2008 INTERNATIONAL ORTHOTROPIC BRIDGE CONFERENCE

August 25-30, 2008

Sacramento, California

Conference Proceedings

American Society of Civil Engineers
Sacramento Section / Structural Engineers Institute/OBC 2008
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2008 INTERNATIONAL ORTHOTROPIC BRIDGE CONFERENCE
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Foreward:

Greetings, from the ASCE/SEI Organizing Committee for the 2008 Orthotropic Bridge Conference. The best theme to describe this conference was "Moving Forward". I was fortunate to be able to be a part of the team that worked on the 2004 OBC and I marvel at how the good work at that conference has translated into results at our 2008 conference. The introduction of the FHWA guidance on orthotropic bridges as a part of this conference was in part influenced by the input from the many experts in public and private practice, received at our 2004 meeting, an example of how the influence and comments from industry and public works collectively move the business of bridge design forward. Thank you again for joining us at the 2008 Orthotropic Bridge Conference, the program was the result of hard work by a committed team of volunteers, sponsors and authors of the many fine papers and talks you enjoyed during our time together. I have attached a copy of the proceedings for the 2008 conference for your files. Let's continue to work together to make a positive move forward for design, construction and maintenance of Orthotropic steel bridges!

Our next conference is tentatively scheduled for Spring 2012, join us to once again move the field of orthotropic steel bridge engineering forward!

Sincerely,

Natalie E. Calderone, Chair
Orthotropic Bridge Conference 2008

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Sacramento Section Structural Engineering Institute:

The 2008 International Orthotropic Bridge conference proceedings will provide insight into the performance of Orthotropic bridges which grace California's public highway system and advance the methods used to design and maintain these structures in the future. Thank you on behalf of the Sacramento Section of ASCE's Structural Engineering Institute for your conference participation and your interest in steel bridge structures!

Sincerely,

Joyce E. Copelan, M.S., P.E. Chair
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2008 INTERNATIONAL

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Keynote Addresses

2008 International Orthotropic Bridge Conference

WE SHALL USE NO TECHNOLOGY BEFORE ITS TIME

Chuck Seim P.E.
Consulting Bridge Engineer
El Cerrito, California, USA

ORTHOTROPIC BRIDGE CONFERENCE
Sacramento, CA
August 26,2008

2008 International Orthotropic Bridge Conference

What, you may ask is "Technology" and "Time"?

- Let's look at the Pont du Gard Aqueduct:

Nimes, France,
1st Century BPE

Spans 20m to
24m, 47m high

Stone Masonry

Orthotropic Bridge Conference
Sacramento, September 2008

ENGINEERING
AN ART OR A SCIENCE

Man-Chung Tang
Chairman of the Board, **T.Y.LIN** International

ENGINEERING
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Review of Orthotropic Steel Deck Bridge and Some Fatigue Cracks and Retrofitting Measures in Japan

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Abstract

In the past three decades Japan has constructed numerous orthotropic steel deck (OSD) bridges. The system is very attractive for the bridge designer, not only for long span bridges, but also urban elevated highway systems, because they are lighter in weight and faster to fabricate and to erect. However, because of increases in weight and number of trucks in the traffic stream, some standard types of OSD started exhibiting fatigue cracks at the welded joints. In this paper the background and state of the art of OSD bridges in Japan is reviewed. Some typical fatigue cracks observed in the past are also reviewed with some discussion of experience with their retrofitting measures.

1. Introduction

Orthotropic steel decks (OSD) are lighter than concrete decks, which is essential for seismic design. Their fabrication in a shop makes the weld quality better and the construction time shorter. For these reasons, they have been widely used for decks in long span bridges such as cable-stayed bridges and suspension bridges, in elevated urban expressways and in some bridges on national highways. The OSD is composed of a deck plate stiffened with longitudinal open ribs such as bulb plates and flat plates, or with longitudinal closed ribs such as trough rib and semicircle rib. The trough ribs are more commonly used for OSD than the open ribs because the trough rib has higher torsional rigidity and provides a good distribution of load in the transverse direction. The trough rib spacing can be normally larger than the open rib spacing, which leads to fewer amounts of welds between the trough ribs to the deck plate.

In the 1970s, a Japanese standard design of OSD was established through joint research carried out by the Honshu Shikoku Bridge Authority (HSBA) and the Public

Design of Orthotropic Bridges

Design and Construction of the Orthotropic Steel Deck Bridge in Elin Pelin, Bulgaria

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Abstract

The paper presents the 300m long, Gerber type orthotropic steel deck bridge in the town of Elin Pelin (Bulgaria). Details on the bidding procedure, such as participants, bidding requirements are described in detail. Following is an account on the abilities of the contractor to provide the service required, including a description of the modular structures they specialize in. Next, the particular structure proposed is described in detail, including structural action and detailed design of the orthotropic deck, all principal and secondary members. Finally, a brief note is given on the seismic design, followed by the technical and economical constraints imposed on the contractor by the client.

Introduction

The construction of the elevated road link on road II-165 Yordankino – Elin Pelin – Novi Han started on completion of a competitive design-and-build bidding procedure in which eight companies took part – "Nobels Group" from Belgium; "SFEM" from France, "Klos" from the Netherlands, "Krupp" and "Thyssen" from Germany, "S. M. Finsider" from Italy, "Gosha" from former Yugoslavia, "Rudnitsi i Zhelezarnitsa" from Macedonia.

The late Professor Borislav Bankov was the chief expert responsible for the implementation of the bidding procedure. He set-out the following criteria for evaluation of the tenders:

- grade of steel used
- vehicle loading type (minimum class 60 of DIN 1072)
- number and type of the assembly units
- piers; type, structural and aesthetic design
- total weight of structural steel

Having failed to meet some of the above criteria, five tenders were not allowed to the final round of the evaluation, with only three tenders reaching it; those

Orthotropic Steel Deck Bridges in Korea

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Abstract

Recently, the long-span bridges have been continuously constructed in Korea and the superstructures with the orthotropic steel decks will be extensively applied to long-span bridges. This paper introduces long-span bridges with the orthotropic steel decks constructed in Korea. Geometry and Dimension of longitudinal rib are shown. In this paper the brief overview, section details, design philosophy, design loads, and connection details of these bridges are described.

Introduction

The total bridges in Korea are about 1,989 km in length and 22,937 in number in 2007. The share of steel bridges was only 2% in 1970, then jumped to 20% in early 1990 and consistently increased to 45% in 2007. Fabricated steel box girder is the main system, about 90% of the total, which is different from other countries.

The eight types of conventional steel as shown in Table 1. are being used in Korea. SM means Steel for Marines and is for welded structures. SMA means Steel for Marine Atmosphere and is for the weathering steel.

THE NEW STEEL-AND-LIGHT "DOORWAY" FOR THE CITY OF PADUA

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ABSTRACT:

The city of Padua is an important trading hub in the north-eastern productive region of Italy, located near the intersection of the major highways crossing the country in E-W and N-S directions. The ring of speedways that distribute the vehicular flow inside the city is about to be completed by this new viaduct, near the gate of A4 toll road. Its particular location, and its relevant both functional and architectural values make it the most important access to the city, that is exactly what the municipality of Padua (the client) wished for this site.

The steel viaduct is 544m long, with a transversal road width of 13.50m. Its 11 spans in bending continuity and the two separated ways are borne by V-shaped piers that are also in bending continuity at their top connection with the deck, so that the whole bridge is nearly "integral", since the middle piers are rigidly fixed to their diaphragm-wall foundations, while only the lateral ones are not restrained at their bottom, with the use of steel-teflon bearings.

Estimation of Compressive Strength of Trapezoidal-Shaped Ribs in Orthotropic Decks

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Abstract

Current provisions in the AASHTO LRFD Bridge Design Specifications permit that trapezoidal-shaped longitudinal stiffening ribs of orthotropic decks are designed as simply supported columns. The combination of global (column) and local (beam) effects on the ribs should be considered at the strength limit state. There is currently no provision stipulating a procedure for computing the load carrying strength of these ribs.

Results from recent experiments on trapezoidal-shaped ribs confirmed the importance of considering the continuity of ribs. The beam-column behavior of these ribs when subjected to simultaneous AASHTO truck wheel loads and axial compressive forces is practically identical to the column behavior of the ribs. From these results, a procedure by the sum of strength of parts (SSP) has been developed for estimating the load carrying strength of the ribs in the design stage.

Presented in this paper is the estimated compressive strength of the ribs of eight orthotropic decks in service. The buckling strength of the rib walls and the hypothetical yield strength of the column are compared. The estimated compressive strengths of the ribs are also compared with those of a finite element analysis. The estimated compressive strength of each rib is slightly below the strength by the finite element analysis, being on the conservative side.

Introduction

Longitudinal stiffening ribs of steel orthotropic decks are continuous components of the deck system. Trapezoidal-shaped ribs are most common in this country. These ribs are primarily subjected to compressive forces from the global action of the bridge deck and to bending moments from the local loads of the trucks on the deck.

International Orthotropic Bridge Conference 2008

The Slope Deflection Method for Orthotropic Plated Bridge Decks

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Abstract

Orthotropic plated bridge decks are highly sensitive to fatigue damage, due to the large amount of welded connections, the high patch loads and the large number of stress cycles. For highway bridges, the stiffener web to deck plate weld is often the determining fatigue detail for the deck design. This paper develops a detailed analytical model for the stresses in this detail, using the slope-deflection method. It models a cross-section of the deck plate, but incorporates the influence of the horizontal and vertical stiffness of the entire orthotropic plate as well as the torsional rigidity of the longitudinal stiffeners. This calculation method allows for the determination of all internal forces of the determining cross-section of the bridge deck.

Keywords: Orthotropic deck, Orthotropic bridge, Analytical method, Slope-deflection method, Stiffener to deck plate detail, Fatigue

1. Introduction

Orthotropic plated bridge decks consist of a complex network of longitudinal stiffeners, transversal stiffeners or crossbeams and the deck plate itself. Working as a whole, the deck plate takes part in the structural working of the overall bridge concept, which in its turn results in an extremely lightweight and durable bridge deck concept. Orthotropic plated bridge decks are nevertheless very sensitive to fatigue damage, because of the large number of welded connections in the deck (De Backer, 2006). This paper will focus on the stiffener to deck plate detail, halfway between the crossbeams in particular. This fatigue detail is especially important for highway bridges where the concentrated wheel loads of the heavy lorries will cause extremely high load cycles, often determining the fatigue behavior of the entire bridge deck (Wolchuk, 1963).

Analysis of Distress Characters and Design of Steel Orthotropic Bridge Decks Pavement in China

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Abstract

More than ten steel orthotropic bridges with long spans have been constructed in recent five years in China. But pavement distress will happen in about three years after opening to traffic for most of the steel orthotropic bridges. Rehabilitation and renovation mean high cost of economy and traffic function. The typical distresses of steel orthotropic bridge deck pavement are summarized and the distress causes are analyzed in aspects of pavement material, traffic load, temperature and steel deck structure. And a sample of the Humen Bridge in south China within whose steel orthotropic deck serious cracks have appeared is analyzed in details. The basic characters of polymer-modified asphalt (PMA), Guss asphalt and epoxy asphalt are studied through experiments. And the fatigue resistance and fatigue failure rule of the three types of pavement materials are studied and compared. The performance of the three types of pavement are surveyed and analyzed for typical steel orthotropic bridges. The optimization analysis of steel orthotropic bridge deck structure is made through the finite element method. The synthetic analysis of the design of steel orthotropic bridge deck and pavement is made including the factors of traffic load, deck structure, temperature, pavement material, bridge slope, construction and maintenance. Suggestions on steel orthotropic bridge deck and pavement design are given for different conditions.

Introduction

The orthotropic deck consists of a deck plate supported into mutually perpendicular directions by a system of transverse ‘crossbeams’ and longitudinal stiffeners. It may therefore be linked to a plate with dissimilar elastic properties in the two directions. Originally, the main stimulus for the development of orthotropic decks came from the need to rebuild various long-span bridges in Germany after World War II, against a

The five-point bending test: a way to the dimensioning of the asphalt layer on steel orthotropic decks

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Abstract

This paper deals with the evolving behavior of asphalt mixtures on steel orthotropic plate, such as the Millau viaduct in France, the highest bridge in the world. This is of great importance when dealing with durability: due to the softness of such a support, the asphalt pavement is subjected to considerable strain that may generate top-down cracks in the asphalt layer at right angles to the orthotropic plate stiffeners and shear cracks at the interface between asphalt and steel.

In response a five-point bending fatigue test to test the performance of asphalt surfacing materials being considered for application over orthotropic steel bridge decks was initially developed by the French Laboratoire des Ponts et Chaussées (LCPC) in the 70's. The test has been improved by work done at the ENTPE laboratory in 2003. . It is now the standard device in France for the design of the best asphalt mixture having a strong resistance to cracking.

The aim of our study is to obtain a continuous follow-up of our material performance throughout the fatigue test and to detect cracks through the asphalt. Displacement sensors will be used that can detect the initiation of cracks where cracks are likely to appear. Significant strain increases and decreases are observed when cracks are created and propagated in the thickness of the asphalt. A second innovative method has been developed: a non-destructive measurement technique based on ultrasonic measurements. A few precautions must be taken into account: P-wave (compression) and S-wave (shear) are used in transmission in a homogeneous area with an adequate excitation frequency. From velocities and amplitudes of waves and under the assumption of linear viscoelasticity, complex modulus M* and the time dependent evolution of damage are followed up. Results of displacement sensors and wave transducers are complementary. Nevertheless, ultrasonic waves give more information about the mechanical evolutionary behavior of the material. Finally, this test is modeled by means of *Comsol Multiphysics* software based on the finite elements method.

Keywords: five-point bending test, fatigue test, asphalt pavement, steel orthotropic plate, cracks, wave propagation, viscoelasticity.

International Orthotropic Bridge Conference 2008

Orthotropic Deck Design and Fabrication for Fatigue Recommendations from Research

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Abstract

There has been much research done on fatigue of orthotropic bridge decks this work has been carried out through full-scale tests, field measurements and modeling analysis all over the world over the past several decades. The research has led to better fatigue design and construction of orthotropic decks. This paper is intended to study the mechanism of orthotropic deck fatigue, learn the findings from existing research and recommend practical and cost-effective solutions to fatigue design and fabrication. The study will be based on research conducted in Japan (mainly) and in the US (some). The current design specifications for fatigue and fabrication practices are first introduced. More focus will be on the findings from large-scale fatigue tests (fixed-point fatigue load and running wheel fatigue load) and the solutions to avoid fatigue damage at each fatigue critical detail. The details verified by tests are of special interest for standardization of orthotropic deck design. Recommendations will be made for cost-effective fatigue design and fabrication.

Introduction

Orthotropic Steel Bridge Decks provide a great deal of advantage to long span, viaduct and movable bridges where dead load is an issue, such as for seismic zones, foundations in poor soil conditions and where lifting equipment limitations are an issue. However, design, fabrication, inspection and maintenance of orthotropic decks require more caution, labor and time, and eventually more cost due to their relatively low stiffness and numerous weld joints involved. Compared with other types of bridge decks, design and fabrication of orthotropic decks is a big challenge for engineers because of their complexity. Particularly, fatigue is a controlling factor for vehicle wheel loads act directly on the deck systems that are composed of thin plate elements. Generally, use of orthotropic decks is not a routine practice as is the use of concrete decks, but for special projects where other alternates may not be appropriate such as the conditions described previously they are a consideration.

The obstacles for bridge owners to use orthotropic decks may include: 1) High fabrication cost (automatic welding process; QC/QA; field welding etc.); 2) Previous unsuccessful examples; 3) High inspection cost due to numerous welded details and less qualified inspectors; 4) Long-term maintenance issue (corrosion; overlay etc.). Once fatigue cracking has developed, it is difficult to find and repair on site. Therefore, scrutinized

Fatigue Issues for Orthotropic Bridges

International Orthotropic Bridge Conference 2008

Fabrication Procedure Effects on Fatigue Resistance of Welded Joints in Steel Orthotropic Decks

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Abstract: A common practice for the fabrication of steel orthotropic bridge decks in the US is to use 80% partial joint penetration (PJP) groove welds between the closed ribs and deck plate. However, it is difficult to eliminate weld melt-through with the thin rib plates. Heat straightening after welding, sometimes combined with pre-cambering, is used to meet the deck plate flatness requirement. To study the effects of both weld melt-through and distortion control measures on the fatigue resistance of the rib-to-deck plate welded joint, six full-scale, two-span, orthotropic deck specimens were subjected to laboratory testing. Specimens, 10 m long and 3 m wide with four closed ribs, were fabricated with and without weld melt-through and were heat straightened; three specimens were also pre-cambered. To simulate the effect of repetitive truck traffic, each specimen was tested up to 8 million cycles. Test results showed that six cracks initiated from the weld toe outside the rib. Only one crack developed at the weld root inside the rib; this crack initiated from a location transitioning from the 80% to 100% PJP weld. None of the cracks propagated through the deck plate thickness. Pre-cambering was beneficial in fatigue resistance as two effectively pre-cambered specimens did not experience cracking in the PJP welds.

Introduction

Steel orthotropic deck systems have been widely used for long- and medium-span bridges due to overall light weight, expedient construction, large capacity for heavy loads, and structural redundancy, etc. Low dead weight is particularly important for long-span bridges and the span records recently achieved would not be possible without steel orthotropic decks (Wolchuk and Baker 2004). Despite their light weight and other excellent structural characteristics, steel orthotropic bridge decks have experienced a variety of fatigue problems resulting from high cyclic stresses in conjunction with inadequate welding details (Kaczinski et al. 1997, Bocchieri and Fisher 1998). One location that is prone to fatigue cracking is the cutout in the floor beam diaphragms (Connor and Fisher 2000, Machida et al. 2003, Tsakopoulos and Fisher 2003). Another location is the rib-to-deck welded joints (Gurney 1992, Xiao et al. 2005, Miki 2006). Longitudinal ribs welded to the deck plate can be either open ribs or closed ribs. Decks with closed ribs are preferred

Bending fatigue tests on trough to deck welded details of orthotropic steel deck

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ABSTRACT

Fatigue cracks have been found in deck plates from weld roots of the welded joints between trough ribs and deck plates in orthotropic steel bridge decks in some heavily loaded highways in Japan. Such cracks have received much attention as one of prioritized research topics in steel bridge maintenance field. Many research projects on the matter are underway. In this study, bending fatigue tests were carried out on 300mm wide specimens, which modeled the trough to deck plate welded details of commonly used orthotropic steel decks in Japan, to investigate the fatigue behaviors and fatigue strength of welded details. The test specimen is composed of a main plate subjected to bending stress and a rib or a full U rib. The main plate is 12 and 14 mm thick; the rib is 6 or 8 mm thick. The fatigue test results presented in the S-N diagram are also compared to previous test data and the prediction using one-millimeter stress method. Moreover, how to use the test results for fatigue durability evaluation of orthotropic steel deck is also discussed.

Key words: bending fatigue tests, orthotropic steel deck, fatigue crack, fatigue strength

1. Introduction

Recently, fatigue cracks have been found in the welded joints between trough ribs and deck plates in orthotropic steel bridge decks in heavily loaded highways in Japan

Fatigue Behaviors of Cutout at Crossbeam of Trapezoidal Rib Orthotropic Deck

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Abstract

Fatigue problems in steel bridges have been investigated for a long time by structural engineers; the same problems in orthotropic steel bridges were discovered in the late of last century. The intersections between deck plate, crossbeam, and longitudinal rib are very sensitive elements where fatigue cracking can occur. Among these, the connection between crossbeam and longitudinal rib, and especially the cutout at the crossbeam for longitudinal rib traversing, are susceptible to fatigue cracks due to high stress concentrations. In this paper the influence of cutout shape and loading location to the trapezoidal rib orthotropic deck are highlighted. At this stage of the research stress analysis via finite element is the main investigation for fatigue, and effective stress range of orthotropic deck, applied to S-N curve, is analyzed based on static analysis. The results of the analysis can contribute to an evaluation of the service life to the orthotropic deck design.

Keyword: fatigue analysis; cutout; numerical modeling; orthotropic deck

Introduction

Fatigue failure in steel bridges has been investigated intensively in the last decades, especially in Europe (BS5400, 1980) and the United States (Fisher, 1984). In recent years, fatigue cracks and failures in orthotropic deck have stimulated researchers to investigate fatigue behavior of steel bridges (Wolchuk, 1990; Camo, 2004). The structure of an orthotropic deck, and also the corresponding structural behavior, are very different compared to the traditional bridge deck. The orthotropic deck is composed of flat deck plates, crossbeams and ribs of different shape. The concentration of the stress in the connections between deck plate, crossbeam, and longitudinal rib together to the cycling loads until reach fatigue level stress, can

Fatigue Life Prediction of U-rib to Crossbeam Joints Using Fracture Mechanics Approach

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Abstract

The propagation life of orthotropic steel deck specimens is evaluated under mode I and mixed-mode conditions. Crack growth analysis is carried out by stress intensity factor and strain energy density factor. The stress intensity factor is computed by numerical extrapolation, introducing cracks in the sub-models. Fixed values of crack growth parameters are used for single simulations as well as parametric studies for sensitivity analysis. The propagation under the condition of mixed mode was slower than that of mode I. Material properties had great influence on fatigue life prediction.

1. Introduction

Fatigue fracture of structures under mixed-mode loading conditions has drawn special attention due to its close proximity to realistic conditions in engineering structures. In addition, fracture toughness values determined by standard fracture testing procedures are typically for tensile loading, or pure mode I. Therefore, development of a crack growth criterion and test data under mixed-mode conditions is important and necessary for potential structural applications. The angled crack problem has been given special attention by fracture mechanics investigators [1-5].

The maximum tensile stress criterion [6] and the minimum strain energy density criterion [7] are still commonly used for prediction of crack propagation. Despite the fact that these two criteria have their differences and individual weakness, they are applied in the same manner by employing an idealized continuum condition.

In this study, the propagation life of orthotropic steel deck specimens is evaluated under pure-mode and mixed-mode loading conditions. Crack growth analysis is carried out by stress intensity factor and strain energy density factor. The stress intensity factors are computed by numerical extrapolation, introducing cracks in the sub-models. Fixed values of crack growth parameters are used for single simulations as well as parametric studies for sensitivity analysis.

Lifetime Evaluation of Orthotropic Steel Bridge Decks

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Abstract

The fatigue performance of orthotropic steel bridge decks depends on the magnitude and number of stress cycles applied, and the deck details. The stress induced in a deck plate will be reduced by the presence of a stiff surfacing material. This paper describes how the likely fatigue lifetime of an orthotropic steel bridge deck with asphalt surfacings could be estimated using probabilistic assessment methodology. In particular, the daily variations in temperature, which affect the asphalt surfacings, are considered. An example of application of the methodology to a realistic bridge is described.

Introduction

Orthotropic steel bridge decks have been selected in the design of long-span steel bridges because of their favourable characteristics of having a high longitudinal stiffness, their light weight nature and short installation times. Two basic types of longitudinal ribs are used; open ribs, and closed ribs of a trapezoidal or rounded cross section. The closed ribs are more commonly used than the open ribs because open ribs are less torsionally rigid and require more welding. Fatigue cracks, however, have often developed at welded connections in orthotropic steel bridges with closed ribs due to the high number of high magnitude axle loads. Many relevant investigations have been conducted internationally (e.g. Wolchuk 1990; Beamish et al. 2006; Jong 2006; Miki 2006; Kolstein 2007; Sugioka et al. 2007). Six locations of fatigue cracks have been identified: (1) at the welded joint between the deck plate and the longitudinal rib between the crossbeams; (2) at the welded joint between the deck plate and the longitudinal rib at the crossbeam; (3) at the longitudinal rib splice welded joint; (4) at the welded joint between the longitudinal rib and the crossbeam; (5) at the welded joint between vertical stiffener and deck plate; and (6) at the butt

Review of the fatigue behaviors and finite element analysis of orthotropic steel bridge decks

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Abstract

Orthotropic steel bridge deck is a popular deck type in the world and widely used in steel bridges. However, it is prone to fatigue. Fatigue cracks have been found in many bridges. The complex details of orthotropic deck suffer from fatigue cracks, and the rehabilitation expenses are very high. Foreign researchers have done much beneficial work, but there is still much further work to be done. In recent years, China applied orthotropic decks in their newly constructed long-span cable-supported bridges. For insufficient cognition of fatigue problems, fatigue cracks were found immediately in early constructed bridges when they are open to traffic for several years. In addition, fatigue problems are prominent in Chinese steel decks for more oversize and overload trucks, and China should do more research on fatigue behaviors of the orthotropic steel decks. This paper presents a review of the fatigue behaviors of orthotropic steel bridge decks. The classifications of main details, fatigue research methods, along with the rehabilitation methods of details also have been focused in current paper. Then a typical steel box girder stiffened by orthotropic deck is simulated using finite element method, the effects of different dimension varieties for the fatigue details are investigated. Finally, based on finite element analysis results, general conclusions are made along with recommendations for the fatigue design of orthotropic steel decks.

Keywords: orthotropic steel deck; fatigue details; finite element method

Orthotropic Bridge Research

THE EFFECT OF STIFFENER DISTORTION OF ORTHOTROPIC BRIDGE DECKS ON LOAD DISPERSAL BEHAVIOR AND STRESS CONCENTRATIONS

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1 INTRODUCTION

Modern design of orthotropic bridge decks aims for higher and more slender longitudinal stiffeners. Because of this and due to the use of low plate thickness, a large part of the torsional rigidity of the closed section stiffeners is lost by distortion. This profile distortion has two important implications. First, the reduction of torsional rigidity creates a drastic reduction of the load dispersal in the orthotropic plated deck. Second, the distortional deformations, partially restrained at the connection with the floor beams foreseen with web cut-outs, results in large stress concentrations in the rib wall, which can result in fatigue cracking.
Research has been initiated on this subject. The aim is to develop an analytical method to calculate the stress singularities at the connection with the floor beam, besides aiming at conceptual recommendations for distortion free orthotropic plates. Therefore an analytical model is necessary which describes the distributions of the forces and in an orthotropic deck in relation to the deformations. This project also includes the development of a fully parameterized finite element model and the building of a test site where an orthotropic deck can be tested under actual traffic load.

2 STIFFENER – FLOORBEAM CONNECTION

The intersection of such closed stiffeners, generally of trapezoidal cross-section, with the transverse floor beams must be such that the longitudinal stiffeners pass continuously through the floor beam. For this, two possible solutions exist: the connection can be made either welded completely along its edge, or alternatively, an additional web cut-out can be foreseen in the floor beam web. This last arrangement relieves the longitudinally stressed stiffener soffit of early fatigue failure, since the stress variations at the connection edge point are substantially lower compared to those at the stiffener soffit.

Experimental Study on Durability of Orthotropic Steel Decks and Deckplate Thickness

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Abstract

Orthotropic steel decks (OSD) are widely applied in Japan for the purpose of seismic resistance, span length, reduction of construction costs etc. because they allow the reduction of dead load.

Japan is an archipelagic country, metropolitan and industrial areas have been developed in the narrow plains along coasts. Within these areas there is a lot of traffic including high percentages of heavy commercial vehicles on the roads. Many of these coastal plain areas feature the soft ground found in deltas, alluvial fans or reclaimed ground, OSD are often used in order to reduce the dead load for bridges on the arterial road network. Since the 60's the number of applications of OSD in Japan has increased. At the outset of their use in the 60's, OSD features were primarily open cross sections with valve plates or flat bars. Around 1975, OSD with U-shaped ribs, were introduced, which seems reasonable because they are comparatively rigid for their weight.. In recent years, most of the OSDs are stiffened with U-shaped ribs.

Fatigue damage of OSD is often observed in Japan. Especially, in scallops at cross sections between ribs and transverse ribs, and fillet welds between U-shaped ribs and deck plates, many cracks were observed through inspection and then repaired.

Field Investigations and Measurements of Orthotropic Steel Decks to Draft Efficient Method of Stock Management

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***Keyword**: Orthotropic Steel Decks, Field Investigation, Fatigue Cracks*

Abstract

This study intended to find ways to develop screening and investigation methods of orthotropic steel decks. We conducted four steps of investigations: (1) Desktop study; (2) Simple investigation; (3) Inside-of-girder investigation; and (4) Detailed investigation and stress measurement. Then verify the tendency of fatigue damage, and organizing the relationship of pavement failure and steel deck fatigue damage. In addition, the relationship between fatigue damage, service life and heavy vehicle traffic volume are shown.

Introduction

In Japan, we have more stocks of orthotropic steel decks than the other countries in the world, because orthotropic steel decks often are adopted for bridges in the soft ground area or urban area where they are limited by the height of girders or the weight of bridges. In recent years, there have been reports of fatigue damage to 20 year or older orthotropic steel deck bridges on heavy-traffic roads [Miki, 2007]. The reported cases include cases of fatigue damage

Field Measurement and Development of an Experimental System for Fatigue-Cracking from Weld Roots between Deck Plate and U-rib in Orthotropic Steel Decks

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***Keyword**: Field Measurement, Actual Stress, Fatigue Test, Experimental System*

Abstract

Recently, fatigue cracks have been observed at weld joints between deck plates and U-ribs in orthotropic steel decks after about 30 years of service in Japan. Some of these cracks, so -called "root cracks", initiate from the weld roots and then propagate through thickness of deck plate. Root cracks may be a threat to traffic safety, moreover they can not be observed by visual inspection. However, fatigue behavior of root cracks has not yet been efficiently clarified.

In this study, we developed a new type of the experimental system focusing on root cracks. The characteristics of the system enable us to examine fatigue behavior of them in parametric with the smaller specimens of orthotropic steel deck. Static tests and fatigue tests were carried out by using the system considering dispersion of traffic wheel loads by asphalt pavement and actual stress wave obtained from the results of field measurement at the orthotropic steel deck in which the root cracks had been observed.

Fatigue cracks at M1 Bridge

Outline of the target bridge; M1 Bridge consists of 2 simple box girder bridges and 1 continuous 3-spans box girder bridge with orthotropic steel decks (**Fig.1**). The total bridge length is 405.8m. M1 Bridge is located in the heavy traffic route in Tokyo Metro bay area, and it opened

Wearing Surfaces on Orthotropic Bridges

Research on Steel Fiber Reinforced Concrete Pavement on Orthotropic Steel Deck

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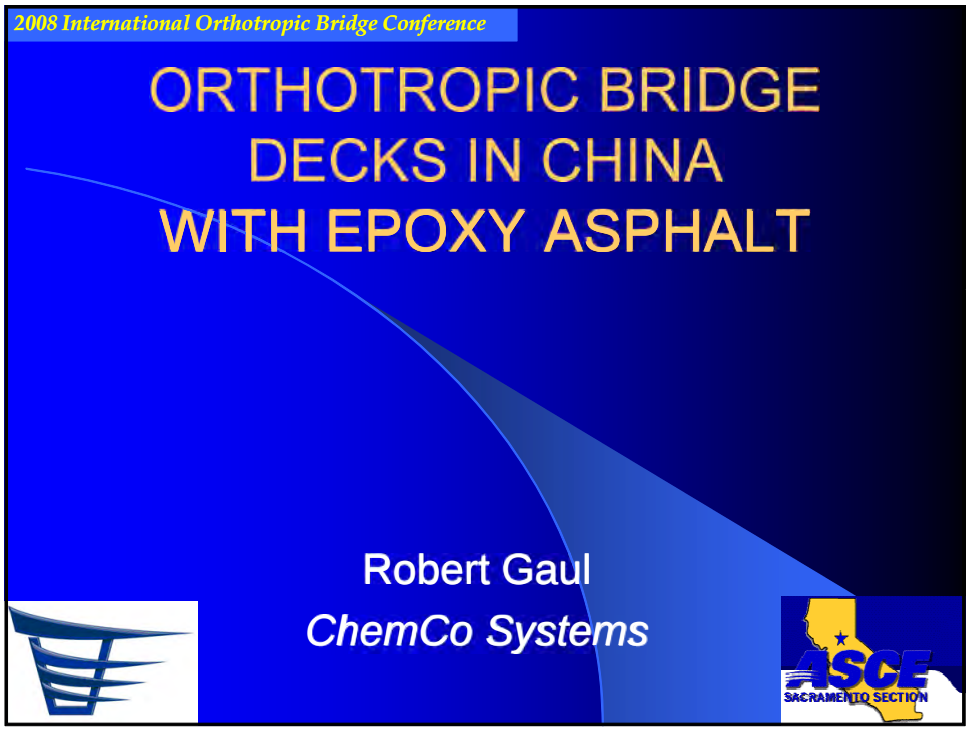
***Keyword**: SFRC, Pavement, Fatigue Crack, Deck Plate, Trough Rib, Epoxy Adhesive, Wheel Running Test*

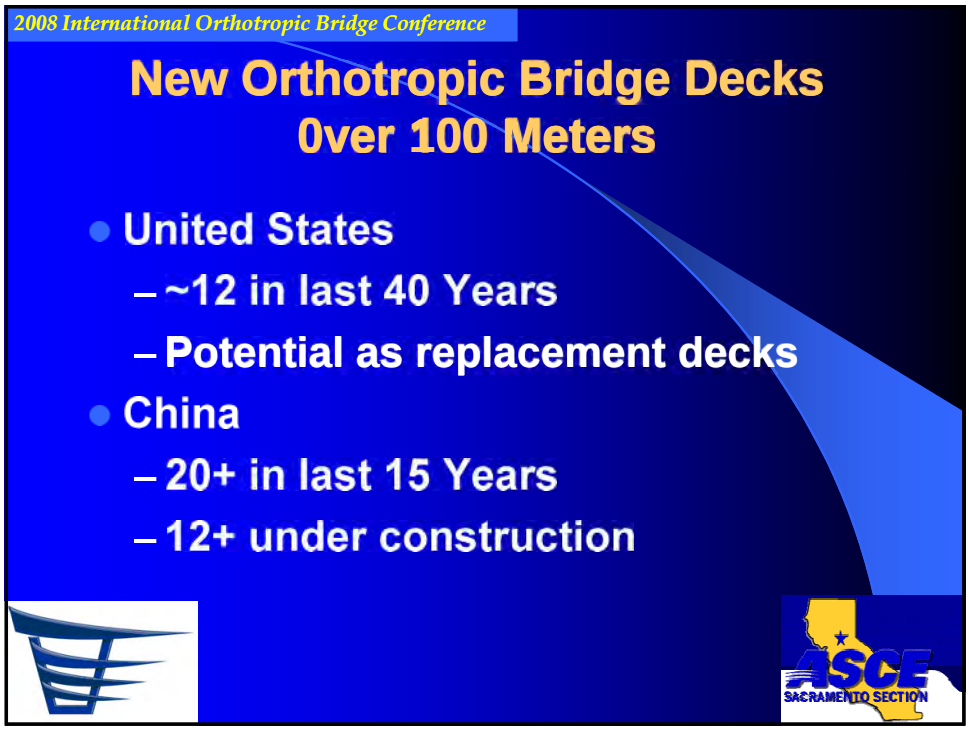
Abstract

In order to reinforce Orthotropic Steel Deck (OSD) against fatigue, Steel Fiber Reinforced Concrete (SFRC) pavement has been researched. Stress at root of trough rib weld is reduced by SFRC pavement because it eases local bending of the deck plate by composite action to the deck. One of concerns is durability of SFRC, especially its cracked area above locations of web plate of OSD. PWRI has been conducting wheel running tests to evaluate fatigue durability of SFRC pavement by using real size specimen. Influences of cracks and water are taken into account for the test, but decrease of tensile strength of the pavement was not observed after 2 million times of wheel running whose second half was in wet condition.

Overview of the research

Many fatigue cracks are observed on existing OSD[1)]. Among them, cracks that occur around four types of structural details in Figure 1 are chosen for the author's research objects because of their numbers and urgency for safety. Several repair/reinforce methods dealing with those cracks are being investigated, which can be categorized in two ways; one is mainly using steel attachments, the other is utilizing composite action by rigid pavement such as SFRC that is stiffer than asphalt. The composite action is expected to ease local bending of deck plate as shown in


2008 International Orthotropic Bridge Conference
ORTHOTROPIC BRIDGE DECKS IN CHINA WITH EPOXY ASPHALT
Robert Gaul
ChemCo Systems
ASCE
SACRAMENTO SECTION


2008 International Orthotropic Bridge Conference
New Orthotropic Bridge Decks Over 100 Meters
United States
~12 in last 40 Years
Potential as replacement decks
China
20+ in last 15 Years
12+ under construction
ASCE
SACRAMENTO SECTION

Reduction of traffic induced stresses using reinforced high strength concrete

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Abstract

Since the first occurrence of fatigue cracks in the trough to deck plate joint of steel orthotropic bridge decks in the Netherlands, two corrective measures with relatively high impact are applied. In the case of movable bridges, having limited possibility to increase the weight, the plate is replaced by a thicker steel plate.
The asphalt surfacing on fixed bridges is replaced by a reinforced high strength concrete (RHPC) system. The development and application as a first pilot project on the Caland Bridge in the harbor area of Rotterdam has been reported during the Orthotropic Bridge Conference in 2004. Since than more applications of this renovation technique have been carried out on fixed bridges in the Netherlands. Stress spectra measurements and stress measurements using a calibrated truck have been performed on the Moerdijk bridge (28.000 m^2), both before and after the application of the RHPC system in order to check if the prediction models based on FEM simulations and laboratory tests are correct. The results of these stress measurements are reported in the paper. Considerable reduction of local bending stresses in the deck plate due to the replacement of mastic asphalt with RHPC was found, which is in accordance with the expectations. This stress reduction leads to a significant lifetime enhancement of the deck plate structure. The paper ends with an interpretation of the measured stress reductions in relation to the lifetime enhancement of the bridge deck.

The Planning and Design of Gwangyang Suspension Bridge with Epoxy Asphalt in Korea

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ABSTRACT

This paper describes the features of structural design including planning and detail design of a suspension bridge connecting Myodo Island and Gwangyang City in Korea.

This bridge is under construction now in the third section of approach road of Yeosu National Industrial Complex from 2007 to 2012. The total length of bridge is 2,260 m with center span of 1,545 m. The bridge has the floating-type stiffening girder which has no vertical supporting points at the pylon. The height of the Pylons is 270 m and sag ratio is 1/9. The bridge is designed to allow the passage of 18,000TEU-class vessels service, reduce risk of ship collision, diminish size of anchorages, and reduce construction cost. The choice of longer than 1500 m of center span length was inevitable with regard to the navigation channel, wind climate, construction cost, and requirements to improve the technical level of the structural components applied to date for existing suspension bridge systems.

We performed a thorough investigation of not only previous applied designs and construction methods, but also recent advanced designs and construction methods. By introducing twin orthotropic box girders, the aerodynamic stability of the whole bridge could be guaranteed. In addition, the most optimized section type of twin box girder suppressing the vortex shedding vibration and minimizing the drag force coefficient could be found through wind tunnel tests.

We choose Epoxy Asphalt for pavement to reduce the dead loads on the bridge, which requires only 5 cm of pavement compared to 8 cm of regular pavement systems. By adopting Epoxy Asphalt, we not only reduced 7 % of cable weight but also save on maintenance costs. Additionally, we adopted 1,860 MPa high-tensile strength wire for the main cables.

DESIGN OF A DECK SURFACING FOR THE LONGEST CABLE－STAYED BRIDGE IN THE WORLD：THE SUTONG BRIDGE

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Abstract

The behavior of bituminous surfacings on steel orthotropic decks under heavy truck traffic and environmental conditions is highly complex. Because of the geometry of the structure, fatigue failure often occurs in the wearing course just above the webs of main girder or longitudinal ribs under repeated traffic loading. Furthermore, interfacial dis-bonding between the wearing course and underlying steel plate has been experienced. The design of a bituminous wearing surface on Sutong Bridge -the longest cable-stayed bridge in the world is presented. The design process was divided into three parts: analysis of service condition, a finite element study and laboratory tests. The results shows that Sutong Bridge will endure the ambient temperature of -15~+70C and increasing heavy truck traffic. A finite element model of box-girder and wearing surfacing was established for calculating stresses and strains. The performances of two types of Epoxy Asphalt were compared, and strength between overlay and steel deck are tested. Finally, composite beam fatigue tests show that excellent fatigue resistant of deck surfacing can be achieved when the designed Epoxy Asphalt Mixture and Epoxy Asphalt Bond Coat are used.

Key words: orthotropic steel bridge deck, bituminous surfacing, Epoxy Asphalt, finite element analysis, composite beam fatigue test, Sutong Bridge

IMPORTANCE OF INTERFACE LAYER ON BEHAVIOUR AND DURABILITY OF ORTHOTROPIC STEEL DECKS

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Abstract

Deck plates of orthotropic steel bridges experienced early and threatening fatigue cracks at the heavy vehicle lane. Previous research developed a new stiffer surface layer for renovations of the fixed bridges based on reinforced high performance concrete. The study presented in this paper focuses on a possible renovation system for movable bridges in which a second steel plate is added to the existing bridge deck. The properties and durability of the interface layer between the two steel plates strongly influence the response and efficiency of the structure. The study focuses on two solutions, a thin epoxy layer namely Bonded Steel Plates and thick polyurethane layer namely Sandwich Steel Plates. Structural calculations were carried out based on analytical solutions using Classical Laminate Plate Theory and First order shear Deformation plate Theory. The different parameters of the renovations structures were varied and the results for the two solutions are compared. Based on the weight restrictions and geometrical properties of the existence deck plate, one can choose the most efficient interface layer from the material available, i.e., the lightweight structure solution that provides the increase of stiffness required for the renovation.

Introduction

Recently, orthotropic steel bridges experienced some early fatigue failures of several welded connections in the steel deck plate. The most threatening cracks initiated at the welded connection between the trough web and the deck plate. These fatigue cracks are located at the crossbeam and grow through the thickness of the steel deck plate. They are caused by the cyclic loading of the axles of heavy vehicles in the heavy vehicle lane

Concrete overlays to improve the fatigue life of movable orthotropic steel bridges

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Abstract

Orthotropic steel bridges are subjected to severe fatigue loading by increased traffic, both in terms of number of loads and their magnitude. Replacing the wearing course by a 50 mm heavily reinforced high strength concrete overlay is a measure that has proven to be successful in reducing fatigue stresses in the steel. Movable steel bridges are provided with such a relatively lightweight wearing course that application of a concrete overlay is only an option when its thickness is considerably reduced, down to 20-25 mm. Traditional steel bar reinforcement will then have a too small concrete cover to prevent the steel from corroding. Alternatives might be the use of carbon fiber or stainless steel (6 mm) bars.

The bending stiffness of the combined 12 mm steel deck plate and 20-25 mm reinforced concrete composite structure was tested. The results provided information on how to calculate the stresses in the steel deck plate and the reinforcement bar in a cracked cross-section. The static bar-concrete bond strength and the minimum concrete cover required to prevent concrete cover splitting induced bond failure were investigated.

The 20 mm overlay was also tested in fatigue, the stresses occurring based on Eurocode loading and simulated in four-point bending tests. The calculation model developed from the static test results was used to calculate stress ranges. The fatigue curves of the materials used were defined and extended service life predictions were carried out.

Introduction

In 1998, the Civil Engineering Division of the Dutch Ministry of Transport, Public Works and Water Management formed a special task force to investigate the causes of damage to the deck plates of steel orthotropic bridges. This action was taken because of the premature failure of the replaced, only 7 years old movable part of the Brienenoord Bridge, a bridge in one of the busiest Dutch motorways. Figures 1 and 2 present a view of this type of bridge and characteristic damage to the deck plate [1]. The research carried out demonstrated that the service life of orthotropic bridges can be considerably

Title: Alternative Waterproofing System & Wearing Course on Orthotropic Bridge Decks and Approaches.

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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 very cost effective one-step solution as a waterproofing system combined with a superior wearing surface that will not rut or shove and can be installed if far less time than any Epoxy system, or torch/spray applied systems saving tremendous dollars on each project installation.

Performance testing of the Rosphalt material as compared to alternate waterproofing systems used on Bridge Decks has proved to provide solutions that can expedite the construction process saving both time and money. Typical systems that Rosphalt can be compared to both from a performance, life cycle and time saving vantage are Epoxy overlay systems, Epoxy asphalt, HMA with TLA or any torch/spray applied systems.

Examples of Bridge rehabilitation projects undertaken in New Brunswick Canada (Orthotropic), and most recently lanes 2 & 4 on the Upper deck of the George Washington Bridge (GWB) which had all of its Truck traffic moved to the upper deck after 9/11.

Orthotropic bridge decks are unique and are approached independently. Longs Creek (New Brunswick, Canada) 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 a 1 inch wearing surface. Hawkshaw New Brunswick) also required two lifts due to the rivet design however offered more challenges due to sharp left banks and grade level approaching 4 percent. The main focus of this paper will be on Performance evaluation of materials for use on the George Washington Bridge in New York City.

Rosphalt has over twenty years of history for successful applications. Independent studies from a variety of State DOT's, agencies such as Massport, and studies from Technology centers such as WPI (Worchester Polytechnical Institute), Georgia Institute of Technology, Rutgers University and PRI Asphalt Technology have proven Rosphalt to be one of the best long term cost effective solutions on the market today.

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Application of Reinforced High Performance Concrete Overlays on Orthotropic Steel Bridge Decks - theory and practice.

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Abstract

The first applications of the Reinforced High Performance Concrete Overlay (RHPC overlay) were in cargo ships, multi-storey car parks and APRONS. Thanks to several modifications and more knowledge acquired on the functioning of the reinforcement, the RHPC overlay became a very successful “problem solver” for industrial floors. The RHPC overlay has been applied on sub bases constructed from a wide range of different materials; sometimes the sub base was even extremely deteriorated and/or cracked or structurally under-dimensioned. Even though these solutions were applied on a large scale and performed well, they didn’t get as much attention as the recent applications in which the RHPC overlay is used to re-strengthen infrastructural structures like orthotropic steel bridge decks and concrete viaducts. After a large research project of 6 years including a pilot project and the application on two large orthotropic steel bridge decks it is concluded in The Netherlands that the RHPC overlay is, up to now, the only good and durable solution (besides replacement of the whole bridge) to re-strengthen orthotropic steel bridge decks that suffer from fatigue cracks in the deck plate. The development of the RHPC overlay, its characteristics and properties and the execution of the pilot project have been reported during the Orthotropic Bridge Conference in 2004 by several authors from the Netherlands [Buitelaar, P. *et al* 2004, De Jong, F.B.P. *et al* 2004]. In 2005 -2008 the RHPC overlay was applied in four phases on two large orthotropic bridge decks, the Moerdijk bridge (32,000 m^2) and the Hagenstein bridges (8,400 m^2), both in the Netherlands. This paper reports about the practical applicability of the RHPC overlay on large bridge decks, including the problems faced during and after placing, the details, quality control and gives an overview of the results. The reduction of the

Wearing course influence on the orthotropic steel bridge deck behavior from numerical simulations of the five-point bending test

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Abstract

The structural role of the wearing courses on orthotropic steel deck bridges is usually not estimated during the design process. Both geometry of the structure and very high flexibility of steel plates induce severe stress and strain fields in the steel bridge surfacing.
In this paper, we quantify the influence of a bituminous mix surfacing on the steel plate response when considering the French five-point bending fatigue test. Mechanical behavior of bituminous mixes is very complex. It includes a great thermal sensitivity. Moreover in the small strain domain (for strain amplitudes below about 10-4) the behavior can be considered as linear. Therefore, the theory of linear viscoelasticity can be applied. After introducing the French five-point bending fatigue test used at the research center of “EIFFAGE Travaux Publics” company, in parallel to the construction of the Millau Viaduct (France) –the highest bridge in the world–, a numerical parametric study using the Finite Element Method (FEM) is presented. The specimens are made of a 12-mm-thick steel plate, a 3-mm-thick sealing sheet and a 60-mm-thick bituminous mix. Different wearing course behaviors are considered introducing temperature and viscous effects. This behavior is modeled using the linear part of the general thermo-viscoplastic model « DBN » (Di Benedetto and Neifar), recently developed at ENTPE laboratory and briefly described in this paper. An important observation is that the rigidity of the intermediate bituminous sealing sheet as well as the wearing course behavior seem to have a great influence on the orthotropic multilayer specimen complex behavior.

Key Words: orthotropic steel bridges deck, bituminous mix, French five-point bending test, viscoelasticity, FEM, bituminous sealing sheet

Maintenance and Rehabilitation of Orthotropic Bridges

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Nondestructive Evaluation of Fatigue Cracks in Steel Bridges by Infrared Thermography

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Abstract

A new remote nondestructive inspection technique, based on thermoelastic temperature measurement by infrared thermography, was developed for evaluation of fatigue cracks propagated from welded joints in steel bridges. Fatigue cracks were detected from localized thermoelastic temperature changes at crack tips due to stress singularities under wheel loading from traffic on the bridge. Self-reference lock-in data processing techniques were developed for the improvement of signal/noise ratio of the thermal images in the crack detection process. Thermoelastic stress analyses in the vicinity of crack tips were carried out, after the crack detection process by the self-reference lock-in thermography. Stress distributions under wheel loading by the traffic was measured by the infrared thermography. Stress intensity factors K_{I} and K_{II} were obtained from the measured stress distribution. It was found that these fracture mechanics parameters can be evaluated with reasonable accuracy by the proposed technique. It gave us the guide for the assessment of the exigency of repair or the evaluation of the remaining life based on the crack propagation rate.

1. Introduction

In recent years, fatigue crack propagations in aged steel structures have become serious problems which might lead to catastrophic failures of the structures. For large-scale steel structures such as steel decks in steel bridges, non-destructive inspection for possible aged deteriorations and fatigue damage are indispensable for securing their safety and for estimating their remaining lives. Thermoelastic stress measurement using infrared thermography has been getting an increased attention as

A NEW REHABILITATION METHOD FOR INSIDE CORROSION OF STIFFENERS WITH HOLLOW SHAPE

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1 Introduction

Bridges with orthotropic steel decks have been built since 1950. Therefore a considerable amount of these bridges are now older than 30 years. During the last decades traffic loads have significantly been raised in almost all countries. As a result of this, fatigue cracks occurred in several bridges.
A very critical detail is the stiffener to deck joint. Orthotropic steel decks of road bridges usually have closed stiffeners. If cracks occur in these welds, water may get into the hollow section. Since there is no corrosion protection, the invisible corrosion process may then increase rapidly.
This paper presents a new rehabilitation method for these stiffeners with inside corrosion by installing a circular woven fabric inside the hollow section.

2 Inside Corrosion of stiffeners with hollow shape

Bridges in Germany with orthotropic steel deck. Since the mid Fifties steel bridges with orthotropic decks have been built in Germany. Figure 1 shows the typical construction of this kind of steel bridges. In the following decades this kind of construction experienced a rapid development in Germany as well as in other countries. Mainly major bridges have been built as a steel construction with orthotropic deck. Just in Germany more than 25 bridges with orthotropic deck and a length exceeding 500 meters have been built between the years 1954 and 1978. Nowadays about 3000 bridges of this type are in use.
For stiffening the deck plate longitudinal webs of different shapes have been used (see Figure 2). Open sections are mainly used for railway bridges (section 5) or pedestrian bridges (section 5 and 6). For road bridges, representing the prevailing

Counter Measures against Fatigue Cracks on Orthotropic Bridge Decks of Tokyo Metropolitan Expressways

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Abstract

In recent years, approximately 6,000 cracks have been found on 1,200 spans of orthotropic steel decks in the Metropolitan Expressway network in the greater Tokyo Area. Some of those cracks have been found penetrating deck plates. These cracks are now being repaired, and Steel Fiber Reinforced Concrete is being applied partly on orthotropic steel decks in order to reduce the stress levels in the decks caused by heavy traffic loads. Meanwhile, a new detail of orthotropic bridge decks has been devised for new bridge projects. Additionally, a new type composite deck has been developed in Metropolitan Expressway Co., Ltd. and experimentally employed on a part of a new viaduct.

Introduction

Since the first route of the Metropolitan Expressway Network was constructed in 1962, the network has extended to 293.5km by 2008. The number of vehicles using the Metropolitan Expressway amounts to approximately 1.14 million per day, which comprises 9% of heavy-duty cargo vehicles. Approximately 76 % of the expressways consist of elevated structures, approximately 84% of which are steel structures. Light weight orthotropic steel decks are used in approximately 1,200 spans with a total length of approximately 25km, which are mainly constructed in water front areas with soft ground (See Figure 1).

Fatigue Cracks in Orthotropic Steel Decks

In recent years, approximately 6,000 fatigue cracks have been found in orthotropic steel decks. As shown in Table 1, about two-thirds of orthotropic steel decks with trough ribs which were built more than 10 years ago have fatigue cracks. Most of

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HAZARD CLASSIFICATION FOR ORTHOTROPIC PLATES AND SUSTAINABLE REPAIR METHOD USING STEEL-ELASTOMER-STEEL SANDWICH (SPS)

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Abstract

The development of orthotropic plates on their way from the first application to the present standard solution has produced some variations with a particular sensitivity to fatigue. Within a recent study [i] this development has been examined and cracking hazards due to fatigue of the orthotropic plate have been systemized and classified.
For the important task of developing a standard solution for new bridges, but also considering solutions for fatigue in existing bridge decks, in particular the durability of the deck plate and of its welded connection to the stiffeners is the key problem. To reduce the fatigue loading of the deck plate there are two basic possibilities: to reinforce the deck plate directly or to enhance the efficiency of the asphalt layer to improve its composite action with the deck plate.
Among the various methods to reinforce the deck plate directly the strengthening by a steel-elastomer-sandwich (SPS) has proved to be extremely effective. This SPS (Sandwich Plate System) is a sandwich structure composed of two steel plates (the existing deck plate is the bottom skin, and an additional new deck plate is used for the top skin) with a core of solid polymer (polyurethane). Initially developed as a technique for the refurbishment of steel decks of Roll-on-Roll-off ferry ships, now it has been also applied as a refurbishment procedure for steel decks of bridges. Supported by various theoretical analyses and a fundamental set of laboratory tests with regard to durability, thermal characteristics and local bearing capacity the practical applicability of SPS has been proven successfully in pilot projects for railway bridges as well as highway bridges under severe traffic.

A new Procedure and device for the examination of Stiffeners with hollow shape

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1. Introduction

Orthotropic steel decks of road bridges usually have closed stiffeners with hollow shape. If a crack occurs in these joints, water can come in the initial closed stiffener. As the inside has no protection, the invisible corrosion process can increase very fast. Bridge inspectors have in the past only visual inspection of the exteriors of the Stiffeners performed. During a routine repair of the Highway Bridge “Rader Insel” in Germany the inspectors found out, that the thickness of the stiffener was locally reduced from 6 mm to 3.8 mm caused by water and thawing salt, which seeped in through the cracked welds.

This paper presents a new Procedure and device for the examination of Stiffeners with hollow shape.

2. Current Technology in the Inspection of Steel Bridges

The Gauging of Blank Thickness
Next to the mentioned visual, in the past, inspections of the hollow shape were already gauging the blank thickness of vertical rips from steel bridges through acoustic discharge measurement or through the measurements of the eddy current procedure. With the eddy current method through a conductor, which creates a changing magnetic field, they induce eddy currents into the material that has been researched. This testing method takes advantage of the effect that most of the vitiation and damages in electric conductible material also has a different electrical conductibility than the actual material. Based on the vast measuring tolerance this procedure is often disputed and is rarely used.

The acoustic discharge measurement of blank thickness is in contrast to this. It is a well-established alternative to gauge blank thickness. There is an adequate number of easily handled equipment on the gauging technique market. The measurement happens from the outside. This means access to the hollow shape is necessary.

Redecking Issues for the Walt Whitman Bridge

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INTRODUCTION

The Walt Whitman Bridge is a supension bridge that spans 3540 ft from anchorage to anchorage. It was erected in 1957 with a concrete filled grid deck spanning transversely over 18WFx50 stringers, which are spaced at approximately 5 ft on center [2]. Recent inspections have indicated that the existing deck should be replaced. Also, inspection of the cable wires and subsequent analyses indicated that, because of cable wire corrrosion, the cable safety factor had been reduced by 15 % to a value of 2.34. Although the reliability of the cables is still very high, issues of deck weight play a significant part in decision making for this redecking project. The options seen as suitable for redecking are: a) a concrete filled grid deck, with improved stringer framing features; and b) a jointless orthotropic deck, spannning continuously over floor trusses spaced at 20ft -2 in on center. Aside from the deck weight issue, facts that bear on the results of life cycles costs are a) the relatively lower initial cost of the filled grid deck; b) the recent volatility of prices of steel plate; c) the expected life of each of the alternates; and d) maintenance costs expected for each alternate, including that of the wearing surface on each alternate.

ISSUES AND CONSTRUCTION PARAMETERS

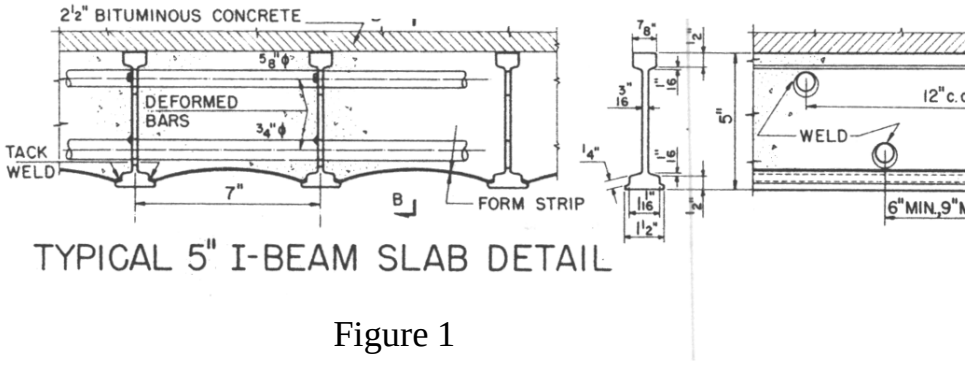

Figure 1

Figure 1 shows the dimensions of the existing filled grid slab and its reinforcement. Figure 2 shows the existing bridge half section and how the filled grid is incorporated into the bridge floor system.

Enhancing the fatigue strength of trough to deck plate joints in orthotropic steel decks using ultrasonic impact treatment (UIT)

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Abstract

Since the first occurrence of fatigue cracks in the trough to deck plate joint of steel orthotropic bridge decks in The Netherlands, two corrective measures with relatively high impact have been applied. In the case of moveable bridges, having limited possibility to increase the weight, the plate is replaced by a thicker steel plate. The asphalt surfacing on fixed bridges is replaced by a reinforced high strength concrete system. Both corrective measures decrease the traffic induced stresses in the steel structure resulting in longer fatigue life of the welded joints.
Considering the available information in the literature, preventive or (after crack repair) corrective treatment of the trough to deck plate welds using the ultrasonic impact treatment (UIT) could also improve the fatigue endurance of this particular welded joint. Especially in case of weld toe cracking, UIT has proven to increase the fatigue endurance of other welded joints considerably. In that case, possibly, the steel deck plate could be installed with a less heavy renovation technique as the two corrective measures mentioned before. In the paper, fatigue tests on trough to deck plates will be reported. Specimens in the as-welded situation as well as treated by the ultrasonic impact treatment are included. The results will be compared with previous test programs and the current detail categories in the design rules.

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REDECKING EXISTING BRIDGES WITH ORTHOTROPIC STEEL DECK PANELS

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ABSTRACT

The technique of orthotropic steel deck panel replacement is an innovative Accelerated Bridge Construction "ABC" technique for renovating existing bridges. Bridges built and in operation with Steel Orthotropic steel decks in North America are very rare. Many feel that welded Orthotropic steel decks are too challenging to design and offer little benefit to the owners of bridges. The advantages of lowest erection lifting weight for large piece installation will be demonstrated with a table plus selected case histories. Featured bridges from around the world include the Cologne-Rodenkirchen Bridge (1994); Wakato Suspension of Japan, (1999); Angus L. Macdonald Bridge (1999); the Tamar Suspension Bridge, UK (2001); and the Tornionjoki Cantilever Truss Bridge (2002). A comprehensive reference list is provided to assist in obtaining more detailed information.

1: WORLD WIDE TABLE OF ORTHOTROPIC REDECKING PROJECTS

Panelized decking was first promoted in the literature in the 1960's or possibly earlier, Chang (7). The Soviet – Russian government uses a standardized open rib deck system for all of its bridges, Mangus (1), (11), ASCE (2). Featured bridges from around the world deemed to be the most valuable to the reader are listed below in the following table. Roman Wolchuk (3), (4), (5), & (6) has documented bridges redecked in North America. His articles and those of the project engineers are recommended reading..

Union Pacific Railroad Bridge 60.97 Reconstruction

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ABSTRACT: Union Pacific Railroad Bridge 60.97 crosses the Trinity River near Goodrich, Texas. The railroad parallels U.S. Highway 59 at this location, and the railroad bridge is immediately upstream from the highway structure. The original bridge was built around the turn of the last century, and consisted of steel truss and plate girder spans on stone masonry and steel cylinder piers. The piers were founded on timber piling. Over the years several spans had been replaced. The main river crossing in early 2004 consisted (from south to north) of steel beam span approaches, a steel pony truss, a through-plate girder swing span, and a 150'-0" long through truss. The swing span dated from the period when the Trinity River was a navigable waterway, prior to the construction of Livingston Dam upstream of the bridge. The Trinity River has a history of flooding, and the railroad has experienced prior damage to several of its crossings. Steel sheet pile cofferdams were built around each of the existing piers to provide protection for the timber piles.

1 INTRODUCTION

1.1 Emergency Repairs (2004):

The Trinity River experienced severe flooding in 2004. Scour at the bridge site extended below the pier protection and undermined the timber pile foundations. This led to failure of a pier and partial collapse of the structure *(Figure 1 & 2)*. A train was crossing the bridge at the time of the failure, and had to be removed prior to repair work. This line is a critical part of the Union Pacific system, so repair crews worked around the clock to restore the bridge to service *(Figure 3)*. Union Pacific and contracted forces removed the pony truss span (to the left in *Figure 1*) and cut back the end of the swing span (to the right in *Figure 1& 2*). Two new pile bents were constructed to support new superstructure spans. One important time-saver in this process was the use of a replacement span that had originally been fabricated for a project in Louisiana on a different railroad. The Louisiana project had been delayed, making the span immediately available. The Union Pacific "borrowed" this span, agreeing to pay for fabrication of a replacement for it *(Figure 3)*.

Figure 1

Figure 2

Figure 3

Roster of Conference Attendees