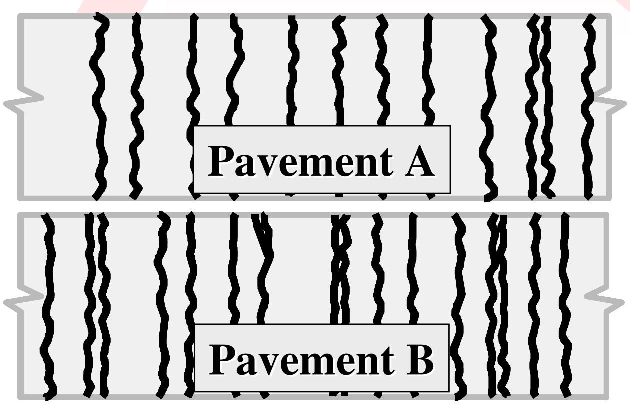
POST-MORTEM CRCP CASE STUDY: AGGREGATE SELECTION DOCUMENTATION

Case Study Topic: ***How does coarse aggregate type affect the performance of CRCP for a set of climatic conditions?***

BACKGROUND

Two continuously reinforced concrete pavements (CRCP), Pavement A and Pavement B, were placed at the same time on the same day, December 12th, 1997. However, Pavement A has been performing significantly better with fewer punchouts and lower maintenance costs than Pavement B for the past 5 years. To determine what is causing this difference in performance, Joe Engineer picks up the HIPERPAV II Guidelines and looks at sections IV.2: Early-Age Pavement Behavior, IV.3: Early-Age Problems and IV.4: Impact of Early-Age Behavior on Long-Term Performance. The early age indicators of long-term CRCP performance are: crack spacing, crack width and steel stresses. Walking down the CRC pavements, Joe Engineer notices that the cracks are spaced closer in Pavement B than in Pavement A. On Pavement A, crack spacings are distributed between 3.5 and 8 ft, while on Pavement B the spacing is less than 3.5 ft in some instances.

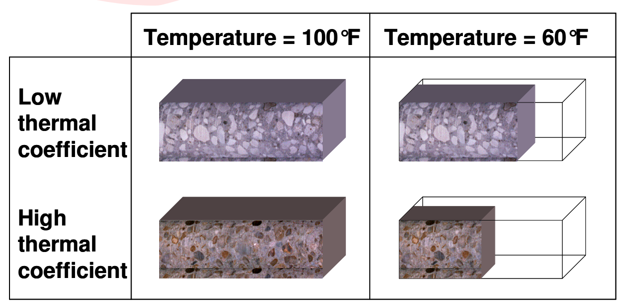


Further investigating the reasons behind this performance difference, Joe studies the construction documents to see if there is a difference in materials used or construction procedures followed when building Pavements A and B. The only difference he can find is that limestone aggregate was used in Pavement A and that siliceous river gravel was used in Pavement B after studying the mix designs.

For this case study, HIPERPAV is used to assess the behavior of an 11-inch CRCP constructed with concrete containing different aggregate types, namely siliceous river gravel, basalt, granite/gneiss, sandstone and limestone. The climatic database in HIPERPAV is used to estimate the temperatures at noon on December 12th.

ANALYSIS STRATEGY

HIPERPAV can be used to understand how aggregate type affects the early-age performance of CRCP. The expansion and contraction of the concrete greatly depends on the coarse aggregate coefficient of thermal expansion (CTE), since coarse aggregate comprises about half of the concrete volume. Since temperature changes are the greatest in the pavement immediately after construction, its volume changes are significant at early-ages. The following figure shows how the concrete volume changes based on its CTE when it is subjected to a temperature drop.



The CTE is especially important for pavements placed in the summer season when temperature extremes are high, as in our case study. During hot weather placement, the peak ambient temperature may coincide with the peak heat of hydration (as in morning placements). Under such conditions, concrete pavements having a high concrete CTE tend to have an increased probability for early-age cracking, when compared to pavements constructed with coarse aggregate having a lower thermal coefficient.

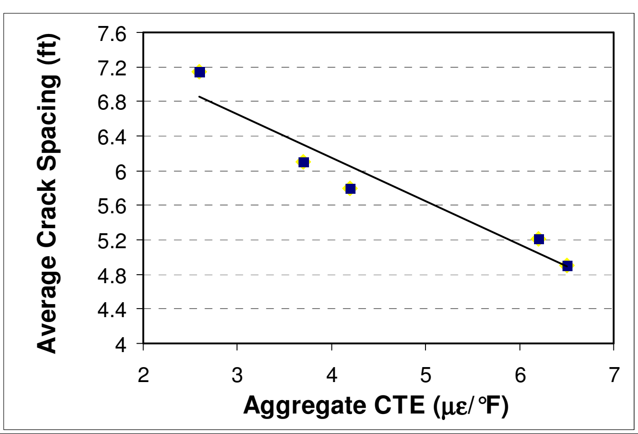
The following table provides HIPERPAV's default CTE values for the selected aggregates.

Aggregate Type	CTE (με/°F)
Siliceous River Gravel	6.5
Sandstone	6.2
Limestone	2.6
Granite / Gneiss	4.2
Basalt	3.7

For each of these aggregate types, HIPERPAV analyses are performed to determine how aggregate CTE impacts CRCP crack spacing, crack width and steel stresses. It is expected that the aggregate with the lower CTE will yield a pavement with longer crack spacings, and therefore, fewer long-term failures (punchouts) (IV.4.7).

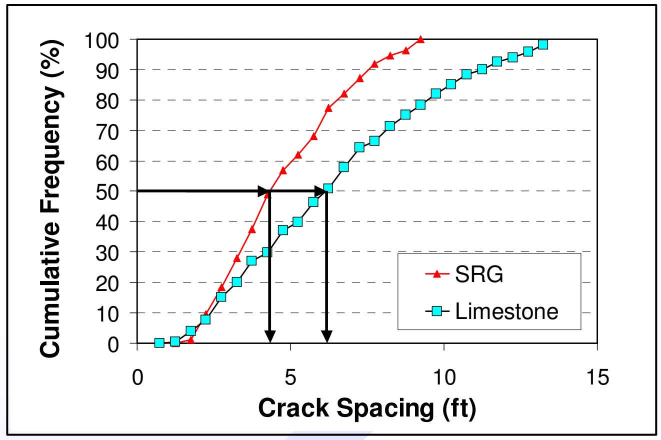
SOLUTION

HIPERPAV runs were performed to assess how the aggregate types listed above influence CRCP performance. PCC CTE is assumed to be 20% higher than aggregate CTE. The impact of changing the aggregate CTE on crack spacing can clearly be seen in the following figure.



For aggregate with a low CTE, the crack spacing is high (6.8 ft), which translates to a reduced number of punchouts in the long-term.

Looking at the cumulative crack spacing for the pavements containing SRG and limestone at one year, it is apparent that the average crack spacing is smaller for the pavement with the SRG.



From these results, it can be concluded that CRCP will have better long-term performance provided the concrete used in its construction has a low CTE. In this case study, changing the aggregate in the concrete from one with a high CTE to one with a low CTE resulted in a larger average crack spacing. This translates to less distress in the long-term.

The pavement constructed with the low CTE aggregate provides better performance since the thermal stresses are reduced. If low CTE aggregates are not available, as is often the case, and a high CTE aggregate has to be used, HIPERPAV can be used to optimize the time of day and the season of placement to ensure the best CRCP performance possible.