FRP
Fiber Reinforced Plastics
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Guest Author – Mr. Minoru Sugita

Mr. Sugita is regarded as one of the prominent leaders promoting research and development of FRP reinforcement in Japan. He was one of the pioneers in charge of the development of NEFMAC, a grid shaped FRP reinforcement. He is also one of the founders of "NEFCOM Corporation," the NEFMAC dealer, and served as NEFCOM's fourth president until June 1994. Largely due his extensive activity in the promotion of NEFMAC, over 1.5 million m² of this material have been used in the construction industry.

Guest Author:
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Mr. Sugita was instrumental in the initiation of the Association of Composite Materials Using Continuous Fiber for Concrete Reinforcement (CCC) in Japan in 1988, and served as the first chairman of the CCC. The Association currently consists of 27 private companies producing and using FRP reinforcement products in Japan; their goal is to promote the use of FRP reinforcements in practical applications. The CCC plays a major role in entrusting research to institutions, participating in construction projects, and collecting and exchanging information between industry and research institutions.

Mr. Sugita initiated the technical collaboration with Autocon Equipment Inc. Canada NEFMAC, which is producing NEFMAC in Canada. This cooperation is the result of technology transfer generated by the established Japan-Canada Technological exchange. He is also a member of the ACI Committee 440 for FRP Reinforcement.

As of July 1994, Mr. Sugita is the general manager of Ohsaki Research Institute, Inc. (Tokyo, Japan), a division of the Shimizu Corporation. Currently, Mr. Sugita concentrates his efforts on the development of Intelligent Structural Materials and their application in civil engineering structures. The research group is working on utilizing the electric resistance characteristics of the NEFMAC (Glass and Carbon Fibre) to measure and memorize the strain induced due to loads, including earthquake loads.

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Composite Structures

New Bridge Deck Uses Recycled Wood and ACM

A single-lane prototype pre-stressed log bridge with three continuous spans of 5 m each was constructed by the Ministry of Transportation of Ontario, Canada. The bridge was pre-stressed transversely with aramid fibre ropes (PARAFIL). Special anchors for the cables were designed for this application.

The pre-stressed log bridge recycles discarded utility timber poles, or logs, which are difficult to discard because of previous treatment with chemicals. To minimize wastage, the logs are trimmed on two parallel faces, stacked together against their trimmed faces, and pre-stressed transversely through the cables as shown in Fig. 1. The pre-stressed log bridges make efficient use of a waste product and use the densest and strongest portion of the tree trunk, which is usually discarded in making lumber pieces.

The pre-stressing scheme of the Ontario prototype was different from that required by the Ontario bridge code; the deck was first stressed to the full pre-determined force and then almost immediately released to about 70% of the maximum force. The bridge was proof tested on August 17, 1994, as shown in Fig. 2, in the presence of a large invited audience. Observations taken over about two months have shown that, unlike conventional stress laminated wood decks, the prototype bridge has experienced virtually no prestress loss.

For further information, please contact Baidar Bakht, Ontario Ministry of Transportation, R&D Branch, Tel: 416/235-4674, FAX: 416/235-4872.

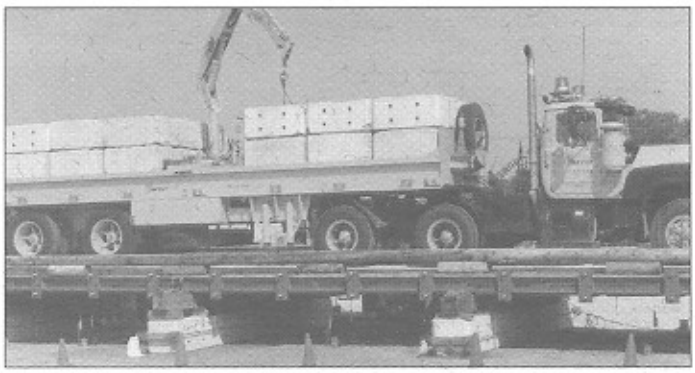

Fig. 2. Proof test of the prestressed log bridge

Composite Heliports

Advances in composite technology are making it possible to build heliports in locations that are inaccessible for traditional steel and concrete construction.

This capability has been repeatedly demonstrated by Asahi Glass Matex Co. Ltd. (AGM), Tokyo. AGM has designed and built 20 composite heliports throughout Japan in remote locations. The performance and design of the AGM heliport has earned the company an award from the Japanese Ministry of International Trade and Industry.

The isopolyester composite pultruded structural parts called "Plalloy" can be transported by helicopter and installed on flexible foundations. Two examples are the recently-constructed heliports on Miyakojima Island in Okinawa and on Matsuame Oshima Island in northern Japan.

These heliports withstand the shock of take-off and landing from helicopters weighing more than 10 tons (22,000 lbs.). The structures can endure typhoon winds, extreme temperatures, and other severe weather often

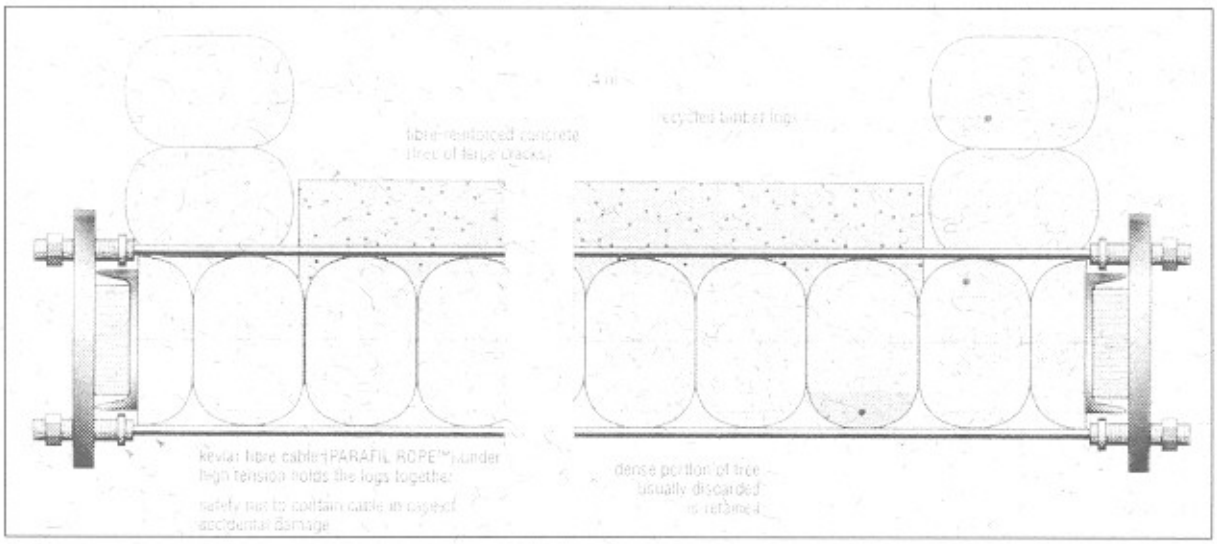

Fig. 1. Prestressed log bridge

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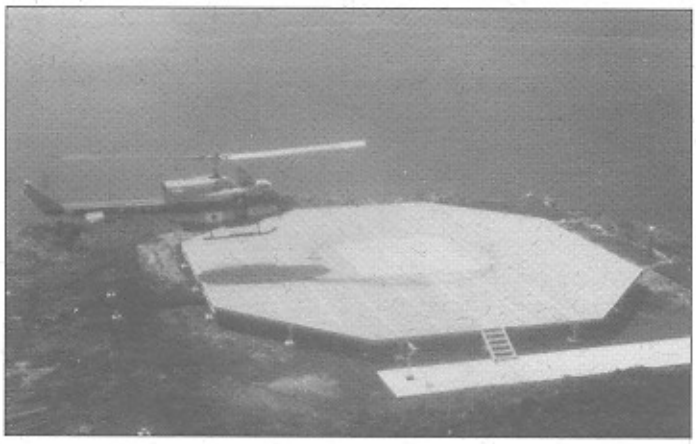

Fig. 3. Composite heliport

experienced in the South Pacific and northern Japan, as shown in Fig. 3.

Heliports now in service incorporate parts ranging in size from an 8-mm diameter rod to a 250 mm square pipe with a 12 mm wall thickness. Using pre-assembled units, the company can build a 20 meter square heliport on-site in ten days without heavy construction equipment. The landing pad can be levelled on rocky or uneven ground with adjustable jacks.

For further information, please contact Mr. Toshiyuki Abe, Chief Engineer, Asahi Glass Matex Co., Ltd., 1-2-27 Miyashimo, Sagamihara, Kanagawa, Japan, FAX: (+81)427/4-7357.

AWTTB Nears Completion

The world's largest demonstration project for waterfront application of structural composites is nearing completion at the U.S. Navy's Naval Facilities Engineering Services Center in Port Hueneme, California, shown in Fig. 4. When completed, the Advanced Waterfront Technology Test Bed (AWTTB) will be a 20-foot wide by 160 foot-long demonstration pier using CFRP tendons for prestressed/pretensioned concrete pilings, vinyl ester/glass tendon reinforced pile caps, CFRP tendons for prestressed/pre-tensioned concrete deck sections and a heavy-duty all-composite deck.

The load requirements for this structure will be the U.S. Navy's largest mobile crane; 221,000 lbs. distributed over a 2.5 ft. by 2.5 ft. area and with a 1.7:1 safety factor and L/D deflection of 1/300.

The all composite deck section is being fabricated from pultruded glass-fiber reinforced vinyl ester and isophthalic polyester box beam sections, reinforced laterally by filament-wound epoxy tubular "pins" which transfer shear loads between sections. Vinyl ester/glass and isophthalic polyester/glass pultruded deck plates complete the installation, acting to transfer loads across the structure.

The AWTTB will also feature ancillary composite applications for waterfront use including guardrails, ladders, catwalks, grating, piping, pipe hangers, under pier utilities, panelling signs, electrical conduit & enclosures, lighting and utility poles.

This project is a joint effort of the U.S. Army Corps of Engineers Construction Engineering Research Laboratories (USACERL) of Champaign, Illinois and South Dakota School of Mines and Technology in Rapid City, South Dakota as well as the U.S. Navy's Naval Facilities Engineering services Center (NFESC) and the Marine/Waterfront Task Group (MWTG) of the SPI/Composites Institute of New York, NY.

All composite-reinforced piles, pile caps and decking have already been fabricated and installed at the job

Fig. 4. Waterfront demonstration projects in California

site in Port Hueneme. The all-composite deck section has been pultruded. Pre-fabrication and fitting assembly started in September 1994 at Composite Technology, Inc. in Fort Worth, Texas, with final assembly and installation on the AWTTB in September 1994.

The AWTTB will be dedicated to the memory of Chuck Weir, one of the composite industry's pioneers in the use of composites in waterfront applications and a retired Navy Seabee. For further information, please contact John D. Busel at the Composites Institute, Tel. 212/351-5413 or FAX 212/370-1731.

Workshops

NSF Coordinated Program for Research on Advanced Composites in Construction (RACC)

In the summer of 1993, The National Science Foundation (NSF) through Dr. John B. Scalzi initiated the idea for the development of a "coordinated" research plan to assist NSF in prioritizing and directing research activity in the area of composite materials for construction.

The goal of the Coordinated Program for Research on Advanced Composites in Construction (RACC) was to outline a strategic research plan that can provide the basic understanding and the engineering background for the use of advanced composites in construction, and can facilitate their introduction in the market place in a safe, efficient and timely fashion.

A Planning Committee consisting of 46 members in total was formed. Three groups of experts were identified: those with expertise in composite materials but no prior involvement with the construction industry, those with an expertise in the construction industry and no prior involvement with composite materials, and those with expertise and prior involvement in both composite materials and the construction industry. A balance of individuals from academia, government and industry was sought. In the advanced composite materials area, the plan was subdivided into five "topic areas", as follows: 1. Reinforced Concrete; 2. Prestressed Concrete and Cables; 3. Structural Shapes; 4. Structural Systems; 5. Repair and Rehabilitation Systems.

In the construction industry area, the plan was subdivided into five "focus areas," as follows: 1. Materials and Manufacturing; 2. Characterization and Testing; 3. Analysis and Design, including development of both analytical codes and procedures; 4. Construction Processes, including human factors in construction, construction simulation and constructiuon automation; 5. Economics and Marketing.

The Committee convened at NSF headquarters on July 7-9, 1994 for a workshop meeting to finalize the project. The purpose of the workshop meeting was: a) to review the state of current research and practice; b) to discuss objectives, philosophy, directions and priorities for the coordinated program; c) to plan the individual research activities for each of the selected topical areas; and d) to draft the final plan for program administration and exchange procedures.

The workshop consisted of eight sessions. Seven of the sessions were held on July 7 and 8, 1994 and were attended by the full Planning Committee.

Table 1 summarizes the recommended budgets for the five topic areas of the program. Even though a comprehensive approach was taken for the plan, each application area is treated independently from the others for ease of implementation.

For more information please contact: Dr. John B. Scalzi, Program Director, National Science Foundation (Tel: 703/306-1361; FAX: 703/306-0291; E-MAIL: JSCALZI@NSF.GOV)

Table 1: Budget Summary, RACC

TOPIC (APPLICATION) AREA	Budget ($M) Years 1-3	Years 4-5
Reinforced Concrete	5.5	5.0
Prestressed Concrete and Cables	3.8	2.7
Structural Shapes	6.4	4.2
Structural Systems	11.4	2.1
Repair and Rehabilitation Systems	11.9	11.4
TOTAL	39.0	25.4

FRP'S Discussed at Pueto Rico Workshop

A conference and workshop on the Repair and Rehabilitation of the Infrastructure of the Americas were held recently in Puerto Rico, in order to assess the state of practice in different American countries and to discuss research priorities in the repair and rehabilitation of their deteriorating infrastructure. The conference and workshop were organized by the CoHemis Center of the University of Puerto Rico, and took place at the Mayagüez campus on 29-31 August 1994, under the chairmanship of Dr. Houssam Toutanji.

Discussions were held on: methodologies for evaluation of deteriorating structures; methods for dealing with repair and rehabilitation; identification of economical repair methods; development of new tools and materials.

The various topics presented were: *Repair of Reinforced Concrete Columns with Advanced Composite Materials Confinement; Fiber Composite Wrap for Rehabilitation of Concrete Structures; Rehabilitation of the Infrastructure with Advanced Composite Materials; Seismic Retrofitting of Concrete*

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Columns with Composite Materials; and Rehabilitation of Concrete Structure Using Polyaramid Tendons.

Other topics included many papers on seismic behaviour of existing structures, lessons from past earthquakes, developments in concrete materials (including fibre-reinforced concrete, and innovative non-destructive methods for the evaluation of road infrastructures, such as imaging technologies and neural networks. Copies of the proceeding of the Conference are available from Dr. Houssam A. Toutanji, University of Puerto Rico at Mayagüez, P.O. Box 5000, Mayagüez, PR 00681-5000, at a cost of US $35.

Thesis

SPEISSER, Evelyne. 1994. "Physical and Mechanical Properties of FRP Rebars for Concrete Structures" (in French), M.Sc. Thesis, Université de Sherbrooke, Sherbrooke, Québec, Canada.

NADIPELLI, Murali. 1994. "Experimental investigations of Local Buckling and Failure of Pultruded Fiber Reinforced Plastic Beams." M.Sc. (C.E.) Thesis, Catholic University of America, Washington, D.C. USA.

New Products

● Ultra-light Ground Anchor Using Aramid FRP

The Research Institute of the Japan Highway Public Corporation and Sumitomo Construction Co., Ltd. have developed a new, highly durable ultra-light ground anchor using Aramid FRP Technora rods and light-weight pressure plates using glass FRP. Compared to conventional anchors using PC steel, the weight of the anchor tendons has been reduced to one-sixth, while the pressure plates are only one-twentieth of the weight of the conventional type using concrete blocks.

The practical applicability of the ultra-light ground anchors was confirmed by their use in slope retaining work during the reconstruction of an expressway in Takatsui City, Osaka, carried out by the Japan Highway Public Corp. The anchors were designed to give a stabilizing force of 400 kN and the anchor length of 20-30 m. A total of 36 anchors was installed, as shown in Fig. 5.

The ultra-light ground anchors using Aramid FRP are corrosion free, light weight, and easy to install. For further information, please contact Mr. J. Mizutani, Civil Eng. Division, Sumitomo Construction Co. Ltd., FAX (+81)3/3353-6656.

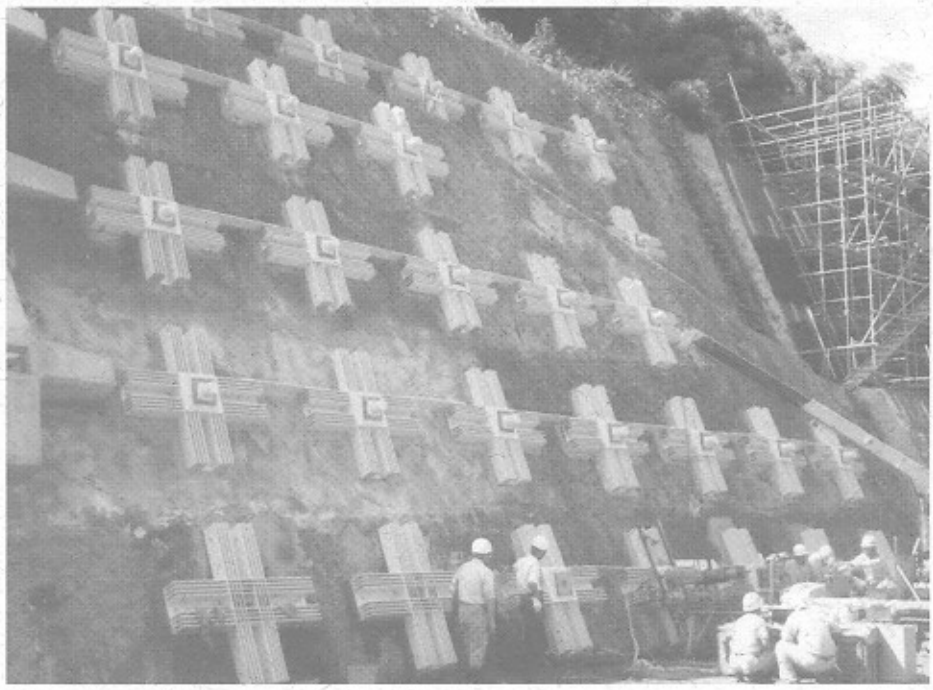

Fig. 5. Ultra-light ground anchor using Aramid FRP

Conferences

FRP Specialty Sessions at the 4th SMSB

Two FRP specialty sessions were held at the Fourth International Conference on Short and Medium Span Bridges. A Plenary Session title "ACM in Structures", a parallel session titled "Fibre- Reinforced Structures", were held.

The papers in the Plenary Session were: *Use of Advanced Composite Materials in Bridges and Structures in Japan; The World's First Advanced Composite Road Bridge; First Smart Bridge in Canada; Statics and Dynamics of an FRP Vehicle Bridge; Static and Fatigue Tests of Carbon Fiber Composite Tendons in Prestressed Concrete Planks;* and *Strengthening of Concrete Columns with Unidirectional Composite Sheets.*

Paper titles in the parallel session were: *Strengthening of Existing Concrete Bridge Girders for Shear Deficiencies Using Externally Bonded Carbon Fibre-Reinforced Plastic Sheets; Flexural Strengthening of Reinforced Concrete Beams with Composite Plates; Mechanical Behaviour and Design Concept of Prestressed Composite Girder with FRP Tendons; Wood and Wood Composite Design Using High-Strength Fiber-Reinforced Plastic (FirP™Panel) with Special Emphasis on Glued Laminated Beam Bridges; Properties of Fatigue and the Application of Slab Thickness Increasing Method Using Steel Fiber Reinforced Concrete; Development of Composite Slab Bridges with Rigid Urethane Used as Light Filler; Column Retrofit of Short and Medium Span Bridges & Structures Using High Strength Fiber Composites; and Strength/Stiffness Characteristics of a Prestressed Kevlar Cable/FRP Trussed Structural System.*

The proceedings of the Conference can be ordered from The Canadian Society for Civil Engineering, 700-2050 Mansfield, Montreal, Quebec, Canada H3A 1Z2 Tel 514/842-5653, FAX 514/842-8123. Cost is $90 Cdn funds (includes taxes and surface mail in Canada), USA add $10 Cdn and overseas add $20.

SPI-CI 50th Annual Conference and EXPO '95

The SPI Composites Institute will hold its 50th Annual Conference and Expo '95 in the Cincinnati, Ohio, Convention Centre, January 30 to February 1, 1995. The Conference theme, "Composites Rebuild America," reflects the coverage that will be given to civil engineering/infrastructure applications. Conference activities will include the presentation of over 80 technical and marketing papers, seminars, exhibits, and a display of award winning composite products.

ACI will sponsor sessions on composite reinforced concrete. ASCE will feature a discussion on the development of standards for specifying composite materials, and the U.S. National institute of Standards and technology (NIST) will report on the status of its Advanced Technology competition as it relates to composite proposals.

For further information, please contact the Composites Institute, 355 Lexington Ave. New York, NY 10017. Tel: 212/351-5410. FAX: 212/370-1731.

ICCI '96

The First International Conference on Composites in Infrastructure (ICCI '96) will be held in Tucson, Arizona from January 15-17, 1996. The conference, organized by the National Science Foundation and the University of Arizona, will provide a forum for construction industry representatives, researchers, regulatory agencies, and composite manufacturers to exchange information on the latest advances in the use of composite materials in civil engineering construction. An exhibit program will be organized to complement the information sessions.

The conference is soliciting quality papers on the following topics: Basic characterization of composite materials; Aspects of composite materials in the rehabilitation of the infrastructure; Environmental considerations in the use of composites; Utilization of composites in marine front and offshore systems; Life cycle costs and reliability of composites; Design specification standards; Construction practice; Manufacturing processes; Case studies and field applications; Fire resistance; Non-destructive evaluation; Service life and durability.

Authors wishing to contribute papers should submit an abstract of no more than 250 words by February 1, 1995 to: Prof. M. Ehsani, Engineering Professional Development, University of Arizona, Box 9, Harvill Building, Room 235, Tucson AZ 85721 Tel: 602/ 621-3054, Fax: 602/ 621-1443; E-mail: baltes@bigdog.engr.arizona.edu.

Research

Full-scale Testing of Externally-reinforced FRC Bridge Deck

Steel-concrete composite bridges are an economical solution for short and medium span highway bridges, but maintenance of such systems is proving costly, given North America's harsh winter environment, the prevalent use of de-icing chemicals and the advanced age of the bridge infrastructure. The maintenance concerns stem largely from corrosion of the steel reinforcing bars in conventionally reinforced concrete decks. Researchers at the Technical University of Nova Scotia have devised a unique reinforcement scheme that eliminates the steel reinforcement in the deck, thereby circumventing the main source of maintenance problems.

On the last afternoon of the Fourth International Short and Medium Span Bridge Conference, fifty delegates attended the testing of a full-scale externally-reinforced FRC bridge deck on steel girders (Fig. 6). The steel-# concrete composite bridge consisted of two W610 X 241 (Imperial W24 X 162) girders spaced at 2 m (6.56 ft) and spanning 12.5 m (41 ft). The 175 mm (7 in) deck was composed of FRC using 38 mm (1.5 in) fibrillated polypropylene fibres, 0.34% by weight of concrete, for crack control, and 30 MPa (4.4 ksi) concrete. The external reinforcement consisted of steel straps welded to the underside of the steel girder top flange. The load was applied through a 250 x 500 mm (10 x 20 in) loading pad, to simulate the wheel loading of a double tire vehicle. Theoretical analysis indicated a punching shear failure at 840 kN (189 kips). The experimental failure was punching shear at 940 kN (211 kips).

For further information please contact Dr. Aftab Mufti, NS CAD/CAM Centre, Box 1000, TUNS, Halifax, NS, CANADA B3J 2X4. Tel: 902/420-7763, FAX: 902/422-8380 Email: mufti@tuns.ca

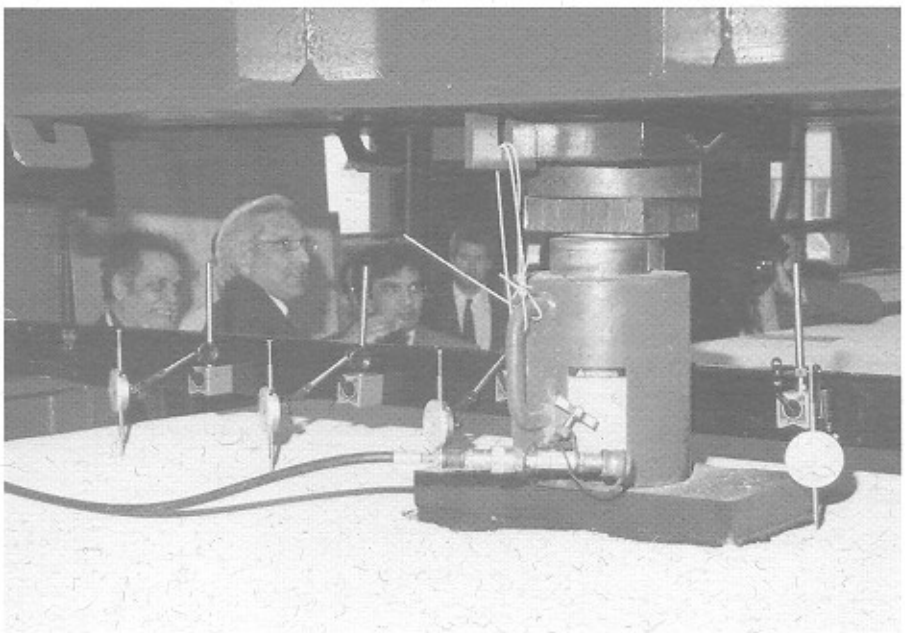

Fig. 6. Full-scale testing of an FRC Deck

New Publications

"Characteristics of Glass Fiber-reinforced Composite Materials for Use in Roadside Safety Barriers"

Glass fiber reinforced composite materials are currently under investigation by the Federal Highway Adminstration, U.S. Department of Transportation (FHWA) for road-side safety structure applications. Roadside safety structures include barriers, sign supports, and crash cushions. These structures, in addition to their specific transportation functions, must also be crashworthy to vehicles and vehicle occupants. Impact testing was performed in a previous study (report FHWA-RD-93-090) for glass fiber-reinforced composites. This study focuses on gaining an increased understanding of the mechanical properties of these materials.

To order a copy of the report, please contact the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161, USA. Quote Publication No. FHWA-RD-94-048, July 1994.

Conferences

- **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.

- **The SPI Composites Institute 50th Annual Conference and Expo '95**

  Cincinnati, Ohio, **30 January to 1 February 1995**. Contact the Composites Institute, 355 Lexington Ave. New York, NY 10017. Tel: (212) 351-5410. FAX: (212) 370-1731.

- **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**. Contact: IABSE Secretariat, ETH-Hönggerberg, CH-8093 Zurich, Switzerland, FAX: (+41)1/371-2131.

- **The First International Conference on Composites in Infrastructure (ICCI '96)**

  Tucson, Arizona, USA. **15-17 January 1996**. Abstracts; 250 words by 1 February 1995 to: Prof. M. Ehsani, University of Arizona, Fax: 602/621-1443; E-mail: baltes@bigdog.engr.arizona.edu.

- **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: 204/261-5465.

- **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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