (FRP) reinforcing bars and prestressing tendons and of developing guiding documents for the use of these materials in reinforced concrete. The meeting, attended by 17 people, resulted with the official formation of such a committee.

After six years of existence, ACI 440 has 47 voting members, 48 associate members, and nine consulting members. Presently, the technical, educational, and management activities of the committee are handled by the following subcommittees: A) Membership, B) Title and Mission, C) State-Of-The-Art Report, D) Research, E) Professional Education, F) Repair, G) Student Education, H) Reinforced Concrete, I) Prestressed Concrete, and J) Stay-In-Place Formwork. The major tasks under completion are design and construction documents (in the form of guidelines or provisional codes) for RC and PC structures and repair.

ACI 440 organized the First International Symposium on FRP Reinforcement for Concrete Structures in Vancouver, British Columbia, Canada, during the Spring 1993 Convention (see ACI Special Publication 138 for the symposium proceedings). This event continued and will continue every two years. After Belgium in 1995 and Japan in 1997, the fourth symposium will be held again in North America (Baltimore, Fall 1999 Convention).

In the Spring of 1996, ACI 440 published the State-Of-The-Art Report on FRP Reinforcement available as publication ACI 440R-96.

For more information contact: Prof. Antonio Nanni (ACI 440 Chairman), by facsimile at 814-863-4789 or by e-mail at axn2@psu.edu.

Applications

Repair of Parking Structures

Structural Preservation Systems Inc. of Baltimore, Maryland, USA, has used Tonen's Forca Tow Sheet to repair shear cracks in beam column interfaces. The shear cracks were discovered on a number of support members in the Palm Beach Hilton parking garage in southern Florida. The original construction method was a combination of cast-in-place and precast assembly. The cracks, which appear at 45 degrees starting at the beam column interface, are typically caused by insufficient reinforcement.

Three conventional repair strategies were considered: (1) Enlarging the column with a rebar cage and added concrete which would serve to shorten the span and reduce shear stress. (2) Enlarging the overhead beams by dowelling in additional shear bar reinforcement and encasing with a larger concrete cross section. (3) Adding supplemental steel support and columns, which is not always a viable alternative due to traffic flow and clearance constraints.

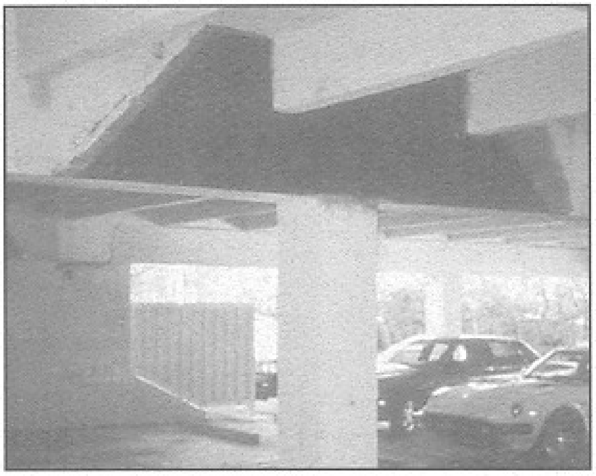

Figure 1. Repair of the main beam for shear strength using Tonen's Forca Tow Sheets.

A fourth repair strategy of using externally bonded fiber sheet was accepted by the owner. A single layer of FTS C1-30 carbon fiber tow sheet on both sides of the beam, oriented at 45 degrees was equivalent to No. 6 stirrups on 20 cm (8 inch) centres as shown in Figure (1). Prior to the application of the sheet, the cracks were injected with epoxy resin.

Compared to conventional methods, this repair had advantages of no overhead or other space encroachment, downtime/interruption time lessened, and use of non-corroding materials in a severe marine environment (garage situated in close proximity to the ocean). From an aesthetic standpoint, the use of a colour-matching urethane topcoat, Figure (2), made the repair virtually undetectable. Finally, it was estimated that labour savings over conventional methods resulted in a 35 percent direct cost savings to the owners.

For more information, contact Howard Kliger, Tonen Corp., by fax at 908-754-5292 or by e-mail at ruuj98a@prodigy.com.

Figure 2. The main beam after completion of the repair.

FiRP™ Glulams for Bridge Girders

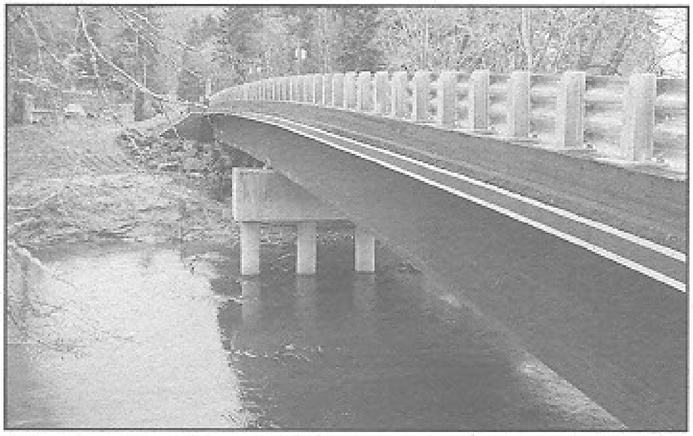

Figure 3. Clallam Bay, Washington, using FiRP™ glulams girders.

FiRP™ reinforced glulam are structural glued laminated timbers reinforced with high-strength fiber reinforced plastics (FRP). FiRP™ glulams are having a major impact on the future of the glulam industry and the use of FRP composites in infrastructure and building construction. Glulams are an engineered wood composite used for structural members. FiRP™ glulam is less variable in stiffness and strength; therefore, it is considered more reliable than conventional glulam. An HS-25 bridge with two 25 m spans was recently constructed at Clallam Bay, Washington, using FiRP™ glulams for girders as shown in Figure (3). When the girders were set in place, initial deflections of the six main girders differed by less than 3 mm. As a result, the construction crew spent less time installing and adjusting the members. This uniformity should ultimately also benefit the wear surface because the bridge will flex more uniformly.

For more information, contact Maureen Boles, Wood Science and Technology Institute, by fax at 541-753-5231.

FRP for Transformer Room

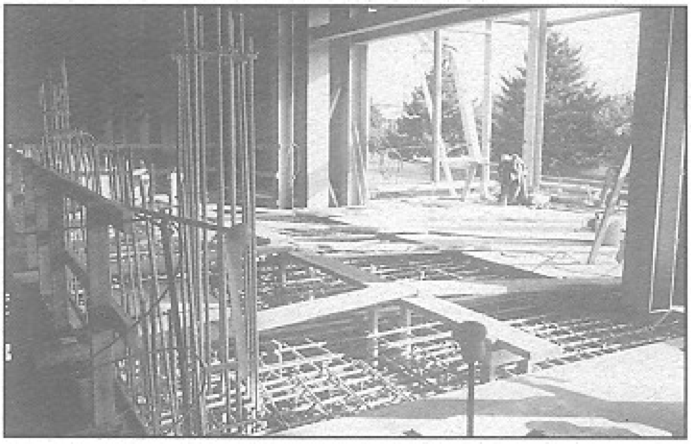

Figure 4. 18 inch slab reinforced by GFRP at 9 inches on centre.

The major expansion of Carpenter Technology Corporation at their plant in Reading, Pennsylvania, required construction of speciality transformers and other electronic equipment for the Vim furnace. These transformers generate extremely high magnetic fields which prohibit the use of conventional steel as a structural system. The two practical solutions were concrete reinforced with stainless steel bars or use of fiber glass reinforced plastic (GFRP) bars. Due to concerns about using metallic materials, GFRP bars were selected. The GFRP bars was also economically favourable since the cost was considerably less than stainless steel bars. In spite of the lack of design standard, a safe design was achieved based on published papers in journals and conferences, including the ACI state-of-the-art report. Construction of the transformer room, Figure (4), was completed in November 1996.

For further information, contact Brian Lipko, Fluor Daniel, by telephone at 609-797-7525.

First Carbon Composite Retrofit for Caltrans

In mid-December 1996, XXsys Technologies, Inc. started work on the first Caltrans contract specifying the use of carbon composite jackets for seismic retrofit. The company is using its Robo-Wrapper™ technology to retrofit six bridge columns on Interstate 5 in San Diego at the Manchester exit which crosses over the San Elijo Lagoon, see Figure (5).

XXsys uses a carbon composite material to retrofit seismically deficient bridge columns to provide fast, cost-effective structural reinforcement. In April of 1996, Caltrans approved the technology as an alternate seismic retrofit technique after extensive testing, using simulated seismic loads and on-site demonstrations. The testing was conducted at the University of California at San Diego's Powell Structural Research Laboratories, a world leader in seismic research.

The prime contract was awarded to Burns Pacific Construction Company in mid-September. XXsys is teaming with FCI Constructors to provide the seismic retrofit services.

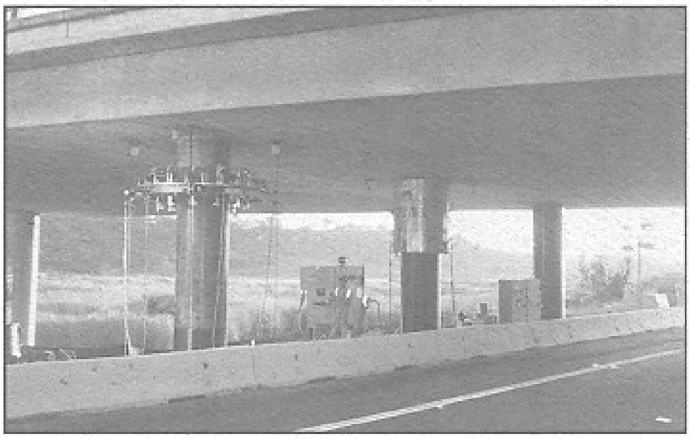

Figure 5. Repair of bridge columns using Robo-Wrapper™ technology.

For further information, contact Vince Reardon by fax at 619-974-8208.

Rehabilitation of Columns of a Highway Overpass Using Fiber Composite Materials

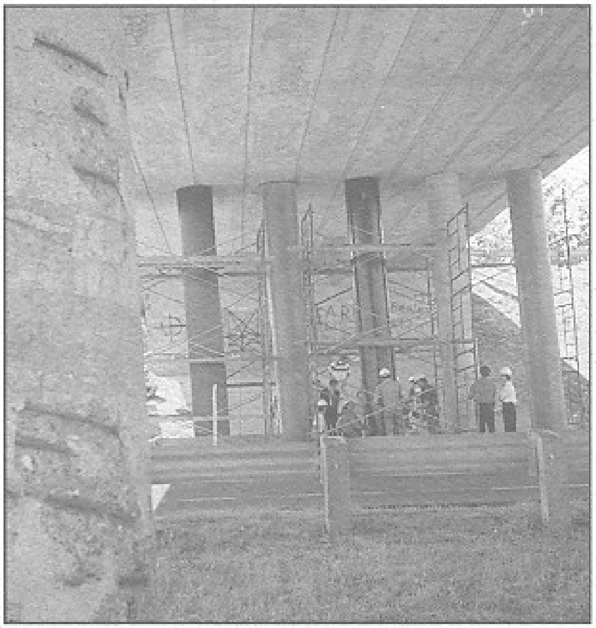

Figure 6. Rehabilitation of Highway 10 overpass in Canada.

Within its research and technology transfer activities, the ISIS Canada Network of Centres of Excellence in Sherbrooke undertook the rehabilitation of an overpass located at Exit 100 of Highway 10 at Saint-Étienne-de-Bolton in Québec, Canada, see Figure (6). The repair work, which lasted about three weeks, was performed during the month of August 1996. The overpass consisted of 18 circular columns measuring 760 mm in diameter and six metres in height. Twelve columns were in need of repair due to corrosion damage caused mainly by the close proximity of the highway lanes. Concrete failure was caused by corrosion of the rebars which led to damage of the columns. Nine of the columns were repaired with composite materials, and three with conventional materials. Of the nine columns wrapped with composites, five were wrapped with glass fiber and four with carbon fiber. The composites used were supplied by three different companies, thus allowing comparative measurements (qualitative and quantitative) between materials and manufacturers. Optical fibers were then installed on an experimental basis on four of the rehabilitated columns. The installation of optical fibers is the first step towards monitoring, and it will permit the validation of this technique for numerous civil engineering applications.

For more information, please contact Dr. Kenneth Neale, Université de Sherbrooke, by fax at 819-821-7974.

GFRP Framed Structure

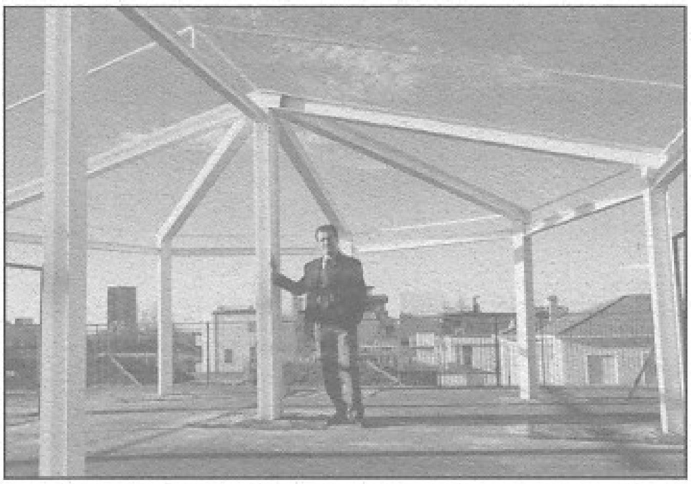

Figure 7. GFRP for floor terrace, Rimini, Italy.

The realization of a GRFP framed structure was carried out over the fourth floor terrace of a hotel in Rimini, an Italian resort town on the Adriatic Sea. It consists of a covering roof of about 60 m^2 for civil facilities.

The choice of FRP over more traditional materials lies primarily in the lightness and the corrosion resistance of the composite materials under the adverse environmental conditions of the site due to its vicinity to the sea.

The structure is made up of an assemblage of pultruded "H" shaped beams (H150 x 150 x 6.4). The columns were connected with adhesive to the floor by large composite plates. All other members were jointed bolts to allow for future disassembly.

The covering skin was made of precast poly-uretanic insulated sandwich panels firmly connected with rivets to the frame. The walls consisted of precast aluminum and glass panels erected and fixed to the columns.

The frame has been designed for environmental loads such as wind, snow and earthquake. Connections were carefully detailed drastically reducing the number of different types, as commonly practiced for industrial design and requested for this type of structure. Some connections were simulated by a computer virtual 3D software so as to check the correctness of the designed elements.

The whole structure was erected in only two days. After completion, a finishing coat was applied to serve for both fire resistance and UV protection. The project cost, inclusive of material and manpower, was not significantly different from that of a steel structure.

Designer: Dr. O. Manfroni, Coed Engineering, Rimini, Italy, fax: +39-541-78-25-70.

FRP Consulting: Co-Force, Composite For Civil Engineering, International Consultants, Italy, +39 541-78-27-42 (http://iper.net/co-force).

Client: Hotel "A Casa Mia", Rimini, Italy.

FRP Manufacturing: Morrison Molded Fiber Glass Company (MMFG) - Bristol, Virginia, USA.

FRP Supports for FRP Pipe

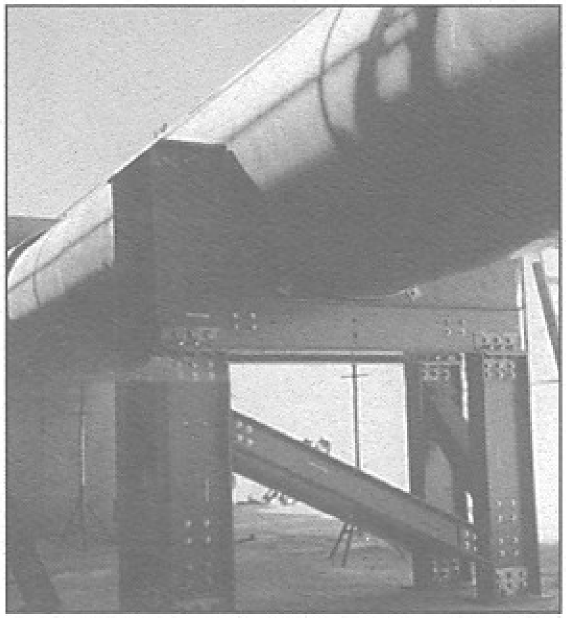

Figure 8. FRP supports for FRP pipes.

EXTREN® fiberglass structural shapes produced by MMFG were used to support 100 feet and 54 inch diameter pipes at the Metro Wastewater Treatment in St. Paul, Minnesota, USA, see Figure (8). The dynamic thrust loading during charging of the pipe and their expansion/contraction for a possible 120 degree differential were considered in the design. The project is scheduled to be constructed in 1997.

For more information, please contact Vickie Clark by telephone at 540-645-8143 or by fax at 540-645-8132.

Composite Fender Piling

Twenty-four composite fender pilings from Creative Pultrusions, Seaward International and Trimax were installed at Berth 7 at Port Newark by the Port of New York/New Jersey in early October of 1996. The installation was part of the Construction Productivity Advancement Research Project (CPAP), an ongoing collaboration between the U.S. Army Corps of Engineers Construction Engineering Research Laboratories, Rutgers University and the Market Development Alliance (MDA) of SPI's Composite Institute.

Creative Pultrusions' piling, 13 inches in diameter and 60 feet in length, is comprised of pultruded glass and incorporates a tic-tac-toe profile and a high-density polyethelene (HDPE) bumper. The bumper protects the composite and helps to absorb the shock of impact from a vessel. Seward International's SEAPILE® Composite Marine piling, 13 inches in diameter and 60 feet in length, is comprised of 100% recycled, high-density polyethelene (HDPE) blend, Duralin™, which is reinforced with eight glass/polyester pultruded rebars. Trimax's piling, 10 inches in diameter and 60 feet in length, contains 75% recycled HDPE, 20% fiberglass and 5% proprietary additive. It is manufactured using a continuous extrusion process. Each company installed eight pilings at Berth 7, where car carriers are the typical ships docked. All the pilings were driven with a hammer, which has a rated energy of 8750 foot-pounds.

For further information, please contact John Busel by telephone at 212-351-5413.

Strengthening of Roof Structures

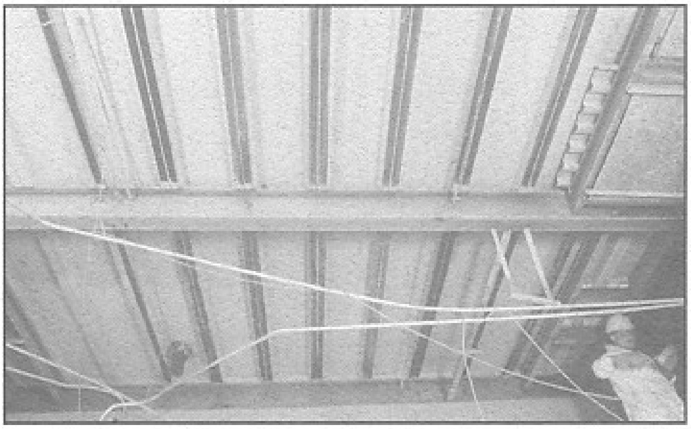

Figure 9. Repair of roof structures using CFRP laminates.

Changing industrial needs at the North End Pollution Control Centre in Winnipeg, Manitoba, Canada, necessitated strengthening of the sixty year-old concrete roof structure. The roof structure of this building was designed to carry its own weight and snow load, in addition to the live load specified by the Canadian Code at the time for inaccessible roofts. The roof structure consists of simply supported precast concrete panels. Recent upgrading of the building demanded the installation of large equipment on the top of the existing roof creating significant drift snow load. Carbon fiber reinforced plastic (CFRP) laminates were used to strengthen and control the deformation of existing roof panels, see Figure (9). The use of epoxy-bonded CFRP laminates were selected due to their characteristics of high strength, low weight and ease of application. This technique introduced considerable savings in comparison to conventional repair methods proposed for the same structure.

For more information, please contract Dr. Sami Rizkalla by fax at 204-261-5465.

FRP for Roof Structures

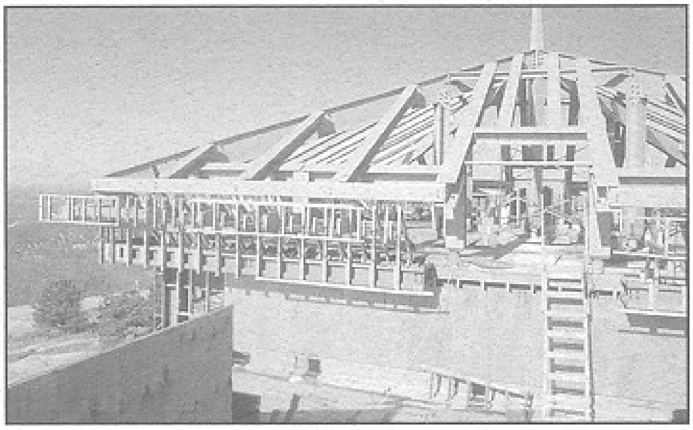

Figure 10. FRP for roof of the Aerial Train Station, Stone Mountain, Georgia, USA.

EXTREN® fiberglass structural shapes, DURASHIELD® building panels and FIBERBOLT® fiberglass studs and nuts were used for roof tops of the Aerial Train Station in Stone Mountain, Georgia, USA, see Figure (10). Fiberglass was used to avoid interference with radio frequencies and maintain the aesthetically pleasing look of the park, and certainly satisfied the structural requirements of the roof. The EXTREN® , which is available in a 24 inch I-beam and 40 foot lengths, is currently the largest fiberglass structural shape in commercial production by MMFG. The roof used 64 rafters and 17 columns. The roof is covered by 3400 white DURASHIELD® fiberglass panels.

For more information, please contact Vickie Clark by telephone at 540-645-8143 or by fax at 540-645-8132.

Research

FRP Modular for Bridge Decks

Collaboration of the research team of West Virginia University, USA state and federal agencies and the Composites Institute has developed a system intended to replace deteriorated concrete decks with FRP modules, as shown in Figure (11). Deck

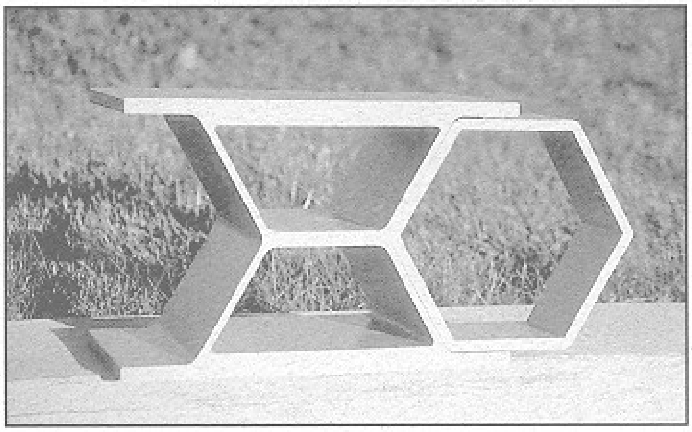

Figure 11. FRP modular for bridge decks.

modulus were designed with enhanced cross-section and fiber architecture. Testing prototypes and a field demonstration deck were fabricated by VARTM and Pultrusion. Two bridge demonstration projects are planned to utilize this system supported by steel beams as shown in Figure (12). The deck product is designed and tested under the CPAR program of the US Army Corps of Engineers.

For further information, please contact Dr. Roberto Lopez-Anido by fax at 304-293-7109.

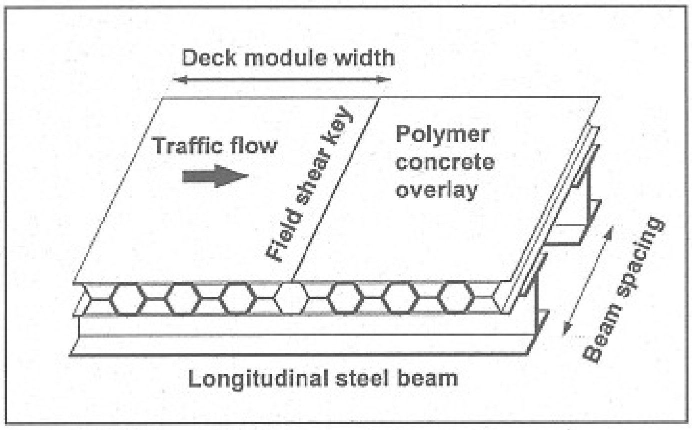

Figure 12. Portion of FRP deck supported on steel beams.

International Research on Advanced Composites in Construction (IRACC'96)

International Research on Advanced Composites in Construction (IRACC'96) is an activity aimed at identifying a) the critical items affecting the performance and use of FRP in construction and, b) coordination of the efforts necessary to make the process more efficient at the international level.

The research tasks deal with characterization, manufacturing, testing, procedures, standards, analysis/design criteria, and prototype demonstrations relative to the use of advanced composites in construction. They are subdivided into five topic (application) areas: non-prestressed reinforcement for concrete (RC), prestressed reinforcement for concrete and cables (PC), structural shapes, structural systems and repair/rehabilitation systems.

A Planning Committee of 66 members was formed. The technical knowledge of the committee members as well as their affiliations were considered in order to ensure broad-based input. Equal balance among members according to geographical distribution and affiliation (i.e. academia, government and industry) was also sought. The Planning Committee was invited to the Grand Hotel Baglioni in Bologna, Italy, June 9 to 11, 1996, for a workshop meeting. The purposes of the workshop meeting were to review the state of current research and practice, and discuss objectives, philosophy, directions and priorities of coordinated activities for a more synergetic effect.

A follow-up meeting was conducted in Montreal, Canada, on August 11, 1996. The meeting was held in conjunction with the Second International Conference on Advanced Composite Materials in Bridges and Structures (ACMBS-II). This additional meeting provided an opportunity to finalize the conclusions of IRACC'96 and present them to a broader audience. At the plenary session a consensus was reached on the following items:

The IRACC'96 final report will be made available on the Internet at the following address: http://www.iper.net/co-force. On the same home page, a research-in-progress report will be maintained listing world-wide activities. The report will be updated with entries directly from the home page.

IRACC should continue meeting. Japanese participants have offered to host the next workshop in Sapporo, Japan, in conjunction with the Third International Symposium on Non-Metallic (FRP) Reinforcement for Concrete Structures (FRPRCS-3) to be held October 14 to 16, 1997.

The action plan should materialize with work in the following areas: round-robin product testing for reinforcement for concrete, numerical simulation modelling prior to testing (e.g. jacketing of FRP columns), and performance specifications for the connection of structural shapes.

For more information, please contact A. Nanni by fax at 814-863-4789 or by e-mail at axn2@psu.edu; or IRACC secretariat M. Arduini by fax at +39-51-64-43-495 or by e-mail at scienzac4@ingbo1.cineca.it.

FRP for Large Span Highway

The Province of Manitoba in Canada accepted the challenge of constructing the world's longest span concrete highway bridge prestressed and reinforced for shear using carbon fiber reinforced plastic (CFRP) reinforcement. A portion of the concrete deck slab is also reinforced exclusively by FRP reinforcement. The bridge, located over the Assiniboine River in Headingley, Manitoba, Canada, consists of five spans, 32.5 meters each. A portion of the barrier wall will also be reinforced with glass fiber reinforced plastic reinforcement (GFRP). The bridge features optical fiber sensors connected to a telephone line for continuous monitoring of the performance of the bridge under traffic and environmental conditions as shown in Figure (13).

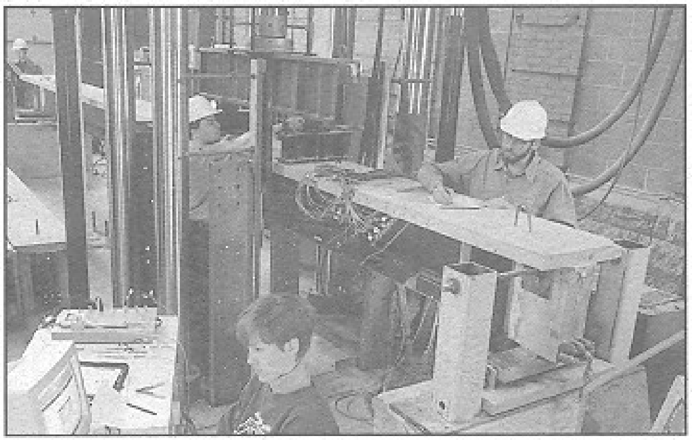

Figure 13. Continuous monitoring of Headingley Bridge, Manitoba, Canada.

Six 10 meter (30 ft.) concrete beams prestressed and reinforced for shear by the same carbon fiber reinforced plastic (CFRP) reinforcement which will be used for Headingley Bridge were tested at the University of Manitoba. A full-scale deck slab of the bridge, totally reinforced by CFRP, was also tested using equivalent truck wheel load as shown in Figure (14). Both the slabs and the beams were monitored by bragg grating optic fiber sensors which will be used for the bridge. The research project included an evaluation of the effect of bending CFRP used for the stirrups.

For more information, please contact Dr. Sami Rizkalla by fax at 204-261-5465.

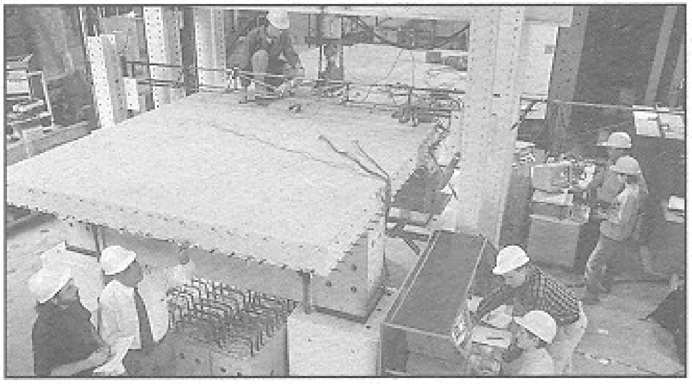

Figure 14. Full-scale testing of deck slab reinforced by leadline bars.

Awards

Prince Philip Award to Maunsell Structural Plastics

The growing importance of polymers in the building and construction industries has been recognized by the presentation on November 13, 1996, of The Institute of Materials' coveted 'Prince Philip Award for Polymers in the Service of Mankind' to Maunsell Structural Plastics Ltd., part of the international Maunsell group of consulting engineers.

Maunsell staff were presented with this prestigious Institute of Materials award by HRH The Duke of Edinburgh at a special ceremony held at Buckingham Palace. The award recognizes Maunsell's work in the development of the world-leading Advanced Composite Construction System, a lightweight, high-strength, durable, modular construction system for buildings and bridges.

The latest high-profile use of this system is in the new bridges on the M4 Motorway approach road to the Second Severn Crossing. Maunsell's design and development work has effectively laid the foundations for a new world industry in polymer-based structural materials.

For further information, please contact Allan Churchman, by fax at 181-553-6723.

Conferences

Advanced Composites Conference and Exposition (ACCE'97), Renaissance Centre, Detroit, Michigan, April 7 to 10, 1997. For further information, please fax 810-355-1492.

JEC - Journees Europeenes des composities Conference and Exhibition, CNIT Center, La Defense, Paris, France, April 23 to 25, 1997. For further information, please fax 33-1-4059-8546.

The State-of-the-Art of the Repair and Rehabilitation of Reinforced Concrete Structures, Maracaibo, Venezuela, April 28 to May 1, 1997. For further information, please contact Professor Houssam Toutanji of the University of Puerto Rico by fax at 809-265-3390.

The National Seminar on Advanced Composite Material Bridges - Advancing FRP Bridges and Structures into the 21st Century, Washington, D.C., May 5 to 7, 1997. For further information, please contact Barbara Murdock in Washington at 202-289-8100.

42nd International SAMPE Symposium/Exhibition - Evolving Technologies for the Competitive Edge, Anaheim Convention Center, Anaheim, California, May 5 to 8, 1997. For further information, please fax 818-332-8929 or e-mail at 102022.3113@compuserve.com.

Canadian Society for Civil Engineering 25th Annual Conference, Sherbrooke, Québec, May 27 to 31, 1997. For further information, please contact the Department of Civil Engineering at the Université de Sherbrooke in Québec by fax at 819-821-7974.

1997 International Conference on Engineering Materials, Citadel Ottawa, Hotel, Ottawa, Canada (covers repairs and rehabilitation materials and FRP materials), June 8 to 11, 1997. Please contact Akthem Al-Manaseer at Bradley University, Peoria, IL, USA, by fax at 309-677-2867.

International Conference on Rehabilitation and Development of Civil Engineering Infrastructure Systems, Beirut, Lebanon, June 9 to 11, 1997. For further information, please contact the American University of Beirut by e-mail at mharajli@aub.edu.lb.

Fourth International Conference on Composites Engineering (ICCE/4), Khola Coast, Hawaii, July 6 to 11, 1997. For further information, please contact Dr. David Hui of the University of New Orleans by telephone at 504-280-6652, by fax at 504-280-5539 or by e-mail at dxhme@uno.edu.

The Seventh International Conference and Exhibition - Structural Faults and Repair '97, Edinburgh, Scotland, July 8 to 10, 1997. For further information, please fax 44-131-452-8596.

US-Canada-Europe Workshop on Bridge Engineering, Dubendorf and Zurich, Switzerland, July 14 and 15, 1997. For further information, please call +41-1-823-4200 or fax +41-1-821-62-44.

First Engineering Foundation Conference on High Strength Concrete, Kona, Hawaii, July 13 to 18, 1997. For further information, please contact the Engineering Foundation by telephone at 212-705-7836, by fax at 212-705-7441 or by e-mail at englnd@aol.com.

The Fourth International Kerensky Conference - Structures in the New Millennium, Hong Kong, China, September 3 to 5, 1997. For further information, please contact the Conference Secretary by fax at 852-2559-5337 or e-mail at civilcom@hkucc.hku.hk.

International Conference on Composite Construction - Conventional and Innovative, Innsbruck, Austria, September 16 to 18, 1997. For further information, please call +41-1-633-2647 or fax +41-1-371-2131.

FRP in Corrosion and Construction 10th International Technical Conference and Exhibition, Caesar's Palace, Las Vegas, includes infrastructure and building, September 22 to 25, 1997. Contact SPI Western Composites Institute by fax at 714-261-6959 or by e-mail at dplummer@socplas.org.

Third FRP International Symposium on Non-Metallic (FRP) Reinforcement for Concrete Structures, Sapporo, Japan, October 14 to16, 1997. Contact: Secretariat FRPRCS-3, Japan Concrete Institute, TBR - 708, 5-7 Kojimachim Chiyoda-ku, Tokyo 102, Japan.

5th Japan International Sampe Symposium and Exhibition (JISSE-5), Tokyo, Japan, October 28 to 31, 1997. For further information, please contact Prof. M. Yamabe of the Kanazawa Institute of Technology by telephone at +81-762-94-6703, by fax at +81-762-94-0183 or by e-mail at yamabe@neptune.cisp.kanazawa-it.ac.jp.

Second International Conference on Composites in Infrastructure (ICCI'98), Tucson, Arizona, January 5 to 7, 1998. Please visit their web site at http://engr.arizona.edu/~ICCI for further information.

Second International Conference on Concrete Under Severe Conditions, Tromsø, Norway, June 21 to 24, 1998. For further information, please contact professor O. E. Gjørv of the Norwegian University of Science and Technology by telephone at +47-73-59-45-48, by fax at +47-73-59-45-51 or by e-mail at bml@bygg.ntnu.no.

The Structural Engineers World Congress (SEWC), San Francisco, July 18 to 23, 1998. For further information, please contact Dr. N. K. Srivastava by fax at 506-858-4082.

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