Subsealing of Concrete Pavements

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This paper concerns the experiences in District No. 4 of the New York State Department of Public Works with the salvage and restoration of old concrete pavements. These pavements were pumping badly and due to loss of subgrade support were consequently being weakened under the pounding of heavier and greater volumes of traffic. These experiences cover a period since 1948. Most of these pavements were constructed in the late 1920's and early 1930's and had been subjected to severe use. Also, they were not built to the present standards of foundation and subgrade construction, and were laid on a variety of soils prevalent in western New York. The methods used, their application, and the results obtained, are discussed.

The effect of this work, has been to restore the foundations of hundreds of miles of pavement and adapt them to present-day traffic through widening and serving as bases for asphaltic concrete overlays at an economical cost. The net result has been a consistent rehabilitation of a 1,400-mi highway system meeting present demands of traffic.

●DURING THE late 1920's and 1930's, the State of New York embarked on an ambitious program of highway construction, in order to meet the demands of traffic which had been steadily increasing since the end of World War I. Under this program a large mileage of concrete pavement was built, which has faithfully served to the present.

In most all cases, the original investment made in these pavements has paid handsome dividends to the public, by providing adequate roads and thereby being a major and important factor in the development of the economy to the highest level of all time.

However, the time has long since come and gone when these roads must be modernized to such standards that they can meet the requirements of greater volumes of traffic, heavier loads, and higher speeds. Call it the tyranny of the wheels, but it must be faced that the populace and economy have become increasingly dependent on the motor vehicle for the transportation of people and goods. As a result, the best possible means must be provided for that vehicle to use in going from one point to another. Even though these concrete pavements, built in the 1920's and 1930's, had more than paid off their original investments in the great majority of cases, it was believed possible to salvage these pavements and cause them to provide many more years of useful service. Also, where the terrain had been favorable so that major reconstruction to meet modern profile and alignment standards would not be necessary, these pavements, if salvaged by proper treatment, could be widened and resurfaced to give a modern highway. Thus, for a comparatively low cost and in a comparatively short time, a large percentage of the highway system could be rehabilitated. The major factor in effecting this rehabilitation was found to be the subsealing of old concrete pavements, and it has proved highly successful.

In 1948 N.Y. District No. 4, which has about 10 percent of the total State highway mileage (approximately 1,400 mi), had many miles of concrete pavements that were "pumping" very badly. This "pumping" was due to water penetrating the joints in the pavement and saturating the foundation soils. In five of the six counties of the District, the soils encountered in most areas are mixtures of clay, silt and loam.

When the roads were originally built, it was not the practice to place a blanket of granular material on the subgrade as is the standard today. Such a gravel blanket was thought an unwarranted expense as the concrete pavements, being rigid, would bridge over any weak areas. However, as the amount of traffic and the loads superimposed by trucks increased year after year, the poor underlying soils when saturated by water weakened the foundation, and "pumping" resulted. The process of "pumping" is merely the deflection of the pavement as loads pass over them, and because of poor subgrade support, water is forced upward through the joints and cracks and outward along the edges of the pavement. It can readily be seen that this is a process like a chain reaction which will ultimately destroy the pavement structure by breaking down the pavement slab.

This "pumping" was not just a theory but could be observed every time a loaded truck passed over a joint after a heavy rain. The water was actually forced out through the joints and cracks in a stream as thick as a lead pencil and spurting 6 to 8 ft into the air. It was obvious, where this occurred, that the slab was deflecting and broken, with the loose section jumping up and down.

Conditions became so critical that it was found necessary to do something immediately to correct these situations, otherwise substantial mileage of pavement would become a total loss. The remedy had to be quick and thorough as sufficient funds and time were not available to reconstruct these roads.

In the summer of 1948, under the general direction of the then incumbent District Engineer, A.R. Mulligan, and under the direct field supervision of the District Supervisor of Maintenance, Charles W. Donnelly, experimental work was carried on to find a remedy. A 20-ft wide concrete pavement, built in the 1920's, was selected. This road is on a heavily traveled truck route between the Cities of Rochester and Buffalo.

The pavement was in very bad condition, and after a rain the conditions of pumping described previously were prevalent. It was realized that unless something was done soon complete failure would result.

As the first step in the experimental work, it was decided to fill all joints and cracks with a light grade of asphalt emulsion using a large distributor to haul and furnish the material in large quantities at the site of work.

The material from the distributor was placed into large heating kettles from which maintenance personnel drew off the asphalt into pouring pots and filled the joints and cracks by hand. In addition other members of the crew filled the joints directly from the distributor by means of a $\frac{5}{8}$-in. hose.

This operation, using 3 foremen and 14 men, was very crude and the method used, though necessary in order to place as much material as possible in a short time, was frankly an experiment in subsealing the pavement and restoring subgrade support.

After pouring was complete, it was found by inspection that asphalt had completely disappeared beneath the concrete slab. It was also found, during the operation of filling the joints with the hose directly from the distributor, that material would run into the joint for a period of 5 to 10 min.

A second pouring was started into the same joints, but investigation indicated that material again disappeared. It was necessary to repeat this pouring operation four times before material ceased to disappear. By this time pumping had stopped and the slabs had stopped "racking."

Between 1948 and 1958, this pavement had to be subsealed once or twice a year. In 1958 it was widened and resurfaced, and it is now one of the better pavements in the District, in excellent condition, and carrying very heavy truck traffic between two large cities.

As time went on, more efficient methods for subsealing pavements were developed as well as special equipment designed to make these new methods effective. For example, it was found that a more satisfactory subsealing could be obtained by pouring the asphalt emulsion hot and letting it flow through the cracks and joints by gravity. Also, it was found necessary to cut down the old expansion joints to about $\frac{1}{4}$ in. below surface of pavement. This depression allows the material to run along the joint and the bottom of the slab. It will eventually fill the joint and not run out and over the pavement surface.

The reason for the effectiveness of the subsealing with the asphalt emulsion is that the asphaltic material flows under the pavement slab, fills all voids, and at the same time penetrates the underlying material, thus stabilizing the subgrade. When later

methods of applying the asphaltic emulsion under pressure were developed, it was found that the penetration of asphalt into the soil was from 1 to 2 in.

During the 1951 season forcing the asphalt emulsion beneath the slab by using pressure was begun. A "quick-breaking" type of asphalt emulsion that meets New York State specifications for Item 70-B, and which is substantially AASHO Specification RS-1, was used with good results. However, a heavier grade was found easier to control and also found not to break out through the pavement and shoulders as readily as the lighter material. At the same time it was discovered that if the material was heated from 130 to 140 F, it worked even better.

In the District maintenance shop a special attachment, consisting of a tapered nozzel and a shut-off valve, was developed. A hose connects this nozzle to either a large distributor or a small Tarrant machine. Through this attachment the asphalt emulsion is pumped through previously drilled holes in the concrete slab at a pressure of 20 to 50 psi. These holes are drilled adjacent to a joint or to cracks, and locations are determined by the locations of joints and cracks. Generally holes are 5 to 10 ft from the joint and 2 to 3 ft from the center line. The size of the holes drilled are approximately 1½ in. in diameter, using standard drill steel from 1⅛ to 1⅜ in. in diameter. By pumping asphaltic material into these holes on different days, it was found, at some locations, that as much as 200 gal was forced under the pavement at some joints.

As yet, no effort has been made to blow the water from beneath the slab with air pressure, prior to pumping the asphalt emulsion into the holes. The water that may be present under the slab is expected to be forced out by the pressure of asphalt. Air pressure has not been used for fear of blowing the mud which may exist under the slab into the small cracks and channels that may be underneath and thus restrict the flow of bituminous material used in the subsealing.

When applying the asphalt under pressure in subsealing work, the shoulders must be carefully watched for possible blow-up material to the surface of shoulder. At the first appearance of any asphalt on the surface at the shoulder, the asphalt flow through nozzle should stop immediately.

On subsealing operations where the material is simply poured into the joint by gravity no extrusion of asphalt material has ever been observed either at time of pouring or at a later date. This is due to the fact that the time element is long enough to permit the asphalt to cure and set.

When subsealing was done using pressure and large quantities of material were used in a short time because of cavities under concrete slab, it has been found necessary to have traffic lanes closed for a few hours to permit curing and setting of asphalt. No extrusion of the material was observed at a later date.

As stated previously, the asphalt emulsion meets New York State specification for Item 70 B, Grade B, the same material used for scale patching and pavement repairs. Therefore, no special material is required for subsealing work. By heating the material to 140 F, it becomes less viscous and will flow under the slab more easily, guaranteeing more complete filling of all cavities.

The use of asphalt emulsion for this purpose is strictly for subsealing and stabilizing subgrade soil at locations made apparent by observation of pavement conditions and "pumping." No attempt is made to jack up any depressed slabs to theoretical elevations; depressed areas, after subsealing, are brought up to correct grade by spreading and rolling plant-mixed asphaltic concrete.

In 1952 a statewide investigation of concrete pavement joint supports was made. In sawing out sections of joints, the maintenance personnel deliberately selected those joints that had suffered severe faulting and had been treated the previous season by subsealing with asphalt emulsion under pressure. The subsoil under the slab consisted of a silty clay and sand mixture. A number of soil samples were removed and examined.

It was interesting to observe that the emulsion had penetrated the soil from 1 to 2 in. From this observation it is apparent that the asphalt emulsion not only fills the voids in and below the pavement slab but it also stabilizes the subgrade, which is extremely important.

If a concrete pavement is properly subsealed once, it is a fairly easy operation to go over these pavements once or twice a year to further subseal and fill any cracks. Also,

if a subsealing job is going to be successful over a long period of time, it is important to do other, very necessary maintenance work to the pavement and highway section; such as,

1. Cut down all high shoulders so that pavement can drain off to ditches quickly and not allow water to stand along edges and saturate subgrades.
2. Restore all ditches to original designed grades to insure proper carrying away of water.
3. Clean all outfall ditches and make sure they operate 100 percent efficiently.

If these maintenance operations are carried on faithfully and adequate drainage of the highway section maintained at all times, the subsealing work will be 100 percent effective, inasmuch as water is the greatest enemy of the pavement section.

In District No. 4, there are no known concrete pavements that are "pumping" at the present time. From 1948 to 1953, the District concentrated on this work, from necessity. Since 1951, this subsealing operation has become just one part of the over-all program for maintaining concrete pavements which consist of subsealing, joint repairs, scale patching, shoulder maintenance, ditch maintenance, etc. Therefore, the operation of subsealing and allied maintenance by the District's forces during the past twelve years has paid handsome dividends by making it possible to utilize hundreds of miles of these old concrete pavements as foundations for a concentrated widening and resurfacing program at a low cost per mile. This is borne out by the fact that of the 1,400 mi of highways in District No. 4, approximately 400 mi have been widened and resurfaced so that they meet modern standards, utilizing salvaged concrete pavements that were saved from deterioration and destruction through subsealing.

In Monroe County alone, over 90 mi of this work was done within the last 2½ years at an average cost of $100,000 per mi. Some costs ran as low as $50,000 per mi, but average was brought up because of greater width on some jobs. Had the pavements been allowed to break up, the cost of replacement would have been many times more. This represents a tremendous saving to the taxpayer and at the same time provides him with a substantial mileage of new pavement with a minimum of inconvenience.

In conclusion, from 1948 to 1961, District No. 4 has used an average of 300,000 gal of of asphalt emulsion per year for subsealing, scale patching, and joint pouring. This work was done entirely separate from the regular surface treatment program, completely with the District's own forces, and without additional funds or equipment.