TECH-LINE

BGFMA
www.bgfma.org

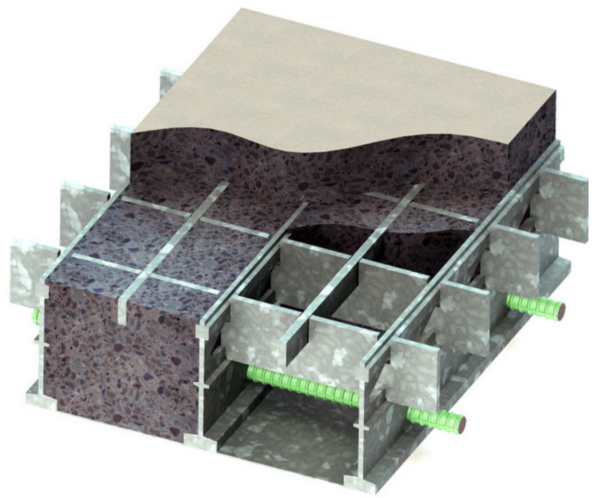
Technical Update of The Bridge Grid Flooring Manufacturers Association

Tech-Line, Issue #3, May 2010

Design of Filled Grid Deck Systems to Meet AASHTO LRFD Criteria

Grid reinforced concrete bridge decks have been used in new bridge construction since the 1920's. These durable deck systems are often considered today for both new and rehabilitation bridge projects - especially when weight reduction and speed of construction are important considerations.

Traditionally, grid reinforced concrete decks have been designed in accordance with AASHTO Standard Specifications and allowable stresses in which the strength of the composite steel and concrete slab is determined by means of the transformed area method. Simple span live load moment equations for main bars perpendicular and parallel to the direction of traffic are defined in AASHTO Article 3.24 with provisions that these moments may be reduced for continuous span conditions.



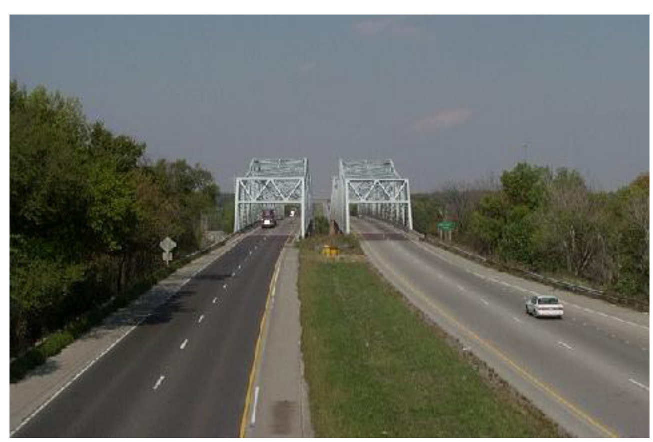
Rectangular Fully Filled Grid Deck

AASHTO introduced the first LRFD Bridge Design Specification in 1994 which included revised live load moment equations derived from orthotropic plate theory and stiffness ratios obtained in full-scale laboratory tests of filled and partially filled grids. However, the design of grid reinforced concrete decks in accordance with these guidelines was rarely used as design continued to be based on AASHTO Standard Specifications for the vast majority of bridges.

In 2000, AASHTO and FHWA set a transition date of October 1, 2007 after which all new bridges shall be designed by the LRFD Specification. In the meantime, 2003 Interims to the LRFD Bridge Design Specification introduced several revisions affecting the design of grid reinforced concrete decks. These changes included new live load moment equations, introduction of live load deflection equations, and fatigue assessment provisions. The code also expanded the coverage of Article 4.6.2.1.8 to include unfilled grid decks composite with reinforced concrete slabs (i.e. Exodermic™ Deck Systems).

Unfortunately, application of the current design provisions set forth in AASHTO Article 4.6.2.1.8 introduced in 2003 yield some disconcerting results. Design of filled and partially filled grid decks under these guidelines results in maximum spans significantly less than that being spanned by grid decks on in-service bridges – many of which are well over 30 years old with average daily truck volumes exceeding 5000 vehicles per day.

For example, the bridge on Interstate 55 over the Des Plaines River in Will County, IL is comprised of a flush filled 4-1/4" full-depth deck with an asphalt overlay. The deck was originally installed in 1980 with continuous spans (continued)



Interstate 55 Bridges, Will County, IL

over stringers spaced at 6.5 feet, and has a reported ADTT of 7014 trucks per day. Based on inspection reports the deck is in satisfactory condition and functioning as designed. When this deck system is checked using the current AASHTO LRFD code, fatigue in the negative bending moment region controls the grid deck design and limits the maximum span to less than one foot when stresses are kept below the fatigue limit. This maximum span is calculated from the rearranged AASHTO-LRFD equation 4.6.2.1.8-1.

$$L=\left[\frac{M_{LL}}{(1.28)(D^{0.197})(C)}\right]^{\left(\frac{1}{0.459}\right)}=\left[\frac{3.95\,{}^{kip-in}/_{in}}{(1.28)(3.40^{0.197})(0.8)}\right]^{\left(\frac{1}{0.459}\right)}=11.2in$$

Interstate 55 Bridge Full-Depth Grid Deck

Since the grid deck on this structure is spanning well beyond the allowable fatigue limit, failure due to fatigue cracking would be predicted to occur little more than 3 months after being opened to traffic. This calculated result is obviously much different than the 28+ year satisfactory service life experienced by the grid deck on the Interstate 55 bridge.

To evaluate the apparent discrepancy between the current LRFD design code and the historical performance of grid decks, the BGFMA contracted with Oregon State University Professor Christopher Higgins, PhD, P.E. The BGFMA supplied Professor Higgins deck design details, supporting bridge details, performance information, as well as traffic and historical data of 26 in-service decks whose designs predate the current AASHTO-LRFD design procedures. This deck data was analyzed, compared to service performance, and the findings summarized in a report entitled *Calibration of AASHTO-LRFD Section 4.6.2.1.8 with Historical Performance of Filled, Partially Filled, Unfilled Composite Grid Decks*. Several conclusions from the report include:

- The current AASHTO-LRFD grid deck moment provisions are not substantially higher than those specified for design of traditional reinforced concrete decks.
- The grid decks provide yielding moment resistance sufficient to resist design moment demands for both positive and negative moment locations so strength does not appear to limit design of grid decks.
- The 26 grid decks met current fatigue provisions for positive moment even if the continuity factor is set to 1.0.
- The current fatigue provisions for negative moment regions limited span lengths for all grid decks in the study. Predicted service lives for most decks were unreasonably short relative to their field performance.

Proposed code revisions have been drafted based on the results of this study to eliminate the fatigue check for welded connections encased in concrete, which was specifically excluded from the AASHTO-LRFD Specification prior to the 2003 Interims. These proposed code revisions have been supplied to AASHTO for consideration and action. It should be noted that the fatigue check is still required for unfilled grid decks composite with reinforced concrete slabs as the internal connections are not encased in concrete.

BGFMA
www.bgfma.org
Bridge Grid Flooring Manufacturers Association
300 East Cherry Street
North Baltimore, OH 45872
p 419.257.3561 f 419.257.2200