Bridge Structures, Vol. 1, No. 3, September 2005, 129–132

Editorial

This issue of *Bridge Structures* contains a select number of papers that were presented at the Third New York City Bridge Conference. Following a tradition of presenting the latest in bridge engineering technology, the bound proceedings for the New York City Bridge Conference contain a select number of original papers presented at the conference. The conference was organized and sponsored by the Bridge Engineering Association, along with a distinguished group of renowned bridge engineers from all over the world. On September 12–13, 2005, bridge engineers from Asia, Canada, Europe, South America, and the United States presented on the state-of-the-art in bridge engineering.

This issue leads off with a paper by Virlogeux on the "State-of-the-art in cable vibrations of cable-stayed bridges." Much attention has been given to stay cable vibrations, after its first observance at the Brotonne Bridge in France in 1977. Since that time, significant progress has been made in bridge aerodynamics. This includes theoretical approaches, wind tunnel tests, and computer software development for the evaluation of structural response. In his paper Virlogeux presents a simplified view of cable vibrations in cable-stayed bridges. Different types of cable vibrations are described with an emphasis on parametric excitation. Countermeasures to eliminate or reduce cable vibrations are discussed with examples of cable vibrations. Modern pedestrian bridges have become symbols of their respective urban environments, with their sleek appearance and slender proportions. While this type of daring designs may provide an aesthetic value to pedestrian bridges, they present new challenges that are not properly addressed in the bridge design codes of practice. A prominent challenge is the lateral vibrations induced by pedestrians walking across a pedestrian bridge. In their paper, "Interactive horizontal load model for pedestrians crossing footbridges", Archbold *et al.* examine the lateral response of a cable-stayed footbridge to individual pedestrian crossings for a range of pacing frequencies. They conclude that their model demonstrates good and significantly improved agreement with measured lateral accelerations, for a range of test subjects, over a range of pacing frequencies, on a full-scale bridge. Several long span tied arch and truss bridges have experienced horizontal floorbeam cracking in the region of the upper web-to-flange weld or in the web gap between the top flange and the connection angles where simple web shear connections have been used. A recent study on a 189-m span tied arch bridge over the Monongahela River, in Pittsburgh, in Pennsylvania, USA, has evaluated the cause of this type of cracking and resulted in an effective retrofit strategy. In "Evaluation and retrofit of floorbeam cracking on a tied arch bridge", Connor *et al.* report on the design and remote monitoring of two retrofitted floorbeam connections. The monitoring was conducted for a period of almost 40 days as random vehicles crossed the bridge. The exact geometry of the retrofit was determined through a parametric finite element study, which was subsequently confirmed with field-measured data. The authors conclude that the retrofit provides sufficient flexibility at the connection without producing high stress ranges at critical locations.

The history of the development of specifications related to horizontally curved girder bridges spans over 30 years. During the late 1960s and early 1970s, a group of U.S. researchers called "The Consortium of University Research Teams", or "CURT", developed guidance on the analysis of curved girder bridges and characterizations of the strength and stability of curved girders. This work led to software products and the design provisions that became codified in the 1980 AASHTO *Guide Specifications for Horizontally Curved Highway Bridges* (1980 Guide). These Specifications were initially produced in the working stress design format, but were quickly converted to load factor design (LFD). In 1993, an updated version of the 1980 Guide was released. Recognizing the need to update the technology in these earlier design specifications, a major research effort was initiated by the U.S. Federal Highway Administration (FHWA), which involved both experimental and analytic investigations of curved steel bridges. The load and resistance factor design (LRFD) provisions for curved girder design were accepted for inclusion in the *AASHTO LRFD Bridge Design Specifications* at the June 2004 meeting of the Subcommittee on Bridges and Structures. In "Specifications and guidelines for the design of curved steel girder bridges", Kulicki presents the evolution of curved girder design specifications and the multi-path approach to develop these specifications. Closed stiffener orthotropic decks have been used successfully on a number of tied arch railway bridges for the high speed railway network in Belgium. In these bridges, the orthotropic plate contributes to both the deck plate action and the main load carrying system as the horizontal arch tie. Although the basic structural action is comparable to that of road (highway) bridges, specific differences exist. These differences originate from a substantial discrepancy in the

Bridge Structures
ISSN 1573-2487 print/ISSN 1744-8999 online © 2005 Taylor & Francis
http://www.tandf.co.uk/journals
DOI: 10.1080/15732480500313223

load scenarios of the railway bridges versus those of the road (highway) bridges. De Corte *et al.* investigate these differences in their paper "Efficiency of closed stiffener orthotropic deck panels for railway bridges". Their study is based on finite element simulations and detailed in-service strain gauge measurements on a number of bridges. Ahmad and Zouib present the design of hybrid steel girders for the Ohio approach spans of the Blennerhassett Island Bridge over the Ohio River and historical Blennerhassett Island connecting Wood County, West Virginia, to Washington County, Ohio, in the United States. One of the limitations in the 1998 AASHTO LRFD Bridge Design Specifications, with 2003 interims, is that there is no allowance for tension field action when considering shear design for hybrid sections. The shear design of girders using the 1998 AASHTO Specifications required more than 120 transverse stiffeners per girder. The use of tension field action for the design of hybrid girders, which is allowed in the 2004 AASHTO LRFD Bridge Design Specifications, reduced the number of required transverse stiffeners required to 36 per girder. This reduction in stiffeners reduced the cost for each girder by approximately 10%. Tension field action involves the effects of out-of-plane forces on the transverse stiffeners due to the shear post-buckling response of the web panels. In their paper "Tension field action behavior in the hybrid steel girders for Ohio approach spans of Blennerhassett Island Bridge", the authors present the stresses in the web and the transverse stiffeners for the two designs; with and without tension field action. A three-dimensional finite element model is used which includes consideration of materials and geometric nonlinearity. The analysis concludes that the anticipated tension field is in good agreement with the assumptions made in the design. Modern bridge structures which are built by assembling slender arches, three-dimensional thin straight or curved members, and cable structures are often too deformable to be treated with first-order elastic theory. The analysis of such structures requires the employment of large displacement theory. Additionally, a post-elastic non-linear analysis is required to control and evaluate damage without collapse in the seismic design philosophies for bridge structures. It is therefore essential to develop an effective procedure that considers both geometric and material non-linearities for the three-dimensional analysis of bridge structural members. Arici and Granata present "A general method for nonlinear analysis of bridge structures" for the analysis of linear and non-linear behaviours of curved structures using the transfer matrix method (TMM). The procedure is a TMM extension to geometric and material non-linear formulations, with large displacements, small deformations and localized plastic hinges. The authors present numerical applications to demonstrate the proposed method. Crack development in reinforced concrete approach slabs, in both integral and non-integral bridge abutments, of new or rehabilitated approach systems, has been a persistent problem. Transverse and longitudinal cracking has led to the disruption of concrete approach slabs which results in shortening their life expectancy and increases the costs associated with their maintenance. In "Finite element analysis of bridge approach slabs considering soil–structure interaction", Khodair and Nassif present results of a study employed to identify the probable causes and locations of cracks in bridge approach and transition slabs and the factors influencing the crack development. A finite element (FE) model has been developed to study the cracking phenomenon in bridge approach and transition slabs under vehicular live load and soil settlement. A field survey was conducted to determine the extent and probable causes of crack development in these slabs at various bridge sites in the State of New Jersey in the United States. The data collected from field observations was compared with the predictions of the FE model to determine its reliability and consistency. The FE model was employed to conduct a parametric study to evaluate the effect of various designs as well as soil parameters on the cracking behavior of the slabs. The results from the parametric study showed that increasing the slab thickness would significantly increase the cracking load carrying capacity of the approach slab. However, an increase in soil settlement has an adverse effect on cracking load carrying capacity. Based on the results of their study, the authors present two design alternatives, which according to their analysis, exhibited better cracking resistance than the current practice design detail. The application of externally post-tensioned segmental members is a very attractive solution, compared with classical construction methods. The use of this solution results in smaller precast elements tied together by post-tensioned tendons, and the advantages include fast and versatile construction, high quality control and lower overall cost. In "Finite element analysis of segnmental concrete bridges", Ribeiro *et al.* present a formulation for the simulation of the structural behavior of members composed of externally post-tensioned segments. The analysis allows for serviceability limit states verifications when sections are fully compressed. It also allows for verification of the ultimate limit states when joint openings and load transfers at the joints are considered. To evaluate the accuracy of the numerical results, the authors present a comparison between their model and experimental data from the literature. Traditionally, concrete parapets are treated solely as superimposed dead load in a bridge structural design. Parapets are detailed from a safety standpoint to resist impact forces from vehicle loading. However, in the global design models, the inherent strength of the parapets is not considered as a contributing factor to the overall strength of the bridge structure as a system. As part of an evaluation of global performance of bridge structures, Brenner *et al.* prepared a set of three-dimensional finite element models of a simple span, composite concrete–steel stringer bridge. Their paper on the "Evaluation of highway bridge strength considering parapets" describes a study evaluating the increase in design strength, performance and capacity when including bridge parapets are included in the bridge analytical model. These models evaluate the overall strength and deflections under standard traffic loadings, with and without the stiffness contribution of the concrete parapets. The models predict a substantial increase in strength when including the parapets as a structural element rather than merely a superimposed dead load. Furthermore, standard details and construction procedures commonly in use to provide adequate strength for current code requirements seem to also provide sufficient strength to enable composite action between the parapets and the bridge deck. The paper investigates the advantages of including the evaluation of parapet strength, and initial load rating and analysis during the life history of the bridge structure.

Multihazard consideration for infrastructure applications is gaining popularity due to the anticipated overall cost reduction it offers while maintaining the needed safety levels. This approach considers increasing the complexity of the structural systems to meet the demands of the current environment and takes advantage of the recent developments and innovations in computing, analytical, and sensing technologies. At present, no quantitative methods have been developed to fulfill such a promise. "Theory of multihazards for bridge structures", by Ettouney *et al.*, discusses the need for multihazards considerations in infrastructure applications and provides a quantitative approach to multihazard considerations. A general theory of multihazards in infrastructure is introduced and applied to structural analysis, design, life cycle cost, risk assessment, and Structural Health Monitoring.

Seismic bridge design has become oriented towards specific performance objectives. This concept is widely known as Performance-Based-Earthquake-Engineering (PBEE), and is being incorporated in the new generation of seismic guidelines from the National Earthquake Hazards Reduction Program (NEHRP), Standard Specifications for Highway Bridges (AASHTO), and the International Building Code (IBC). To achieve this goal, key ground motion parameters must be determined and correlated with the identified critical indices of potential damage of a bridge system in order to predict the performance in terms of seismic demand and capacity. Nikolaou presents a "Geographic information systems for ground motion evaluation in seismic bridge analysis." The methodology is developed for establishing potential long-term seismic risk for bridges. The GIS graphical and computational capabilities to analyze spatially distributed problems are shown to be an ideal, powerful tool for establishing ground motions within the performance-based criteria of modern seismic bridge design. Near-field ground motions cause significant damages to highway bridges because of high peak ground accelerations and high peak ground velocities with long period pulses. To quantitatively assess the influence of near-field ground motions on seismically excited highway bridges, Tan *et al.* propose a ground motion model consisting of both pulse-type low frequency (near-field) and broadband frequency (far-field) components. In their paper "Near-field effects on seismically excited highway bridge with nonlinear viscous dampers", the authors incorporate the effects of the local site condition and the seismic source by varying the relative contributions of near-field pulse-type and far-field broadband random ground motion components in the synthetic ground motion. Nonlinear viscous dampers are employed to improve the safety of the bridge during near-field ground motions. Simulation results demonstrate that pulse-type components in ground motions amplify the response quantities of the highway bridge significantly compared with those of a broadband component. The study concludes that nonlinear viscous dampers are effective in providing safety for the highway bridge against pulse-type components of near-field earthquakes. Also on the theme of seismic hazard assessment, one of the major concerns is the estimation of the impact of an earthquake event on the society for emergency planning, economic analysis and disaster mitigation purposes. Bridges are the key components of transportation systems and are essential for emergency response and efficient post-event recovery. In order to estimate the total loss, it is necessary to include the post earthquake performance of the network in the analysis as well as the direct loss from damage to the bridges. In "Seismic performance of the San Francisco Bay Area transportation network bridges", Stergiou and Kiremidjian present the impact of bridge retrofitting on direct loss reduction in the San Francisco Bay Area in California, USA. For this purpose, the losses from the characteristic earthquakes on the San Andreas and Hayward faults due to ground shaking, landslide or liquefaction are estimated for pre- and post retrofitted bridges. The loss estimates indicate that the annual risk reduction due to retrofitting is about 15% for the San Andreas fault and 10% for the Hayward fault events. If all possible events are taken into consideration, these values are expected to further increase demonstrating the benefit of retrofitting.

A common theme of the last three papers of this issue is bridge maintenance and health monitoring. An efficient transportation network is of paramount importance for the economic and social development of a modern society. Bridges are the arteries of transportation infrastructure that support human activities and cultivate economic growth. Periodic inspection and maintenance plays a major role in keeping bridge structures operational and in safe condition. Appropriate maintenance avoids major bridge rehabilitation and replacement, and extends the structural service life with cost-effective measures. Effective maintenance programs involve several aspects such as scheduling a maintenance activity, the activity itself, and the scope of such an activity. The main challenge faced by bridge managers is how to institute maintenance activities with minimum expenditures. The road network in Croatia is by far the most important element of the country's land transportation system. The existing 6800 km long trunk roads are becoming insufficient for modern traffic demands. Additionally, the existing road network is getting older and it requires allocation of huge financial resources to maintain its serviceability. Over the last decades Croatia made large investments in order to complete the 1500-km long highway network that would integrate the most distant parts of the country and provide for quick, easy and comfortable transportation of people, goods and services. The Croatian highway network may not seem long, but it is worth mentioning that Croatia already has more kilometers of highways per 100,000 citizens than the United Kingdom, Ireland, Greece or Italy. In their paper "Maintaining safety and serviceability of concrete bridges in Croatia", Radić *et al.* discuss the management, maintenance and repair of Croatian bridges. To illustrate the grave consequences of neglecting bridge maintenance, several case studies are discussed, including world-renowned structures such as the Krk bridges. The paper concludes that if bridge owners act only when damage of a bridge structure becomes self evident, the repairs are not only expensive, but very difficult to perform. In "Structural health monitoring for bridge maintenance", Alampalli *et al.* illustrate the possible role of Structural Health Monitoring (SHM) on bridge maintenance and management aspects. The paper illustrates a cost/benefit (value) approach for use of SHM in maintenance applications to quantify the decision-making process involved with maintenance activities. Several examples are presented to show the effectiveness of using SHM in maintenance activities, with a detailed illustration. Finally, Bernini *et al.* investigate "Damage detection in bending beams through Brillouin distributed optic-fibre sensor" for strain measurements in beams. Several researchers have stressed the theoretical and practical difficulties related to these kinds of measurements. These include mechanical characterization of optic-fiber, decay of strains in the protective coatings, spatial resolution of the Brillouin scattering, brittleness of the glass core, elastic–plastic response of the coatings, end effects, and different effects of strain readings in dilatation or in contraction. A solution to each of these problems would entail further research effort. However, all the works pointed out that the qualitative strain response of bending beams is clearly accounted for by distributed optical fiber sensors. In spite of the above-mentioned uncertainties, the distributed nature of the sensor makes it very attractive when safety assessments of large structures such as bridges are involved. The authors present a comparison of the experimentally measured strains, carried out on a damaged and an undamaged beam. The measurements revealed the presence and position of defects in the beam. Quality and accuracy of the measurements carried out with distributed optical fiber sensors are discussed, focusing on the applicability of the identification method.

The Third New York City Bridge Conference had a significant international impact. Along with the impressive list of authors included in this volume, distinguished authors of papers published in the conference CD-ROM proceedings presented new technologies from all over the world. Throughout September 12 – 13, 2005, authors from Belgium, Brazil, Canada, Croatia, Denmark, England, France, Ireland, Germany, Italy, Japan, Russia, Spain, Taiwan and the United States, each with a considerable contribution, presented on the state-of-the-art in bridge engineering practice.

The editor thanks the authors and expresses a special note of gratitude to the reviewers. This publication is a result of the sacrifice of time and effort, dedication and collective wisdom of this body of technical experts in reviewing papers. The editor acknowledges with appreciation their contributions.

Khaled M. Mahmoud, PhD, PE
Editor-in-Chief
Bridge Technology Consulting & Engineering
New York, New York, September 2005