REPORT OF COMMITTEE ON MAINTENANCE OF JOINTS IN CONCRETE PAVEMENTS AS RELATED TO THE PUMPING ACTION OF THE SLABS

HAROLD ALLEN, *Chairman*

Materials Engineer, Public Roads Administration

The committee presents as a progress report papers covering experiences and methods of control used in Missouri, Ohio, Indiana, New Jersey and Tennessee. These papers describe work that has been done in an effort to determine the causes of pumping, to develop maintenance procedures that will relieve the condition on existing pavements and to develop pavement and subgrade details that will prevent its occurrence on future construction. The conclusions presented are those of each author and do not necessarily represent the opinion of the committee as a whole.

These papers will be published by the Highway Research Board in a separate bulletin. The following are abstracts of the six papers.

MAINTENANCE METHODS FOR PREVENTING AND CORRECTING THE PUMPING ACTION OF CONCRETE PAVEMENT SLABS—MISSOURI

BY REX M. WHITTON, *Engineer of Maintenance*

Missouri State Highway Department

The type of concrete pavement failure that is causing the most concern today in Missouri is the result of "slab pumping" or the deflection of the pavement under a moving load. "Slab pumping" is the ejection of water thru the joints and cracks in concrete pavements carrying soil particles from the subgrade. Continued "slab pumping" results in voids under the concrete pavement and finally the breakdown of the pavement itself.

It has been proven through both research and observation that four factors must be present to create a "pumping slab." They are, namely:

1. Heavy axle loads
2. Joints or cracks in the pavement
3. Unsuitable subgrade soil
4. "Free" water under the slab

The elimination of any one or more of these factors extends the life of the concrete pavement for many years.

The range of soil types on which pumping has occurred is extensive. Any soil that can be puddled into a suspension in water will react to the rocking action at pavement joints and cracks and in the presence of water will develop pumping. There are some soil types developed in areas of low relief possessing a distinct clay-pan, such as the Putnam Silt or Lebanon Silt, which are relatively more susceptible to pumping than the more drainable types such as the Knox Silt or the Marshall Silt. However, any clay or silt type soil in the proper environment will develop pumping.

In 1941, when the pumping action was noted on heavily traveled routes in Missouri where the condition had heretofore been present but less intense, a special study was made of the problem. After obtaining the experience of other States, a decision was made to use the mud-jack with a slurry mix of loam top soil and portland cement instead of the semi-stiff mix. A more fluid mix was necessary to give a greater spread of the mixture under the pavement and to fill more of the small voids and channels.

The slurry mix was obtained by mixing the soil and cement, the proportions being four sacks of portland cement per cubic yard of top soil with 50 to 55 per cent water added, in the pugmill of the mud-jack.

Observations in the field indicated that, by the use of this slurry mix, the soil-cement would be pushed or pumped through to the top of the pavement at cracks 20 and 25 ft. from the point of injection. Also by using this mix, the pavement was not set up on stools as was the probable condition in previous years when the stiff mix was employed for raising settlements.

The holes for corrective and preventive mud-jack work are now placed 10 in. to 12 in. from the centerline and 10 in. to 12 in. beyond the transferse crack or joint in the direction of traffic. Since the use of air in conjunction with the pressure supplied by the mud-jack has not been utilized due to lack of equipment, we have come to the conclusion that one hole should be drilled in diagonal corners at the location mentioned so that the greatest amount of slurry can be pumped under the pavement.

Experimental sections were set up using both the one-hole method and the two-hole method, and it was found that 0.09 cu. yd. more slurry was pumped per crack where two holes were used instead of one. When it is necessary to use a hole on the outside of the pavement for filling or for raising purposes, it should be placed 30 in. from the edge of the pavement and 30 in. beyond the crack in the direction of traffic. By using this spacing, the inside and outside hole will not be in the same line, which, if it were the case, would establish a plane of weakness and could cause a break if the treated joint should resume pumping in future years.

The holes are drilled with a pneumatic jack-hammer using an 18-in. drill steel and a 1½-in. removable bit. Where the selected soil desired is not available, it is more desirable to use a 1¾-in. or 2-in. hole so that a larger nozzle opening can be used and thus avoid delays from the rocks and roots in the mixture. However, the 1½-in. hole is used in all cases where desirable soil can be obtained for the work. Usually one man not only drills the holes, but moves the equipment ahead as his work progresses, takes care of the compressor, and shifts the barricade which protects him from traffic. He may drill as many as 325 holes 1½-in. in diameter per 10-hr. day, but the total varies with the condition of the pavement to be treated and the number of moves required per mile, as well as with the kind of coarse aggregate that has been used in the concrete.

The 1½ in. holes cost an average of $0.07 per hole, and in some sections of the State, 402 holes are required per mile to treat every joint and crack.

On one section, 32 miles in length, an average of 354 holes and 35.45 cu. yd. of slurry per mile were used. The cost of the work on this section was $24.78 per mile for drilling the 1½-in. holes and $256.66 per mile for the material and pumping operation, or a total cost of $281.44 per mile.

In a study of the deflections of the pavement under moving loads, it was found that deflections increased immediately after filling the voids under the pavement with the soil-cement slurry and then decreased after a period had elapsed. For a 12,000-lb. rear axle load, the deflections were reduced as much as 0.007 in. and for a 16,000-lb. rear axle load as much as 0.011 in. between measurements made 9 days and 153 days after mud-jacking.

It was found that a few of the mud-jacked slabs resumed pumping and that the work had to be supplemented with joint and crack waterproofing to keep surface water from reaching the subgrade. On pavements that were cracked extensively, the best method of water proofing joints was the use of a substantial bituminous surface or upper deck not less than 1 in. thick.

After a study of design features from the viewpoint of a maintenance engineer, it was concluded that expansion or contraction joints should not be used in concrete pavements except at highway intersections, bridge ends or other locations where the pavement abuts a fixed object.

A definite relation between the type of aggregate and the crack interval in concrete pavements in which no joints were placed was found. In one instance, on a pavement built in 1926 without expansion joints, the crack interval was 22.9 ft. for a highly expansive aggregate and 76.8 ft. for an aggregate having a low volume change. On another project built in 1925, these values were 21.9 and 92.8 ft., respectively. In view of the fact that a short crack interval encourages "slab pumping," it seems logical that considerable thought should be given to the aggregate used in the construction of concrete pavement.