GROUTS FOR SUBSEALING

by

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Abstract

Voids that may form under pavement slabs, the sub-base, or both, cause a loss of support and promote deterioration of the pavement. The loss of support results in increased slab deflections and stresses which can lead to the complete breakup of slabs. To restore the slab support, materials in a plastic state are forced under pressure into the voids and depressions under the slab without raising it in a process called "subsealing".(1,2,3) Under pressure, the plastic materials also displace pockets of free water that contribute to slab pumping and to erosion. If the slab is lifted during the subsealing operation, the term "slabjacking" is used.

For subsealing, cement grouts and asphalt cements have been used with the former now being used far more extensively than the latter. Hot asphalt is said to be too viscous to completely penetrate the voids, and the heat it gives off can weaken or crack a slab.(4) Also, it can entail safety hazards for those using it.

Grout Mixtures

Grout mixtures used in subsealing must flow with low internal friction to move through small openings and follow water channels in filling voids. They must also have sufficient body to displace free water and develop adequate strength and durability. (5) When hardened, the mixtures should be relatively insoluble, incompressible, and resistant to erosion.

Materials

Over the years a variety of grout mixtures have been used. Early grouts included soil -- usually sandy or silty loam -- and cement, but problems in compressibility and erosion were encountered with these. (1) Sand-cement grouts also have been used. (6) Sufficient water is added to ensure good pumping and flow characteristics. The size, shape, and grading of the particles in the materials have been given attention in efforts to produce needed flow characteristics. It has been reported that grouts containing fine sand do not have flow characteristics as good as those without sand. (5)

Currently, two types of grouts are widely used: one made with cement plus limestone dust and the other with cement plus pozzolan. Although both types have been used successfully, the cement-pozzolan grouts are preferred and highly recommended because of their ready availability and low cost, and because of the good flowability resulting from the small size and spherical shape of the pozzolan particles and the high strength and durability resulting from the pozzolanic reaction. A study from Illinois has concluded that fly ash grouts were stronger and more flowable than those made with limestone dust.(7) Also in the latter, the grain shape of the dust is critical for flowability. Flat rhombohderal, and other nonspherical shapes are not recommended. (3) Pozzolan grouts are made with natural pozzolans such as volcanic ash and diatomaceous earth, or with artificial pozzolans, such as fly ash. The pozzolan should conform to the requirements of ASTM C 618, and the effect of the pozzolan on strength and time of setting must be determined in trial mixtures. A typical mixture currently used contains three parts pozzolan and one part cement, type I or type II. Some of the fly ashes are sufficiently reactive that different proportions may be considered. If early strength is needed, type III cement may be used.

At certain times, especially when small voids are to be filled, the use of a neat cement and water mixture has been found to be desirable for subsealing. Different cement-water ratios have been used.
Chemical admixtures have been used in grouts to achieve desired properties, however, they should be tested in trial mixtures with the other materials to be used to avoid potential problems. Chemical admixtures may include water-reducing agents, accelerators, retarders, and expanding agents to offset shrinkage. The current trend is to use no chemical admixture. (3)

<u>Properties</u>

Flowability -- The addition of water improves flowability, however, excess water delays the time of setting, reduces strength and increases shrinkage of the grout on drying. Therefore, the amount of water should be well controlled. The required water content is determined by use of a flow cone which measures the flowability of the mixture in terms of the time required to empty the cone, as is explained in ASTM C 939.(8) The flow generally varies between 10 and 16 seconds for grouts containing fly ash and 16 to 22 seconds for those with limestone dust. (3) An increase in the amount of water added results in a reduced time of flow. Time of Setting -- The time of initial setting of a grout usually occurs between 1 and 6 hours at temperature above 70°F.(4) Grout injected is normally restrained and cannot be displaced laterally. Thus, it can support traffic even before setting. Generally, traffic may be permitted on slabs 2 hours after grouting. Strength -- The strengths of grouts can be determined using the standard mortar cube test, ASTM C 109.(8) At 7 days a compressive strength in excess of the 600 psi is expected. The ultimate strength of the grout will be much higher, usually ranging from 1,500 to 4,000 psi. (3)

<u>Equipment</u>

The equipment needed during subsealing consists of:

1. air compressors to drive pneumatic hammers

2. pneumatic hammers with drills for drilling holes,

3. a grout plant with colloidal mixer and a pump capable of applying from 50 to 250 psi

4. a flow cone to determine the consistency of the mixture,

5. rubber grout packers to seal the open space between grout injection pipe and drilled holes, and

6. wooden plugs to plug* the holes. (5)
   * (current procedures do not include plugs.) (9).

Procedure

Subsealing can be applied to the entire project or to localized areas. (3,5) However, one should be cautious in making a blanket application, since harmful stresses can develop in areas where there are no voids. In jointed concrete pavements, most pumping occurs at joints and transverse cracks of medium-high severity and corner breaks may develop at joints and working transverse cracks. Subsealing is usually considered at those locations. In continuously reinforced concrete pavements, pumping can occur anywhere, and subsealing is typically applied in areas where there is loss of support of the slab. These can be located through deflection tests, observed pavement pumping, and coring.(5)

Holes must be drilled in a pattern that best facilitates filling the areas where loss of support has occurred. Areas that do not exhibit a loss of support should not be subsealed.(3) Preliminary deflection tests can be helpful in selecting an initial hole pattern which later can be altered to meet the conditions encountered.

Holes should be drilled through the slab and just into the base where there is a non-stabilized or granular base and where there is a stabilized base, holes should be drilled through the base and a maximum of 3 inches into the subgrade. Care should be exercised during drilling. High impact hammers with drills that may cause coning of the underside of the slab, or other damage should not be used. Grouting should begin at a low pumping rate and pressure. However, a short surge up to 200 psi can be allowed at the start, but this should quickly drop below 100 psi to a range of from 30 to 50 psi. Pumping is stopped if (a) the initial pressure does not drop, (b) the pumping pressure increases, (c) the slab lift exceeds a specified limit (often 0.125 inches), (d) grout is observed flowing from adjacent holes, cracks or joints, or (e) grout is flowing into an unusually large cavity as indicated by prolonged grouting.(3) After grouting is completed at any one hole, the packer is removed from the hole and the hole may be plugged immediately with tapered wooden plugs. However, the current procedure is not to use plugs and to let the slab settle.(9) When plugs are used, they are removed and the hole filled with cement grout after the grout has set sufficiently that it will not be forced back through the hole.

Experience

An FHWA survey of rehabilitation techniques conducted in 1983 indicated that 26 states have used portland cement grout subsealing, as shown in Table 1. Additions to the list are expected; e.g., Virginia is presently using subsealing as a part of the Pavement Restoration Program.(9)

TABLE 1

States Using Portland-Cement Grout Subsealing

State	Years Used	Routinely Used	Occasionally Used	Tried, But No Longer Used
Alabama	4	x		
Arkansas	6	x		
California	3	x		
Colorado	2		x	
Florida	7	x		
Georgia	10	x		
Iowa	1			x
Idaho	4		x	
Illinois	3		x	
Kentucky	30		x	
Louisiana	25		x	
Maryland	5		x	
Mississippi	35	x		
North Carolina	10	x		
New Jersey	50		x	
New Mexico	5	x		
New York	2		x	
Ohio	1		x	
Oregon	2		x	
Pennsylvania	4		x	
South Carolina	7		x	
Tennessee	5	x		
Texas	10		x	
Washington	6	x		
West Virginia	21		x	
Wyoming	2	x		

References

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4. "Pavement Undersealing Principles and Techniques," ChemGrout, La Grange Park, Illinois.

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NUCLEATION KINETICS OF THE ADMIXTURE CALCIUM CHLORIDE

by

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Abstract

Of the several missions assigned to TRB committee (A2E05) "Chemical Additions and Admixtures for Concrete", the most interesting one perhaps is "the elucidation of admixture reaction kinetics."

What follows is such elucidation. It pertains to the admixture calcium chloride, and is excerpted from a paper which was formally presented at 65th Annual Meeting of the TRB, titled "Use of Calcium Chloride Accelerated High Early Strength Concrete for Slab Repair and Replacement," by John W. Bugler of the New York State Department of Transportation (Region 10-Hauppauge, NY 11788).

The Accelerating Admixture - Calcium Chloride

The Chemistry - Background. The major reaction products of hydration of alite [substituted tricalcium silicate (C_3S)] are calcium silicate hydrate, ($3CaO\ 2SiO_2\ 3H_2O$) or abbreviation C-S-H and calcium hydroxide, $Ca(OH)_2$ or abbreviation CH. The C-S-H is largely a microcrystalline amorphous gel of enormous surface area (500 m^2/g) and occupies about 70% (volume) of the hydrated material. The calcium hydroxide is crystalline and occupies about 20% (volume) of the hydrated material. They are formed as follows:

$$C_3S + H \longrightarrow C\text{-}S\text{-}H + CH$$

$$\text{Tricalcium Silicate} + \text{water} \longrightarrow \text{Calcium Silicate Hydrate} + \text{Calcium Hydroxide}$$

$$2(3CaO\ SiO_2) + 6H_2O \longrightarrow 3CaO \cdot 2SiO_2 \cdot 3H_2O + 3Ca(OH)_2$$