Editor's Note

Papers in This Issue

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This November 2011 issue of the *Journal* features papers submitted for the special issue on AASHTO-LRFD Bridge Design and Guide Specifications: Recent, Ongoing, and Future Refinements. Although AASHTO-LRFD code has been accepted by the bridge engineering community, its provisions continue to evolve with the advanced research in different areas of bridge engineering. This issue features 23 technical papers that discuss research on recent, ongoing, and future refinements in AASHTO-LRFD provisions. The first manuscript,"Perspectives on AASHTO Load and Resistance Factor Design," by guest editor Dr. Daniel Tobias, presents a brief synopsis of the evolution of the LRFD code, including topics and research that are being considered at present as well as several possible future topics that could or should be addressed. This manuscript also discusses the processes by which researchers and practitioners can affect future refinements for most structural AASHTO publications.

Next, four manuscripts in this issue focus on extreme events, such as blast, seismic, and impact loads. In "Performance of Bridge Columns Subjected to Blast Loads: Experimental Program," Williamson et al. present research carried out under the National Cooperative Highway Research Program (NCHRP) project 12-72 on the response of critical bridge components subjected to blast loads. The paper includes a description of the experimental research program on 10 different half-scale column designs in which the design parameters that have the greatest impact on the performance of blast-loaded bridge columns have been evaluated.

In their companion manuscript "Performance of Bridge Columns Subjected to Blast Loads: Results and Recommendations," Williamson et al. present results from the test program to identify the design parameters that most significantly influence the performance of blast-loaded reinforced concrete bridge columns. Using the scaled standoff distance as the primary variable to assess threat severity, three separate blast design categories are recommended. In "Evaluation of Combination Rules for Orthogonal Seismic Demands in Nonlinear Time History Analysis of Bridges," authors Bisadi and Head investigate 100/30, 100/40, and square root of the sum of the squares (SRSS) combination rules for orthogonal seismic demands when conducting nonlinear time history analysis of bridges. Demands resulting from these combination rules are compared with those resulting by applying paired ground motions in various directions. The probability of underestimation is computed for each combination rule, assuming a uniform distribution for the excitation angle. On the basis of detailed investigations, the authors recommend the use of the 100/40 rule with the major component of earthquakes for the nonlinear time history analysis of bridges. In "Equivalent Static Analysis Method for Barge Impact-Resistant Bridge Design," Getter et al. present a static analysis procedure that emulates pier response modes arising during dynamic barge impact events. The proposed method provides a simplified means of approximating dynamic amplification effects and is shown to produce conservative predictions (relative to dynamic analysis) of both pier and foundation design forces.

The next three papers in this issue relate to geotechnical aspects of the LRFD code. In "Introduction to PILOT Database and Establishment of LRFD Resistance Factors for the Construction Control of Driven Steel H-Piles," Roling et al. present a recently established and publicly available database for pile load tests (PILOT), which is an amalgamated, electronic source of rich information comprising both static and dynamic data for driven piles for use in the establishment of resistance factors for load and resistance factor design. Using the findings associated with a regional calibration of LRFD resistance factors for the construction control of driven piles in Iowa by means of dynamic pile driving formulas, the economic gains realized with a regional database such as PILOT are demonstrated at the state, national, and international levels. The paper "LRFD Resistance Factors for Design of Driven H-Piles in Layered Soils" by AbdelSalam et al. investigates the load and resistance factor design of piles embedded in layered soils that are commonly classified as sand, clay, and mixed soil sites using static analysis methods at the strength limit state. Unlike the current practice, the main emphasis of this study is to use a more clearly defined, less ambiguous classification for the sites on the basis of the percentage of soil types present along the pile embedment length. In addition to a locally developed static method known as the Bluebook approach, several commonly adopted static analysis approaches as well as combinations of methods have been examined with due consideration to soil variation along the pile length. In "Performance-Based Design of Drilled Shaft Bridge Foundations," Roberts et al. present a performance-based soil-structure interaction design approach for the strength and service limit state axial design of drilled shafts using the AASHTO-LRFD approach. The approach explicitly incorporates field load test data into the design to increase design efficiency while satisfying the limit states. A design example, using drilled shaft load test data acquired via the O-Cell technology, has also been included to demonstrate the developed methodology for use in day-to-day bridge foundation design.

The next two papers in this issue are related to bridge decks. In "Proposed Revisions to AASHTO-LRFD Bridge Design Specifications for Orthotropic Steel Deck Bridges," Kozy et al. summarize proposed changes to the fifth edition of the AASHTO-LRFD bridge design specifications related to orthotropic deck bridges. This current version of AASHTO-LRFD contains provisions that provide limited guidance to complete the fatigue design. Contained within the proposed changes discussed in this manuscript is a new framework for design verification, which may be based on different levels of design or physical testing. Criteria related to loads, load factors, limit states including fatigue in particular, resistance, and analysis requirements are covered in detail. Designs made according to these new provisions can be expected to perform very well and meet the design service life as per AASHTO-LRFD. In "Performance Evaluation of Empirically and Traditionally Designed Bridge Decks," Shoukry et al. compare the performance of the empirically designed reinforced concrete bridge decks with those designed using traditional analytical design methods by correlating the theoretical results with field observations. A case study of Buffalo Creek Bridge was selected for this study, as it was originally constructed with an empirical deck that developed severe cracking and was reconstructed using traditional design methods.

The next four papers in this issue related to loads and load distribution. In "Framework for Simplified Live-Load Distribution-Factor Computations," Puckett et al. investigate the development of simplified live-load distribution-factor equations for moment and shear to replace those in the current LRFD specifications. The research uses an automated process to compare live-load distribution-factor (LLDF) calculated using several simplified methods and a grillage analysis for over 1,500 bridges. On the basis of the comparison to grillage analysis, two simplified methods were chosen for further investigation: an adjusted uniform distribution method and an adjusted lever rule. Calibration factors were used to improve accuracy for both methods. Based on fundamental concepts, these methods were shown to be simple and accurate. These methods predict both moment and shear distribution factors with reasonable accuracy. In "Investigation of AASHTO Live-Load Reduction in Reinforced Concrete Slab Bridges," El Meski et al. present an investigation on the effect of multipresence factor of load reduction factors used in the AASHTO Bridge Design Specifications. Typical one-span, two-equal-span continuous, simply supported, three- and four-lane reinforced concrete slab highway bridges were selected for this study to investigate reduced and fully loaded cases. For the three- and four-lane bridge cases, AASHTO Standard Specifications generally correlate well with or overestimate the finite-element analysis (FEA) reduced maximum moments and edge beam moments by up to 15 and 30%, respectively. This overestimation is more pronounced in short-span bridges. This research supports the current AASHTO-LRFD multiple-presence factors of 0.85 for three lanes and 0.65 for four lanes in estimating longitudinal bending moments in concrete slab bridges. The FEA results highlight the importance of considering span length in determining the multipresence factors when designing three-lane or more concrete slab bridges. In "Unified Approach for LRFD Live-Load Moments in Bridge Decks," Higgins et al. develop new analytical expressions for moment in bridge decks subjected to arbitrary patch loading considering each of the three cases of orthotropy: (1) relatively torsionally stiff, flexurally soft decks; (2) relatively uniformly thick deck (such as a reinforced concrete deck); and (3) relatively torsionally soft, flexurally stiff decks. Using these newly developed expressions, the AASHTO-LRFD notional live-load models are combined with impact, multiple-presence, and live-load factors to determine maximum strong direction live-load moments for the Strength I design limit state. Design equations have been developed to estimate the maximum strong direction live-load moments without having to perform cumbersome moving load analysis for common deck orientations. Using the proposed formulations, bridge deck strength design demands can be treated in a unified way across different deck types using only four equations. In "Calibration of Live Load Factor in LRFD Bridge Design Specifications Based on State-Specific Traffic Environments," Kwon et al. present calibration of live-load factor in the Strength I limit state in the AASHTO-LRFD Bridge Design Specification on the basis of state-specific traffic environments and bridge configurations. Traffic data collected for five years at weigh-in-motion stations in Missouri are used to simulate realistic truck loads. In addition, typical bridge configurations identified from statistical analyses of the 2007 National Bridge Inventory are used to define representative bridges in Missouri. Reliability analysis results using the weigh-in-motion data and the representative bridge configurations show that most bridges have reliability indexes higher than 3.5. Live-load calibration factors for the state of Missouri are proposed as a function of the bridge's average daily truck traffic.

The next four papers in this issue relate to prestressing and posttensioning in bridges. In "Investigation of Bursting Forces in Anchorage Zones: Compression-Dispersion Models and Unified Design Equation," He and Liu present a generalized method to calculate bursting forces in posttensioned anchorage zones. Compression-dispersion models are individually formulated for anchorage zones with single concentric, eccentric, and inclined tendons, and a unified equation for calculating bursting forces is developed accordingly. Finite-element evaluation and experimental verification show that the proposed equation provides accurate and safe predictions for different loading conditions, whereas the AASHTO equation is found to be overly conservative in most cases. In "Proposed Modification of AASHTO-LRFD for Computing Stress in Unbonded Tendons at Ultimate," Harajli investigates conservatism in the AASHTO-LRFD equation for computing stress in unbounded tendons at ultimate. On the basis of the results from this research, supported by a large body of test data, he has developed an expression for evaluating the equivalent plastic hinge length in unbonded members at ultimate. This expression can be used in conjunction with the concept of collapse mechanism for developing a general strain compatibility model and a direct equation for evaluating stress in unbonded externally or internally posttensioned continuous members. In "Evaluation of FRP Posttensioned Slab Bridge Strips Using AASHTO-LRFD Bridge Design Specifications," Noel and Soudki investigate GFRP-reinforced slab strips cast with self-consolidating concrete (SCC) and posttensioned with carbon-fiber-reinforced polymer (CFRP) tendons to improve the serviceability, shear capacity, and deformability of slab bridges. In this study, the flexural performance of five FRP-reinforced slabs and one steel-reinforced control slab are compared with the design provisions of AASHTO-LRFD Bridge Design Specifications. In "Full-Scale Testing of Pretensioned High-Strength Concrete Girders with Debonding Method," Kim et al. have investigated experimentally flexural and shear behavior of three full-scale pretensioned high-strength concrete bridge girders to evaluate the applicability of high-strength concrete and a higher percentage of debonding ratio to pretensioned bridge girders. The test results indicated that performance in terms of load carrying capacities, ductility, and crack patterns was improved by using high-strength concrete compared with predictions of AASHTO specifications. In addition, the prestressed concrete specimen, in which higher percentages of debonded strands were used, showed superior load-carrying capacities, stiffness, and ductility compared with the specimen in which the number of partially debonded strands does not exceed 25% of the total number of strands.

The next three papers in this issue focus on reliability issues in bridge load rating. In "Bridge Rating Using System Reliability Assessment. I: Assessment and Verification by Load Testing," Wang et al. investigate improvements to the current bridge rating process using structural reliability methods. The paper appraises current bridge rating methods and summarizes a coordinated program of analysis and load testing of several bridges to support recommended improvements to the bridge rating process. In the companion paper "Bridge Rating Using System Reliability Assessment. II: Improvements to Bridge Rating Practices," the authors present the reliability basis for the recommended load rating, develop methods that closely couple the rating process to the results of in situ inspection and evaluation, and recommend specific improvements to current bridge rating methods in a format that is consistent with the Load and Resistance Factor Rating (LRFR) option in the AASHTO Manual for Bridge Evaluation. In "Reliability-Based Dynamic Load Allowance for Capacity Rating of Prestressed Concrete Girder Bridges," Deng et al. investigate the reliability indexes of a selected group of prestressed concrete girder bridges, designed following the AASHTO-LRFD code, by modeling the dynamic load allowance, IM, explicitly as a random variable for different road surface conditions (RSCs). It is found that, although the calculated bridge reliability indexes are usually above the target reliability index value of 3.5 under above-average RSCs, they can be significantly below the target value of 3.5 when the RSCs are below average. Following the load rating procedure proposed by the AASHTO LRFR manual, it is also found that the code-employed IM value may overestimate the rating factors when RSCs are below average. On the basis of these results, appropriate IM values are suggested for different RSCs to achieve a consistent target reliability index and a reliable load rating.

The remaining two papers in this issue focus of different aspects of bridge engineering. The paper "Revisit of AASHTO Effective Flange Width Provisions for Box Girders" by Lin and Zhao investigate shear lag effects along the flange of thin-walled flexural members, such as box girders. Effective flange width is widely used to consider shear lag effects in bridge design. On the basis of extensive parametric studies, the authors propose equations to calculate the effective flange width for box girders. The proposed provisions consider the critical factors, such as geometry of the girder, loading pattern, material properties, and existence of longitudinal stiffeners for the shear lag behavior. The paper "Evaluation of AASHTO-LRFD Design Methods for Thermal Loads in Fixed-Flexible Twin-Walled R/C Bridge Piers" by Schultz et al. investigates the design of reinforced concrete fixed-flexible twin-walled bridge piers for lateral loads. As the bridge experiences lateral loads, primarily from temperature fluctuations and time-dependent effects, the walls undergo cracking, requiring designers to consider sectional stiffness reductions. This study was carried out by developing two types of finite-element models representing the recently constructed Wakota Bridge in South St. Paul, Minnesota: one using a design-level program (SAP2000) and the other using a research-level program (ABAQUS). For an arbitrary temperature load, a commonly used refined design method, implemented in the design-level program, was evaluated for accuracy of reduced section properties relative to a more descriptive progressive cracking solution provided by the research model.