

Bridge Talk

Number 3

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Fiber-Reinforced Polymer Bridge Decks

by Patrick A. Cassity, PE, SE, J. Muller International, Chicago, IL

Fiber-reinforced polymers or FRP's are robust materials that are highly resistant to corrosive action, have a high strength to weight ratio and are well suited for assembly line production into modular components that can be rapidly erected. However, FRP material costs are significantly greater than traditional concrete and steel materials. Therefore, cost savings due to either reduced weight, increased speed of construction or lower maintenance and increased life expectancy must offset this higher cost to make sensible use of FRP materials.

Because of the severe environmental conditioning that bridge decks are subject to and the fact that they account for a major percentage of a bridge structures dead load, they are the most suitable bridge application for FRP materials. An 8-inch deep FRP deck weighs approximately 20 lbs./sq. ft. as compared to 100 lbs./sq. ft. for a concrete deck of the same depth. In addition, FRP decks can be constructed faster than conventional cast-in-place decks that take more time due to formwork construction, rebar placement and concrete curing.

Overview of Typical Deck Systems

The majority of the FRP deck systems on the market today utilize glass-reinforcing fibers set in a polyester or vinylester resin matrix. Other FRP material systems that utilize carbon or aramid fibers and epoxy resins offer superior structural performance characteristics but are cost prohibitive for use in bridge deck systems.

The typical deck systems on the market today consist of two principal types: pultruded tubes that are bonded together with adhesive and honeycomb or sandwich core systems that are hand laid-up or utilize vacuum assisted resin transfer molding techniques. An example of a pultruded tube or beam system is shown in Figure 1. Each deck system is factory assembled into deck panels that are sized appropriately for shipment to the site. The panels are then erected and bonded together in the field using high performance adhesives.

All of the deck systems require an overlay to provide adequate skid resistance and sufficient geometric tolerances. The overlay system can consist of a conventional latex concrete, micro-silica concrete or high-density concrete; however, these types of overlays do not have comparable stiffness, tensile strength and compressive strength properties as compared to FRP deck systems. This lack of compatibility can lead to debonding and/or cracking of the overlay if the interaction between the deck and overlay is not properly analyzed and accounted for. Thin polymer modified concrete and epoxy overlays are better suited for FRP deck applications.

Hot-applied asphalt has been used as an overlay for FRP decks; however, the temperature of the asphalt typically exceeds the glass transition temperature of the resin. FRP materials begin to lose their rigidity as they approach the glass transition temperature of the polymer and start to exhibit a viscoelastic type behavior. The corresponding effect on the behavior and performance of the deck should be analyzed and tested prior to the use of a hot-applied asphalt overlay.

FRP decks that are supported by beams require a haunch or fillet between the beam and deck to provide adequate tolerance to accommodate geometric imperfections introduced during fabrication or erection of the beams. Either a conventional non-shrink grout or polymer modified grout can be used to form the haunch. Regardless of whether the bridge is designed for composite or noncomposite action under superimposed loads, the deck must be connected to the

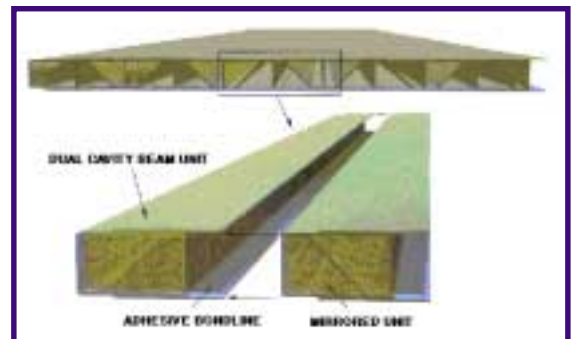
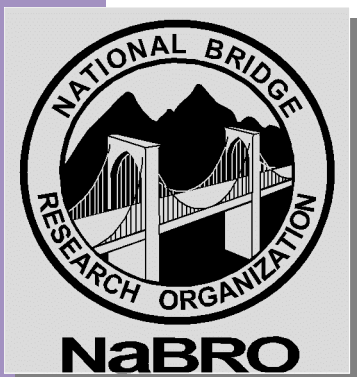


Figure 1 - DuraSpan™ deck system by Martin Marietta Composites, Inc.



Letter from the Director



Dr. Atorod Azizinamini

Developing a guideline to evaluate the success of an academic institution is an issue that has been debated extensively. This is particularly true when it comes to the

relationship between research and other missions of a university. What should be the ultimate measure by which one should judge the effectiveness of a research entity in a university? Is it the number of publications that a faculty produces? Is it the level of funding? Is

it the recognition by ones peers? In the industrial setting, especially the service oriented sector, the success of a company is directly related to satisfying the needs of its clientele. In an academic institution, we also have clientele, except that our main clientele are our undergraduate and graduate students. Our clientele's needs include providing them with the highest level of education that is possible.

This requires continuously

educating those whose mission is educating undergraduate and graduate students. Being on the forefront and cutting edge of technical subjects is ever more important. It is primarily through research that an academic institution remains at the forefront of technology. Therefore, one could perhaps argue that an ultimate measure of success in a university setting is the development of knowledgeable professionals or, in our case, the best

engineers that could meet the demands of society. Without research, publication or funds, one could not achieve such goals.

This is one of the main reasons that we at NaBRO emphasize the development of our graduate students. Through research, our graduate students acquire the knowledge and competence required of them in the future. In this issue, you will meet two of our graduate students. Mr. Nick Lampe, who will begin his professional career with HDR Inc., in Omaha, Nebraska starting August 2000 and Dr. Ahmed Elremaily who just completed his Ph.D.

What should be the ultimate measure by which one should judge the effectiveness of a research entity in a university?

students with all the training that is needed? Do we have all the resources that we need to be completely effective? The answer is certainly no. This is where the involvement of those with interests in bridge engineering becomes crucial. At best, NaBRO can only partially achieve its goals alone. Involvement of our alumni is crucial to our success.

Without your involvement, elevating NaBRO to the next level will be a formidable, if not impossible, task to achieve. Give us a call or drop us a letter and let us know your opinion about how we can be more productive in accomplishing our mission. We always welcome your involvement at any level or in any form.

SPECIAL NOTE TO UNLALUMNI :

If you wish to receive future issues of Bridge Talk, please visit the NaBRO web page at www.nabro.unl.edu to subscribe.

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The National Bridge Research Organization (NaBRO) at the University of Nebraska-Lincoln (UNL) is dedicated to developing, collecting and disseminating the latest technologies for the advancement of bridge design, construction, retrofit and maintenance. This is accomplished through partnership with industry, government agencies and academia. NaBRO's mission evolves around three initiatives: a) research, b) education and c) technology transfer.

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Fiber-Reinforced Polymer Bridge Decks

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beams with a nominal number of connectors in order to provide adequate confinement of the haunch. Otherwise, the haunch will break apart over time as the deck rotates over the beam line and separates from the haunch as the deck is subject to unsymmetrical live loading.

The method of connecting FRP decks to beams is one topic that requires further research and testing to optimize the cost and performance of this detail. Welded shear studs contained within grout-filled pockets have been used successfully for connecting FRP decks to steel beams to achieve full composite action. The key to this approach is to ensure adequate strength and confinement of the grout in order to develop the required connection capacity. The advantage to this approach is that it utilizes conventional technology; however, the trade-off is the increased fabrication cost associated with cutting holes in the deck and forming the pocket at each connection location. Figure 2 shows a typical detail for this type of connection.

Cost Effective Applications

The cost of FRP deck systems is approximately two to three times that of conventional cast-in-place reinforced concrete decks. This high initial cost must be offset by either a savings associated with a reduction in life cycle cost or a savings associated with the reduction in dead load. Thus, the two primary market applications for FRP decks are replacement of deteriorated concrete decks on high volume roadways and rehabilitation of weight sensitive structures.

Traffic delays can cost as much as hundreds of thousands of dollars per week in wasted fuel and reduced productivity on high volume roadways or on roadways located in urban areas that are heavily relied upon by motorists and businesses for commerce, safety and mobility. These costs are often referred to as user costs. The actual delay cost is heavily dependent upon the traffic volume and delay time. The benefit of FRP decks is that they result in a system that can be rapidly erected and offer enhanced durability that significantly reduces the need for future rehabilitation.

Life cycle cost analyses conducted by our firm have shown that FRP bridge decks used on conventional multi-beam overpass bridges can reduce the life cycle cost of a bridge anywhere from 10 to 30 percent over a 75 year design life. The major component of the cost savings is a reduction in user costs associated with the increased speed of construction and fewer traffic impacts due to a reduction in maintenance requirements. The user costs were found to account for as much as 80 percent of the life cycle cost of a bridge.

However, transportation officials operate under the constraint of yearly budgets that do not

always allow the expenditure of more money today in order to save money in the future. In addition, it is sometimes difficult to quantify the magnitude of the user costs or even to convince people that it is a real cost that should be factored into the decision making process. The fact that the traveling public is becoming increasingly intolerant of traffic impacts caused by bridge construction and maintenance activities may force the industry to make a fundamental change to life cycle cost based decision making.

The second major market area is related to weight sensitive structures including cable-stayed, suspension, arch, moveable and truss bridges. However, the most promising markets seem to be replacement of open grating decks on moveable bridges and replacement of open steel grating or concrete decks on truss bridges. FRP decks offer the advantage of a closed deck system that protects the floor system of the bridge thereby increasing the overall durability of the structure. In addition, there are a significant number of existing truss bridges with concrete decks that are deficient with respect to live load capacity. FRP decks are approximately 20 percent of the weight of a concrete deck. By replacing an existing concrete deck with an FRP deck, the live load carrying capacity of the bridge can be increased without requiring significant rehabilitation or replacement of the main structural members.

Summary

FRP deck systems offer the benefit of a lightweight decking system that can be rapidly erected and provides excellent long-term durability. FRP deck systems are available today as a viable alternative

to traditional decks. Nonetheless, further research, development and validation of FRP deck systems is necessary in order to further optimize and standardize these deck systems so that they gain widespread acceptance in our industry. Standard design and construction specifications are also necessary to give engineers and contractors the information necessary to properly design and build FRP decks. We also must make use of the 40-year successful track record of FRP's in the aerospace and boating industries to educate ourselves with respect to the long-term durability characteristics relating to fatigue, freeze-thaw, creep and moisture.

FRP decks will likely never be competitive with conventional deck systems based upon first cost alone. Our industry needs to make a fundamental change in our approach to quantifying costs and making decisions regarding the use of specific structure types and components. Life cycle cost based decision making needs to be standardized and accepted in order to truly begin to appreciate and take advantage of the speed of construction and durability attributes of FRP decks.

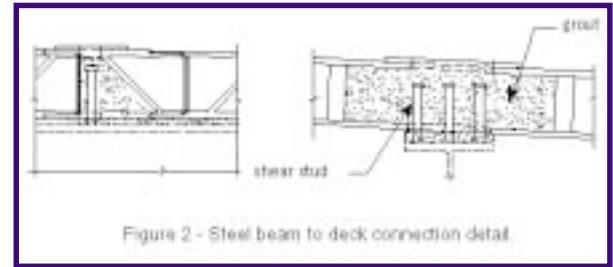


Figure 2 - Steel beam to deck connection detail

👉 UPCOMING EVENT 👈

“Short Course on Design of Steel Bridges Using AASHTO LRFD Bridge Design Specifications”

A six hour long short course devoted to the design of steel bridges using the *AASHTO LRFD Bridge Design Specifications* will be taught on November 29, 2000, from 10:00 a.m. to 5:00 p.m. at the Hyatt Regency Baltimore on the Inner Harbor in Baltimore, MD. This short course will be taught by Dr. Atorod Azizinamini, P.E., Associate Professor of Civil Engineering at the University of Nebraska-Lincoln and Dr. Dennis Mertz, P.E., Associate Professor of Civil Engineering at the University of Delaware. Registration for this short course will be \$150 before August 25, 2000 and \$200 after August 25, 2000. The registration fee will include refreshments, a notebook containing the material to be covered in the class and a Certificate of Attendance that could be used for continuing education credit.

This course is suited for engineering professionals engaged in the design of steel bridges. The topics to be discussed in the class include (1) Load models for strength and fatigue limit states. (2) Distribution factors for various load conditions and limit states. (3) An efficient approach for organizing analysis results suited for LRFD design. (4) Fatigue and fracture design and analysis considerations. (5) Design of positive and negative sections for both compact and non-compact sections. (6) Flexural design requirements such as ductility provisions for positive sections. (7) Constructibility design provisions. (8) Shear design provisions for stiffened and unstiffened panels.

If you are interested in obtaining more information about the class, please visit the NaBRO web page at www.nabro.unl.edu.

☞ UPCOMING CONFERENCES ☞

“Steel Bridge Design and Construction for the New Millennium with emphasis on High Performance Steel”

A two-day conference is scheduled to be held in Baltimore, Maryland on November 30 and December 1, 2000. The theme of the conference is “Steel Bridge Design and Construction for the New Millennium with emphasis on High Performance Steel”. The day before the conference, on November 29, 2000, a six hour long short course will be taught on the design of steel bridges using the *AASHTO LRFD Bridge Design Specifications*.

This conference, which is sponsored mainly by the Federal Highway Administration, will bring together design professionals, state and federal agencies, fabricators, contractors, steel producers and academia, to share in the latest developments of steel bridge design and construction with emphasis on High Performance Steel. Presentations will include topics to be presented for the first time, such as cost comparison of bridges designed using 50 and 70 ksi steels, a work that is being prepared by HDR, Inc. A complete program for this

**November 30 - December 1, 2000
Baltimore, Maryland**

conference can be viewed by visiting the NaBRO web page at www.nabro.unl.edu.

An important part of this two day long conference is a panel discussion at the end of the final conference day. This panel discussion will focus on the lessons learned from the design, fabrication and construction of High Performance Steel bridges currently in service and look at the past, present and future of steel bridges. The members of the panel will consist of 20 state bridge engineers from different states or their representatives, consultants, academicians, fabricators and contractors. This is a very unique opportunity for consultants, fabricators and contractors to become familiar with state agencies' viewpoints on HPS and how they can become more competitive.

For those who are interested in becoming familiar with the design of steel bridges using

the latest (2000 interim) *AASHTO LRFD Bridge Design Specification*, a six hour long class will be taught the day before the conference starts, on November 29, 2000. This class will be held at the conference site.

The conference will be held at the Hyatt Regency Baltimore on the Inner Harbor. The registration for this conference is \$150 before August 25, 2000 and \$200.00 after August 25, 2000. The registration fee will include continental breakfast, lunch and breaks for both days, social hour and conference proceedings. The registration for the short course is \$150 before August 25, 2000 and \$200 after August 25, 2000. The registration fee will include refreshments, a notebook containing the material to be covered in the class and a Certificate of Attendance that could be used for continuing education credit. To register for these events, please visit the NaBRO web page at www.nabro.unl.edu or the FHWA web page at www.fhwa.dot.gov/bridge.

“International Conference on High Performance Materials in Bridges”

**July 29 - August 3, 2001
Kona, Hawaii**

*Call for Papers/Posters
Abstract Deadline: July 30, 2000*

A United Engineering Foundation (UEF) and National Bridge Research Organization (NaBRO) Conference, “International Conference on High Performance Materials in Bridges”, will be held in Kona, Hawaii July 29 – August 3, 2001. This conference is for designers, researchers, contractors, fabricators and government officials involved in the use of High Performance Materials as applied to bridge structures. The conference will include presentations by keynote speakers summarizing major activities around the world. The conference theme will include the following subjects:

1. *Advances in material research for using High Performance Steel, High Performance Concrete, Fiber Reinforced Polymers and Advanced Wood Composites as applied to bridges.*
2. *Design issues and related research studies in the field of High Performance Steel, High Performance Concrete, Fiber Reinforced Polymers and Advanced Wood Composites.*
3. *Code provisions related to the use of High Performance Steel, High Performance Concrete, Fiber Reinforced Polymers and Advanced Wood Composites in bridges.*
4. *Case Studies in utilizing High Performance Steel, High Performance Concrete, Fiber Reinforced Polymers and Advanced Wood Composites in bridges.*
5. *Innovative use of High Performance Materials in bridges.*
6. *Contractors' and Fabricators' experiences in using High Performance Materials in bridge fabrication and construction.*
7. *Results from monitoring performance of bridges constructed using High Performance Materials in bridges.*
8. *Theme presentations and providing a summary of active national projects in countries promoting the use of High Performance Materials.*
9. *Future trends in using High Performance Materials in bridges.*

Paper Submissions:

Both oral and poster papers will be presented and proceedings of the conference will be published in special ASCE publications. Interested individuals are invited to submit a one-page abstract for consideration by **July 30, 2000**. Authors should follow directions on the UEF website (<http://www.engfnd.org>) and submit the abstract electronically. All abstracts will be reviewed by the oral and poster session chairs, and authors will be notified whether their abstract has been accepted before **October 15, 2000**. Papers will be due by **January 15, 2001**.

TEA-21 Promotes Innovative Bridge Materials and Technologies

by John M. Hooks, P.E., Structural Engineer, FHWA Office of Bridge Technology and Milo Cress, P.E., Structural Engineer, FHWA NE Division

The Transportation Efficiency Act for the 21st Century (TEA-21) authorized a major new initiative intended to improve the condition, durability, and capacity of the Nation's 585,000 bridges. TEA-21's Innovative Bridge Research & Construction (IBRC) Program champions the use of innovative materials to repair, rehabilitate, replace bridges or to construct new bridges.

The goal of the IBRC Program—to accelerate the adoption of innovative materials—is consistent with the FHWA's strategic goals to increase mobility and productivity on the Nation's highway systems. The legislated goals of the IBRC program include new, cost-effective bridge applications of innovative material, reduced maintenance and life-cycle costs of bridges and construction techniques to reduce construction time and traffic congestion.

TEA-21 funds IBRC technology deployment through grants to State DOTs for specific repair, rehabilitation, and construction projects. Over the 6-year life of the program, IBRC funding totals \$102M for construction and also \$6M for related research, development and technology transfer.

FY 1998-99 and FY 2000 IBRC Solicitations Attract 289 Projects

Forty-one States submitted candidate proposals for 289 projects that deployed innovative materials for structures. The States identified projects. Selection criteria for the program were mainly concerned that projects meet one or more of the program goals. No materials were restricted from consideration, but the evaluation panel looked primarily for those that increase durability, increase load carrying capacity and/or produce more durable bridges.

Of the 289 projects submitted, evaluators identified 116 that were well-qualified for funding with FY 1998-1999 and FY 2000 IBRC grants. Grants were made for the entire scope of the innovation process, including engineering, repair or construction, and post-construction monitoring and evaluation. Projects submitted also encompassed a range of innovative materials, including high-performance concrete and high-performance steel, fiber-reinforced composites, and alternative systems for protecting reinforcing bars. The following graph indicates the number of projects by materials use.

Building Better Bridges

Two bridge projects provide excellent examples of how the IBRC and cooperative partnerships can produce better, innovative bridges.

One well-recognized model of incorporating new materials and technologies in bridge construction is the Salem Avenue Bridge (Montgomery SR 49) in Dayton, Ohio. When completed, this twin 5-span, 680-foot-long, 48-foot-wide bridge will incorporate the largest fiber reinforced polymer (FRP) composite bridge deck in the United States—65,280 square feet. In addition to the Ohio Department of Transportation (ODOT), partners include the FHWA, HITEC, The Composites Institute, Montgomery County Engineers, four universities, the U.S. Army Corps of Engineers, and four manufacturers. For example, environmental testing and materials testing was done by the University of Maine. The University of Kentucky tested the deck panels, and the University of Cincinnati and Ohio University were responsible for field monitoring. The Corps of Engineers is conducting 10 million cycles of fatigue testing on the bridge materials. Half of the materials will be tested at -22 °F, the other half will be tested at 120 °F. Fiber optics will provide long-term monitoring of the internal structure.

IBRC funds are also participating in the Nebraska High Performance Steel Initiative which began in 1996. The 3-Phase initiative was funded by a partnership between the Federal Highway Administration, Nebraska Department of Roads, AISI, NSBA, and University of Nebraska-NABRO. The first phase resulted in the construction of a 2-lane single-span bridge (153.5 feet end-to-end by 37.5 feet O-O with five (5) girder lines) using HPS70W steel. This bridge was designed for 50W steel and fabricated with HPS70W steel. Full-scale laboratory tests were carried out and the fabrication documented during this phase addressed AASHTO limitations and concerns about welding of HPS70W steel. The Phase I Nebraska Snyder-South Highway 79 bridge was constructed in 1997 and opened to traffic in December 1997.

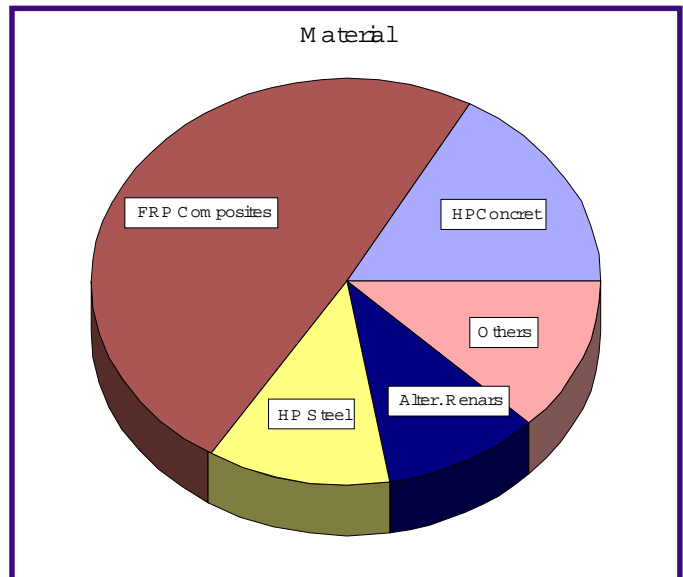
The second phase involved optimized design and construction of a 2-span bridge. This bridge was designed by the Nebraska Department of Roads in 1998, and let to contract in April of 1998. Girders are hybrid with HPS70W flanges and 50W webs. This bridge that carries Dodge Street over I-480 in Omaha, Nebraska has two (2) 236.5 foot spans and is 72 feet out-to-out, with eight (8) girder lines. The first half of the

structure was completed in 1999 and the second half is to be completed in mid-2000. A technology transfer seminar was held for about 200 professionals in Kansas City, Missouri, to share developments with design professionals, researchers, and bridge owners. An additional technology transfer seminar is scheduled for November 29-December 1, 2000 in Baltimore, MD.

The third phase of the initiative will culminate in design and construction of an innovative configuration that can be fabricated by most fabricators and will offer efficiencies in fabrication and construction. A site for the Phase III bridge was tentatively identified in 2000, and concepts were developed by J. Muller, International. The double-box concept was chosen by a panel of experts after review of several concepts during a meeting in Kansas City on June 18, 1999. This bridge will target single and multiple spans between 150 and 180 feet. Design and testing are underway and it is expected the bridge will be let to contract and constructed in 2001.

The Salem Avenue project and the Nebraska High Performance Steel Initiative are but two examples of the opportunity that TEA-21 and IBRC give States to use innovative materials and imaginative procedures to build efficient and cost-effective bridges—the spans to our Nation's tomorrow.

To learn more about the Innovative Bridge Research and Construction Program, including the solicitation and selection of projects for FY 2000 and beyond, visit <http://ibrc.fhwa.dot.gov>.



Bridge Engineer Profile: Lyman Freemon, State Bridge Engineer for the Nebraska Department of Roads

His name has become synonymous with innovation in bridge engineering. For a relatively small state, Nebraska is home to the first bridges opened to traffic and constructed with high performance concrete and high performance steel. The man with the vision directing these initiatives is Lyman Freemon, State Bridge Engineer for the State of Nebraska. Quiet in appearance, Lyman is an intelligent engineer who listens to ideas and has the ability to sort through them and choose ones that will benefit the taxpayers. Born and raised in Nebraska, Lyman attended Hastings College in Hastings, Nebraska. Following his graduation



Lyman Freemon

with a degree in Civil Engineering from the University of Nebraska, Lyman began his professional career at the Nebraska Department of Roads (NDOR). He has been a dedicated state employee and except for a one-year leave to attend graduate school at the University of Nebraska, his entire professional career has been with NDOR. Lyman's career at NDOR has taken him through many responsibilities. Since 1958, when he started his career with NDOR he has served the institution at various capacities. His first ten years were with the bridge division. During this period, he was involved in designing various bridge types, laying a foundation for a division that he would later lead. During the same period, while working in the bridge division, Lyman wrote many of Nebraska's structural, bridge and geometry computer programs. This was a period in which electronic computational methods were in their infancy, even at university levels. In 1969, Lyman was promoted to manager of the Project Control Division. Later, in 1972, he was appointed to manager of the Management Systems Division. In 1974, Lyman was elevated to Roadway Design Engineer. In 1989, he returned to the same section at NDOR, in which he began his career by returning to the Bridge Division as State Bridge Engineer.

Since 1989, under Lyman's leadership, several new ideas have emerged from NDOR's Bridge Division that have had national impact. Development of new prestress girder shapes (NU sections), adaptation of high performance materials in bridge construction and development of new maintenance and inspection procedures for bridges are among new initiatives that Lyman has spearheaded.

According to Lyman, one of his most rewarding accomplishments during his tenure has been the development of professional engineers into capable leaders. Many who were supervised by Lyman have been elevated to higher positions and responsibilities. The latest example is Mr. Moe Jamshidi, former Assistant Bridge Engineer, who now heads the Material and Testing Divisions of NDOR.

One of Lyman's unique capabilities is his open minded approach to new and innovative ideas. Oftentimes, new ideas are put to rest before they have a chance to show their benefits. Ideas that have been generated in the Bridge Division of NDOR are finding their way into other states. In some cases, the Bridge Division of NDOR has paved the way so that other State Department's of Transportation could easily adopt new bridge technologies. Nebraska's High Performance Steel bridge initiative is a good example. With Lyman's vision, Nebraska and Tennessee have been in the forefront of applying this new material to bridge construction. Many limitations in the AASHTO codes have been removed, partially based on the Nebraska work. These achievements are the legacies that Lyman Freemon as Bridge Engineer has established in Nebraska and it is a legacy that has already made its mark on the bridge engineering profession.

NaBRO Affiliated Researcher Profile: Dr. Catherine French, University of Minnesota

Dr. Catherine French is Associate Department Head and Professor of the Department of Civil Engineering at the University of Minnesota. She received her B.S.C.E. from the University of Minnesota in 1979 and M.S. and Ph.D. degrees from the University of Illinois at Urbana-Champaign in 1980 and 1984, respectively. She started her academic carrier in 1984 at the University of Minnesota and was promoted to the ranks of associate and full professor in 1990 and 1997, respectively.

Professor French's research has focussed on two primary areas: earthquake engineering and infrastructure research. Her interest in earthquake engineering began during her doctoral dissertation studies when she investigated the behavior of three one-tenth scale reinforced concrete frame-wall structures tested on an earthquake simulator at the University of Illinois. At the University of Minnesota, Professor French has targeted her research toward understanding the behavior of reinforced and prestressed concrete structural systems subjected to earthquake loading, and toward addressing durability and application of new materials such as high-strength concrete and FRP to the infrastructure. She has investigated

several issues with regard to system performance, including development of new details, repair and retrofitting methods, corrosion, freeze-thaw durability, connections and experimental techniques. Typical research contributions in this area include: Determination of the effective slab width of a T-beam subjected to lateral loading; Effectiveness of techniques to repair moderate earthquake damage; Behavior of connections in precast



Dr. Catherine French

concrete frame buildings subjected to lateral loading; and Effective Force Testing (EFT). In the area of infrastructure research, Professor French has conducted materials research, as well as investigations on bridge systems. The objective of her studies is to investigate the integrity of current bridge systems in service, to develop repair techniques, to improve or prolong the life of bridge systems and to develop new materials and systems to improve the performance of new construction. One of Professor French's more exciting and interesting current research projects, which is a contribution to the field of earthquake engineering, is related to the development of a real time earthquake simulation technique, "Effective Force Testing." Her scholarly research activities are reflected in

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Graduate Student Profiles: Nick Lampe and Ahmed Elremaily



Nick Lampe

Nick is pursuing his M.S. Degree in Structural Engineering at the University of Nebraska-Lincoln, under the supervision of Dr. Atorod Azizinamini. He expects to complete graduation degree requirements by August 2000. He has accepted a Bridge Engineering position with HDR, Inc. in Omaha, NE starting August of 2000. Nick's thesis is related to the development of a

cost effective steel bridge system. In this concept, the bridge behaves as a simple span for dead loads and continuity over the support are provided only for live loads. The continuity for live loads is achieved by placing reinforcing bars over the pier, a concept similar to that used in construction of continuous prestress girder bridges. A major component of Nick's research is the development of an economical detail over the pier. Two full-scale test specimens are being fabricated and he will be testing both specimens during the summer of 2000. These tests will provide experimental data that will be used to finalize the design criteria for the new bridge system. Various tests to be conducted will include conducting fatigue tests as well as ultimate load tests. Nick's research also includes conducting linear and non-linear finite element analysis and carrying out a series of designs for evaluating the relative economy offered by rolled shapes and plate girders.

Outside of school, Nick enjoys spending time with his wife of 5 months Brannan, attending tractor pulling events in the summer months and helping out on the family farm in Falls City, NE. Nick's greatest asset is his dedication and work habit. He is a sharp, very diligent and extremely reliable graduate student. He possess all the characteristics that will ensure his future success as a design professional. He is looking forward to the start of his professional career with HDR in Omaha, Nebraska.



Ahmed Elremaily

Congratulations to Dr. Ahmed Elremaily, one of NaBRO's graduate students who recently (May 2000) completed his Ph.D. requirements in Structural Engineering at the University of Nebraska-Lincoln while working under the supervision of Dr. Atorod Azizinamini. Dr. Elremaily has perhaps one of the most diversified backgrounds among recent graduates of

NaBRO. His dissertation topic is related to the development of a connection detail suitable for connecting steel beams to concrete filled tubes in highly seismic areas for high rise buildings. The project was funded by the National Science Foundation and was part of the U.S.-Japan cooperative work in earthquake engineering on composite structures. His investigation included conducting analytical, numerical and experimental tasks. He tested six full scale concrete filled tube columns, results of which were used to develop a analytical model capable of predicting load carrying capacity of concrete filled tube beam columns. The experimental investigation also included testing eight full-scale connection specimens for the purpose of identifying failure modes and developing design provisions. Ahmed's extensive background in earthquake engineering suited him well in conducting his research. His research required carrying out numerous linear and non-linear time history dynamic analyses of high rise buildings. He used results of these analyses in establishing the force and ductility demands for the connection and making sure that his suggested connection detail met the strength and ductility requirements.

While completing his Ph.D., Ahmed also worked for two years, as a research associate for NaBRO. This provided him with the opportunity of learning and practicing bridge engineering. During this period, he conducted various bridge-related projects, drafted reports and journal papers and assisted in proposal writing activities. Ahmed's extensive background in seismic behavior of buildings and bridge design gives him a very unique combination of expertise that one could only expect from a very experienced structural engineer. He is very mature, calm, sharp and professional in his approach and is a very pleasant individual to work with. Ahmed is also a Registered Professional Engineer in the State of Nebraska.

NaBRO Research Highlight: Monitoring Staged Construction of Dodge Street Bridge

Staged construction is a very common technique used in replacing older bridges. The main advantage of this technique is allowing a minimum flow of traffic on the existing one-half of the bridge while the other half is under construction. After construction of the two portions is completed, the portions are then joined together by pouring concrete along the closure points. Usually differences in the girder deflection of the completed deck sections are observed due to shrinkage and creep deflections that take place over different periods of construction. This makes matching the final elevation of the two adjacent concrete decks a challenging task. This problem is more pronounced with steel bridges. Moreover, transverse and longitudinal cracks are often observed over the closure points resulting in premature deterioration of the bridge deck.

The Dodge St. Bridge over I-480 in Omaha, NE, designed by the Nebraska Department of Roads (NDOR) uses staged construction. The NaBRO research team has instrumented the bridge with over 90 sensors and has been constantly monitoring its movements from the start through different stages of construction. The instrumentation is part of an extensive research effort funded by NDOR and FHWA. The overall objective of this project is the development of a manual that could be used to eliminate the problems observed with construction of steel bridges using the staged construction technique. Mr. John Swendroski is the lead graduate student of the project. He is a M.S. student and the findings of this research project will constitute his thesis. Mr. Majid Sarraf, NaBRO Research Assistant Professor is the Co-P.I. of the project. Dr. Azizinamini is directing the project. Dr. Kazem Moslem, a visiting scholar at NaBRO is also assisting in the project by developing a computer program for predicting the time dependent deflection of continuous composite plate girders.



Dodge Street Bridge over I-480 in Omaha, Nebraska:
Staged Construction in Progress.

👉 PAST EVENT 👈

“Recent Advances in Steel Bridge Design and Construction with Emphasis on High Performance Steel” Conference Highlights

This very successful, two-day conference with emphasis on design and construction issues was organized and held by NaBRO at the Embassy Suites Hotel in Kansas City, MO in November 1999. During the 2-day conference, more than 180 design professionals representing state and federal agencies, fabricators, contractors, steel producers and academia exchanged ideas about new innovations and trends to be seen in the design and construction of steel bridges. Attendees from more than 20 different states benefited from 27 oral presentations and two panel discussions. The future of steel bridges and the need for further research in the area of high performance steel were among the key themes of discussion.

The first conference on a similar subject was held in October 1997 in Lincoln, NE, where approximately 120 design professionals participated. In the 1997 conference, the use of High Performance Steel (HPS) was in its infancy and one could note the feeling of a wait and see approach on the part of bridge owners. At the time, Tennessee and Nebraska were the only states to use HPS in bridge construction and other states were evaluating the outcome of Nebraska and Tennessee’s experience before they were to follow the path. The feeling that one got from the 1999 conference in Kansas City was drastically different. This time, the State Department’s of Transportation were showcasing their achievements and presenting their HPS projects.

The conference was co-sponsored by the American Iron and Steel Institute (AISI), Federal Highway Administration (FHWA), National Steel Bridge Alliance (NSBA), Mid-America Transportation Center (MATC) and the Nebraska Department of Roads (NDOR).

The next HPS conference is scheduled for November 30 and December 1, 2000 in Baltimore, MD.



Visit www.NaBRO.unl.edu for more information, announcements, message board and links to interesting bridge web sites.

NaBRO Affiliated Researcher Profile: Dr. Catherine French, University of Minnesota

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her extensive publication record, presentations and student supervision. She is the author or co-author of over fifty publications in refereed journals and conference proceedings.

Her dedication to the profession and service to the engineering community is exemplary and is evident in her involvement to a number of professional activities. She is a member of the ACI 318 building committee, which is a milestone for any structural engineer. She is also a member of the ACI Board of Directors. She is a member of several other ACI committees, which include the ASCE-ACI Committee 445 on shear and torsion, the ASCE-ACI

committee 423 on prestressed concrete, the ACI committee 408 on bond and development of reinforcement, the ACI 374 committee on performance-based seismic design of concrete buildings and the joint ASCE-ACI 352 committee on monolithic joints. Dr. French is also a member of the PCI high strength concrete and seismic committees, the TRB AC203 concrete bridge committee, the Earthquake Engineering Research Institute (EERI) and the International Association of Bridge and Structural Engineering. She has served as president of the ASCE Minnesota section and ACI Minnesota-Iowa section.

Professor French has been recognized by her peers for her outstanding contributions in the

profession and as an effective educator. She is the recipient of a number of awards and fellowships including the Distinguished Mentor Award; Erskine and Fullbright fellowships; Bonestroo, Rosene, Anderlik, and Associates Undergraduate Faculty Award; ASCE Raymond C. Reese Research Prize; NSF Faculty Award for Women and Presidential Young Investigator Award and ASCE Edmund Friedman Young Engineer Award for Professional Achievement.

The civil engineering profession has benefited greatly from the contributions of Dr. French and at NaBRO we are very proud to be affiliated with such an outstanding educator and researcher.



NaBRO

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