GAS TECHNOLOGY INSTITUTE
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Laboratory Testing of RC Grout Used in Pavement Core Reinstatement

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TESTING PROGRAM SUMMARY

Title: Laboratory Testing of RC Grout Used in Pavement Core Reinstatement

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Objective: A laboratory-testing program was carried out in order to evaluate the mix properties, mixing time, and interface shear strength of the RC grout all at a one-hour curing time and constant temperature. The grout is used for intact pavement-core replacement during keyhole operations.

Approach: Laboratory tests were performed on 4-inch diameter asphalt cores with an average height of 5 inches. The cores were drilled from aged asphalt slabs obtained from streets in the Chicago area. Figure 1 shows the drilled cores from the asphalt samples. The cores were then reinstated using the RC grout.

The grout was mixed in controlled lab temperature of about 72°F. Grout samples of about 6 to 8 lb were mixed at various water content ratios and mixed for durations of 30 seconds to one minute (Figure 2). The grout was left to set for a period of one hour before applying the loads

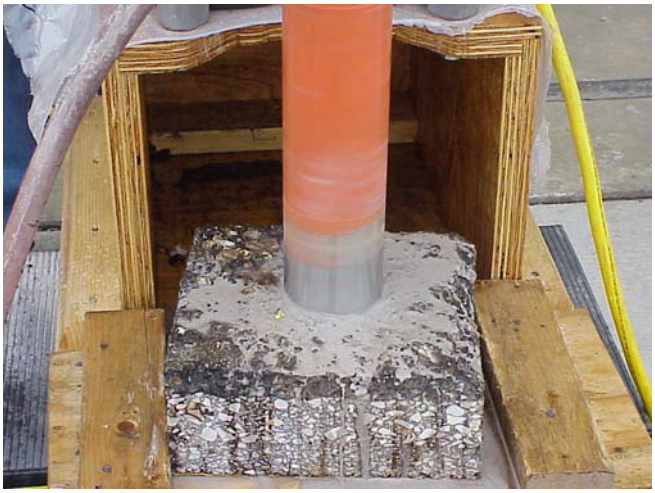

Figure 1. Drilling the 4-inch core in the asphalt specimen

Figure 2. Mixing the grout in the lab

Shear tests were performed by applying a vertical load to the grouted cores. The shear resistance at the grout interface and the displacement of the core were measured during load application. A gap in the base plate was left beneath the core and grouted area to allow for a free displacement of the core. Figure 3 shows a schematic of the shear test. The tests were performed using the MTS compression-testing machine at GTI's ASTM Lab. Figure 4 shows the application of the load on the grouted core.

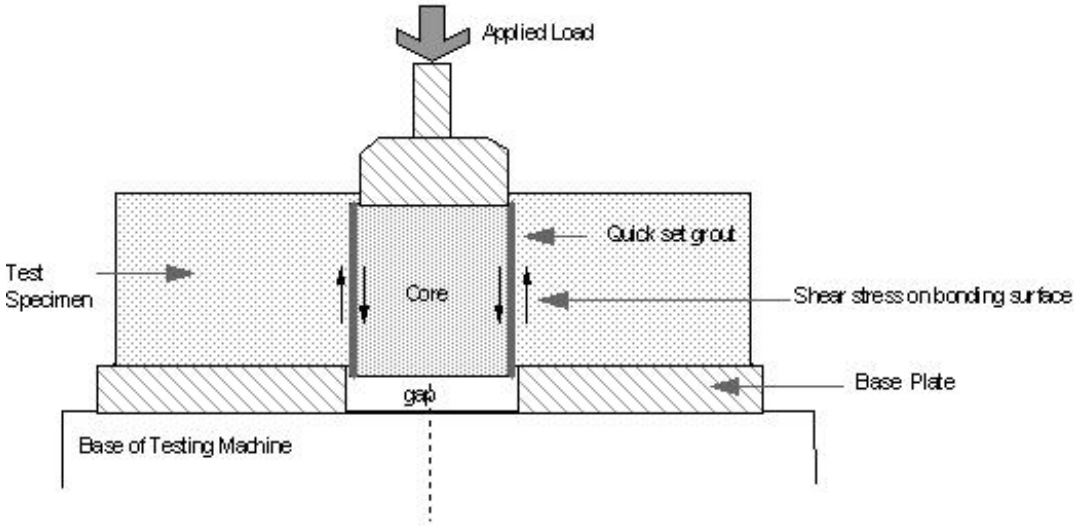

Figure 3. Schematic of the shear testing on the grouted core

Figure 4. Lab test to evaluate the one-hour shear strength of the grout

B. GROUT SELECTION CRITERIA

The selection of the appropriate grout for use in intact core replacement depends on many criteria:

- The grout should provide the shear strength required to transfer the traffic load from the core to the adjacent pavement structure.
- The grout should reach its target strength at an adequate setting time to allow fast opening to traffic.
- The consistency should be of medium viscosity such that it allows flow of grout through the core sides and, it prevents settlement of the core under its own weight.
- The grout should be readily available in the market.

The amount of shear strength required for transferring the vertical load to the adjacent pavement can be estimated by applying a half-axle wheel load of 9 Kips on the top of the core as shown in Figure 5. This value represents the maximum load on the pavement under the standard 'Equivalent Single Axle Load ESAL' of 18 Kips. It should be noted that this amount of load results in a conservative estimation of shear strength as the surrounding pavement usually carries a protion of the wheel load when dual tires run on cores of 18-inch diameter and smaller.

The portion of the wheel load, which is transferred by the grout to the adjacent pavement, depends mainly on the thickness of the core. In thin cores, most of the load is carried out by the base soil under the core. In thicker cores, the load is primarily carried out by shear stress along the kerf of the core (grout line). The maximum shear strength carried out at the interface (τ_{max}) can be calculated from the following equation:

$$\tau_{max} = (\alpha \times 9{,}000 \text{ lbs}) / (\pi D H) \quad \text{(in psi)}$$

Where 'α' is the percentage of wheel load carried by shear stress along the kerf of the core, 'D' is the diameter of the core in inches, and 'H' is the height of the core in inches.

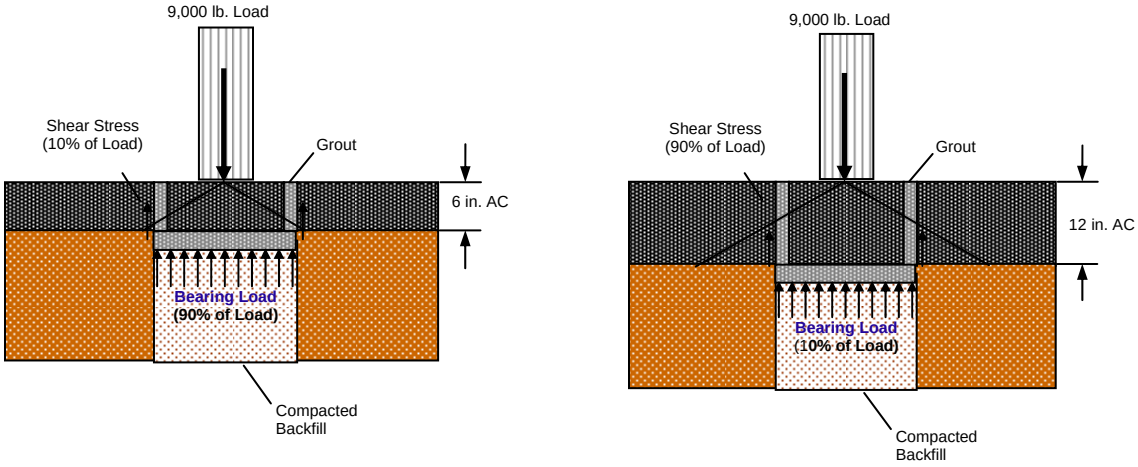

Figure 5 – Differences in shear load carried by the grout in different asphalt thickness

If a conservative approach is taken the entire load would be carried by the grout and 'α' would be 100%. Using this conservative approach an 18-inch diameter core 6 inches thick would have a $\tau_{max,6"}$=26.5 psi and a 12 in. thick core a $\tau_{max,12"}$=13.2 psi.

These values yield an average shear strength (τ_{max}) value of **20 psi** for cores that averaging 8 inches thick. Equating this stress to the test samples (4 in. diameter and 5 in. height) the critical load the test cores and grout would need to support would be 1.26 kips, which would achieve the 20 psi stress.

RESULTS

Table 1 shows the testing parameters and the results of shear strength.

Table 1 . Laboratory testing program

Set	Mixing Ratio (Grout: water)	No. of tests	Mixing Time (sec)	Mixing Temp. (^{O}F)	Set Time (Hour)	Stress at 1% Strain (psi)	Max Shear Strength (psi)
1	1: 0.133	3	30	72	1	16-30	22-45
2	1: 0.145	8	30	72	1	12-18	18-36
3	1: 0.156	2	60	74	1	12	32-44
4	1:0.166	3	30	72	1	0.8-6	0.8-6.5

Summary

Based on the passing criteria values test #4 was the only test that did not pass.

Some additional mix ratio conclusions are listed below.

- The RC grout mixed with water content of 0.145 and 0.156 (equivalent to about 7 to 7.5 pints of water to 50 lb of grout) had a good mix consistency that allowed for easy flow of the grout up the sides of the core during installation. The one-hour shear strength of the grout was 12 to 18 psi at a one-percent strain level.

- The grouts mixed at a water content of 0.133 (equivalent to 6.4 pints of water per 50 pounds of grout) had higher shear strength than the wetter mixes, however, was relatively too dry to allow for easy flow of grout during installation.

- Shear strength of the grout decreases with the increase of water content in the mix. A wet mix ratio of 1:0.166 (equivalent to 1 gallon of water to 50 lb of grout) provided more grout flow during installation. It, however, resulted in much lower shear strength of the grout after one hour.