THE TRANSTEC GROUP

Case Study Topic: ***What changes could be made to minimize risk of high thermal stresses when a cold front is expected to pass by soon after concrete placement?***

BACKGROUND

Drastic temperature drops during the first days after concrete placement may significantly increase the risk of cracking of a pavement structure.

When significant changes in temperature are expected during the construction of concrete pavements, it is important to assess the risk of damage to the pavement as well as measures that would keep the stresses in the concrete at an acceptable level.

For the present scenario, a section of a concrete pavement construction project has been recently placed and a cold front is forecasted to occur the following morning. As a result of the cold front, the minimum air temperature is expected to decrease to 50º F.

The pavement was placed from 6 am in the morning to 6 pm in the afternoon with a maximum air temperature of 85º F and minimum of 70º F under clear sky conditions. The initial mix temperature started at 65ºF in the morning and reached a maximum of 75º F. The subbase temperature increased from 65º F up to 80º F.

The average wind speed for that site is expected to be in the order of 7 mph when the cold front passes by. The curing method being used is a single coat of white curing compound.

It is necessary to assess the impact that the cold front will have and what measures can be used to minimize risks of cracking.

ANALYSIS STRATEGY

For this case, the pavement design, mix design, environmental, and construction information are collected to provide HIPERPAV with the necessary inputs for this analysis.

For situations when a cold front is expected soon after pavement placement, several measures can be taken to minimize the risk of cracking. Common solutions include improved curing techniques and rescheduling the joint sawing operations.

The use of effective curing methods prevents undesirable temperature losses in the pavement and provides a more uniform curing temperature.

On the other hand, joint sawing of the pavement may have to be performed with anticipation to avoid development of excessive stresses due to the temperature differential expected during the cold front.

Figure 1. Pavement protected with polyethylene sheets.

SOLUTION

HIPEPRAV was used to evaluate the pavement behavior for the critical conditions predicted at that site. For this analysis, the pavement was divided in 6 subsections in terms of placement time and HIPERPAV runs were made for each subsection. The climatic conditions, mix temperature, and estimated subbase temperature at the time of placement for each subsection were used in the

analysis. The results are presented in Table 1 in terms of the critical strength to stress ratio. A critical strength to stress ratio lower than one indicates excessive stresses in the slab.

Table 1. Results from HIPERPAV Analysis

Placement Time	Subbase Temp.	Mix Temp.	Strength/Stress Ratio
6:00-8:00	65	65	**0.93 at 24h**
8:00-10:00	67	68	**0.98 at 22h**
10:00-12:00	70	71	**1.12 at 20h**
12:00-14:00	72	75	**1.35 at 18h**
14:00-16:00	74	78	**1.47 at 16h**
16:00-18:00	75	80	**1.67 at 14h**

Using a single coat membrane as curing method, excessive stresses occur in the pavement sections placed from 6:00 am to 10:00 am.

During the morning placement (from 6:00am to 10:00am) the maximum heat of hydration appears to coincide with the maximum air temperature. This situation increases the risk of cracking since a higher temperature differential is developed.

Even though the mix temperatures are larger for the sections placed in the afternoon, the maximum concrete slab temperature and tensile stress are less. This counter intuitive condition occurs because the maximum heat of hydration has a greater offset from the maximum air temperature, thus a large hydration heat does not build up. Thus, for these conditions, the risk of cracking is reduced.

The results for the evaluation of different curing methods are presented in Table 2 in terms of the critical strength to stress ratio observed throughout the 72 hrs of analysis. Table 2 shows that polyethylene sheeting and/or cotton mats would provide the best alternative to avoid risks of cracking in the pavement for the sections placed in the morning. Either of those alternatives should be considered as an option for at least the sections placed in the morning with the most critical conditions.

An analysis for latest joint sawing time was also performed for the case with polyethylene sheeting. The joint sawing analysis was performed by evaluating the stresses with an age at sawcutting of 72 hrs. After this, the age at sawcutting was changed to a time just before excessive stresses are observed to develop in the previous analysis.

The latest age for joint sawing with a safe strength to stress ratio is presented in parenthesis in Table 2 for polyethylene sheeting. Obviously, the sections placed in the afternoon require an earlier joint sawing since for those sections the time of placement is closer to the time the cold front occurs.

Table 2. HIPERPAV Analysis for Different Curing Methods (Critical Strength-Stress Ratio)

Placement Time	Polyethylene Sheeting *	Cotton Mats	P.S. + Cotton M.
6:00-8:00	1.02 (22 h)	1.39	1.41
8:00-10:00	1.10 (20 h)	1.56	1.59
10:00-12:00	1.27 (18 h)	1.96	1.96
12:00-14:00	1.61 (16 h)	3.13	3.13
14:00-16:00	1.79 (15 h)	2.70	2.63
16:00-18:00	2.00 (12 h)	2.33	2.27

* Latest sawcutting time appears in parenthesis.

Performing a similar analysis for the sections placed in the afternoon, using curing compound only, a comparable latest age at sawcutting to the one determined for polyethylene sheeting is obtained.

This case study demonstrates the importance of monitoring the weather conditions during concrete placement. It also shows how potential problems can be predicted, and thereby, mitigated by performing a simple analysis of the pavement behavior with HIPERPAV when critical weather conditions are expected before or during concrete pavement construction.