
Equal Co-Sponsors:
August, 2004

Greetings!

As Mayor of the City of Sacramento, I am pleased to welcome you to the Orthotropic Bridge Conference.

I would also like to welcome you to the City of Sacramento, known as the city of trees and named "America's most integrated city" by *Time* Magazine. Our residents hail from every corner of the globe.

For those of you visiting Sacramento, I hope that you'll take some time to visit some of our wonderful attractions. Sacramento is home to the restored State Capitol, miles of rivers and river parkways, North America's largest railroad museum, the Old Sacramento Historic District, and one of the best small zoos in the country. We are also the home of the Sacramento Kings and Sacramento Monarchs.

Best wishes for a wonderful event.

Sincerely,

HEATHER FARGO
MAYOR

HF:30
FOREWORD

Dear Attendees:

In 1852 ASCE was founded by a few engineers who wanted to share technical information. About 150 years later I came up with the idea for www.orthotropic-bridge.org, and my ASCE friends made it happen. So the spirit and philosophy of ASCE remains unchanged.

The key organizing players and supporting organizations with logos in this successful event are listed on our stationary, copies of which are posted in the appendix of these conference proceedings. The key organizing individuals were employees of the California Department of Transportation (Caltrans), or employees of private engineering firms who do business with Caltrans. This group convinced their friends and colleagues from around the world to attend this conference.

The proceedings include most of the papers presented at the conference. In a few cases where papers are not available, the abstract or PowerPoint alternative are included. Also included in the appendix are some photos and other related conference documents, including the conference program.

I would like to thank the International Bridge Conference (IBC) operated by the Engineers Society of Western Pennsylvania, who allowed us to reprint Jim Valenti’s paper in the proceedings. This paper was presented as part of the 21st Annual International Bridge Conference®, which took place in Pittsburgh, PA (USA), June 14-16, 2004.

I would also like to thank Helena Russell, Bridge Design & Engineering magazine (BD&E), who allowed us to reprint a post conference article. Without positive media help and sponsorship, small events like this cannot succeed.

In addition, three excellent papers, not presented at the conference, have been included in the proceedings. These papers contribute valuable data to the orthotropic deck industry.

We hope that this proceeding will be accepted as a testimony to this successful event, and will inspire a sequel to occur. The papers are grouped according to topic, and the pages have been sequentially numbered in accordance with standard proceedings practice. My close friends and conference supporters are hopeful that we can continue to meet and share ideas about orthotropic bridges. Please see our web site or contact us at the below listed addresses.

Alfred R. Mangus PE
Sacramento, CA
March 2005
ACKNOWLEDGEMENTS

A Big Thank You to Our Volunteers:

To succeed as a leader you need key people to support you. You can never say thank you enough. I came up with the idea of creating an orthotropic bridge conference in January 2002. First and foremost to thank is my friend, Craig Copelan; next are my fellow officers, Ruben Trigueros, Greg Zeiss, Beverly Mason, Dick Weitzenberg, Ben Consolacion, and my Caltrans colleague, Dr. Dash.

After obtaining the support of my fellow ASCE, Capital Branch officers, I proceeded to get the support of key organizations. Lynn Iaquinta of NSBA was our first sponsor, and I was motivated to fulfill the promise of a high-quality venue. Paul Goryl of Parsons helped to create the link to a Parsons’ sponsorship. Myint M. Lwin, FHWA Chief Bridge Engineer, also gave FHWA’s support. I was fortunate to have Bob Luscombe participate early during the planning phases. He was able to double the number of conference sponsors, and led the hotel selection and contract process. Rounding out this conference team are Natalie Calderone, Ray Zelinski, Roman Wolchuk, Check Seim, Dr. Lian Duan, Sarah Picker, Clark Townsend, and Steve J. Lee.

I have been able to obtain support from ASCE National. Jim Rossberg, Director of Structural Engineering Institute (one of the seven ASCE institutes), provided money and ideas. John Casazza, Director of ASCE Continuing Education, has also assisted us. My counterpart, Dennis Ryan of Shasta Branch, chaired a bus tour to visit Redding’s new landmark, the Sundial Bridge. ASCE National President-elect William Henry will visit us at our Thursday evening banquet to support our conference.

Activating non-members is a good thing for ASCE. Colleagues Matthew Socha, Carol Smith and Yusuf Saleh were of great help to ASCE. Sarah Picker has chaired a bus tour to visit various Bay Area orthotropic bridges. Natalie Calderone, who so capably assisted our steering committee with publicity for the conference, has decided to become an ASCE officer based upon the positive experiences she had with this conference. Everyone was impressed with her organizational skills. Lori Tonkin has been doing a tremendous job of managing our vendor booths. The newest team member is Brenda Jew Waters as Media Manager.
Everyone needs a mentor, and serving in that capacity for me has been Norman Root. Norm has given me a lot of tips, and allowed me to brainstorm ideas with him. Along the way were individuals who assisted, but then had other commitments, such as Harry Gobbler and Majid Sarraf.

I have been reconnecting with colleagues over the years, as well as orthotropic committee members. I have met new colleagues and made contacts because of this event. Dr. Wasoodev Hoorpah of OUTA, the French equivalent of NSBA (National Steel Bridge Alliance), generously drove me to the Normandie Orthotropic Cable-stayed Bridge, a two-hour freeway drive one way from Paris.

Numerous Caltrans employees made things happen behind the scenes. It was helpful to have the support of State Bridge Engineer, Rick Land, and SFOBB Manager, Dr. Brian Maroney, plus the Caltrans Steel Bridge Committee. Other important contributors were H. J. Chavez, Valerie Moore, Mike Marquez, Randy Anderson, Carl Huang, Dr. Thimmhardy, Clark Townsend, Mike Whiteside, Victor Tardy, John Stanley, Norman Cottman, and Darrel R. Brown, Mark Sheahan President of PECG, Conrad Bridges, HDR; Paul Goryl & Greg Orsolini of Parsons; Frank Constantino Stirling Lloyd; Carl Angeloff Bayer; Dennis Nottingham PND; Peter Buckland, Buckland & Taylor; Helena Russell Editor Bridge Magazine, Terese Dunphy Bridge Builder Magazine, Roman Wolchuk Wolchuk Engineers

Finally, to my friend Bernard Chan, owner of the Mayflower Chinese Restaurant, and the staff who make eating there for our meetings a pleasure.

Best wishes,

Alfred R. Mangus, P.E.
Chairman, Orthotropic Bridge Conference
President, ASCE, Capital Branch
Junior Director, ASCE, Sacram
## Contents

### Keynote Papers

**OBC-04-01** — Unified European Rules for the Design of Bridges with Steel Orthotropic Decks  
Gerhard Sedlacek and Christian Müller; *Technische Hochschule, Aachen, Germany*

**OBC-04-02** — A Performance Based Surfacing for the Orthotropic Deck of the New San Francisco-Oakland Bay Bridge East Span Seismic Safety Project  
Charles Seim and Rafael Manzanarez; *T.Y. Lin International, California, USA*

**OBC-04-03** — Orthotropic Decks with Long Rib Spans  
Roman Wolchuk; *Roman Wolchuk Consulting Engineers, New Jersey, USA*

**OBC-04-07** — Steel Bridges – Past, Present and Future  
M. Myint Lwin; *FHWA, Washington, D.C., USA*

**OBC-04-04** — Fremont Orthotropic Bridge Deck - Longest Tied Steel Arch in Western Hemisphere  
Michael J. Abrahams and Mark Hirota; *Parsons Brinckerhoff Quade & Douglas, Inc., New York, USA*

**OBC-04-05** — Orthotropic Deck Bridges in Ukraine  
Mykhail Korniev; *Mostobud, Ukraine*

**OBC-04-06** — A Review of Alaska’s Orthotropic Bridges  
Dennis Nottingham; *PND Incorporated, Alaska, USA*

**OBC-04-26** — Orthotropic Decks for Small and Medium Span Bridges in France – Evolution and Recent Trends  
Wasoodev Hoorpah; *OUTA, France*

**OBC-04-27** — The New Tacoma Narrows Suspension Bridge – Orthotropic Superstructure  
Kenneth Serzan, John Clenance and Jeffrey Lu; *Parsons, New York, USA*

**OBC-04-51** — Steel Orthotropic Box Girder on the New Alfred Zampa Suspension Bridge Across the Carquinez Strait, First in the US  
Ken Serzan and Dyab Khazem; *Parsons, New York, USA*
Fabrication and Construction

OBC-04-08 — Methods of Flux Cored Wires Arc Welding and Ultrasonic Testing for Longitudinal Weld of U-shaped Rib and Deck Plate
Kenji Kuramoto, Makoto Yuda, and Wataru Fujimoto; Kawada Industries, Inc., Japan

OBC-04-09 — A New Orthotropic Bridge Deck: Design, Fabrication and Construction of the Shenley Bridge Incorporating an SPS Orthotropic Bridge Deck
Richard B. Vincent and Angelo Ferro; The Canam Manac Group, Inc., Canada

OBC-04-10 — Orthotropic Deck Fabrication for the Triborough Bridge
Brendan J. Scahill; Greenman-Pedersen, Inc., New York, USA

OBC-04-11 — Box Girders, Design, Fabrication, Operation and Maintenance
Ove Sorensen; COWI, Denmark

OBC-04-58 — Construction of Epoxy Asphalt Pavements on Orthotropic Steel Bridge Decks
R. W. Gaul; ChemCo System, Inc., California, USA

OBC-04-59 — Constructability Innovations for the SFOBB
Sarah Picker; Professional Engineers in California Government (PECG), Caltrans, California, USA

OBC-04-60 — Launching and Construction of the Chiapas Bridge
Superstructure
Carlos De La Mora, Ingenieros Civiles Asociados, Mexico; Roberto Gomez, Institute of Engineering, Mexico; Douglas Williams, California, USA

OBC-04-62 — Integrated Hydraulic Solutions for the World’s Largest Orthotropic Bridge
Peter Crisci, Enerpac, Milwaukee, Wisconsin, USA

Maintenance and Rehabilitation

OBC-04-12 — Golden Gate Bridge Deck and Sidewalk Replacement
Daniel E. Mohn, Ewa Z. Bauer, Mary C. Currie, Frank L. Stahl; Golden Gate Bridge, Highway and Transportation District, California, USA

OBC-04-13 — High Performance Steel for Highway Bridges
Vasant Mistry; FHWA, Washington, D.C., USA

OBC-04-14 — Durability Evaluation of Nagoya Expressway Orthotropic Steel Deck
Kentaro Yamada, Tatsuya Ojio, Hirofumi Maeno and Masanori Iwasaki; Nagoya University, Japan

OBC-04-41 — Strengthening a Bridge Deck with High Performance Concrete
F. B. P. de Jong and M. H. Kolstein; Delft University of Technology, Netherlands

OBC-04-42 — Resurfacing of Orthotropic Bridge Decks in the UK – Practical and Design Considerations
Neil McFadyen, Robert Brady, and Ian Firth; Flint & Neill Partnership Consulting Engineer, UK
OBC-04-43 — Maintenance Philosophy and Systematic Lifetime Assessment for Decks Suffering from Fatigue
F. B. P. de Jong and P. D. Boersma; Delft University of Technology, Netherlands

Wearing Surfaces

OBC-04-34 — Waterproofing the Steel Orthotropic Deck of the Carquinez Bridge
Frank J. Constantino; Stirling Lloyd Products, Inc, UK

OBC-04-35 — Reinforced High Performance Concrete Overlay System for Rehabilitation and Strengthening of Orthotropic Steel Bridge Decks
P. Buitelaar, Contec ApS; C.R. Braam, Delft University of Technology, Netherlands; and N. Kaptijn, Ministry of Transport, Netherlands

OBC-04-36 — The Successful Use of Thin Polysulfide Epoxy Polymer Concrete Overlays on Steel Orthotropic Bridge Decks
Michael S. Stenko and Arif J. Chawalwala; Transpo Industries, Inc., New York, USA

OBC-04-37 — Alternative Waterproof System and Wearing Course for Orthotropic Bridge Decks
Doug Zuberer; Chase Specialty Coatings, Massachusetts, USA

OBC-04-45 — Wearing Surface Systems for Orthotropic Bridge Decks – Issues Related to Testing and Performance Evaluation
Vellore S. Gopalaratnam; University of Missouri-Columbia, Missouri, USA

Fatigue

OBC-04-61 — Modern Fatigue Design of Orthotropic Bridge Decks in the United States
Robert J. Connor and John W. Fisher Lehigh University, Pennsylvania, USA

OBC-04-15 — European Research on the Improvement of the Fatigue Resistance and Design of Steel Orthotropic Bridge Decks
M. H. Kolstein; Delft University of Technology, Netherlands

OBC-04-16 — Overview Fatigue Phenomenon in Orthotropic Bridge Decks in the Netherlands
F. B. P. de Jong; Delft University of Technology, Netherlands

OBC-04-17 — Fatigue Strength Verification of Steel Orthotropic Plated Bridge Deck for Railway Bridges
Wouter De Corte and Philippe Van Bogaert; Ghent University, Belgium

OBC-04-18 — Fatigue Resistance and Ultimate Strength of SPS Bridge Decks
Thomas Murray and Stephen J. Kennedy; Intelligent Engineering Ltd., Canada

OBC-04-23 — Assessment of Fatigue Strength of Steel Orthotropic Plated Bridge Decks from Continuous Measured Stress Spectra
Wouter De Corte; Ghent University, Belgium
OBC-04-24 — Analysis of Fatigue Damage Patterns in Orthotropic Steel Deck of Tokyo Metropolitan Expressways
Tarou Yuge, Fumitaka Machida, Hisashi Morikawa, Chitoshi Miki, Takeshi Kamiki, and Takashi Masui; Technology Center of Metropolitan Expressway, Japan

OBC-04-25 — Local Stresses and Fatigue Durability of Asphalt Paved Orthotropic Steel Deck
Xiaohua Cheng, NJDOT, New Jersey; Jun Murakoshi and Kazuhiro Nishikawa, PRWI, Japan; and Harukazu Ohashi, Parsons, New York, USA

Research

OBC-04-19 — Design and Field Load Testing of the Shenley Bridge, Quebec, Canada
D. J. Laurie Kennedy and R. A. Dorton; Intelligent Engineering Ltd., Canada

OBC-04-20 — Stress Measurements on Fatigue-Damaged Structures with Orthotropic Steel Decks in Summer and Winter
Fumitaka Machida, Tarou Yuge, Chitoshi Miki, Eiki Yamaguchi, Tetsuhiro Shimozato, and Takashi Masui; Technology Center of Metropolitan Expressway, Japan

OBC-04-21 — Compression Behavior of Steel Orthotropic Deck Panels for the New San Francisco-Oakland Bay Bridge
Chung-Che Chou, National Chiao Tung University, Taiwan; C.M. Uang and F. Seible; University of California, San Diego, USA

OBC-04-22 — Research Project TU Delft; Behaviour Conventional Bridge Decks & Development of Renovation Techniques
F. B. P. de Jong, M. H. Kolstein, and F. S. K. Bijlaard; Delft University of Technology, Netherlands

OBC-04-30 — Design & Testing for the Orthotropic Deck of the Bronx Whitestone Bridge
Sante Camo and Qi Ye; Weidlinger Associates, Inc., New York, USA

OBC-04-31 — Accuracy of Weigh-In-Motion by Steel Bridge
Eiki Yamaguchi, Kazushi Matsuo, Shinichi Kawamura, Yusuke Kobayashi, Masafumi Mori, Kunihiro Momota, Tatsushi Nishinohara; Kyushu Institute of Technology, Japan

OBC-04-32 — The Role of Site Measurements to Improve the Knowledge About the Fatigue Behavior of Steel Orthotropic Bridge Decks
M. H. Kolstein; Delft University of Technology, Netherlands

OBC-04-33 — Orthotropic Deck Design Innovation Verified by Laboratory and Field Testing for Williamsburg Bridge Deck Replacement
Dyab Khazem and Ken Serzan; Parsons, New York, USA

OBC-04-46 — Testing Program for the Self-Anchored Suspension Span of San Francisco – Oakland Bay Bridge
Wenyi Long and Vong Toan; Professional Engineers in California Government (PECG), Caltrans, California, USA
**OBC-04-47 — Rationalized Steel Deck Structure and Large Model Test**

Kazuyuki Mizuguchi, *Japan Highway Public Works*; Kentaro Yamada, *Nagoya University*; Masanori Iwasaki and Susumu Inokuchi, *Yokogawa-Bridge Corp. Japan*

**USA Bridges**

**OBC-04-38 — New Carquinez Bridge**

Michael Marquez; *Professional Engineers in California Government (PECG), Caltrans, California, USA*

**OBC-04-39 — New Carquinez Strait Suspension Bridge Fabrication and Sea Transportation of Orthotropic Steel Box Girder Segments**

Michael Marquez, Eugene Thimmhardy, and Raymond W. Wolfe; *Professional Engineers in California Government (PECG), Caltrans, California, USA*

**OBC-04-40 — Technical Fabrication Issues with Steel Orthotropic Box Girder Bridges**

Mazen Wahbeh and Jim Merrill, *Mactec Engineering*; Brian Boal, *Professional Engineers in California Government (PECG), Caltrans, California, USA*

**OBC-04-50 — First Curved Steel Orthotropic Box Bridge in the US**

James E. Roberts, *Imbsen Associates Inc., California, USA*; and Alfred Mangus, *Professional Engineers in California Government (PECG), Caltrans, California, USA*

**OBC-04-52 — A New Replacement Orthotropic Steel Deck for the Triborough Bridge Significantly Reduces Dead Load Mass**

James Valenti; *Greenman-Pedersen, Inc., New York, USA*

**OBC-04-54 — New San Francisco Oakland Bay Bridge Self-Anchored Suspension Bridge — Impact of Seismic Requirements on Orthotropic Box Design**


**OBC-04-55 — New San Francisco Oakland Bay Bridge Self-Anchored Suspension Bridge — Orthotropic Deck Design**

George Baker; *Roman Wolchuk Consulting Engineers, California*; and Marwan Nader, *T.Y. Lin International, California, USA*

**OBC-04-56 — Skyway Orthotropic Box Girder Superstructure**

Sajid Abbas, *T.Y. Lin International*; and Brian Maroney; *Professional Engineers in California Government, (PECG), Caltrans, California, USA*
OBC-04-57 — Cost Estimating Orthotropic Bridge Superstructures
Chris Traina and Brian Maroney; Professional Engineers in California Government, (PECG), Caltrans, California, USA

Published Paper Only

OBC-04-28 — Structure, Design and Construction of Steel Orthotropic Bridge in Sofia
Banko B. Bankov, Doncho N. Partov, and Christo T. Christov; Higher School of Civil Engineering, Bulgaria

OBC-04-63 — Renewal Application Research into Design of Suspension Bridge Stiffened by Steel Slab Girder
Gongyi Xu., China Zhongtie Major Bridge Reconnaissance & Design Institute Co., Ltd., Wuhan, Hubei, China

OBC-04-64 — A New Design Concept for Steel Bridge Decks
S. R. Bright, Cass Hayward LLP, Welsh Street, Chepstow and J.W. Smith., Dept. Civil Engineering, University of Bristol, Bristol

Paper as PowerPoint Presentation

OBC-04-39 — New Carquinez Strait Suspension Bridge Fabrication and Sea Transportation of Orthotropic Steel Box Girder Segments
Michael Marquez, Eugene Thimmhardy, and Raymond W. Wolfe; Professional Engineers in California Government (PECG), Caltrans, California, USA

OBC-04-50 — First Curved Steel Orthotropic Box Bridge in the US
James E. Roberts, Imbsen Associates Inc., California, USA; and Alfred Mangus, Professional Engineers in California Government (PECG), Caltrans, California, USA

Appendices

Index of Papers
ASCE Engineerogram 2004 August Issue
ASCE Engineerogram 2004 Sept Issue
Photo of ASCE Sacramento Section Capital Branch Officers, by Jon Hirtz
Photo of 2004 OBC Committee, by Jon Hirtz
Orthotropic Bridge Deck Conference Highlights International Cooperation, Bridge Design & Engineering by Roman Wolchuk
CD-ROM Order Form
Keynote Papers
UNIFIED EUROPEAN RULES FOR THE DESIGN OF BRIDGES WITH STEEL ORTHOTROPIC DECKS

Gerhard Sedlacek* and Christian Müller*

*Technische Hochschule, Aachen, Germany, Tel: +48 (0241) 80-25177, Fax: +49 (0241) 8022-140

Abstract

(1) For the single European market of construction products, and construction works unified technical rules are being prepared that will substitute the various different National rules to avoid obstacles to trade and free exchange of services.

(2) The new technical rules comprise specifications for materials and semi-finished products (EN’s), design rules for products and works (structural Eurocodes) and General requirements for delivery and execution of metallic structures.

(3) For steel structures the relevant Eurocode is Eurocode 3 which consists of part 1 with general rules and rules for buildings. Part 2 for bridges, part 3 for masts and towers, part 4 for silos, tanks and pipelines, part 5 for steel piling and part 6 for crane and machinery supporting structures.

(4) Eurocode 3 – part 2 related to steel bridges will be used together with the action-codes for selfweight, traffic actions on bridges, wind actions, thermal actions and actions from construction. It refers to other parts of Eurocode 3, e.g. part 1.1 General assessment methods, part 1-5 Plate buckling, part 1-8 Connections and joints, part 1-9 Fatigue, part 1-10 Choice of material and part 1-11 High strength tensile elements as ropes and …

(5) For bridges durability is a pre-dominant aspect that is reflected by
- particular design rules and rules for choice of material to be damage-tolerant,
- requirements for fatigue assessment,
- recommendations for the choice of products and for structural detailing to achieve sufficient quality of execution.

(6) Eurocode 3 – Part 2 has a particular annex with detailing rules, execution tolerances and inspection rules for orthotropic deck plates, that are already being applied for public works.

(7) In Germany the Eurocodes have already been introduced by the Federal Ministry for Traffic and public works since Mai 2003.
A PERFORMANCE BASED SURFACING FOR THE ORTHOTROPIC DECK OF THE NEW SAN FRANCISCO-OAKLAND BAY BRIDGE

Charles Seim P.E.* and Rafael Manzanarez P.E.**

*Consulting Engineer, El Cerrito, CA, Formerly V. P., T. Y. Lin International, San Francisco, CA, USA. **Vice President, T. Y. Lin International, San Francisco, CA, USA.

Abstract

The year 1967 saw the introduction in the U. S. of two major bridges with orthotropic steel plate decks: The San Mateo Bridge (SMB) in California, in October, and The Poplar Street Bridge (PSB) in St. Louis, Missouri, in November. Both bridges were similar in design with twin, steel-box girders with orthotropic steel plate decks; however, the surfacings selected for paving the two bridges were very different. For the surfacing of the SMB deck, a performance-based testing program was developed in which over 40 different materials were laboratory tested for fatigue resistance and bonding strength. Only one material survived the two-million-cycle performance requirement and could be laid using conventional paving equipment. The original surfacing is still in service, in 2004, on the SMB whereas the PSB has been resurfaced several times.

In the 1970s, the two concrete decks of the San Francisco-Oakland Bay Bridge (Bay Bridge) were experiencing wet sliding accidents. Performance-based laboratory testing showed that epoxy asphalt with a metagraywacke aggregate would maintain skid resistance. Both decks were surfaced in 1976 and 1977, and that material is still in service in 2004 and still provides adequate skid resistance.

Based on these excellent performances the Golden Gate Bridge, Highway, and Transportation District laboratory tested epoxy asphalt with the metagraywacke aggregate and selected it for the surfacing of the orthotropic steel deck that replaced the original concrete deck of the Golden Gate Bridge. The 1985 surfacing is still in service.

California is now replacing the existing eastern spans of the San Francisco-Oakland Bay Bridge with a twin concrete viaduct and a self-anchored suspension span with orthotropic steel deck. To avoid inconvenience to bridge users caused by frequent resurfacing, the surfacing is designated to have a performance life of 30-years. At the present time, based on performance, California has selected epoxy asphalt with metagraywacke aggregates for the surfacing of the self-anchored suspension span.
The thesis of this paper is that a surfacing for an orthotropic deck should be selected as an engineered material based on performance criteria and testing, as are the steel and concrete. The performance criteria are based on a selected service life and adequate skid and fatigue resistance to truck wheel passages during that service life.

**Introduction**

Orthotropic decks for major bridges were first introduced into the U.S. in 1967 with the completion of the San Mateo-Hayward Bridge near San Francisco, California, in October, and the Poplar Street Bridge in St. Louis, Missouri, in November. Both structures are welded steel box girders with orthotropic steel-plate decks, designed in accordance with the criteria and design methods of the AISC *Design Manual for Orthotropic Steel Plate Deck Bridges* (1963). This Manual was based on the German code of practice of that time for design of orthotropic deck components and surfacings because the orthotropic steel deck had been conceived and developed in Germany in the 1950s.

Since the pioneering construction of these two major orthotropic bridges in the U.S., the *AASHTO Bridge Design Specifications* (LFD) have controlled the design of orthotropic decks and the AISC Design Manual has become a valuable reference manual. The *AASHTO Bridge Design Specifications* (1994) underwent major changes in the publication of the Load and Resistance Factor Design Method (LRFD). One of the most important changes introduced in the LRFD specification for the design of orthotropic steel plate decks was the requirement that the steel deck plate thickness be 14 mm minimum, or 4 percent of the span between the webs of the ribs.

**Deflection Characteristics of Orthotropic Decks**

A characteristic of orthotropic decks is that passing truck wheels deform the steel deck plate with relatively large deflections that also deform the wearing surfacing that is bonded to the steel. These deformations of the steel deck plate and the bonded wearing surfacing material are primarily caused by flexibility of the steel deck plate. Steel deck plate deformations are also related to rib spacing, relative deflection between ribs, floor-beam spacing, and the thickness and type of material used for the wearing surface.

Automobiles and light trucks produce smaller deflections and less fatigue damage than that caused by loaded or overloaded trucks. The repetitive deflections from loaded truck wheels cause large fatigue tensile-strains in the wearing surfacing, shear stresses on the bond line of the surfacing to the steel deck plate, as well as smaller induced fatigue stresses in the steel deck components. The tension moment-curvatures of the wearing surfacing bonded to an orthotropic steel deck plate, produced by loaded truck wheel loads, are much larger than the tension moment-curvatures produced by the same truck wheel loads on the pavements of highways.
ORTHOTROPIC DECKS WITH LONG RIB SPANS

Roman Wolchuk*, F. ASCE

Consulting engineer, Roman Wolchuk Consulting Engineers, Jersey city, NY, USA.
Email: wolchuk@bellatlantic.net

Abstract

Because of lateral load distribution capacity of orthotropic bridge decks, the governing force effects of the wheel loads are not linearly dependent on the deck spans between transverse supports, as is the case with concrete decks supported by stringers. Lateral load distribution of orthotropic decks increases with increasing rib spans and the governing load, stresses and deflections of one rib do not significantly increase with the span for spans longer than 20 – 25 ft (6 – 7.5 m), which are the usual limits in the present U.S. practice.

Feasibility of longer rib spans has been demonstrated in redecking of the Champlain Bridge over the St. Lawrence River in Montreal where 32’- 2 ½” (9.8 m) rib spans were necessitated by the spacing of existing cross beams. The new deck installed in 1992 performs satisfactorily under heavy truck traffic. It features 15” (381 mm) deep trapezoidal ribs and is structurally integrated with the lower chords of the main trusses. The steel weight of the deck is 51 psf (249 kg/sq.m), the cost of installed steel deck, including old deck removal and the shear connectors to trusses, was abt. US$ 104 /s.f. (US$ 1,120 / s.m.). Comparable figures for the 1985 redecking of the Golden Gate Bridge, with 25 ft (7.6 m) spans of shallower ribs discontinuous at alternate cross beams and no shear connectors, are: deck steel weight 53 psf (259 kg/sq.m), the steel unit cost $ 75 /s.f. ($ 807 / s.m.)

In the design of ribs with long spans effects of truck wheel loads on the left and the right side of the rib under consideration cannot be disregarded. In the 30 ft (9 m) rib span range additional effects do not exceed 10% of the single rib loading.

Fabrication labor cost (detailing, cutting, welding) of orthotropic decks with usual geometric features may account for up to 70-80 % of the total shop cost, the steel material cost being relatively less significant. Therefore substantial labor cost savings could be obtained if the number of ribs were reduced by increasing the deck plate thickness and spreading deeper ribs farther apart while lengthening the rib spans and simplifying the rib/cross
STEEL BRIDGES – PAST, PRESENT AND FUTURE

M. Myint Lwin

*Director, FHWA Office of Bridge Technology, 400 Seventh Street SW, Washington, DC, USA. Email: MYINTLWIN@aol.com

Abstract

The Industrial Revolution of the 19th Century produced iron to replace timber and masonry for bridge construction. The bridge builders at the time were excited about the strength and ability of cast and wrought iron members to stretch the spans of bridges. Many railway bridges were constructed of cast and wrought iron. Unfortunately, many of these bridges failed due to fatigue or overloads after only 12 to 30 years of service. The bridge builders realized that they needed something with higher strength, better ductility and more fatigue resistant than iron. That something turned out to be steel.

With the introduction of the Bessemer and open-hearth steel-making processes in the mid-1850's, steel became available at reasonable cost and in large quantity for bridge construction. The first all-steel bridge in the United States was built in 1880. Since that time, bridge steels have progressed from carbon steels to specialty steels, such as nickel and silicon steels, to low alloy steels, to quenched and tempered high strength steels, and now to high-performance steels for the 21st Century. Collaborative research will develop steels of superior mechanical and chemical properties to meet the performance demands of future steel bridges.

Bridge engineers and maintenance personnel have to work with the design, construction, maintenance, inspection, and repair of steel bridges of the past and present. They need to understand the properties of bridge steels for new design and for repairing existing bridges to avoid premature failures.
EXISTING AND FUTURE STEEL BRIDGE INFRASTRUCTURE – SOME OBSERVATIONS

John W. Fisher*

*John W. Fisher, Professor Emeritus of Civil Engineering, Director Emeritus ATLSS Center, Lehigh University, Bethlehem, PA 18015, USA. Email: jwf2@lehigh.edu

Abstract

This presentation examines steel bridge infrastructure built prior to 1980 for its fatigue design and performance while in service. A summary is provided of the development of fatigue design criteria based on stress range alone which was introduced in 1974. The principal inadequacies of prior fatigue provisions is reviewed and identified as one of the causes of fatigue cracking in older steel bridges at Category E and E’ details.

Improvement of existing details by end weld treatment using peening and gas tungsten arc remelting is examined as a procedure to enhance fatigue resistance. Experience with treatment procedures carried out in the 1970’s is reviewed. A major problem identified in this decade has been cracking at intersecting welds. Experience with intersecting welds extends back to the 1970’s. This experience is reviewed and assessed for details that create conditions of high triaxiality in girder webs such as observed with embedded defects in the Lafayette Street Bridge in St. Paul, MN that developed fatigue cracks and experienced brittle fracture. A variant was the geometric conditions found in the Hoan Bridge in Milwaukee that resulted in brittle fracture without detectable fatigue cracking in the region of high triaxiality. Related to this behavior is an examination of web gap fatigue cracking from distortion and the sensitivity of web details to small geometric changes. Other examples of secondary stresses from out-of-plane distortion are examined as this remains the greatest source of crack development today.

For the future, high performance steel will be examined for the benefits it will bring to bridge structures. Its fatigue and fracture resistance will be reviewed as well as the use and applicability of gas metal arc welding for fabrication of steel components. These materials and processes will become more common in bridge construction in the decades ahead. Fatigue improvement by Ultrasonic Impact Treatment (UTI) is examined as well as the need for end weld design changes. These offer a means of eliminating fatigue as a design limit state for weld toe cracking at most details.
The orthotropic steel deck is examined as the one system likely to provide modularity for prefabrication and easy erection that is capable of providing a 100 year life when 16mm or thicker deck plates are coupled with thin epoxy concrete wearing surfaces. These are shown to permit immediate use and are not pot hole sensitive even for extended periods making them ideal for metropolitan areas.
FOUR DECADES OF EXPERIENCE WITH ORTHOTROPIC DECKS

Peter G. Buckland

Principal, Buckland & Taylor Ltd., 101-788 Harbourside Drive, North Vancouver, BC, V7P 3R7, Canada; PH 604-986-1222; pbuckland@b-t.com

Abstract

The author’s experience ranges from the 1960’s Severn Bridge in the UK to the present. In that time, various changes have been seen in the design of steel orthotropic bridge decks. Early designs, such as the Severn Bridge, gave great consideration to ease of fabrication and construction. However, at that time little was known about the two key issues with orthotropic decks: fatigue and paving. With the passage of time, designs have changed as more has been learned about the performance of these decks and their paving, to the point where current designs provide some of the most difficult structural steel fabrication in the industry.

The history of these designs is traced, and it is argued that orthotropic deck design does not need to be as complicated to fabricate as is presently being maintained. With difficulty of fabrication come both extra cost and difficulty with maintaining quality.

Some of the parameters that affect durability are examined, including deck plate thickness, trough-to-deck welds, and the ability of the system to absorb secondary strains without excessive stresses.

Examples are given of successful orthotropic deck designs, and the importance is emphasized of designing both for ease of fabrication and construction, and for a long service life.

Introduction

This paper traces the developments of orthotropic deck design as experienced by the Author, with observations based on that experience. Specific bridges are referenced, and while this is far from an exhaustive list, it is believed to represent a typical historic trend.

Severn Bridge, UK

The all-welded steel structure of the Severn Bridge, designed by Freeman Fox and Partners in the 1950’s, is well known for the revolutionary streamlined airfoil shape
FRENCH EXPERIENCE WITH LONG-SPAN CABLE-STAYED BRIDGES
WITH ORTHOTROPIC DECK

Michel Virlogeux*

*Ingenieur Consultant, France

Abstract

Three major cable-stayed bridges have been built in France with an orthotropic deck: the Saint Nazaire Bridge over the River Loire (completed in 1975) which had the world record during some years. The Normandie Bridge over the estuary of the River Seine (completed in 1995) which also detained the world record with a main span of 856 meters, and the Millau Viaduct crossing the valley of the river Tarn with a series of six successive spans of 342 meters suspended from seven pylons.

These three bridges have an orthotropic box-girder to carry the roadways, with a unique cell suspended from both sides for the first two of them and with three cells and an axial suspension for the last one. The design of their orthotropic decks has been directly inspired from the German tradition developed in the late fifties and in the sixties.

The deck of the Saint-Nazaire Bridge -under traffic for more than 28 years -is in perfect condition and the design of the two later bridges have been only slightly amended. taking advantage from the experience of the English suspension bridges (mainly the Severn Bridge) and of some more classical French bridges.

The paper will describe the three box-girders, and more specifically I will evoke the fatigue analyses conducted for the Normandie Bridge, but more extensively the fabrication of the orthotropic plate, prefabrication of segments, mock up assembly and final erection, including stringers continuity.
Design
FREMONT ORTHOTROPIC BRIDGE DECK
LONGEST STEEL ARCH IN WESTERN HEMISPHERE

by Michael J. Abrahams* and Mark Hirota**

*Technical Director, Major Bridges, Parsons Brinckerhoff Quade & Douglas, Inc., Abrahams@pbworld.com. ** Senior Supervising Engineer, Parsons Brinckerhoff Quade & Douglas, Inc., former Chief Bridge Engineer, Oregon Department of Transportation, Hirota@pbworld.com.

Abstract

Opened in 1973, the graceful Fremont Bridge is still the longest bridge (main span) in Oregon, and the longest steel arch bridge in the Western Hemisphere. Its 6,000-ton (5400 tonne) center span lift was the heaviest anywhere, accomplished with techniques and technology never used before at that scale. This erection method was selected because it had the least impact on navigation and the lowest cost. Innovative features include a weight-saving orthotropic deck and welded box girder and high-strength quenched and tempered (T-1) steel. Of the lower Willamette River bridges in Portland, Fremont is the only arch, with its unusual three-span tied arch design inspired partly by European engineers as a solution to site conditions.

The bridge was opened to traffic November 15, 1973, and after 30 years of carrying heavy interstate traffic, its steel orthotropic deck has proven to be a trouble free design. The original epoxy asphalt wearing surface performed well, but due to normal wear was replaced with asphalt, as epoxy asphalt was no longer available locally. The asphalt has not performed as well as the epoxy asphalt.

Introduction

On Thursday, November 15, 1973, the world's longest tied arch bridge was opened to traffic. The Fremont Bridge, as part of the Stadium Freeway (I-405), spans the Willamette River and completes the inner loop of the Portland, Oregon highway system (Figure 1). Since the arch structure rises some 400 feet (122m) above the Willamette River, it is a significant contribution to the Portland skyline.

Description of Bridge

Figure 2 shows the Plan and Elevation views of the overall structure. It is a three-span tied arch with a 1255' 4" (382.7m) main span flanked by two 448' 4" (136.7m) side spans. The center span completely bridges the river and provides a vertical clearance of 167' (50.9m) above low water at the Harbor Line. The dominant
ORTHOTROPIC DECK BRIDGES IN UKRAINE

Dr. Mykhailo Korniyiv*

*Engineering Manager, Mostobud, Kyiv. Email: ”, S-bridge@carrier.kiev.ua

Abstract

The first orthotropic deck in Ukraine was installed in 1976 on a cable-stayed bridge over the Dnipro River in Kyiv. Subsequently several orthotropic deck bridges were built, among them the cable-stayed South Bridge in Kyiv (1992), a similar structure in Odesa, as well as several major plate girder bridges over the Dnipro in Dnipropetrovsk, Dniprodzerzhynsk and Zaporizhia. Ukrainian bridge engineers were also responsible for the design of most major orthotropic deck bridges in the former Soviet Union (in Russia, Latvia) and are currently active in bridge construction in the polar regions of Russia (Salekhard cable stayed bridge). Characteristic features of these structures, fabrication and construction procedures are discussed. Open-rib deck systems are used. Currently several new orthotropic deck structures are in the planning and design stage, among them the Podil tied arch bridge and the Harbor Bridge in Kyiv.

Introduction

Ukraine is bisected in the North–South direction by the Dnipro River, one of the longest rivers in Europe. Along its banks are situated large cities and industrial centers: Kyiv, Cherkasy, Kremenchuk, Dnipropetrovsk, Dniprodzerzhynsk, Kakhivra, Kherson. Most of these cities are bisected by the river, however, in all of them the capacity of existing bridges is inadequate. During the past 2 decades only four new bridges over the Dnipro were built, the last one in Dnipropetrovsk (2000) was completed 20 years after the start of its construction. Important industrial centers as Zaporizhia and Kremenchuk are still awaiting the necessary river crossings. Such conditions are caused not only by financial difficulties of the cities but also by insufficient attention of the government to transportation problems. The capital city of Kyiv with population of three million is no exception. The four existing bridges serving a daily traffic of 270,000 vehicles are overloaded and the city cannot afford to close any one of them for badly needed rehabilitation.
A Review of Alaska’s Orthotropic Bridges

Dennis Nottingham, P.E.*

*President, P|N|D Incorporated, Consulting Engineers, 1506 W. 36th Avenue, Anchorage, AK 99503, PH 907-561-1011; Fellow, American Society of Civil Engineers (ASCE); M.S., Civil Engineering, 1960, and B.S., Civil Engineering, 1959, Montana State; imartin@pnd-anc.com

Abstract

Alaska began use of orthotropic steel bridges in 1969 in the form of award-winning moveable vehicle transfer bridges on the state’s ferry system. In 1971, the nearly half-mile-long award-winning Yukon River Pipeline/Vehicle Bridge on the Trans-Alaska Pipeline System was designed following which other smaller, but interesting orthotropic bridges have been built.

The Yukon River Bridge received Lincoln Arc Welding Foundation’s top award for excellence in welded steel design, and the Tudor Trail Crossing, a more recent orthotropic steel bridge, received a National Steel Bridge Alliance top award.

The Yukon River Bridge was built at a time when the AASHO Bridge Code was almost non-responsive to seismic design, thus a new approach had to be developed for the design of this important bridge in an active seismic area. The older AASHO Code and the new approach will be discussed and will help illustrate the advanced engineering used for this design at this early time. New cold-weather steels were also used, bringing steel design into a new era.

Remoteness of the Yukon crossing dictated consideration of logistics and materials needed to assure completion and use in a very short time frame. Components had to be effectively designed to be damage-free to insure a fail-safe product.

On the smaller side, the Tudor Trail Crossing had to be designed for a wide variety of users including racing sled dogs for which no design criteria had been developed. Much concern and discussion was rendered moot when the dogs never lost stride over the bridge.

This paper will discuss the aspects and performance of some of these projects and some new developments including cold-weather asphalt deck paving and required bonding agents and coatings for steel which assure no corrosion.

Positive features of lightweight steel orthotropic bridges and steel substructures in areas of high seismicity will also be discussed.
ORTHOTROPIC DECKS FOR SMALL AND MEDIUM SPAN BRIDGES IN FRANCE – EVOLUTION AND RECENT TRENDS

Wasoodev HOORPAH*

Bridge Consultant to OTUA – www.otua.org, Email: w.hoorpah@mio.fr

Abstract

This paper will describe orthotropic deck design, construction and fabrication in France for small and medium span bridges. Orthotropic decks have been used in France since the 1960’s for bridges where there is a necessity for low dead weight: movable bridges, temporary fly-overs, shallow decks, complete pre-fabricated decks and long spans. The first generation steel decks appeared after the Second World War with the composite “Robinson plate” associating a thin concrete slab 60 to 100 mm thick to a 8 mm steel plate. Nowadays, orthotropic decks are being built for medium span crossings apart from the very long span cable-stayed bridges. The choice can be due to shorter construction delay with mounting of the completely prefabricated deck. Industrial prefabrication of the structural elements and robotized shop-assembling have helped to lower the fabrication cost.

The structural design: cover plate, ribs, cross-beams and diaphragms have also undergone a constant evolution together with the fabrication methods. The fatigue cracks that were observed in the first constructions have now been perfectly mastered by specific detailing of the welding between structural elements. The wearing surface has also been carefully analyzed and behaves quite well nowadays. The progress of the steel material has also played a major role in the development of orthotropic steel decks.

Keywords: short and medium span, structural evolution, design, fabrication, stiffeners, wearing surface.

Introduction

Steel orthotropic decks were first built in France in the 1960’s. In Germany from where the French engineers were inspired by this new technique, the first orthotropic deck was used in 1950 at Kurpfalz ridge at Mannheim: a 3 span continuous bridge with spans of 56, 75 and 56 m over the Neckar. This opened the way to about forty other bridges up to 1960 in West Germany. At the same time was built in Yugoslavia
THE NEW TACOMA NARROWS SUSPENSION BRIDGE
–ORTHOTROPIC SUPERSTRUCTURE

Kenneth Serzan*, P.E., John Clenance**, P.E. and Jeffrey Lu***, P.E.

*Vice President, **Project Engineer, ***Senior Engineer, Parsons Transportation Group, USA

Abstract

The new Tacoma Narrows Suspension Bridge has a 854m main span supported by reinforced concrete towers. When completed, the new bridge will be the first major suspension bridge in the world to be constructed under a design-build contracting arrangement. The towers will be founded on massive gravity caissons of open-dredge construction. Gravity anchorages on the hillside of the Narrows will serve to secure the main suspension cables. The superstructure consists of a continuous welded and bolted truss with an integral orthotropic deck. The truss elements consist of both closed box and open I-sections. The bridge is also designed to accommodate a future lower roadway or LRT system. The project schedule includes a fast-track design in order to conform to the overall project delivery schedule of 55 months.

The paper will discuss the design aspects of this unique orthotropic truss superstructure, including the development of design details to satisfy both serviceability and fatigue requirements and to facilitate fabrication and erection. The paper will further address the global and local modeling of the bridge superstructure in order to determine the demands on the various components.

Keywords: Tacoma Narrows Bridge, suspension bridge, suspension bridge design advancements, orthotropic deck, suspension system.

Project History and Background

The Tacoma Narrows in Washington State is the narrowest waterway in Puget Sound and separates the Olympic Peninsula from Washington’s “mainland.” In 1940 the first suspension bridge spanning the waterway opened to traffic. Dubbed “Galloping Gertie,” it collapsed a short four months later and still endures as the textbook example of a most graphic and unforgettable engineering failure. Gertie also became a great teaching tool for bridge engineers to perfect their knowledge on how to design and build suspension bridges.

In 1950, ten years after Gertie’s spectacular collapse, the second Tacoma Narrows Bridge opened to traffic. Built directly on Gertie’s caissons and over Gertie’s
STEEL ORTHOTROPIC BOX GIRDER ON THE NEW ALFRED ZAMPA MEMORIAL SUSPENSION BRIDGE ACROSS THE CARQUINEZ STRAIT

Kenneth Serzan*, P.E. and Dyab Khazem**

*Vice President, **Project Engineer, Parsons Transportation Group, USA

Abstract

The new Carquinez Strait Bridge is the first major suspension bridge to be erected in the United States since the second Chesapeake Bay Bridge in 1973. It replaces an existing steel cantilever truss bridge built in 1927 that was determined to be seismically inadequate. The new bridge consists of a closed steel box girder superstructure, two 512 mm diameter main cables, twin reinforced concrete towers and gravity cable anchorages. This project has set new standards for modern suspension bridge design in the United States, particularly with respect to seismic safety.

Some of the key elements of the design discussed in this paper are the global design loading criteria for long span suspension bridges; state-of-the-art design detailing of fatigue sensitive welded connections; the finite element analysis approach for determination of state-of-stress in steel box girder elements and the erection of the superstructure.

Keywords: Carquinez Bridge, suspension bridge, suspension bridge design advancements, orthotropic deck, suspension system, design loading.

Project History and Background

The Carquinez Strait, located about twenty miles northeast of San Francisco, carries the Sacramento River into San Francisco Bay (Figure 1). The strait is spanned by

Figure 1: The New Alfred Zampa Suspension Bridge
Fabrication and Construction
METHOD OF FLUX CORED WIRE ARC WELDING AND ULTRASONIC TESTING FOR LONGITUDINAL WELD OF U-SHAPED RIB AND DECK PLATE

Kenji Kuramoto*, Makoto Yuda** and Wataru Fujimoto***

*QC Engineer, Shikoku Plant, Kawada Industries, Inc., 17 Nishiminato-machi, Tadotsu-cho, Nakatado-gun, Kagawa-pref., Japan, 764-8520; PH +81-877-32-5115; kenji.kuramoto@kawada.co.jp  **Chief Engineer, Welding Laboratory, Kawada Industries, Inc., 17 Nishiminato-machi, Tadotsu-cho, Nakatado-gun, Kagawa-pref., Japan, 764-8520; PH +81-877-32-5115; makoto.yuda@kawada.co.jp  ***QC Manager, Shikoku Plant, Kawada Industries, Inc., 17 Nishiminato-machi, Tadotsu-cho, Nakatado-gun, Kagawa-pref., Japan, 764-8520; PH +81-877-32-5115; wataru.fujimoto@kawada.co.jp

Abstract

Recently, requirement of penetration depth in longitudinal weld at U-shaped rib and deck plate is specified to 75% by revision of Japan Highway Standards. Also, we established welding method by FCAW to achieve 80% penetration of longitudinal weld at U-shaped rib and deck plate to meet overseas projects. We developed a new UT-method to check depth of 80% penetration. It was not yet established in Japan.

Introduction

In recent years, detecting the penetration depth of the longitudinal welds of U-shaped rib and steel deck plate is one of important issues in the bridge industry in Japan. The requirement for the penetration depth (see Figure 1) has been clearly stated in the “Specifications for Highway Bridges version 2002” issued by Japan Road Association. On the other hand, we have been developing the procedures of Flux Cored Arc Welding (FCAW) that could achieve the required penetration. We have been also trying to establish the new method of ultrasonic testing to detect the penetration depth.
A NEW ORTHOTROPIC BRIDGE DECK:  
DESIGN, FABRICATION AND CONSTRUCTION OF  
THE SHENLEY BRIDGE  
INCORPORATING AN SPS ORTHOTROPIC BRIDGE DECK  

Richard B. Vincent* and Angelo Ferro**  

*Richard B. Vincent, Vice President Engineering, Research and Development, The Canam Manac Group Inc., 270 Chemin du Tremblay, Boucherville, QC, J4B 5X9. Tel.: 450-641-4000; Fax.: 450-641-4001; richard.vincent@canammanac.com  
**Angelo Ferro, Structural Engineer, Intelligent Engineering (Canada) Limited, 72 Chamberlain Avenue, Ottawa, ON, K1S 1V9. Tel.: 613-569-3111; Fax.: 613-569-3222; ferro@ie-sps.com  

Abstract  

The Structal Division of The Canam Manac Group Inc. has constructed the first steel bridge utilizing an orthotropic steel deck that incorporates the Sandwich Plate System (SPS) technology. An SPS plate consists of a sandwich of two steel plates separated by an elastomer core. 

The SPS orthotropic bridge deck consists of prefabricated deck panels with each panel section length equal to the bridge width. The panel width is selected to optimize material procurement, ease of fabrication, transportation and erection. The Shenley bridge has a span of 22 m. (72.2 ft.), a width of 7.52 m. (24.7 ft.) and panel widths of 2.44 m. (8.0 ft.). 

The deck panel is designed to continuously span between the main bridge girders and cantilevers over the edge girders to support the curb and railings. The longitudinal panel edges are framed with angles or bent plates that act as cross stringers incorporating the SPS plate as the top flange. This allows the deck panel to be designed for a large cantilever span. The guard rails may be attached directly into the ends of the panels. The SPS deck panel is designed to act compositely with the main girder. Horizontal shear is transferred directly via angles or bent plates welded to the underside of the SPS plate and bolted to the top flange of each main girder. 

Connection details, shop fabrication, weld sequencing, construction tolerances and elastomer injection for SPS bridge decks will be presented. Corrosion protection of the steel panel and the steel beneath the wearing surface will be treated including preferred membrane details and adhesion of the wearing surface. Details treating horizontal curves, vertical curves or a combination of both will be included. Deck replacement details will be proposed for the replacement of concrete decks on existing bridges with the possibility of upgrading the load rating or adding additional lanes to these bridges. Erection procedures for placing of the deck panels will discussed displaying the inherent speed of construction this deck system exhibits.
ORTHOTROPIC DECK FABRICATION FOR
THE TRIBOROUGH BRIDGE

Brendan J. Scahill*, P.E. & C.W.I.

*Resident Engineer – Greenman-Pedersen, Inc., 20-10 North Hoyt Avenue, Astoria, New York, 11102. Tel. (718) 932-8741, Fax: (718) 932 – 8956
Email: Scahill8@AOL.com

Abstract

The Triborough Bridge facility is actually three separate bridges that provide a vital traffic link among The Bronx, Queens and Manhattan boroughs in New York City. Owned by the Triborough Bridge and Tunnel Authority (TBTA) and opened in 1936, the suspension bridge is a major crossing that spans 1,380 feet between towers over the “Hell Gate” section of the East River, connecting Queens to Randall’s Island. About 170,000 vehicles utilize the bridge crossing on a daily basis.

In the spring of 2001, the $144 million Deck Replacement on the Suspended Span and Queens Viaduct rehabilitation project (TB-64A) was started. This unique project is a major undertaking, involving removal of the entire concrete deck roadway (eight traffic lanes) and replacement with a new orthotropic deck system (252,000 sq.ft.) while maintaining seven traffic lanes in an urban environment.

During this presentation, an in-depth overview of the fabrication process of the 392 steel orthotropic deck panels (10’-4” x 57’-0”) for the Triborough Bridge will be discussed. The comprehensive overview of the fabrication process will include: preparation of raw materials, quality control (QC), quality assurance (QA), the independent inspection agency, documentation, the automated welding process (SAW), the preassembly process, coordination and transportation of deck panels to the United States.
BOX GIRDERS, DESIGN, FABRICATION, OPERATION AND MAINTENANCE

Ove Sørensen*

*Chief Bridge Engineer, COWI AS Lyngby, Denmark, e-mail: ovs@cowi.dk

Abstract

The paper presents experience from more than 170 000 tons of steel box girders for cable supported bridges such as; The Little Belt Bridge (Denmark), The Faroe Bridges (Denmark), The Pont d’Normandie (France), The Great Belt Bridge (Denmark), The Stonecutters Bridge (Hong Kong).

The paper focuses on the topics: Design, fabrication, operation and maintenance of orthotropic decks. Arrangements of orthotropic decks as integrated parts of box girders are illustrated and explained.

Typical details are shown and difficulties with fabrication and NDE-examination will be highlighted.

Results from fatigue tests of full scale test panels will be explained including the influence of the pavement on the fatigue life of the deck. Results from stress measurements on orthotropic bridge decks in operation will be presented and compared with FEM-model results.

Keywords: Box girder, Orthotropic deck, Steel bridge, Operation and maintenance, Corrosion protection by dehumidification.

1. Introduction

Stream-lined box girders were introduced by Danish and British bridge designers in the late 1960's. Since then steel box girders with an integral orthotropic deck has been commonly applied for long span bridges in order to reduce the dead load and provide the required aerodynamic stability.

During the last 35 years, COWI has been involved in the design and construction supervision of a number of major bridges as listed in fig. 1.
CONSTRUCTION OF EPOXY ASPHALT
PAVEMENTS ON ORTHOTROPIC STEEL BRIDGE DECKS

Robert. W. Gaul*

*Vice President, ChemCo Systems, Inc. 2800 Bay Road, Redwood City, CA 94063; PH 650-261-3790; gaul@chemcosystems.com

Abstract

Epoxy Asphalt is a polymer concrete that uses an asphalt-extended epoxy polymer system as the binder. The contractor uses asphalt paving equipment to install Epoxy Asphalt in the same manner that he would use to install conventional asphalt concrete.

Since the San Mateo Bridge approximately 20 orthotropic steel decks have been paved with Epoxy Asphalt, most with satisfactory results and a few with less than satisfactory durability. The less than satisfactory results can all be traced to either pavement design that asks too much of the paving material or inadequate control of construction practices.

Laboratory test programs that included fatigue tests at expected service temperature extremes and at expected overload conditions have helped engineers to avoid design mistakes that show up as fatigue cracks several years after apparently successful pavement installations.

When construction practices have been carefully controlled, especially the control of Epoxy Asphalt aggregate temperature and assuring that compaction is adequate and complete before the temperature of the paving mat has dropped too far, results have been excellent. These have been the keys to successful installations.

With nearly 50,000 tons having been placed on orthotropic steel bridge decks Epoxy Asphalt continues today to be used on some of the world's longest long-span bridges.

Introduction

Epoxy asphalt is a polymer concrete that incorporates an asphalt-extended two-component epoxy polymer system as the binder. The contractor uses asphalt paving equipment to install epoxy asphalt in the same manner that he would use to install conventional asphalt concrete. However, because the rate of chemical reaction of
CONSTRUCTABILITY INNOVATIONS FOR THE SFOBB

Sarah Picker* and Jay Murphy**

*Professional Engineer in California Government, 5245 College Avenue, Suite 312, Oakland, CA 94618; 510 597-0656, **President, Murphy-Pacific Corporation, 5630 Margarido Drive, Oakland, CA 94618; 510 655-4911

Abstract

This paper examines the history of Murphy-Pacific Corporation, a California general contractor and steel fabricator/erector and discusses the construction by Murphy-Pacific of the San Mateo-Hayward Bridge. This structure was the first major orthotropic bridge opened to traffic in the United States; and additionally won the AISC prize bridge award and the ASCE outstanding civil engineering achievement. The relevance of this company to an orthotropic bridge discussion is that Murphy-Pacific was a business involved with the fabrication and erection engineering and subsequent construction of the same. They built four orthotropic bridges on the West Coast of the United States and performed many construction and emergency repair contracts for California bridge projects.

The company’s development over the 20th century is described and the major orthotropic bridges that they have built and other construction contracts are named. This highly accomplished truss bridge fabricator/erector made the transition from fabricating rolled structural steel shapes used in truss bridges to welding built up steel plate boxes and stiffened deck plates used in the orthotropic bridge. One such project is the San Mateo-Hayward Bridge, opened to traffic in 1968, a $70 million crossing of the southern San Francisco Bay. You will note that the logo for this conference is a cross section of the structure.

Company History

J. Philip Murphy started his company, J. Philip Murphy Corporation, in 1938 as reinforcing steel bar contractor. He moved into other phases of construction, including salvage projects, bridge building and office building construction. One of company’s first salvage jobs was the collapsed Tacoma Narrows Suspension Bridge.

On February 1, 1945, J. Philip Murphy Corporation merged with Judson-Pacific Corporation structural steel fabricating division, and Judson Pacific Murphy Corporation formed. This gave Murphy-Pacific the ability to fabricate as well as erect
LAUNCHING AND CONSTRUCTION OF THE CHIAPAS BRIDGE SUPERSTRUCTURE

Carlos De La Mora*, Roberto Gomez** and Douglas Williams***

*Ingenieros Civiles Asociados, S.A. de C.V. Minería No. 145 Col. Escandon, C.P. 11800 México, D.F., México PH:(52)55-5272-9991, Ext. 3217; FAX Ext. 5066;email: carlos.delamora@icacc.com.mx. ** Institute of Engineering, UNAM, Apdo. Postal 70-472, Coyoacan, México D.F. México; PH.(52)56223464; FAX: (52)5622-3477; email: rgom@pumas.ingen.unam.mx. ***721 Ocean Ave.,Richmond, CA 94801, USA PH: 510.235.9353; FAX: 510.232.9546; email: etc@weldengineers.com

Abstract

Different activities developed to verify the structural safety of the Chiapas bridge during several stages of construction of the superstructure will be presented. The superstructure comprises 8 continuous spans of 124, 168, 168,168, 168, 168, 152 y 92m with a total length of 1208m. It was launched using a nose of 44m length and 120t of weight. To reduce the level of stresses along the deck and to control the vertical deflection at the tip of the launching nose, eight stayed cables attached to a temporary pylon were used during launching. Up to date, the maximum span length of this bridge is the longest constructed using the incremental launching scheme; the owner of the bridge is the Ministry of Communication and Transportation of Mexico. The bridge was open to traffic by the end of December 2003.

In this paper, some problems derived from an unconscious process of design and construction of the orthotropic deck will be described. It will be shown how the basic procedures needed to satisfy constructability were not taken into account during design. In order to obtain reliable information about the original design, a mathematical model was elaborated to verify the flexural behavior and the stress levels induced when launching the superstructure. Zones of major stresses were identified and emphasis was placed on several aspects to be considered to improve the safety of the superstructure during launching.

A yield criterion was selected to evaluate the failure of the plates of the deck. Assumptions used for the elastic analysis under different static loading (dead, wind, earthquake and temperature loads) and cantilever lengths are described as well. Because of the refined mesh of the finite element model, especial considerations were given to straightness and flatness as well as other dimensional tolerances problems induced during welding and assembly of the segments. Influence of these variables
INTEGRATED HYDRAULIC SOLUTIONS FOR THE
WORLD’S LARGEST ORTHOTROPIC BRIDGE

Peter Crisci*

*Enerpac, Milwaukee, Wisconsin, USA

Abstract

Nearing completion in Millau, France, the world’s largest orthotropic bridge features a steel span with sculptured vertical piers, the highest towering 800 feet above the Tarn River. This paper describes the use of high-pressure hydraulics in the erection of the temporary piers and the launching of the steel deck of the Millau viaduct.

Key Words: Bridge Launching, Hydraulics in Bridge Construction, Orthotropic

The Project

Nearing completion in southern France, the world’s largest orthotropic bridge is the final link in the A75 highway between Paris and Barcelona. Studies for the Millau Viaduct began in 1988 because of severe summer congestion in the area of the A75 route surrounding the town of Millau.

The choice was made early-on to cross over the Tarn Valley by means of a long viaduct. The alternative of descents into the valley with a tunnel under the river would be more costly and dangerous to implement, and it posed a far greater threat to the local environment. The engineering-architectural team of Sogelerg, EEG, SERF, and Foster was awarded the project. Contractor Eiffage S.A. is expected to complete the 39 month project for a scheduled opening in December 2004. Project cost is a relatively modest $410 million.
Maintenance and Rehabilitation
GOLDEN GATE BRIDGE
DECK AND SIDEWALK REPLACEMENT

Daniel E. Mohn*, PE, Fellow ASCE, Ewa Z. Bauer**, PE, Member ASCE, Mary C. Currie**, And Frank L. Stahl***, PE, Fellow ASCE

*Golden Gate Bridge, Highway and Transportation District (retired); **Golden Gate Bridge, Highway and Transportation District; ***Ammann & Whitney (retired)

Abstract

The Golden Gate Bridge (Bridge), owned, operated and maintained by the Golden Gate Bridge, Highway and Transportation District (District), San Francisco, CA, was opened to traffic in May 1937. By 1967, its original concrete roadway was beginning to show signs of wear and distress. Ammann and Whitney (A&W), New York, NY, stated, in its 1969 inspection report, that corrosion was beginning to intrude between the concrete deck and its supporting steel stringers and that the concrete slab had extensive transverse cracking. Further investigation resulted in the recommendation that the original roadway slab and its supporting stringers be replaced in their entirety. The Bridge Deck and Sidewalk Replacement Project, at the time the largest contractual undertaking by the District since the original construction of the Bridge, was completed in 1985. This project was accomplished under the leadership of District Engineer Mr. Harry D. Rellich until his retirement on December 30, 1981, and then by District Engineer Mr. Daniel E. Mohn.

Original Deck and Sidewalk Design

The Bridge roadway extends 8,981 feet between the San Francisco and Marin abutments. Prior to the deck replacement, the roadway was sixty feet wide between curbs, except in the curved end portions towards the San Francisco and Marin abutments where the roadway widened slightly. The original roadway slab was of seven-inch-thick reinforced concrete with a specified ultimate concrete strength of 4,000 pounds per square inch (psi). The main steel reinforcement was a preformed bar truss placed transverse to the centerline of the Bridge at six-inch spacing. Longitudinal reinforcement consisted of one-half-inch diameter deformed bars at the top and three-quarter-inch deformed bars at the bottom. Steel stringers twenty-four inches deep and generally spaced four feet, nine inches apart supported the concrete slab.

In the suspension span, three-quarter-inch-wide transverse expansion joints were located at fifty-foot intervals corresponding to the location of the suspender ropes and to the floorbeam spacing of the supporting steel framework. These expansion joints
HIGH PERFORMANCE STEEL FOR HIGHWAY BRIDGES

Vasant C. Mistry*

*Senior Bridge Engineer, Federal Highway Administration, 400-7th Street, S.W., Room 3203, Washington, D.C. 20590; Phone: 202-366-4599; vasant.mistry@fhwa.dot.gov

Abstract

All steels possess a combination of properties that determines how well steel performs. Strength, weldability, toughness, ductility, corrosion resistance, and formability are all important to determine how well steel performs. High-performance steel (HPS) can be defined as having an optimized balance of these properties to give maximum performance in bridge structures while remaining cost-effective.

Introduction

The U.S. Transportation system represents huge investments on the part of governments and taxpayers. There is a widespread concern over the state of infrastructure. Despite indications of increased investment, it is clear that funds available are not likely to meet all of the needs of this sector in the long run. More than ever, wise investment decisions concerning roads and bridges will be crucial to the future of transportation.

The problem we face today, such as the aging infrastructure, stretches our resources thin and challenges our creativity. As a critical part of the infrastructure, deficient bridges represent a major impediment to mobility on our highways. The resultant time lost to congestion is a drag on our nation’s productivity. Innovative materials, such as high performance steel, will play an increasingly important role as we attempt to meet all of the transportation challenges of the future, including enhancing and expanding our bridge infrastructure. We will be more dependent on high performance materials such as High Performance Steel to give us structures that have 100-year design lives and that will help us with our goal to improve mobility by eliminating deficient bridges.

Development of High Performance Steel

Two new grades of high performance structural steel, HPS 70W and HPS 50W, are developed and now commercially available for highway bridge construction.
DURABILITY EVALUATION OF NAGOYA EXPRESSWAY ORTHOTROPIC STEEL DECK

Kentaro YAMADA*, Tatsuya OJIO**, and Hiroyumi MAENO***

*Prof., Ph.D., Graduate School of Environmental Studies Nagoya University, yamada@civil.nagoya-u.ac.jp, **MS, Research Associate, Nagoya University, ***Dr. Eng., Nagoya Expressway, and Masanori IWASAKI, Dr. Eng., Yokogawa Bridge.

Abstract

Fatigue durability of orthotropic steel decks of Japanese standard type, used in Nagoya Expressways, was evaluated from stress measurement and analysis in 1994. It was 12 mm thick steel deck plate stiffened with trough ribs of U-320x240x6 mm. Asphalt pavement of 80mm thick is placed on the deck. Based on the stress measurements and stress analysis fatigue life of such orthotropic steel decks was evaluated for the axle load distribution, which was measured previously on national highways and expressways in 1980s. It was concluded that the orthotropic steel deck had fatigue life over 50 years with the axle distribution used in the analysis and number of trucks given. It was re-evaluated recently by using recent axle loads in service in major national routes and expressways. The measurement was carried out by Bridge Weigh-in-Motion system using reaction forces.

Introduction

Orthotropic Steel Decks in Japan. The orthotropic steel deck has been used in Japan since 1960s for urban elevated highways and long span bridges. Several different details of longitudinal stiffeners and cross beams were used at the beginning, which were fabricated in the shop. Then, they tried to use uniform shape for the longitudinal trough ribs for the orthotropic steel decks. Dimensions of trough ribs were then standardized by the Japanese Society of Steel Construction (JSSC), and were distributed from steel supplier.

Since the early stage of application of orthotropic steel decks, fatigue assessment was carried out, although fatigue design was not explicitly required for highway bridges in Japan. Number of stress measurements and analysis were carried out in 1970s, for example, when the Honshu Shikoku Bridges, one of the biggest bridge construction projects in Japan, were under design process by the Honshu Shikoku Bridge Authority (HSBA) (Fukui 1978). The studies revealed that fatigue life of orthotropic steel deck was sufficiently long for the given design loads and for the properly fabricated details.
STRENGTHENING A BRIDGE DECK WITH HIGH PERFORMANCE CONCRETE

F.B.P. de Jong* and M.H.Kolstein**

*Civil Engineer, Delft University of Technology, P.O.Box 5048, 2600 GA, Delft, The Netherlands; Phone +31-15 278 57 16; f.b.p.dejong@citg.tudelft.nl and Ministry of Transport, P.O.Box 59, 2700 AB, Zoetermeer, The Netherlands; Phone +31 – 79 329 25 19 f.b.p.dejong@bwd.rws.minvenw.nl **Senior Research Engineer, Delft University of Technology, P.O.Box 5048, 2600 GA, Delft, The Netherlands; Phone +31-15 278 40 05; m.h.kolstein@citg.tudelft.nl

Abstract

Renovation techniques have been developed both for movable and fixed bridges. A very effective solution for fixed bridges is the replacement of the mastic asphalt wearing course, which is 50 mm thick on the majority of the bridges in the Netherlands, by a layer of 50 mm reinforced high performance concrete. The paper describes the development of this renovation technique. Attention will be paid to the FEM calculations and the laboratory static and fatigue tests.

After completion of the development stage this renovation has been applied on a part the Caland bridge in the harbour area of Rotterdam. The paper describes this innovative renovation project. In five days in may 2003 the old asphaltic surfacing has been removed, the fatigue cracks in the steel deck plate have been repaired and the new surfacing of high performance concrete has been applied.

Stress spectra measurements have been performed on the Caland bridge, both before and after the application of the concrete surfacing in order to check if the prediction models based on the FEM simulations and the laboratory test are correct. In total 18 strain gauges have been applied at different locations at the bridge deck. The location of the strain gauges is explained in the paper.

The results of these stress spectra measurements are reported in this paper. The reduction of the local bending stresses in the deck plate due to the replacement of asphalt with concrete is approximately 70-80 %, which is in accordance with the expectations.

This stress reduction leads to a significant lifetime enhancement of the deck plate structure. The papers ends with an interpretation of the measured stress reductions in relation to the lifetime enhancement of the bridge deck, for two types of fatigue cracks.
RESURFACING OF ORTHOTROPIC BRIDGE DECKS IN THE UK – PRACTICAL AND DESIGN CONSIDERATIONS

Neil McFadyen*, Robert Brady** and Ian Firth***

*Principal Engineer, Flint & Neill Partnership (FNP), Berkeley, Gloucestershire, GL13 9LB UK, Tel: +44 1454 260910, Fax: +44 1454 260784, Email: anm@flintneill.co.uk
**Associate, Flint & Neill Partnership, UK. ***Senior Partner, Flint & Neill Partnership, UK.

Abstract

Due to increasing traffic demand, the need to find an improved replacement surfacing system for the UK’s stock of lightweight steel box girder bridges arose in the mid 1980s and continues to the present day. These structures, constructed during the 60s and 70s, were originally provided with a thin surfacing system comprising a mastic asphalt wearing course and a flexible rubberised waterproofing membrane.

The paper describes the resurfacing of a number of major bridges with orthotropic steel decks, giving some of the background to the research and development of the surfacing systems and describing the important practical aspects of their application, including deck inspection and repair. With reference to research findings and the experience gained on a number of bridges, the paper will provide useful information on specifying and running resurfacing contracts with long-term performance in mind.

Two markedly different systems are described; a development of the original mastic asphalt system and an all epoxy system. Conclusions are drawn on the effectiveness of the systems from the point of view of asphalt durability, enhancement of the performance of underlying steelwork and the reliability of the application process.

The paper addresses both design issues and practical considerations for the owner, specifier and applicator.

Keywords: Orthotropic Deck, Repair, Surfacing, Composite Action, Stress Reduction, Fatigue, Waterproofing.
Abstract

This paper consists of two parts. The first part describes a new kind of maintenance philosophy. Conventional maintenance strategies are formed by time based inspection intervals and replacement of parts of the structure at the end of their lifetime. This strategy and the insufficiency of this strategy to handle fatigue problems are described. Subsequently the properties of a new risk based maintenance strategy, based on probabilistic calculations models, are described. Successful implementation of this strategy is only possible if the necessary tools in this strategy are available. The paper describes the tools in the strategy. These are lifetime calculation models, local reparation techniques, renovation techniques for complete bridge decks and inspection techniques. This strategy and the developed tools have resulted in practical solutions for the 80 fixed and movable bridges in the Netherlands, which enables the bridge owners to maintain their bridges, minimizing the risks and maintenance costs.

The second part of the paper describes more in detail the lifetime calculation model, which is of vital importance to minimize risks and to schedule inspections and renovations. Reliable lifetime calculations need accurate models of the number and amplitude of the stress cycles and the fatigue behaviour. A formal model to calculate the fatigue crack growth of deck plate cracks is presented. Based on this formal model a computer program has been developed for bridges in the Netherlands. Aspects related to the number and amplitude of the cycles are investigated. These are traffic properties, axle load distributions, the fatigue classification and the calculation of the stresses at the crack location. Special attention has been paid to the effect of the asphalt wearing courses, which are applied at fixed bridges. Asphalt has a reducing effect on the stress in the steel deck plae, but
Wearing Surface
WATERPROOFING THE STEEL ORTHOTROPIC DECK OF THE CARQUINEZ BRIDGE

Frank J. Constantino*

*Stirling Lloyd Products, Inc.

Abstract

Following the 1989 Loma Prieta earthquake, the State of California Department of Transportation (Caltrans) conducted a seismic review of all of their major toll bridges, including the two multi-span bridges that crossed the Carquinez Straits, carrying traffic on Interstate 80 between Crockett and Vallejo, CA. They concluded that the eastbound structure built in 1958 could continue in service after a seismic upgrade; however it would be more costly to upgrade the westbound structure, the original 1927 bridge, than to replace it.

The demand for the new bridge came about largely because of the findings compounded by the expected growth in the volume of traffic on Interstate 80. Adding extra lanes to the existing bridges was not an option and with traffic flows of approximately 105,000 vehicles per day being carried by the bridges, a figure forecast to rise to 128,000 by 2010, a new bridge was of paramount importance.

The decision to build the bridge was taken and Caltrans appointed a joint venture consultancy team of Parsons Transportation Group and Opac Consulting Engineers to undertake studies into the type of bridge required. Their proposal was a suspension bridge with a steel orthotropic deck, supported by two 124m (410 ft) concrete towers as opposed to the more traditional choice of a truss stiffened deck. Not only was this a more aesthetic and cost effective option, but it would also take less time to construct and have a far superior seismic performance.

By their very nature, steel orthotropic decks are a stern test for any waterproofing system. Not only are they far livelier than conventional truss stiffened decks, they are also subject to a greater level of expansion and contraction, as the heating and cooling cycle of a steel is considerably quicker than that of a concrete deck. Additionally, because of the need to reduce the dead load on this type of deck, very thin mastic and/or polymer modified asphalt surfacing tends to be used which must be heated to a higher application temperature than conventional surfacing. This in turn necessitates a waterproofing system of the highest quality, which is durable and resilient enough to withstand these strains placed upon it along with developing very high bond strengths to the steel deck and to the asphalt pavement.
Reinforced High Performance Concrete Overlay System for Rehabilitation and Strengthening of Orthotropic Steel Bridge decks.

Peter Buitelaar*, René Braam** and Niek Kaptijn***

*Technical Manager; Contec ApS; Axel Kiers Vej 30, DK-8270 Højbjerg, Denmark; phone +4586721722; telefax +4586721723; E-mail pbu.contec-aps@wxs.nl, pb@contec-aps.dk

**Dr. Ir. Drs., Research Engineer; Delft University of Technology Concrete Structures Group; P.O.Box 5048, NL-2600 GA Delft, Netherlands; phone +31152782779; telefax +31152785895; E-mail C.R.Braam@ct.tudelft.nl

***Ing., Senior Research Engineer; Ministry of Transport, Public Works and Water Management, Civil Engineering Division; P.O.Box 1286 NL-5004 BG, Tilburg, The Netherlands; phone +31134645717; telefax +31 134645787; E-mail n.kaptijn@bwd.rws.minvenw.nl

Abstract

After serious damage of the bascule of the Van Brienenoord Bridge in one of the main highways in the Netherlands and its replacement a special Task Force was formed within the Civil Engineering Division of the Dutch Ministry of Transport, Public Works and Water Management. The aim was to investigate the cause, to understand and control the fatigue mechanism for the 80 steel fixed and movable bridges in the Netherlands and to develop practical solutions for cost effective rehabilitation and renovation. This project including the research is described in detail in papers presented earlier in different conferences and in this conference [Boersma P.D. and de Jong F.B.P. 2003, De Jong F.B.P. and Boersma P.D. 2003, De Jong F.B.P. et al 2004, M. H. Kolstein 2004]. A large research project including a pilot project in 2003 is executed during the last 6 years to develop a new revolutionary high strength concrete wearing course on orthotropic steel bridges which is also extending the service life of the total construction by solving fatigue problems in specific deck details. This is a very promising solution since it turns the deck plate in a much more rigid construction with a higher “plate factor” due the monolithic composite interaction between the RHPC (Reinforced High Performance Concrete) overlay and the steel deck plate. The RHPC overlay with a thickness of minimum 5 cm will result in a stress reduction with a factor of 4 – 5 in the deck plate and a factor 3 – 4 in the trough wall and thus extend the service life of the orthotropic bridge deck with some extra decades without additional maintenance. Project initiator is the Civil Engineering Division of the Dutch Ministry of Transport, Public Works and Water Management in close co-operation with Contec ApS, inventor of the Ultra Thin
The Successful Use of Thin Polysulfide Epoxy Polymer Concrete Overlays on Steel Orthotropic Bridge Decks
Michael S. Stenko* and Arif J. Chawalwala**

*President, Transpo Industries, 20 Jones Street, New Rochelle, NY 10801, USA. Email: mstenko@transpo.com, Tel./Fax.914-636-1000/914-636-1282, **Senior Product Development Engineer, Transpo Industries, 20 Jones Street, New Rochelle, NY 10801, USA, Email: achawalwala@transpo.com, Tel./Fax. 914-636-1000/914-636-1282

Abstract

Specially formulated polysulfide epoxy polymer concrete bridge overlays were developed over twenty years ago. Based on their long-term service performance, they have been recognized as a very effective wearing surface for use on existing and new steel orthotropic bridge decks. These thin overlays offer reduced dead load as compared to asphalt overlays, and do not heave in high temperature locations. Unlike other epoxy systems, polysulfide epoxy overlays are formulated to resist the long-term effects of ultra violet rays, which can lead to oxygenation, overlay material hardening, and premature material failure.

There are two methods of application that are currently in use; they are multiple coat Broom-And-Seed Method and the single coat Slurry Method. Each of the application methods has its benefits. This paper discusses these benefits as well as a direct comparison of the long-term performance of each method.

Successful application and overlay performance are based on proper project specifications and inspection during the application. Surface preparation, environmental conditions, material mixing, application, wearing surface aggregate broadcast and inspection are discussed along with the significance of each.

These overlays have been applied at the job site on existing structures and new orthotropic deck panels and also shop applied at either the steel fabricator or a specialty coating facility. Field applications enable the overlay to be installed as a monolithic surface; however, there are environmental considerations that may make this method undesirable. Shop application will reduce the environmental considerations however provisions must be made in the overlay for the field welding necessary during deck construction. The effects of welding heat on a shop-applied overlay can cause severe damage; however testing has shown that the use of an “overlay cutback” in the heat-affected area is effective in preventing such damage.
ALTERNATIVE WATERPROOF SYSTEM & WEARING COURSE FOR ORTHOTROPIC BRIDGE DECKS

Doug Zuberer*

Director Business Development Chase SCG/Royston Labs, 26 Summer Street, Bridgewater, MA 02324, USA. Tel: 508-279-1789 x 211, Fax: 508-697-6419, Email: dzuberer@chasecorp.com

Abstract

With more than twenty years of experience using a super polymerized asphalt additive in a “Dry Mix” design the purpose of the paper is to show that both independent testing and field experience reflects that Rosphalt 50 offers a cost effective one-step solution as a waterproofing system combined with a superior wearing surface that will not rut or shove.

Performance testing of the Rosphalt material as compared to alternate waterproofing systems used on Orthotropic Bridge Decks has proved to provide solutions that can expedite the construction process saving both time and money.

Examples of Orthotropic Bridge rehabilitation projects undertaken in New Brunswick Canada will be the primary focus of the paper.

Each bridge is unique and is approached independently. Longs Creek was a two-lane horizontal steel deck with 1 ¼” rivets requiring a two lift placement. This first lift covered the rivets and was then followed by 1 inch wearing surface. Total Rosphalt tonnage approx. 300T. Hawkshaw also required two lifts due to the rivet design however offered more challenges due to sharp left banks and grade level approaching 4 percent. Total Rosphalt tonnage approx. 800T.

Additionally, Rosphalt has been used on many other structures with the same success as both an interlayer design as well as full depth covering a wide variety of structures including both new bridge designs as well as rehabilitation projects.

Introduction

After many years research projects funded by FHWA and State DOT’s and other Independent agencies, they are all are still looking to solve problems associated with our road and bridge deck systems.
WEARING SURFACE SYSTEMS FOR ORTHOTROPIC BRIDGE DECKS
ISSUES RELATED TO TESTING AND PERFORMANCE EVALUATION 1

Vellore S. Gopalaratnam*

Professor of Civil Engineering, University of Missouri-Columbia, USA.

Abstract

The presentation will review data from laboratory and field investigations on the performance of wearing surface systems for orthotropic steel plate bridge decks obtained over a 15-year period. Focus will be on the Poplar Street Bridge in St. Louis, Missouri, where field performance data is also available for over 10 years. Major issues and challenges related to testing such composite systems under temperature-varying fatigue loads will be presented. Performance of several wearing surface systems including thick asphalt concretes and thin polymer concrete both in the laboratory and field tests will be discussed. Temperature-dependent material properties and their influence on deck stiffness and stress-levels and consequent simulation in small-scale laboratory tests will also be addressed. The talk will also address field experience with maintenance of a serviceable wearing surface and issues related to potential wearing surface cracking and delamination.
Fatigue
MODERN FATIGUE DESIGN OF ORTHOTROPIC BRIDGE DECKS IN THE UNITED STATES

Robert J. Connor* and John W. Fisher*

*ATLSS Engineering Research Center, Lehigh University, Bethlehem, PA, USA

Abstract

Since the introduction of the first version of the AASHTO LRFD Bridge Design Specifications in 1994, there have been significant advancements related to fatigue design of orthotropic bridge decks. This work has included both laboratory and field studies that focused both on the fatigue resistance and loading issues specific to these deck systems. In addition, further understanding of the performance of these complex structural systems has been realized by the detailed analytical studies completed in conjunction with these research projects. A great deal of this work has already been incorporated in the latest versions of the AASHTO LRFD Bridge Design Specifications (2003).

This research has led to details with improved fatigue resistance, for example at the welded rib-to-diaphragm connection in closed rib systems. With the advancements in finite element (FE) modeling software and powerful desktop computers, the finite element method has emerged as the premiere means for preliminary and final design as well as evaluation of orthotropic deck systems. This is especially true when considering the fatigue-limit-state as it is essential that local stresses be accurately determined at critical fatigue details. Existing approximate methods, which may be useful for estimating overall stresses, are not appropriate when using the fatigue design provisions included in the modern AASHTO LRFD Specifications. Hence, guidelines for the FE modeling of orthotropic bridge decks have also been developed which are consistent with the objectives and fatigue requirements of the AASHTO LRFD Specifications.

This paper will report on the current practice for the fatigue design of orthotropic bridge decks and present a summary of the results of recent studies in the United States. Details possessing enhanced fatigue resistance that are also cost effective will be presented for guidance to designers. Discussion will also include guidelines on analysis, loading, and in-situ behavior in the context of fatigue performance.
EUROPEAN RESEARCH ON THE IMPROVEMENT OF
THE FATIGUE RESISTANCE AND DESIGN OF
STEEL ORTHOTROPIC BRIDGE DECKS

Henk Kolstein*

*Senior Researcher/Lecturer, Delft University of Technology, Faculty of Civil Engineering and Geosciences, P.O. Box 5048, 2600 GA, Delft, The Netherlands; Phone +31-15 278 4005; Fax +31-15 278 3173; m.h.kolstein@citg.tudelft.nl

Abstract

The orthotropic steel deck has been used as a lightweight deck in steel bridges since many years. This type of structure has suffered several developments since 1950 (e.g. in view of the shape of longitudinal stiffeners, the distance of cross beams, the connection of the longitudinal stiffeners to the web of crossbeams etc.) and there are also differences between railway bridges and road bridges. The fabrication of the joint details represents a considerable amount of the costs of the bridge.

In the last decades, the traffic intensity and the wheel loads on bridges have increased considerably, resulting in fatigue cracks in modern steel bridges within their service lives. Also, detailing of the welded connections and execution of welding was not always carried out to a sufficiently high standard. Although cracks are found at many locations, they are usually not immediately threatening the performance of the bridge. A long time before they can develop to such dimensions, they have been detected. Repair however, causes large expenses; as bridge decks are large areas thus include many spots to be repaired. Detail studies of the fatigue design and the behaviour of steel bridges were required.

As the deck is directly subjected to the severe impact of heavy wheel loads the research concentrates on the components of orthotropic deck structures. This paper reviews the European Coal and Steel Community funded research on welded details of such a deck in relation to observed fatigue failures. It highlights the practical experience and recommendations on how to reduce the risk of fatigue failures.

Introduction

Early bridges with orthotropic decks have been designed using codes mainly relating to the behaviour under static loading. Since the early eighties for the assessment of fatigue various codes exists. For example one of the leading codes in this respect, the British Standard on fatigue (BS 5400, 1980) defines (i) the fatigue design codes to be used, (ii) the allowable stress ranges for a service life of 120 years and (iii) the
OVERVIEW FATIGUE PHENOMENON IN ORTHOTROPIC BRIDGE DECKS IN THE NETHERLANDS

F.B.P.de Jong*

*Civil Engineer, Delft University of Technology, P.O.Box 5048, 2600 GA, Delft, The Netherlands; Phone +31-15 278 57 16; f.b.p.dejong@citg.tudelft.nl and Ministry of Transport, P.O.Box 59, 2700 AB, Zoetermeer, The Netherlands; Phone +31 – 79 329 25 19; f.b.p.dejong@bwd.rws.minvenw.nl

Abstract

An orthotropic steel bridge deck is a construction type with advantages. It is a lightweight construction, which is beneficial especially in case of larger spans. However over the last decades several details showed fatigue cracks. Well-known examples of fatigue cracks in the Netherlands are those observed in the bascule bridge Van Brienenoord in Rotterdam in summer 1997. Due to the huge amount of heavy vehicle traffic at the highways and the heavy but still growing axle loads, several fatigue cracks have already been observed in bridge decks and more cracks are expected. A lot of orthotropic steel bridge decks in the Netherlands are built up in the sixties and seventies. Fatigue problems are nowadays a challenging problem for bridge engineers.

This introductory paper describes several fatigue prone details. Especially four types of cracks are discussed in this paper. These are cracks in the deck plate (1), cracks in the longitudinal weld between deck plate and longitudinal trough profile (2), cracks in the trough splice joint (3) and cracks in the connection between the trough profile and the crossbeam (4). For those four crack types the mechanical background is briefly analysed. The description of the cracks is illustrated with visual observations of the cracks in the steel structure itself and also with visual observations of the surfacing layers.

The analysis of these structural details leads to the conclusion that especially fatigue cracks in the deck plate are potentially disturbing the traffic flow. For this reason emphasis on solutions for this type has been made. The analysis also leads to conclusions that are useful for the development of improved bridge deck structures.

History

In the third decade of the 20th century, engineers in Germany and the USA were searching for an alternative to wooden and concrete decks supported by stringers and crossbeams. They considered steel decks as a promising alternative. The objectives were cost savings by a reduction of the steel mass and also achieving a reduction of
FATIGUE STRENGTH VERIFICATION OF STEEL ORTHOTROPIC PLATED BRIDGE DECK FOR RAILWAY BRIDGES

Wouter De Corte* and Philippe Van Bogaert**

*Research Assistant, PhD Student, Department of Civil Engineering, Ghent University, Technologiepark 904, B-9052 Ghent, Belgium, PH: +32 9 264 5490; wouter.decorte@ugent.be
**Professor, Head of Bridges Section, Department of Civil Engineering, Ghent University, Technologiepark 904, B-9052 Ghent, Belgium, PH: +32 9 264 5488; philippe.vanbogaert@ugent.be

Abstract

Although orthotropic plated decks are most frequently used for road bridges, some examples of the use of this type of decking for railway bridges exist. In these cases the deck will be subject to higher loads as compared to road bridges, yet a number of mechanisms will lead to a better structural performance and use of the structural capacity of the deck, especially concerning fatigue. This latter phenomenon limits the design possibilities quite largely for road bridges, certainly for the deckplate. For railway bridges, in many cases a more favorable situation is created which is mostly overlooked. On the other hand, some locations still need attention and may be subject to fatigue inducing load cycles. The article describes a number of mechanisms related to the railway loading that contribute to the rather positive structural behavior of railway bridges with orthotropic deck.

Introduction

During recent years a number of large steel bridges have been built for the High Speed Line in Belgium. Due to vertical clearance and maximum vertical slope restrictions, the structural depth of these bridges has to be the smallest possible. For this reason an orthotropic plated deck is chosen in several occasions. This type of steel deck, combined with an arch as main load carrying system results in a low structural depth. However the slender bridge deck may suffer from heavy fatigue strength limitations. As the orthotropic deck consists of a series of longitudinal and transverse stiffeners welded to the lower side of the deckplate, a large amount of welding is necessary. These welds result in many fatigue sensitive locations. One of these sensitive locations is the stiffener connection. This joint is made from one side only and has a low fatigue resistance for transverse bending. Especially for road bridges, this location has lead to problems on various road bridges in Europe. For railway bridges however this location is virtually free from fatigue due to the load dispersal through rails, sleepers and ballast and due to the structural stiffness of the
FATIGUE RESISTANCE AND ULTIMATE STRENGTH OF SPS BRIDGE DECKS

Thomas Murray* and Stephen J. Kennedy**

Prof. of Structural Steel Design, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0105, USA. Tel: (540) 231-6074, Fax: (540) 231-7532, Email: thmurray@vt.edu; ** Technical Director, Intelligent Engineering Ltd., 72 Chamberlain Ave., Ottawa, ON K1S 1V9, Canada, Tel: (613) 569-3111 Ext –229, Fax: (613) 569-3222, Email: sik@ie-sps.com

Abstract

Intelligent Engineering has developed a new construction technology, the Sandwich Plate System (SPS), for use in marine and civil engineering markets, over a ten-year period and has approvals from the Quebec Ministry of Transportation, the six major Classification Societies (ABS, BV, DnV, GL, LR and ClassNK) and several flag state administrations (Transport Canada, Danish Maritime Authority, Swedish Administration, UK Maritime Coast Guard Administration). The sandwich plate consists of two metal plates, which are separated by a compact elastomer core. The resulting composite structure is structurally equivalent to or better than traditional stiffened plate construction and has a number of inherent characteristics such as superior high impact resistance, improved vibration damping, viso-elastic core which reduces shipborne noise, built-in structural fire protection, and simplicity in construction which eliminates a significant number of fatigue and corrosion prone details.

This type of construction can be effectively used as bridge deck panels in the form of planks or plates integrated with stringers and beams. The prefabricated bridge deck panels are made composite with steel girders by bolting. The weight of the deck can be reduced by 75% over comparable concrete deck structures and the deck provides a viable alternative to orthotropic bridge decks as it eliminates the fatigue prone details associated with welds between the troughs and the deck plate. These lighter composite sandwich decks prove to be more durable and can reduce both the superstructure and substructure costs.

This paper describes a series of tests being conducted at Virginia Polytechnical Institute on a new structural deck system that is made composite with steel girders. The tests include fatigue tests associated with a finishing weld between prefabricated bridge deck panels, an ultimate strength test on an isolated bridge deck panel and a series of load tests on a 40 foot long half-scale bridge structure subject to both positive and negative moments (loaded eccentricaly and concentrically). A comparison between the data obtained from the tests and the results from finite element predictions will be presented.
ASSESSMENT OF FATIGUE STRENGTH OF STEEL ORTHOTROPIC PLATED BRIDGE DECKS FROM CONTINUOUS MEASURED STRESS SPECTRA

Wouter De Corte*

*Research Assistant, PhD Student, Department of Civil Engineering, Ghent University, Technologiepark 904, B-9052 Ghent, Belgium, PH: +32 9 264 5490; wouter.decorte@ugent.be

Abstract

Fatigue resistance of orthotropic plated bridge decks can only be calculated moderately accurate using analytical formulae or plate analysis methods. Finite element calculations for the various fatigue sensitive details prove to be more accurate. However, for railway bridges, the load distribution through rails, sleepers and ballast remains uncertain and is a function of the rail and sleeper type. For road bridges, the influence of the wearing course is uncertain. The real fatigue damage resulting from a train or vehicle crossing can be easily assessed at various locations through continuous strain gauge measurements at high frequency. The resulting stress spectra retrieved from the various train or lorry types crossing the bridge can be combined with present and future expectations for passenger and freight traffic at the bridge location. The Palmgren-Miner rule links the magnitude and number of the different stress variations, producing more accurate predictions of estimated fatigue life. This method reveals the critical points within the fatigue calculation of an orthotropic bridge.

Introduction

During recent years a number of large steel bridges have been built for the High Speed Line in Belgium (Van Bogaert, 2003). Due to vertical clearance and maximum vertical slope restrictions, the structural depth of these bridges has to be the smallest possible. For this reason an orthotropic plated deck is chosen in several occasions. This type of steel deck, combined with an arch as main load carrying system results in a low structural depth. However the slender bridge deck may suffer from heavy fatigue strength limitations. As the orthotropic deck consists of a series of longitudinal and transverse stiffeners welded to the lower side of the deckplate, a large amount of welding is necessary. These welds result in many fatigue sensitive locations. In addition the calculation of this type of deck with analytical methods (Troitsky, 1967) or simple finite element models does not necessarily reveal the true stresses and strains in these locations. Nevertheless a highly accurate fatigue calculation is necessary to achieve a cost effective and yet safe design. For these
ANALYSIS OF FATIGUE DAMAGE PATTERNS IN ORTHOTROPIC STEEL DECK OF TOKYO METROPOLITAN EXPRESSWAYS

Tarou YUGE*, Fumitaka MACHIDA, Hisashi MORIKAWA, Chitoshi MIKI, Takeshi KAMIKI and Takashi MASUI

*Assistant Engineer, Metropolitan Expressway Retrofit Project, Technology Center of Metropolitan Expressway, 3-10-11, Toranomon, Minato-ku, Tokyo, 105-0001, Japan, PH +81-01-3578-5757; taroyuge@temex.or.jp

Abstract

A steel deck is a member that supports the load of a vehicle wheel directly and its fatigue damage is greatly affected by the running location of the load of the wheel and the number of repetitions. The current approach inspections have revealed fatigue cracks at 1,391 locations in 276 spans of steel deck bridges (as of March, 2004). The objectives of our study are to establish methods for inspection and repair that are efficient and reliable. In our study so far, we have clarified potential crack initiation points for each longitudinal rib type. We also have verified correlations with the traffic data and the structural data and found some crack patterns that correlated and some that did not.

1. Introduction

The network of Tokyo Metropolitan Expressway has continually expanded since construction began in 1962. Over 50% of the expressway length has been in service for over 20 years, and the increase in the traffic volume of the large vehicle is remarkable in recent years. Fatigue damage of steel structures including steel piers and main girders is increasing due to these factors, and particularly due to excessively heavy vehicles. Steel plate girder bridges with orthotropic steel decks to limit the weight of the super-structures, while spans are becoming longer and construction times shorter in consideration of site characteristics. The spans in the Tokyo Metropolitan Area now total more than 1,100. (Table 1)

By using the current approach inspections, fatigue cracks have been found in steel decks. The crack count is increasing because the inspections are still in progress. Of the 856 spans of steel deck bridges of the Tokyo Metropolitan Expressways requiring an approach inspection, 276 spans (32%) had been inspected as of March 31, 2004. Fatigue cracks have been found at 1,391 locations of these 106 spans. (Table 2) Depending on their location, some cracks did not impair the general safety of the bridge but did disturb traffic on the lane. Emergency measures have already been applied to some of them. Repairs and reinforcements after the emergency measures are now under study.
LOCAL STRESSES AND FATIGUE DURABILITY OF ASPHALT PAVED ORTHOTROPIC STEEL DECKS

Xiaohua Cheng*, Jun Murakoshi**, Kazuhiro Nishikawa*** and Harukazu Ohashi****

* Member of ASCE; Civil Engineer, Bureau of Structural Engineering, New Jersey Department of Transportation, 1035 Parkway Ave., Trenton, NJ 08625; PH 609-530-2464; FAX 609-530-5777; Xiaohua.Cheng@dot.state.nj.us, ** Team Leader, Structures Research Group, Public Works Research Institute, 1-6 Minamihara, Tsukuba, Japan 305-8516; PH +81-298-79-6792; FAX +81-298-79-6739; murakosi@pwri.go.jp, *** Director, Planning and Research Administration Department, Public Works Research Institute, 1-6 Minamihara, Tsukuba, Japan 305-8516; PH+81-298-79-6700; nishikawa@pwri.go.jp, **** Project Engineer, Parsons, 100 Broadway, New York, NY 10005; PH 212-266-8348; FAX 212-266-8540; harukazu.ohashi@parsons.com

Abstract

Orthotropic steel deck system is used in highway bridges for the light weight, easy in-suit construction and long durability compared with concrete slabs. It is susceptible to flexural distortion in the thin plate members and high local stresses at weld connections and cutouts, and hence vulnerable to fatigue damage. Careful detailing is desired. On the other hand, increasing deck plate thickness and ensuring the composite effect of pavement with orthotropic deck may enhance the overall rigidity of the deck system and improve the local stresses to some extent. In order to investigate local stresses and effect of asphalt pavement, stress measurements were made on a large-scale non-paved, and an asphalt paved cable stayed bridge in summer and winter. The specimens and the bridge were designed in compliance with the design guidance of Honshu-Shikoku Bridge Authority (HSBA) of Japan. Partial results are reported in this paper. The effect of asphalt pavement on stress range and fatigue is discussed based on the results. Equivalent composite effect of asphalt pavement and deck plate to a plain steel deck plate is also examined using finite element analysis. It was revealed that the HSBA standard asphalt pavement is beneficial to fatigue and the effect varies for different details in the orthotropic deck.

Key Words: Orthotropic deck, Asphalt pavement, Local stress, Fatigue, Welded detail

Introduction

With the rapid development of large vehicle weight and traffic volume, fatigue cracking has been reported for some welded details that were subjected to high local stresses in orthotropic bridge decks of national highway and urban viaduct bridges, such as at the weld toe of the cutout at the intersection of longitudinal U-rib and diaphragm (an example in
Research
DESIGN AND FIELD LOAD TESTING OF
THE SHENLEY BRIDGE, QUÉBEC, CANADA

R.A. Dorton*, D.J.L. Kennedy, F. ASCE**, and A.E. Martino**

* R. A. Dorton, Buckland and Taylor Limited, 34 Kingland Crescent, Willowdale ON M2J 2B7; PH. 416-502-8033; roger.dorton@sympatico.ca
** D. J. L. Kennedy and A.E. Martino, Intelligent Engineering (Canada) Limited, 72 Chamberlain Avenue, Ottawa ON. K1S 1V9; PH. 613-569-3111; djlk@ie-sps.ca

Abstract

The cross section of the Shenley Bridge suggests that it is simply a slab-on-girder bridge, even if the slab acts compositely with the three longitudinal girders. However the deck panels, with moderately sized but widely spaced edge stiffeners, span transversely between the girders and longitudinally the main girders act as deck stiffeners even though they are rather large and very widely spaced. [Different proportions of deck thicknesses and stiffeners could give an orthotropic bridge approaching more usual proportions.] The fundamental difference of the Shenley Bridge from the usual orthotropic bridge is that the deck plate is not a single trough-stiffened steel plate but a steel Sandwich Plate System (SPS) that is stiff enough by itself, self stiffened if you will, to span many times that of a single steel plate thus reducing the number of stiffeners markedly. An SPS unit consists of two steel faceplates bonded to an elastomer core. The design of the Shenley Bridge (erected in November 2003) to carry gravity loads, particularly as related to the SPS deck panels, is discussed and the results of full-scale static load tests are presented and analysed. Testing and monitoring of this bridge in service, along with very considerable laboratory testing opens the door to the adoption of SPS decks in long span bridges.

Introduction

In the (patented) Sandwich Plate System (SPS), two steel plates are bonded to a compact polyurethane elastomer core as shown in Figure 1. The elastomer, as a two-part liquid, is injected into closed cavities formed by the steel faceplates and perimeter bars. The latter are not shown in the figure. To obtain a factored bond strength of 4 MPa or better on setting, the faceplates are grit blasted and have to be dry and free of grease, dirt and other contaminants when the elastomer is injected. An SPS designation, SPS 6-50-6, denotes the thicknesses of the three sandwich components – steel-elastomer-steel – in millimetres. In flexure, the plates act as flanges and the core as the web. The flexural stiffness and strength of a sandwich plate are many times those of a single steel plate and are tailored to meet particular structural requirements by selecting appropriate thicknesses for the sandwich
STRESS MEASUREMENTS ON FATIGUE-DAMAGED STRUCTURES
WITH ORTHOTROPIC STEEL DECKS IN SUMMER AND WINTER

Fumitaka MACHIDA*, Tarou YUGE, Chitoshi MIKI,
Eiki YAMAGUCHI, Tetsuhiro SHIMOZATO, Takashi MASUI

*Chief Project Manager, Metropolitan Expressway Retrofit Project, Technology
Center of Metropolitan Expressway, 3-10-11, Toranomon, Minato-ku, Tokyo, 105-0001, Japan, PH +81-3-3578-5757; machida@tecmex.or.jp

Abstract

The orthotropic steel deck is a structural member assembled by welding thin steel plates, and it supports the wheel load directly. Therefore, the transverse distribution of vehicle positions, the number of repetitions of wheel loads, the accuracy of the member assembly, and the weld quality greatly influence the fatigue damage. Tokyo Metropolitan Expressways carry an average of 43,000 vehicles per day in each direction, an average of 8.8% of which are large vehicles, although the percentage is higher in some heavily traveled routes. As steel plate decks are expected to suffer fatigue damage under these conditions, the detailed inspections were conducted to observe the stress conditions, and to confirm the occurrence of the crack at the position where the generation of the fatigue crack was forecast. This report describes the results of the stress condition measurements. The bridge, which detailed inspection had been executed, was a three-span continuous box girder bridge with an orthotropic steel deck. And, this bridge exists in the heavy traffic route with 80,000 vehicles per a day in each direction. In addition, the large-sized car mixing rate of this route was 15%.

The stress condition studies were conducted in summer and winter in order to assess the influence of pavement stiffness. A 245 kN gross weight loading vehicle was used for loading tests. Besides the loading test, stresses were also measured under general traffic conditions, and through a 72-hour stress frequency test. The stresses were measured at the following crack-occurring locations in order to investigate the causes of crack occurrence:

1. Vertical stiffener of main girder web to steel deck plate connections
2. Trough rib to deck plate connections
3. Intersection of trough rib and floor-beam

Keywords: orthotropic steel deck, pavement stiffness, temperature dependency
COMPRESSION BEHAVIOR OF STEEL ORTHOTROPIC DECK PANELS FOR THE NEW SAN FRANCISCO-OAKLAND BAY BRIDGE

C. C. Chou*, C. M. Uang**, and F. Seible***

*Assistant Professor, Department of Civil Engineering, National Chiao Tung University, Hsinchu 300, Taiwan, Tel: 886-3-571-2121 ext: 54961, email: chchou@mail.nctu.edu.tw
**Professor, Department of Structural Engineering, University of California, San Diego, La Jolla, CA 92093-0085, USA, Tel: 858-534-9880, email: cmu@ucsd.edu
***Dean, Jacobs School of Engineering, University of California, San Diego, La Jolla, CA 92093-0085, USA, Tel: 858-534-4640, email: seible@ucsd.edu

Abstract

Compression tests were conducted on two reduced-scale orthotropic plates to verify the design strength of steel box girders for the new East Span of the San Francisco-Oakland Bay Bridge. The first specimen, composed of three longitudinal closed ribs and a top deck plate, failed in global buckling and local buckling in the deck plate and ribs. The second specimen, which was composed of four longitudinal T-shaped ribs and a bottom deck plate, experienced global buckling, torsional buckling of the ribs, and local buckling of the deck plate. The ultimate strength and failure mode of both specimens were evaluated by two bridge design specifications: the 1998 AASHTO-LRFD specification and the 2002 Japanese JRA specification. Findings from code comparisons showed that (1) sufficient flexural rigidity of ribs were provided for both specimens, (2) the JRA specification slightly over-estimated the ultimate strength of both specimens, and (3) neither specification predicted torsional-buckling of the T-shaped ribs in Specimen 2. A general-purpose nonlinear finite element analysis program (ABAQUS) was used to perform a correlation study. The analysis showed that the ultimate strength and post-buckling behavior of the specimens could be reliably predicted when both the effects of residual stresses and initial geometric imperfections were considered in the model.

Introduction

The new East Span of the San Francisco-Oakland Bay Bridge (SFOBB), designed by the joint venture of T.Y. Lin International and Moffatt & Nichol, features a 565-m long single tower steel self-anchored suspension bridge with a main span of 385 m (see Figure 1). The cable is anchored to the deck at the east bent and is looped around at the west bent. The suspenders spaced at 10 m are splayed to the exterior sides of the steel orthotropic box girders, and floor beams are spaced at 5 m inside the box girder. Two box girders, which are interconnected with cross beams at 30 m on
RESEARCH PROJECT TU DELFT; BEHAVIOUR CONVENTIONAL BRIDGE DECKS & DEVELOPMENT OF RENOVATION TECHNIQUES

F.B.P.de Jong*, M.H.Kolstein** and F.S.K.Bijlaard***

*Civil Engineer, Delft University of Technology, P.O.Box 5048, 2600 GA, Delft, The Netherlands; Phone +31-15 278 57 16; f.b.p.dejong@citg.tudelft.nl and Ministry of Transport, P.O.Box 59, 2700 AB, Zoetermeer, The Netherlands; Phone +31 – 79 329 25 19; f.b.p.dejong@bwd.rws.minvenw.nl

**Senior Research Engineer, Delft University of Technology, P.O.Box 5048, 2600 GA, Delft, The Netherlands; Phone +31-15 278 40 05; m.h.kolstein@citg.tudelft.nl

***Professor of Steel Structures, Delft University of Technology, P.O.Box 5048, 2600 GA, Delft, The Netherlands; Phone +31-15 278 16 75; f.s.k.bijlaard@citg.tudelft.nl

Abstract

In order to develop solutions for the fatigue problems in several bridges a research program has been started a few years ago at Delft University of Technology. The aim of this program is to gain more understanding of the fatigue behaviour of orthotropic bridge decks with respect to deck plate cracking, and also to develop long term renovation techniques for bridge decks with fatigue cracks.

To obtain more insight in the behaviour of conventional orthotropic steel bridge decks a lot of static experiments have been performed on a realistic bridge deck sample in the Lintrack, a heavy vehicle simulator with a moving wheel load. These tests are in fact a realistic simulation of heavy vehicle traffic on highways. In the experiments strain distributions are measured, therefore approximately 150 strain gauges are applied at several locations at the test panel; both at the steel as at the surfacing. Experiments are performed without and with two different wearing courses, four wheel types, two wheel loads, two velocities and three different temperatures in order to achieve understanding of the influence of these parameters.

To obtain more insight in the fatigue behaviour and to derive a detail classification a serie of fatigue tests have been performed. This paper describes the test set up and results. The results are compared with crack growth models based on fracture mechanics. Besides this fatigue test also a static test has been performed to investigate the stress patterns in the deck plate as function of the wheel load, and the size of the footprint.

To deal with the fatigue problems in the future a new kind of maintenance philosophy has been developed for bridge decks. Essential parts of this philosophy
DESIGN AND TESTING FOR THE ORTHOTROPIC DECK OF THE BRONX WHITESTONE BRIDGE

Sante Camo* and Qi Ye**

*Associate principal, Weidlinger Associates, 275 Hudson St. New York, NY. USA. Member AWS, ASM. Email: camo@wai.com. Tel: 212 367 2822.
**Associate, Weidlinger Associates, Member ASCE. Email: ye@wai.com. Tel 212 367 2811

Abstract

Present Design provisions do not provide adequate guidance for the design of orthotropic deck connections and in cases mislead engineers into details of poor performance. AASHTO’s 75 year life criterion renders orthotropic decks economically not viable. Infinite life criteria should be applied to make orthotropic decks competitive against rival deck systems.

The parametric studies were conducted to shed light in design fuzzy areas. They included an investigation on a total of 12 “hot spots” around the cut-out impacted by several fabrication parameters. Deck plate thickness and rib thickness were not parameters.

The parametric study, laboratory and field prototype testing showed that a) the diaphragm of ¾ inch was optimal; b) the intermediate diaphragm was essential for reducing stresses at the toe of the cut-out and elsewhere; c) it confirmed that in-plane stresses are preponderant. The presence or absence of continuity plate gives rise to advantages and disadvantages that are discussed and need further laboratory research to be resolved.

The study reveals that orthotropic decks need separate design criteria for infinite life and a greater repertoire of fatigue details. Analysis and testing of the Bronx Whitestone prototypes showed that 145 year lives are possible and even greater lives are feasible with detail improvements. This requires further research.

Tests to assess the performance of two polymer concrete wearing surfaces gave indication of behavior in normal and cold temperatures, but were inadequate to estimate fatigue life.

Background

The Bronx Whitestone Bridge original deck was a filled grid system on cross-beams spaced at 5 ft on center. It showed sign of degradation after 55 years of service (in 1990). Subsequent discoveries that the cables of the bridge had suffered degradation, due to wire corrosion, indicated that the bridge dead load should be reduced to restore the safety factor on the cables.
ACCURACY OF WEIGH-IN-MOTION BY STEEL BRIDGE


* Department of Civil Engineering, Kyushu Institute of Technology, Tobata, Kitakyushu 804-8550, Japan, Tel +81-93-884-3110, Fax +81-93-884-3100, E-mail yamaguch@civil.kyutech.ac.jp

Abstract

For constructing a good maintenance scheme of an existing bridge, it is essential to know traffic loads acting upon it. Therefore, the development of methods estimating the weights of heavy trucks has attracted many researchers in the area of bridge engineering. Needless to say, the methods that do not disturb traffic flow are preferable. This class of method is known as Bridge Weigh-In-Motion. One of such methods is based on the measurement of the deformation of a steel girder. By running trucks of known weights, the influence lines of a bridge under investigation are established first. Then by the measurements under traffic flow, the weights of running trucks can be estimated. The superposition technique is the mainstay of this approach.

For the accuracy of this type of method, a simple steel bridge is preferred. Namely, a short simply-supported straight steel bridge suits the method, since the deformation behavior of such a bridge is simple. However, that kind of bridge is not always available. Actually, the highway of our interest does not have steel bridges except one which is a continuous skew plate-girder bridge, far from an ideal structure.

Because of this, we conducted an initial test very carefully: we used three trucks of known weights and carried out various running patterns. In total, 88 running tests were conducted. Based on the results obtained with one running test, we have adjusted and established a method of Weigh-In-Motion for estimating the weights of running trucks. This method was then tried out against the other test data. The method has proven to give the weights of running trucks with about 10% error at most. From a practical point of view, this much of error is acceptable. Therefore, the usage of a continuous skew steel-plate-girder bridge for Weigh-In-Motion can be justified.

Keywords: Bridge Weigh-In-Motion, traffic loads, steel bridge, continuous skew bridge
THE ROLE OF SITE MEASUREMENTS TO IMPROVE THE KNOWLEDGE ABOUT THE FATIGUE BEHAVIOUR OF STEEL ORTHOTROPIC BRIDGES

Henk Kolstein*

*Senior Researcher/Lecturer, Delft University of Technology, Faculty of Civil Engineering and Geosciences, P.O. Box 5048, 2600 GA, Delft, The Netherlands; Phone +31-15 278 4005; Fax +31-15 278 3173; m.h.kolstein@citg.tudelft.nl

Abstract

Over the years strain measurements have been carried on a couple of bridges in the Netherlands to obtain typical stress spectra of steel orthotropic bridge decks. The direct reasons for these measurements varied from the improvement of numerical models, studying the composite action of wearing courses in reducing strains and they played an important role in evaluating fatigue cracks in typical details on existing structures in the Netherlands. Typical results of three case studies will be presented in this paper.

Fatigue Cracks in the Deck Plate of the Bascule Bridge Van Brienenoord

Introduction. In 1997 cracks have been found in the 7 years old orthotropic steel deck plate of the heavy loaded bascule bridge Van Brienenoord in The Netherlands (Kolstein, 1998). The number of trucks in the slow lane of this bridge amounts to be about 7000 per day. The main span of the bascule bridge is 60 m and the total width including 6 traffic lanes amounts to 27 m.

The cross section of the bascule bridge is shown in Figure 1. The shape of the longitudinal stiffener is a so called Krupp profile FHK 2/325/6 with a structural height of 325 mm, a base distance between the outer side of the trough legs of 300 mm, bottom width of 105 mm and a plate thickness of 6 mm. The plate thickness of the crossbeam support amounts to be 10 mm. The surfacing on the 12 mm deck plate of the bascule bridge consists of an 8 mm rather thin epoxy layer (compared to thick surfacing systems of 40 to 80 mm on fixed bridges).

During visual examination of the condition of the surfacing of this bridge one longitudinal crack of 800 mm was found in the slow lane. The crack was located at the intersection of the continuous longitudinal trough stiffener and the crossbeam. As shown in Figure 2 and 3 the cracks initiated at the root of the stiffener-deck plate weld. They propagated through the total deck plate and the surfacing and grow in longitudinal direction parallel to the stiffener to deck plate weld.
ORTHOTROPIC DECK DESIGN INNOVATION VERIFIED BY LABORATORY AND FIELD TESTING FOR WILLIAMSBURG BRIDGE DECK REPLACEMENT

Dyab Khazem * and Kenneth Serzan **

*Deputy Technical Director, M.ASCE, Parsons 100 Broadway, New York, NY 10005, PH 212-266-8355 dyab.a.khazem@parsons.com
**Vice President, M. ASCE, Parsons, New York, NY, 10005, PH 212-266-8350 kenneth.p.serzan@parsons.com

Abstract

The Williamsburg bridge spanning the East river in New York city, built in 1903, held the title of the longest suspension bridge for nearly two decades after its completion. The bridge was originally constructed for rapid transit, trolleys, horse drawn carriages and pedestrians. The bridge has had several deck replacements due to the premature failure of the deck under heavy traffic and deicing salt attack.

After a comprehensive study, completed in 1993, Parsons recommended the replacement of the old steel grid deck with a steel orthotropic deck that is integral with the floor system and stiffening truss thereby, reducing dead load and improving the bridge live load carrying capacity and structural efficiency.

Since steel orthotropic decks at the time were known to have had fatigue problems, Parsons developed innovative fatigue resistant details to address those problems. These details underwent a comprehensive testing program at Lehigh University. The laboratory testing was used to validate the analytical computer models and after construction the deck was load tested and monitored to verify measured stresses in the laboratory.

The details used on this project have been adopted by AASHTO LRFD and used on subsequent orthotropic deck projects in the United States.

Key Words: Orthotropic Deck, Fatigue testing, Field testing, Strain gages, Design loading, test loading, Williamsburg Bridge, Global Deck interaction with stiffening truss, Laboratory and controlled field testing, structural health monitoring.

Project History and Background

In 1994, at the age of 91, and after decades of use, the steel grid deck had started bowing upward, a manifestation of what is called deck growth phenomenon. The deflection had separated the deck from the bridge's cross beams and was causing
TESTING PROGRAM FOR THE SELF-ANCHORED SUSPENSION SPAN OF SAN FRANCISCO – OAKLAND BAY BRIDGE

Wenyi Long*; Vong Toan**
*Senior Bridge Engineer, California Department of Transportation, MS 12, 1727 30th Street, Sacramento, CA 95816. Tel.: (916) 227-9878. E-mail: wenyi_long@dot.ca.gov.
**Supervising Bridge Engineer, California Department of Transportation, MS 9-5/6G, 1801 30th Street, Sacramento, CA 95816. Tel: (916) 227-4484. E-mail: vong_toan@dot.ca.gov.

Abstract

The new east span of San Francisco – Oakland Bay Bridge (SFOBB) is composed of four distinct structures: a low-rise post-tensioned concrete box girder near the Oakland shore (Oakland Touchdown), a concrete structure with segmental box girders (Skyway), a steel Self-Anchored Suspension (SAS) signature span, and a doubly post-tensioned concrete box girder that connects to Yerba Buena Island (Transition structure). The Self-Anchored Suspension signature span consists of a single steel tower, a superstructure with dual orthotropic box girders with a main span of 385 m and a back span of 180 m. The new east span is designed as a lifeline structure under the Safety Evaluation Earthquake (SEE). As a lifeline structure, the new span shall be almost immediately able to open to the public traffic after minor inspection and reparation following a major earthquake. To ensure that the SAS can achieve the desired performance, a series of tests have been carried out for different structural components by universities and laboratories.

Three tests are described in this paper: shear links for the tower, orthotropic box plates and the columns for the west pier. The shear links connecting legs of the single tower have been modeled by full size and half size scale specimens and tested by the University of California at San Diego (UCSD) and the University of Nevada at Reno (UNR) respectively. Shear links were tested to evaluate shear link deformation capacity, to assess shear link overstrength, to investigate the replaceability of shear links, to appraise the connection details between shear links and the tower and to provide characteristics for global parameter studies. The orthotropic box plates of the SAS superstructure were simulated by approximately half-scale specimens for deck, wall plate and bottom plate and tested at UCSD. The test objective for the SAS box girder were to verify the design capacity of the stiffened panel, to examine local buckling behavior of longitudinal ribs and to evaluate the post-buckling behavior of the stiffened panel. The west pier (W2) of the SAS span consists of four columns. Two columns in the longitudinal direction of the bridge were modeled by quarter-scale specimens and tested at UCSD. The objectives of the W2 testing are to prove
RATIONALIZED STEEL DECK STRUCTURE AND LARGE MODEL TEST FOR DEVELOPING A NEW TYPE OF STRUCTURE

Kazuyuki Mizuguchi*, Kentaro Yamada**, Masanori Iwasaki*** and Susumu Inokuchi****

*Chief, Japan Highway, 3-3-2 Kasumigaseki Chiyoda-ku Tokyo Japan 100-8979; PH +81-3-3506-0271; kazuyuki.mizuguchi@jhnet.go.jp **PhD., Nagoya-University, Furou-cho Chikusa-ku Nagoya-shi Aichi Japan 464-8603; PH +81-52-789-4618; yamada@civil.nagoya-u.ac.jp ***Manager, Yokogawa-Bridge, 4-4-44 Shibaura Minato-ku Tokyo Japan 108-0023; PH +81-3-3452-4111; m.iwasaki@yokogawa-bridge.co.jp ****Chief, Yokogawa-Bridge, 27 Yamano-cho Funabashi-shi Chiba Japan 273-0026; PH +81-47-435-6161; s.inokuchi@yokogawa-bridge.co.jp

Abstract

Japan Highway Public Corporation (JH) has adopted a new type of orthotropic steel deck structure for bridges to be built in the section between the Nagoya Minami Interchange and the Toyookake Interchange of the New Tomei Expressway.

This section runs in parallel with National Highway Route 23, an important arterial road, running directly over Route 23 over a distance of about 3 km. Since it was anticipated that bridge erection and construction scheduling would be hampered by many restrictions and that design traffic volume would be very large, a highly rational and durable type of structure was selected. For the superstructure, steel box girder bridge structure with a typical span length of 80 m was adopted in view of the span length requirements determined by the relative locations of the two roads as well as constructibility and seismic performance requirements. In order to achieve rationalization and labor saving in the manufacturing process and enhance structural durability in addition to satisfying the requirements mentioned above, a new type of orthotropic steel deck structure was adopted.

The paper will briefly describe the rationalized steel deck structure and discusses a large model test conducted for the purpose of developing a new type of structure.

Keyword: Rationalized Steel Deck, Loading Test, Fatigue Life, New Tomei-Meishin Expressway

Introduction

In building new bridges, more rational structures have been adopted and uses of more labor saving methods have been encouraged. Rational structures are required in steel orthotropic decks as well.

In order to enhance the cost-effectiveness and durability of steel orthotropic decks, the number of member pieces can be reduced, points on steel members vulnerable to fatigue can be reduced or the durability of pavement can be enhanced.
FULL-SCALE FATIGUE TEST OF ORTHOTROPIC STEEL DECK UNDER RUNNING WHEEL LOADING

Xiaohua Cheng*,Jun Murakoshi** and Akira Moriyama***

* Member of ASCE; Civil Engineer, Bureau of Structural Engineering, New Jersey Department of Transportation, 1035 Parkway Ave., Trenton, NJ 08625; PH 609-530-2464; FAX 609-530-5777; Xiaohua.Cheng@dot.state.nj.us
** Team Leader, Structures Research Group, Public Works Research Institute, 1-6 Minami hara, Tsukuba, Japan 305-8516; PH +81-298-79-6792; FAX +81-298-79-6739; murakosi@pwri.go.jp
*** Deputy Manager, Long-span Bridge Engineering Center, Honshu-Shikokoku Bridge Authority, 4-1-22, Onoedori, Chou-ku, Kobe, Japan 651-0088; PH +81-78-291-1073; FAX +81-78-291-1359; moriyama@hsba.go.jp

Abstract

Numerous experimental studies on fatigue behavior of orthotropic steel bridge decks have been carried out through fatigue tests on prototype or sub-model specimens by various institutes. Most of the studies were conducted under fix-point cyclic loading. This may result in focusing on a specific welded detail and lack of information on the other details and the effect of other load positions. To simulate truck wheel loads moving on an orthotropic deck, a unique running wheel loading machine was used to conduct crawl loading test and fatigue test on a full-scale orthotropic deck specimen at Public Works Research Institute (PWRI). This paper presents the test procedure and results of local stress response and fatigue behavior under the running wheel loads. The local stresses for various locations with respect to the transverse and longitudinal loading positions were obtained. Fatigue test was conducted under the longitudinally moving load at the most critical transverse position. Fatigue crack development was observed. Fatigue life was correlated to the local stress and compared with current fatigue design curves.

Key Words: Orthotropic deck; Fatigue; Welded detail; Wheel load; Local stress; Influence line

Introduction

Orthotropic deck is widely used in long-span bridges, movable bridges and urban viaduct bridges to help reduce self-weight of the superstructures. Orthotropic deck is composed of thin plate members connected by welds and bolted splices, and subject to direct wheel load of vehicles. Both load-induced fatigue and distortion-induced fatigue are the concern in structural design of an orthotropic deck system. The Guidelines for Orthotropic Deck Design of Honshu-Shikokoku Bridge Authority [HSBA, 1989] and Fatigue Design Guidelines for Steel Highway Bridges of Japan Road Association [JRA, 2002] specify the fatigue design through
THE USE OF DISPERSION LAYERS TO REDUCE THE FATIGUE DAMAGE IN ORTHOTROPIC STEEL BRIDGE DECKS

Hans De Backer*, Bart De Pauw**, Wouter De Corte*** and Philippe Van Bogaert****

*Civ. Eng., Civil Engineering Department, Ghent University, Technologiepark Zwijnaarde 904, 9052 Gent, Belgium, E-mail: Hans.DeBacker@UGent.be, Tel.: +32 9 264 54 34, Fax: +32 9 264 58 37 **Civ. Eng., Civil Engineering Department, Ghent University, Technologiepark Zwijnaarde 904, 9052 Gent, Belgium, E-mail: BDP@TUCRail.be, Tel.: +32 2 529 79 35, Fax: +32 9 264 58 37 ***Civ. Eng., Civil Engineering Department, Ghent University, Technologiepark Zwijnaarde 904, 9052 Gent, Belgium, E-mail: Wouter.DeCorte@UGent.be, Tel.: +32 9 264 54 90, Fax: +32 9 264 58 37 ****Civ. Eng., Ph.D., Professor, Civil Engineering Department, Ghent University, Technologiepark Zwijnaarde 904, 9052 Gent, Belgium, E-mail: Philippe.VanBogaert@UGent.be, Tel.: +32 9 264 58 88, Fax: +32 9 264 58 37

Abstract

Steel orthotropic bridge deck plates for highway bridges are highly sensitive to fatigue damage, due to the large amount of welded connections, the high patch loads and large number of stress cycles caused by road traffic. Wearing courses may contribute to the dispersal of concentrated wheel loads. However this contribution is not always sufficient. (E.g. the case of movable bridges, having extremely thin wearing courses) There is a distinct need to develop thin, light systems, improving the load dispersal. This paper presents several possible solutions. The first one is as simple as placing an asphalt layer on top of the deck plate. The second one consists of an additional steel deck plate separated from the main structure by an independent layer. This additional layer may consist either of a rubber slab or of a synthetic plate or any material having load dispersal characteristics and low mass. Finally the use of a FRP sandwich panel on top of the steel deck plate is being considered. In this case too, the objective is to reach a better distribution of the live load before it reaches the orthotropic deck. All systems are analyzed by finite element calculations and are tested on a full scale arch bridge with an orthotropic steel bridge deck by means of strain gauge measurements. The test bridge is part of the High Speed Railway Line in Belgium. The tests are conducted using heavy trucks as live load before the installation of the railway tracks. The main advantage of the considered systems is to improve the dispersal of the live load, depending on the characteristics of the intermediate layer. In addition, other mechanisms of load transfer, resulting in improved fatigue behavior are tested. The independent load dispersal systems do not affect the fatigue damage of the actual structure; hence they do not increase the cost of the final structure. In principle, the use of dispersion layers should nullify the problem of fatigue durability with orthotropic decks for roads carrying heavy traffic.
USA Bridges
NEW CARQUINEZ BRIDGE

Michael Marquez*, P.E.

Senior Bridge Engineer, State of California Department of Transportation, Engineering Service Center, 1801 30th Street MS9-2/10G, Sacramento, CA 95816, USA

Abstract

The first major suspension bridge in North America in over 30 years is being built within the San Francisco Bay Area. With a total length of 1060 meters and a main span of 728, the $216 million suspension bridge incorporates the latest in seismic analysis/design, foundation design, and a state-of-the-art steel orthotropic box girder superstructure.

Hollow concrete towers supported on cast-in-place concrete piles provide flexible and ductile performance required for resisting 3 major San Francisco Bay Area faults, including the San Andreas Fault.

The superstructure consists of the largest single steel orthotropic box girder to be constructed in North America, with a width of 29 meters and a depth of 3 meters. The design was based upon extensive testing to insure against fatigue failures prone to similar welded steel structures. Fabrication requires achieving stringent fit-up tolerances for welded subassemblies. This requires the extensive use of pre-cambering and mechanical restraints to limit weld distortion.

Construction of the bridge is currently underway and is schedule for completion in Fall 2003.
NEW CARQUINEZ STRAIT SUSPENSION BRIDGE
FABRICATION AND SEA TRANSPORTATION OF ORTHOTROPIC STEEL
BOX GIRDER SEGMENTS

Michael Marquez*, P.E., Eugene Thimmhardy**, Ph.D.
and Raymond W. Wolfe***, Ph.D., P.E.

*Senior Bridge Engineer; **Bridge Engineer; ***Supervising Bridge Engineer;
California Department of Transportation, 1801 30th Street, Sacramento, CA, 95816

Abstract

The New Carquinez Strait Suspension Bridge, with a total length of 1060.0 m and a
main span of 728.0 m, is the first in a new series of major suspension bridges to be
built across the United States in over 30 years. When completed in October 2003, the
bridge will set new design standards for modern suspension bridges. Located within
the San Francisco Bay Area, the new bridge represents the first modern suspension
bridge designed to meet the latest seismic criteria. In addition, the superstructure will
be the largest state-of-the-art steel orthotropic box girder built in North America.

Continuous for the entire length of the bridge, the all welded superstructure is 29.0 m
wide and 3.0 m deep. The bridge deck was fabricated in 24 complete orthotropic box
girder segments of 49 m in length. State-of-the-art connection details were used to
improve the fatigue resistance. Fabrication of all segments were performed within a
single facility in Japan, and shipped transpacific to the bridge site. After which, each
box segment was erected and assembled in its final location.

Referring mainly to the bridge superstructure, the paper presents and discusses the
main challenges encountered during fabrication of the steel box girder segments and
their components. The orthotropic box girder consists of large welded stiffened plates
that require good fabrication practices to meet design requirements. Extensive use of
distortion control measures, innovative welding techniques, and strict control of
component geometry were necessary to achieve specified tolerances. Also included in
the discussion are details of shop segment sub-assembly, support, and sea
transportation of the girder segments.
TECHNICAL FABRICATION ISSUES WITH STEEL ORTHOTROPIC BOX GIRDER BRIDGES

Mazen Wahbeh*, P.E., Brian Boal, P.E.**, and Jim Merrill*, P.E.

*Mactec Engineering, San Diego, CA., **California Department of Transportation, Oakland, CA.

Abstract

The technical difficulties with the fabrication of steel orthotropic box girder (OOG) bridges became very apparent during the construction of the third bridge crossing the Carquinez Strait at the town of Crockett, California. The new Carquinez Bridge has been officially designated the Alfred Zampa Memorial Bridge by the California Legislature. The Alfred Zampa Bridge (AZB) is located 20 miles northeast of San Francisco on I-80 and is in close proximity to several active seismic faults. The bridge was opened for traffic on November 8, 2003. The first and most complicated issue discussed in this paper is the welding of the partial joint penetrations (PJP) groove weld connecting the stiffening troughs to the steel plates of the deck, soffit, and side panels of the OBG. This critical joint in orthotropic steel bridges is prone to fatigue. The weld is subject to both normal forces and bending moments. Fatigue damage to this weld can cause significant damage to the function of the composite behavior of the steel girder box and its pavement. In addition, the repair of such a weld is extremely costly should this weld experience any fatigue damage. This paper will discuss the procedures used in developing, testing, and finally performing this weld on the AZB.

The second technical issue discussed in this paper is the how to address weld induced distortion in order to achieve the required fabrication tolerances of the OBG. The basic concept of the OBG is to utilize relatively thin steel members in order to reduce the weight of the structure while obtaining orthotropic properties. Since thin steel members are welded together to achieve such properties, the heat distortion is a major consideration when attempting to determine how best to achieve the tight tolerances for the finished geometry of the structure. This paper will discuss some of the technical difficulties encountered during the fabrication of the components of the OBG for the AZB.
FIRST CURVED STEEL ORTHOTROPIC BOX BRIDGE IN THE US

James E. Roberts* and Alfred Mangus**

*Consulting Engineer, Sacramento, California, USA; **California Department of Transportation, Sacramento, California, USA.

Abstract

The 7.1 magnitude Loma Prieta earthquake of October 17, 1989 caused the collapse of the upper roadway on the Cypress Street Viaduct in Oakland, California, resulting in 41 deaths and 108-injuries. The I-880 Cypress Street Viaduct, a two-level reinforced concrete structure was completed in 1957, and carried between 140,000 and 160,000 vehicles per day on eight lanes of mixed-flow traffic. The replacement project consists of seven bridge projects on a new alignment, worth about $500 million dollars. The truck access route into the Port of Oakland is one of eleven bridges in the final $130 million contract. "The Maritime Off-Ramp" is a new unique curved steel orthotropic box girder bridge that provides access to the Port of Oakland through a U-turn from Westbound I-80. The 2,356-foot long "Maritime Off-Ramp" is called the Horseshoe Line or "HS" Line because of its 250-foot radius horseshoe shape. There are fewer than 100 Orthotropic bridges in North America (nine in California); over 100 in Asia and about 1,000 in Europe. Because of the success of the Maritime Off-Ramp other more complex bridges were initiated. Next completed was the 2500 foot span suspension bridge was fabricated in Japan for the Carquinez straits, and called the Alfred Zampa Memorial Bridge. One bid was received the proposed 385 meter span suspension bridge to replace the east cantilever truss span of the San Francisco Oakland Bay Bridge and a portion of ‘skyway’ is under fabrication prototype welding procedures phases. "The Maritime Off-Ramp" was California’s 10th Orthotropic Bridge used for highway traffic.

The Maritime Off-Ramp Bridge was fabricated in Vancouver, Washington and shipped to the San Francisco Bay area by ocean going barges. The ramp crosses over more than 30 traffic lanes adjacent to the toll plaza for the San Francisco-Oakland Bay Bridge, necessitating night erection during off peak traffic hours. The contractor utilized a series of self-propelled special heavy lift hydraulic platforms (SHLHP) to move the sections from the barges to the erection site, and to erect the units onto the bents. The design of these erection units allowed the girders to be moved on six axes during the erection process. The entire operation was conducted during a 10-hour window from midnight Saturday night. To add to the difficulties there was a heavy rain during the erection operation over the Toll Plaza lanes.
A NEW REPLACEMENT ORTHOTROPIC STEEL DECK FOR THE TRIBOROUGH BRIDGE SIGNIFICANTLY REDUCES DEAD LOAD MASS

J. Valenti, P.E.

Introduction

The Triborough Bridge facility is actually three separate bridges that provide a vital traffic link among the boroughs of Queens, Manhattan, and The Bronx in New York City. Owned and operated by the Triborough Bridge and Tunnel Authority (TBTA) and opened to vehicular traffic in 1936, the suspension bridge is a major crossing that spans 1,380 feet between towers over the Hell Gate section of the East River. About 170,000 vehicles cross the bridge daily.

In summer 2002, as part of the $144 million Deck Replacement on Suspended Spans and Queens Viaduct rehabilitation project, the removal and replacement of the existing roadway began. This unique project included the removal of 252,000 sqft of concrete road deck and underlying support steel and replacement with a new steel orthotropic deck system on the bridge suspended span. The work was performed in eight (8) distinct stages while working under live load conditions (maintaining seven lanes of active traffic) in an urban environment.

The Orthotropic Deck Panels

The orthotropic panels specified for this project are 5/8” plate steel, manufactured in South Korea by the Hyundai Corporation. A series of longitudinal “U” shaped ribs welded to the panels’ underside provide rigid support. Each panel has subfloorbeams (generally four, some three or five, depending on length of panel) that serve as bearing members. The panels (underside) are shop coated with a specified paint system including an inorganic zinc rich primer, epoxy intermediate coat, and a polyurethane topcoat. After arrival via cargo ship at the Port of New Jersey in Carteret, the panels were off-loaded and transported on flatbed trailers to a coating applications facility in central New Jersey, where a 3/8” layer of aggregate (Transpo T-48) was applied to the panel-riding surface. The entire topside of each panel was coated with an epoxy binder and aggregate material, with the exception of a 7.5” strip either side of the longitudinal joint (to be welded later) and 1 sqft surrounding each lifting lug location (four lifting lugs per panel). The remaining areas were coated

* This paper was presented as part of the 21st Annual International Bridge Conference®, which took place in Pittsburgh, PA (USA), June 14-16, 2004
NEW SAN FRANCISCO OAKLAND BAY BRIDGE SELF-ANCHORED SUSPENSION BRIDGE – IMPACT OF SEISMIC REQUIREMENTS ON ORTHOTROPIC BOX DESIGN

Marwan Nader*, George Baker**, PE
James Duxbury*** and Sante Camo****, PE

* T.Y. Lin International, USA; ** Roman Wolchuk Consulting Engineers, USA; *** T.Y. Lin International, USA; **** Weidlinger Associates, Inc., USA

Abstract

A comparative review of the box girders and orthotropic deck in a new self-anchored suspension bridge is presented. While suspension bridge girder designs are typically governed by traffic loads, in the Bay Bridge the girder’s chief loading is a global compression stress of 115 Mpa due to the main cable tension.

The orthotropic deck and box girder system is designed to satisfy the compactness requirements of Caltrans Bridge Design Specifications, with the further requirement that wall stability conditions of Caltrans Report ATC-32 be met, for safety against catastrophic failure and localized seismic damage.

The compactness requirements and seismic demands result in a final product which is qualitatively and quantitatively more robust than typical designs. This paper illustrates the cost of building a major bridge in one of the world’s most demanding seismic zones.

Keywords: suspension bridge, self-anchored, box girder, orthotropic deck, seismic design, comparative cost

Introduction

The San Francisco Oakland Bay Bridge is the main route between San Francisco and Oakland, California, carrying more than 280,000 vehicles daily. The 15km long structure contains dual suspension bridges, a tunnel, truss spans, and a cantilever bridge. In 1989 an earthquake of magnitude 7.1 occurred at the city of Loma Prieta, 95 km from San Francisco (Figure 1). Among the damaged structures was the collapse of one span of the Bay Bridge (Figure 2). The bridge remained closed for one month at great economic cost to the region.
NEW SAN FRANCISCO OAKLAND BAY BRIDGE SELF-ANCHORED SUSPENSION BRIDGE – ORTHOTROPIC DECK DESIGN

George Baker*, PE, Marwan Nader** and Sante Camo****, PE,

*Roman Wolchuk Consulting Engineers, USA; **T.Y.Lin International, USA; ***Weidlinger Associates, Inc., USA

Abstract

A design review of the orthotropic deck in a new self-anchored suspension bridge is presented. Dual steel box girders span 585 meters supported by the suspension cable. The orthotropic decks which form the top flanges of the box girders consist of 14mm deck plates and 12mm triangular closed ribs with rounded bottoms. While bridge deck designs are typically governed by traffic loads, in the Bay Bridge the deck accommodates a global compression stress of 115 MPa due to the main cable tension. In addition to the cable force and local wheel loads the deck is also subjected to longitudinal seismic forces and transverse loading due to bending of the structural system between the suspenders, and due to vierendeel effects at the connections of crossbeams under lateral wind and seismic loads.

The orthotropic deck is designed to resist primarily compressive loads. In addition, it must satisfy the compactness requirements of Caltrans Bridge Design Specifications, and additional wall stability requirements for safety against catastrophic failure and localized seismic damage.

Keywords: suspension bridge, self-anchored, box girder, orthotropic deck, cable, anchorage

Introduction

The structural system of the SFOBB-Self Anchored Suspension Bridge (SAS) has been described in the companion paper and elsewhere [1,2]. The selection of the steel orthotropic deck system, rather than an equivalent concrete deck was based on the advantages of the steel. Steel orthotropic decks are substantially lighter than concrete, and in a self-anchored suspension bridge weight is very important. The steel deck, being highly redundant and fully integrated with the rest of the box girder, contributes to the survivability of the system under seismic conditions. There are no steel to concrete interfaces, which would be the weakest points in the structure. Finally, a well-designed steel deck is more durable than a concrete deck, and a design life of 150 years may be expected.

The steel orthotropic decks for this bridge are noteworthy because they were designed as compression members meeting seismic compactness requirements [3,4], and because of the high degree of interaction among the various structural components. In the self-anchored suspension system there is an inherent interdependence of suspended weight and the local design of girders. All suspended weight contributes to the total tension of the main cable. The main cable is anchored into the longitudinal box girders, placing them into axial compression.
SKYWAY ORTHOTROPIC BOX SUPERSTRUCTURE

Sajid Abbas*, P.E., Ph.D., and Brain Maroney, P.E., Dr. Engr.

*T.Y.Lin International, USA; ** California Department of Transportation, Oakland, California, USA.

Abstract

The San Francisco-Oakland Bay Bridge Seismic Safety Project incorporates replacement of some 2 miles of the eastern spans of the bridge. The replacement structure type is predominately prestressed box girder bridge, however, the western-most ends of the Skyway superstructure are single-cell orthotropic box girder. This relatively small part of the Skyway structure is larger than most of California highway bridges. The steel box sections were selected for compatibility with the planned adjacent steel self-anchored segment of the bridge and to facilitate the erection stages of the Skyway. In this paper, justification for the type-selection of the orthotropic box and details of the design are presented and explained.
COST ESTIMATING ORTHOTROPIC BRIDGE SUPERSTRUCTURES

Chris Traina* and Brian Maroney*

*California Department of Transportation, Oakland, California, USA.

Abstract

Cost estimating of orthotropic bridge is a complex task. Experiences in the State of California can be analyzed to demonstrate this condition. This paper reviews California orthotropic deck and box superstructures and their costs. Focus is placed on the San Francisco-Oakland Bay Bridge and other California Toll Bridges and data collected and reviewed for cost estimating of that bridge. Cost estimating analysis techniques are discussed. From this, conclusions are drawn which offer lessons for future type-selection.
Published Paper
Only
STRUCTURE, DESIGN AND CONSTRUCTION OF A STEEL ORTHOTROPIC BRIDGE IN SOFIA

Borislav Bankov, Hristo Hristov, Doncho Partov* and Dobromir Dinev**

*Assoc. Prof. PhD, Higher School of Construction Engineering “L. Karavelov”, 32 Suhodolska str., Sofia 1373, Bulgaria; e-mail: partov@vsu.bg, **Assist. Prof., Univ. of Arch., Civil Eng. and Geodesy, Faculty of Civil Eng., 1 Smirnenski Blvd., Sofia 1046, Bulgaria; e-mail: ddinev_fce@uacg.bg

Abstract

In this paper the authors present the conception design and technology of construction of the steel orthotropic 90 m long bridge in Sofia, Bulgaria. The steel bridge is part of a multi-span reinforced concrete (R/C) bridge with total length 2114 m, total width 21.5 m and average height above the ground about 10 m. In transverse direction the orthotropic bridge is built with two individual parallel three-box-type decks for a two-way traffic. Each deck has a roadway of 7.5 m width, with two lanes. The bridge is analysed as a frame structure using the Finite Elements Method. The design parameters of the bridge are verified by static and dynamic tests.

Introduction

At the beginning of the 90's, in Sofia, the capital of Bulgaria, arose the necessity of a long bridge connecting the center of the city with the airport. For this purpose a reinforced concrete (R/C) bridge with a total length of 2114 m, total width 21.5 m and height above the ground about 10 m was designed and constructed. The bridge is located in a densely populated urban environment.

Figure 1. Side view of the steel orthotropic bridge.

This important, effective and aesthetic bridge serves as connection between the busiest input-output highway and the airport of Sofia. It ensures a convenient access
RENEWAL APPLICATION RESEARCH INTO DESIGN OF SUSPENSION BRIDGE STIFFENED BY STEEL SLAB GIRDER

Xu Gongyi*

*China Zhongtie Major Bridge Reconnaissance & Design Institute Co., Ltd., Wuhan, Hubei 430050 China. Southwest Jiaotong University, Chengdu, Sichuan 610031 China

Abstract

This paper introduces application research into design of suspension bridge stiffened by steel slab girder with reference to the Liuzhou Hongguang Bridge. This bridge is renewal application of this structure type after the collapse of Old Tacoma Bridge internationally. The Bridge is a suspension bridge with 380m main span stiffened by orthotropic steel slab, which is 27.8m wide and 2.2m deep. The center distance is 22.8m between longitudinal beams and 2.75m between transversal beams, corresponding to the 22.8m distance between anchorage point of hangers and 8.25m longitudinal panel distance. In order to ensure wind resistance safety of the bridge, some wind resistance research achievements of the Tacoma Old Narrow Bridge were employed in design, at the same time, detailed theoretical analysis and wind tunnel test were undertaken. As a result, longitudinal dampers, middle buckles and wind guide skirts, etc, are adopted to improve dynamic performance of the structure.

Key Words: steel slab girder, Suspension bridge, stiffening girder, design

1. Design Selection

A suspension bridge stiffened by steel slab girder was proposed for the Liuzhou Hongguang Bridge taking account of the following conditions:

1) A single span bridge structure is determined by the local construction condition: The bridge site is located at the downtown area of Liuzhou City of Guangxi Province, at the very “U” curve section of the Liujiang River, producing an angle as small as 5° between bridge axis and the watercourse, where the river current is very complex. A single span structure is the most applicable choice because there are two existing bridges 925m upstream and 950 downstream of the bridge site respectively.

2) Restricted transportation condition. The downtown area around the site is very crowded; the navigation of this river section is of “V” grade and the water level variation is large, so the heavy cargo transportation is restricted.

3) Great expectation for the proposal from the Owner. There are many bridges of various types except for a suspension one in Liuzhou City. The owner hopes that the proposed bridge becomes another symbol of the city to meet public demand.

4) Economy reason: Guangxi province is an under-developed province in China and cost-effectiveness is the major issue for a project.

5) Small wind velocity. The surveyed maximum wind velocity at bridge site is
A NEW DESIGN CONCEPT FOR STEEL BRIDGE DECKS

S R BRIGHT* and J W SMITH**

*Cass Hayward LLP, Welsh Street, Chepstow. Tel. 0774 6955097, **Dept. Civil Engineering, University of Bristol, Bristol, BS8 1T

Abstract

Orthotropic decks provide a lightweight form of construction, essential for weight-critical structures. However, their cost and poor record of fatigue durability has discouraged their use for mainstream construction. As a result, steel decks are generally considered an option of last resort, only used where the minimisation of self-weight is essential, such as long-span and moveable bridges.

An innovation is proposed to overcome these problems and transform the design of steel decks. The innovation is based upon the use of laser welding to produce an enclosed “sandwich panel” profile.

Preliminary fatigue tests have been performed which demonstrate the viability of the proposal. Laser welds are extremely cheap to produce and the use of proprietary rolled sections offers significant savings in construction costs compared to conventional steel deck designs. The sandwich design thus has the potential to provide a competitive, lightweight alternative to the concrete decks used in general bridgeworks.

Further testing of a complete deck assembly is required to exploit the future potential of the system.

Constraints of Conventional Steel Deck Designs

There are numerous constraints associated with the use of conventional steel decks:

1. Fabrication cost and complexity: Steel decks generally cost around four times as much as an equivalent concrete deck.
Additional PowerPoint Presentation
New Carquinez Strait Bridge.
Fabrication and Sea Transportation of Orthotropic Steel Box Girder Segments.

Eugene Thimmhardt, Michael Marquez and Raymond Wolfe
California Department of Transportation

Orthotropic Bridge Conference
Sacramento, CA
August 25-27, 2004

Copyright, Caltrans 2004
Index by Number of Paper Presented:

OBC-04-01 — Unified European Rules for the Design of Bridges with Steel Orthotropic Decks
Gerhard Sedlacek and Christian Müller; Technische Hochschule, Aachen, Germany

OBC-04-02 — A Performance Based Surfacing for the Orthotropic Deck of the New San Francisco-Oakland Bay Bridge East Span Seismic Safety Project
Charles Seim and Rafael Manzanarez; T.Y. Lin International, California, USA

OBC-04-03 — Orthotropic Decks with Long Rib Spans
Roman Wolchuk; Roman Wolchuk Consulting Engineers, New Jersey, USA

OBC-04-04 — Fremont Orthotropic Bridge Deck - Longest Tied Steel Arch in Western Hemisphere
Michael J. Abrahams and Mark Hirota; Parsons Brinckerhoff Quade & Douglas, Inc., New York, USA

OBC-04-05 — Orthotropic Deck Bridges in Ukraine
Mykhailo Korniev; Mostobud, Ukraine

OBC-04-06 — A Review of Alaska’s Orthotropic Bridges
Dennis Nottingham; PND Incorporated, Alaska, USA

OBC-04-07 — Bridge Steels – Past, Present and Future
M. Myint Lwin; FHWA, Washington, D.C., USA

OBC-04-08 — Methods of Flux Cored Wires Arc Welding and Ultrasonic Testing for Longitudinal Weld of U-shaped Rib and Deck Plate
Kenji Kuramoto, Makoto Yuda, and Wataru Fujimoto; Kawada Industries, Inc., Japan

OBC-04-09 — Fabrication and Construction of the Shenley Bridge Incorporating an SPS Orthotropic Bridge Deck
Richard B. Vincent and Angelo Ferro; The Canam Manac Group, Inc., Canada

OBC-04-10 — Orhtotropic Deck Fabrication for the Triborough Bridge
Brendan J. Scahill; Greenman-Pedersen, Inc., New York, USA

OBC-04-11 — Box Girders, Design, Fabrication, Operation and Maintenance
Ove Sørensen; COWI, Denmark

OBC-04-12 — Golden Gate Bridge Deck and Sidewalk Replacement
Daniel E. Mohn, Ewa Z. Bauer, Mary C. Currie, Frank L. Stahl; Golden Gate Bridge, Highway and Transportation District, California, USA
OBC-04-13 — High Performance Steel for Highway Bridges
Vasant Mistry; FHWA, Washington, D.C., USA

OBC-04-14 — Durability Evaluation of Nagoya Expressway Orthotropic Steel Deck
Kentaro Yamada, Tatsuya Ojio, Hirofumi Maeno and Masanori Iwasaki; Nagoya University, Japan

OBC-04-15 — European Research on the Improvement of the Fatigue Resistance and Design of Steel Orthotropic Bridge Decks
M. H. Kolstein; Delft University of Technology, Netherlands

OBC-04-16 — Overview Fatigue Phenomenon in Orthotropic Bridge Decks in the Netherlands
F. B. P. de Jong; Delft University of Technology, Netherlands

OBC-04-17 — Fatigue Strength Verification of Steel Orthotropic Plated Bridge Deck for Railway Bridges
Wouter De Corte and Philippe Van Bogaert; Ghent University, Belgium

OBC-04-18 — Fatigue Resistance and Ultimate Strength of SPS Bridge Decks
Dr. Stephen J. Kennedy and Dr. Thomas Murray; Intelligent Engineering Ltd., Canada

OBC-04-19 — Design and Field Load Testing of the Shenley Bridge, Québec, Canada
D. J. Laurie Kennedy and R. A. Dorton; Intelligent Engineering Ltd., Canada

OBC-04-20 — Stress Measurements on Fatigue-Damaged Structures with Orthotropic Steel Decks in Summer and Winter
Fumitaka Machida, Tarou Yuge, Chitoshi Miki, Eiki Yamaguchi, Tetsuhiro Shimozato, and Takashi Masui; Technology Center of Metropolitan Expressway, Japan

OBC-04-21 — Compression Behavior of Steel Orthotropic Deck Panels for the New San Francisco-Oakland Bay Bridge
Chung-Che Chou, National Chiao Tung University, Taiwan; C.M. Uang and F. Seible; University of California, San Diego, USA

OBC-04-22 — Research Project TU Delft; Behaviour Conventional Bridge Decks & Development of Renovation Techniques
F. B. P. de Jong, M. H. Kolstein, and F. S. K. Bijlaard; Delft University of Technology, Netherlands

OBC-04-23 — Assessment of Fatigue Strength of Steel Orthotropic Plated Bridge Decks from Continuous Measured Stress Spectra
Wouter De Corte; Ghent University, Belgium
OBC-04-24 — Analysis of Fatigue Damage Patterns in Orthotropic Steel Deck of Tokyo Metropolitan Expressways
Tarou Yuge, Fumitaka Machida, Hisashi Morikawa, Chitoshi Miki, Takeshi Kamiki, and Takashi Masui; Technology Center of Metropolitan Expressway, Japan

OBC-04-25 — Local Stresses and Fatigue Durability of Asphalt Paved Orthotropic Steel Deck
Xiaohua Cheng, NJDOT, New Jersey; Jun Murakoshi and Kazuhiro Nishikawa, PRWI, Japan; and Harukazu Ohashi, Parsons, New York, USA

OBC-04-26 — Orthotropic Decks for Small and Medium Span Bridges in France – Evolution and Recent Trends
Wasoodev Hoorpah; MIO-OTUA, France

OBC-04-27 — The New Tacoma Narrows Suspension Bridge – Orthotropic Superstructure
Kenneth Serzan, John Clenance and Jeffrey Lu; Parsons, New York, USA

OBC-04-29 — Existing and Future Steel Bridge Infrastructure – Some Observations
John W. Fisher; Lehigh University, Pennsylvania, USA

OBC-04-30 — Parametric Studies & Testing for the Orthotropic Deck of the Bronx Whitestone Bridge
Sante Camo and Qi Ye; Weidlinger Associates, Inc., New York, USA

OBC-04-31 — Accuracy of Weigh-In-Motion by Steel Bridge
Eiki Yamaguchi, Kazushi Matsuo, Shinichi Kawamura, Yusuke Kobayashi, Masafumi Mori, Kunihiro Momota, Tatsushi Nishinohara; Kyushu Institute of Technology, Japan

OBC-04-32 — The Role of Site Measurements to Improve the Knowledge About the Fatigue Behavior of Steel Orthotropic Bridge Decks
M. H. Kolstein; Delft University of Technology, Netherlands

OBC-04-33 — Orthotropic Deck Design Innovation Verified by Laboratory and Field Testing for Williamsburg Bridge Deck Replacement
Dyab Khazem and Ken Serzan; Parsons, New York, USA

OBC-04-34 — Waterproofing the Steel Orthotropic Deck of the Carquinez Bridge
Frank J. Constantino; Stirling Lloyd Products, Inc, UK

OBC-04-35 — Reinforced High Performance Concrete Overlay System for Rehabilitation and Strengthening of Orthotropic Steel Bridge Decks
C.R. Braam, Delft University of Technology, Netherlands; P. Buitelaar, Contec ApS; and N. Kaptijn, Ministry of Transport, Netherlands

OBC-04-36 — The Successful Use of Thin Polysulfide Epoxy Polymer Concrete Overlays on Steel Orthotropic Bridge Decks
Michael S. Stenko and Arif J. Chawalwala; Transpo Industries, Inc., New York, USA
OBC-04-37 — Alternative Waterproof System and Wearing Course for Orthotropic Bridge Decks
Doug Zuberer; Chase Specialty Coatings, Massachusetts, USA

OBC-04-38 — New Carquinez Bridge
Michael Marquez; Professional Engineers in California Government (PECG), Caltrans, California, USA

OBC-04-39 — New Carquinez Strait Suspension Bridge Fabrication and Sea Transportation of Orthotropic Steel Box Girder Segments
Michael Marquez, Eugene Thimmhardy, and Raymond W. Wolfe; Professional Engineers in California Government (PECG), Caltrans, California, USA

OBC-04-40 — Technical Fabrication Issues with Steel Orthotropic Box Girder Bridges
Mazen Wahbeh and Jim Merrill, Mactec Engineering; Brian Boal, Professional Engineers in California Government (PECG), Caltrans, California, USA

OBC-04-41 — Strengthening a Bridge Deck with High Performance Concrete
F. B. P. de Jong and M. H. Kolstein; Delft University of Technology, Netherlands

OBC-04-42 — Resurfacing of Orthotropic Bridge Decks in the UK – Practical and Design Considerations
Neil McFadyen, Robert Brady, and Ian Firth; Flint & Neill Partnership Consulting Engineer, UK

OBC-04-43 — Maintenance Philosophy and Systematic Lifetime Assessment for Decks Suffering from Fatigue
F. B. P. de Jong and P. D. Boersma; Delft University of Technology, Netherlands

OBC-04-44 — Four Decades of Experience with Orthotropic Decks
Peter G. Buckland; Buckland & Taylor Ltd, Canada

OBC-04-45 — Wearing Surface Systems for Orthotropic Bridge Decks - Issues Related to Testing and Performance Evaluation
Vellore S. Gopalaratnam; University of Missouri-Columbia, Missouri, USA

OBC-04-46 — Testing Program for the Self-Anchored Suspension Span of San Francisco – Oakland Bay Bridge
Wenyi Long and Vong Toan; Professional Engineers in California Government (PECG), Caltrans, California, USA

OBC-04-47 — Rationalized Steel Deck Structure and Large Model Test for Developing a New Type of Structure
Kazuyuki Mizuguchi, Japan Highway Public Works; Kentaro Yamada, Nagoya University; Masanori Iwasaki and Susumu Inokuchi, Yokogawa-Bridge Corp. Japan
OBC-04-48 — Full-Scale Fatigue Test of Orthotropic Steel Deck Under Running Wheel Loading
Xiaohua Cheng, NJDOT, New Jersey, USA; Jun Murakoshi, PWRI, Japan; and Akira Moriyama, HSBA, Japan

OBC-04-49 — The Use of Dispersion Layers to Reduce Fatigue Damage in Orthotropic Steel Bridge Decks,
Hans De Backer, Bart De Pauw, Wouter De Corte, Philippe Van Bogaert; Ghent University, Belgium

OBC-04-50 — First Curved Steel Orthotropic Box Bridge in the US
James E. Roberts, Imbsen Associates Inc., California, USA; and Alfred Mangus, Professional Engineers in California Government (PECG), Caltrans, California, USA

OBC-04-51 — Steel Orthotropic Box Girder on the New Alfred Zampa Suspension Bridge Across the Carquinez Strait, First in the US
Dyab Khazem and Ken Serzan; Parsons, New York, USA

OBC-04-52 — A New Replacement Orthotropic Steel Deck for the Triborough Bridge Significantly Reduces Dead Load Mass
James Valenti; Greenman-Pedersen, Inc., New York, USA

OBC-04-53 — French Experience with Long-Span Cable-Stayed Bridges with Orthotropic Deck
Michel Virlogeux; Ingenieur Consultant, France

OBC-04-54 — New San Francisco Oakland Bay Bridge Self-Anchored Suspension Bridge – Impact of Seismic Requirements on Orthotropic Box Design
Marwan Nader, T.Y. Lin International; George Baker, Roman Wolchuk Consulting Engineers; Sante Camo, Weidlinger Associates, Inc.; and James Duxbury, T.Y. Lin International, USA

OBC-04-55 — New San Francisco Oakland Bay Bridge Self-Anchored Suspension Bridge – Orthotropic Deck Design
George Baker; Roman Wolchuk Consulting Engineers, California; and Marwan Nader, T.Y. Lin International, California, USA

OBC-04-56 — Skyway Orthotropic Box Girder Superstructure
Sajid Abbas, T.Y. Lin International; and Brian Maroney; Professional Engineers in California Government, (PECG), Caltrans, California, USA

OBC-04-57 — Cost Estimating Orthotropic Bridge Superstructures
Chris Traina and Brian Maroney; Professional Engineers in California Government, (PECG), Caltrans, California, USA
OBC-04-58 — Construction of Epoxy Asphalt Pavements on Orthotropic Steel Bridge Decks
R. W. Gaul; ChemCo System, Inc., California, USA

OBC-04-59 — Constructability Innovations for the SFOBB
Sarah Picker; Professional Engineers in California Government (PECG), Caltrans, California, USA

OBC-04-60 — Launching and Construction of the Chiapas Bridge Superstructure
Carlos De La Mora, Ingenieros Civiles Asociados, Mexico; Roberto Gomez, Institute of Engineering, Mexico; Douglas Williams, California, USA

OBC-04-61 — Modern Fatigue Design of Orthotropic Bridge Decks in the United States
John W. Fisher and Robert J. Connor; Lehigh University, Pennsylvania, USA

OBC-04-62 — Integrated Hydraulic Solutions for the World’s Largest Orthotropic Bridge
Peter Crisci; Enerpac

PPO OBC-04-28 — Structure, Design and Construction of Steel Orthotropic Bridge in Sofia
Doncho N. Partov, Banko B. Bankov, and Christo T. Christov; Higher School of Civil Engineering, Bulgaria

PPO OBC-04-63 — Renewal Application Research into Design of Suspension Bridge Stiffened by Steel Slab Girder
Gongyi Xu, Zhangong Fu, and Hong Su, China Zhongtie Major Bridge Reconnaissance & Design Institute Company, Ltd., Wuhan, Hubei, Peoples Republic of China

PPO OBC-04-64 — A New Design Concept for Steel Bridge Decks
S. R. Bright, Cass Hayward LLP, Welsh Street, Chepstow and J.W. Smith, Dept. Civil Engineering, University of Bristol, Bristol

Index by Presenting Author:

Michael J. Abrahams and Mark Hirota; Parsons Brinckerhoff Quade & Douglas, Inc., New York, USA
OBC-04-04 — Fremont Orthotropic Bridge Deck - Longest Tied Steel Arch in Western Hemisphere
George Baker; Roman Wolchuk Consulting Engineers, California; and Marwan Nader, T.Y. Lin International, California, USA
OBC-04-55 — New San Francisco Oakland Bay Bridge Self-Anchored Suspension Bridge – Orthotropic Deck Design
Ewa Z. Bauer, Daniel E. Mohn, Mary C. Currie, Frank L. Stahl; *Golden Gate Bridge, Highway and Transportation District, California, USA*  
OBC-04-12 — Golden Gate Bridge Deck and Sidewalk Replacement

Peter G. Buckland; *Buckland & Taylor Ltd, Canada*  
OBC-04-44 — Four Decades of Experience with Orthotropic Decks

OBC-04-35 — Reinforced High Performance Concrete Overlay System for Rehabilitation and Strengthening of Orthotropic Steel Bridge Decks

Sante Camo and Qi Ye; *Weidlinger Associates, Inc., New York, USA*  
OBC-04-30 — Parametric Studies & Testing for the Orthotropic Deck of the Bronx Whitestone Bridge

Xiaohua Cheng, *NJDOT, New Jersey; Jun Murakoshi and Kazuhiro Nishikawa, PRWI, Japan*; and Harukazu Ohashi, *Parsons, New York, USA*  
OBC-04-25 — Local Stresses and Fatigue Durability of Asphalt Paved Orthotropic Steel Deck

Xiaohua Cheng, *NJDOT, New Jersey, USA*; Jun Murakoshi, *PWRI, Japan*; and Akira Moriyama, *HSBA, Japan*  
OBC-04-48 — Full-Scale Fatigue Test of Orthotropic Steel Deck Under Running Wheel Loading

Chung-Che Chou, *National Chiao Tung University, Taiwan; C.M. Uang and F. Seible, University of California, San Diego, USA*  
OBC-04-21 — Compression Behavior of Steel Orthotropic Deck Panels for the New San Francisco-Oakland Bay Bridge

Robert J. Connor and John W. Fisher; *Lehigh University, Pennsylvania, USA*  
OBC-04-61 — Modern Fatigue Design of Orthotropic Bridge Decks in the United States

Frank J. Constantino; *Stirling Lloyd Products, Inc, UK*  
OBC-04-34 — Waterproofing the Steel Orthotropic Deck of the Carquinez Bridge

Peter Crisci; *Enerpac*  
OBC-04-62 — Integrated Hydraulic Solutions for the World’s Largest Orthotropic Bridge

Hans De Backer, Bart De Pauw, Wouter De Corte, Philippe Van Bogaert; *Ghent University, Belgium*  
OBC-04-49 — The Use of Dispersion Layers to Reduce Fatigue Damage in Orthotropic Steel Bridge Decks,
Wouter De Corte and Philippe Van Bogaert; *Ghent University, Belgium*

**OBC-04-17** — Fatigue Strength Verification of Steel Orthotropic Plated Bridge Deck for Railway Bridges

Wouter De Corte; *Ghent University, Belgium*

**OBC-04-23** — Assessment of Fatigue Strength of Steel Orthotropic Plated Bridge Decks from Continuous Measured Stress Spectra

F. B. P. de Jong; *Delft University of Technology, Netherlands*

**OBC-04-16** — Overview Fatigue Phenomenon in Orthotropic Bridge Decks in the Netherlands

F. B. P. de Jong, M. H. Kolstein, and F. S. K. Bijlaard; *Delft University of Technology, Netherlands*

**OBC-04-22** — Research Project TU Delft; Behaviour Conventional Bridge Decks & Development of Renovation Techniques

F. B. P. de Jong and M. H. Kolstein; *Delft University of Technology, Netherlands*

**OBC-04-41** — Strengthening a Bridge Deck with High Performance Concrete

F. B. P. de Jong and P. D. Boersma; *Delft University of Technology, Netherlands*

**OBC-04-43** — Maintenance Philosophy and Systematic Lifetime Assessment for Decks Suffering from Fatigue

Carlos De La Mora, *Ingenieros Civiles Asociados, Mexico*; Roberto Gomez, *Institute of Engineering, Mexico*; Douglas Williams, *California, USA*

**OBC-04-60** — Launching and Construction of the Chiapas Bridge Superstructure

John W. Fisher; *Lehigh University, Pennsylvania, USA*

**OBC-04-29** — Existing and Future Steel Bridge Infrastructure – Some Observations

R. W. Gaul; *ChemCo System, Inc., California, USA*

**OBC-04-58** — Construction of Epoxy Asphalt Pavements on Orthotropic Steel Bridge Decks

Vellore S. Gopalaratnam; *University of Missouri-Columbia, Missouri, USA*

**OBC-04-45** — Wearing Surface Systems for Orthotropic Bridge Decks - Issues Related to Testing and Performance Evaluation

Wasoodev Hoorpah; *MIO-OTUA, France*

**OBC-04-26** — Orthotropic Decks for Small and Medium Span Bridges in France – Evolution and Recent Trends
Susumu Inokuchi and Masanori Iwasaki, *Yokogawa-Bridge Corp., Japan*; Kazuyuki Mizuguchi, *Japan Highway Public Works*; Kentaro Yamada, *Nagoya University*

**OBC-04-47** — Rationalized Steel Deck Structure and Large Model Test for Developing a New Type of Structure

D. J. Laurie Kennedy and R. A. Dorton; *Intelligent Engineering Ltd., Canada*

**OBC-04-19** — Design and Field Load Testing of the Shenley Bridge, Québec, Canada

Dr. Stephen J. Kennedy and Dr. Thomas Murray; *Intelligent Engineering Ltd., Canada*

**OBC-04-18** — Fatigue Resistance and Ultimate Strength of SPS Bridge Decks

M. H. Kolstein; *Delft University of Technology, Netherlands*

**OBC-04-15** — European Research on the Improvement of the Fatigue Resistance and Design of Steel Orthotropic Bridge Decks

M. H. Kolstein; *Delft University of Technology, Netherlands*

**OBC-04-32** — The Role of Site Measurements to Improve the Knowledge About the Fatigue Behavior of Steel Orthotropic Bridge Decks

Mykhailo Korniev; *Mostobud, Ukraine*

**OBC-04-05** — Orthotropic Deck Bridges in Ukraine

Kenji Kuramoto, Makoto Yuda, and Wataru Fujimoto; *Kawada Industries, Inc., Japan*

**OBC-04-08** — Methods of Flux Cored Wires Arc Welding and Ultrasonic Testing for Longitudinal Weld of U-shaped Rib and Deck Plate

Wenyi Long and Vong Toan; *Professional Engineers in California Government (PECG), Caltrans, California, USA*

**OBC-04-46** — Testing Program for the Self-Anchored Suspension Span of San Francisco – Oakland Bay Bridge

M. Myint Lwin; *FHWA, Washington, D.C., USA*

**OBC-04-07** — Bridge Steels – Past, Present and Future

Fumitaka Machida, Tarou Yuge, Chitoshi Miki, Eiki Yamaguchi, Tetsuhiro Shimozato, and Takashi Masui; *Technology Center of Metropolitan Expressway, Japan*

**OBC-04-20** — Stress Measurements on Fatigue-Damaged Structures with Orthotropic Steel Decks in Summer and Winter

Brian Maroney *Professional Engineers in California Government, (PECG), Caltrans, California, USA*; and Sajid Abbas, *T.Y. Lin International*

**OBC-04-56** — Skyway Orthotropic Box Girder Superstructure

Brian Maroney and Chris Traina; *Professional Engineers in California Government, (PECG), Caltrans, California, USA*

**OBC-04-57** — Cost Estimating Orthotropic Bridge Superstructures
Michael Marquez; *Professional Engineers in California Government (PECG), Caltrans, California, USA*

**OBC-04-38 — New Carquinez Bridge**

Michael Marquez, Eugene Thimmhardy, and Raymond W. Wolfe; *Professional Engineers in California Government (PECG), Caltrans, California, USA*

**OBC-04-39 — New Carquinez Strait Suspension Bridge Fabrication and Sea Transportation of Orthotropic Steel Box Girder Segments**

Neil McFadyen, Robert Brady, and Ian Firth; *Flint & Neill Partnership Consulting Engineer, UK*

**OBC-04-42 — Resurfacing of Orthotropic Bridge Decks in the UK – Practical and Design Considerations**

Vasant Mistry; *FHWA, Washington, D.C., USA*

**OBC-04-13 — High Performance Steel for Highway Bridges**


**OBC-04-54 — New San Francisco Oakland Bay Bridge Self-Anchored Suspension Bridge – Impact of Seismic Requirements on Orthotropic Box Design**

Dennis Nottingham; *PND Incorporated, Alaska, USA*

**OBC-04-06 — A Review of Alaska’s Orthotropic Bridges**

Doncho N. Partov, Banko B. Bankov, and Christo T. Christov; *Higher School of Civil Engineering, Bulgaria*

**OBC-04-28 — Structure, Design and Construction of Steel Orthotropic Bridge in Sofia**

Sarah Picker; *Professional Engineers in California Government (PECG), Caltrans, California, USA*

**OBC-04-59 — Constructability Innovations for the SFOBB**

James E. Roberts, *Imbsen Associates Inc., California, USA*; and Alfred Mangus, *Professional Engineers in California Government (PECG), Caltrans, California, USA*

**OBC-04-50 — First Curved Steel Orthotropic Box Bridge in the US**

Brendan J. Scahill; *Greenman-Pedersen, Inc., New York, USA (Abstract only)*

**OBC-04-10 — Orhtotropic Deck Fabrication for the Triborough Bridge**

Gerhard Sedlacek and Christian Müller; *Technische Hochschule, Aachen, Germany*

**OBC-04-01 — Unified European Rules for the Design of Bridges with Steel Orthotropic Decks**
Charles Seim and Rafael Manzanarez; T.Y. Lin International, California, USA
OBC-04-02 — A Performance Based Surfacing for the Orthotropic Deck of the New San Francisco-Oakland Bay Bridge East Span Seismic Safety Project

Kenneth Serzan, John Clenance and Jeffrey Lu; Parsons, New York, USA
OBC-04-27 — The New Tacoma Narrows Suspension Bridge – Orthotropic Superstructure

Ken Serzan and Dyab Khazem; Parsons, New York, USA
OBC-04-33 — Orthotropic Deck Design Innovation Verified by Laboratory and Field Testing for Williamsburg Bridge Deck Replacement

Ken Serzan and Dyab Khazem; Parsons, New York, USA
OBC-04-51 — Steel Orthotropic Box Girder on the New Alfred Zampa Suspension Bridge Across the Carquinez Strait, First in the US

Ove Sørensen; COWI, Denmark
OBC-04-11 — Box Girders, Design, Fabrication, Operation and Maintenance

Michael S. Stenko and Arif J. Chawalwala; Transpo Industries, Inc., New York, USA
OBC-04-36 — The Successful Use of Thin Polysulfide Epoxy Polymer Concrete Overlays on Steel Orthotropic Bridge Decks

James Valenti; Greenman-Pedersen, Inc., New York, USA
OBC-04-52 — A New Replacement Orthotropic Steel Deck for the Triborough Bridge Significantly Reduces Dead Load Mass

Richard B. Vincent and Angelo Ferro; The Canam Manac Group, Inc., Canada
OBC-04-09 — Fabrication and Construction of the Shenley Bridge Incorporating an SPS Orthotropic Bridge Deck

Michel Virlogeux; Ingenieur Consultant, France
OBC-04-53 — French Experience with Long-Span Cable-Stayed Bridges with Orthotropic Deck

Mazen Wahbeh and Jim Merrill, Mactec Engineering; Brian Boal, Professional Engineers in California Government (PECG), Caltrans, California, USA
OBC-04-40 — Technical Fabrication Issues with Steel Orthotropic Box Girder Bridges

Roman Wolchuk; Roman Wolchuk Consulting Engineers, New Jersey, USA
OBC-04-03 — Orthotropic Decks with Long Rib Spans

Gongyi Xu, Zhangong Fu, and Hong Su, China Zhongtie Major Bridge Reconnaissance & Design Institute Company, Ltd., Wuhan, Hubei, Peoples Republic of China
PPO OBC-04-63 — Renewal Application Research into Design of Suspension Bridge Stiffened by Steel Slab Girder
Kentaro Yamada, Tatsuya Ojio, Hirofumi Maeno and Masanori Iwasaki; Nagoya University, Japan
**OBC-04-14 — Durability Evaluation of Nagoya Expressway Orthotropic Steel Deck**

Eiki Yamaguchi, Kazushi Matsuo, Shinichi Kawamura, Yusuke Kobayashi, Masafumi Mori, Kunihiro Momota, Tatsushi Nishinohara; Kyushu Institute of Technology, Japan
**OBC-04-31 — Accuracy of Weigh-In-Motion by Steel Bridge**

Tarou Yuge, Fumitaka Machida, Hisashi Morikawa, Chitoshi Miki, Takeshi Kamiki, and Takashi Masui; Technology Center of Metropolitan Expressway, Japan
**OBC-04-24 — Analysis of Fatigue Damage Patterns in Orthotropic Steel Deck of Tokyo Metropolitan Expressways**

Doug Zuberer; Chase Specialty Coatings, Massachusetts, USA
**OBC-04-37 — Alternative Waterproof System and Wearing Course for Orthotropic Bridge Decks**
My favorite quote on the qualities of effective leadership is “lead, follow, or get out of the way.” As I sit here typing away on the day of my only aunt’s funeral, a flood of memories come back of times spent before and after attending the 1993, 1995, 1998, 2001 and 2003 Pittsburgh, PA International Bridge Conferences (largest in the USA). My Aunt Izora had a long life, just shy of 88 years, and the legacy of five great grandchildren.

It’s made me stop and think about my own mortality and about what I would like to accomplish during the remainder of my life. My last correspondence with Aunt Izora was a postcard from France during my recent visit there. My primary goal during my June 16-26, 2004 visit was to learn more about France’s very large orthotropic bridges so that I could share the information with my colleagues here in the USA.

As President of the Capital Branch of ASCE, you only have 12 months to make some changes. Only about 8% of our membership are involved with any type of bridges. The number of ASCE members really interested in orthotropic bridges is even smaller. Many other organizations have bridge conferences. The Engineers Society of Western Pennsylvania, (older than ASCE, but very small,) has the Pittsburgh IBC where three times as many people attend compared to any ASCE bridge meeting or conference. As an ASCE leader, I wanted to grab a “piece of the conference pie” for ASCE. I realized due my years of studying orthotropic bridges, that this was a topic that had sufficient interest within the bridge engineering community in which to take a risk by creating www.orthotropic-bridge.org.

To succeed as a leader, you need key people to support you. My idea started about two years ago. First and foremost was my friend Craig Copelan. Next my fellow officers, Ruben, Greg, Beverly, Dick, Ben and

IN THIS ISSUE
Board of Directors
Capital Branch Luncheon
Career Opportunities
Central Valley Branch
District 13 Report
Extraordinary Women 2
Feather River Branch
Law and Civil Engineering Leadership
OBC Attendees 4
President’s Message 1
Reception for William Henry 2
Rivercats Tickets
Shasta Branch Luncheon
YMF, Capital Branch

By Alfred R. Mangus, P.E., Sacramento Section Junior Director and Capital Branch President

Sacramento Section President’s Message

Transportation Reauthorization Update Conference Committee closes in on 300 Billion Dollar figure

As I have outlined over the past several months in articles on this topic, congress continues to move slowly toward the reauthorization of the Highway funding bill. The current funding authorization of TEA 21 expired originally in October of 2003. It has been extended several times while debate on the amount of funding to provide to states has raged on. The administration has threatened a veto of funding levels over its proposal of 257 billion. Both House and Senate versions exceed this amount by a considerable margin. Further stirring the debate has been discussion of increases in gas taxes to pay for funding above the threshold established by the administration. Think about the impact of this bill on your practice of Civil Engineering. Do you as a government employee, or does your firm practice in the area of transportation? If you do, the passage of this bill with an enhanced funding level is very important to you. ASCE is encouraging their membership to contact their elected federal representatives regarding this issue, and to encourage them to promptly pass a highway bill funded at the 300 billion dollar level. It appears that the conference process currently underway will move toward this funding level.

The U. S. House of Representatives and the Senate acted on Thursday, July 22nd, to extend the Safety, Transit and Motor Carrier programs within the Transportation Equity Act for the 21st Century (TEA 21) for two months until September 30, 2004 to allow further work on a multi-year reauthorization. Curiously, the Federal Aid Highway program was only extended through September 24th. This is the latest in a series of extensions that started with the sunset of TEA21 in September 2003. The conference committee which has been meeting to discuss this issue remains split over the funding level for this legislation. The House Bill (H.R. 3550) is at $284 billion, and the corresponding Senate version of the bill is at 318 billion. Agreement on the funding level has been considered a key step in the conference process. Complicating this issue is the Administration’s
Laura Bush to Serve as Honorary Chair of the Advisory Committee for Extraordinary Women Engineers Project

Reston, Va. - Mrs. Laura Bush, the first lady of the United States, has accepted the position of honorary chair of the Advisory Committee for the Extraordinary Women Engineers Project (EWEP), the EWEP coalition announced today.

The Extraordinary Women Engineers Project is an awareness and outreach program designed to encourage young women to choose engineering as a career and to develop a new generation of role models for those already in the field. EWEP is supported by a coalition of more than 50 engineering organizations, professional societies and universities, including the American Association of Engineering Societies and the National Academy of Engineering. Together, the supporting organizations represent more than one million engineers worldwide.

"I am pleased to accept the position of honorary chair," Mrs. Bush said. "I applaud the Extraordinary Women Engineers Project for inspiring young women to be engineers and for promoting diversity within the engineering profession." A former public school teacher and librarian, Mrs. Bush is known as an advocate for education, reading and women’s issues.

"I sincerely appreciate that Mrs. Laura Bush has accepted the position of honorary chair of the Extraordinary Women’s Project," says Patricia D. Galloway, P.E., F.ASCE, PMP, president of the American Society of Civil Engineers and chair of the EWEP Steering Committee. "I believe that the project closely matches with Mrs. Laura Bush’s ideas on education and advancing young women into technical fields of study." A diverse workforce has been proven to result in a better completed project or service, Galloway adds.

The primary objectives of the program are to demonstrate to students from all backgrounds that engineering is an exciting career path; to promote diversity within the engineering profession; to motivate role models by celebrating the achievements of women engineers; and to increase public awareness about the importance of engineering in everyday life. The resources for the program will be developed jointly by educators and engineers and will include a flagship publication and television documentary presenting inspirational personal stories of women engineers, a national outreach campaign, and corresponding educational resources and training.

In addition to Mrs. Bush, the EWEP Advisory Committee includes Galloway, president and CEO of the Nielsen Wurster Group, Inc. in Princeton, New Jersey; Deborah L. Grubbe, P.E., corporate director of safety and health, E.I. du Pont de Nemours & Co., Inc. in Wilmington, Delaware; U.S. Representative Rush Holt, a member of the Committee on Education and the Workforce and the House Permanent Select Committee on Intelligence; Dr. Paul Horn, senior vice president of research of IBM, TJ Watson Research Center, Yorktown Heights, New York; Dr. Linda Katehi, John A. Edwardson Dean of Engineering, Purdue University; Terry S. Kees, vice president of Homeland Security Systems, Lockheed Martin Integrated Systems and Solutions, Fairfax, Virginia; and Terri Morse, corporate director of technical affiliations, Boeing World Headquarters, Chicago, Illinois. Members of the Advisory Committee will assist in the content development and promotion of the project.

For more information on the Extraordinary Women Engineers Project, visit www.engineeringwomen.org or contact Jane Howell, American Society of Civil Engineers, (703) 295-6000, or jhowell@asce.org.

A reception with a “no host” bar in the California Room of the Holiday Inn Capitol Plaza will be held for ASCE National President-elect Bill Henry on Thursday night, August 26th from 5:00 p.m. to 6:30 p.m. All ASCE members are invited to attend for free in order to meet and greet Bill. The west wall to the vendor booths will be open, so anyone may visit vendor booths and see the #5 in the country U.C. Davis student steel bridge on display.
my Caltrans colleague Dr. Dash. Vivian, our wonderful Section Secretary, has been very helpful and creative developing the electronic and paper documents that you see and read about the conference. Vivian has provided ideas and done many tasks, such as obtaining bus contracts for field trips. I was fortunate to have Bob Luscombe participate early during the planning phases, who doubled the number of conference sponsors and led the hotel selection plus contract process. Rounding out this team are Natalie Calderone, Ray Zelinski, Roman Wolchuk, Chuck Seim, Dr. Lian Duan, Sarah Picker, Clark Townsend and Steve J. Lee.

I have been able to obtain support from ASCE National. Jim Rossberg, Director of Structural Engineering Institute, (one of the seven ASCE institutes) provided money and ideas. John Casazza, Director of ASCE Continuing Education, has also assisted us. My counterpart, Dennis Ryan of Shasta Branch, has chaired a bus tour at my request to visit Redding’s new landmark, the Sundial Bridge. ASCE National President William Henry will visit us in August to support www.orthotropic-bridge.org.

Activating non-members is a good thing for ASCE. Colleagues Matthew Socha, Carol Smith and Yusuf Saleh were of great help to ASCE. Natalie Calderone, who so capably assisted our steering committee with publicity for the conference, has decided to become an ASCE officer based upon the positive experiences she had with this conference. Everyone was impressed with her organizational skills. Lori Tonkin has been doing a tremendous job of managing our vendor booths. We have six organizations that have paid $500 to have booths. Thanks Lori! The newest team member is Brenda Jew Waters as “Media Manager.”

Everyone needs a mentor, and serving in that capacity for me has been Norman Root. Norm has given me a lot of tips, and allowed me to brainstorm ideas with him. Along the way were individuals who assisted, but then had other commitments. Harry Gobbler, and Majid Sarraf helped us.

I have been reconnecting with colleagues that I have developed over the years, as well as orthotropic committee members. I have met new colleagues and made contacts because of this event. Dr. Wasoodev Hoorpah of OTUA, the French equivalent of NSBA (National Steel Bridge Alliance), generously drove me to the Normandie Orthotropic Cable-stayed Bridge, a two-hour freeway drive one way from Paris. Dr. Hoorpah took this photo of me standing next to this massive bridge (longest span in 1993). We also exchanged ideas, and he will be presenting his thoughts on orthotropic bridges at the conference, and to Caltrans Engineers at the Caltrans building.

You may be asking yourself, “How can I help ASCE’s www.orthotropic-bridge.org now??” We are inviting non-engineers to visit the ASCE, Me, Myself and Infrastructure exhibit in the Turtle Bay Museum on Sunday August 29, starting at 1:00 p.m. Dennis and his colleagues in Shasta spent a lot of time getting this exhibit to Redding. ASCE National created this exhibit to explain what all categories of ASCE members do to help society. This is an opportunity to explain our profession to non-engineers. The Museum has other interesting exhibits and gift items. Next to this exhibit is the artwork of Dr. Santiago Calatrava for the concept for the new “Sundial Bridge.” The reduced fee of $65 for the trip includes the $15 Museum admission fee and bus fare. We decided to let people select what restaurant meal they would like (from a low-price snack to a more expensive dinner). There is no charge to walk across the new “Sundial Bridge.” It is spectacular at sunset with glass floor panels lit from below.

Please see the preliminary listing of conference attendees at the end of this article. Late fees have been waived until Friday, Aug 20 because we would like to reach the 250-person room limit.

Our Saturday bus tour to the San Francisco Bay Area is about 50% full. There are still a few spaces available, but we recommend that if you are interested, that you please sign up today. Please consider the chance to network with out-of-town folks. This trip includes three meals, and stops at the Golden Gate Bridge Gift Shop. The Golden Gate Bridge now has an Orthotropic Steel Deck, and their engineers are explaining why at the conference. We also plan to stop at the new East Spans of SFOBB visitor’s center. Other big bridges are the Alfred Zampa Suspension Bridge at Carquinez, and the San Mateo - Hayward Bridge, as well as other small orthotropic bridges. It’s been months since we have had a field trip. Please consider attending.

Finally, both the Wolchuk Bridge Orthotropic Seminar and my Introduction to Orthotropic Bridges course are both filling up rapidly. Some seats are still available in both classrooms at the Holiday Inn at 3rd & J Street.
### Preliminary List of Orthotropic Bridge Conference Attendees

<table>
<thead>
<tr>
<th>Mr. Terrance Aarnio</th>
<th>Oregon Iron Works</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr. Conn Abnee</td>
<td>NSBA</td>
</tr>
<tr>
<td>Mr. Michael J. Abrahams</td>
<td>Parsons Brinckerhoff Quade &amp; Douglas, Inc.</td>
</tr>
<tr>
<td>Mr. Sachin Agrawal</td>
<td>None Listed</td>
</tr>
<tr>
<td>Ms. Ofelia Alcantara</td>
<td>Caltrans</td>
</tr>
<tr>
<td>Mr. Jess Avila</td>
<td>Caltrans</td>
</tr>
<tr>
<td>Mr. George Baker</td>
<td>Consulting Engineer/ Wolchuk</td>
</tr>
<tr>
<td>Ms. Ewa Bauer</td>
<td>Golden Gate Bridge, Highway &amp; Trans. Distrikt</td>
</tr>
<tr>
<td>Mr. John Bither</td>
<td>Caltrans</td>
</tr>
<tr>
<td>Mr. Nathan Brown</td>
<td>Wyoming DOT</td>
</tr>
<tr>
<td>Dr. Peter Buckland</td>
<td>Buckland &amp; Taylor Ltd</td>
</tr>
<tr>
<td>Mr. Peter Buitelaar</td>
<td>Contec ApS</td>
</tr>
<tr>
<td>Mr. Sante Camo</td>
<td>Weidlinger Associates, Inc.</td>
</tr>
<tr>
<td>Dr. Xiaohua Cheng</td>
<td>New Jersey Dept. of Trans.</td>
</tr>
<tr>
<td>Dr. Chung-Chi Chou</td>
<td>National Chiao Tung Univ.</td>
</tr>
<tr>
<td>Dr. Robert J. Connor</td>
<td>Lehigh University</td>
</tr>
<tr>
<td>Mr. Frank J. Constantino</td>
<td>Stirling Lloyd Products, Inc.</td>
</tr>
<tr>
<td>Prof. Hans De Backer</td>
<td>Ghent University</td>
</tr>
<tr>
<td>Mr. Wouter De Corte</td>
<td>Ghent University</td>
</tr>
<tr>
<td>Mr. F.B.P. de Jong</td>
<td>Delft University of Tech.</td>
</tr>
<tr>
<td>Mr. Carlos De la Mora</td>
<td>Ingenieros Civiles Asociados</td>
</tr>
<tr>
<td>Mr. Newton Dodson</td>
<td>N. Montgomery Dodson, P.E.</td>
</tr>
<tr>
<td>Mr. Roger A. Horton</td>
<td>Buckland &amp; Taylor, Ltd.</td>
</tr>
<tr>
<td>Mr. Jorge Estrada</td>
<td>Caltrans</td>
</tr>
<tr>
<td>Mr. John W. Fisher</td>
<td>Lehigh University</td>
</tr>
<tr>
<td>Mr. R. W. Gaul</td>
<td>ChemCo System, Inc.</td>
</tr>
<tr>
<td>Mr. Vellore Gopalaratnam</td>
<td>University of Missouri-Columbia</td>
</tr>
<tr>
<td>Mr. Simon Greensted</td>
<td>Stirling Lloyd Prod., Inc.</td>
</tr>
<tr>
<td>Mr. Thomas Hickman</td>
<td>Oregon Iron Works</td>
</tr>
<tr>
<td>Dr. Wasoodev Hoorpah</td>
<td>M.I.O.</td>
</tr>
<tr>
<td>Mr. Garth Howlett</td>
<td>Yokogawa-Bridge Corp.</td>
</tr>
<tr>
<td>Mr. Vincent Jacob</td>
<td>Caltrans</td>
</tr>
<tr>
<td>Mr. Wan Chun Jen</td>
<td>Lehigh University, ATLSS</td>
</tr>
<tr>
<td>Mr. Atsunori Kawabata</td>
<td>JFE Engineering Co.</td>
</tr>
<tr>
<td>Dr. D.J. Laurie Kennedy</td>
<td>Intelligent Engineering Ltd.</td>
</tr>
<tr>
<td>Dr. Stephen J. Kennedy</td>
<td>Intelligent Engineering Ltd.</td>
</tr>
<tr>
<td>Mr. Martine Klein</td>
<td>None listed</td>
</tr>
<tr>
<td>Mr. M.H. Kolstein</td>
<td>Delft University of Tech.</td>
</tr>
<tr>
<td>Dr. Mykhailo Korniev</td>
<td>Mostobud</td>
</tr>
<tr>
<td>Mr. Kenji Kuramoto</td>
<td>KAWADA Industries, Inc.</td>
</tr>
<tr>
<td>Mr. Rick Land</td>
<td>Caltrans</td>
</tr>
<tr>
<td>Mr. Pat Leonard</td>
<td>Oregon Iron Works</td>
</tr>
<tr>
<td>Mr. Wenyi Long</td>
<td>Caltrans</td>
</tr>
<tr>
<td>Mr. Myint Lwin</td>
<td>FHWA</td>
</tr>
<tr>
<td>Mr. Fumitaka Machida</td>
<td>Metropolitan Expressway Retrofit Project</td>
</tr>
<tr>
<td>Mr. Brian Maroney</td>
<td>Caltrans</td>
</tr>
<tr>
<td>Mr. Michael Marquez</td>
<td>Caltrans</td>
</tr>
<tr>
<td>Mr. Raymond J McCabe</td>
<td>HNTB Corporation</td>
</tr>
<tr>
<td>Mr. Neil McFadyen</td>
<td>Flint &amp; Neill Partnership</td>
</tr>
<tr>
<td>Mr. Jim Merrill</td>
<td>MACTEC</td>
</tr>
<tr>
<td>Mr. Chitoshi Miki</td>
<td>Tokyo Institute of Tech.</td>
</tr>
<tr>
<td>Mr. Alan Miller (CA)</td>
<td>None listed</td>
</tr>
<tr>
<td>Mr. Alan Miller (TX)</td>
<td>Huitz-Zollars</td>
</tr>
<tr>
<td>Mr. Vasant Mistry</td>
<td>FHWA</td>
</tr>
<tr>
<td>Mr. Daniel E. Mohn</td>
<td></td>
</tr>
<tr>
<td>Mr. Juan Murillo</td>
<td>Parsons Brinckerhoff</td>
</tr>
<tr>
<td>Mr. Marwan Nader</td>
<td>TY Lin International</td>
</tr>
<tr>
<td>Ms. Martha Nevai</td>
<td>FHWA</td>
</tr>
<tr>
<td>Mr. Howard Ng</td>
<td>Caltrans</td>
</tr>
<tr>
<td>Mr. Dennis Nottingham</td>
<td>PND Incorporated</td>
</tr>
<tr>
<td>Mr. Tom Ostrom</td>
<td>Caltrans</td>
</tr>
<tr>
<td>Dr. Doncho N. Partov</td>
<td>Higher School of Civil Eng.</td>
</tr>
<tr>
<td>Ms. Sarah Picker</td>
<td>Caltrans</td>
</tr>
<tr>
<td>Ms. Shannon Post</td>
<td>Caltrans</td>
</tr>
<tr>
<td>Mr. Charlie Quade</td>
<td>Huitz-Zollars</td>
</tr>
<tr>
<td>Mr. Michael Rhodes</td>
<td>Nolte Associates</td>
</tr>
<tr>
<td>Mr. James Roberts</td>
<td>Self Employed</td>
</tr>
<tr>
<td>Mr. Alex Rong</td>
<td>Delaware River Port Auth.</td>
</tr>
<tr>
<td>Mr. Brendan Scahill</td>
<td>Greenman-Pedersen, Inc.</td>
</tr>
<tr>
<td>Mr. Hassan Sederat</td>
<td>SC Solutions, Inc.</td>
</tr>
<tr>
<td>Prof. Gerhard Sadelke</td>
<td>RWTH Aachen</td>
</tr>
<tr>
<td>Mr. Charles Seim</td>
<td>TY Lin International</td>
</tr>
<tr>
<td>Mr. Ken Serzan</td>
<td>Parsons</td>
</tr>
<tr>
<td>Mr. Robert C. Smith</td>
<td>Mabey Bridge &amp; Shore, Inc.</td>
</tr>
<tr>
<td>Mr. William H. Smith</td>
<td>Barnhart Crane &amp; Rigging</td>
</tr>
<tr>
<td>Mr. Ove Sorensen</td>
<td>COWI</td>
</tr>
<tr>
<td>Mr. Henry Springer</td>
<td>KNIK Arm Bridge &amp; Toll Authority</td>
</tr>
<tr>
<td>Mr. M. Stenko Tigi</td>
<td>Transpo Industries, Inc.</td>
</tr>
<tr>
<td>Mr. Kevin Thompson</td>
<td>Caltrans</td>
</tr>
<tr>
<td>Mr. Vong Toan</td>
<td>Caltrans</td>
</tr>
<tr>
<td>Mr. Jun Tsanabuchi</td>
<td>Mitsubishi Internatinal Corp.</td>
</tr>
<tr>
<td>Mr. Robert Turton</td>
<td>HDR Engineering, Inc.</td>
</tr>
<tr>
<td>Mr. Chia-Ming Uang</td>
<td>Univ. of Calif., San Diego</td>
</tr>
<tr>
<td>Mr. James Valenti, P.E.</td>
<td>Greenman-Pedersen, Inc.</td>
</tr>
<tr>
<td>Mr. Richard B. Vincent</td>
<td>The Canam Manac Group, Inc.</td>
</tr>
<tr>
<td>Mr. Michel Virlogeux</td>
<td>Ingenieur Consultant</td>
</tr>
<tr>
<td>Mr. Nhan T. Vo</td>
<td>T.Y. Lin International</td>
</tr>
<tr>
<td>Mr. Fletcher Waggoner</td>
<td>SC Solutions, Inc.</td>
</tr>
<tr>
<td>Mr. Mazen Wahbeh</td>
<td>MACTEC</td>
</tr>
<tr>
<td>Dr. Dayi Wang</td>
<td>Jacobs Civil, Inc.</td>
</tr>
<tr>
<td>Mr. Williams Russell &amp; Johnson</td>
<td>Caltrans</td>
</tr>
<tr>
<td>Mr. Steve Wiman</td>
<td>Caltrans</td>
</tr>
<tr>
<td>Mr. Roman Wolchuk</td>
<td>Consulting Engineer</td>
</tr>
<tr>
<td>Mr. Ray Wolfe</td>
<td>Caltrans</td>
</tr>
<tr>
<td>Prof. Kentaro Yamada</td>
<td>Nagoya University</td>
</tr>
<tr>
<td>Mr. Eiki Yamaguchi</td>
<td>Kyushu Institute of Tech.</td>
</tr>
<tr>
<td>Dr. Tarou Yuge</td>
<td>Metropolitan Expressway Retrofit Project</td>
</tr>
<tr>
<td>Mr. Howard Zabell</td>
<td>Harris &amp; Associates</td>
</tr>
<tr>
<td>Mr. Jaime Ziegler</td>
<td>Jaime Ziegler Civ. Eng.</td>
</tr>
<tr>
<td>Mr. Doug Zuberer</td>
<td>Chase Specialty Coatings</td>
</tr>
</tbody>
</table>
The Engineerogram

September 2004

Volume 66, Number 9

IN THIS ISSUE

Board of Directors 2 Law and Civil Engineering 9
Capital Branch Luncheon 9 Leadership 1
Cap. Br. President’s Message 8 Legislative Corner 4-5
Career Opportunities 6-8 Orthotropic Bridge Conference
Central Valley Branch 5 Conference Highlights 1
Code Conversation 10 President’s Message 1
Feather River Branch 6 Shasta Branch Luncheon 5
Installation Banquet 10 YMF, Capital Branch 3

Highlights of the Orthotropic Bridge Conference

by Alfred R. Mangus, P.E., Sacramento Section Junior Director and Capital Branch President

As Shakespeare wrote “All’s well that ends well.” The Orthotropic Bridge Conference was successful in everything, except for the fun golf event.

I would like to thank HDR for sponsoring the Welcoming Breakfast at the Conference.

Following is a pictorial recording of the conference events:

(All images by Mr. Jon Hirtz, Hirtz Commercial Services)

Orthotropic Bridge Conference Committee Members
Front (L to R): John Ruzic, Matthew Socha, Natalie Calderone, Bob Luscombe, Brenda Jew Waters
Back (L to R): Richard Weitzenberg, Umakant Dash, Alfred R. Mangus, Norman Root, Ray Zelinski, Eric Delong, Lian Duan, Peter Luong

Capital Branch Officers
Front (L to R): Natalie Calderone, Alfred R. Mangus, Beverly Mason
Back (L to R): Greg Zeiss, Craig Copelan, William Henry, Richard Weitzenberg, John Pulver

Councilman Steve Cohn
Brenda Jew Waters

Continued on Page 11

Sacramento Section President’s Message

by Craig Copelan, P.E., Sacramento Section President

End-of-Year Wrap Up

This has been a great year, and I would like to extend a big thank you to all of the people who pulled together to make ASCE events successful and professionally done. ASCE is unique in that it is an organization that pulls civil engineers together around shared interests, and allows them to develop contacts and leadership skills.

I have enjoyed my assignment during this last year as your Sacramento Section President, and the opportunity to share

Continued on Page 2
Highlights of the Orthotropic Bridge Conference - Continued from Page 1

Roman Wolchuk

Neil McFadyen, Sibdas Chakrabarti, Gerhard Sedlacek

Jim Rossberg

Dennis Nottingham

Myint Lwin

M.C. Tang

Gerhard Sedlacek

Bill Henry, Beverly Mason

Michael J. Abrahams

Robert Connor, John Fisher, Chitoshi Miki

2004 ASCE/NSBA Steel Bridge entries by CSU, Sacramento & UC Davis

Masaaki Hasegawa, Mrs. Duan, Lian Duan, Xiaohua Cheng, Yusuf Saleh, Myint Lwin

Rick Land

Daniel Mohn, Peter Buckland Mrs. Buckland, D. J. Laurie Kennedy
2004-2005 Capital Branch Officers
(Including Mr. William Henry and Mr. John Pulver)

Photo by Mr. Jon Hirtz
Orthotropic bridge deck conference highlights international cooperation

Engineers and researchers from around the world contributed examples and experience to the recent conference on orthotropic bridge decks that was held in Sacramento, California. The event, which was organized by the local Capital Branch of the Sacramento Section of the American Society of Civil Engineers, attracted delegates from North America, Europe, China and Japan, and was preceded by a two-day seminar on the design of orthotropic deck bridges.

Some 63 papers were presented during the three-day conference, of which 26 were by authors from outside the USA. Thematic sessions were dedicated to various aspects of orthotropic deck bridges: design, research, fatigue, maintenance and rehabilitation, surfacing, fabrication, construction and major current projects. In sessions on fatigue and new research, Japanese speakers reported in eight papers on durability valuation of orthotropic decks based on experiences with the Tokyo and Nagoya metropolitan elevated expressway systems, which contain over 1500 orthotropic bridge decks. Most of them have 12mm thick deck plates and 240mm deep U-shaped ribs, in accordance with the earlier standards, and 80mm-thick asphalt pavement. Fatigue cracks were found on 228 spans, mainly at the rib-to-deck plate connections. Cracking usually developed in the summer, when pavement contribution to deck stiffness was insignificant. For new structures a new, more durable and economical type of orthotropic decks was developed, with a deck plate 18mm thick and the ribs deeper and spaced farther apart. The current research programme at Delft University, funded by the European Coal & Steel Community, was discussed in seven presentations dealing with fatigue resistance of details and rehabilitation of orthotropic bridges built in the 1960s with thin deck plates. At critical rib-crossover intersections, ribs welded all-around to crossbeams, without free cutouts at rib bottoms, were found to perform better than these with customary cutouts. Careful execution of connecting welds is essential. Rehabilitation methods aimed at increasing deck rigidity were investigated, including bonded concrete overlays and the use of thicker overlays.

In sessions on ongoing American bridge projects the Carquinez, San Francisco-Oakland Bay and the new Tacoma bridge were the subject of several papers.

In the keynote presentation, the chairman of the Eurocode committee on steel bridges, Gerhard Sedlacek discussed unified European rules for the design of orthotropic decks that will substitute the various national rules to avoid obstacles to trade and free exchange of services. The new rules for typical structures are based on the empirical approach and allow the use of recommended standard details for which analytical calculations by designers are not required.

Principles of performance-based design of deck surfacings were presented by Charles Sein, while Myint Lwin and Vasant Mistri, representing the Federal Highway Administration, addressed the subject of bridge steels, with emphasis on new low-carbon steel grades now available for bridge construction. John Fisher commented on fatigue as a key factor affecting steel bridge longevity and French consultant Michel Verlogeux described the design and construction of the record-breaking French cable-stayed bridges, including the new high-level Millau Viaduct. Peter Buckland discussed experiences with orthotropic decks using simplified details at the rib-crossover intersections. Simplification and use of longer rib spans with the purpose of enhancing structural efficiency and reducing the cost of labour associated with orthotropic decks was advocated by Roman Wolchuk.

The seminar preceding the conference was presented by Roman Wolchuk, Consulting Engineers and gave a world-wide overview of the state-of-art of orthotropic deck bridges, including a history of the development of this type of structure, some practical design methods and discussion of the existing US (AASHTO) and European (Eurocode) provisions for orthotropic decks.

In the review of fatigue design rules, a distinction was made between the traditional notion of "load-induced" fatigue amenable to analytical investigation and "distortion-induced" fatigue, where numerical analysis is impractical for design purposes. Also noted were limitations of classical analytical methods based on elastic theory at deck details subject to residual yield stress caused by welding, as well as the fact that inappropriate welding and fabrication procedures rather than stress fluctuations may be the prevalent cause of cracking of orthotropic decks. In the design of new decks, therefore, the emphasis should be on the use of appropriate fabrication precautions based on experience and the avoidance of unfavourable geometric configurations and fatigue-prone details. Similarly, reliable performance of wearing surfacing, which must be considered an integral component of the steel deck system, should be based on providing adequate local rigidity of the deck and empirical criteria, rather than on theoretical analysis.

Discussion of these subjects continued in an informal evening meeting chaired by Myint Lwin of the Federal Highway Administration. An ad hoc committee was set up, including US and European engineers, with the purpose of preparing proposed guidelines meeting the needs of bridge engineers and applying for funding. It was suggested that such guidelines would be useful for the world-wide engineering community.

Roman Wolchuk

The papers from the conference are now available from ASCE Sacramento Section, fax: +1 916 774 6402, email asce@sacsec.org
ASCE/SEI Sponsored Event

Orthotropic Bridge Conference

Hayward/San Mateo OCEA 1968
http://www.asce.org/opal/past_ocea.cfm#1968

PROCEEDINGS — CD-ROM
Order Form
August 25-27, 2004

Name ________________________________________________________________
Title __________________________________________________________________
Organization _____________________________________________________________
Address __________________________________________________________________
City ____________________________ State ___________ Zip __________
Country __________________________________________________________________
Telephone _______________________________________________________________
Fax _____________________________________________________________________
E-mail __________________________________________________________________

Please check your organization’s classification:
Consultant   Government   Contractor   Manufacturer    Academic    Other

<table>
<thead>
<tr>
<th>Qty.</th>
<th>Cost of Each CD</th>
<th>Total</th>
</tr>
</thead>
</table>
| ___  | X $125.00       | $_____

(Cost will include tax and shipping charges. CD-ROM will be shipped 1-2 weeks after receipt of order.)

How to Reach Us:
Checks or Money Order should be made payable to:
ASCE, Capital Branch
The completed order form should be submitted to:
ASCE, Capital Branch
P.O. Box 2997
Citrus Heights, CA 95611-2997

Inquiries may be directed to:
Phone: 916-961-ASCE (2723)
Fax: 916-408-1408

Payment Information:
Must be complete before processing can occur.
A Check or Money Order for $___________ is enclosed.

(We are unable to accept credit card charges at this time.)
**CURVED STEEL ORTHOTROPIC BRIDGE FOR I-880**
The first curved all steel bridge in North America was fabricated in 350 ton pieces.

**NEW CARQUINÉZ SUSPENSION BRIDGE**
Gravity-Anchored, Orthotropic Steel Deck

**DATA BLOCK:**
- **Owner:** California Department of Transportation
- **Engineer:** ICF Keiser Engineers, Inc. & Construction Group
- **Lifting Specialist:** Crowley Maritime Services, Inc.
- **Fabricator:** Universal Structural, Inc.
- **Erector:** Shaughnessy
- **General Contractor:** Kiewit Marmolejo
- **Official Name:** Al Zampa Memorial Bridge
- **Width:** 29 meters
- **Length:** 1056 meters
- **Kilograms of steel:** 4,535,925
- **Cost:** $231 million

State of the art Structural Engineering design methods were used to create two new and improved bridges in the Bay Area that are resistant to future earthquake forces. The horseshoe shaped orthotropic steel bridge was part of the new I-880 Urban Freeway in Oakland, California. The Al Zampa Memorial is the first U.S. suspension bridge with an aerodynamic orthotropic steel deck with concrete towers.