FRP
Fiber Reinforced Plastics
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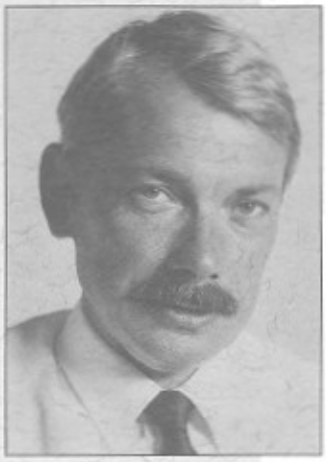
Guest Author Mr. Peter Head

Design and Construction of the World's Longest Span GFRP Bridge



Mr. Peter Head
Director of Maunsell Structural Plastics International Maunsell Group of Consulting Engineers

Mr. Head, a founding Director of Maunsell Structural Plastics, part of the large multi-disciplinary international Maunsell Group of Consulting Engineers, has spent the last 12 years leading a team working towards the cost effective application of advanced composites in construction. This work has been alongside his responsibility for design and construction of some of the world's largest steel and concrete bridges. He has therefore been in a unique position to expand on the benefits of composite materials to clients, particularly in bridges where lightness, speed of construction and good durability are of considerable benefit.

In 1992, this work lead Maunsell to bring together a team of industrial partners with Dundee University to design and build a 63 meter span, 113 meter long cable-stayed footbridge for the Aberfeldy Golf Club, Scotland. Limited funds were available for construction and future maintenance, and it was recognised that a highly optimised design (Figure 1 and 2) using lightweight glass reinforced polyester pultrusions for the deck and towers could be assembled on site, on very economical foundations, by students from the University. It was quickly established that such a method would enable the bridge to be built within the Golf Club's budget. Confidence in the design of the complex structure was derived from Maunsell's Limit State Design Method, already used successfully and proven by previous research projects for long- and short-term performance of similar smaller bonded structures. Static and dynamic finite element analyses were carried out to calculate stresses and dynamic performance in extreme wind,

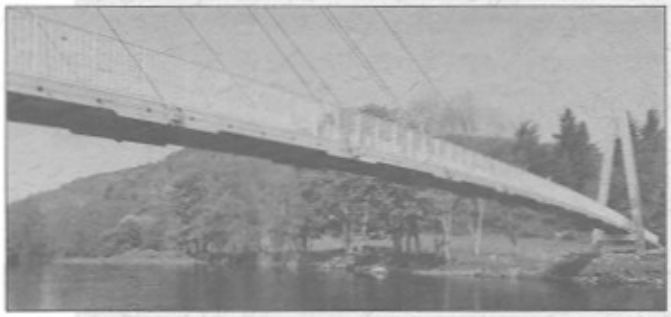


Figure 1. Linksleader Footbridge, Aberfeldy Golf Club, Scotland

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• American Concrete Institute • American Society of Civil Engineers • Canadian Society for Civil Engineering •
• Composite Institute • Japan Concrete Institute • ACMBS Network of Canada •

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flooding and live load conditions. The bridge becomes one with public access and has to be designed for full UK loading (see data).

Three pultrusions with a patented interlocking geometry (Figure 3) were used to build the structure, with bonding using a specially formulated epoxy resin being carried out on the site. No mechanical fixings were used to connect pultrusions. The deck is continuous over the 113 meter length and is also fitted with a GFRP handrail.

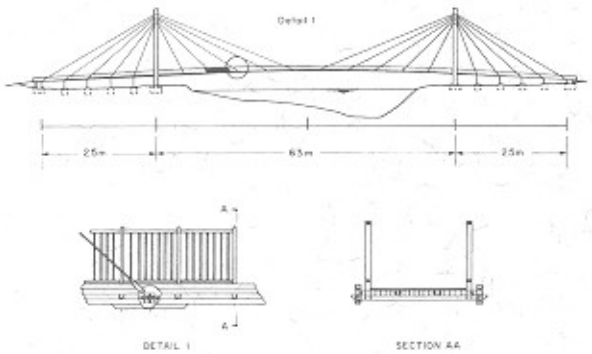

Figure 2. General Arrangement of Linksleader Footbridge

An innovative launching technique was used to complete construction in only eight weeks on site with a team of an average of six students and no cranage. Kevlar Parafil cable stays were chosen for lightness and ease of erection.

The bridge was completed in October 1992, only one year after initial discussions. It has since been subject to the worst flooding and winds ever experienced in the area without any ill effects. It has demonstrated that high quality pultruded GFRP sections can be used to build major attractive, competitive civil engineering structures.

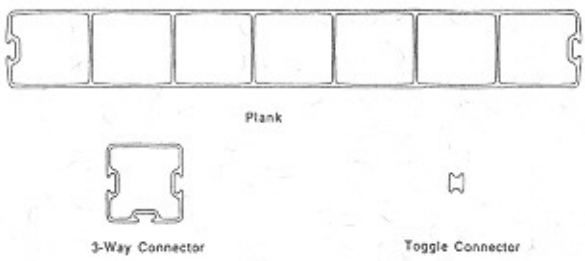

Figure 3. Pultruded Elements used for the bridge

Bridge Data

Weight of GFRP	Deck 150 k/m Towers 2.5 tons each
GRP Glass fiber content	60% by volume
Resin	Isophthalic Polyester
Deck Width	2100 mm
Deck Length	113 meters
Tower Height	17.5 meters
Design Live Loading	1000 k/m

FRP for Hollow Core Slabs

Braided aramid fiber bars (FiBRA) were used for pretensioned, prestressed hollow core precast concrete slabs. Mass production process of the slabs has been developed and they are currently commercialized as "FiBRA-spancrete". Typical FiBRA-spancrete are 120 mm in thickness, 990 mm in width, and 5 meters in length. The slabs have been used for decks of offshore structures in the Tokyo Bay area. FiBRA-spancrete is corrosion free and does not require cover painting. Figure (4) shows FiBRA-spancrete during flexural testing. For further information, please contact Mr. Tadashi Okamoto, R&D Division, Mitsui Construction Co. Ltd., 3-10-1 Iwamoto-Cho, Chiyoda-Ku, Tokyo, 101 Japan, FAX: 8135821-7640.

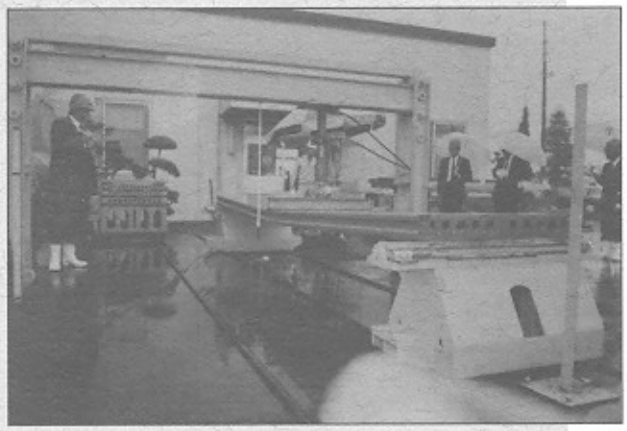

Figure 4. Hollow core slabs "FiBRA-spancrete" prestressed by FiBRA bars

Editor's Message

It is my pleasure to announce that the Canadian Network on Advanced Composite Materials in Bridges and Structures, ACMBS, has decided to join *FRP International*. On May 17, 1993, the Canadian Minister of Industry, Science and Technology Canada, the Honourable Michael Wilson, announced a federal contribution of $590,000 (CDN) to the Canadian Society for Civil Engineering to assist in the establishment of this Network. The Network is comprised of Canadian and International members of industry, academia, and government as well as professional and industrial associations focused on fostering the application of new technologies in this field. The grant is provided under the TOP-AIM initiative (Technology Outreach Program/Advanced Industrial Materials). We are pleased to have them join our international family.

- Sami Rizkalla

New Products

FRP for Shear Reinforcement

Use of FRP rods for shear reinforcement is limited due to the difficulty in shaping the rods into stirrup configurations which normally require sharp corners. Kajima Corporation and Sumitomo Chemical Ltd., jointly developed a new technology to facilitate using FRP rods for shear reinforcements at any location without requiring special equipment. Using the characteristics of the carbon fiber as a conductor, electric current is used to generate heat in the CFRP rods, to cure the impregnated thermoset resin of the "rope prepreg". The new product is shown in Figure (5). It has been demonstrated that the CFRP rods fabricated by this new technique can replace conventional steel as shear reinforcements for concrete structures. For further information, please contact Mr. Kazumasa Okumura, Kajima Technical Research Institute 19-1, Tobitakyu 2-Chome, Chofu-shi, Tokyo 182, Japan FAX: 0424-89-7078.

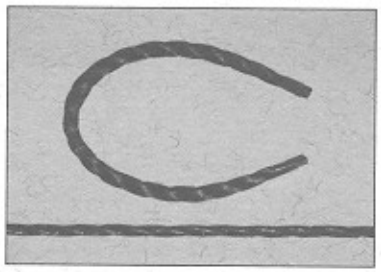

Figure 5. "Rope prepreg" produced by KAJIMA for shear reinforcement

GRAPHLITE ™ by NEPTCO

NEPTCO, USA, is currently manufacturing GRAPHLITE™ carbon fiber rods, Figure (6), which will be used in prestressing and post-tensioning concrete deck and piles of a pier test bend in Port Heuneme, California, this coming fall.

The project is a collaboration between the U.S. Army Corps of Engineers Construction Research Laboratory (USACERL) of Champaign, Il., and the South Dakota School of Mines and Technology.

The project's objective is to demonstrate a revolutionary breakthrough in corrosion prevention of reinforcement cable for prestressed concrete. Cables will be constructed using seven 4 mm GRAPHLITE™ rods stranded with one twist per foot and anchored with a system developed by Dr. S. Iyer at the South Dakota School of Mines and Technology. GRAPHLITE™, made from AMOCO's T300 carbon fiber in an epoxy matrix, is manufactured by NEPTCO using a process which assures an exceptional fiber alignment resulting in superior tensile strength.

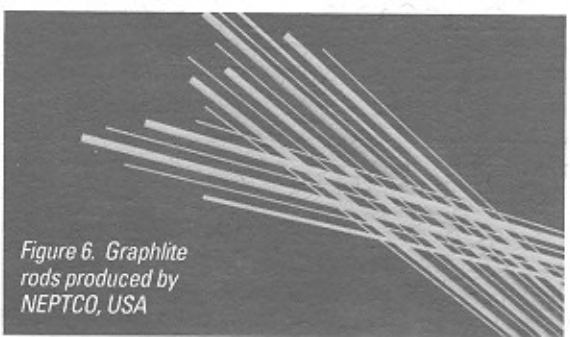

Figure 6. Graphlite rods produced by NEPTCO, USA

The overall dimensions of the pier will be 160 ft. by 15 ft. with the carbon prestressing cables being used over a 40 ft. length for pilings and a 10 ft. section for the concrete deck. Another deck section of 15 ft. by 20 ft. will be all composite produced by the Composite Institute of SPI.

For more information about composite prestressing cables call Stan Raczelowski at NEPTCO Incorporated, Telephone: (401) 722-5500.

SIREG Italy produces *Arapree*

Until recently Arapree bars were produced in a pilot-plant by AKZO in the Netherlands. Arapree is a combined development of AKZO and HBG of non-metallic aramid fiber based tensile elements (Twaron in epoxy) for use in reinforcing or prestressing concrete.

The AKZO management decision not to enter actual manufacture of aramid-based products, but to remain the main fiber producer, opened up possibilities for SIREG to incorporate the production and the know-how of Arapree, Figure (7).

SIREG is an Italian firm practising ranges of polymer products in water-filter and soil techniques. They specialize in using Arapree for ground anchor applications. SIREG can provide Arapree in an extended range of sizes and shapes.

For further information, contact Mrs. R. Valagussa (Foreign Sales Dept.) SIREG; Via del Bruno 12, 20043 Arcore ITALY, FAX: (+39) 39 61 5996.

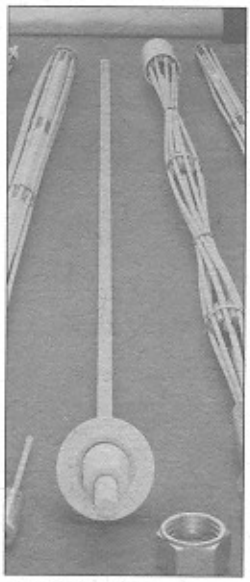

Figure 7. Arapree produced by SIREG, Italy

NDI - the Netherlands - a New Producer of Carbon Fiber Bars

NDI (Nederlandse Draad Industrie) is pleased with the results of the pilot-production of carbon fiber based bars, brand name Carbon Stress.

NDI is a subsidiary of the Dutch Steel producer Hoogovens. NDI is aiming to exploit the characteristics of the tensile-elements, such as perfect chemical resistance and fatigue endurance, in a range of engineering

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areas for concrete construction, ground engineering and stay-cables. Permanent anchorage systems are under development.

Current available sizes are 5, 6 and 7 mm, with a cross sectional tensile strength of 2400 MPa, combined with a strain capacity of 1.6% and an elastic modulus of 160 GPa.

For further information please contact: NDI BV., P.O. Box 3400 Venlo-Blerick, Netherlands.

Low Cost Guideways for Maglev

The Department of Transportation (DOT), Federal Railroads Administration (FRA), recently funded a research project at the Massachusetts Institute of Technology on "Low Cost Guideways for Maglev". Part of the project dealt with the optimum application of composite materials as reinforcement of the concrete guideways for Maglev. A novel hybrid composite rod, which consists of a unidirectional GFRP core surrounded by a relatively thin layer of CFRP, was developed at the end of 1991. The strategic control of carbon and glass in the hybrid makes possible a pseudo-ductile failure mode. At the same time, the CFRP layer provides some protection to the inner GFRP core from the alkaline environment of concrete. Polygon Corp. manufactured the rod using carbon fibers donated by Toray Industries. Researchers at M.I.T. are currently working on an improvement of the hybrid rod concept by combining an inner GFRP core with an intermediate low-stiffness CFRP layer and an outer high-stiffness CFRP layer, aimed at improving both ductility and durability. For further information contact Prof. Thanasis C. Triantafillou, Dept. of Civil & Environmental Engineering, M.I.T. Room 1-229, Cambridge, MA 02139.

Call for Papers

"Bond of FRP Rebars" - ACI San Francisco Convention, 1994

A technical session on the subject of "Bond of FRP Rebars" will be held at the ACI Convention, March 20-25, 1994 in San Francisco, CA. The session, sponsored by ACI Committees 408 and 440, will include presentations covering any aspects of the bonding of FRP rebars or tendons to concrete. Contributions for presentation from recently completed studies and ongoing investigations would be especially appreciated. Persons interested in making a presentation and submitting a paper for this session are asked to send their abstracts by September 15, 1993, to Prof. Mohammed Ehsani, the Session Chairman. Participants will be notified of their acceptance by October 1, 1993. Please send Abstracts to: Prof. M. Ehsani, Department of Civil Engineering, 206 Civil Engineering Bldg. University of Arizona, Tucson, AZ, 85721, TEL: (602) 621-6589;

FRP Research

FRP for Stress-laminated Wood Bridge Deck

The Structures Research Office of the Ministry of Transportation of Ontario (MTO) Canada, is investigating PARAFIL™, a commercial aramid fiber rope, to transversely prestress stressed laminated wood bridge decks (SWD). Presently, high strength steel rods are used. Since aramid fibers are less stiff than steel, the use of small diameter PARAFIL ropes is expected to reduce prestress losses sufficiently to eliminate the need for restressing. In addition, aramid fibers do not require corrosion protection. Special anchors for this application, are being developed with the assistance of the Nova Scotia CAD/CAM Centre, Technical University of Nova Scotia, using CAD drawings prepared at MTO.

For further information please contact: John Maheu, Associate Research Engineer, Structures Office, Room 320 Central Bldg, 1201 Wilson Avenue, Downsview, Ontario, M3M 1J8, FAX: (416) 235-4872.

FRP Research by University of Arkansas and Auburn University

The Arkansas Highway and Transportation Department is funding a project to investigate the properties of fiber-reinforced bars and their potential for use in reinforced concrete bridge decks. Phase I will include testing samples of various types of fiber-reinforced bars to determine their material properties. A state-of-the-art report on concrete reinforced with non-metallic reinforcement will be compiled.

Phase II will include static and fatigue testing of beam specimens. The fiber-reinforced bars tested in this phase will be the ones identified in Phase I as having the most promise for use in bridge decks. The purpose of this phase will be to develop a design methodology for concrete reinforced with fiber-reinforced bars including design for nominal moment strength and development. For further information, please contact John Schemmel or Larry Pleimann, at the Civil Engineering Department, University of Arkansas, Room 190 Bell Engineering Centre, Fayetteville, AK, 72701 FAX: (501) 575-7168.

Composite Materials May Replace Steel in Bridges

The Catholic University of America (CUA) has received $200,000 US in federal funding toward a full-scale demonstration of a glass and composite material technology that could one day replace steel reinforcement rods in concrete bridges. A CUA researcher proposes to test the material in a 100 ft. segment of John McCormack Road along the east side of CUA's campus.

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Lawrence C. Bank, a civil engineering associate professor, (Figure 8) who is researching the material, indicated that glass fiber-reinforced pultruded material might be more resistant to corrosion and require less energy to produce than steel. If the material proves successful, it could be an asset for the construction industry, which must replace or repair 238,000 bridges in the United States by 2005.

McCormack Road is used extensively by heavy vehicles and needs frequent repairs. The road testing site would mimic the properties of a bridge, with built-in sensors and other laboratory features. Researchers would evaluate the composite material over three years, providing valuable information on construction techniques and long-term cost-effectiveness.

For more information, contact Dr. L. Bank at Catholic University of America, FAX: (202) 319-4499.

Figure 8. Dr. L. Bank inspects the surface of McCormack Road, Catholic University of Amerca Campus (photo by Matthew Barrick, CUA Public Affairs)

Conferences and Meetings

Special FRP Session at 1993 Annual Conference of CSCE

A special session on FRP was held at the 1993 Annual Conference of the Canadian Society for Civil Engineering. The papers presented at the session are published in Volume IV of the Proceedings of the Conference. The authors and titles are:

- LABOSSIÈRE, P. and Erki, M.A., *Influence of Loading Type on the Reliability of Laminates.*
- McKENNA, J.K. and Erki, M.A., *Strengthening of concrete beams using externally bonded fibre composite sheets.*
- MUFTI, A.A., Bakht, B., and Maheu, J., *An example of the use of CAD/CAM in Structures Research.*
- NEWHOOK, J., and Gilkie, R.C., *The influence of glass fiber reinforced polyester laminates on the flexural behaviour of timber beams containing natural defects.*
- WRIGHT, R.G. and Cambridge, C.B., *Flexural behaviour of concrete reinforced with pre-stressed fibre-reinforced plastic grids.*

To purchase copies of the Proceedings, contact the Canadian Society for Civil Engineering, Head Quarters, 2050 Mansfield, Suite 700, Montréal, Québec, Canada, H3A 1Z2; FAX: (514) 842-8123.

Second Canadian International Conference on Composites

The CANCOM '93 will be held in Ottawa, Canada, on the 27th-29th of September, 1993. The conference includes sessions covering each of the following topics:

- Materials
- Design and Analysis
- Manufacturing Methods
- Joining and Fabrication
- Inspection and Quality Assurance
- Technology and Business
- Fatigue and Fracture

For conference registration or information please contact W. Wallace, Director, Structures and Materials Laboratory, NRC-CNRC, Ottawa, Canada, K1A 0R6, FAX: (613) 953-7136.

USA Federal Highway Administration Structures Research Program

The FHWA initiated a program of pilot development and feasibility research on FRP at the beginning of the 1980's. By 1989, the results of this early program convinced FHWA's top management that there would be a high return on funds invested in a full-scale national program of FRP research.

In 1990, the New Materials priority research area was developed with the support of business, academia and government agencies. An independent Structures Advisory Council Working Group, comprised largely of research directors (or equivalent) of professional and trade organizations, AASHTO and the Federal and local governments determined that new materials research was among the highest priority areas of research that the FHWA should sponsor or conduct. This technical area has attracted significant Congressional interest as well.

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The FHWA commitment in this area will be long-term. The agency's program, as it is now planned, will involve a partnership between the government, universities, and private industry to answer the significant theoretical and practical questions involved in the introduction of new materials on a large scale in civil construction.

The FHWA will directly sponsor the development of data on the long-term durability, toughness, strength and stiffness of advanced composites subject to the environment, operating conditions, and loadings of transportation structures.

The agency will cooperatively sponsor university and private sector development of practical structures and structural elements: bridge decks, cables, reinforcing bars, prestressing tendons, fasteners and primary members. Some of the specific programs completed or in progress are:

- Accelerated test methods for determining the long-term performance of FRP structures
- Environmental durability of FRP
- Impact/ tear resistance of FRP
- Concrete/ Rebar compatibility of FRP- reinforced concrete
- Buckling of FRP structural shapes
- Transfer of composite technology to highway bridges (UC- Long Beach - completed)
- Modular deck concepts (Georgia Tech - in progress)
- FRP Cables (Cal State - Long Beach - completed)
- Modular FRP Bridge Deck (Cal State - Long Beach - in progress)
- FRP Rebars for Bridge Decks (West Virginia University - in progress)
- Development of FRP for Highway Application (West Virginia University -in progress)
- FRP Rebar for concrete Bridge Decks (University of Maryland - in progress)
- FRP Grating (Catholic University)/FRP grid (University of New Hampshire), Reinforced Concrete Bridge Decks (in progress)
- Advanced Composite Cable Stayed Bridge (University of California- San Diego -1993 start)

For more information, please contact Mr. Eric Munley, Research Structural Engineer, FHWA, McLean, VA. 22101, USA. FAX: (703) 285-2379

Steel Ban Opens way for Non-metallic Tendons

Following the collapse of two bridges, one in Wales and one in Belgium, and known problems with grouting in other structures, the Department of Transport (DTp) in the United Kingdom has placed a temporary ban on the use of grouted internal prestressing tendons. The problems are associated with incomplete grouting, which can, in certain circumstances, lead to corrosion of the tendons. Voids and localised corrosion are very difficult to detect, and the partially complete grouting makes it impossible to replace the tendons.

The DTp is not putting any restrictions on pretensioned steel tendons, nor on external tendons which can be inspected and replaced. Although not specifically mentioned by the DTp, this opens the way for the use of non-metallic tendons, as corrosion of steel tendons is always more likely when they are removed from the high alkalinity of the concrete. An added incentive to use new materials is the practice of whole-life costing, which is a standard practice in the U.K. Future maintenance costs have to be discounted to present values, and added to the initial construction costs when comparing alternative designs. The effects of this procedure on the use of glass, carbon or aramid tendons depends on the values chosen for future costs; if realistic estimates are made of the costs of traffic disruption to users when bridges are replaced, the higher initial costs of more durable materials may be outweighed.

For more information, contact Dr Chris Burgoyne, University of Cambridge, Dept. of Engineering, Trumpington Street, Cambridge, CB2 1PZ, UK.

World's First Vehicular Bridge using Lightweight Advanced Composite

The University of California at San Diego (UCSD) and the USA defense industry are evaluating ways to use advanced composite materials for a new earthquake-resistant bridge in San Diego. The initial phase of the bridge is being funded by a $1.6 million US grant from the Federal Highway Administration to UCSD. The research and development team, which is headed by UCSD Applied Mechanics and Structural Engineering Professors Gilbert Hegemier and Frieder Seible, consists of a consortium of seven defence industry participants who worked extensively with fiber-reinforced composites for the military.

The 450 ft. long structure would connect the west side of the UCSD campus to the east campus and a new hospital. The proposed bridge is a cable-stayed bridge, supported by a series of cables connected to an A-frame pylon located on the west side of I-5 in the "Golden Triangle" region of San Diego. The bridge, 60 ft. wide, would be designed for two 12 ft. vehicle lanes, a 13 ft. walkway, a utility tunnel and two bicycle lanes.

The entire structure, including cables and bridge deck, would be built from composite materials whose properties and performance can be tailored for specific applications. Hegemier estimates that the new bridge could be as much as one-fifth to one tenth as light as a comparable bridge built from conventional materials. This

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type of bridge should be easier and quicker to build; thereby significantly reducing the construction costs. Since such bridges are much lighter, they would be less sensitive to ground motion from earthquakes than conventional structures.

The 18-month grant will involve experimental pilot tests at UCSD of materials components and subassemblages to verify manufacturers' claims on properties and variabilities. At each step, researchers will conduct both computer simulations and experiments to verify the response to extreme environmental and load conditions.

The research and development phase is estimated to take three years; construction of the bridge is estimated to take one year. The total cost of the four year effort would be approximately $55 million US.

CERF Releases Details of $2-$4 Billion National High-Performance Construction Materials Program

The Civil Engineering Research Foundation (CERF) released the details of a proposed ten-year research program aimed at enhancing the construction materials that are vital to President Clinton's plans to re-invigorate America's infrastructure. The CONstruction MATerials program (CONMAT) is outlined in a set of reports recently published by CERF entitled *High-Performance Construction Materials and Systems: an Essential Program for America and Its Infrastructure.* The high-level Executive Report (Report 93.5011.B), which is addressed to President Clinton and the Congress, outlines the program and notes the substantial benefits that derive from its adoption. The companion Technical Report (Report 93-5011) contains action plans and detailed program budgets for the first construction materials addressed under the program; concrete and steel.

The report's recommendations urge that "the President, his Administration, and the congress act now to enable the successful program by:

- providing a strong program focus and oversight through the [White House] Office of Science and Technology Policy
- ensuring federal funding of $2 billion over ten years
- authorizing the establishment of the National Coordinating Council (NCC) as defined in [the] report."

The report also urges industry and academia to work together to achieve the program's goals of developing and implementing a variety of stronger, more durable materials. Next steps planned for the program include a workshop scheduled for fall 1993, organization of additional materials-specific committees, and development of a comprehensive program plan encompassing all materials and complete funding aspects.

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New Publications

M.Sc. and Ph.D. Theses

In the last issue, *FRP International* began publishing a list of completed M.Sc. and Ph.D. theses related to the use of advanced composite fiber-reinforced plastic materials for Civil Engineering applications. Please send additional information to the Editor or any of the Associate Editors. The following are some of the theses completed in 1992-93:

Fawaz, Z., *Analytical, Numerical, and Experimental Investigation of Biaxial Fatigue Rupture of Fibre-reinforced Laminates* (in French). Ph.D. Thesis. Université de Sherbrooke, Sherbrooke, Québec, Canada, J1K 2R1. 1992.

Masmoudi, R., *Investigation of the Delamination in a Graphite-Epoxy Layered Composite Subjected to Static and Cyclic Loadings* (in French). M.Sc. Thesis. Université de Sherbrooke, Sherbrooke, Québec, Canada, J1K 2R1. 1992.

McKay, K.S., *Aramid Reinforced Plastic Tendons in Pretensioned Concrete Applications.* M.Eng. Thesis. Royal Military College of Canada, Kingston, Ontario, Canada, K7K 5L0. 1992.

McKenna, J.K., *Post-strengthening of Reinforced Concrete Members Using Fiber-composite Materials.* M.Eng. Thesis. Royal Military College of Canada, Kingston, Ontario, Canada, K7K 5L0. 1993.

Wegner, L.D., *An Experimental and Analytical Investigation of the Failure Behaviour of Fiber-Reinforced Concrete Deck Slabs without Steel Reinforcement,* M.Sc. Thesis, Technical University of Nova Scotia, Halifax, Nova Scotia, Canada, B3K 2X4, 1992.

Lewis, P.J., *Carbon Fiber Reinforced Concrete Formwork Panels,* Senior Engineering Thesis, Technical University of Nova Scotia, Halifax, Nova Scotia, Canada, B3K 2X4, 1993.

Phelan, R.S., *High Performance Maglev Guideway Design,* Dept. of Civil and Environmental Engineering, M.I.T., January 1993.

Deskovic, N., *Innovative Design of FRP Composite Members Combined with Concrete,* Dept. of Civil and Environmental Engineering, M.I.T., April 1993.

Plevris, N., *Time-dependent Behaviour and Design of Reinforced Concrete and Wood Structures Strengthened with FRP Laminates,* Dept. of Civil and Environmental Engineering, M.I.T., April 1993.

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Sets of the reports are now available from ASCE for $125 US. The Executive Report (Report 93-5011.B) can be purchased separately for $40 US; the Technical Report (93-5011) costs $100 US. ASCE members are eligible for a 25% discount.

For more information contact Paul Knapp, Communications Coordinator, Civil Engineering Research Foundation, 1015-15th Street N.W., Suite 600, Washington D.C. FAX: (202) 789-2943.

First Concrete Highway Bridge Prestressed by FRP in Canada

The City of Calgary has undertaken the challenge of constructing the first FRP prestressed concrete highway bridge in Canada, scheduled for July 1993. They have adopted two different types of carbon fiber-based tendons to prestress eight precast concrete girders of a continuous two-span skew highway bridge in Calgary, Alberta, Canada. Bulb-T section precast prestressed girders are used for both the 22.83 and 19.23 meter spans of the bridge. The girders are post-tensioned by conventional prestressing steel tendons to provide continuity over the middle pier. Four girders are prestressed by 8 mm diameter Leadline tendons developed by Mitsubishi Kasei. The other four girders are prestressed using 15.2 mm diameter carbon fiber composite cables (CFCC) developed by Tokyo Rope. The project is jointly sponsored by Industry, Science and Technology Canada, North Asia Relations Division; SCI Engineers Contractors Inc.; Mitsubishi Kasei Canada; Itochu Canada; the University of Toronto; the University of Manitoba and the Advanced Composite Materials in Bridges and Structures Network of Canada.

A multichannel fiber optic sensing system will be used to monitor the behaviour of the bridge over its lifetime. The optical fibers were installed and monitored by the research group of the University of Toronto Institute for Aerospace Studies.

The project included an experimental research program conducted at the Structural Engineering and Construction R&D Facility at University of Manitoba to examine 6.3 meter beams prestressed by Leadline and Tokyo Rope tendons and monitored by optical fibers similar to the one used for the bridge girders. The beams were tested under static and cyclic loading to evaluate various limit state behaviours including the fatigue behaviour under a load range equivalent to service loading conditions; see Figure (9). For more information, contact Dr. Sami Rizkalla, University of Manitoba, Winnipeg, Canada, R3T 2N2. FAX: (204) 275-3773.

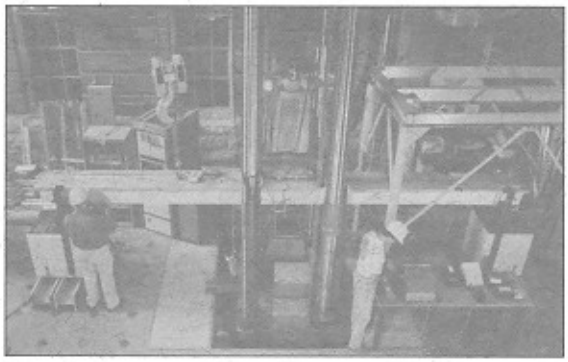

Figure 9.
Testing of 1:4 scale model of the Calgary Bridge girders at University of Manitoba

Faculty of Engineering
Room 350 Engineering Bldg.
University of Manitoba
Winnipeg, Manitoba
R3T 2N2

STAMP

To:_____