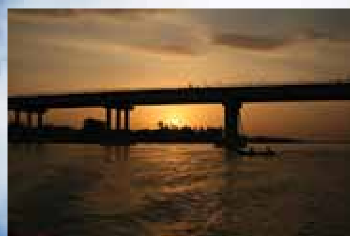
Pittsburgh
ENGINEER

SUMMER 2011

Quarterly Publication of the Engineers' Society of Western Pennsylvania

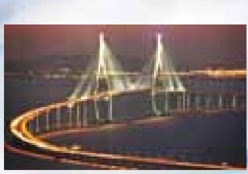



SPECIAL IBC ISSUE: Bridges without Borders

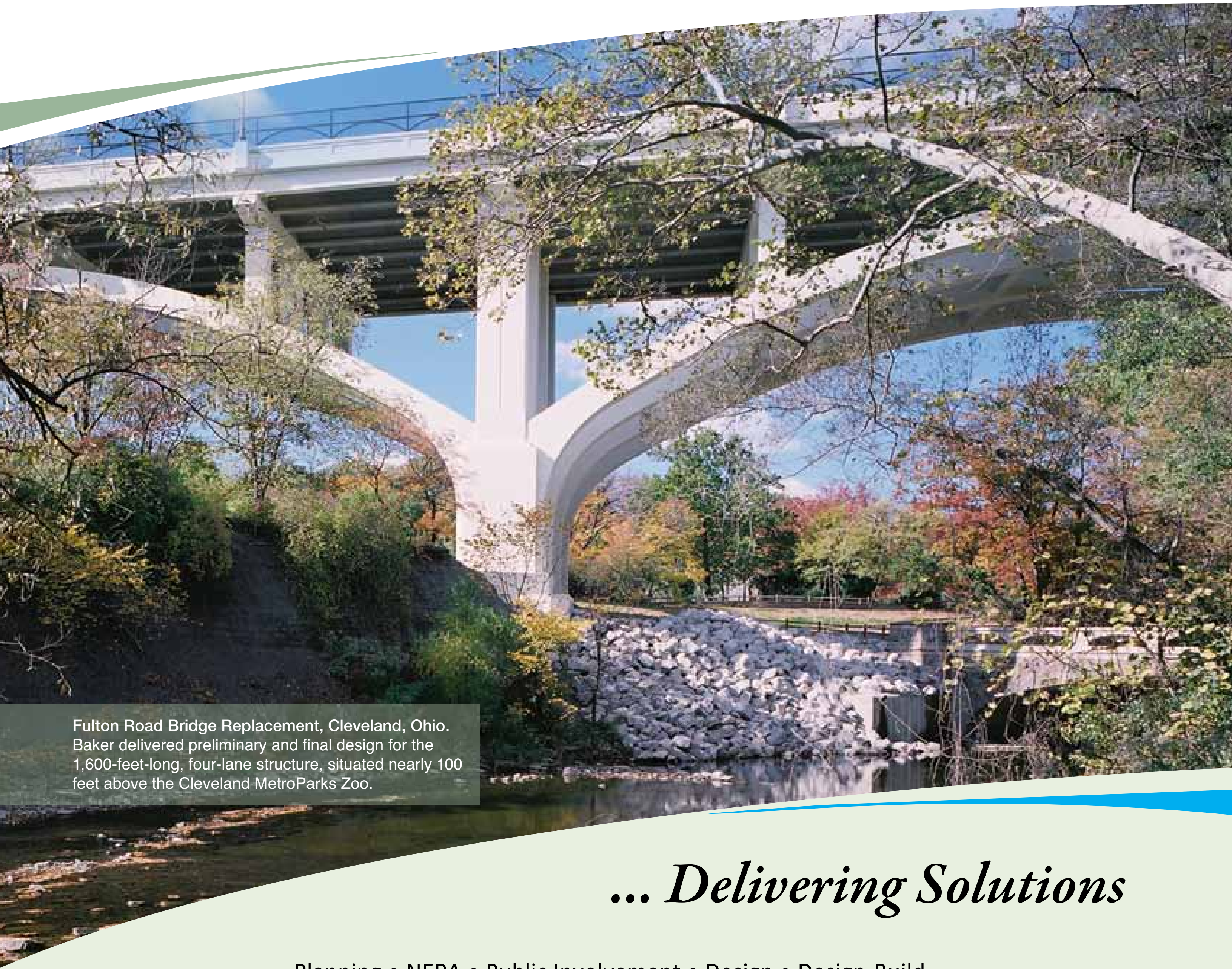








Fulton Road Bridge Replacement, Cleveland, Ohio. Baker delivered preliminary and final design for the 1,600-feet-long, four-lane structure, situated nearly 100 feet above the Cleveland MetroParks Zoo.

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In this issue...

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Guest Editor Column

We Are Global Citizens

By Thomas G. Leech, P.E., S.E. and George Horas, P.E.

Every day, our world seems smaller and smaller and borders vanish. Events, which occur a hemisphere away, can be viewed in real time daily. News is brought to us instantaneously on cable television. We buy products where the raw materials are processed in one continent and manufactured in another. Through the internet, we interact with colleagues not only in our own county, but in many cases, throughout the world. Through conferences, such as the International Bridge Conference®, we interact personally with colleagues from around the globe. Our universities now train our students to think globally.

As we look around, we see surface transportation and transit systems being constructed in all corners of the globe, each with their own unique signature. We see highway systems blossoming in developing countries; many of which have dual language signage. We see the emergence of high speed rail as a primary inter-city surface transportation mode in Asia.

As we look closer at these surface transportation systems throughout the world, we see bridges, many with expressions unique to the countries where they reside. We see bridges that express distinctly European character; we see futuristic bridges that now separately define the Middle East and Asian character. We see architectural expressions in pedestrian bridges worldwide that defy norms and express unique symbolism with intriguing forms that capture distinct images which resonate in changing light and shadow conditions.

As the Engineers' Society of Western Pennsylvania prepares for the 28th Annual International Bridge Conference®, we will welcome the Republic of Korea as our "featured country" of this year's conference. Some of the photos of the bridges that grace the cover of this magazine are unique Korean expressions, all within the city of Seoul, South Korea. Other photos reflect separately unique expressions from Europe, Asia and other locales. And with this issue of the Pittsburgh Engineer, we look to the globe for our contributing authors and topics.

This issue of the Special Edition of the *Pittsburgh Engineer* takes a global perspective as we look for bridges beyond our own borders…hence *Bridges without Borders* is the theme for our magazine and the 2011 IBC as well. As you read through the many articles of this edition, authored by global contributors, you will view bridges and transportation systems in North America, in Europe, in Asia, in the Middle East, in Africa and in far away islands such as New Zealand. This edition will not only survey bridges from many continents but raise your awareness of the uniqueness of the geography and landscape that continually challenge bridge engineers worldwide.

Enjoy the cultural experience as you read and digest the contributions of the many authors. Imagine bridge engineering on a global scale. And enjoy the many pictures of bridges from around the world.

Thomas G. Leech, P.E., S.E.
Gannett Fleming, Inc.

George M. Horas, P.E.
alfred benesch & company

Chairman's Welcome

By Thomas J. Vena, P.E.

As the General Chairman of the 28th Annual International Bridge Conference, (IBC), I am pleased to welcome all of you to Pittsburgh, Pennsylvania. The IBC Executive Committee has worked diligently to develop an outstanding conference program. Our goal was to provide a broad spectrum of bridge engineering that covers all aspects of the practice. The program contains topics in design, construction, inspection, testing, rehabilitation, preservation, replacement and much more. The conference provides an environment of many opportunities for participants to share and learn from each other in all areas of the bridge engineering practice, educational seminars have been chosen to provide participants with timely learning in the design and construction of the Hoover Dam by pass bridge, AASHTO/FWHA highway tunnel domestic scan, Geothermal energy pile system and moving from bridge inspector to management, presented by the FHWA/AASHTO. You will find this conference to be educational, informative, practical and innovative.

The Engineers' Society of Western Pennsylvania (ESWP) is the primary sponsor for the IBC. The conference is assembled by the volunteer efforts of the IBC Executive Committee, which is composed of bridge owners, designers, constructors, manufacturers, suppliers and educators. The IBC Executive Committee along with the ESWP staff has spent many hours developing an outstanding program. Our objective is to always provide the attendee with the highest quality and practical value that is available. Last year's conference attracted more than 1,600 bridge professionals from over 40 states and 20 countries, and we have planned for similar attendance at this year's conference.

The theme of this year's conference is "*Bridges without Borders.*" This theme is reflected in the many outstanding papers that we have received from authors all over the world. We are grateful that the authors are willing to share their ideas and allow us all to benefit from the shared knowledge. The technical program is the heart and soul of the IBC and it is comprised of 75 technical papers that were selected from nearly 200 abstracts.

We are pleased to start this year's conference with an outstanding group of keynote speakers, featuring nationally known leaders, including:

- Al Engel, Vice-President of Amtrak, Washington, D.C.
- Andrew Herrmann, P.E., ASCE President,Washington, DC
- Bob Luffy, former CEO, American Bridge Company, Pittsburgh,PA
- Malcolm T. Kerley, P.E., AASHTO, Richmond, VA
- M. Myint Lwin, P.E., S.E., Director, Office of Bridge Technology (HIBT), Federal Highway Administration, Washington, DC
- Hyeong-Ryeol KIM, Ph.D., P.E., Director General, Road Policy Bureau, Ministry of Land, Transport and Maritime Affairs (MLTM), Republic of Korea

We are honored to have the Republic of Korea at the 28th Annual IBC as our "Featured Country." This years featured country session will include a keynote lecture by the Director General for Road Policies of Korean Government, a state-of the art presentation on specific bridges in completion or near completion in 2011 and the special country exhibition featuring recent vibrant activities of Korean construction technology and industry.

Thomas J. Vena, P.E.
2011 IBC General Chair

This year we will also be offering Seminars, Workshops and Special Interest Sessions to keep you current with the latest technology advancements in the world of bridge engineering. We will again be offering our annual Bus Tour on Tuesday afternoon, and it will highlight some current bridge construction projects in the Pittsburgh area. These tours fill up quick, advance reservations are recommended. A full schedule can be found on our website at internationalbridgeconference.org

The 2011 IBC Exhibitor's Hall will be integrated similarly to the 2010 Exhibitor's Hall with some minor upgrades to make your experience better and more productive. We have enhanced networking opportunities for all the attendees; the Technical Sessions will be located in rooms within the exhibit hall itself. This will allow plenty of time for exhibitors and conference attendees to interact between sessions, coffee breaks and lunchtimes. We are anticipating an even larger hall of exhibitors of more than 200 and we encourage you to take the time to visit with them and see what they have to offer.

We are looking forward to setting record attendance of more than 1,600 attendees and as always we greatly appreciate your attendance and your contributions to the professional.

For those of you who are considering attending the IBC for the first time, we trust that you will find the Conference a rewarding and exciting educational experience, as have many thousands before you.

For those who have attended the IBC previously, we eagerly anticipate your return to Pittsburgh to make this June's Conference truly profitable and memorable for you. Come and learn about the latest developments in the bridge industry and take advantage of the networking opportunities that occur at the IBC and its related functions. On behalf of the entire IBC Executive Committee, I welcome you to the 28th Annual International Bridge Conference®.

Thomas J. Vena, P.E. is the General Chair of the 2011 International Bridge Conference®, and the Vice President of Operations for A&A Consultants Inc.

Counterpart to Korean History – The Han River Bridges

by Dr. Sung Il Jo

Seogang Bridge

Seoul, capital of South Korea, is one of the worldwide cities that has grown most rapidly and innovatively during past century. It is a miracle that Seoul is ranked 10th place in Business Week's 'Top Global Cities 2010' just 50 years after the devastating Korean War. What astonishes us more is the fact that this miraculous rise from ruins to a city of worldwide attraction spawned a significant impact on bridge construction over the Han River, the river flowing from east to west through Seoul. The Han River affords beautiful and comfortable leisure parks for the people to be in harmony with urban nature. The river penetrates metropolitan Seoul, splitting the city into two separate regions, Kangnam ("south") and Kangbuk ("north"). It is also a milestone for the past 50 years when Seoul has emerged from industrialization to the cutting-edge IT era. There are 31 bridges spanning the Han River, including two bridges currently under construction. Now, let's meet some pieces of art which allied last century's "miracle of the Han River", from the Han River Iron Bridge (1900) to the World Cup Bridge (2015).

First Masterpiece that Overcame the Agony of War – the Han River Iron Bridge

The Han River Iron Bridge (1900) is the first bridge built across the Han River that carries intact the sorrow of Korean War and it's modernization. While starting with a single line of steel trusses when first constructed , it was expanded to 3 lines in 1944, and expanded to 4 lines in 1995 by accelerated modernization. In June 1950, during the outbreak of Korean War, this bridge was the only way to cross the Han River besides ferry boats and it was destroyed. However, it was restored in 1957 by overcoming the hardship of war and it played a pivotal role in South Korea's industrialization. In 2006, it was registered as a modern cultural heritage because the bridge shared Korea's past historical adversities and current prosperity. Overall, the Han River Iron Bridge, which has been linking Han River for more than a century, is a magnificent product illustrating Korea's modern era.

Miracle of Han River begins – Yanghwa Bridge

During first 3 years of the Korean War, almost everything was destroyed in the Korean peninsula. However in 1965, less than a decade since the truce, the Korean economy had already burgeoned up to a 10% annual growth rate and with this comes the commencement of Korea's recent bridge history, starting with the Yanghwa Bridge. The Yanghwa Bridge (Jan 1965) is the first bridge traversing the Han River built by Korean engineers under supervision of HDEC (Hyundai Engineering and Construction Co., Ltd). The superstructure is composed of 3-span continuous girders. Caissons were mainly used for it's foundations along with some spread footings. Afterwards, there were numerous constructions across the Han River. Starting with the Yanghwa Bridge, 16 new bridge constructions were carried out through 1990 demonstrating a significant commitment to the nation's civil works. For instance, modern technologies besides simple labor were not available in 1900's. But with immense economic growth and development in civil engineering, outstanding progress was made in the field of design and construction of state-of-the-art bridges such as cable-stayed bridges and suspension bridges.

A New Takeoff Through Olympic Games – Olympic Bridge

The world festival, the 1988 Olympic Games, was held at Seoul. Spectators from all around the world were astonished with the 'Han River's miracle' which overcame grief and hardship so quickly since the Korean War. Suddenly, South Korea was one of the rapidly developing countries in the world that went through tremendous growth in every sector. The Olympic Bridge (1990) was built to commemorate 1988 Seoul Olympics and South Korea's renaissance. The bridge has a total length of 1,225m, a width of 32m, and four 88m pylons which stands for the 1988 Olympics while 24 cables symbolize the 24th summer Olympic event.

Olympic Bridge

Improving Bridge's Safety Grade – Wonhyo Bridge

During the industrial boom from 1960 to 1970, most bridges were constructed as Grade II bridges (with a maximum vehicle load of 32.4t). Heavy trucks rapidly increased due to economic growth which inevitably lead to the introduction of Grade I bridges (with a maximum vehicle load of 43.2t). The WonHyo Bridge is Korea's initial Grade II bridge using the DYWIDAG method. This method's drawback is the minor deflection in central spans. Inspection in 1993 showed this defection exceeded the acceptable range. After installing additional PT strands in the upper part of concrete box girders, it was upgraded into a new Grade I bridge.

Eco-friendly Construction – Seogang Bridge

Civil work should be performed with minimal damage and pollution to the natural environment. Emphasis should be placed on the prevention of water contamination when constructing bridges across a river. The Seogang Bridge(1996) used the ILM(Incremental Launching Method) from the starting point to Bamseom island for a total length of 960m so that water of Han River and northern Bamseom island (a huge habitat of migratory birds) was preserved. The Nielson Arch method, with a total length of 150m, displays a gorgeous appearance. It was assembled on a land factory located near the construction site using material transported from remote factories. Since work in the water was drastically reduced, more concentration on quality and safety of the bridge could be achieved. In particular, the newly adapted construction method, 'Floating heavy lifting', used the natural force of tidal wind. This epoch-making, eco-friendly event was the first in Korea showing huge advancement in technology.

Messenger Between Culture, Art, and Nature – Banpo Bridge, Gwangjin Bridge

A new role was recently given to the bridges across Han River. In addition to just a linkage between lands divided by water as in the past, great artistic value that mingles urban city to nature was addressed. In 2009, the Moonlight Rainbow Fountain was added to Banpo Bridge which, as a cultural affair connected the infrastructure to Seoul citizens. Five splendid colors of water are pumped out 5 to8 times daily accompanied with grandiose classical music. The water at least gives a slight breeze from the suffocating heat of the Korean capital. The Banpo Bridge (1982) is a steel double-deck bridge, 1,490m long and 25m wide. Along with Kangnam region's urban development, the purpose of this bridge was to make Seoul's overall traffic flexible and efficient by connecting the Seoul-Busan highway to the center of Seoul. The 'Bridge You Wanna Walk' attached to the Gwangjin Bridge, furnished sidewalks to make it more people-oriented and therefore enabling folks to harmoniously interact with nature. The Gwangjin Bridge was rehabilitated in 2003 from the old bridge built in 1936. It is formed as a steel box girder with a 1,056m length and 20m width. Gwangjin's 'Bridge You Wanna Walk' project was implemented in 2009 by reducing four-lane roads to two-lanes. Renovation that brought larger pedestrian sidewalks, benches, and set up of an observation platform made the bridge more attractive. After a year, this fabulous bridge has now become the Times Square of Seoul enabling citizens to communicate between culture, art, and nature .

New Challenge for 21st Century – Gayang, Amsa, and World Cup Bridge.

The simply shaped Gayang Bridge was completed in 2002 when all Koreans were enchanted with the World Cup tournaments. It is the second longest steel-deck bridge in the world with a maximum continuous span length of 400m . During World Cup 2002, newly installed panorama lighting on the bridge enraptured many tourists. The Amsa Bridge which is expected to be completed in 2013, has a '3 span continuous half-through arch' system. By using 23,000 tons of steel, a span length of 323m will be achieved for the steel-deck of main bridge. The construction area of Amsa Bridge is located in (the dry) waterworks reserve with many 'fragmental zones of fault' forming the stratum. As a result, a new technique called 'steel caisson tube method' will be used for the pier foundations, which will provide a perfect quality of foundation and will eradicate water contamination due to the erection performed in dry riverbed. Similar to the Seogang Bridge, the Amsa Bridge will also apply the 'Floating heavy lifting' method to set up the arch core. The World Cup Bridge (2015) will be an asymmetric hybrid cable-stayed bridge that will have the longest main span (540m) on the Han River. In addition, the 100m tall pylon with 78 degree inclination will form a particular elegance. While the lofty pylon represents the gateway to Seoul, the World Cup Bridge's main theme is consolidation of old tradition to new millennium. The Han River bridges in the 21st century are taking off to the next stage with advanced techniques, nature-friendliness, and elegance.

New Millennium's Takeoff – Change and Development

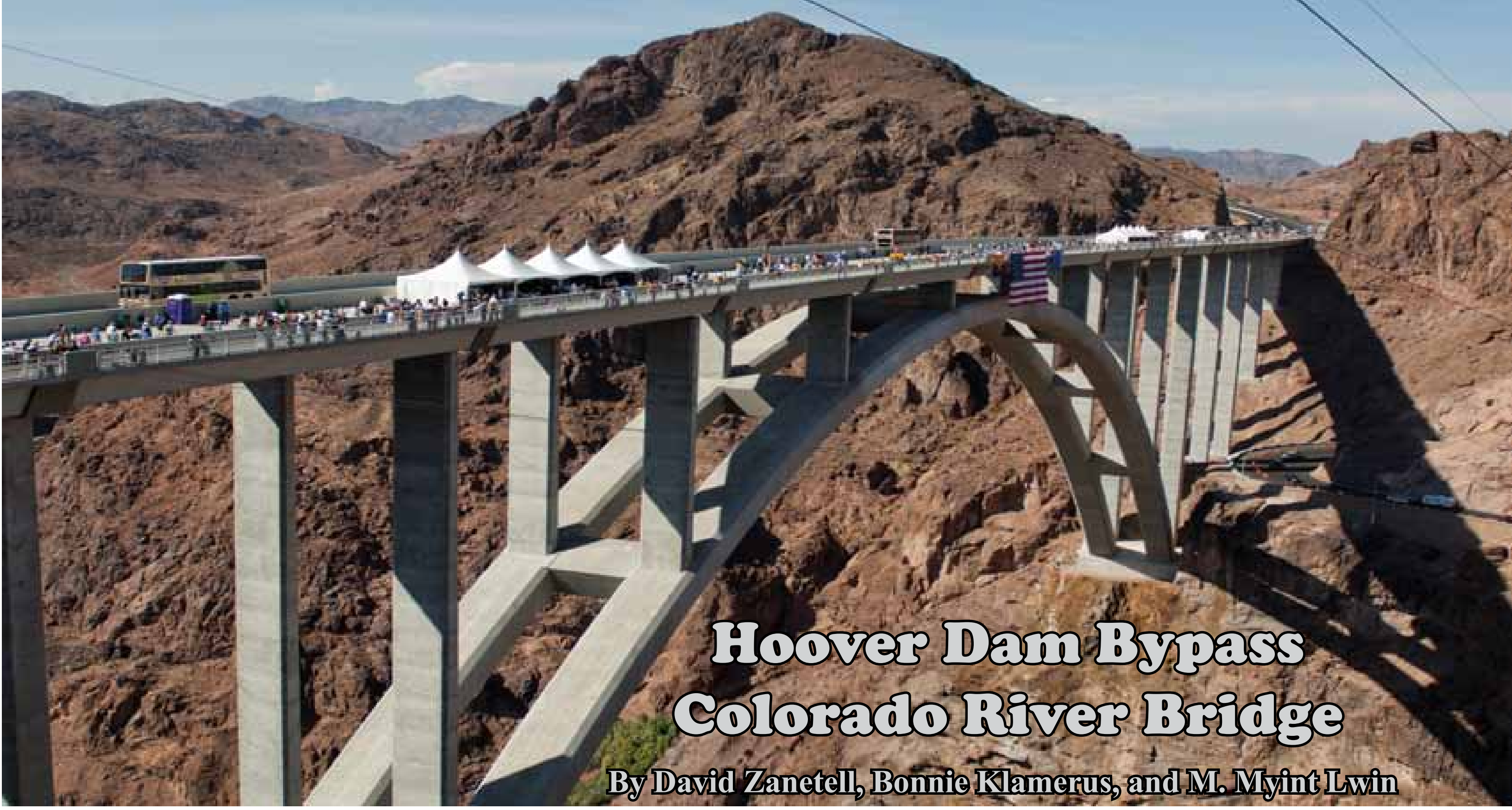
Beginning from renaissance of modernization (early 1900s) to the Korean War (1950) and the 1988 Olympic Games, the Han River went through many waves of change. Folks got busy as a bee, incessant urban development went on, and it superficially seemed like a better quality of life. However, they were not able to keep composure and happiness like before. Unlike the past when they were only aiming economic growth, Seoul is on a different journey these days. Seoul city's 'Han River renaissance' project envisages a far-reaching transformation pointing to culture, and nature. It connects people to flowers and trees where it used to be all concrete floors; it encourages people to ride bikes instead of vehicles so that we can breathe every minute of Seoul's nature, art, and urban life.


World Cup Bridge

In addition to the graceful sites mentioned earlier, the Han River is now emerging as one of most representative recreation parks for millions of Seoul citizens. Similar to when the Han River Iron Bridge (1900) was first built, we eagerly look forward to the sensation these bridges will bring in new millennium.


Hangang Iron Bridge

Dr. Sung Il Jo is the director-general in Seoul Metropolitan Government, South Korea and is responsible for planning and construction of new roads in Seoul, as well as responsible for the maintenance and management of existing road facilities such as bridges, viaducts and tunnels. Dr. Jo has participated in a number of bridge construction projects since 1992 including the Seogang Bridgeand the Gayang Bridge over the Han River. Recently, Dr. Jo worked for the Office of the President in South Korea as a Deputy Secretary to the President for Land and Maritime Affairs.



Hoover Dam Bypass Colorado River Bridge

By David Zanetell, Bonnie Klamerus, and M. Myint Lwin

Communities came out to celebrate the completion of the new bridge (Photo courtesy of the Federal Highway Administration, Central Federal Lands)

Official Name of the Bridge

The United States Congress officially named the new Hoover Dam Bypass Bridge the “Mike O’Callaghan-Pat Tillman Memorial Bridge” after two prominent local citizens who dedicated themselves to public service and the greater good. Mike O’Callaghan was a longtime Nevadan, former Governor, community leader, war hero, and businessman. He died in March 2004 at the age of 74. Pat Tillman graduated with honors from Arizona State University and played professional football for the Arizona Cardinals before joining the Army. He was killed in Afghanistan in 2004 at the age of 27.

Project Teams

Teamwork was a critical factor in the success of the $240 million Hoover Dam Bypass Project. With U.S. 93 crossing the boundary between Nevada and Arizona on federally-owned lands, the project location demanded a multi-agency team comprised of FHWA, the land management agencies, and both states. From 1997 through the project’s opening in October 2010, the Federal Highway Administration’s Central Federal Lands Highway Division (CFLHD) led the complex, fast-paced project completing the environmental process, selecting a world-class consultant team, and managing design and construction of all elements of the project, including the Colorado River Bridge..

A Project Management team composed of high-level agency representatives served as the conduit to their respective agencies and was empowered to make key decisions to advance the project goals in a timely manner. The team was comprised of members from Central Federal Lands Highway Division, Federal Highway Administration, the States of Arizona and Nevada, Bureau of Reclamation, Western Area Power Administration, and the National Park Service.

Led by CFLHD, aesthetic and cultural guidance was the purview of the Design Advisory Panel with representatives from the Project Management Team, State Historic Preservation Offices of Arizona and Nevada, Advisory Council in Historic Preservation, National Historic Landmark Coordinator, Native American Tribal Representatives and historic architects

Led by HDR Engineering, Inc., the project consultant team developed the mon iker, Hoover Support Team, and was responsible for engineering design, technical expertise and construction RFI support to CFLHD on the project. Members from HDR, Sverdrup Civil, Inc. (currently Jacobs Engineering, Inc.), T.Y. Lin International and numerous sub-consultants comprised the team. PB Americas and PBS&J Constructors lent construction inspection and support to the project.

> “We are all honored to have been a part of this historic project. Completing a project that was once thought impossible on budget represents the best of who we are as engineers and as an industry. Nothing is impossible if we align our skills to a common goal.”
> ...Dave Zanetell, Hoover Dam Bypass Project Manager.

Public Outreach

The Hoover Dam Bypass was a high-profile project from the start. The environmental studies engaged public comment on the project’s impact in the region and its benefits to transportation and commerce between the north and south U.S, borders. During project development, design and construction, the goal was community and public awareness. From 2001 to 2010, a total of twelve published newsletters were mailed to hundreds of people on the mailing list at regular intervals during the design and construction of the project. The newsletters briefed the public on the latest happenings. In addition, the project team developed a public website, www.hooverdambypass.org, to house background material and up-to-date information for public use. Updates regarding schedule, design decisions, construction progress, traffic impacts, and more were regularly posted on the site. Monthly construction photos were uploaded to the site for public use and viewing and included descriptions of the work. An avenue for public email comments was also available on the site.

The world watched the construction of the bridge on the project website via web cameras perched atop the canyon walls at each end. Daily time-lapse photos of various views afforded the public film clips of the progressing work. Using the cameras, viewers were also able to capture their own shots and post photos on the website with comments forming an interesting assembly of views and viewpoints.


The Bridge with the Hoover Dam in the Background

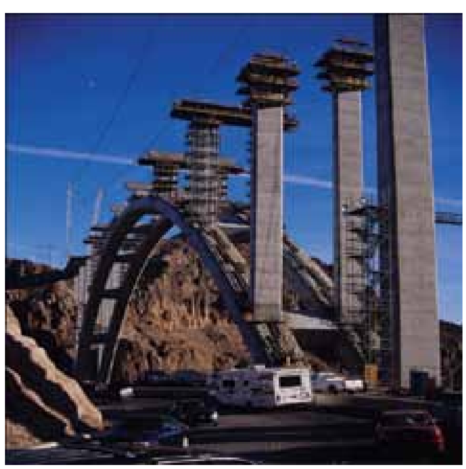
Project Background

Prior to the completion of the new bridge, the existing route used the top of Hoover Dam to cross the Colorado River. U.S. 93 is the major commercial corridor between the states of Arizona, Nevada, and Utah; it is also on the North American Free Trade Agreement (NAFTA) route between Mexico and Canada. U.S. 93 was identified as a high priority corridor in the National Highway System Designation Act of 1995. The traffic congestion caused by the inadequacy of the existing highway across the dam imposed a serious economic burden on the states of Arizona, Nevada, and Utah.


Cable supported construction of the twin rib concrete arches

The traffic volumes, combined with the sharp curves on U.S. 93 in the vicinity of Hoover Dam, created a potentially dangerous situation. A major catastrophe could occur, involving innocent bystanders, millions of dollars in property damage to the dam and its facilities, contamination of the waters of Lake Mead or the Colorado River, and interruption of the power and water supply for people in the Southwest.

By developing an alternate crossing of the river near Hoover Dam, through-vehicle and truck traffic are removed from the top of the dam. This new route eliminates the problems with the former highway--sharp turns, narrow roadways, inadequate shoulders, poor sight distance, and low travel speeds.


Spandrel columns constructed on the concrete arches

Design work on the Hoover Dam Bypass Project began in August 2001. The 3.5-mile long project was parceled into 6 separate yet overlapping construction contracts, including the Colorado River Bridge project. The new alignment is located approximately 1,500 feet downstream of the Hoover Dam.

Design Features

The type study for the Hoover Dam Bypass Colorado River Bridge was developed by the Design Team comprised of Central Federal Lands Highway Division (CFLHD) and the Hoover Support Team consultants, with guidance from the project stakeholders: the Federal Highway Administration, the Arizona Department of Transportation, the Nevada Department of Transportation, the Bureau of Reclamation, the National Park Service and the Western Area Power Administration. The public had the opportunity to comment on various bridge alternatives through the project website and by casting ballots at the visitor center at Hoover Dam.

A two-phase type study process was used to first, narrow the candidates from all-feasible bridge types down to a deck arch bridge, and then to examine multiple deck arch options for a detailed type selection. Benefits in time and schedule were realized by eliminating extensive analysis of bridge concepts that were not technically or economically feasible and focusing on economizing features of the selected bridge type. As a result, a composite concrete-steel deck arch bridge was selected to address the specific design issues inherent to the Hoover Dam site. It was selected on the merits of cost, schedule, aesthetics, durability, low vulnerability, and technical excellence.

Key features of the Colorado River Bridge include twin concrete arch ribs, concrete columns and caps, steel struts between the ribs, structural steel box girder superstructure, and cast-in-place concrete deck. (Photo 1) The specific advantages of the concrete-steel composite design included the following:

- The concrete-steel composite alternative integrated the best of concrete and steel, using concrete in compression for the arches and columns, and lighter steel for the upper structures.
- The concrete-steel composite offered advantages for prefabrication and accelerated schedule.

Construction Features

The bridge construction contract was awarded in October of 2004 for $114M to Obayashi Corporation / PSM Construction USA, Inc. (Joint Venture). Construction began in early 2005 and was completed in August of 2010, on budget without dispute or claims. The bridge was opened to traffic on October 19, 2010.

The new 1,900 foot long Hoover Dam Bypass Colorado River Bridge spans the Black Canyon about 1,500 feet south of the Hoover Dam, connecting the Arizona and Nevada Approach highways nearly 900-feet above the river. (Photo 2) Twin arch ribs spanning 1060 feet form the longest concrete arch in the western hemisphere. At nearly 300 feet, the precast columns are the tallest in the world (Photo 3). The roadway deck is supported on four structural steel tub girders per span, and a sidewalk is located on north side affording visitors a spectacular view of Hoover Dam.

Photo 4 – On October 14, 2010, Dignitaries dedicated the Mike O'Callaghan-Pat Tillman Memorial Bridge.

The twin arches are comprised of 106 individual segments, 53 in each arch, and were cast approximately 24 feet at a time using a traveling form system. High-strength concrete with 56-day compressive strengths of 10,000 psi was required to handle the design and construction loads on each arch. A temporary cable supported system using pairs of 150-foot tall pylons connected to the deck above the ends of the arch anchored the forestay cables attached to alternating arch segments and the backstay cables running through concrete anchor blocks off each end of the bridge. As arch construction commenced from each side of the canyon, pre-fabricated structural steel struts were installed between the ribs at each spandrel column location. High-strength bars were used to post-tension the strut legs to the arch through ducts cast in the walls of the hollow arch.

The construction met very stringent environmental, design and quality assurance requirements. Because of their size, the arch and columns required integral engineering analysis to maintain tight tolerances. The arches were completed in August 2009 meeting within 3/8" of each other. After the temporary cables and towers were removed, precast segments forming the spandrel columns were set in a symmetrical pattern starting at the arch apex. In similar fashion, the tub girders were set symmetrically and post-tensioned across integral concrete pier caps.

Over 1,200 trade and craft workers have worked on the six bypass projects. One unique aspect of the Colorado River Bridge project was a 'high line' crane system used to transport concrete and steel bridge components, as well as workers and other materials. Photo Nos. 2 through 5 show the various stages of construction.

Dedication and Grand Opening

On October 14, 2010 dignitaries (Photo 4) dedicated the Mike O'Callaghan-Pat Tillman Memorial Bridge in a formal ceremony on the Hoover Dam Visitor Center observation deck while stakeholders, engineers, construction workers, and their families watched and cheered from the bridge deck. Hundreds of people stood under the hot sun to listen to inspiring speeches, watch the color guards, and the colorful tribal dance troops performing native dances.

On October 16, 2010, nearly 20,000 citizens from all parts of the world came to celebrate the completion of the bridge. Visitors had a chance to walk on the bridge, enjoy the majestic view of the iconic Hoover Dam and Lake Mead, and awesome scenic view of the Colorado River and the Black Canyon. The National Park Service set up tents on the bridge to exhibit and explain the wonders of Nature in the Lake Meade National Recreation Area.

Key Facts

Location	Hoover Dam Reservation Area Lake Mead National Recreation Area Clark County, Nevada Mohave County, Arizona
Carries	4 Lanes of U.S. Route 93 and a sidewalk
Crosses	The Colorado River at the Nevada/ Arizona state line
Owned By	Arizona Department of Transportation and Nevada Department of Transportation
Bridge Type	Concrete-Steel Composite Arch Bridge
Total Length	1,900 feet
Height	900 feet
Arch Span	1,060 feet
Construction End	October 14, 2010
Bypass Opened	October 19, 2010

Dave Zanetell is the Director of Engineering for the Central Federal Lands Highway Division of the FHWA and was the Hoover Dam Bypass Project Manager. Bonnie Klamerus is a structural engineer for Central Federal Lands Highway Division, FHWA. M. Myint Lwin, P.E., S.E. is the Director, Office of Bridge Technology (HIBT), Federal Highway Administration (Washington, D.C.)

The Hoover Dam Bypass Colorado River Bridge will receive the IBC 2011 Eugene C. Fig, Jr. Medal for Signature Bridges at the International Bridge Conference on June 7, 2011.

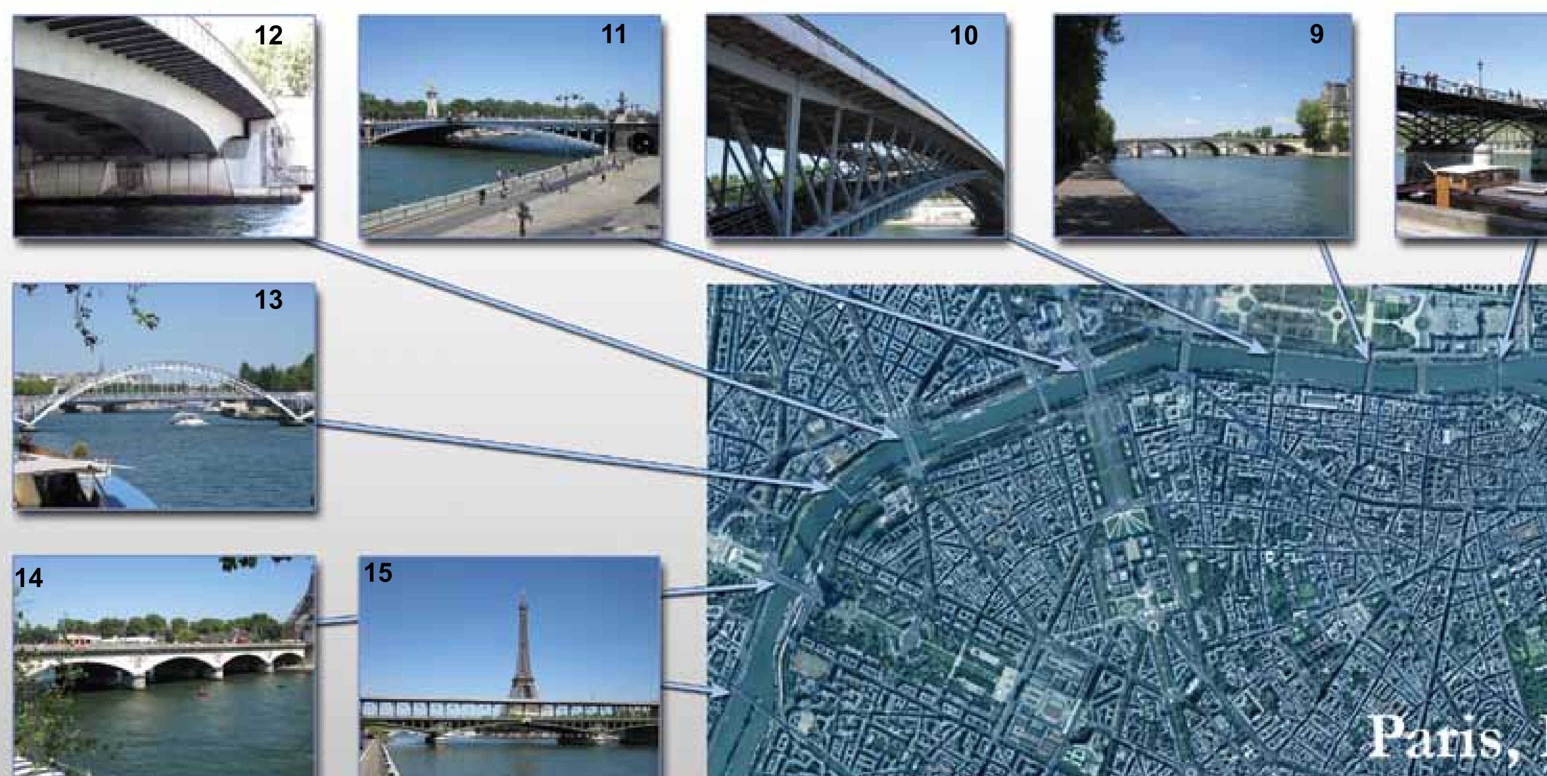
A Leisurely Walk Along the Seine River

Fifteen Beautiful Bridges of Paris… Engineering, Architecture & Arts

By Thomas G. Leech, P.E., S.E.

Take one sunny day, put on a pair of comfortable tennis shoes, prepare to walk five miles and see some of the most beautiful bridges in the world. Exit Paris's Metro line 6 near the eastern boundary of the city, amble downstream along the river bank and reenter Metro line 6 near the western boundary of the city. Along the way, enjoy fifteen of the most unique expressions of engineering, architecture and arts reflected in Parisian bridges.

The Seine River, with its headwaters at in the Langres plateau in eastern France, 50 miles from the Atlantic, meanders through the bowl shaped Paris Basin on its way to the sea. The Paris Basin lies in a relatively quiet tectonic region, and for millennia the Paris Basin has experienced rising and falling oceans through periods of global warming and cooling. The climax of epochs of glacial cooling was punctuated by the flow swift melt waters in the Seine that reduced the landscape to level terrain interrupted by small resistant promontory ridges. On a large island in the middle of the river, a small fishing village was born, bridges were built and then a large city arose. Today, as the Seine enters Paris, it flows under the most architecturally interesting and, in some cases, most historically



significant bridges in the world. Paris is called the City of Lights. It could equally be named the City of Beautiful Bridges.

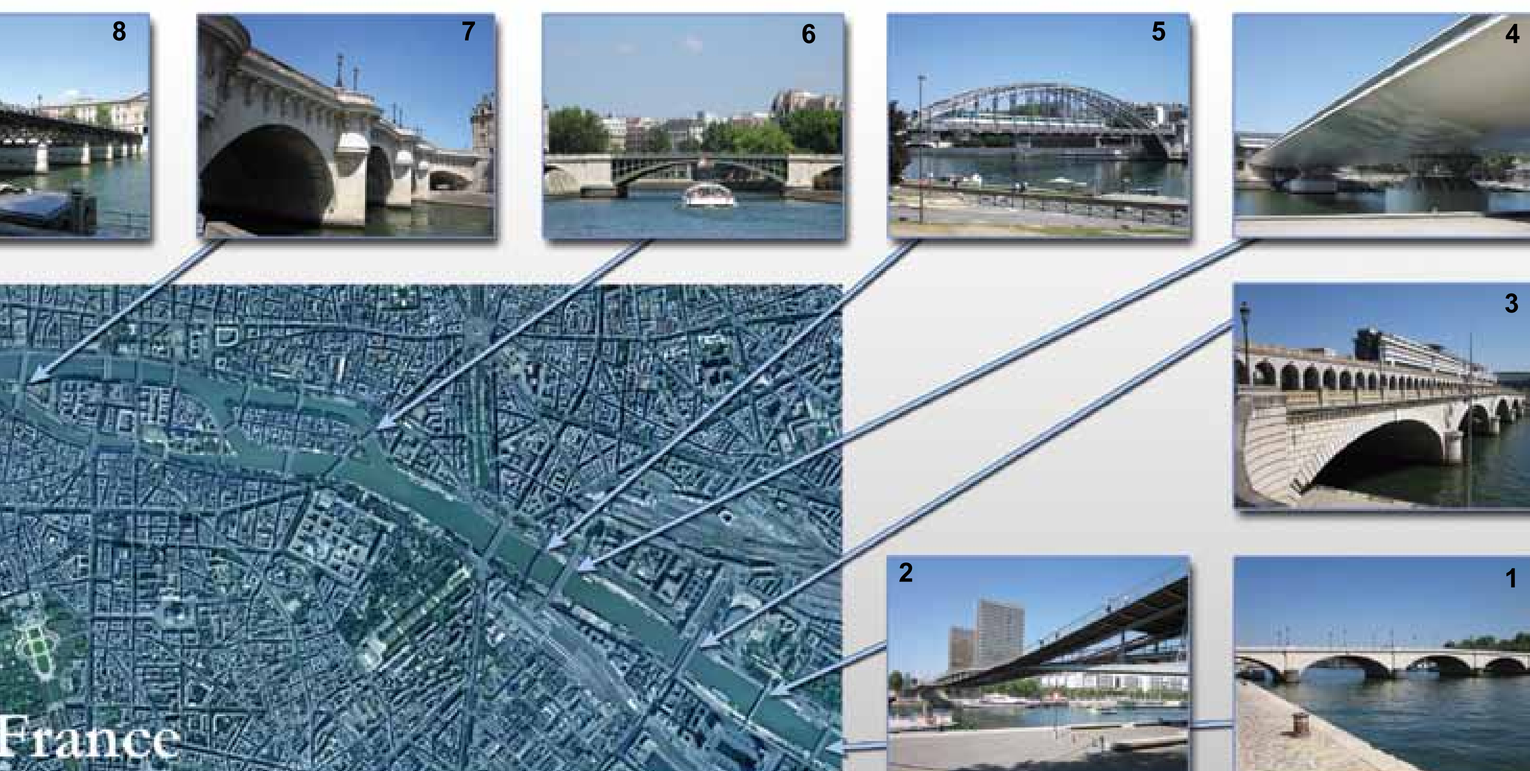
On the Left Bank of the Seine (heading downstream) lays the seat of French education and arts. On the Right Bank lays the seat of French government. The bridges spanning the Seine literally and symbolically link arts, education and government. The bridges of the Seine are a fusion of engineering, architecture and arts combining well proportioned structural forms, grace and symbolism.

While geography has provided the location for the bridges of the Seine, history has provided rich context for an understanding of the fusion of form, art and symbolism of these bridges. It is believed that a settlement on the site of modern-day Paris was founded about 250 BC by a Celtic tribe called the Parisii, who established a fishing village traditionally assumed be located on the Île de la Cité, the largest island on the Seine within the city. Since that time the city has developed and prospered. While images of the Bastille, the guillotine and the first revolution of 1789 color our imagination as an emerging French Republic, there are other equally important dated milestones in history which have had a direct effect on the design of many of the Seine River Bridges. These milestones include the formation of modern Pairs in 1853 where, under Napoleon (III)'s rule, Prefect Baron Haussmann modernized the City to a drastic extent, demolishing much of the old city and replacing it with a network of wide, straight boulevards and radiating circuses. This was followed by the Third Republic, formed after the Prussian war of 1870 where the Belle Époque ("Beautiful Era") period began. This period was characterized by new technological and medical discoveries and optimisms, art nouveau architecture and artistic movements like impressionism, all of which had a direct influence on the bridges of that era and beyond.

Paris has 37 bridges which cross the Seine, of which four are pedestrian only and two are rail bridges. Three link Ile Saint-Louis (the smaller island), eight link Ile de la Cite (the larger island) and one links the two islands to each other. Fifteen of the bridges represent the finest expression of Parisan bridge architecture. To capture the best light on each of the bridges, let us begin the five mile walking tour starting in the mid-morning on the eastern side of Paris and travel from east to west. One half mile east of Metro Line 6 Station (Quai de la Gare), our walking journey begins as we walk along the orderly and well developed waterfront. On this small journey we will stop at fifteen beautiful bridge sites along the way.

Bridge No.l : Pont de Tolbiac – a robust, classically styled series of uniform masonry elliptical arches: The bridge was completed in 1882, built in a wave of urbanization of eastern Paris. The five-arched masonry bridge was constructed by the engineers Bernard and Pérouse after a more ambitious design by Gustave Eiffel was refused. It was hit by a downed British plane in 1943, but survives today unimpeded and ever beautiful.

Bridge No. 2: Simone de Beauvoir footbridge – a light and delicate steel, lenticular arch-stress ribbon which in illusion appears as if it is hanging without visible support: The lenticular structure with five separate walking levels was constructed by Eiffel Constructions métalliques in the Alsace. The central span of the bridge (named the peltinée) was transported by canal, through the North Sea, through the English Channel, then along the French rivers to its destination, and was hoisted in place in two hours on January 29, 2006, around three o'clock in the morning. The pedestrian bridge is named after France's first influential feminist.



Bridge No. 3: Pont de Bercy – a series of elliptical masonry arches with a Roman styled concrete aqueduct cast upon the superstructure: The original ferry at the site was replaced by a suspension bridge in 1832, then reconstructed as a stone structure in 1864. The bridge was further enlarged in 1904 to support the metro with an aqueduct styled structure cast upon the superstructure. The bridge was subsequently symmetrically widened in 1992 by reinforced concrete and dressed in a stone façade to match the original (1864) structure.

Bridge No. 4: Pont Charles de Gaulle – a monolithic steel box girder with a "disappearing" design: In 1986, the Council of Paris conducted a Europe-wide competition to determine the best project design for the site of a new bridge. At the conclusion of the competition, the concept set forth was based on the rationale that the choice did not detract from the aesthetic exterior of the nearby downstream lenticular Viaduc d'Austerlitz and that it discretely preserves the existing view of the river. In fact from certain perspectives, the bridge literally "disappears" from view.

Bridge No. 5: Viaduc d'Austerlitz – a braided steel arch with a unique Belle Époque expression: In 1903 the Building Society (La Societé de Construction de Levallois-Perret) proposed a bridge with a span reaching 140 m (460 ft), which was a record for Parisian bridges at the time. The completed metro viaduct consists of an interwoven parabolic steel arch and separate steel arch defined by a cubic parabola joined together at three distinct locations - two at the intersection with the deck and one at the crown. The steel arches are fitted with marine-themed reliefs, including dolphins, seashells and seaweeds. Near the footings, the arches are etched with figures of the Parisian Coat of Arms, which symbolizes steadfastness. Playful zodiac symbols adorn the approach columns – a common theme throughout the city.

Bridge Nos. 6A & 6B: Pont de Sully – a series delicate cast iron arches flanked by stout masonry arches: A pair of pedestrian suspension bridges originally connected the left bank of the Seine with the right bank across the eastern tip of the iÎle St. Louis (smaller island). After destruction of the left bank bridge during the revolution in 1848 and collapse of the right bank bridge due to cable corrosion in 1872, the current bridges were built in 1876 under Prefect Baron Haussmann's modernization of the city. One bridge, connecting the island with the right bank (the Passerelle Damiette), is comprised of contrasting cast iron and masonry arches. A separate bridge between the island and the left bank (the Passerelle de Constantine) is a series of cast iron arches.

Bridge Nos. 7A & 7B: Pont Neu – a series of continuous, short span stone arches: With the corner stone laid in 1578, and a long delay due to the Wars of Religion, the bridge was inaugurated in 1607. As the oldest standing bridge crossing the Seine, the bridge was styled a series of repeating, small span stone arches following Roman engineering precedent. Its name was given to distinguish it from older bridges that were lined on both sides of the river. At the time of construction it was the only Parisian bridge that did not have houses built upon it, presumably to retain an unobstructed view of the King's castle (presently the Louvre). Standing by the western tip of the Ile de la Cite, the island in the middle of the river that was the heart of medieval Paris, the bridge connects the Rive Gauche (left bank) and the Rive Droite (right bank). A major restoration of was begun in 1994 and was completed in 2007, the year of its 400th anniversary.

Bridge No. 8: Passerelle des Arts – an airy light and delicate series of small span steel arches symbolically and physically connecting the Institut de France (left bank) and the central square of the palais du Louvre (right bank): The Passerelle des Arts (bridge of the arts) was originally built in 1804, initially constructed in cast iron and conceived to resemble a suspended garden, with trees, banks of flowers, and benches. Suffering damage due to aerial bombardments in WW I & WWII and subsequent ship collision, Paris's first iron bridge partially collapsed in 1977. The new pedestrian bridge was re-built in 1984 "identically" according to the early 19th century plans except that there are now seven steel arch spans instead of the original nine cast iron arch spans.

Bridge No. 9: Pont Royal – a majestic series of stone arches: A 15 span wooden arch bridge was the first bridge constructed at the site in 1632, replacing a ferry that offered the first crossing in 1550. After fires and two floods, the later destroying the bridge, the present masonry arches were built in 1689. The bridge, situated in close proximity to the Louvre Palace as well as financed by and subsequently named by the King Louis XIV, underwent a reconstruction in 1850 (after the 1848 revolution). In 1939, it was classified as an historical monument.

Bridge No. 10: Passerelle de Solférino – an unusual architectural expression that requires some study to properly identify the supporting steel arch: Originally constructed as a cast iron bridge in 1861, and later replaced by a steel pedestrian bridge in 1961 and subsequently demolished, the new Passerelle de Solférino, supported by a pair of variable width arches, was constructed in 1999, crossing the Seine with a single span. This steel bridge is architecturally unique and partially covered which gives it a light and warm appearance. In 2006, on the centenary of his birth , the bridge was renamed Passerelle Léopold Sédar Senghor in honor of the first president of Senegal , who as a Senglaise poet, was the first African to sit as a member of the French Academy (Académie française).

Bridge No. 11: Pont Alexandre III – an ornate, flat steel arch best illustrating the fusion of engineering, architecture and art in Parisian bridge design: Regarded as the most ornate and extravagant bridge in Paris, the bridge, with its exuberant Art Nouveau lamps, cherubs, nymphs and winged horses at either end, was built in 1900 and named after Tsar Alexander III. Its construction was considered a marvel of 19th century engineering. Four gilt-bronze statues of Fames watch over the bridge, supported on massive 17-meter socles. At the centers of the arches are copper castings representing the Nymphs of the Seine with the arms of France and the Nymphs of the Neva with the arms of Imperial Russia.

Bridge No. 12: Pont de L'Alma – two span, steel, asymmetric box girder: At the site, a symmetric bridge was initially constructed in 1856. The original structure, containing ornate statues at each of 4 river piers, was considered unsafe after 80 cm (2-'6") of settlement occurred. The bridge was reconstructed in 1974 and styled deliberately in an asymmetric span arrangement, the only such arrangement of a river crossing in Paris, where all other structures follow well ordered rules of symmetry. With the 1974 construction, the statue of Zouave was retained. The bridge takes its name from the battle of Alma, where the French defeated the Russian army. It was the first war in which the Zouaves (the Papal Army) took part; hence the statue of the Zouave at the bridge. The statue was used to measure the height of the water; in the 1910 record flood, it reached the Zouave's beard.

Bridge No. 13: Passerelle Debilly – a "temporary" steel arch: In order to accommodate visitor traffic to the 1900 World's Fair across the Seine, the General Commissioner of the Exposition approved the construction of a "provisional" footbridge, intended for removal at the close of the exhibition. Built on a metallic framework resting on two stone piers at the riverbanks, the structure was initially decorated with dark green ceramic tiles arranged in a fashion that suggests the impression of waves. In 1941, the footbridge was characterized by the president of the architectural society as a "forgotten accessory of a past event" and strongly considered for demolition; however, with the onset of WWII all demolition plans were abandoned. Its distinctive shape has historical architectural merit and it was eventually included in the supplementary registry of historical monuments in 1966.

Bridge No. 14: Pont d'Iéna – stone arch ordered to be built by degree of Napoléon: This bridge which leads to the Eiffel Tower (left bank) coming from the Trocadéro (the wide esplanade on the right bank), was built in 1814. It was named after the German city of Jena (Iéna in French) where Napoléon had defeated the Prussian army in 1806. The statues, which were added in 1853, include a Gallic warrior, a Celtic warrior, a Roman warrior and an Arab warrior. In anticipation of the 1937 World's Fair, the bridge was widened using cast in place concrete construction, the bridge was faced with stone and the statues were repositioned. The bridge has been part of the supplementary registry of historic monuments since 1975.

Bridge No. 15: Pont de Bir-Hakeim – a pair of three span steel trusses connecting the right bank, the island of swans (île des Cygnes) and the left bank: Completed in 1905, replacing a bridge erected at the site in 1878, the truss's diagonals are hidden from view by placement of an ornamental fascia metal façade to give the appearance of a sleek arch structure. The metal facade of the bridge is decorated at the (false) arch spring lines with castings of allegorical figures and the tip of the island (at the bridge mid-point) has widened plaza which is adorned with a bronze ornamental statue "reaching out" to the Eiffel Tower. The bridge has two levels: one for motor vehicles and pedestrians, and the upper level, a metro viaduct supported by metal colonnades, except where it passes over the île des Cygnes, where it rests on a masonry arch. Originally named Viaduc de Passy, it was renamed in 1949 after the Battle of Bir-Hakeim where French troops resisted Italian and German forces in 1942.

From the Pont de Bir-Hakeim, it is but a short walk to the Metro Line 6 Station (Bir-Hakeim), and as our walking journey ends, we leave the waterfront and end our journey to the fifteen beautiful bridge sites, best representing the Parisian fusion of engineering, architecture and arts.

Thomas G. Leech, P.E., S.E. is the National Practice Bridge Manager for Gannett Fleming Inc. All photos are courtesy of the author. The rendering was created by Jonathan D. McHugh, P.E.

Great Bridges in Great Britain

A history of landmarks in form and design

By Eric Dues

Much has been written about the history of Great Britain; and any country with such a long and storied history naturally has a history of infrastructure associated with it. The first bridges on the islands were likely built of wood and cobles by tradesman and local inhabitants, but the significant design and construction of bridges began when the Roman Empire expanded as far north as Hadrian's famous wall in Scotland.

One of the most famous bridges is notable due more to its location than its grandeur; according to historians some form of bridge has been present near the current site of the London Bridge since the second century (in a city then referred to as Londinium). Unlike any other, the London Bridge has served as a witness to the history of bridges throughout Great Britain. From Viking battles for the bridge to the blitz during WWII, the various bridges at this location have always been rebuilt; showing the value society places on the importance and need of bridges. While the bridge has consisted of wood, roman arches, and to the present day prestressed concrete arches, perhaps its most important legacy is from the 1756 law that led to the first legal requirement that carriages pass each other on the left hand side of the road!

The Industrial Revolutionaries

The period between the 18th to 19th centuries was a major turning point in the history of human civilization; a time period commonly referred to as the industrial revolution. The great advances in the production of cast iron that occurred in the second half of the 17th century eventually allowed for the mechanisms of the time period to be invented and built, including the steam engine and rail transportation. Inevitably, a signature bridge of the era was also constructed of the durable and now cost-effective material.

Coalbrookdale (northeast of Birmingham) was at the epicenter of the new cast-iron production and also had a major river that was used for the transportation of British goods. The frequent flooding of the gorge and the need to move goods not only up and down Severn River (Britain's second largest river), but across the river, led to the idea of a single span bridge being constructed across it. By 1773 a small-time architect, who had never successfully designed a bridge, proposed a plan for a single-span cast-iron bridge across a river. His design was accepted by the legendary Coalbrookdale ironmaster Abraham Darby III, whose grandfather ushered in the new coke fired iron production.


The Ironbridge (elevation looking West)

With the recent rise in industry, and the unique local expertise of ironworking, the stage was set to construct the first major iron bridge. The 5 arched ribs of the main 100 foot span were each cast in two halves and the entire 378 tons of cast iron was erected in as little as 3 months. As recent as 2001 it was unclear exactly how the bridge was built, so the BBC analyzed and erected a scale model to help shed more light on the grand scope of the project. While relatively simple by today's standard, the span was most likely constructed by cantilevering each half-arch rib from each shore and tying the subsequent ribs together into a rigid frame. The use of coped and dovetailed joints made construction similar to wood construction, and the fit-up was made easier by casting many elements in sand pits on site.

There is a rich history of the industrial revolution in Great Britain and this iconic structure is a monument to it. It has been listed as a United Nations Educational, Scientific and Cultural Organization (UNESCO) world heritage site and was so marveled during its time that the local village and the gorge were officially named Ironbridge.

The Rise of Steel

Sir Henry Bessemer applied for a patent on his new steel production process in 1855, leading to a supply of steel that was stronger, cheaper, and more readily available. Naturally, pioneering bridge engineers of the time realized the enormous benefits of a reliable supply of steel. In Scotland the need for a grand water crossing collided with the new advancements in steel production, creating a showpiece to our profession that still stands to this day.

The Firth of Forth Bridge that we know today as an iconic bridge could have easily taken on an entirely different form. The earliest real proposals for a crossing were a tunnel in 1806 and a bridge in 1818. Finally, in 1873 a railroad consortium commissioned an engineer to design a bridge to cross the great body of water. The designer chosen for the Forth crossing had recently completed a 2-mile long viaduct over the Firth of Tay built largely out of cast iron; but after it collapsed in the worst structural disaster in Great Britain's history (killing all 75 on board the train), he was replaced with a new pair of engineers.

The Forth Rail Bridge - elevation as seen from the North Shore in North Queensferry

While poor detailing and maintenance also played roles, the disaster is primarily attributed to being under designed for wind. The repercussions affected the bridge industry as a whole and specifically the Forth Bridge.

Measures put into place following the Tay disaster led to an early bridge inspection program, called for the use of steel over cast iron, dictated wind loads on bridges, and forever changed the Firth of Forth. With the change in the design team, the bridge plans were switched from the original suspension bridge proposal, for which foundations had been laid, to the world's largest balanced cantilever structure. It would be constructed entirely out of Bessemer's new steel.

The Firth of Forth Bridge was designed to withstand winds much greater than those that caused the Firth of Tay collapse. The combination of span length and lateral loading resulted in one of the most recognizable bridges in the world that is still in use today, over 120 years later. The 8,276 foot long bridge and its 680 foot cantilevers hulk over the landscape yet seem to fit naturally into the wide glacial waterway.

It took seven years to build the two 1,710 foot main, two side, and 15 approach spans. It was finally complete in 1890 after taking the lives of 57 of the construction workers; not including the sickness of those afflicted with caissons disease while working on the 70 foot diameter caissons.

The size of the 12 foot diameter main members of the cantilevered spans is impressive and the 50,500 tons of steel left the public with a feeling of safety following the Tay disaster. Either watching or riding a train crossing the Firth of Forth on this bridge gives one a sense of scale that is overwhelming. The innovative construction and design has left such a legacy that UNESCO also recognizes this icon as a world heritage site.

A New Millennium

In 1993 the Queen appointed the first commissioners to the Millennium Commission in the United Kingdom. The commission, funded by income from the National Lottery, would be used to fund grand projects nationwide in celebration of the new millennium. Funding from this Millennium Commission as well as the European Regional Development Fund was used to construct another first-of-its kind bridge between Newcastle and Gateshead in northern Britain.

The Discovery Museum in Newcastle is a testament to the rich history of industrialism in the region. Their rich coal mining and shipbuilding history was an integral part of the industrial revolution and the reason for the cities rise to prominence. The mining and heavy manufacturing industries were so prevalent that it led both to a unique Geordie English dialect, and the regions steady decline along with the end of the industrial revolution. With the decline of industries in the 20th century, including the closing of coal mines, Newcastle and Gateshead needed to reinvent their region. They chose to do this through repurposing and rebuilding infrastructure to create a vibrant city focused on technology.

In 1996 Gateshead Council chose a design that would link developments on both sides of the River Tyne and also compliment the historic bridges already crossing the river. The winning design would be another landmark British bridge that made history through its unique design and form. Although the bridge's arch is a perfect complement to the through arch of 1928 Tyne Bridge, the opening mechanism of the Millennium Bridge is what makes this pedestrian and cycle bridge a new piece of bridge history.

The bridge is shaped out of two opposing arches; a vertical steel arch is used to hang cables that support the horizontally curved steel and concrete deck over the Tyne. The arches span 413 feet, and where they intersect on either side of the river

The Gateshead Millennium Bridge - closed, looking west three 18” diameter hydraulic rams rotate the vertical arch 40 degrees in less than 5 minutes. Likewise, the cables connecting the two arches pull the deck up with the rotating vertical arch. This impressive balancing of forces results in two arches over the river, each with enough clearance to allow for river vessels up to 82 feet tall.

Rotating an 800 ton arched bridge around a central point is certainly a unique feat of bridge engineering, and likewise the design and construction of such a structure is one that had unique challenges that were not possible 100 years previous. Being able to assemble the bridge offsite and place it atop its foundations whole was only possible through the use of the largest (at its time) floating crane in the world. Being able to model the complex dynamics and loads of this bridge in a notoriously windy climate was only made possible through the use of non-linear finite element programs. The meticulous planning even went as far as making the bridge self cleaning; anything on the deck rolls into special traps on each end of the bridge every time it is opened!

The Gateshead Millennium Bridge - open, looking north

Throughout the history of Great Britain, seemingly innovative ideas, including bridges, were planned and executed using the latest material and design technologies. Each innovation shifted the paradigm in a new direction; new generations of engineers were met with a new perceived baseline of what was possible. In the 1600’s, the iron process was not yet reliable enough for use in constructing a major bridge. Before Bessemer, steel supplies were too short and too inconsistent to design a monumental cantilever structure out of it. As recent as the late 20th century, office computers were not powerful enough to analyze the advanced dynamics and forces involved in a rotating arch bridge.

The Queen officially opened the Gateshead Millennium Bridge in 2002. Each of the above described British landmarks was built in approximately 100 year intervals using the latest advancements, be it in material or design. In 90 years, perhaps the Gateshead Millennium Bridge will be a UNESCO world heritage site. This naturally leads to the question…*what will an innovative bridge look like and be made of at the turn of the next century?*

Eric Dues, P.E. is Structural Engineer for Gannett Fleming, Inc., Columbus Ohio. All photos are courtesy of the author.

Penn State University's
2010 European Bridge Tour

By Marie-Louise Abram and Austin Kieffer

In May of 2010, eight Junior and Senior Level Engineering Students attending Pennsylvania State University, The Capital College, along with faculty advisor Dr. Joe Cecere and travel guides embarked on a one week tour of historic and contemporary bridges in Switzerland, Germany and France. Highlights of the tour included personal views and inspections of the Sunniberg Bridge, Klosters, Switzerland, the Salginatobel Bridge, Schiers, Switzerland, the Tri-Countries Bridge, Wiel-am Rhine, Germany, the Felsenau Bridge, Bern, Switzerland and the Millau Viaduct, Tarn River Valley, France. The tour was designed to provide a hands-on experience of well known and distinct European Bridges and place a new emphasis on a global perspective as a necessary component of the engineering education

In 2008, Penn State Harrisburg created an office of international programs with the objective of providing international opportunities for students and faculty. Mr. William Stout, Chairman and CEO of Gannett Fleming, Inc., serving as an officer of the College's Board of Advisers, felt inspired to help students and to assist in the development of an international engineering opportunity. This willingness and conversation with an industry partner created a course entitled "European Bridge Tours". The objectives of the three credit course were developed by faculty in the Civil Engineering Program at Penn State Harrisburg with support from the Bridge Practice of Gannett Fleming Inc. The objectives included independent research of the design of the five selected European bridges, classroom study of the means and methods of current European bridge construction, and tour of the five selected bridges. The students who participated were supported financially by the company and given a chance to experience some of the most unique and beautiful bridges in Switzerland, Germany and France. In Europe, the site visits provided the students an opportunity to meet people intimately connected to each bridge including: one of the original designers of the extradosed Sunniberg Bridge, a local spokesperson passionate for communicating the deep history of the beautiful Salginatobel Bridge, the owner of the new Wiel-am Rhine Pedestrian Bridge, the contractor undertaking the restoration of the Felsenau Bridge and the concessionaire for the magnificent, new Millau Viaduct. The tour, with a strong educational component, also provided the students opportunities to view many other local European bridges and afforded an exposure to a wide variety of geological settings including the Swiss Alps, the Rhine and Rhone River valleys and France's Massif Central mountains.

Penn State's vision...is that all students become "global citizens, who think globally while acting locally"

Salginatobel Bridge, students and local tour guide

Penn State Harrisburg has emphasized internationalizing the student experience as a way of providing global exposure and competence. In order for the university and its students to remain competitive and relevant, the University recognizes that it must promote and engender the ideals of internationalization at its core. Penn State's vision, as articulated in its current strategic plan, is that all students become "global citizens, who think globally while acting locally". This bridge course was an ideal opportunity for many students to have their first international experience as well as to consider the changing world of engineering.

To capture the experience of the student, we posed the following three questions: How has the European Bridge Tour shaped your overall vision of Civil Engineering? How has the European Bridge Tour broadened your educational experience? What was the bridge that you (and your classmate) were assigned to as a champion, and how did the personal experience alter your perception of the significance of the bridge's design and/or construction? The students' responses follow in their own words - MLA.

How the European Bridge Tour has shaped my overall vision of Civil Engineering

The European Bridge Tour has created a sharper vision for me in the Civil Engineering Industry. Due in part to the trip I have learned to take a new vision of respecting the environment when designing structures. The trip has shown me that every civil engineering structure is created by engineers who realize there is more than one purpose of a structure such as transportation. Many structures influence the natural environment. The trip it has shown me that the engineers who created the showcased bridges did not just design the structures for one main purpose or for simply transportation, but designed them to be aesthetically pleasing, environmentally friendly, and to exceed the normal service life of a structure.

Millau Viaduct, PSU students

Besides bridges …

...there were numerous cultural differences which astounded me (and my classmates) in many ways. The most challenging for me to overcome was the easy-going personality of the French culture. There was never a rush for most individuals and timeliness seemed to not be an issue for most. It was not uncommon to spend 2-3 hours at a small pizza shop to eat due to the serving culture. The language barrier was very difficult for me and my fellow classmates, however we did survive. The language barrier did result in four of us managing to get an 80 Swiss Franc fine since we failed to purchase the proper tickets.

How the personal experience altered my perception of the significance of the bridge's design and/or construction?

The Salginatobel Bridge was assigned to me and a partner; so prior to the trip, we researched all the commonly known facts so we could be familiar with the structure when visiting. After visiting the bridge we were simply astounded how a structure built from scratch using very basic materials and all manual labor could still be in service almost a century later. I am sure our perception of the bridge did not differ much from other individuals also on the trip. The bridge was simply hands down one of the most monumental structures on the trip just for the simple fact of its long history.

The Student Perspective

The Europe bridge tour was a spectacular experience for students and professionals alike. As a college student, the European Bridge Tour was an unforgettable experience for me and other students. The trip was a priceless education tool. It helped me understand the marvels of early yet effective design techniques, as well as new innovative design. It was incredible for me to see a structure such as Sanginatobel Bridge, which was built in the early 1900s and yet is still in full service. In my judgment, the most astounding structure of the entire trip was certainly the Millau Viaduct, which seemed to be reaching into the clouds with its incredible height.

Tri-Counties Bridge, students, faculty, city bridge engineer and tour guide

How the European Bridge Tour has broadened my educational experience

The European Bridge Tour has supplemented my education by extending theory, to practice to real world application. The bridge tour taught me that just because there may not be a design codes to create a bridge with an eccentric superstructure (such as the Tri Countries Pedestrian Bridge) or a 1,125 feet tall bridge (such as the Millau Viaduct) does not mean that it is not possible. The European Bridge Tour taught me that almost any design is possible and still able to be put into service safely. Although many of the designs of the bridges pushed the limits of bridge design, they were still constructed safely and put into service.

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The 2010 PSU European Bridge Tour was sponsored by the Penn State Harrisburg and Gannett Fleming, Inc. IBC Magazine Editor and Gannett Fleming National Bridge Practice Manager, Tom Leech assisted in the planning of the tour and accompanied the students and faculty advisor as a guide.

Cultural Quiz – How well do you know the Republic of Korea?

The Republic of Korea, known to the western world as South Korea, is the featured country for IBC 2011. How well do you know South Korea? You will find out as you take the following simple test. Answers are located at the bottom of this page—Editor.

Q1: South Korea is approximately 160 miles wide by 210 miles long for a total area of 38,691 square miles. It has approximately the same area as which of the following states: A: Texas; B: California; C: Virginia; D: Vermont

Q2: Is this statement True or False?

South Korea lies in a temperate climate region with a predominantly mountainous terrain.

Q3: In 1988, Seoul hosted the 1988 Summer Olympics. Which of the following statements is not true.

A: After having demolished the world record in the 100m dash at the Olympic Trials sprinter Florence Griffith Joyner set a Olympic Record (10.62 seconds) in the 100 meter dash and a still-standing world record (21.34 seconds) in the 200 meter dash to capture gold medals in both events.

B: Canadian Ben Johnson won the 100m with a new world record, but was disqualified after he tests positive for stanozolol. (He still claims to this day that André Action Jackson, "the Mystery Man," put the stanozolol in his food or his drink.)

C: The United States basketball team, nicknamed the Dream Team, reached the Gold Medal beating Croatia in the final.

D: US diver Greg Louganis won back-to-back titles on both diving events, but only after hitting the springboard with his head in the 3 m event final.

Q4: There are many mostly small and uninhabited islands, which lie off the western and southern coasts of South Korea. For instance, Jeju-do, the country's largest island, is located about 100 kilometers (about 60 mi) off the southern coast of South Korea. Jeju is also the site of South Korea's highest point: Hallasan, an extinct volcano, which reaches 1,950 meters (6,398 ft) above sea level. The approximate number of islands which lie off the South Korean coast is:

A: 13,200; B: 5,200, C: 3,000; D: 1,700

Q5: South Korea's terrain is mostly mountainous, most of which is not arable. Lowlands, located primarily in the west and southeast, make up only approximately what % of the total land area.

A: 5%; B: 13%; C: 21%; D: 30%

Q6: Is the following statement True or False?

South Korea can be divided into four general regions: an eastern region of high mountain ranges and narrow coastal plains; a western region of broad coastal plains, river basins, and rolling hills; a southwestern region of mountains and valleys; and a southeastern region dominated by the broad basin of the Nakdong River.

Q7: South Korea has many national parks which are either land based, historical/cultural or marine setting including Jiri-san NP, the largest massif mountain in South Korea with many hiking trails and historic temples and Dadohae Marine NP, South Korea's largest national park which includes 8 sections and 1,700 islands. The total number of National Parks in South Korea is:

A: 10

B: 20

C: 30

D: 40

Q8: The Korean language is an Ural-altaic language. Which of the following is not true:

A: Korean is similar to Japanese in grammar and sentence structure.

B: Korean is distantly related to Finnish and Hungarian in basic form.

C: Korean is a non-tonal language, with sound elements combined to make whole syllables.

D: Korean is a simple language with standardized rules and subject-object-verb sentence structure.

Q9: Seoul is a mega city, main entry point and the capital of South Korea. The city of presently 10,000,000 people is over 600 years old. It lies at the same latitude of which major American city:

A: Washington, D.C; B: New York, NY; C: Richmond, VA; D: Atlanta, GA.

Q10: The recently completed Incheon Bridge which serves Seoul, links the recently completed Incheon International Airport (based on Yongjing island) and the international business district of New Songdo City. Which of the following statements is false:

A: Construction began in 1995.

B: The bridge is longer than the current Seohae Bridge (the first bridge crossing) and is among the five longest bridges of its kind in the world.

C: The bridge shortens the journey time from Incheon Airport to the metropolitan districts of Seoul by 40 minutes.

D: KODA Development, a joint venture between UK-based AMEC and the city of Incheon, financed and managed the project, and will manage the bridge for 30 years and later return the facility to the Korean government.

Answers to Cultural Quiz: 1-C, 2-T, 3-C, 4-C, 5-D, 6-T, 7-B, 8-D, 9–C, 10-A

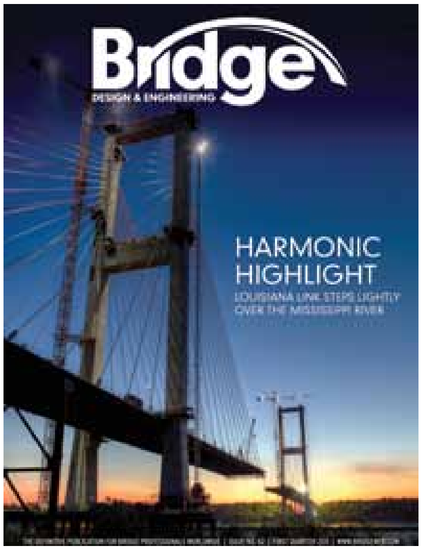
Bonus Question: name the three scenes in the photos accompanying this quiz?

Bonus question answer: cityscape of Seoul, Incheon Bridge and Seonimgyo Bridge (lower left)

A View From Europe
...via conversation with Helena Russell

IBC Magazine caught up with Helena Russell, editor of Bridge design & engineering Magazine and posed a few questions about the magazine and her view of the bridge industry ... from Europe - Editor.

Q: Share a little if you can about your magazine – Bridge design & engineering.



Choosing the cover picture of the magazine can be a tough job, but it is always great to see the finished version.

Bridge design & engineering - or Bd&e as we call it for short - is the only international publication aimed at bridge engineers, architects, owners and those working in the bridge industry. The first thing that people usually notice about it is its size, visuals and print quality. Being a non-standard size gives us greater scope for using dramatic pictures of bridge structures, and we do this because we recognise that visual impact and aesthetics is very important to bridge engineers. We make a lot of effort to accompany our in-depth technical articles and project reports with stunning images, where we can, and we also try to make our publication reflect print quality and design standards that are more akin to architectural publications than to engineering magazines. Many of our readers use the images and ideas in the magazine for inspiration.

Q: Your magazine was conceived in 1995; what sparked the genesis of you first edition?

The magazine was actually conceived as a spin-off from World Highways magazine, which is still produced by the publisher that launched Bd&e. Although I've been editor for many years, I did not actually launch the title. The first issue of Bd&e was edited by Russ Swan, the former editor of World Highways, who recognized that there was a gap in the market for this type of magazine. Bridges were becoming much more high-profile and technically complex, and there was a noticeable development in new technology such as cables, bearings, seismic equipment and so on, aimed specifically at this market. The company already had access to potential subscribers through its existing highway magazine, so it was a perfect opportunity to launch this new publication. Ironically I was initially head-hunted to take over as editor of World Highways when Russ decided to move full-time to editing Bd&e. I turned the job down as it didn't really appeal to me, but just a few years later, when Russ left Bd&e, I finally got the job I had been coveting! In 2000 the magazine was sold to Hemming Group; my colleague Lisa Bentley (group advertising manager) and I transferred with the title, and we have been here ever since.

Q: Where did the idea for your logo come from?

The logo has gone through a few changes over the years, but has remained faithful to the concept – the combination of the curving arch and the shape of the letters in the word 'bridge'. We have noticed a few imitators of late, with similar logos cropping up here and there. We don't take it personally though, we see it as flattery!

Q: How wide is your circulation?

Our circulation is truly worldwide, split approximately a third in Europe, a third in North America, and the remainder in the rest of the world. Understandably our circulation is higher in English-speaking regions, but the international nature of the bridge industry means that although many of our readers are not native English speakers, they have the technical vocabulary and specialist knowledge to be able to read and digest our content. We are seeing increases in subscriptions in the Asia Pacific region and Middle East in particular. One of the things we find in particular with Bd&e is that our renewal rate is very high – once people have seen the magazine or subscribed for a year, they don't want to let it go.

Q: What kind of articles are you looking for; where should the focus be?

In terms of content we aim to publish articles rather than journal papers, the idea being to inspire rather than offer a comprehensive technical summary of how a bridge was designed or built. We try to focus on the unusual, innovative or inspirational aspects

Working on an international magazine offers great opportunities to find out about fascinating projects all around the world, such as the Qingshuipu Bridge in Ningbo, in China.

of each particular project, rather than including a standard list of how many cubic metres of concrete were used, or tonnes of rebar. The two main criteria for an article to be considered for publication in the magazine are firstly that it should be current (either

A visit to the Humber Bridge in 2010: proving that not only do I get out of the office sometimes, but not all of the most exciting projects are overseas!

under planning, design, construction, or finished within the last three months) and secondly that it should have some angle that makes it of interest to our readers around the world.

Q: Are you looking for a geographic region?

No, we are keen to hear from bridge industry professionals anywhere in the world – after all, bridge engineering is an international language. Bridge design & engineering magazine and our new, re-launched website www.bridgeweb.com aim to be the first place people come to for information about the industry, wherever in the world they live or work.

Q: What current trends do you see in the bridge industry?

A lot of energy and expertise is going into developing and fine-tuning technology aimed at extending the life of existing bridges, building more durable ones, and doing so while minimizing the impact on the travelling public and the environment. Hence we are seeing efforts being targeted on techniques for heavy lifting, launching and manoeuvring of whole bridges in one go, as well as development of durable materials, strengthening and rehabilitation techniques, and smart monitoring and testing of existing structures.

Q: How have these trends changed since 1995?

I don't think these trends have really changed much in ten years, but they have been given increasing priority, and the solutions have developed to become more sophisticated. We have also seen greater emphasis being placed on aesthetics and environmental considerations – and the industry has definitely gone through a bit of a learning curve over the last decade as regards the best way to organise design competitions. Clients have finally started to understand that they can't expect bridge designers to churn out endless competition entries for little or no remuneration; a fair and transparent process will get the best results without quashing creativity.

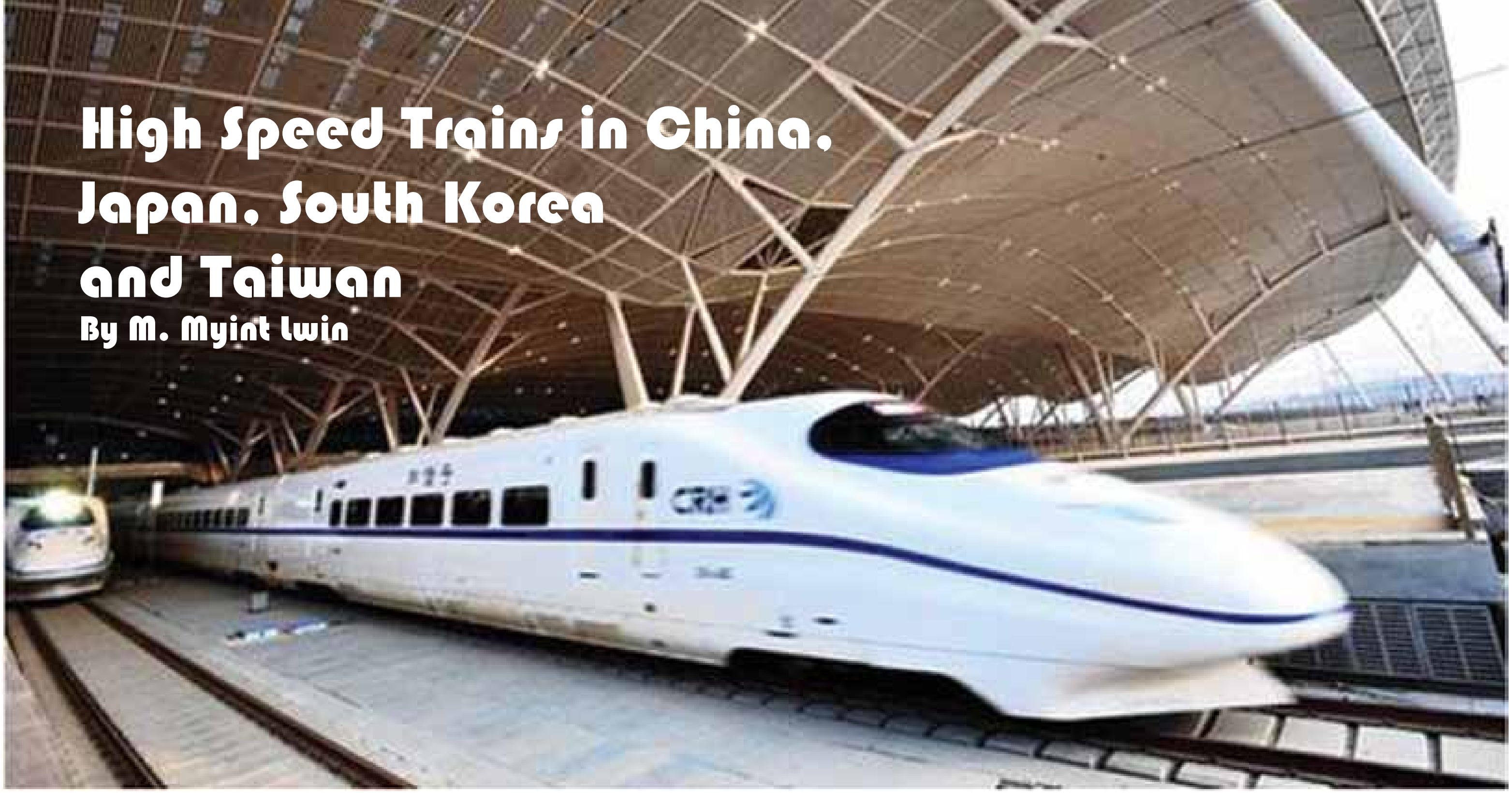
Q: Tell me about your footbridge awards program; how did this get started, how has it evolved?

The footbridge awards were launched back in 2002 with the intention of recognizing the creativity of bridge engineers designing a whole new breed of pedestrian structures. New materials which allowed bridges to become longer and lighter, and techniques that enabled steel fabricators to produce very complex shapes resulted in a sea change in the scope and range of footbridges that were being built. The awards were also timed to coincide with a specialist footbridge conference which was launched to address issues relating to footbridge design – in particular dynamics and pedestrian-induced vibrations as had been witnessed on a number of long, light structures. Since then we have held the awards every three years, in tandem with the conference, and they have attracted an increasing number of entries. The judging process is always fascinating, and it's inspiring and educational to witness the sheer range of creativity that is on display among the entries. It's always tough to choose the winners, and this year looks like being no exception. The winners will be announced at the Footbridge Conference which will be held in Poland in July; it is an excellent event for anyone involved in bridge design and construction, and will be a great opportunity to meet bridge professionals from around the world.

Q: Will we see you at the IBC 2011?

Absolutely – it's one of the main events at which we get the chance to catch up with our North American readers and commercial partners, and of course with the expanded international remit of the conference, we increasingly bump into people we know from Europe and the rest of the world too. You can catch up with me and my colleagues at our booth, or else you are likely to see me making notes in some of the technical sessions or visiting the other booths in the exhibition hall.

Helena Russell is the editor of Bridge design & engineering Magazine and a member of the International Bridge Conference Awards Committee. Helena, along with Carl Angeloff, was instrumental in initiating IBC's Hayden Award Medal for structures demonstrating vision and innovation in special use bridges.



High Speed Trains in China, Japan, South Korea and Taiwan

By M. Myint Lwin

My wife and I have ridden the high speed trains in China, Japan, South Korea and Taiwan, and we would like to share our experience and observation of the network of high speed trains in these countries. Any speeds at 120 mph or faster are high speed for us. The development of high speed rails in these countries are so intensive and fast that each time we visit these countries new lines are opening up and higher speed trains are operating. A year ago we visited China and rode on a train reaching speed of 238 mph! At this speed we can easily make a one-day business trip from Washington, D.C. to Boston, MA, without the screening or the padding of an airport.

High speed trains in China, Japan, South Korea and Taiwan are very punctual, departing and arriving within few minutes of schedule. The cars are clean and relatively quiet. The seats are roomy and comfortable. The service personnel are courteous and care for their jobs and customers.

There are generally two classes of seats, the standard and business classes. There are reserved and non-reserved seats, which can be bought at the ticket counters, ticket machines or online up to 30 days ahead of travel date. (See Photos 1 and 2) The following information is needed to buy tickets at the counters:

- Number of travelers
- Date of travel
- Departing Station
- Arriving Station
- Class of Cars – ordinary or special class; standard or business class
- Reserved or non-reserved seats
- Smoking or non-smoking cars, if available.

For countries where we have very limited skill in the native languages, we find it very helpful to have the above information written in English on a piece of paper and hand it to the salesperson at the ticket counter. Salespersons are generally familiar with the English needed for purchase of train tickets and seat reservations. The next step is to find the platform and the appropriate train. Signs at the train stations are multilingual. English is one of the languages. Announcements in the trains are in English also.

In the trains, foods are served by small food carts stocked with a selection of snacks, drinks and boxed meals. The carts come through quite frequently. US dollars are not accepted for purchases in the trains, so passengers must carry currency of the country they are traveling in so as not to go hungry! Some trains have vending machines with drinks and pay phones. Wireless internet is available on the newer trains so that passengers can respond to e-mails and get some work done!

The high speed train systems are fun and easy to use if we do some homework before using them for the first time in a country. Knowing the native language is not a requirement for experiencing rides in the trains, enjoying the beautiful bridges and tunnels along the way, seeing the picturesque countryside, and observing the cultures and life of the people. We venture to talk to the locals in their native language. They are always very helpful and pleased with the conversation. Sometimes the local folks want us to speak English to them so they can practice their English. We always treasure these opportunities as part of the enrichment of our travels.

Photo 1: M. Myint Lwin alongside a high speed train

HIGH SPEED TRAINS... *in China*

Traditionally China has a large network of railways to move people and goods, and connect the towns and cities

Photo 2: Interior view of a typical high speed train car

of the country. Traveling by the conventional trains in China between cities is the most economical. It is cheaper than flying and saves a night of hotel costs. The speeds of the conventional trains averaged about 25-30 mph. Through a series of improvement in grade, reduction in curvatures, and use of continuous welded rails, several existing lines are able to operate at speeds up to 100 mph by 2007. Four classes of accommodations are available. For the day trips there are the soft seats and hard seats. For the overnight rides, there are the soft sleepers and hard sleepers. A trip from Beijing to Xian on a conventional train will be an overnight ride lasting as long as 14 hours. This is still the main mode of transportation for most people in China.

As early as 1990 China has been planning, experimenting and acquiring high speed rail (HSR) technologies with the goal of expanding the high speed rail systems to connect major cities from densely populated and prosperous coastal areas to the inland regions to raise the living standards and productivity of the people. China has supplemented its high speed rail research and development with those of Germany, Japan and Sweden to build a high speed rail network across the country.

In 2000, the Shanghai Municipal Government purchased a turnkey Maglev Train from Germany for connecting the Shanghai Pudong International Airport and the City, a distance of 19 miles. In 2004, the Shanghai Maglev Train was put into operation and became the world's first commercially-operated high speed rail. The trip lasts less than 8 minutes. On the trip we rode on, the train peaked momentarily at 238 mph, but it was capable of reaching a peak speed of 267 mph. It remains the fastest high speed train in operation in China.

In 2006, the China State Council adopted the conventional track HSR technology over maglev. This decision cleared the way for accelerated construction of standard gauge HSR lines in China. China's Railway Network Plan consists of 8 high speed rail corridors, four running north-south and four running east-west. Through upgrading of existing conventional rail lines and building new passenger-designated lines (PDL), China's HSR Network Plan is to reach 16,000 miles of high speed rail lines operating at 217 mph by 2015. The Guangzhou-Wuhan HSR was opened in 2009. It is a passenger-dedicated trunk line, reaching a top speed of 220 mph and average at 190 mph, and making the entire 601-mile trip in 3 hours. (See Photo 3)

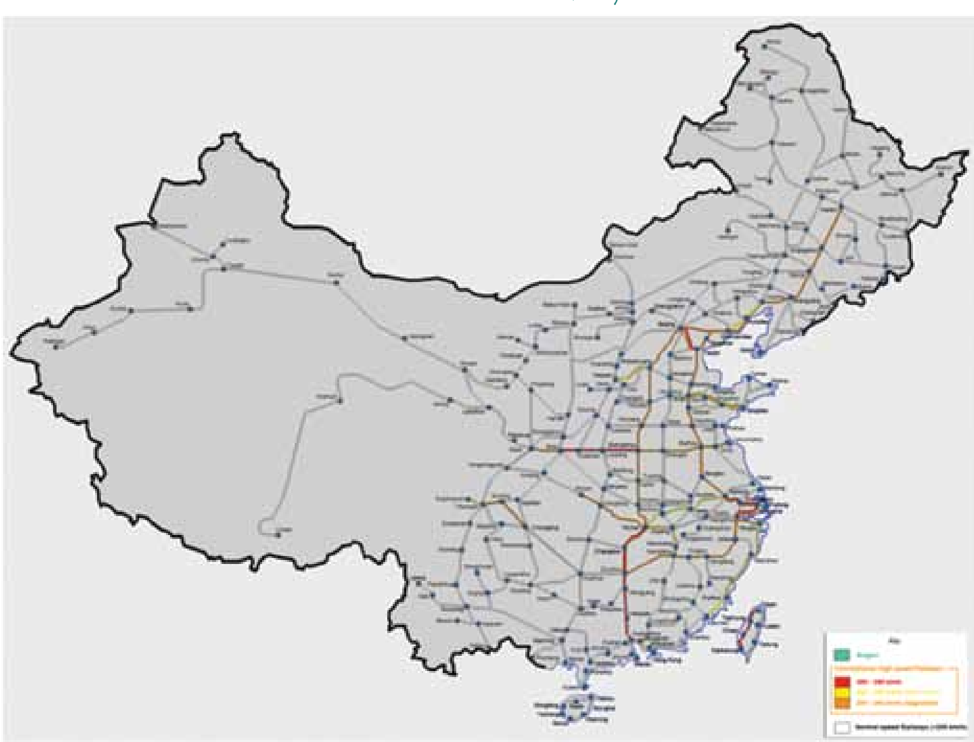


Photo 3: Network of Railways in China. HSR are shown in color.

The train stations and the trains are always very crowded. The average daily ridership is 237,000 in 2007, 349,000 in 2008, 492,000 in 2009 and 796,000 in 2010. Following is an example to show the choices a traveler has in planning a trip. Which mode of transportation will you use for a trip from Wuxi, Jiangsu Province to Chongqing, Sichuan Province, a distance of about 1,100 miles? The table shows the cost and time for the trip by conventional trains, high speed trains and by air.

Table 1 Cost and Time for Several Modes of Transportation

Mode	Seat	Cost		Time
Conventional Trains	Hard	116 Yuan	US$17	33 Hours
	Soft	201 Yuan	US$29	33 Hours
High Speed Trains	Standard	473 Yuan	US$69	14 Hours
Airplane	Economy	1,500 Yuan	US$220	3 Hours

Most of the people, most of the time will take the conventional trains. Majority of the tourists and businessmen will take the high speed trains or airplanes. On special occasions, such as, the Chinese New Year, the Korean New Year, the Mid-August Moon Festival, etc., many more people will crowd the high speed trains to get home as soon as they can afford.

HIGH SPEED TRAINS
...in Japan

Japan, by necessity, is the pioneer in high speed rail, which they call "Shinkansen", meaning new trunk line and we refer to them as "bullet trains". The first Shinkansen was planned in 1930, but World War II disrupted the development until 1959. In 1964, Japan opened its first Shinkansen line called the Tokaido Shinkansen, connecting Tokyo and Kyoto, a distance of 296 miles. When opened in

Photo 4: Japan's High speed rail network

1964, the Tokaido Shinkansen was the world's first high speed rail line, running at 125 mph. Today, three trains, Nozomi, Hikari and Kodama, operate on the Tokaido Shinkansen. The Nozomi is the fastest train, running at peak speed of 186 mph and at average speed of 130 mph including stoppages. The Nozomi makes the Tokyo to Kyoto trip of 296 miles in 2 hours and 15 minutes! The Shinkansens (see photo 4) are operated by Japan Railways (JR)

Japan celebrated 40 years of high speed rail in 2004, with the Tokaido Shinkansen line alone carrying 4.16 billion passengers, while the total network carried over 6 billion passengers. Shinkansen has an outstanding safety record. In its 47 years of operation, there have been no passenger fatalities due to derailments or collisions. Japan is proud of their safety records. The March 11 9.0 magnitude earthquake in Sendai, Japan, did not cause any injuries or derailments of the Shinkansens.

The Japanese and their visitors use the Shinkansens as their main mode of transportation to places of work, leisure, worship and relaxation. The train stations in big cities are very crowded in the morning and evening, with riders dashing here and there, grabbing newspapers, snacks and lunch boxes before riding the trains. A few years back, a U.S. group arrived Tokyo in the late afternoon. Some of us were hungry and wanted to find a restaurant. I told them to follow the crowd. Sure enough, they were heading to the train station to go home, and we found restaurants in and around the station. In Japan, if you lose your sense of direction, follow the crowd and you will get to a train station!

HIGH SPEED TRAINS
...in South Korea

South Korea invested US$16 billion from 1991 to 2002 to build the first Korea High Speed Rail (KHSR) project connecting Seoul and Busan with a high speed rail line of 255 miles and six stations along the most densely populated regions of the country. (See Photo 5) The trains operate at 186 mph and carry 1,000 passengers each, while the design speed is 217 mph. Research and development are ongoing to improve performance and speeds.

South Korea inaugurated its first Korean KTX high speed rail line in December 2004. This main line is called the Gyeongbu Line. With an operating train speed of 186 mph, the trip from Seoul to Busan has been reduced from over 4 hours to less than 2 hours. A second line has branched out to Mokpo along the west coastal regions of the country with an expected opening in 2014.

In the first 100 days after opening the Gyeongbu Line, the ridership was only at about 50% of prediction, averaging 70,000 passengers daily. However, the ridership increased in the following two years leading to a profitable operation in 2007. The average daily ridership is 102,000 in 2007, 103,000 in 2008, 103,000 in 2009 and 107,000 in 2010. The one-day ridership record was set at 178,584 on January 26, 2009, the Korean New Year.

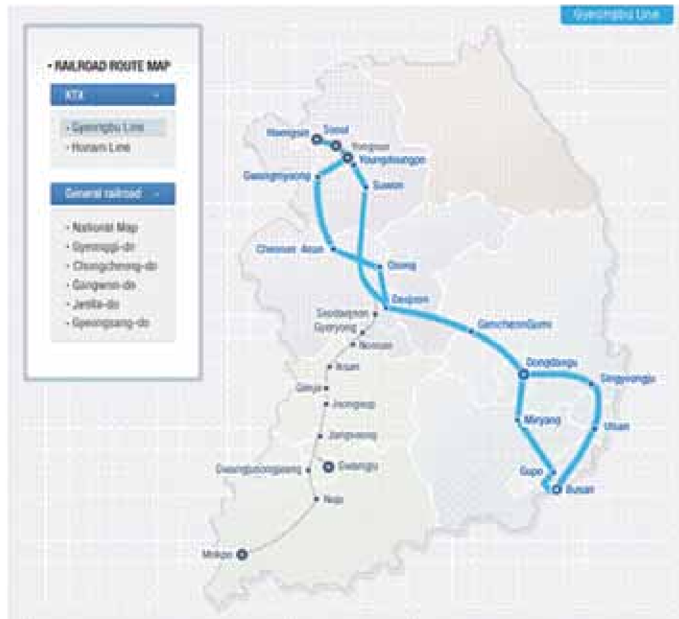


Photo 5: South Korean HSR Map

HIGH SPEED TRAINS
...in Taiwan

Most of the population of Taiwan lives on the west coast of the country. For the efficient movement of people and goods, a high speed rail system is needed to relieve highway congestion, enhance economic growth and make more areas accessible for development. Beginning January 5, 2007, a high speed rail line runs along the west coast of Taiwan, covering about 214 miles from Taipei to Kaohsiung with an operating speed of 217 mph. (See Photo 6) The Taiwan High Speed Rail Corporation (THSRC) operates the system. The four-hour trip by the conventional train is cut down to 1 hour and 36 minutes by the high speed train, costing about US$50 for standard car, and US$65 for business car (a reduction from US$81 in 2007).

At this high speed, we were able to make a day-trip from

Photo 6: Taiwan High Speed Rail Route

Taipei to Kaohsiung to see the extensive damages caused by Typhoon Morakot in August 2009. Typhoon Morakot was the deadliest and most damaging to buildings, roads and bridges in the recorded history of Taiwan. The heavy rainfall caused severe flooding, enormous mudslides and debris flow that destroyed over 100 bridges. Taiwan is still recovering from the wide spread damage to the highway infrastructure. Replacement bridges are being built stronger to resist storm related forces, higher and deeper to account for floods and scour.

The high speed train route passes through 14 cities and 77 towns, bridges, viaducts and tunnels along the scenic west coast of Taiwan. Currently there are eight stations along the route. Four more stations, one scheduled to open in 2012 and three in 2015 to increase ridership. The average daily ridership is 43,000 in 2007, 84,000 in 2008, 89,000 in 2009 and 101,000 in 2010.

CLOSING REMARKS

Bridges, viaducts and tunnels make up majority of the mileage of the high speed rail lines. High speed trains in Asia are attracting increasing numbers of riders, because they are safe, economical, comfortable, clean and punctual. The attendants are polite, helpful and efficient. The amenities are appealing to the travelers.

Many safety features are incorporated into the design and operation of the high speed trains. High design, operation and safety standards are established to eliminate at grade crossings, minimize curvatures, build passenger-dedicated lines and double tracking, and install disaster monitoring, warning and avoidance systems. Modern high speed trains are equipped with high-tech devices to assure safety and comfort. For examples, earthquake warning system that can bring the train to a stop, obstruction detection device, rail temperature sensor, tunnel alarm device for safety of workers in the tunnel, dragging detector to warn of obstacle being dragged by the train, on-car computer systems to control the train, self-diagnosis system for checking the functioning of the facilities in the trains.

Interestingly, we have not ridden in the Acela Express operated by Amtrak, running between Washington, D.C. and Boston. This high speed rail service is capable of operating at 150 mph. However, it is now operating at an average speed of about 60 mph. Each time we wanted to ride on it to go to New York City, the seats were fully booked. We will make it one of these days! Good to know that the Acela Express Line is popular, attractive to riders and is operating at a profit.

M. Myint Lwin is the Director of the Office of Bridge Technology, Federal Highway Administration, Washington D.C., a member of the International Bridge Conference Executive Committee and frequent contributor to the IBC Special Edition of the ***Pittsburgh Engineer***

Perspectives
FROM THE 7TH PRC-US BRIDGE ENGINEERING WORKSHOP

By Li Xue and Thomas G. Leech, P.E., S.E.

As a young Chinese bridge engineer this workshop is very successful and gorgeous for me, I achieved a lot not only in technology, but in culture and friendship. My job is mainly about writing and editing highway bridge standards and specifications. During this workshop I learned the system and progress of the writing of standards and specifications in USA, which is really much better and sound. We should use them for reference in my opinion.

Aside from technical activities, much time was spent connecting and communicating. The US delegates and Chinese delegates became friends and even family. We quickly got to know each other, developed an understanding, and learned from each other. From my own perspective, I think the basic difference between western people and Chinese people is that the westerners pay more attention to individuality while the Chinese pay more attention to collectivity. I do realize that from time to time, there does exist some difficulties in China, not only in technology but in daily life. But more and more opportunities like this workshop happen, and our government is quite supportive. So, I have 100% confidence in our government and our people, as we are trying our best to make things better and better. (Elsa) Li Xue (PRC)

These words captured the youthful and optimistic spirit of the 7th PRC-US Bridge Engineering Workshop, conducted in Shanghai, China in September of 2010. The PRC-US Bridge Engineering Workshop includes a collaboration of Chinese and US government engineers, academicians and practitioners, who share a special interest in bridges. The workshops are designed to exchange state-of-the-art information on highway bridge technologies and to plan and develop future cooperative research projects between the People's Republic of China and the United States. The workshops have been conducted in alternating years with the location alternating between the Peoples Republic of China (PRC) and the US.

The *PRC-US Bridge Engineering Workshop* began initially under the name of the *Seismic Analysis and Design of Special Bridges* workshop series. This series was conceived as a collaborative project between the People's Republic of China (PRC) and the United States. The initial focus of the series was earthquake engineering and earthquake disaster mitigation. Led by Dr. Lichu Fan, State Key Laboratory for Disaster Reduction in Civil Engineering, Tongji University, China and Dr. George C. Lee, MCEER, University at Buffalo, the series, which commenced in 2002, has received primarily sponsorship by the Federal Highway Administration in the US, the Chinese National Natural Science Foundation and other agencies in China. Typically the location of the workshops has alternated between the Peoples Republic of China and the United States. The first workshop was conducted at Tongji University in Shanghai, China and the second workshop was conducted at the State University of New York, in Buffalo.

Conference Participants – Technical Sessions - Tongji University

The initial focus of the workshops was to share technical information and construction experience in the seismic design and performance of "special" highway bridges. "Special" bridges include major long span bridges, small-to-moderate-span bridges with complex geometries and bridges located on hazardous sites. The long-term objective of the series is to develop a knowledge base and guidelines for these unique structures. The scope of the workshop series has broadened over time as reflected in the current name: the PRC-US Bridge Engineering Workshop. Currently

Conference Participants and Guests – Technical Visit – Yangtze River Crossing

the workshop series reflects equal interest in the design and safety of all bridges as well as the seismic resistance and maintenance of bridges with emphasis on the exchange of state-of-the-art information on highway bridge technologies.

The 7th PRC-US Bridge Engineering Workshop returned to Shanghai, China and Tongji University. The university, with more than 30,000 students and 8,000 staff members, is a comprehensive university highly ranked in Engineering. As one of the oldest and notable universities in China, Tongji was established in 1907 by the German government together with German physicians in Shanghai. The city of Shanghai, straddling both sides of the Yangpu River and situated near the mouth of the Yangtzee River in eastern China, has, after rapid growth in the past twenty years, become one of the world's leading cities, exerting influence over finance, commerce, fashion, and culture. Shanghai has also become a popular tourist destination renowned for its historical landmarks such as The Bund and Yuyuan Garden (west bank), and its extensive yet growing Pudong skyline (east bank). It hosted the World Expo in 2010, attracting 73 million visitors. It is described as the "showpiece" of the booming economy of China. Shanghai also features a 30 km (18 mile), 431 km/hr (268 mph) Maglev intermodal connection from Pudong International Airport to the local transit system within the city.

The 7th *PRC-US Bridge Engineering Workshop* was conducted at the close of the Labor Day weekend in 2010 and featured a two day technical session and a two day technical and cultural visit to Shanghai and its environs. While English was the official langue of the conference, the technical sessions included conversations in both English and Mandarin Chinese. The sessions, conducted on a dual parallel track, emphasized Structural Safety and Seismic-Resistance of Bridges. Design codes, specifically the US LFRD code, was a "hot" topic of conversation as ready comparisons between the emerging bridge codes of China and the current US LRFD sparked interesting conversation. Each session included presentation of technical papers and dialogue between delegates. The dialogue was quite instrumental in fostering collegiate discussion between the participants and was culturally awakening , leading to a better understanding of the differences in growth, maturation and approach taken towards the rational design and construction of highway bridges and tunnels in each county. The hefty 340 page workshop proceedings was available to all participants in the conference, who represented an equal mix of Chinese and US government engineers, academicians and practitioners.

Highlights of the two day technical and cultural visit included a trip to the newly constructed and expressive Yangtze

Conference Participants and Guests – Cultural Visit – Bridge of Many Colors

River Bridge and Tunnel, an impressive toll facility with even more impressive state of the art, high-tech operations center. The cultural visit also included a trip to the 2010 World Expo with VIP privileges to many exhibitions, a night cruise on the Yangpu River, a night walk along the Bund (west bank) and a visit to the Yuyuan Garden. Most impressive to bridge engineers was the varied and well illuminated bridges, throughout the city. All major bridges, whether river crossing or grade separation, have significant accent lighting, with much of the night time lighting modulating with variable non-repeating patterns and colors. And of course, on the free day after the conference and cultural visits, most US bridge engineers "had" to ride the Maglev, and at least one of them more than once.

For many of us from both countries, the 7th *PRC-US Bridge Engineering Workshop* was a singular lifetime event, rich in education and culture, opening a new dialogue to engineering colleagues from two continents.

(Elsa) Li Xue is a specification writer for CCCC Highway Consultants Co., Ltd. (PRC). Thomas G. Leech, P.E., S.E. is the National Practice Bridge Manager for Gannett Fleming Inc., is the IBC Magazine Guest Editor and was an invited speaker to the workshop.

Value Planning Approach An International Perspective

By Muthiah Kasi PE, SE, CVS (Life)

Seventeen-Arch Bridge in Beijing, China - a rainbow over the River

Bridge design and construction is fairly uniform and consistent throughout the world. Codes in various countries are similar and enforce consistent behaviors. However, the application of codes and how resources are spent varies around the world. Engineers are truly operating on a global stage. Guidelines and codes of practice and procedure are focused on how to design and build and not so much on building the right project, a fair amount of which is based on user's needs and desires. One should keep in mind that there is a big difference between "build the project right" and "build the right project." For the latter part, there is a need for a management tool to comfortably serve the clients from a global perspective. Value Planning offers such a management tool.

Value Planning is often misunderstood and confused with cost reduction. Value Planning is not a cost reduction tool. It helps designers to deliver a cost effective project that can yield a higher return for the investment. The core approach of the Value Planning process is to recognize users, owners and other stakeholders and understand their needs, desires and constraints. In addition to satisfying the basic functions of a project, the process focuses on the four enhancing function categories; Assure Dependability, Assure Convenience, Satisfy Stakeholders and Attract Stakeholders.

Value Planning is gaining attention on the international scene equally by countries both on the rise and experiencing economic hardship. Observations in this paper are based on seminars and workshops conducted in United States, Canada, Austria, Middle East, Taiwan, China and India. These observations clearly demonstrate the need for a Value Planning process to serve local needs in the global market. In each of the case studies shown here, the strengths of each culture are learned and concepts that can balance their needs and desires are observed.

Sharing and learning different practices through team workshops is the theme of this article.

Value Planning:

Value Planning is based on three factors:

1. Every project impacts someone (users, owners and other stakeholders)
2. Every stakeholder has project expectations (constraints, needs and desires)
3. The cost of satisfying these expectations must be measured (value and mismatch)

The justification is based on the culture and practices of the local residents. Value Planning follows the Value Engineering methodology in the planning phase. As designers, we should understand and follow the tradition, culture and practices to give our clients better value.

Observation of a Case Study in Austria:

When I was invited to be a keynote speaker at a Value Engineering conference in Vienna for the Royal Academy of Architects and Engineers, I planned to present a Value Planning case study of a pedestrian bridge among other examples. I dropped the pedestrian bridge case study when I learned that the value of pedestrian bridges or underpasses, as defined in Midwest USA, is not the same in Austria. In Vienna, they are eliminating pedestrian underpasses and establishing more at-grade crossings since pedestrians are treated as the primary user of the roadway (see Figure 1). In the United States, pedestrians are separated in high volume traffic areas to assure safety and minimize liability. This reduces convenience to pedestrians while improving traffic operation. The Value Planning process begins with identifying users, owners and stakeholders before looking at options. This approach will avoid the delivery of a project that violates local initiatives.

Figure 2a and 2b: Beauty as well as strength

Observation of a Case Study in China:

China is pushing their envelope by building everything to be the best, unique and one-of-a-kind. Attracting stakeholders is a priority in constructed projects (See Figures 2a and 2b). China is historically known for its unique and innovative construction approach. When one travels through Beijing, one marvels at the beauty of the Seventeen-Arch Bridge. The Seventeen-Arch Bridge, connecting the Kunming Lake in the east and Nanhu Island in the west, was built during the Emperor Qianlong Period (1711-1799). The stunning landscape projects an image of a rainbow arching over the water. There are 544 distinctive carved white marble lions on top of the parapet with carved bizarre beasts at the ends. This tradition still dominates their desire to spend resources for beauty and appearance. In addition, they accommodate two wheeled and non-motorized vehicles and pedestrians in all of their bridges. While this may create management, technical and financial risks, it is an important element that requires careful consideration.

For those who have followed the American design and practice, it is obvious that there are risks in their approach. Looking at a recently built cable-stayed bridge, one notices the absence of shoulder and median barrier to separate two-way traffic. However, it is not a risk in Shanghai since it is customary to not have a physical barrier between two-way traffic. Any cost to increase the width to accommodate a median barrier and shoulder is perceived as a mismatch (high cost with low need). The Value Planning process can help address the perceived mismatches, weigh the risks and arrive at solutions that balance use and safety.

Observation of Case Study in Taiwan:

The approach to construction in Taiwan is similar to China. When we performed a Value Planning study of tunnel construction for the Nankang-Ilan Expressway in Taiwan, satisfying and attracting stakeholders dominated the selection of ideas. Building the biggest TBM tunnel was the most important element, despite the risk. Being in the middle of a fault that the geological experts pointed out may risk a TBM machine getting stuck would negatively impact the schedule, which was critical. The Team evaluated the Assure Dependability Function and the Attract Stakeholder Function to balance the risks, desires and costs. It stressed the advantages of the New Austrian Tunneling Method (NATM) in scheduling and mitigating the risk of geological conditions, especially in the presence of the aforementioned fault. The final recommendations were based on balancing the needs and desires of the stakeholders.

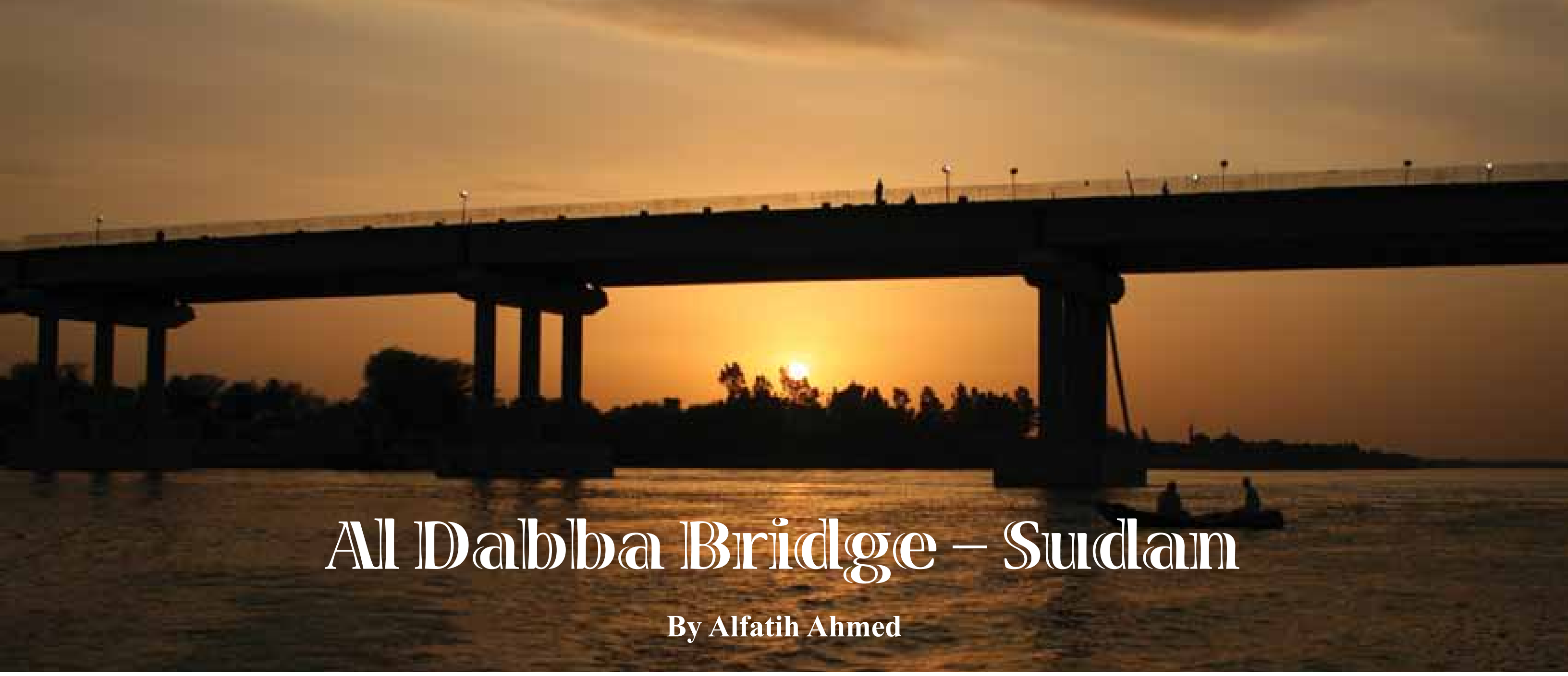
Observation of a Case Study in Middle East

A Value Planning study of an airport design in Cairo, Egypt showed some interesting facts. The airport design in its original form showed that 61% of the cost was allocated to the Attract Stakeholder Function. The Value Planning Team suggested ways of reducing the Attract Stakeholder Functions and add more to Assure Dependability and Assure Convenience Functions. The airport that had more glass was changed to increase the stone and concrete exteriors which increased safety and security concerns. Also, in a hot climate, the glass exterior material did not yield higher value to the customers. It is common for people to like certain concepts that are built elsewhere. The Value Planning process forces the participants to test perceived concepts against what is needed and assure that the return on investment and the risk are justified.

Observation of a Case Study in India:

One of India's major driving forces is to build more bridges to increase mobility. Bihar, an Indian State, has completed construction of 2,100 bridges in four and a half years. This means they have opened an average of one and a half bridges a day. This has created a shortage of available skilled and experienced labor. The Value Planning approach was implemented to evaluate construction methods that relied on less field labor like precast construction. Realizing these challenges, two companies (SEW and Asia Engineering Company) invited me to conduct a seven day workshop to train upper level managers to be familiar with Value Planning and other techniques. These techniques included Value Planning, Balanced Score Card, Key Performance Indicator and Lean Management. At the end of the workshop, the managers were able to successfully employ the various techniques. It is hoped that they will continue to use Value Planning to build the right project and the other techniques to build the project right.

Part of Value Planning training is to learn techniques practiced in other countries. I observed a bridge under construction in Tirunelvely, India which differed from traditional abutment construction. An abutment has two major functions; support vertical load and resist lateral pressure, and is constructed to carry the vertical load and an MSE wall is built to resist the earth pressure. If the bridge is to be lengthened in the future, the abutment can be easily relocated without any disturbance to the bridge superstructure since the pier is supporting the vertical load. Some can argue ...(*Continued on Page 31*)



Al Dabba Bridge – Sudan

By Alfatih Ahmed

The Sudanese Government in recent years has been improving the transportation infrastructure in northern Sudan through the construction of several major highways. As a result of the highway improvements, three major bridge crossings over the Nile were required. The crossings occurred at: Al Damar, Dongola and Al Dabba. The new infrastructure will reduce travel times to the northern towns from the capital Khartoum by 3-4 hours and from the port by the Red Sea by 8-9 hours.

All three bridges were built by A&A Engineers and Constructors leading a consortium of local contractors. Since the three projects were fast track, the Design/Build method was used for project delivery. A&A was awarded the Design/Build contract for the three bridges. A&A appointed Tony Gee Partners LLP of London to perform detail design and technical assistance during construction.

Al Dabba Bridge is the latest bridge to be completed and was opened earlier this year.

It was completed in 15 Months from start of studies to completion of construction and preliminary hand over. Preliminary Engineering was started in March 2009 and it included surveying, bathometric survey, hydraulics and geotechnical engineering. Detailed design commenced by TGP in April 2009 and the bridge was completed with the cross-over ceremony taking place in June 2010. The duration of the project from design to completion was a record for this size of bridge in Sudan.

To meet a tight construction schedule, A&A proposed to build the pile cap above the low water level to eliminate driving sheet piles and dewatering for each substructure unit. Also "T" girders with wide flanges were proposed for the superstructure. They have many advantages such as providing lateral support for the beams during erection, and eliminating the need for intermediate diaphragms. Another advantage is that they act as a form for the deck and save time and cost of deck forming.

The bridge has an overall length of 366.6m and comprises 7 spans of 40.9m and two end spans of 40.15m. It carries a dual two lane highway with an overall carriageway width of 16.0m. A minimum clearance above high water of 6.5m was provided for local boats and future barge use. The bridge is located on the edge of the Nubian Desert where temperatures can rise to 45 degrees C.

The design was undertaken to British standards and UK highway loading with an allowance for 40 units of HB. The area is subject to low seismicity and the bridge was designed for a peak ground acceleration of 0.065g corresponding to a 1 in 300 year event. Seismic design provisions were in accordance with AASHTO.

At the bridge location, the depth of the Nile varies seasonally between 8.0m and 19.0m with control of the flow also dependent on the operations of the Merowe Dam. To assess the effects of scour a study of the Nile at the bridge location was undertaken by Khartoum University. This included collecting data on the river and modelling a length upstream from the bridge in order to determine the flow characteristics for a 1:100 year event. Based on the results of the modelling, and the proposed foundation arrangement, the predicted maximum scour was 6.5m. The maximum height from scoured bed level to underside of the deck was therefore approximately 32m. As a result design of the substructure was a critical aspect of the design.

The shallow water piers were supported on 3 x 1.8m diameter bored piles in a single row while the deep water piers were supported on two rows of 3 x 1.5m diameter bored piles. Piling operations were undertaken using barge mounted piling rigs during the low water season when the current was not as severe. The piles were bored through the superficial deposits into the underlying Weathered Sandstone to form a rock socket, with steel casings providing lateral support to drilling above rock level. The unconfined compressive strength of the Sandstone is between 2.0MN/m2 and 8.0MN/m2 resulting in a required socket length of 8.0m. The pile toe level was approximately 25.0m below bed level.

The substructure is comprised of concrete pile caps supporting three concrete columns and a crosshead. The pilecap was designed to be constructed above low water during the dry season. TGP used a 3D model of the bridge in LUSAS to design the substructure and assess the distribution of longitudinal and transverse loads between the piers. This was particularly necessary for vessel impact which was critical to the design. The slenderness of the piles and the effect of deflections were assessed using second order (P-Δ) and buckling analyses. The program REPUTE was used to calculate the forces in the piles within the ground, taking into account soil structure interaction and plasticity effects in the soil.

Based on previous experience in Sudan, quality control of the concrete was an issue and high compressive strengths were difficult to consistently achieve with the local aggregate. The design strength was therefore limited to 45N/mm2. This placed a practical restriction on the pre-stressing that could be sensibly applied and the maximum span of the deck without significantly increasing the weight of the beam. A&A and TGP considered various deck and span arrangements that took into account the locally available skills, experience and equipment before arriving at the type of construction that would be best suited for the site.

Each span is comprised of eight precast, post tensioned, reinforced concrete beams at 2.5m centres with an insitu concrete topping. The spans are simply supported between piers with a link slab connecting the decks to form two continuous bridges. The girders are "T" shaped with a thin widened top flange 2.5m wide that provides lateral stability to the beam during erection and acts as a soffit shutter while casting the deck. A full width working platform is therefore provided after erecting all eight beams enabling construction to proceed at a rapid pace. Additional formwork was only required for concreting of the end diaphragms, expansion joint cantilevers, deck parapet upstands and median barrier. The beams were post tensioned with 5 draped tendons comprising 13 x 15mm diameter strands. All the pre-stressing components were provided by OVM from China. The beams were supported on elastomeric bearings.

The girders were cast and stressed in a pre-casting facility established by A&A at the site. A&A also included a rail mounted beam handling system for moving and storing the beams ready for transportation to the deck for erection. A proprietary single box type launching gantry supplied by NRS was used to erect the beams span by span over the river. The gantry was completely self supporting on the permanent new piers. The beams were moved along the deck using rail mounted trolleys and subsequently picked up by the launcher for placing in their final position. The maximum beam weight erected was 100T.

Delivery of the project in the required timescale, taking advantage of the low water season for piling and substructure construction, required close cooperation between A&A, TGP and the Client's Engineer. This enabled construction to progress while the design was being prepared and approved. A rapid response to construction difficulties and in particular piling problems by all parties involved ensured a successfully project delivered.

Mr. Ahmed is the president of A&A Consultants, Inc in Pittsburgh, PA. In most recent years, his interest has focused on the Design/Build project delivery method in developing countries. Also, serving as president of A&A Engineers and Constructors, in Khartoum Sudan, he has been instrumental in developing innovative ideas that can help save cost and successfully optimize construction time when Design/Build contract is used as a project delivery method.

Value Planning Approach:

An International Perspective

(*Continued from Page 29*)

...that it is not cost effective since one element is replaced by two elements. Even though the first cost is more, it may save future cost if the bridge is to be lengthened and the bridge traffic and road (below) traffic has increased.

Conclusion

The following three features of the Value Planning process makes it very beneficial to stakeholders on a global scale:

1. Structure: Value Planning is an organized process that emphasizes creativity and logical reasoning based on customer needs and desires. Value Planning is not a cost reduction technique. Instead, it is meant to deliver the customer a defined value product. If a solution is based on creative and logical reasons, it will lead to an efficient solution that in most cases results in cost savings.
2. Learning to Work Together: Value Planning stresses team work and demonstrates how working together can balance conflicting interests. Its' main focus is not on how the technology works, but rather how people working together can make a difference.
3. Documenting and Communicating Information: Documentation and communication is equally important in the process to understand and sell the results.

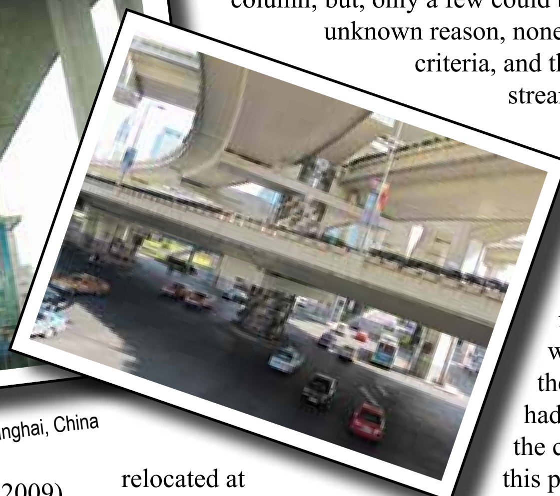
Building the right project is the objective of any Value Planning process. This objective will be realized with a desirable balance of performance, acceptance and cost is achieved in the Value Planning process. Performance should include present and long-term operation and maintenance. Acceptance requires understanding and respect of local cultures and practices. Cost includes affordability and return on investment.

Muthiah Kasi PE, SE, CVS is the Chairman of the Board of Alfred Benesch and company. He has served as Project Manager for Buildings, Bridges and Highways for Alfred Benesch and company for the past 40 years. He is a Fellow of SAVE International organization and serves as a Director of the Value engineering certification Board. He is the Sub Committee Chairman of ASTM Building Economics. He has published or coauthored books on Bridges and Value Engineering

The Tale of the "Dragon Pillar"

Under Shanghai's Elevated Expressways

By YuWen Li



Urban Elevated Expressway Network in Shanghai, China

People who travel in Shanghai, China will be amazed by the modernized transportation system developed in the past twenty years. As the biggest and most populous city in China (Shanghai's permanent population amounted to 19.2 million at the end of 2009), improvement of surface transportation has been accomplished by simultaneously going under (subway system), going over (elevated expressway), and going laterally (widening). (These photos were taken when I revisited Shanghai in 2006 after eighteen years since my last visit.)

After hearing a few "wows!" from me as I returned to Shanghai in 2006, my college classmate and long time friend said I may be interested to see the "*Dragon Pillar*" that is located at Chengdu Road and Yan'an Road intersection. I have to say that once I saw it, I was very proud to be a structural/bridge engineer, although I had nothing to do with anything that happened in Shanghai. The Dragon Pillar that supports the five-level expressway is a single column wrapped with stainless steel plates covered with dragons. I was first stunned by the arrangement of the entire system, but then said to myself "*no big deal, I can do it...what's the deal with dragons?*" I asked. Here is the story I was told, a piece of local legend, one of many versions.

This legend was traced back to the nineties (1995-1999). The massive construction of the city's Yan'an elevated expressway had been going smoothly until reaching its hub point at the intersection with Chengdu Road. Many piles were designed to support the single column; but, only a few could be driven for some unknown reason, none of them met the design criteria, and the project was stalled. A stream of engineers and experts were brought in but could not figure out the cause of the delay. Gradually, people started to spread a rumor that the column was poorly located and the Feng-Shui (harmony) had been disturbed. While the column could not be relocated at this point, the senior monk from Longhua Temple was summoned to provide the remedy. Site visits by the monks revealed the problem – a dragon was sleeping beneath the work site, and the driven piles hit the back of the dragon! In order for the dragon to move willingly, a series of ceremonies were held to call upon the dragon's sacrifice for the happiness of people of Shanghai. It worked, and project was finally finished on schedule. To honor the sacrifice made by the dragon, the column was decorated with dragons, as well as with the companions of phoenix, sun and moon, all renowned symbols of happiness and fortune in China.

Although people like to tell folk tales, the fact that public works like infrastructure projects can generate great interests in people is amazing itself. If the US infrastructure projects can have public support at the same level as in China, we can revitalize our highway system in no time.

YuWen Li, P.E. is a senior structural engineer for Gannett Fleming, Inc., Valley Forge Pennsylvania.

The Sheik Zayed Bridge

By Owen Trickey

On November 28 of 2010, the Emirate of Abu Dhabi opened its newest bridge across the Khor Al Maqta (Maqta Channel) connecting the island of Abu Dhabi to the mainland. The bridge is named after Sheikh Zayed bin Sultan Al Nahyan, the ruler of Abu Dhabi and the president of the United Arab Emirates (U.A.E.) from 1971 until his death in 2004. The new bridge, started by Archirodon Construction (Overseas) Company S.A. and completed by Six Construct (Sixco) at a cost of $300M (US), is the new main gateway over the channel to the city of Abu Dhabi and carries the fourth traffic route connecting the mainland to the island of Abu Dhabi. At the opening ceremony, Sheikh Khalifa bin Zayed Al Nahyan, the current president of the U.A.E., ruler of Abu Dhabi, and Sheikh Zayed's son, said the project underscores the Emirate's commitment to achieving the goals of Plan Abu Dhabi 2030, Abu Dhabi's ambitious development plan.

The bridge was designed by the Iraqi-born architect, Zaha Hadid. Hadid is best known for being the first woman to win the prestigious Pritzker Architecture Prize. The structure is composed of asymmetrical arches, of varying heights, that form a sinusoidal waveform providing a structural silhouette across the channel. Its design evokes an image of undulating dunes crossing the desert. According to Hadid, the bridge's arches are "a collection, or strands of structures, gathered on one shore, (that are) are lifted and 'propelled' over the length of the channel." The bridge is meant to be a new icon for Abu Dhabi in addition to reducing the travel time to the Corniche in downtown Abu Dhabi by 15 minutes.

The bridge incorporates a dynamic lighting system on both the arches and the underside of the bridge deck. The lights appear to "flow' across the channel providing a dramatic experience for users and enhancing the bridges iconic status.

According to lighting designer Rogier van der Heide, the lighting design "is based on two principles: Firstly, it (the lighting scheme) is a metaphor of energy flowing across the water, visualized (sic) by colours (sic) of light cross-fading from one to another while simultaneously moving along the bridge's spine. Secondly, the lighting renders the bridge's spine at night in a 3-dimensional fashion, by projecting different colours (sic) on horizontal and vertical surfaces, that way articulating the spatial structure of the bridge's spine."

The structural design was performed by Highpoint Rendel, Ltd. The eleven-span bridge is a total length of 842 meters (2,762 feet) with a maximum span of 140 meters (459 feet). The primary load supporting members consist of two lines of hybrid arches. Each line of arches consists of five individual arches with asymmetric peaks, the highest of which rises 63 meters (207 feet) above the roadway. Each arch consists of cast-in-place post-tensioned concrete thrust blocks projecting diagonally from the piers. The thrust blocks support steel box members that form the central portion of each arch. The arches are linked together using transverse post-tensioned concrete members located close to the thrust blocks.

The arches support two, four-lane carriageways, positioned side-by-side, consisting of cast-in-place reinforced concrete post-tensioned box girders. Each carriageway carries four, 3.65 meter (12 feet) wide traffic lanes, two 3.0 meter (9.8 feet) wide shoulders, a 2.0 meter (6.6 feet) wide emergency lane, a pedestrian walkway, and high-containment vehicle parapets. In Spans 7 and 9 (the main channel spans), each carriageway is suspended from the arches using steel hangers attached to cross girders spanning between the two carriageways. The rest of the spans are supported from below on inclined post-tensioned concrete supports rising vertically from the pile caps or directly the arches. The design of the carriageways was particularly challenging because they are located outside the arches and cantilever a substantial distance. A 100 meter (238 feet) wide ship channel is provided with a vertical clearance of 16 meters (52 feet) underneath the carriageways.

The new bridge is constructed on silty fine grained sands overlying weak bedrock of mudstones and siltstones with layers of gypsum in the upper layers. The foundations consist of 1,500 mm (4.92 feet) diameter drilled shafts and were constructed using cofferdams. A total 670 drilled shafts were required with an average length on 22.6 meters (74 feet).

The new bridge was designed for a service life of 100 years in accordance with the AASHTO LRFD Bridge Design Specifications for a load equal to twice that of the HL-93 vehicular live load. It was designed for a temperature range of 0°C (32°F) to +60°C (140°F) and a design wind gust velocity of 45 m/sec (157 mph). The piers can resist a 1,200 (metric) tonne (1,322 ton) impact from a barge or tug travelling 5 knots. The possibility of progressive collapse was also considered and the bridge can remain serviceable if one cable is removed or damaged and will not collapse if two cables are damaged in an extreme event. The bridge is located in AASHTO LRFD Seismic Zone 2 and was designed for to resist the 475-year earthquake and a peak spectral response 0.225g while being checked for the 750-year earthquake.

Due to Abu Dhabi's location and climate, corrosion protection for the reinforcement steel is always a concern. The average high temperatures in the summer months reach approximately 105°F and the record high is 118°F. Because it is near the coast, humidity is typically over 80% and salt penetration can be a problem. Typically, epoxy coated steel is not used. Instead, emphasis is placed on concrete mix design and crack control. Concrete mixes with 70% ground granulated blast furnace slag (GGBS) and calcium nitrite corrosion inhibitor were used and clear cover for severe exposure conditions was specified for all reinforcement steel. Where corrosion resistant steel is used, such as tidal or splash zones, stainless steel bars are specified. A dehumidification system was provided for the interior of the steel arches as well.

Construction of the bridge began in July of 2003. Archirodon Construction (Overseas) Co. S.A. was the original contractor but they were replaced by Six Construct, Ltd, a subsidiary of the BESIX Group.

Owen Trickey, PE is the Department Manager of the Bridge Group in the Mount Laurel, NJ office of Gannett Fleming, Inc. All photos are courtesy of the author.

If you would like to learn more about the Sheik Zayed Bridge see both the Case Study: Sheikh Zayed Bridge – Abu Dhab by Joe Bar and Verdy Jones, Bridges middle east 2009, and the Sheikh Zayed Bridge now illuminated (2011); World architecture news.: <http://www.worldarchitecturenews.com/index.php?fuseaction=wanappln.projectview&upload_id=16010> (March 13, 2011).

2011 IBC Bridge Awards Program

By Herb Mandel, P.E.

Roebling Winner:

"... One of the 'jewels' of the industry..."

George S. Richardson Winner:

"... Very impressive... a 'wow' bridge..."

Gustav Lindenthal Winner:

"... It's a beautiful structure..."

Eugene C. Figg, Jr. Winner:

"... Monumental work in a fantastic, natural setting, complementing the engineering wonder of Hoover Dam... and a pride of the communities..."

Arthur C. Hayden Winner:

"... -eye catching... this is a bridge you simply cannot ignore... its beautiful... I have never seen anything like this..."

These are just some of the many comments of the International Bridge Conference® Award's Committee as they viewed, voted and selected this year's winners.

The International Bridge Conference® in conjunctions with Roads and Bridges Magazine, bridge design and engineering Magazine and the Bayer Corporation, annually awards five medals and one student award to recognize individuals and projects of distinction. The medals are named in honor of the distinguished engineers who have significantly impacted the bridge engineering profession worldwide. The student award is named in honor of a former IBC General Chairman, a champion of the student award's program and a friend to the community at large. And this year we additionally have added as special recognition award, as well.

Interest in the IBC awards program is quite robust nationwide and internationally. This year the Awards Committee reviewed more than thirty nominations for the four bridge metal categories alone, half of which were projects nominated beyond the borders of the United States. After lengthy deliberations, the following individuals and projects were deemed worthy of this year's awards.

John A. Roebling Medal

Michael J. Abrahams, PE

The John A. Roebling Medal recognizes an individual for lifetime achievement in bridge engineering. We are pleased to recognize Michael J. Abrahams, PE as the 2010 recipient. Upon receiving his M.S., Engineering Mechanics, Columbia University, Mr. Abrams served with the U.S. Peace Corps in the Philippines as a civil engineer working with a Philippines government agency. Shortly thereafter Mr. Abrahams joined Parson Brinkerhoff. Currently, he is Manager of PB's New York Office Structures Department where his responsibilities include providing expert testimony, failure investigation, participating in peer and quality control reviews, conducting studies, preparing contract drawings and specifications, designing and checking design calculations, and providing structural analysis. Mr. Abrahams has overseen the design of 50 major bridges of various types and sizes. In addition, Mr. Abrahams has 20 different professional affiliations, has received numerous awards and prepared numerous publications, presentations and papers. His committee work, amongst others, includes Heavy Movable Structures/Movable Bridges Affiliation, Structural Stability Research Council, and the Transportation Research Board: former member Committee on Seismic Design of Bridges.

George S. Richardson Medal

The George S. Richardson Medal, presented for a single, recent outstanding achievement in bridge engineering, is presented to recognize the Stonecutters Bridge , Hong Kong, China. This striking cable stayed structure features 960 foot tall towers and 3,300 ft main span, spanning the Rambler Channel to Stonecutters Island. As the second longest cable-stayed span in the world, with an unusual span arrangement with 1:4:1 ratio of back/main/fore spans, the bridge features twin aerodynamic decks suspended from two single pole towers supporting 3 lanes of traffic in each opposing direction. The Hong Kong region is susceptible to very strong typhoon winds, a fact that was taken into account in the design of the bridge. The two towers are constructed in concrete until Elevation 560 ft and above that elevation, in composite construction, consisting of an inner concrete ring with a stainless steel skin with a shot peened surface finish.

Stonecutters Bridge , Hong Kong, China

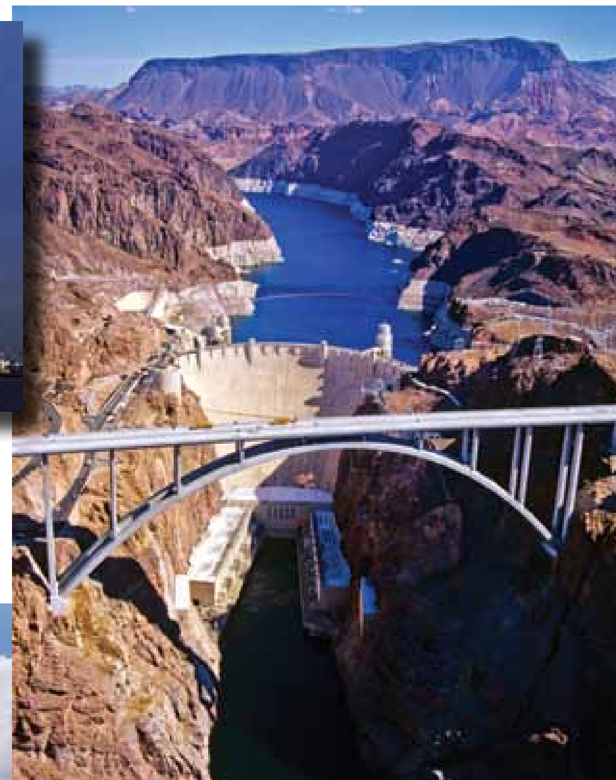
North Arm Fraser Crossing, Vancouver to Richmond, British Columbia, Canada

Gustav Lindenthal Medal

The Gustav Lindentahl Medal, awarded for an outstanding structure that is also aesthetically and environmental pleasing, will be presented to recognize the North Arm Fraser Crossing, extending the Translink Metro Line from Vancouver to Richmond, British Columbia, Canada. As a two-track transit bridge with pedestrian walkway, the bridge is the first use of an extradosed bridge in North America and features precast segmental pylons and precast segmental superstructure. With a main span of 180 meters, the bridge offered a unique solution to many design challenges including: two navigation channels, restricted vertical clearance due to proximity of adjacent airport, seismic concerns, environmental concerns and input from the public.

Eugene C. Figg, Jr. Medal

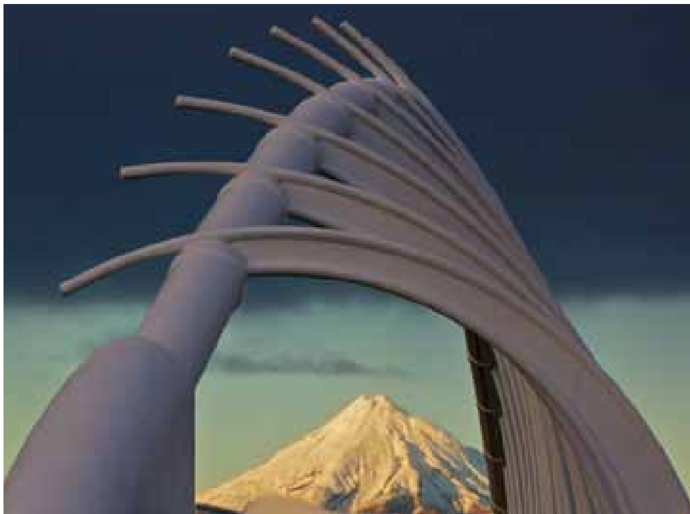
The Eugene C. Figg, Jr. Medal for Signature Bridges, recognizing a single recent outstanding achievement for bridge engineering, which is considered an icon to the community for which it is designed, will be presented to recognize the Mike O'Callaghan-Pat Tillman Memorial (Hoover Dam By-Pass) Bridge. As the highest and longest single span concrete arch bridge in the Western Hemisphere, the bridge features a composite concrete-steel deck arch with arch members constructed from cast in place concrete construction and bracing members constructed from fabricated structural steel, providing most efficiency for accelerated construction. Erection of the arch segments was quite dramatic with the temporary towers used to erect the WV New River Gorge Bridge re-used for this project. The project included large public participation including tribal participation and representatives of adjoining states of Arizona and Nevada. The vertical arch of the bridge wonderfully compliments the horizontal arch of nearby Hoover Dam.



Mike O'Callaghan-Pat Tillman Memorial (Hoover Dam By-Pass) Bridge

Arthur C. Hayden Medal

The Arthur C. Hayden Medal, recognizing a single recent outstanding achievement in bridge engineering demonstrating vision and innovation in special use bridges, will be presented to recognize the Te Rewa Rewa Bridge in New Plymouth, New Zealand. In 2007 the New Plymouth District Council, New Zealand, invited entries into a competition to design and build an iconic



Te Rewa Rewa Bridge, New Plymouth, New Zealand.

bridge "Te Rewa Rewa", that was to be "simultaneously utilitarian and beautiful". In addition, the design was to consider its location on a site historically significant to the local indigenous Maori, where many Maori had died defending their homes in past battles, as well as the widswpt terrain where three bodies of water can be viewed in a single vista, namely the Waiwhakaiho River, Lake Rotomanu and the Tasman Sea. The vision of the architect produced this stunning structure with the following deliberate considerations: Firstly, the deck was aligned to the summit of the near symmetrical and sacred mountain, Taranaki. Secondly, the skewed arch over the deck forms a gateway to signify to the observer that they were entering or leaving sacred land. Thirdly, the series of curved ribs connect the windward side of the deck to the arch, to capture a sense of the prevailing wind. Fourthly, the open and white superstructure in order to frame the natural vistas and be an intriguing form in changing light and shadow conditions.

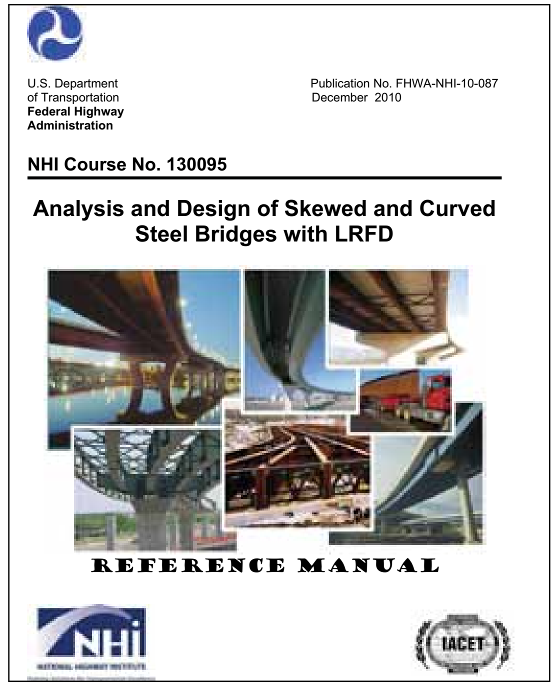
James D. Cooper Student Award

The James D. Cooper Student Award recognizes undergraduate and graduate students who demonstrate an interest and passion for bridge engineering. The award is presented to winners of a student completion for technical writing and engineering insight. The 2010 ward will be presented to Mr. Behrouz Shafei of the University of California at Irvine for his paper entitled: "A Novel Vulnerability Index for Design of RC Bridges Subjected to Seismic Hazards and Environmental Stressors". Mr. Shafei proposes a novel vulnerability index as a reliable time-dependent measure of the seismic damageability of corroded bridges, used directly for structural design and performance assessment as well as a critical parameter for life cycle cost analysis of bridges subject to multiple natural hazards and environmental stressors.

Behrouz Shafei

IBC Engineering Excellence Award

This year the committee judged one of the award nominations to be special and beyond the traditional guidelines of the medal categories. Given the significance of the project which included the preparation of a 1,470-page manual providing instructional material covering the analysis, design, fabrication and construction of skewed and horizontally curved steel bridges using Load and Resistance Factor Design (LRFD), the committee awarded The Engineering Excellence Award for the FHWA Manual entitled: "Analysis and Design of Skewed and Curved Steel Bridges with LRFD Reference Manual". Based on the AASHTO LRFD Bridge Design Specifications, Fifth Edition, 2010, the manual is comprised of five chapters which include a general overview of curved girder bridge design, description of the structural analysis required for skewed and curved steel girder bridges, a discussion of design decisions and details, a discussion of fabrication and construction considerations unique to skewed and curved bridges and comprehensive step-by-step design examples for a skewed and curved I & tub girder bridges, as well as some of the user-friendly design examples and a wide variety of figures, photos and tables.



"... a worthy document that we will use for decades"

The IBC Awards Committee includes Fred Graham, Carl Angeloff, Jim Dwyer, Herb Mandel, Gary Runco, Myint Lwin, Matthew Bunner, Ken Wright, George Horas, Helena Russell, Bill Wilson, Mike Alterio and Tom Leech. The IBC Student Paper Awards Committee includes Dr. John Aidoo, Rose-Hulman Institute of Technology, Dr. James Garrett, Carnegie Mellon University and Dr. Kent Harries, University of Pittsburgh.

Herb Mandell, P.E. (retired) was named Emeritus Member of the International Bridge Conference® Executive Committee in 2010 and for many years has faithfully served on IBC Awards Committee. Herb is never at a loss for words and never without a good quote. – Editor