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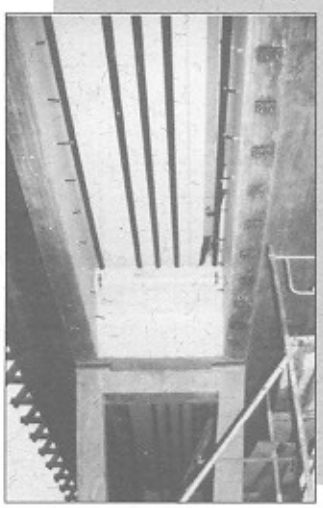
Guest Author – Dr. Ferdinand S. Rostásy,

Institut für Baustoffe, Massivbau und Brandschutz Braunschweig, Germany

Dr. Ferdinand S. Rostásy, Institut für Baustoffe, Massivbau und Brandschutz, Braundschweig, Germany

Dr. Rostásy is a professor of structural materials and concrete construction at the Technical University of Braunschweig in Germany, and is also director of the state materials testing laboratory. Since the early seventies, he and his collaborators have been engaged in research and development of FRP tensile elements for the reinforcing and prestressing of structural concrete members. The cooperation with STRABAG of Cologne, and later with SICOM, led to the development of the HLV post-tensioning system, which consisted of very high strength GFRP bars anchored in a steel housing by a polymeric resin mortar. With this system several bridge structures were post-tensioned in Germany and Austria. Figure A shows the Marienfelde footbridge in Berlin which was post-tensioned with external tendons.



On behalf of the DIBt, the German approval institute, comprehensive tests with GFRP, AFRP and CFRP tendons were performed in Dr. Rostásy's laboratory. As chairman of a Fedération Internationale de la Précontrainte (FIP) working group of internationally renowned experts on FRP, Dr. Rostásy was responsible for an FIP state-of-the-art report on FRP published in 1992. For the last three years, he has been the technical coordinator of a BRITE/EURAM research program on the advancement of FRP for structural concrete. This program is a joint effort of several European contractors and universities.

Figure A: Marienfelde footbridge, Berlin

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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 •

New Publications

EMPA Research Report No 224

The EMPA Research Report No. 224 entitled "Post-Strengthening of Concrete Structures with Pretensioned Advanced Composites" by M. Deuring is now available from EMPA. A video has also been made on this subject and is available in English on VHS-PAL or VHS-NTSC. For requests, please contact Prof. Urs Meier, Swiss Federal Laboratories for Materials Testing and Research, EMPA, CH-8600 Dübendorf, Switzerland.

Impact Characteristics of GFRC Materials for use in Roadside Safety Barriers

The report was published in January 1994 by the U.S. Department of Transportation, Federal Highway Administration (Publication No. FHWA-RD-93-090). Copies are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161. A limited number of copies will be available from the R&T Report Centre, HRD-11, FHWA, 6300 Georgetown Pike, McLean, Virginia, 22101-2296.

Research

Canadian Network Projects

The Advanced Composite Materials in Bridges and Structures Network of Canada (ACMBS), sponsored by Canadian industry, universities and government, has provided seed money to facilitate business alliances for the following industrial projects:

- First Smart Concrete Highway Bridge in Canada (completed November 1993) Contact Dr. S. Rizkalla, FAX: 204/275-3773
- Application of FORCA TOW sheet as a Repair Method for Deteriorated Concrete Piers, Contact J. Crimi, Autocon Composites Inc., FAX: 416/743-6383
- Pre-cast post-tensioned Bridges: A Feasibility Study. Contact Dr. G. Abdel-Sayed, FAX: 519/973-7062
- Study of ACM in Building Applications. Contact Dr. M. S. Cheung FAX: 613/736-2826
- Nova Scotia ACM Bridge Demonstration Project. Contact R. MacDonnell, FAX: 902/423-7593
- DokMarker - The Use of Advanced Industrial Materials in an Innovative Approach to Gravity Stabilised Marine Structures. Contact: Mr. J. Dow, FAX: 902/420-8949

CFRP for Strengthening Bridge Girders

Research into the use of carbon fiber reinforced plastic (CFRP) sheets to strengthen existing concrete bridge girders is currently in progress at the University of Alberta. Dr. J.J. Cheng, in cooperation with Mitsubishi Canada, is investigating the use of CFRP to externally

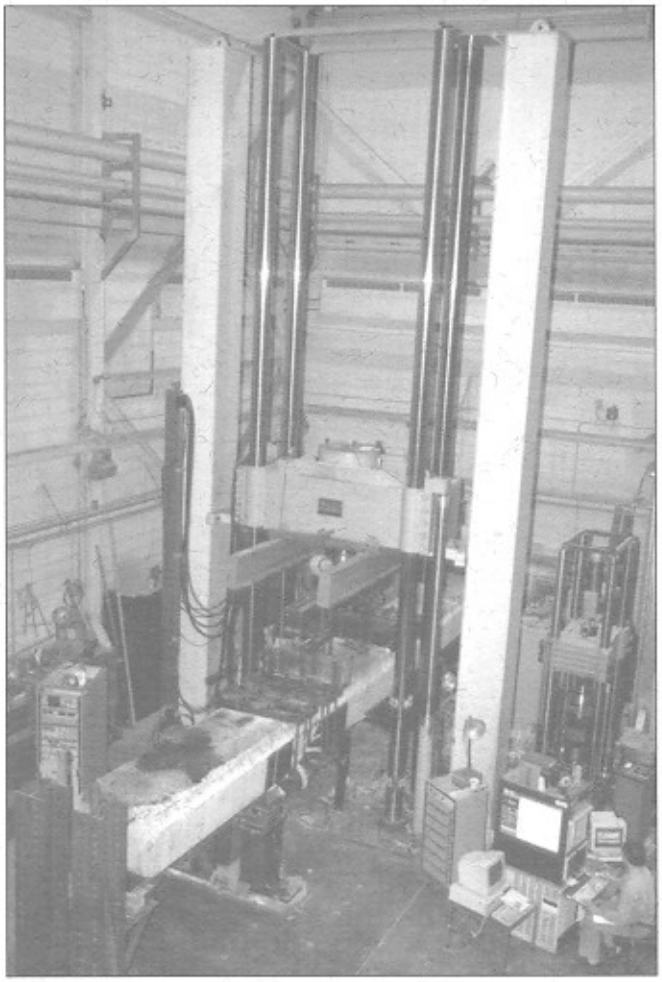

Fig. 1. Overview of test set-up, University of Alberta

strengthen existing pre-cast concrete bridge girders for shear. The testing program, funded and supported by Alberta Transportation and Utilities, involved two major test phases currently being completed at the University of Alberta. The first, a preliminary study, involved 12 meter concrete beams (as shown in Fig. 1). The second phase involved three 30 ft long pre-cast concrete girders salvaged from a bridge demolished in 1993. Results of both test programs showed that the concrete beams could be successfully strengthened using CFRP sheets. The performance of these materials in harsh Canadian winters with freeze/thaw conditions and fatigue loading needs to be confirmed.

For further information please contact Dr. J.J. Cheng, Dept of Civil Engineering, University of Alberta, Edmonton, Canada, FAX: 403/492-0249 e-mail: rcheng@civil.ualberta.ca

FRP Research at Université Laval

The research on the use of FRP at Université Laval is part of a research project entitled "Bridge Evaluation and Strengthening". This project is carried out in close collaboration with École Polytechnique de Montréal. Flexural strengthening of reinforced concrete beams with glass FRP plates has been investigated. To verify the results obtained from a theoretical model based on fundamental hypotheses of reinforced concrete design, tests were performed on beams strengthened with GFRP plates glued and/or mechanically anchored to the tension surface of the beams. Mechanical anchors were used to overcome the difficulty of attaching plates in the field by bonding alone.

Tests show a significant increase in flexural strength, but the measured ultimate moments were lower than the predicted ones. Therefore, the theoretical model has been adjusted to account for relative displacement of the reinforcing plate with respect to the surface of the concrete.

The research carried out to date is summarized in a paper entitled "Flexural strengthening of reinforced concrete beams with composite plates," which will be published in the Proceedings of the Fourth International Conference on Short and Medium Span Bridges to be held in Halifax, August 1994. For further information please contact Dr. A. Picard, Département de génie civil, Université Laval, Québec, QC, Canada. FAX: 418/656-2928.

Double-Tee Beam Bridge System Prestressed with AFRP

The feasibility of using Aramid FRP tendons as prestressing elements for concrete bridges is investigated in this study which is sponsored by the Florida Department of Transportation and Federal Highways Administration. The project includes testing of a 1:2 scaled model of a Double-Tee beam system prestressed by AFRP to study the various limit states behaviour. The project also involves environmental studies on the AFRP tendons exposed to seawater and alkali solutions at 45° C in the stressed and unstressed states.

The bridge system consists of three individual pre-tensioned Double-Tee beams arranged adjacent to each other, and in-situ cement grout used between the longitudinal joints, as shown in Fig. 2. The bridge system was then transversely post-tensioned and subjected to a static load representative of two HS20-44 Truck loads followed by fatigue loads. The bridge system was tested under the ultimate load conditions and the behaviour appeared to be quite encouraging for the prospects of using AFRP in bridge superstructures.

For further information, please contact Dr. M. Arockiasamy, Professor and Director, Centre for Infrastructure and Constructed Facilities, Department of Ocean Engineering, Florida Atlantic University, Boca Raton, Florida, FAX: 407/367-3885.

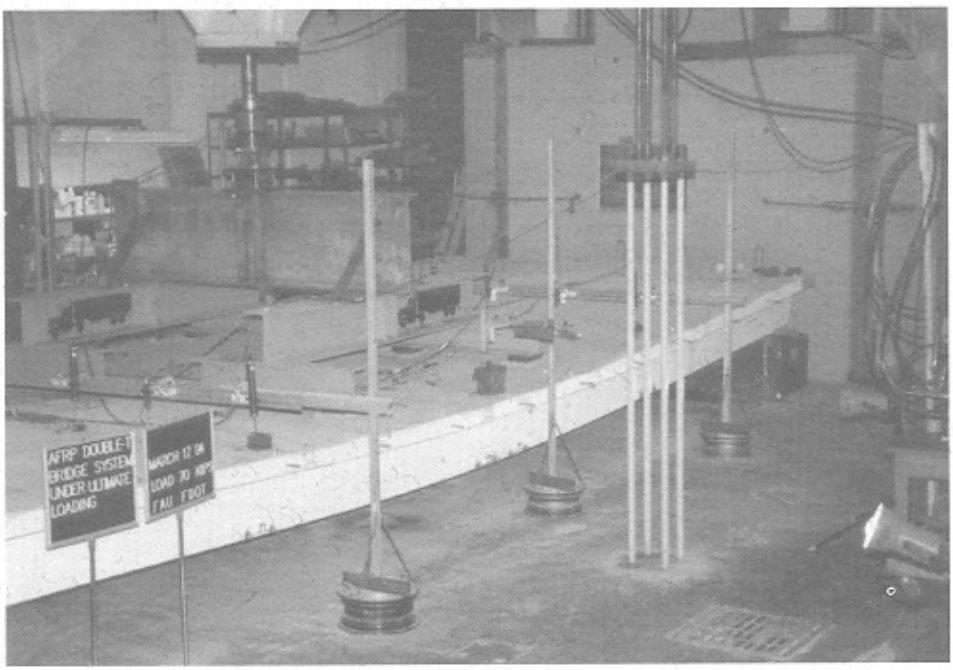

Fig. 2. Ultimate load test of AFRP bridge system

Prototype Fiberglass Vehicle Bridge

A prototype fiberglass (GFRP) vehicle bridge, 20 ft in length and 10 ft wide, is being tested in the Dolphin Structures Laboratory at the Royal Military College of Canada. The structure is a pony-truss bridge, built using standard pultruded GFRP structural sections. The outer trusses are fitted with optional prestressed cables in a queen-post arrangement below the trusses to increase stiffness. The bridge was designed by E.T. Techtonics and fabricated by Creative Pultrusions Incorporated. The structure is undergoing static and dynamic loading to determine its behaviour using three different types of decking. These three decks will consist of transversely post-tensioned laminated wood, GFRP grating, and lightweight fiber-reinforced concrete. It is hoped that this type of bridge may be suitable for particular bridging requirements, such as the need for lightweight bridges for military operations and temporary bridges for low volume roadways. The work is partly sponsored by the Military Engineering Research Group of the Department of National Defence, Canada.

For further information please contact Mr. G.E. Johansen, ET Techtonics, Tel/FAX: 800/854-0954 or Dr. Marie-Anne Erki, Fax: 613/545-3481 e-mail: erki-m@rmc.ca.

Field Testing of FRP at Japan's Southernmost Island

The Japanese Ministry of International Trade and Industry is currently conducting field testing to examine the durability and suitability of FRP for marine structures. The selected site is Okinotrishima Island, which is well-known for its severe weather conditions, including strong sunshine, high temperatures, heavy salt environments and many typhoons. The experiment is part of a five-year project started in 1993 on several new materials. A total of 333 specimens are currently exposed to this environment on the island. The specimens consist of concrete reinforced by CFRP, AFRP and GFRP. Durability is evaluated yearly by testing a selected number of samples. For further information please contact Mr. Akira Kurokawa, senior researcher, Technical Research Institute of Obayashi Co., FAX: +81-3-3580-2454.

ACM for Infrastructure... A Worldwide Multiclient Program

Battelle Memorial Institute of Columbus, Ohio, and Battelle-Europe of Geneva, Switzerland, plan to initiate a multiclient program this fall to assess technology advances and market potential for advanced materials and polymer matrix composites such as carbon fiber, glass fibers and hybrids for civil engineering infrastructure worldwide. The first phase of the program will focus on the defined technology and business needs of the participants, followed by field interviews and analysis of data to identify the most important opportunities in this emerging field. Phase I of the program will be conducted with the assistance of international consultants, one of whom is Professor Urs Meier of Swiss Federal Laboratories for Materials Testing and Research (EMPA), Switzerland.

The objective of this program is to provide the client group with an in-depth analysis of worldwide applied research and development activity, product categories and short- and long-term business potential for advanced polymer matrix composites used in civil engineering infrastructure. The specific cases will include:

- Highway bridge (or similar structure) repair and strengthening, using laminated unidirectional carbon fiber reinforced plastic (CFRP);
- Prefabricated components made of glass and carbon fibers in concrete;
- Glass fiber reinforced pultruded rebars;
- Unidirectionally-reinforced CFRP cables for use as tension elements in large structures such as suspension bridges;
- Off-shore platforms and other structural elements;
- Waterfront pylons;

For additional information, please contact: Dr. Golam Newaz, Battelle Memorial Institute, Columbus, Ohio, FAX: 614/424-7908.

Thesis

BASS, A.J., Behaviour of polymeric composite connections in pultruded frames, M.Sc. Thesis, Department of Engineering, University of Warwick, United Kingdom (April 1994).

Composite Structures

Longest Stress-ribbon Footbridge using FiBRA

The longest stress-ribbon footbridge using Aramid fiber composite cable, FiBRA, has recently been constructed by Tobishima Corporation (Fig. 3) at a golf course in Nagasaki Prefecture, Japan. This bridge is 73.0 m long with a clear span of 64.0 m, using six FiBRA cables in the bridge slab. Each cable consisted of six 14.7 mm diameter FiBRA strands and were post-tensioned before grouting.

For further information, please contact S. Sogabe or H. Okamoto, Civil Engineering Design Department, Tobishima Corp. 5472 Kimagase, Sekiyado, Higashi-Katsushikagun, Chiba, Japan 270-02, FAX: 0471/98-7585.

First Japanese AFRP Road Bridge

Iwafune-cho town, located 100 km north of Tokyo, is the site of the first newly constructed public road bridge, the Yamanaka Bashi bridge, prestressed entirely by braided AFRP tendons in Japan, as shown in Fig. 4. The progressive local government, famous for its support of advanced concrete pavement and technology, commissioned Oriental Construction Co., Ltd. to construct the bridge.

The bridge is a simply supported slab, 9.54 m long and 5.4 m wide, consisting of seven girders which were pretensioned by twelve FiBRA FA15 tendons in a manufacturing plant near the site and transported to the site. These were transversely post-tensioned in-situ with 18 FiBRA FA13 tendons. The corrosion-free AFRP increased the construction costs slightly, but it is expected to decrease the life-cycle costs of the structure.

For further information, please contact Mr. Masamichi Tezuka, Oriental Construction Co., Ltd., FAX: +81-285/83-0021

Composite Panels for Florida Orchard

An new isopolyester composite sea wall was constructed to protect a citrus orchard in Florida from damage and erosion. The successful installation was engineered by Gator Dock & Marine, Inc., Sanford, Florida.

Isopolyester resin is specified to give the composite panel exceptional corrosion resistance at a more reasonable cost than more expensive resins, such as vinyl ester. Manufacturers who supply pultrusion-grade isopolyesters formulate their resins with purified sophthalic acid from Amoco Chemical Company, Chicago.

Barry Hansen, chief engineer for Gator Dock & Marine, emphasized that the composite sea wall greatly exceeds other popular sea wall panels that have numerous problems caused by outward bulging. The new composite wall was installed 1.7 to 1.9 m out of the ground with 3.7 m long sheets.

For further information, please contact Barry Hansen, Chief Engineer, Gator Dock & Marine Inc., FAX: (407) 322-6574.

Fig. 3. Stress-ribbon footbridge in Nagasaki, Japan

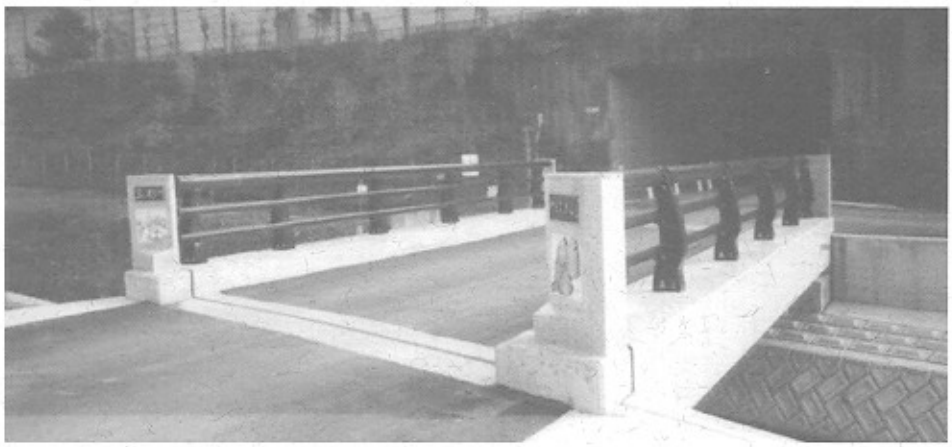

Fig. 4. The Yamanaka Bashi public road bridge, Japan

New Products

New FRP Tendon Anchorage System

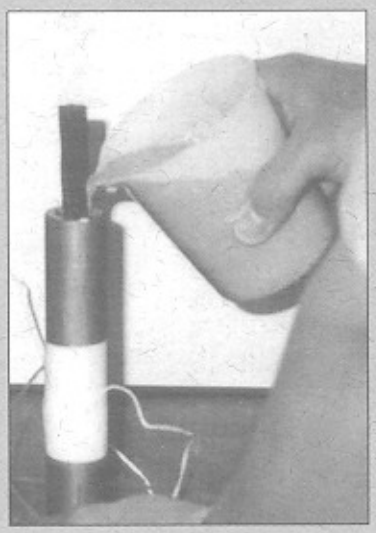

Fig. 5. Exgripper poured into an FRP anchorage system

A new anchorage system for FRP tendons was developed by the Kyushu Institute of Technology and the Nagasaki University and is being produced on a commercial basis by a group of 15 enterprises consisting of general contractors and FRP manufacturers in Japan. The anchorage system used a highly expansive material (Exgripper T.M.) which hardens and reaches more that 500 kgf/cm2 (49 MPa) within 48 hours. After placing the FRP tendon in a cylindrical steel or FRP sleeve, Exgripper is poured, as shown in Fig (5). The FRP tendon is gripped by the high internal expansive pressure of the hardened grout. The system has proven to be a highly durable prestressing system is for FRP tendons.

Exgripper can be applied to the anchorage for FRP ground anchor, internal and external cable anchors, and tensile tests of FRP rods.

For further information, please contact Dr. Tomio Tamura, Technical Research Insitute, Mitsui Construction Co., Ltd., 518-1 Komaki Nagareyama City Chiba Prefecture, Japan. FAX: +81-471/40-5216.
E-mail: 101125.2531@Compuserve.COM

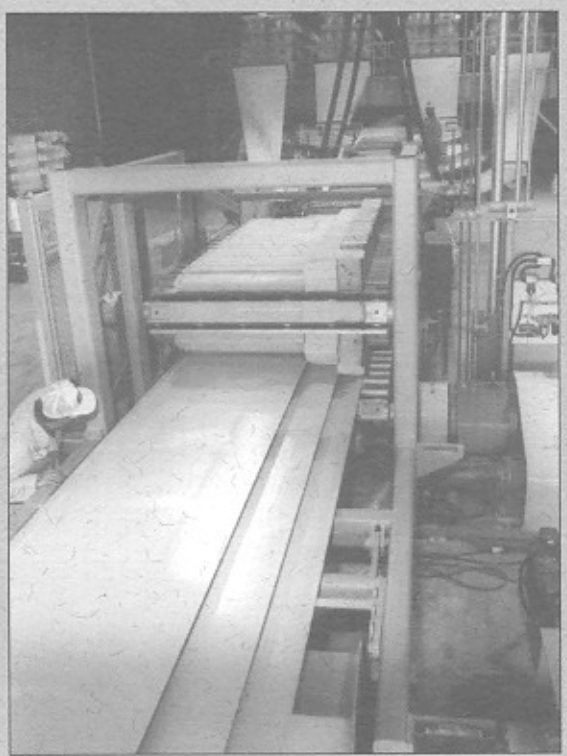

Fig. 6. MMFG's new PULSTAR Series 2000.

New Generation of Pultrusion Equipment

PTI, Pultrusion Technology Incorporated division of Morrison Molded Fiber Glass Company, (MMFG) recently introduced new pultrusion equipment - PULSTAR Series 2000. The new equipment (Fig. 6) provides continuous data display of the pulling force and is capable of producing a broad range of product envelope sizes.

For further information, please contact the Pultrusion Technology Inc. Division, MMFG, 1605 Enterprise Parkway, Twinsburg, OH, USA 44087 FAX: (216) 425-3963.

Fellowships

U.S.A. Fellowship Program

In 1994, the Federal Highway Adminstration (FHWA) continues a series of research projects which involve FRP materials in bridge superstructure applications conducted under FHWA's Eisenhower Graduate Research Fellowship Program in the U.S.A. Graduate students from participating universities conduct original research in FHWA's Structures Laboratory in McLean, VA. Current and recently completed research has focused on FRP composite cables; all-FRP bridge deck system components; reinforced concrete bridge deck system incorporating FRP bar, grating or grid; FRP prestress tendons; and externally applied FRP plates of fabric for retrofit to existing bridge elements.

- In 1994 additional research will begin on anchorage design and fatigue behaviour of FRP bridge cables in support of an effort to install cables on an arch in California. This project is a continuation of the development of the end connection for FRP cables used as hanger element on suspension and tied-arch bridges, by Dr. J. Plecnik, California State/ Long Beach.
- Dr. J. Plecnik of CSLB conducted a series of studies focused on developing and testing components of a modular, advanced composite bridge deck system for use as a replacement system. Experiments conducted through 1993 established the ultimate strength and stiffness of the deck and its components, preliminary fatigue performance criteria and fatigue performance of deck-to-girder connections, and also developed a prototype system for connecting deck panels to each other. The final and current study in this series, conducted by Mr. Ernesto Villalba, involves durability of the fiberglass, resistance to wear of the deck surface under adverse climates, and impact loading, including field testing.
- Three universities are participating with FHWA in projects related to FRP R/C bridge deck system components:

  1. Dr. Larry Bank has recently completed slab performance and durability studies examining FRP pultruded grating-type reinforcement of concrete deck elements in simulated porewater and service environments.

  2. Dr. Charles Goodspeed of the University of New Hampshire completed related slab performance and FRP durability studies involving FRP laminated grids.

  3. Dr. Pedro Albrecht of the University of Maryland/College Park investigated the flexural strength, cracking behaviour, punching shear strength and fatigue performance of fiberglass FRP bars in deck slab elements.

- Two ongoing projects examine FRP prestress tendon behaviour:

  1. Dr. Mohammed Ehsani of the University of Arizona is examining the transfer and flexural bond behaviour and handling characteristics of two carbon-type and three aramid-type FRP tendon-anchorage systems.

  2. Dr. Hamid Sadaatmanesh of the University of Arizona is investigating environmental effects on the durability of two carbon-type and one aramid type of FRP prestress tendon material.

- In the last focus area, the use of externally bonded FRP material for strengthening of existing bridge beam components, Dr. Sadaatmanesh is investigating the external application of FRP plates, fabric and prepreg tow sheets to enhance capacity or repair cracking in beams.

For further information concerning these projects, please contact Mr. Eric Munley, FHWA Turner-Fairbank Research Centre, McLean, VA, FAX: (703) 285-2766. For further information concerning the Eisenhower Graduate Research Fellowship Program, Contact Ms. Ilene Payne, Tel: (703) 285-2781.

Awards

JSCE Award

Dr. H. Mutsuyoshi, Mr. H. Taniguchi, Mr. T. Kita, and Dr. A. Machida have been awarded the Japan Society of Civil Engineers Yoshida Prize, which is the highest prize in concrete engineering in JSCE, for the paper entitled "Improvement in Ductility of PC members Reinforced with FRP." The paper is published in the *Proceedings of JSCE*, 1993-02, No. 460, V-18.

JPCI Awards

Mr. S. Tokumitsu, Mr. K. Hino, Dr. K. Maruyama, and Dr. H. Mutsuyoshi have been awarded the Japan Prestressed Concrete Institute prize for the paper entitled "Development of Externally PC Using Non-Corrosive Materials," published in the *Journal of Prestressed Concrete*, Japan, Vol. 35, No. 5 Sept.-Oct. 1993.

Conferences

- **4th International Conference on Short & Medium Span Bridges (SMSB IV),**
  Halifax, N.S. Canada, 8-11 August 1994. Contact: Dr. A. Mufti, Conference Chair FAX: 902/ 422-8380.
- **International Conference on Design and Manufacturing Using Composites (ATMAM 94)**
  Montréal, Qué., Canada, 10-12 August 1994. Contact: Sophie Mérineau, Conf. Secretary, Fax: (514) 848-3178
- **International Conference on Composites Engineering (ICCE/1),**
  New Orleans, LA, 28-31 August 1994. Contact: Dr. David Hui, Chair, FAX: 504/ 286-6652, e-mail: dxhme@uno.edu
- **ASCE 1994 "Materials Engineering Conference, Infrastructure: New Materials and Methods for Repair",**
  San Diego, CA, 13-16 November 1994. Contact: Kim Basham, Conference Chair FAX: 303/698-1053
- **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.
- **Second International Symposium on Non-Metallic (FRP) Reinforcement for Concrete Structures,**
  Universiteit Ghent, Belgium, 23-25 August 1995. Deadlines: 600 word abstracts -1 Oct. 1994. Contact: Dr. Luc Taerwe, Universiteit Ghent, Dept of Structural Eng'g. Technologiepark-Zwijnaarde 9, B-9052 Gent, Belgium, FAX: +32/9/264-5845, e-mail: beton@mecairis.rug.ac.be.
- **IABSE - Extending the Lifespan of Structures,**
  San Francisco, CA, USA, 23-25 August 1995. Deadline: abstracts (500 words- 4 copies) 30 June 1994. Contact: IABSE Secretariat, ETH-Hönggerberg, CH-8093 Zurich, Switzerland, FAX: +41-1-371-2131.
- **2nd International Conference on the Use of Advanced Composite Materials for Bridges and Structures,**
  Winnipeg, Manitoba, Canada, 11-14 August 1996. Deadlines: t.b.a. Contact: Dr. S. Rizkalla, Faculty of Engineering, University of Manitoba, Winnipeg, MB R3T 5V6 FAX: 204/275-3773.
- **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.

Editor

Dr. S.H. Rizkalla
Associate Dean and Professor,
Department of Civil Engineering
Faculty of Engineering
Winnipeg, Manitoba
Canada R3T 5V6
Tel. (204) 474-9809
Fax (204) 275-3773
Email:
RIZKALLA@bldgeng.lan1.umanitoba.ca

Associate Editors

Dr. A. Nanni (ACI)
Department of Architectural Engineering
Pennsylvania State University
104 Engineering "A" Building
University Park, Pennsylvania 16802
Tel. (814) 863-2084
Fax (814) 863-4789
Email: AXNZ@psuvm.bitnet

Dr. L. Bank (ASCE)
The Catholic University of America
Department of Civil Engineering
Washington, D.C. 20064
Tel. (202) 319-5163
Fax (202) 319-4499
Email: bank@cua.edu

Dr. M.A. Erki (CSCE)
(CSCE - ACMBS Network of Canada)
Royal Military College of Canada
Department of Civil Engineering
Kingston, Ontario
Canada K7K 5L0
Tel. (613) 541-5010*6602
Fax (613) 545-3481
Email: erki-m@rmc.ca

Dr. H. Mutsuyoshi (JCI)
Department of Civil Engineering
Saitama University
255 Shimo - Okubo
Urawa 338, Japan
Tel. (81) 48-852-2111
Fax (81) 48-855-9361
Email: mutuyosi @ sys.cent.
saitama-u.ac.jp

Faculty of Engineering
Room 350 Engineering Bldg.
University of Manitoba
Winnipeg, Manitoba
R3T 5V6

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To:_____