TECH-LINE

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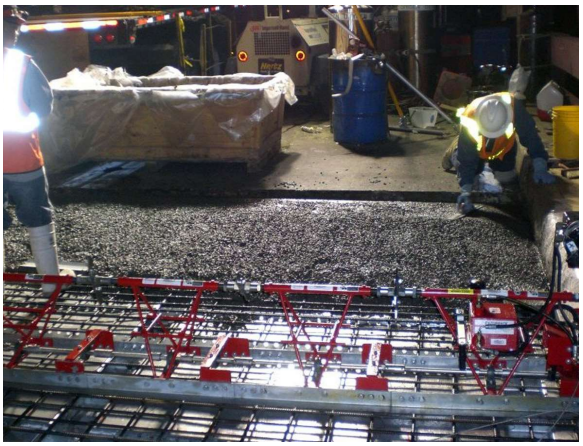
Lightweight Concrete: History, Benefits and Advantages with Grid Reinforced Concrete Decks

The use of lightweight concrete predates the Roman Empire period when local Grecian and Italian volcanic aggregates were used because of their availability, however strengths were limited by the quality of cementitious material. Some improvements were made to the strength of cement paste during the Roman Empire era, but it wasn't until 1824 when Joseph Aspdin developed Portland cement to provide a binder capable of exceeding the strength of lightweight aggregates of that time. The use of expanded shale, clay, and slate (ESCS) began around the turn of the 20th century but significant production and promotion was not seen until the U.S. involvement in World War I when reinforced lightweight concrete was favorably considered by the Federal Government as an alternative material for shipbuilding due to the shortage of plate steel. It is these ESCS aggregates manufactured today that produce the structural lightweight concrete which is 20 to 30 percent lighter than traditional normal weight concrete.



Mathews Bridge in Jacksonville, FL where lightweight concrete was used in conjunction with an Exodermic™ deck to further reduce weight. The deck weighs less than 50 pounds per square foot while maintaining 2 inches of concrete cover over the rebar.

AASHTO bridge design specifications recognize two classes of structural lightweight concrete. "Sand-lightweight concrete" contains normal weight fine aggregate conforming to ASTM C33 and lightweight coarse aggregate that conforms to ASTM C330. "All-lightweight concrete" contains both lightweight coarse and fine aggregates that conform to ASTM C330. Structural lightweight concrete is defined as concrete having a 28-day compressive strength of no less than 2,500 pounds per square inch (psi) and an equilibrium density no greater than 115 pounds per cubic foot (pcf). Typical lightweight concretes used in structures have equilibrium densities between 110 to 115 pcf and compressive strengths in the order of 3,000 to 5,000 psi. Design compressive strengths of up to 10,000 psi can be achieved with some lightweight aggregates.

A primary advantage of specifying grid reinforced concrete decks is their light weight. Grid reinforced concrete decks installed with normal weight concrete are typically 35 to 50 percent lighter than a traditional reinforced concrete slab that would be specified for the same span. For rehabilitation projects, simply reducing the deck dead load may result in an increase of live load capacity or permit widening without the need for expensive and time-consuming strengthening of the superstructure and substructure. For new construction, and especially for cable stay, suspension and moveable bridges, dead load weight reduction translates into savings in the main cables, suspender cables, counterweight, trunnion assemblies, drive machinery, structural steel and substructure. A 15 to 20 percent further weight reduction can be obtained when the same grid reinforced concrete deck is installed with structural lightweight concrete.

Another principal advantage of specifying grid reinforced concrete decks is superior performance and durability. There are several examples of grid reinforced concrete decks constructed with normal weight and structural lightweight concrete that are over 50 years old and are still in service today. The Walt Whitman Bridge (1957), which constructed with normal weight concrete and the Mackinac Bridge (1957), which was constructed using all-lightweight concrete, are just a couple examples. Recently, the 70 year-old grid reinforced concrete deck of the Hatem Bridge (U.S. 40 over the Susquehanna River) was replaced with another grid reinforced concrete deck using structural lightweight concrete.

Some objections to using lightweight concrete include misconceptions about permeability, excessive wear, durability, and construction issues such as pumping. Lightweight concrete has proven to behave similarly to normal weight concrete in both laboratory tests and field performance provided designers and contractors acknowledge the requirements regarding transport, placing and finishing for lightweight concrete. Because lightweight aggregates vary geographically and between suppliers, local producers should be contacted for suggested mix designs, equilibrium properties, and other technical service.

The importance of proper curing on the durability of concrete is well documented. Traditional curing methods such as ponding, fogging, wet burlap, etc. are all forms of "external curing" because they are applied to the external faces of the concrete. However, concrete has benefited from the phenomenon of "internal curing" serendipitously for nearly 100 years. In 2010, the American Concrete Institute (ACI) recognized the recent heightened interest in the subject by defining internal curing as "supplying water throughout a freshly placed cementitious mixture using reservoirs, via pre-wetted lightweight aggregates, that readily release water as needed for hydration or to replace moisture lost through evaporation or self-desiccation." Lightweight aggregate is more absorbent than normal weight aggregate and is typically pre-moistened before batching to prevent absorption of mixing water which could lead to difficulties with pumping and finishing. Once the concrete is placed and hydration begins, the water absorbed in the pre-moistened lightweight aggregate is released into the concrete over time to allow the continuing hydration of Portland cement and reaction of other pozzolans as illustrated in the graphic. Results of recent research on internal curing, including the benefits to grid reinforced concrete decks, are forthcoming from Purdue University which should show how the longevity of grid reinforced concrete decks can be further enhanced.

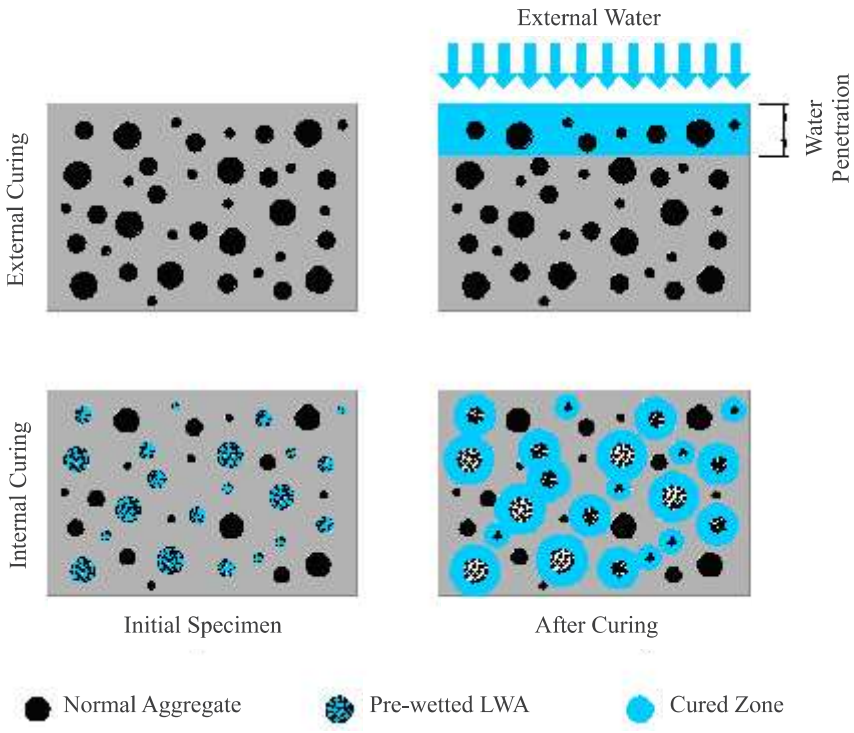


Illustration of the Difference Between External and Internal Curing
(Modeled from Castro, De la Varga, Golias, & Weiss, 2010)

Note: **Carolina Stalite**, a manufacturer of high performance lightweight aggregate, is an Associate Member of the BGFMA. For more detailed information on lightweight aggregates for concrete, visit their website at www.stalite.com

Feel free to contact the Bridge Grid Flooring Manufacturers Association regarding these and other important factors when making an open grid deck selection for your next project.

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