FRP
Fiber Reinforced Polymers
International
Spring 1997 Volume V, Issue 2

Notable Research Activity

EMPA

EMPA, the Swiss Federal Laboratories for Materials Testing and Research, was founded in 1880 under the leadership of Prof. L. von Tetmajer and was originally situated in the basement of the Swiss Institute of Technology, now ETH, in Zurich. EMPA is an independent institution which reports to the Board of the Swiss Federal Institute of Technology. There are EMPA laboratories in Dübendorf, St. Gallen and Thun, with a total of 750 employees.

EMPA is managed by a four-person Board consisting of the EMPA President, Prof. F. Eggimann; Director of the laboratory in Dübendorf, Prof. U. Meier; Director of the laboratory in St. Gallen, Dr. X. Edelmann; and Head of the Department of Logistics/Controlling/Marketing.

EMPA is a national centre for research and testing in the fields of materials, environmental technology, safety and quality of systems, structures, building constructions, installations, processes and products. EMPA creates benefits for society and the economy.

Research activity in the field of fiber reinforced polymer (FRP) is mainly carried out at the Dübendorf facility which houses 450 scientists, engineers and laboratory technicians, and which operates with an annual budget of approximately 50 million US dollars.

Current FRP research and development activities at EMPA Dübendorf include:

- Production and testing of carbon fibre cables for cable-stayed bridges.
- Long time static and fatigue loading of GFRP box girders.
- Fatigue loading of continuous girders post-tensioned with CFRP strands.
- External bonding of reinforcement for post-strengthening.
- CFRP reinforced centrifugally cast high strength concrete poles.
- Fire resistance of girders strengthened by CFRP laminates.
- Patching of metallic components with CFRP.
- Buckling of GFRP and aluminum/CFRP cylindrical shells.
- Optimization of the load transfer area of pin-loaded strap elements.
- A new class of hybrid elements of GFRP reinforced plastic box beams combined with a layer of concrete and CFRP as tension reinforcement.

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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 • ISIS Canada •

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In July 1997, EMPA hosted the first US-Canada-Europe Workshop on Bridge Engineering in Dübendorf, Switzerland. The workshop consisted of a visit to EMPA, a field trip to the Strochenbrucke cable-stayed bridge and field trips to several other bridges and structures which have been strengthened with CFRP strips. The workshop concluded with two days of technical presentations and discussion.

For further information, please contact Prof. Urs Meier by fax at +41-1-821-6244 or visit EMPA's website at http://www.empa.ch.

Application

Rehabilitation of Parking Garage in Canada

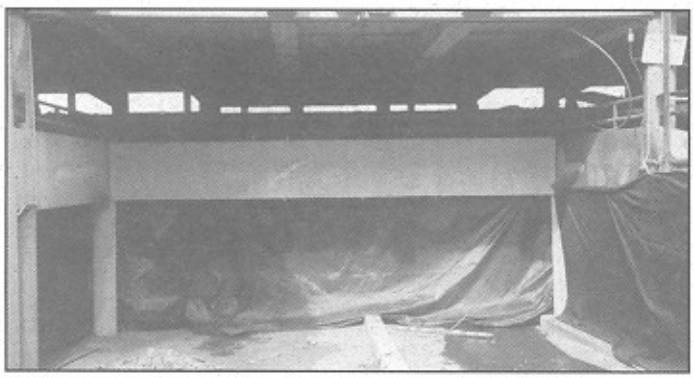

Figure 1. Repair of Parking Garage in Canada.

Composite materials were used to rehabilitate the Webster Parkade which was erected in 1959, Sherbrooke, Quebec, Canada. The repair was essential for continued use of the structure. Rehabilitation included flexural shear of reinforced concrete beams which did not conform to current codes, as well as columns which had been severely damaged by corrosion of the steel reinforcements due to deicing salts during the winter months (Figure 1). The composites used were supplied by three different companies, thus allowing for comparative measurements (qualitative and quantitative) between materials and manufacturers. The suppliers were Tonen Corporation, Mitsubishi Chemical Corporation and Hexcel Fyfe Co. An integrated structural sensing system was installed to monitor the behavior of the parkade under loading variations. Infrared rays were used to determine the success of the bonding between the advanced composite materials and the concrete surfaces. The success of this rehabilitation project was acknowledged with an award given by the Québec Ministry of Municipal Affairs.

For further information, please contact Dr. Kenneth Neale by fax at 819-821-7974.

Repair of Highway Bridge

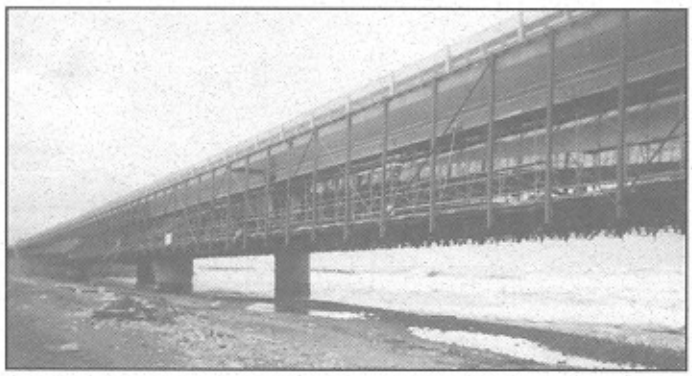

Figure 2. Repair of Highway Bridge.

The Tedorigawa Bridge on Hokuriku Highway in Japan was constructed in 1972 (Figure 2). The bridge, located on the seashore, had been severely damaged due to the ocean environment. Repair areas included the outer surface of the web and the lower surface of the box girder. A water jet was used to remove the top 5 cm of concrete to attach carbon NEFMAC with a 50 mm grid anchored by bolts and covered with a polymer mortar. The total amount of NEFMAC used for this project was approximately 8,000 m^2.

For further information, please contact Mr. Kenichi Sekine, Manager of NEFCOM Corporation, by fax at 81-3-3254-9210 (Japan).

FRP for Renovation of Shopping Centre

Figure 3. Strengthening of City Shopping Centre, Winterthur, Switzerland.

Carbon fiber reinforced polymer (CFRP) strips measuring 3000 m long and 100 mm wide were used for the renovation of the multi-storey reinforced concrete structure of the Co-op City Shopping Centre of Winterthur, Switzerland. The CFRP strips were used to strengthen a 5 m by 3 m opening that had been cut from a 350 mm slab required for elevators and a 14 m by 4 m opening for the escalators, as shown in Figure 3. The CFRP strips were installed in two directions to convert the 32 m by 17 m attic area to a new shopping space as shown in Figure 4. The shopping centre remained open to the public during renovation. The lightweight and flexibility of the CFRP strips allowed installation in the most congested

Figure 4. Strengthening of Two-way Slab.

spaces. The thin and flexible strips allowed for fitting in narrow gaps between the slab and the service conduits without requiring the removal of cables, pipes or ducts.

For further information, please contact Mr. Werner Steiner, Sika, by fax at +41-1-436-4655.

Strengthening of 70 Year-Old R.C. Frame Bridge

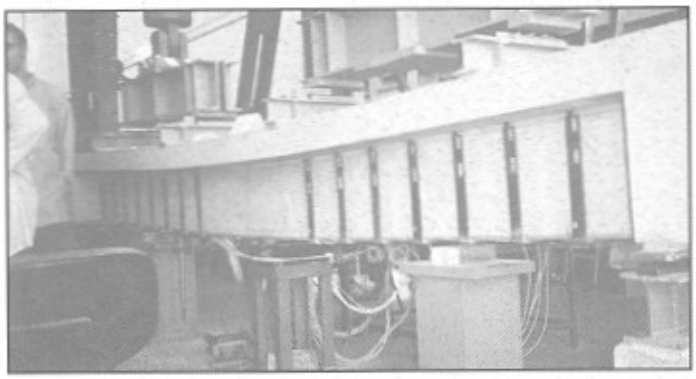

Figure 5. Strengthening Concrete Beam for Bending and Shear.

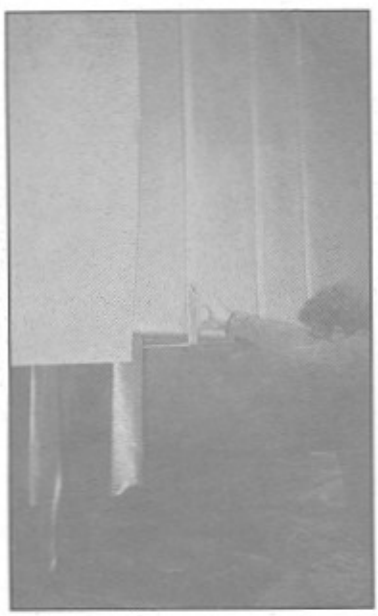

Figure 6. Rehabilitation of Frame Bridge in Germany.

Three, severely deteriorated 70 year-old reinforced concrete frame bridges near Dreselou, Germany, suffered from concrete deterioration and reinforcement corrosion due to chloride attack and a lack of maintenance. In 1993, traffic had to be restricted to vehicles of two tons or less. The plan to use the bridges for 16 ton vehicles required strengthening of the load-carrying capacity up to 98 percent. To strengthen the bridge girders, carbon fiber reinforced polymer (CFRP) plates were selected due to their corrosion resistance and long-term durability.

To obtain approval of the proposed repair method, a series of tests were conducted using scaled beams at the Technical University Brauwschweig, Germany. A single span concrete T-beam, representing the positive moment region of the bridge girder, was strengthened in bending and shear in the same way as proposed for the bridges, see Figure 5. In the fatigue test, the beam survived two million cycles without damage. An increase in load-carrying capacity of 110 percent was attained using CFRP strips. Based on these guidelines, the strengthening work was carried out using Sika CFRP plates as shown in Figure 6.

For further information, please contact Mr. Uwe Neubauer by fax at +49-531-391-4573.

Retrofit of Parking Structures in Salt Lake City, Utah

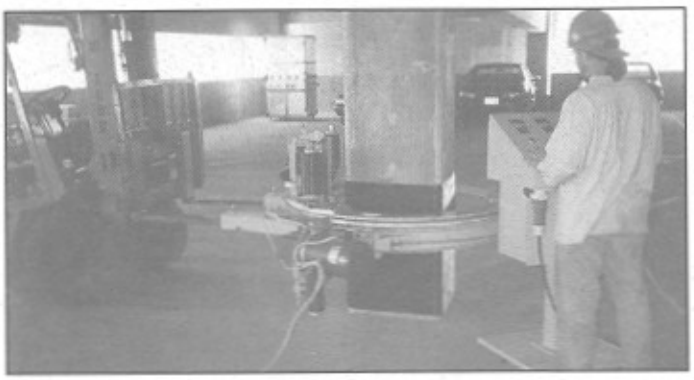

Figure 7. Retrofit of Parking Structures in Salt Lake City, Utah.

XXsys will use its proprietary technologies (Figure 7) to retrofit 122 columns of two, two-storey parking structures at the Medical Arts Building of the Latter Day Saints Hospital in Salt Lake City, Utah, U.S.A. The retrofit will use Robo-Jr.™ which is specifically designed to fit into tight spaces, such as parking structures, and will retrofit columns of 1 m or less in diameter. The project represents public and private sector acceptance of this new technology and its ability to reduce potential earthquake damage.

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

Water Channel Adapts to Ground Subsidence

The ground in the Central Saga District of Japan consists of soft Ariake clay which is liable to ground settlement. Work has been carried out to enhance the functioning of main irrigation channels (the Kubota Trunk Channel and the East and West Trunk Channels) by enabling them to adapt to ground subsidence (Figure 8).

Precast U-shaped blocks measuring approximately 1.5 X 1.9 X 2 m were connected by cables to form a monolithic structure. The connecting cables used were Technora® rods, chosen for their corrosion-free characteristics, high tension and low elasticity which minimizes tension variation due to

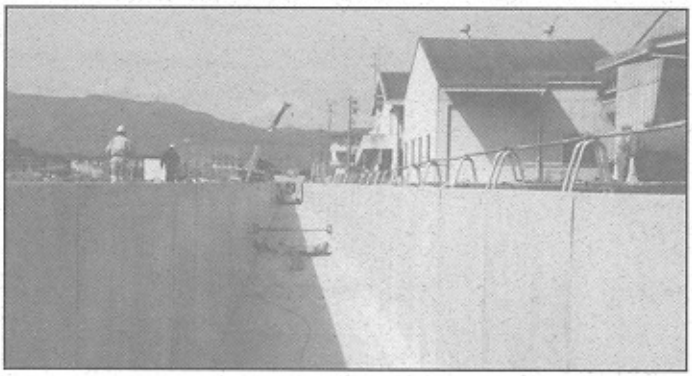

Figure 8. Water Channel Adapts to Ground Settlement.

uneven subsidence. Two or three 3 Φ 6 mm deformed rods were installed at 30 m intervals in the channel section. Tests on full-scale models confirmed the excellent performance of the structure. A total channel length of 6.7 km was installed during 1996.

For more information, please contact Mr. K. Sekijima by fax at 81-3-8320-5533.

Strengthening of Oberriet Bridge, Austria and Switzerland

Figure 9. Strengthening of Oberriet Bridge.

The Oberriet Bridge was build in 1963 to link Austria and Switzerland. The bridge crosses the Rhine River in three spans. Due to an increase in traffic loads, the bridge was strengthened by increasing the cross-sectional area of the deck and adding carbon fiber reinforced plastic (CFRP) strips on the underside of the bridge deck as shown in Figure 9. A total of 160 strips, 4 m in length, were bonded at 750 mm intervals along the entire length of the bridge. The CFRP strips were 80 mm wide and 1.2 mm thick. The concrete surface was prepared by blast cleaning to expose the aggregate and provide a roughness of 0.5 mm to 1.0 mm for proper bonding. The concrete surface was brushed off and cleaned with a vacuum cleaner before applying the epoxy. The CFRP strips are pressed with a hard rubber roller to squeeze out the extra adhesive at the sides.

For further information, please contact Mr. Werner Steiner, Sika, by fax at +41-1-436-4655.

Carbon Fiber Composite Cable for Segmented Bridge

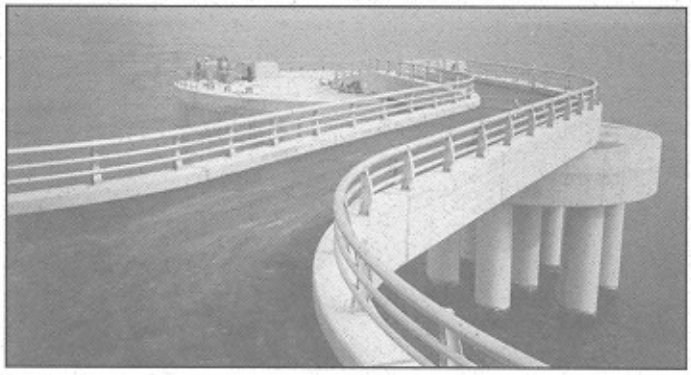

Figure 10. CFCC for Segmented Bridge.

A prestressed concrete segmented bridge was recently constructed in the Haramachi Thermal Power Station of the Tohoku Electric Power Co., Inc. using carbon fiber composite cable (CFCC). The bridge has two spans (Figure 10). The span on the sea side is 12.4 m in length and consists of seven simply supported pretensioned girders. The other span at the wharf side is 25.1 m in length and consists of seven simply supported girders post-tensioned by CFCC of 12.5 mm in diameter. Each of the post-tensioned girders is fabricated from three prefabricated segments which are post-tensioned using eight CFCC cables for each girder. Two out of eight cables were used to prestress the middle segment at the factory and the other six cables were used for post-tensioning at the site to provide continuity of the three segments.

For additional information, please contact P.S. Co. Ltd. by fax at 81-3-5391-6095.

CFCC for Prestressing Concrete Slab Bridge

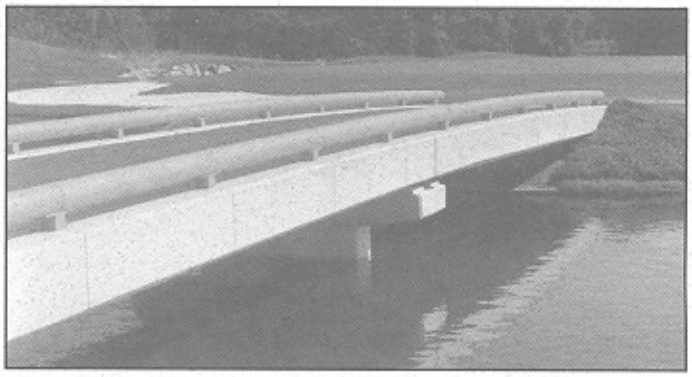

Figure 11. Prestressed Concrete Slab Bridge using Carbon Fiber Composite Cable.

A prestressed concrete slab bridge using a carbon fiber composite cable (CFCC) pretensioning system was constructed at The Park Hill Golf Course, Mie, Japan (Figure 11). This bridge, linking the 18th hole and the clubhouse, has two spans consisting of eight pretensioned simple girders. Each

span is 9.5 m with a total bridge length of 20 m and a width of 3.3 m. The girders have a rectangular section which is 700 mm high and 400 mm wide. Twenty CFCC tendons of 12.5 mm in diameter are used in each girder. The girders were fabricated at Fuji P.S. Corporation's Daito Factory where one long line bench was used to produce three girders simultaneously. The bending test results showed that the strength of these girders is comparable to that of ordinary prestressed concrete girders using steel tendons and normal concrete.

For further information, please contact Hideki Manabe by fax at 81-6-372-3639 or by e-mail at xly00032@niftyserve.or.jp.

Fiber Reinforced Plastic for a Bridge Deck

A new bridge constructed across the Buffalo Creek in McKinleyville, West Virginia, U.S.A., is the first bridge in the United States to use fiber reinforced polymer (FRP) bars in the concrete deck (Figure 12).

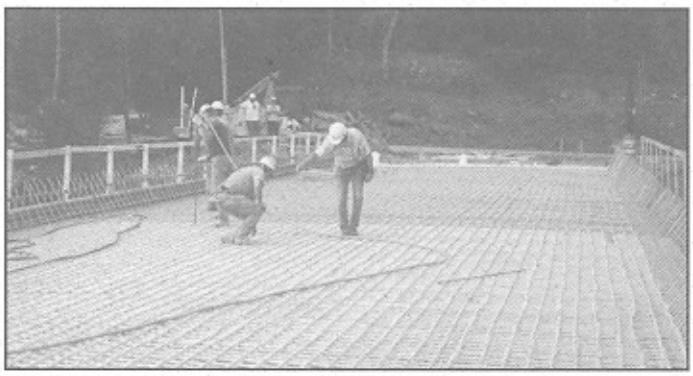

Figure 12. McKinleyville Bridge, West Virginia.

The owner of the bridge, the West Virginia Department of Transportation, Division of Highways (WVDOT-DOH), joined its research partners, the Federal Highway Administration's Department of Transportation, the Constructed Facilities Center of West Virginia University (CFC-WVU), and structural plastics producers, to design and construct an integral abutment bridge with steel stringers and a concrete deck reinforced with FRP bars. This research project was also a part of the Corps of Engineers' (CERL) Construction Productivity Advancement Research Program (CPAR). The contract for bridge construction was awarded to Orders Construction Co., St. Albans, West Virginia, U.S.A.

The McKinleyville Bridge is a 54 m long, three-span continuous structure, accommodating two lanes of traffic. Two manufacturers equally contributed FRP bars for the bridge. Half of the bars required for the bridge deck were supplied by Marshall Industries Composites Inc. of Lima, Ohio, U.S.A., and have an E-glass fiber, recycled polyester resin core combined with urethane-modified vinyl ester sheathing and randomly reinforced deformations. The other half of the bars required for the deck were supplied by International Grating, Inc. of Houston, Texas, U.S.A., and were also made of E-glass fibers and urethane-modified vinyl ester. After the pultruded bar is formed, the rod is wrapped with two additional fiber chords in a helical pattern and then coated with another layer of epoxy resin and rolled in sand for better mechanical bond.

For further information, please contact Dr. Hemanth Thippeswamy, by telephone at 304-293-7608, extension 657.

Laurel Lick Bridge

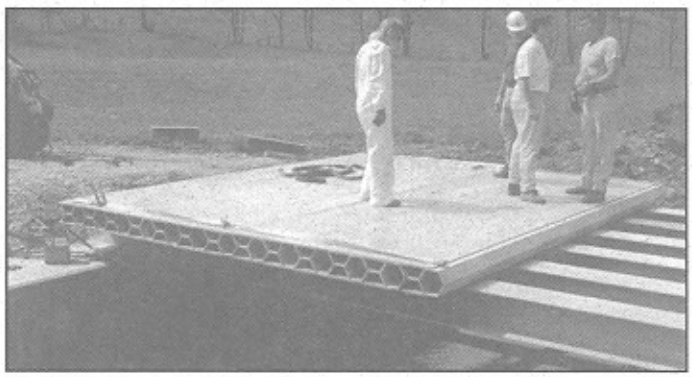

Figure 13. Installation of FRP deck modules in Laurel Lick Bridge.

Fiber reinforced polymer (FRP) composite materials were used to develop a modular bridge deck that has high strength and stiffness to weight ratios, is non-corrosive, and has good fatigue resistance. The composite deck cross-section (made of full-depth hexagons and half-depth trapezoids) and the fiber architecture were designed to provide optimal structural performance for highway bridge loads and were fabricated by pultrusion (Figure 13). The resulting product is called H-deck. The composite deck modules are placed transversely to the traffic direction and are supported by longitudinal beams. The deck depth was constrained to 203 mm, which is the average thickness of concrete decks, in order to utilize the FRP system for concrete deck replacement. The enhanced fiber architecture incorporates E-glass fibers in the form of multi-axial stitched fabrics, continuous rovings, and chopped strand mats. The matrix is a vinyl ester resin with good weathering characteristics and resistance to harsh environments. The composite deck modules are connected to the supporting beams using engineered 12.7 mm blind fasteners from Huck International, Inc. The connection of FRP cellular materials with blind bolts is a new concept that was developed at West Virginia University by conducting joint tests with various geometric and material configurations.

Laurel Lick Bridge, located off county route 26/6 in Lewis County, West Virginia, U.S.A., was constructed in April and May of 1997. The existing structure was in critical condition and needed to be replaced. The new bridge was constructed with a modular FRP deck supported by wide-flange pultruded beams. The length of the bridge deck is 6.10 m and the width is 4.88 m. In addition, the abutments are made of wide-flange pultruded column/piles and multi-cellular panels with a reinforced concrete cap beam. All the FRP elements were fabricated by Creative Pultrusions, Inc. The construction of Laurel Lick Bridge was conducted by

District Seven of West Virginia Division of Highways. The composite components will be instrumented with sensors to monitor their long-term performance.

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

Plaza Parking Garage

A six-month seismic retrofit was recently completed at the underground Plaza Parking Garage in Olympia, Washington, U.S.A. The engineer, Skilling Ward Magnusson Barkshire, Inc. (SWMB) identified the need to provide shear strengthening and additional ductility to the 420 column parking garage in order to satisfy recent seismic design code changes (Figure 14).

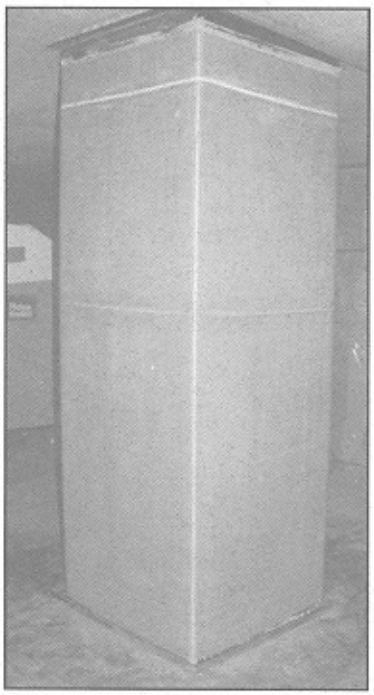

Figure 14. Plaza Parking Garage.

SWMB worked with the engineers at Hexcel Fyfe Co. to design a composite retrofit which could satisfy the design needs and allow for the competitive bidding process. SWMB provided the required level of confining necessary along the height of each column in the project specifications. The specifications were created for either glass or carbon composite jackets.

Contech Services of Seattle, Washington, U.S.A., provided a bid to the owner to install the Hexcel Fyfe Co. Fibrwrap™ System. Contech Services completed the project on time while maintaining operation of the garage. Installation of the Fibrwrap™ System resulted in sequencing of only a five percent closure of the garage.

For further information, please contact Mr. Duane Gee by fax at 619-642-0947.

Research

FRP Combined with Concrete

A new class of hybrid elements which consists of glass fiber reinforced polymer (GFRP) box beams combined with a layer of concrete in the compression flange and a carbon fiber reinforced polymer laminate (CFRP) as additional tension reinforcement, as shown in Figure 15, is proposed by researchers at the Swiss Federal Laboratory for Material Testing and Research (EMPA) in Dübendorf, Switzerland. The effect of shrinkage, creep and fatigue of concrete and GFRP was considered, as well as short and long-term behavior of the proposed section. Use of concrete replaces the need for the thick GFRP compression flange of traditional pultruded FRP sections. The section is suitable for bridges and buildings for their lightweight and corrosion resistance, and could be used for modular systems.

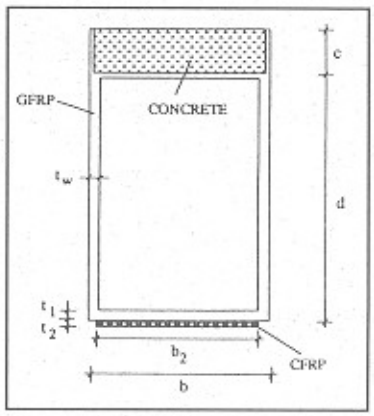

Figure 15. Hybrid FRP Concrete Bram.

For further information, please contact Prof. Urs Meier by fax at +41-1-821-6244 or visit EMPA's website at http://www.empa.ch.

CFRP Reinforced Poles

Replacement of conventional and prestressing steel reinforcements of centrifugally cast concrete poles are currently being studied at the Swiss Federal Laboratory for Material Testing and Research (EMPA) in Dübendorf, Switzerland, together with SACAC, Lenburg, Switzerland. The main goal of this research project is to produce carbon fiber reinforced polymer (CFRP) reinforced and prestressed spun cast high strength concrete poles as shown in Figure 16. The poles should be capable of competing in mechanical properties and weight with steel poles and have outstanding corrosion resistance. Possible application would be poles for power lines, traffic signals and lighting devices. Scale model testing using 120 MPa compression strength concrete and 3200 MPa Φ 3 mm coated CFRP rods is currently underway at EMPA.

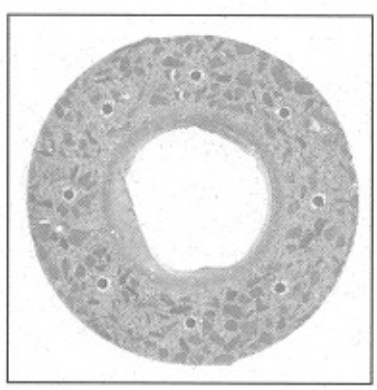

Figure 16. CFRP Prestressed Concrete Spun Poles.

For more information, please contact EMPA Group 101 by fax at +41-1-821-6244 or visit their website at http://www.empa.ch.

Innovative FRP Straps

A novel concept for an optimized load transfer in pin loaded strap elements to post-shear-strengthen existing reinforced concrete structures is being developed at the Swiss Federal

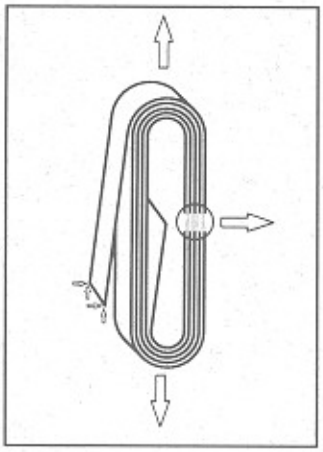

Figure 17. Innovative FRP Straps.

Laboratory for Material Testing and Research (EMPA) in Dübendorf, Switzerland. The concept prevents a significant reduction of strength due to bending of FRP in laminated pin loaded strap elements. The concept is based on the replacement of the solid laminate with a number of non-laminated layers and a thermo-plastic matrix. The innovative system enables the individual layers to move relative to each other until a uniform strain distribution of all layers is achieved as shown in Figure 17. A large number of applications are expected for the novel concept.

For more information, please contact EMPA Group 101 by fax at +41-1-821-6244 or visit their website at http://www.empa.ch.

Products

Carbon Fiber Plant in the United States

Toray Industries Inc. announced an investment of more than seven billion yen to build a polyacrylonitrile (PAN) carbon fiber plant in the United States. The plant, capable of producing 1,800 tons of PAN carbon fiber a year, is expected to become operational in 1999.

Demand for carbon fibers as a reinforcing material in consumer products and civil engineering projects is expected to grow to 21,000 tons in 2005 from 11,000 tons in 1996.

Toray plans to establish aggregate production of 7,800 tons a year in Japan, Europe and the United States.

Toray Carbon Fibers America will be established this month with a start-up capital of 45 million dollars. The company headquarters and the plant will be located at the Decatur, Alabama, U.S.A., plant of Monsanto Co. At the plant, acrylic long-fibers shipped from Japan will be processed into carbon fibers. The products will be marketed in the United States.

Competition

ACI Second Annual Student Competition

ACI will be sponsoring the second student competition in fiber reinforced plastic composites at the fall convention in Atlanta, Georgia, U.S.A. The competition, which is open to undergraduate engineering students worldwide, will be held on Sunday, November 9, 1997, on the campus of Georgia Tech University. Funding is available to help defray travel costs for student contestants and cash prizes will be awarded for the highest ultimate loads and the most accurate predictions. All teams must have a faculty advisor.

For further information, please contact Dr. Vicki Brown by fax at 610-499-4059.

On the Move

Dr. Antonio Nanni

Dr. Antonio Nanni, Professor of Architectural Engineering at Pennsylvania State University and Associate Editor of this newsletter, has been named the first Vernon and Maralee Jones Endowed Professor in Civil Engineering at the University of Missouri-Rolla. After August 1, Dr. Nanni can be reached by fax at 573-341-4729.

Dr. Lawrence C. Bank

Dr. Lawrence C. Bank will take up a position as Full Professor in the Department of Civil and Environmental Engineering at the University of Wisconsin in Madison, Wisconsin, U.S.A., in the fall of 1997. After August 1, 1997, Dr. Bank can be reached by fax at 608-262-5199.

Correction

In reference to the article "GFRP Framed Structures" published Autumn 1996, Volume IV, Issue 4, the supplier of the GFRP frame structures should have read TAEMA and not MMFG as incorrectly reported. FRP International apologizes for this error.

Conference Announcement

Third International Symposium on FRP

The Third International Symposium on Non-Metallic (FRP) Reinforcement for Concrete Structures (FRPRCS-3) will be held October 14 to 16, 1997, at the Garden Palace Hotel in Sapporo, Japan. Ten keynote lectures have been grouped into two themes. The first theme will review the state-of-the-art report on retrofitting and strengthening by continuous fiber. The second theme will present design concepts and procedures for continuous fiber reinforced concrete. Approximately 160 papers covering material properties, testing methods, the structural behaviour of reinforced concrete and prestressed concrete, design procedures, repair and strengthening, and practical applications, as well as technical committee reports of the Japan Concrete Institute (JCI) will be presented.

For further information, please contact the Conference Secretariat by fax at 81-3-3263-2115.

Conferences

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.

International Workshop on Structural Health Monitoring, Stanford University, Stanford, California, United States, September 18 to 20, 1997. For further information, please contact Professor Fu-Kuo Chang by fax at 415-725-3377 or by e-mail at fkchang@leland.stanford.edu.

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 International Symposium on Non-Metallic (FRP) Reinforcement for Concrete Structures, Sapporo, Japan, October 14 to 16, 1997. Contact: Secretariat FRPRCS-3, Japan Concrete Institute, Sohgo Hanzomon Building, 12F, 1-7 Kojimachi, Chiyoda-ku, Tokyo 102, Japan.

European Pultrusion Technology Association (EPTA) 1997 Pultrusion Technology Seminar, October 15 to 16, 1997, Maastricht, Netherlands. For further information, please contact the EPTA Association Office by fax at 31-341-42-56-14.

Precast/Prestressed Concrete Institute 43rd Annual Convention and Exhibition, October 19 to 22, 1997, New Orleans, Louisiana. For further information, please contact the Precast/Prestressed Concrete Institute by telephone at 312-786-0300 or by fax at 312-786-0353.

Fifth 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.

Composites'97, jointly sponsored by the Composite Fabricators Association (CFA) and the Society for Advancement of Material and Process Engineering (SAMPE), October 29 to November 1, 1997, Orlando, Florida, United States. For further information, please contact the CFA at 703-610-9025.

Second Asia-Pacific Conference on Shock and Impact Loads on Structures, Melbourne, Australia, November 26 to 27, 1997. For further information, please contact the Conference Director by fax at 65-235-3530.

Far East and Pacific Rim Symposium on Smart Materials, Structures and MEMS, December 10 to 13, 1997, at the University of South Australia, City West Campus, Adelaide, Australia. For further information, please fax 618-835-9-5566.

Al-Azhar Engineering Fifth International Conference (AEIC'97), December 19 to 22, 1997, Nasr City, Cairo, Egypt. For further information, please contact Dr. M. K. El-Sammy by fax at 202-260-1706.

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

International Composites Expo (ICE'98), Nashville, Tennessee, U.S.A., January 19 to 21, 1998. For further information, please contact the Composites Institute by fax at 212-370-1731.

SPIE's Fifth Annual International Symposium on Smart Structures and Materials, March 1 to 5, 1998, San Diego, California, U.S.A. For further information, please contact SPIE's international headquarters by fax at 360-647-1445.

Fourth World Pultrusion Conference, Connecting with Pultrusion, April 9 to 11, 1998, Vienna, Austria. For further information, please contact the EPTA Association Office by fax at 31-341-42-56-14.

Tenth International Conference on Mechanics of Composite Materials, April 20 to 23, 1998, Riga, Latvia. For further information, please fax 371-782-0467.

Eighth European Conference on Composite Materials - Science, Technologies and Applications (ECCM-8), Naples, Italy, June 3 to 6, 1998. For further information, please contact Professor A. Langella by fax at +39-81-761-4212 or visit the conference website at http://www.eccm98.etruria.net.

The XIIIth FIP Congress, May 23 to 29, 1998, RAI Congress Centre, The Netherlands. For further information, please contact the Congress Secretariat by fax at +31-182-537-510.

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.

Advances in Cement and Concrete, Banff, Alberta, Canada, July 5 to 10, 1998. For further information, please contact the Engineering Foundation by fax at 212-705-7441.

Fifth International Conference on Short and Medium Span Bridges, Calgary, Alberta, July 13 to 16, 1998. For further information, please contact Margaret-Anne Stroh by fax at 403-284-4184.

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

Durability of Composites for Construction, August 5 to 7, 1998, Sherbrooke, Québec, Canada. For further information, please contact Dr. B. Benmokrane by fax at 819-821-7974.

American Society of Civil Engineers 1998 Annual Convention and Exposition, Boston, Massachusetts, October 18 to 21, 1998. For further information, please contact ASCE by fax at 703-295-6144.

Creating with Concrete International Congress, September 6 to 10, 1999, Dundee, Scotland. For further information, please contact Professor R. K. Dhir by telephone at +44-1382-344-347, by fax at +44-1382-345-524 or by e-mail at r.k.dhir@dundee.ac.uk.

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