

WHITE PAPER:

# Improve Bridge Deck Performance by using Lightweight Aggregate

A technical article published in the April 2021 issue of Structure Magazine answers the question, “How does lightweight aggregates help minimize cracking in bridge decks?”

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**Authored by Anton K. Schindler, P.E. Ph. D., William H. Wolfe, and Benjamin E. Byard, P.E., Ph.D, the article highlights the benefits of using lightweight aggregate (LWA) to reduce/control the early age cracking in bridge decks. The article states, “Early age volume change occurs due to the combined effect of temperature, autogenous shrinkage, and drying shrinkage”.**

To paraphrase, LWA used in concrete has a lower modulus of elasticity and coefficient of thermal expansion as compared to that of normal weight aggregate concrete. The use of LWA in concrete reduces the internal strain caused from temperature change. This combined effect will result in less strain from temperature change and less stress when volume changes are restrained.

But what about the benefit of internal curing provided by the use of pre-wetted LWA? This “internal curing effect within the hardened concrete is provided as the absorbed water within the LWA is actually desorbed at the early ages with the progress of hydration that needs and consumes water...The release of the internal curing water from the LWA increases cement hydration and reduces capillary stress”.

Referring back to the informative Schindler, Wolfe, & Byard article, there is a tremendous amount of excellent information in graphical form comparing stress, strength, and modulus of elasticity for varying mixtures using sand lightweight and all lightweight concretes. All concrete mixtures showed 28 day strengths above 4000 psi.

They state that concrete made with LWA has a “lower thermal diffusivity...which leads to higher temperatures as compared to normal weight concrete, but while the magnitude of the peak temperature is important, the decreased

coefficient of thermal expansion of LWA concrete causes a reduced strain per unit temperature change.”

To conclude, the significant reduction in modulus of elasticity and coefficient of thermal expansion leads to a reduction in tensile stress and a significant overall delay in early age cracking in bridge deck concrete applications.

### Key Takaways

One of the best takeaways from the published article has been offered by Jeff Speck, General Manager of Marketing & Technical Sales for Arcosa Lightweight, and perhaps one of our industries’ foremost authorities on the use of LWA in concrete and masonry.

***“I think the key conclusion in the report is that the time it takes for the concrete to develop its first crack is increased as the amount of LWA in the mixture is increased. Internal curing uses a relatively small amount of prewetted fine LWA and the result is an increase in time to first crack.”***

“Structural lightweight concrete replaces most or all of the normal weight coarse and fine aggregate with lightweight coarse or fine aggregate and the result is an even greater increase in time to first crack. As the design and construction communities place more and more emphasis on sustainability, the use of IC (internal curing) and structural lightweight concrete should increase. Reduced cracking and increasing hydration reduces intrusion of deicing salts and other contaminants that cause corrosion of reinforcing steel, which is the biggest cause of concrete failures.”

Speck further adds, regarding internal curing, “the data [in the article] shows the relationship between the decrease in the coefficient of thermal expansion and the modulus of elasticity of the concrete, both of which result from using LWA, and the increase in the time to first crack. The potential for an increase



**ABOVE: Internally cured concrete being placed on the Court Street Bridge in Syracuse, New York**

in compressive strength is a benefit, too, but, this is less critical to the longevity of the bridge deck than reducing cracking.”

### Field Projects

The New York State Department of Transportation (NYSDOT) conducted an initial ten year evaluation on a bridge deck in Latham, NY, (upstate) with severe winter exposure with excellent results. The deck was cast with sand lightweight concrete with a density of 110 #/cu.ft.

The NYSDOT has been using internal curing (IC) for crack reduction by replacing 30% by volume of normal weight fines with saturated light weight fines. They evaluated IC as part of a large research study on multiple bridge decks.

One of their ongoing projects, the Bruckner Expressway in NYC, specifies 12,000 cu.yd. of IC

concrete. Actually, the most recent version of their bridge manual requires that high performance, IC concrete be used on several segments of bridge construction.

Internally cured concrete, by the use of LWA, produces widespread benefits regarding the physical characteristics of concrete.

“As more LWA is added to the concrete, the time to initial cracking is delayed, which will improve the in-place performance of the bridge deck.”

LWA concrete is not only for use in bridge decks, but for streets, intersections, rapid repair work, parking lots, etc., remembering that the goal is longevity and permanence.

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Ref: *Improved Bridge Deck Performance with Lightweight Aggregate Concrete*, Schindler,Wolfe,& Byard,*Structure Magazine*, April 2021 URL: <https://issuu.com/structuremag/docs/structure-apr21-digital/8>