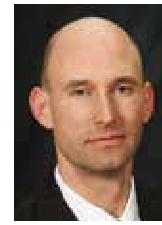
Lightweight Concrete in Highway Infrastructure

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Structural lightweight concrete (LWC) has been used successfully in bridges and structures for a century. The benefits of using LWC are many and varied. The main benefit is in the reduction of dead load in:

- allowing bridge deck widening with few or no changes to the existing structure,
- improving seismic structural response,
- designing longer-span bridges,
- fabricating smaller structural elements and thinner sections,
- lowering handling and transportation costs, and
- reducing foundation and substructure costs.

Lightweight aggregates for LWC may be from volcanic sources, byproducts from coal burning, or manufactured by expanding shales, clays, and slates (ESCS). ESCS lightweight aggregates are the most commonly used in modern LWC construction. ESCS aggregates are structurally strong, dimensionally stable, physically durable, light in weight, highly absorptive and retentive of water, environmentally friendly, and great at controlling cracks.

Features of LWC

LWC is concrete whose density has been reduced through the use of lightweight aggregates. For use in highway bridges and structures, LWC normally uses ESCS as coarse and/or fine aggregates within the concrete mixture proportions. LWC with compressive strengths up to and above 8 ksi are possible.

In practice, a concrete with a density less than 135 lb/ft^3 is considered LWC. Concretes with densities between 120 and 135 lb/ft^3 commonly use a mixture of conventional and lightweight aggregates, while those below 120 lb/ft^3 use all lightweight coarse and fine aggregates. LWC with densities between 100 and 135 lb/ft^3 are appropriate for use in structural applications.

The use of LWC in bridges does necessitate some special considerations. The *AASHTO LRFD Bridge Design Specifications* require that special reduction factors be applied to the resistance afforded by LWC. These provisions are in the process of being updated to accurately reflect the modern LWC mixture proportions commonly deployed in bridges. Use of LWC also requires special quality control processes, including the assurance of aggregate saturation at the initiation of concrete mixing.

Research on Performance

Strong interest in the use of LWC for bridges has resulted in a series of research projects that have aimed to characterize the structural performance of this class of concrete. The National Cooperative Highway Research Program (NCHRP) Project 18-15 titled "High-Performance/High-Strength Lightweight Concrete for Bridge Girders and Decks," led by researchers at Virginia Tech, was recently published as NCHRP Report No. 733. This effort focused on structural performance of LWC with densities below 125 lb/ft^3.

The Federal Highway Administration (FHWA) research group also recognized the potential value of LWC and has recently completed a series of nearly 100 full-scale structural tests characterizing the shear, flexural, strand bond, and mild-steel bond performance of a variety of LWCs with densities of 125 to 135 lb/ft^3. This density range is commonly referred to as specified density concrete and is commonly used in structural elements requiring both reduced weight and high performance.

Currently, the FHWA research group is working with AASHTO Bridge Technical Committee T-10 to compile results from all relevant studies, develop predictive relationships, and draft proposals to update design recommendations pertaining to the variety of density ranges that occur within the LWC class of materials. The results of recent research are promising, indicating that some of the design restrictions placed on LWC decades ago may no longer reflect the performance that can be achieved with modern structural LWC.

Shear test of lightweight concrete prestressed girder at Turner-Fairbank Highway Research Center. Photo: Gary Greene, PSI Inc.

LWC in Highway Bridges

Two examples of bridges using LWC are given here.

Bridge Replacement in North Carolina

The Morganton Bridge replacement project in Fayetteville, N.C., is the first example provided of LWC use in highway bridges. This two-span replacement project consisted of widening the roadway and replacing the aging superstructure over the All-American Freeway (I-66). The project, an America's Transportation Awards winner, was completed in 10 months with the final cost being about 3% under budget.

Lightweight concrete was used in the deck of the Morganton Bridge to reduce deck weight so that the existing columns and foundations could be retained. Photo: Carolina Stalite Co.

High-Strength LWC in Georgia

To determine the practicality and performance of high-strength LWC (HSLWC) bridge girders, the Georgia Department of Transportation (GDOT) designed and constructed the center two spans of the four-span I-85 Ramp crossing SR 34 in Newnan, Ga., with HSLWC for the AASHTO BT-54 girders and normal weight concrete for the bridge deck. The precast, prestressed concrete girders have a span length of 110 ft.

From the construction experience and monitoring results, GDOT determined that HSLWC could be applied to construction practice and the LWC provided an effective material for reducing the weight of a bridge, allowing longer spans to be efficiently constructed.

Closing Remarks

LWC has been tested in laboratories and demonstrated in the field to have good structural properties for constructing durable and sustainable bridges and structures, where weight reduction is an important factor in design. Use of LWC does necessitate developing design and construction specifications to meet the specific needs of a project. Quality control and quality assurance are just as important in LWC practices as in normal weight concrete. Adequate soaking of the lightweight aggregate prior to batching, and proper evaluation of the modulus of elasticity of LWC are essential in the successful application of LWC.

It is important to work with the producers of structural LWC throughout project development. The producers can provide very useful information on design criteria and construction specifications.

Georgia Department of Transportation achieved a 20% decrease in shipping weight using girders with a 10.0 ksi compressive strength lightweight concrete. Photo: Paul Liles, Georgia Department of Transportation.

References

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EDITOR'S NOTE

Another source of information on good guidance and practices is the Expanded Shale, Clay and Slate Institute (ESCSI). This institute represents most of the producers of ESCS in the United States. ESCSI has a reference library of technical documents and recent papers on structural lightweight concrete on its website: http://www.escsi.org. Contact information is also given on the website.