BENEFITS OF LIGHTWEIGHT HPC

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There are many advantages to the use of lightweight aggregate in high performance concrete. This article highlights the primary design- and construction-related benefits.

Improved Structural Efficiency (Strength/Weight)

Structural lightweight concrete is typically 25 to 35 percent lighter than normal weight concrete. This translates into lighter superstructures and smaller loads for substructure design. The award winning Shelby Creek Bridge in Kentucky provides an excellent example of structural efficiency where a 7000 psi (48 MPa) concrete compressive strength was attained with a density of less than 130 pcf (2.08 Mg/cu m).

Reduced Seismic Forces

The new Benicia-Martinez Bridge in California is a cast-in-place concrete, post-tensioned box girder bridge situated in a high seismic zone. The bridge will be built using the balanced cantilever method. To reduce the seismic forces caused by the structure's self weight, the designers have specified a concrete density of 120 pcf (1.92 Mg/cu m) and a concrete compressive strength of 6500 psi (45 MPa).

Improved Constructibility

Constructibility and transportation issues need to be considered early in the design and planning process of any project. Since precast, prestressed concrete bridges cannot be built unless the beams can be transported, lightweight HPC is often used to comply with over-the-road state weight limitations, or to carry more members on each truck. Fewer truck deliveries (especially in restricted areas) are environmentally beneficial, safer, and generate fewer public complaints. The use of a longer crane reach or a smaller crane are added benefits.

Improved Hydration Due To Internal Curing

Lightweight aggregate containing high internal moisture contents may be substituted for conventional aggregates to provide "internal curing." High cementitious concretes with very low water-cementitious materials ratios are vulnerable to self-desiccation. These concretes benefit significantly from the added internal moisture of properly pre-wetted lightweight aggregates. Internal curing is particularly helpful for concretes containing high volumes of silica fume and other materials known to be sensitive to curing procedures. In these applications, density reduction is a positive by-product. Because of the improved cement hydration developed by the moisture released from the reservoir of water absorbed within the pores of the lightweight aggregate, the improvement in the quality of concrete over time is greater with lightweight HPC than with concrete containing normal weight aggregates.

Renovation and Repair

One of the most extensive applications of structural lightweight concrete is in bridge re-decking where lower dead load is achieved. This often means that bridge widths, traffic lanes, and the thickness of structural slabs can be increased while utilizing existing piers, footings, and other structural members. The use of lightweight concrete often allows the live load capacity of older structures to be increased.

Economic Considerations

The use of lightweight aggregates, while more expensive than conventional aggregates, does not increase the total project cost. Consider the use of lightweight HPC on an 8-in. (200-mm) thick concrete bridge slab with a cost premium of $30/cu yd ($39/cu m). One cubic yard (0.76 cu m) of concrete will yield approximately 40 sq ft (3.7 sq m) of deck causing an increase in slab cost of 30/40 = $0.75/sq ft ($8.07/sq m). For a bridge with a total cost of $75/sq ft ($807/sq m) this results in a cost increase of one percent. However, this one percent material cost is offset by the reductions in the cost of slab reinforcement and the reduced size and cost of girders, piers, and foundations all due to a lower superstructure self weight of approximately 20 percent.

Lightweight concrete was used on the Shelby Creek Bridge to reduce superstructure weight. (Photo courtesy of PCI.).

Durability

Lightweight concrete has been used in bridge decks for over 50 years. The excellent in-service performance in these structures as well as in marine structures and ships has demonstrated that lightweight concrete is a durable concrete. More detailed information about durability is provided in Reference 1.

Further Information

For more information on the advantages of lightweight concrete, contact your local supplier of rotary kiln expanded shale, clay, or slate lightweight aggregate. Your nearest supplier may be located by going to www.escsi.org.

Reference

1. Holm, T. A. and Bremner, T. W., "State-of-the-Art Report on High-Strength, High-Durability Structural Low-Density Concrete for Applications in Severe Marine Environments," U.S. Army Corps of Engineers, Report No ERDC/SL TR-00-3, August 2000, 116 pp. available at www.wes.army.mil/SL/INP/reports.htm. (This address is case sensitive.)

Editor's Note

This article is the second in a series that addresses the benefits of specific materials used in HPC. The benefits of silica fume were discussed in the previous edition of HPC Bridge Views.