CASE STUDY: POST MORTEM INVESTIGATION DOCUMENTATION

Case Study Topic: ***A concrete pavement recently constructed is experiencing mid panel random cracking, what might be the causes of this problem?***

BACKGROUND

Cracks developed in concrete pavements due to thermal stresses commonly appear from a few hours to a few days after construction. In some cases, they may not be apparent for 5 or 10 years, but they may rapidly progress into a distress that may significantly affect the long-term performance of the pavement.

Thermal cracking is often due to high temperature differentials, excessive subbase friction, aggregates with high thermal expansion/contraction characteristics, late sawing of contraction joints or a combination of the above.

In this case study a forensics analysis is required for a 10" JCP pavement recently constructed. Mid panel cracking was observed to occur during the first placement on top of a rough Open Graded Hot Mix Asphalt (OG-HMA) subbase. In a second placement, to reduce the cracking potential, white curing compound was applied on top of the subbase to serve as a bond breaker. However, cracks were also observed on the second placement.

Information and measurements collected during a field inspection visit are presented below:

- Joint spacing: 15 ft
- 28-day Lab Indirect Tensile Strength: 520 psi
- The mix design specifies a type I cement mix with 18% fly ash replacement. The aggregate used in this project is of siliceous origin.
- The air temperature based on climatic data collected from the region presents a high of 90°F and a low of 60°F.
- The placement time for the sections where random mid panel cracks were observed was recorded to occur around noon with sunny sky conditions and average wind speed of 5 mph.
- The slab was covered soon after placement with a white curing compound. The initial PCC mix temperature recorded at placement was 65ºF.
- Sawing operations occurred 12 hrs after placement.

ANALYSIS STRATEGY

The use of stabilized bases can often lead to extremely high friction resistance at the slab-subbase interface with minimum slab movement before sliding. This situation generates excessive stresses in the slab, as may be the case for the present scenario.

Friction for any subbase type can be easily characterized with a standardized push-off test. The setup for the push-off test is presented in Figure 1.

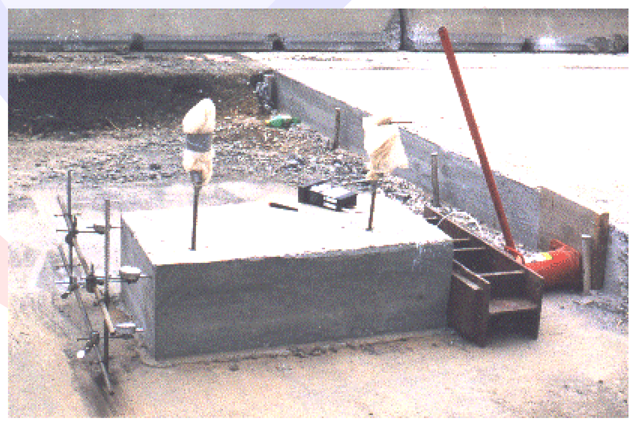

Figure 1. Setup for push-off test.

The results obtained with the push-off tests are the characteristic friction force for that subbase and the displacement/friction relationship as depicted in Figure 2. The level of friction is proportional to the slab displacement until the maximum friction force occurs and the slab slides.

A push-off test was performed on both sections. The information obtained with the push-off test procedure yields a maximum friction force per unit area of 16.0 psi and movement at sliding of 0.0015 inches for the first section. The second section where curing compound was used as bond breaker yield a friction of 15.0 psi and movement of 0.0015 inches.

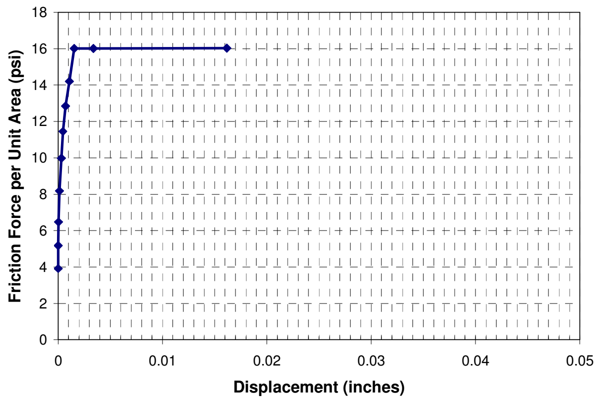

Figure 2. Typical Friction Curve for rough HMA base

SOLUTION

The results of the analysis performed with HIPERPAV and the information collected in the field indicate a high risk of excessive thermal stresses that explains the random cracking observed. According to these results, the strength would be exceeded by the stresses generated in the slab 18 hrs after placement, at 90% reliability for both cases.

Possible causes of cracking for this project may be due to the high friction at the slab/subbase interface, a relatively high concrete temperature differential, the use of aggregates with high Coefficient of Thermal Expansion, and/or late joint sawing.

Several runs were performed with HIPERPAV for the conditions depicted above. Using aggregates with lower coefficient of thermal expansion could contribute to reduce the thermal stresses in the concrete. Placement time was also investigated, and although night placement could reduce the thermal stresses, construction costs might increase significantly. Changes in sawing time were also analyzed with no significant reduction in the stresses observed. Finally it was found that by reducing the subbase friction the potential of high thermal stresses was minimized and yielded the most cost effective solution.

When a subbase with high frictional characteristics exists for a specific project, a bond breaker may be required to minimize friction. The effectiveness of different bond breakers to reduce subbase friction can also be evaluated objectively by performing various push-off tests.

The effect of reducing the subbase friction can be evaluated with HIPERPAV, by comparing the magnitude of the stresses that develop.

For this scenario, several bond breakers on top of the OG-HMA subbase were tested. Table 1 presents the friction characteristics determined from push-off tests and the results obtained with HIPERPAV for each option in terms of the critical strength-stress ratio.

Table 1. Push-off Test Results

Condition	Friction (psi)	Movement at sliding (in)	Critical Strength to Stress Ratio
Untreated OG-HMAC	16.0	0.0015	0.96
Curing Compound	15.0	0.0015	0.97
Slurry seal	12.0	0.08	1.40
Polyethylene Sheeting	1.0	0.09	1.42
1/16" Sand	6.0	0.05	1.39
Petromat	6.0	0.03	1.37

Strength to stress ratio smaller than one indicates excessive stresses. It is observed in Table 1 that with the exception of the curing compound option tried initially; any of the other alternative bond breakers would significantly reduce the friction for the subbase, and thus, minimize the slab cracking potential.

It must be noted that the friction characteristics for the bond breaker materials vary depending on the subbase where they are applied. The values presented here apply only to the OG-HMA subbase where they were tested.