Case Study Topic: ***How would a change in cement type affect saw cutting and probability of cracking on a fast track project?***

BACKGROUND

The use of Type III cements has become more common in the paving industry as its high early strength permits earlier opening to traffic. However, due to their high C_3S content and/or finer grind, the early-age heat development experienced with these cements increases early age stresses. The increased concrete strength and stresses also reduce the time elapsed between initial hardening and possible cracking. As a consequence, the optimum time period for saw cutting may be reduced when Type III cements are used.

In this case study, the contractor experienced random cracking prior to saw cutting, and in some instances random cracks developed after the joints were cut. The use of Type I cement along with Fly Ash (FA) replacement will be investigated as an option to reduce the problems experienced on this project.

The following scenario was selected for this case study. A 10 inch jointed concrete pavement has to be constructed under conditions when it is expected that the maximum temperature during the day will be 90°F and the minimum temperature will be 55°F. Siliceous gravel aggregate will be used and the results will be analyzed at a reliability of 90%. Engineering judgment requires that a change in cement type be accompanied by a change in the water/cement ratio to obtain similar workability and strength. Table 1 summarizes the pertinent HIPERPAV input properties for two mix designs meeting the contract specifications.

Table 1. Mix Designs

Mix Properties	Cement Type: Type I	Cement Type: Type III
Cement Content (lbs/yd^3)	601	703
Type F Fly Ash Content (lbs/yd^3)	150	0
Water Content (lbs/yd^3)	293	295
Water/Cement ratio	0.39	0.42
Coarse Aggregate (lbs/yd^3)	1725	1777
Fine Aggregate Content (lbs/yd^3)	983	1109
Water Reducer	Yes	Yes
28-day Indirect Tensile Str. (psi)	625	575

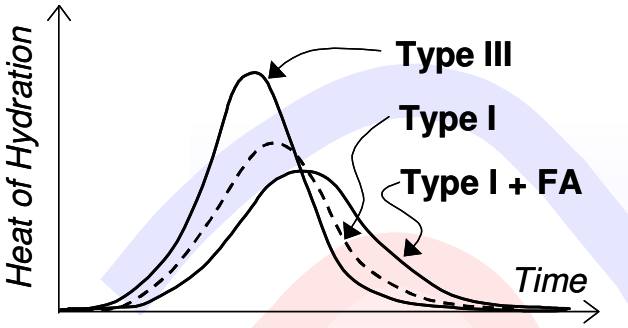
ANALYSIS STRATEGY

The strength gain and stress development should be evaluated in order to determine the feasibility of using a Type I cement with Fly Ash. The **first step** will be to analyze and compare the HIPERPAV results for the two mix designs. At the time the maximum stress is predicted, the strength/stress ratio should be monitored. A strength/stress ratio larger than one will indicate that the pavement has reserve strength. Thus, the objective of this step is to determine if the use of a Type I Cement, will reduce the probability of cracks developing after sawing the joints. The saw cutting at this stage will be assumed to occur at the optimum time.

The **second step** will be to determine a window of time for saw cutting to minimize the potential for cracking prior to saw cutting. HIPERPAV can also be used to estimate when saw cutting should be done. Thus, the objective of this step is to determine if the use of a different cement type will reduce the problem associated with late saw cutting. A saw cutting time of 72 hours will be used as input, as this will allow the evaluation of the predicted stresses in the uncut pavement over the total 72 hour period after placement. The effect of different

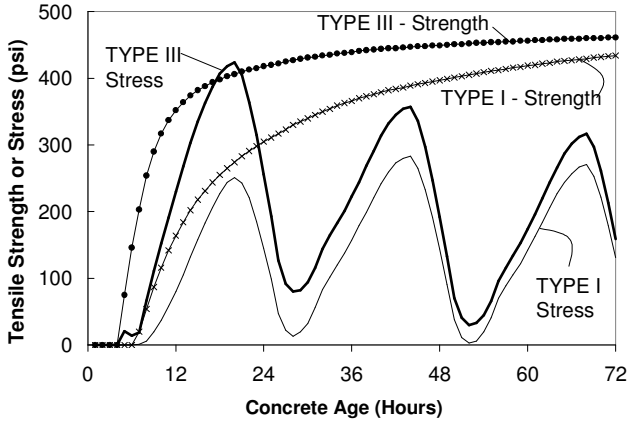
wind speeds could also be investigated at this point to determine the change in the saw cutting time requirements under a wide range of climatic conditions.

It is anticipated that the use of cement Type I + FA would reduce the probability of cracking as the figure below shows that the heat of hydration for a Type I + FA mix is significantly less than that developed during the hydration of a Type III mix. However, the strength gain for the Type III mix is much quicker, and thus it is not as apparent what the net effect will be when using a different cement type.



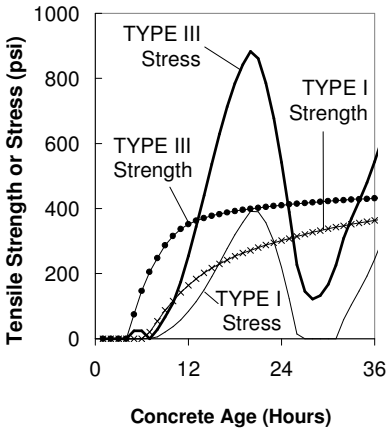
PROPOSED SOLUTION

At first, two HIPERPAV runs were performed to evaluate if the use of a different cement type would reduce the probability of cracks developing after the joints are cut. For this analysis a 10am placement was assumed. The placement temperature for the Type III cement was assumed to be 80°F and 75°F for the Type I cement. The resulting HIPERPAV analyses are summarized in the following figure.



The minimum strength/stress ratios were calculated to be 0.92 for Type I+FA Cement, and 1.04 for Type III Cement. From these results, it can be established that the use of a cement Type I + FA will reduce the probability of cracking after saw cutting.

The second analysis was performed with a saw cut time of 72 hours. The following figure shows the strength and stress development for both cement types. Only the first 36 hours are shown as saw cutting will probably occur before then for these conditions. From this figure, it may be seen that when Type III Cement is used, the time of possible cracking is notably sooner. In this example, the Type III cement requires saw cutting before 12 hours, and the Type I cement requires saw cutting before 15 hours.



Multiple HIPERPAV analyses were also performed in 10 mph intervals for the wind speed. From the following figure it can be seen that an increase in the wind speed reduces the time until cracking may occur.