



## PROACTIVE JPCP CASE STUDY: TIME OF PLACEMENT DOCUMENTATION

**Case Study Topic:** *During high temperature conditions, at what time of day should concrete be placed to minimize the probability of cracking?*

### BACKGROUND

Under hot weather conditions when air temperatures exceed 32°C (90°F), concrete temperatures rapidly increase after placement. This causes the concrete to set at a high temperature, and any significant cooling soon after set will produce high thermal stresses in the pavement. Cracks will likely develop and adversely affect pavement performance. This premature random cracking is commonly called thermal shock (IV.3.2).

Jane Contractor is scheduled to construct a 12-inch JCP in Austin, TX on July 18<sup>th</sup>, one of the hottest days of the year. Knowing that high temperatures can cause unwanted cracking, she picks up the HIPERPAV II Guidelines to obtain guidance on determining the optimal time to start construction and still produce a pavement with good early-age and long-term performance. The time of day recommended in the guidelines for construction is early evening and into the night (IV.5.4.2). Delaying the time of construction to evening takes advantage of nighttime cooling, thereby offsetting the concrete’s heat of hydration. Jane can use HIPERPAV to solve for the exact window of time when paving will produce a high quality pavement at early-age and also in the long-term.

### HIPERPAV ANALYSIS STRATEGY

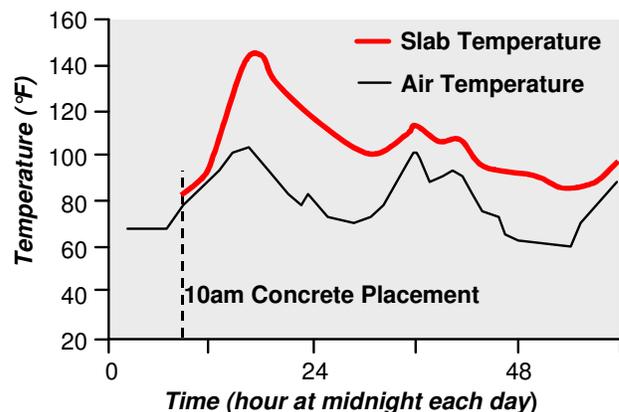
HIPERPAV can be used to assess how changing the time of placement impacts concrete stresses. For this case study, the HIPERPAV temperature database will be used to estimate the climatic conditions on July 18<sup>th</sup>. It is anticipated that the maximum temperature will be approximately 104°F and the minimum temperature 64°F. Jane Contractor is

planning on using a concrete mix specified to reach a laboratory 28-day tensile strength of 460 psi, with siliceous river gravel as the coarse aggregate. Sawcutting will occur at the optimal time.

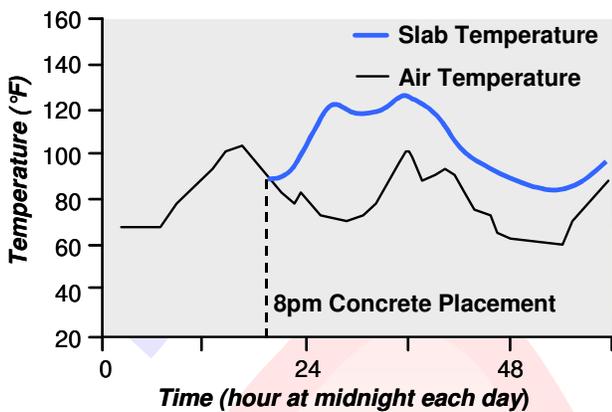
Jane has several options besides changing the time of placement to avoid excessive concrete temperatures. She could use Type II cements or else cool the concrete mix components. But, for this case study, she will instead determine the optimal time of placement for this specific concrete mixture (Type I + Fly Ash) to minimize the probability of cracking.

Twelve HIPERPAV runs will be performed to determine how the time of placement affects the pavement stresses and the concrete strengths. The maximum stress to strength ratio will be determined for each scenario. A stress to strength ratio greater than one indicates the pavement will likely crack. A “Window of Caution” will be noted when the stress to strength ratio is greater than one. No paving should be performed during this time frame.

Changing the time of construction shifts the concrete’s peak heat of hydration, allowing it to be offset from the maximum daily temperature. The figure below illustrates how the concrete temperature rises sharply when its heat of hydration coincides with the peak daily temperature.

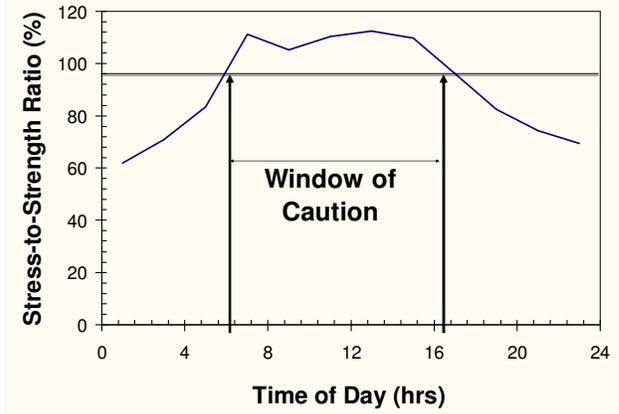


Intuitively, one expects that concrete placed after the maximum air temperature (6pm) and before sunrise (5am) will offset the concrete’s heat of hydration and the maximum daily air temperature. This will produce the most desirable placing conditions, as it forces the peak heat of hydration to coincide with the minimum air temperature. The resulting temperature in the concrete will be low. The effect of early evening placement on concrete temperature is shown in the following illustration.



**SOLUTION**

Jane Contractor performs multiple HIPERPAV analyses at 2-hour intervals using a design reliability of 90%. The impact of changing the time of placement during hot weather conditions on the stress-to-strength ratio can clearly be seen in the next figure. For the conditions analyzed, the “Window of Caution” is from 7am to 5pm. These results clearly demonstrate how HIPERPAV can be used to determine the best time of day for placing concrete to minimize the probability of cracking in JPCP.



Under these assumed conditions, the peak heat of hydration occurs about 6 to 8 hours after placement. Placement at 9am should produce the worst conditions, since 8 hours later the peak air temperature is reached, thereby matching and amplifying the peak heat of hydration temperature.

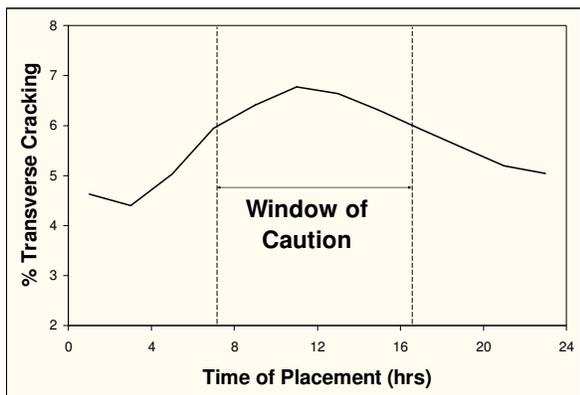
Once the “Window of Caution” is determined, Jane can use HIPERPAV in an iterative manner to further investigate the effect other proactive changes have on minimizing the potential for cracking during the high-risk period of 7am to 5 pm. The measures Jane can look into include different cement types, different aggregate types, cooled batching water, and whitewashing the base.

**Long-Term Performance**

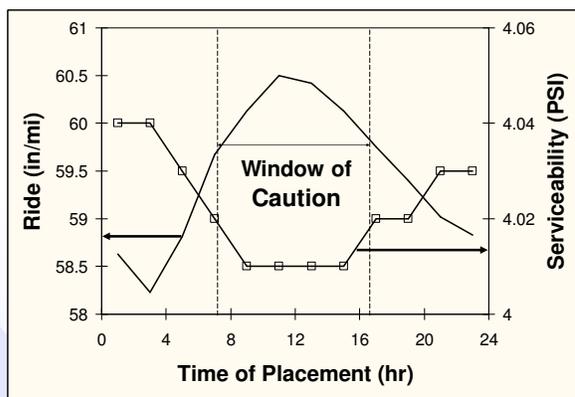
Now that Jane has determined the most favorable time to construct the pavement to prevent early-age failures, she wants to see how the time of placement influences the pavement’s long-term performance. Looking at the HIPERPAV II Guidelines (IV.2), she sees that joint opening, delamination, and built-in curling are some of the primary early-age indicators of long-term performance.

Jane suspects that built-in curling will definitely play a significant role in the long-term performance analysis, since the concrete is being placed during one of the hottest summer months and the pavement will likely set with a positive thermal gradient. According to the guidelines, this will affect pavement smoothness, faulting, and cracking.

Entering the specific load transfer, construction and traffic inputs for his project, Jane assesses long-term performance as a function of placement time at 90% reliability. For all of the runs, joint faulting is a constant 0.01 inches and it is not affected by placement time. However, transverse cracking and smoothness of the pavement change as a function of the time of placement.



The above figure shows that pavements placed during the ‘Window of Caution’ have the highest percentage of transverse cracking in the long term at 30 years, the expected design life. The pavements placed early in the morning and during the night have the lowest amount of long-term damage. Similarly, she finds that the Serviceability and Ride of the pavement will be the best if she places the JPCP outside of the ‘Window of Caution’.



Based on this HIPERPAV analysis, Jane Contractor feels confident that placing her pavement at night and during the early morning hours will result in a pavement with few early-age distresses, and that it will perform well in the long term.