

TECHBRIEF



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Current Provisions and Needed Research for Lightweight Concrete in Highway Bridges

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This document is a technical summary of the unpublished Federal Highway Administration (FHWA) report, *Synthesis of Research and Provisions Regarding the Use of Lightweight Concrete in Highway Bridges* (FHWA Contract No. DTFH61-04-C-00029), which is available only through the National Technical Information Service (www.ntis.gov).

Objective

This TechBrief summarizes a synthesis report on completed research and current American Association of State Highway and Transportation Officials (AASHTO) provisions related to lightweight concrete used in highway bridges. The synthesis report is intended to provide a reference point for an FHWA research program aimed at addressing perceived shortcomings in the AASHTO specifications pertaining to lightweight concrete. The synthesis report also makes recommendations for future research efforts, focusing on the use of lightweight concrete in bridge structures.

Introduction

Significant research efforts currently are being performed both under the direction of the National Cooperative Highway Research Program and by other researchers to update and modify the AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications for the use of normal weight concrete with compressive strengths up to 103 or 124 megapascals (MPa) (15 or 18 kips per square inch (ksi)). These efforts do not address many of the research needs related to lightweight concrete. Current provisions that apply to the use of lightweight concrete need to be verified and/or modified with regard to their applicability to high-performance lightweight concretes.

There is, therefore, a need to review the AASHTO specifications to identify the relevant articles that address or should address the use of lightweight concrete in highway bridges and to synthesize existing research that is relevant to those articles. This information then can be used to define further research needs.

Synthesis Report Scope

The report is a compilation of the relevant provisions of the AASHTO LRFD Bridge Design Specifications and the AASHTO LRFD Bridge Construction Specifications that address or should address the use of lightweight concrete in highway bridges. The review includes versions of both the design and the construction specifications through the 2006 Interim Revisions. For each specification, the report gives a compilation and synthesis of research relating to lightweight concrete and its use in highway bridges.

The report concludes by providing descriptions of five research needs detailing the scope and extent of work required to generate data sufficient for updating the current specifications in areas where gaps exist in the collective body of knowledge.

Conclusions

The synthesis indicates that the majority of provisions in the AASHTO LRFD Bridge Design Specifications are based on normal weight concrete with some form of modification factor applied for all-lightweight and sand-lightweight concretes. This modification is handled in several different ways: (i) adjusted strength reduction factors, (ii) modified factors for shear, (iii) multipliers for development length, and (iv) entirely separate provisions for lightweight concrete. In some articles, more than one modification applies. Most modifications are focused on the reduced tensile strength of lightweight concrete compared to normal strength concrete with a similar compressive strength. The modifications depend on the amount and type of fine aggregate. An assessment is needed to deter-

mine whether this approach is consistent with and best for today's materials and the ability to produce higher strength concretes.

Recommendations

The synthesis report recommends that future research efforts focus on the use of lightweight concrete in bridge structures. Each research effort has the objective of validating the applicability or developing proposed revisions to pertinent articles of the AASHTO LRFD Bridge Design Specifications for use with lightweight concrete having design concrete compressive strengths up to 69 MPa (10.0 ksi) or greater. In conjunction with this, an overall approach needs to be developed for concrete with densities between 1,922 and 2,162 kilograms per cubic meter (120 and 135 pounds per cubic foot). In addition, all research programs should consider that lightweight concrete can be produced with different aggregates, and this may affect their structural behavior. The research programs consequently should include several different lightweight aggregates.

Proposed future research areas include:

- **Material Properties:** Develop and conduct a test program to obtain shrinkage, creep, and prestress loss data for a broader range of lightweight aggregate concretes. Measure prestress losses on full-size precast, prestressed concrete beams stored in an outdoor environment.
- **Flexural and Compression Provisions:** Develop and conduct a test program to obtain additional data for the equivalent rectangular stress block factors. Conduct tests of reinforced concrete beams in pure flexure and under a combination of axial load and flexure. Conduct tests of prestressed concrete beams in flexure. Compare the measured beam strengths with values calculated using the current LRFD specifications and with any proposed revisions for stress block factors.
- **Shear and Torsion Provisions:** Conduct tests to investigate the applicability of articles pertaining to the sectional design method, minimum

transverse reinforcement, and maximum spacing of transverse reinforcement on full-size reinforced and prestressed lightweight concrete beams. Conduct limited tests to investigate the applicability of the articles pertaining to shear friction and the shear strength of brackets, beam ledges, slabs, and footings.

- **Reinforcement Details:** Conduct tests of short axially loaded circular columns with lap splices of the spirals at mid-height. Conduct limited tests on end-block specimens to verify the applicability of article pertaining to post-tensioned anchorage zones. Perform tests of hooked bars of different diameters to verify the current modification factors. Conduct a systematic laboratory test program of simple rectangular prestressed concrete beams to measure transfer length and determine development length.

- **Segmental Construction:** Determine if additional research to extend the LRFD Bridge Design Specification for segmental construction to lightweight concrete is warranted. If warranted, validate the applicability or develop proposed revisions for use with lightweight concrete.

Additional Information

For additional information, contact Benjamin Graybeal at 202-493-3122 or at the Turner-Fairbank Highway Research Center, Office of Infrastructure Research and Development, 6300 Georgetown Pike, McLean, VA 22101-2296.

Researchers—The synthesis report was written by Henry Russell of Henry G. Russell, Inc., in Glenview, IL.

Distribution—The unpublished report covered in this TechBrief is being distributed through the National Technical Information Service (www.ntis.gov).

Availability—The report will be available in August 2007, and may be obtained from the National Technical Information Service (www.ntis.gov).

Key Words—lightweight concrete, AASHTO LRFD, bridge design

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