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KOMPONENT

CRACK-FREE BRIDGE DECKS

Shrinkage-Compensating Concrete May Be The Answer

Fig. 1 – The realignment of State Highway 58 at its junction with Interstate 15.

> *In 1968 the State of Ohio began testing Type K concrete in bridge decks with impressive results.*

Nearly all bridge decks are constructed of concrete. And almost all concrete bridge decks contain cracks - lots of cracks. Cracks are the bane of deck longevity. They allow the ingress of salts that cause corrosion of the reinforcing steel, exacerbating concrete cracking and loss of structural capacity.

Why does concrete crack? Because as it dries it shrinks, and the shrinkage results in tensile stresses in the concrete, which generally exceed the tensile strength of the concrete as it is setting. Bridge decks are structural elements, hence reinforced. As the concrete dries and shrinks, the shrinkage is restrained by the reinforcing steel inducing compressive forces in the steel; compression in the steel creates tension in the concrete.

The tensile strength of concrete is relatively low and takes time and maturity to develop; at early ages the tensile strength is negligible. Attempts to increase concrete's tensile strength by increasing the cement content or by adding supplementary cementitious materials, such as silica fume, fail to improve the situation (or may even exacerbate it) because the additional water needed for the supplementary cementitious material increases shrinkage.

For portland cement, a water-cement ratio of 0.22 to 0.25 is necessary to hydrate the cement - but at this water content the concrete is unworkable. So most concrete is placed at a w/c of 0.50 or more. The excess water results in concrete with a consistency that can be placed and finished, but the excess water isn't needed for cement hydration, and it therefore bleeds off to the surface, creating water channels. This increases total shrinkage since a significant volume of water is lost. The water channels formed during bleeding then provide a means of ingress for deicing salts.

The solution to this problem is to use shrinkage-compensating concrete, that is, concrete that contains a shrinkage-compensating cement, such as Type K, which causes the concrete to expand slightly. Since the reinforcing steel is bonded to the expanding concrete, it is placed in tension, which causes compression in the concrete. The compressive stress in the concrete negates the tensile stresses caused by shrinkage and prevents cracking. As the concrete dries and shrinks, the compressive stress is relieved, but by this time the concrete has developed some tensile strength that prevents cracking. Proper curing delays the shrinkage, allowing the concrete to develop greater tensile strength and therefore fewer cracks.

In 1968 the State of Ohio began testing Type K concrete in bridge decks with impressive results. In 1984, the Ohio Turnpike Commission began a program of bridge deck replacement; since 1985, all deck replacements have been performed with Type K concrete. In the years since, other states, including Indiana, Michigan, Ohio, and Pennsylvania, have also adopted the use of Type K cement in bridge decks.

In Southern California the realignment of State Highway 58 at its junction with Interstate 15 required the construction of two sets of twin bridges. Type K concrete was used in one deck; the other three were placed with normal portland cement concrete (PCC). This high desert area has low humidity, triple digit temperatures in the summer, and freezing conditions in the winter. Inspection of these decks eight years later revealed that the Type K deck was crack-free while the PCC decks each contained myriad cracks.

Another advantage of Type K concrete is that since it doesn't bleed and form water channels, it is a less permeable than PCC. Also, the lack of bleed water means that the surface concrete has a lower w/c ratio, which increases its abrasion resistance.

As with any concrete, good mixing, placing, and finishing practices are required for proper performance, as is curing. A minimum of seven days of water curing is recommended to ensure that sufficient water remains within the concrete for adequate cement hydration.

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Fig. 2 – The realignment of State Highway 58 at its junction with Interstate 15.