TRANSPORTATION RESEARCH RECORD 752

Sealing Joints and Cracks, Thin Resurfacing, and Locating Voids Under Concrete Slabs

TRANSPORTATION RESEARCH BOARD

COMMISSION ON SOCIOTECHNICAL SYSTEMS
NATIONAL RESEARCH COUNCIL

NATIONAL ACADEMY OF SCIENCES
WASHINGTON, D.C. 1980

Effect of Defective Joint Seals on Pavement Performance

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The reasons for installing and maintaining effective sealants in pavement joints and cracks are discussed. There is some controversy about the need for such seals. Results of studies done in Europe on the performance of pavement with unsealed joints are presented. These studies conclude that in most cases effective joint seals will minimize pavement distress. Various types of distress that develop from joint-seal failures are described.

Joints in concrete pavements are necessary, but they can be the source of many problems and subsequent pavement distress if they are improperly designed, constructed, or maintained. Joints are designed to control cracking, minimize stresses in the pavement caused by volume change, and prevent damage to immovable structures. Joints are expected to provide some load transfer between adjacent slabs and thereby prevent a free-edge condition, reduce pavement deflections and stresses, and prevent faulting at joints. Joints are sometimes designed with a reservoir for a joint sealant that will prevent surface water and incompressible foreign materials from entering the opening. It is this last function that is of concern here.

Joint sealants are designed to bond to the concrete in the joint. They are made to withstand many cycles of tension and compression as the joint opens and closes. Sealants are intended to create a waterproof barrier that will prevent surface water from entering the joint and reaching the subbase and subgrade. To be effective, sealants must also resist the intrusion of incompressible surface material—sand, gravel, stone, and other foreign objects—into the joint reservoir and the crack or joint below the seal.

Since most sealants have a limited service life, joints must be resealed periodically to ensure that they will perform the functions for which they are designed.

What effect do defective joint sealants have on pavement performance? Do sealant defects prevent joints from performing their proper function in the pavement?

PERFORMANCE OF PAVEMENT WITH UNSEALED JOINTS

Unfortunately, there is not complete agreement among paving engineers on the need for sealing all pavement joints. California uses a plain pavement design with short joint spacing [an average of 4.7 m (15.5 ft)] and an erosion-resistant subbase. The joints are sealed only in mountainous areas where there is greater than average precipitation.

In 1979, at the 16th World Congress of the Permanent International Association of Road Congresses (PIARC), the Technical Committee on Concrete Roads presented a report (1) that stated that Spain and Austria build many kilometers of pavement with unsealed joints and that France and Germany have both built substantial test sections with unsealed joints. It was also pointed out that there are hundreds of kilometers of concrete pavement built with sealed joints that did not require any maintenance for many years. The PIARC report concludes that, with joint spacings of 4-6 m (13-20 ft), there is no disadvantage in leaving narrow transverse joints unsealed when (a) traffic is light, (b) traffic is heavy but the climate is dry, and (c) traffic is heavy and the climate is wet but the pavement is doweled.

Most research in the United States on test pavements with sealed and unsealed joints has demonstrated some improvements in performance when joints are kept reasonably well sealed.

PAVEMENT DISTRESS RESULTING FROM JOINT-SEAL FAILURES

Today, many engineers are concerned about water in pavements. Workshops, technical papers, research studies, and even textbooks have focused attention on this problem. Cedergren (2) has called attention to the large volume of water that can reach the subbase or subgrade through the joints in a concrete pavement. Water in pavements or, more importantly, water that reaches the subbase or subgrade under a concrete pavement can result in activity that leads to pavement distress.

Pumping—the ejection of a mixture of soil and water from beneath slabs at joints, cracks, and edges—is one of the first symptoms of pavement distress. Mud pumping can occur when concrete pavements are placed directly on fine-grained, plastic soils. Under certain conditions, fines can be pumped from poorly graded granular materials and even from cement-modified soils. Continued, uncontrolled mud pumping can lead to displacement of enough subsoil to create voids under the slab, destroy the uniformity of support, and leave slab ends unsupported. Cooperative pumping studies (3, p. 281) have shown that three conditions are necessary for mud pumping to occur: (a) a subgrade soil that will go into suspension, (b) frequent passage of heavy wheel loads, and (c) the presence of free water between pavement and subgrade.

Pumping of granular subbase occurred on the structurally underdesigned sections of the AASHO Road Test and led to excessive deflections, numerous cracks, and eventual pavement failure. Water in the subbase was an important factor in the process, since pumping of subbase material was observed only during and after rains (4, p. 171).

Pumping or water action at joints, cracks, and pavement edges can also result in faulting of pavement joints and cracks. Faulting can be caused by voids under the leave slab (the pavement panel on which a vehicle leaves the joint, as opposed to the approach slab) that permit settlement and may eventually lead to transverse or diagonal slab cracks 1.8-3 m (6-10 ft) beyond the faulted joint or crack.

Faulting of joints and cracks on stabilized subbases has been attributed to water action under traffic that results in a migration of fine material from the shoulder or the subbase under the leave slab to the subbase under the approach slab. The deposits that build up under the approach slab lift it above the leave slab, which creates a fault.

Studies in California (5) and Georgia (6) have identified this phenomenon. As in the case of pumping, this research has shown that free water must be present to create the conditions that lead to faulting. In California and Georgia, faulting was shown to lead to pavement cracking ahead of the joint if the deposit of material under the approach slab raised the pavement enough to destroy the uniformity of subbase support.

One other form of distress in concrete pavement can be attributed to water action in joints. Corrosion of embedded steel in concrete slabs is accelerated when the brine solution from deicing salts enters joints that are not effectively sealed. Investigations have shown that such accelerated corrosion can cause serious problems, particularly in northern states where large amounts of deicing salts are used. Tie bars installed in longitudinal joints to hold two slabs together are sometimes found to be ruptured as a result of corrosion. Dowels or other load-transfer devices can become badly corroded after several years of service. This corrosion can result in a reduction in cross section and subsequent rupture, or it can cause the free end of the dowel to become immobilized as a result of expansion.

It is obvious from these problems that free water under a pavement can lead to distress. If properly installed and maintained joint seals will prevent surface water from reaching the subbase and subgrade and from entering the shoulder joint, several major forms of pavement distress can be avoided. Waterproof sealing of transverse joints, longitudinal joints, pavement-edge shoulder joints, and open cracks should be an objective during both construction and subsequent maintenance (7).

Distress caused by infiltration of incompressibles may be of even greater concern than damage from water in pavement. Narrow joints in plain concrete pavements with short slabs are subject to some infiltration, but far greater damage can be caused by the long panels used by some states, which have mesh dowel designs that result in excessive joint openings.

If joints are unsealed or if joint seals are ineffective, foreign materials from the shoulder, surface, or subgrade can enter the joints while they are open in cold weather. When the pavement expands during hot weather, the incompressible materials cause nonuniform pressures on the joint faces. Continued expansion of the pavement can cause stresses great enough to cause joint spalling at the surface, the edge, or even the bottom of the slab. Infiltration at the edges of joints can cause longitudinal restraint cracks that can actually split the slabs.

If joints become filled with foreign material and are then subjected to slab expansion during hot and humid weather, serious compression failures can result. In extreme cases, actual pavement buckling or blowups can develop. If transverse joints are allowed to remain unsealed and to fill with foreign material, the joint openings will increase in size and pavements will tend to grow in length, resulting in closing expansion joints at structures and, eventually, damage to bridges and bridge abutments.

Most joint sealants today are designed to resist the entrance of foreign materials from the surface of the pavement. Many of the older type of sealants, however, held such materials until the joint eventually filled. Simply adding additional joint seal to a joint or crack already filled with incompressibles will not help the situation. All foreign material must be removed before resealing.

Unsealed cracks may also contribute to pavement distress if the joint spacing permits the crack to open or if the reinforcing across the crack fails. At first the crack may be narrow and fairly tight, with no spalling. As the crack opens, however, infiltration begins and spalling results. Water action caused by slab deflection at cracks can cause faulting at cracks as well as at joints.

Finally, there is another effect of defective joint seals that does not receive as much attention: Overfilling joints can have a very detrimental effect on the riding quality of the pavement. A few years ago, it was common practice to pour large quantities of joint sealer on the pavement surface over joints and cracks, but this was ineffective as a joint sealer and actually detrimental to pavement appearance and rideability.

Excessively wide, black joints give the impression of bumps and lack of evenness or continuity in the pavement surface. The resulting wide band of sealant is smooth and even textured, quite different from the adjacent pavement texture. It is common for the tires of vehicles to make a slapping or sucking noise as they cross these oversealed joints or cracks. In many cases, the overfilled sealant with embedded foreign material creates a measurable bump on the pavement surface. Such high spots, which are usually found at regular intervals, make for a rough ride and produce a very objectionable thumping noise. Thus, although overfilled joints may not cause serious distress in the pavement, they certainly have a negative effect on the appearance and ride quality of the pavement. In some cases, excess sealant sticks to tires and is pulled from the joint, destroying its effectiveness.

SUMMARY

Some of the more obvious detrimental effects of unsealed or poorly sealed joints and cracks have been discussed here; more could be mentioned. Several sources (8-13) and other papers in this Record provide more details on the subject.

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