



MATES



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JOINT FAULTING IN CONCRETE PAVEMENTS

Almost everyone has had the unpleasant experience of traveling over a concrete roadway where joints have deteriorated into a series of steps, some of which may be an inch or more in height. It may seem unusual also, that the step is always downward in the direction of traffic. On the freeway, you cannot see the faulted edges as you approach, but they show up when you look back in the rear-view mirror. Most people probably attribute the cause of the problem to various combinations of age and heavy traffic. But how often do we pause to consider what forces are at work under the pavement and how we can prevent or minimize them or their effects? Three principal conditions are needed to cause faulting in concrete pavements—heavy and repeated loads, lack of effective load transfer from slab-to-slab across the joints, and the presence of free water under the slab. Consideration of these three factors should suggest ways of eliminating or at least minimizing the problem.

First, let us consider the mechanisms by which this, the most common type of joint faulting, occurs. Figures 1 and 2 show a loaded truck axle moving over a joint that is without load transfer dowels, and is resting on a water-saturated base material. Figure 1 shows the axle approaching the joint. As it approaches the joint traveling from position 1 to 2, the load under the left side of the joint (at point A) increases from zero up to the full weight of the axle,

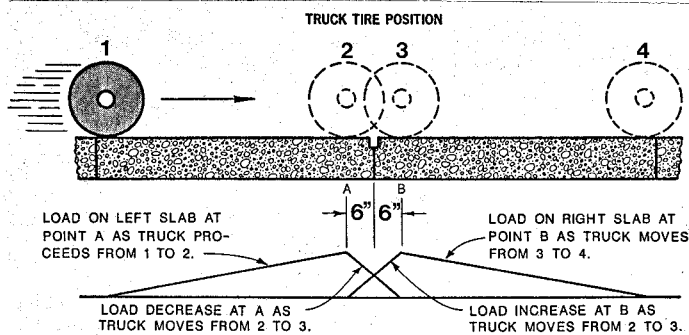


Figure 1. Loading at adjacent slabs without load transfer as a truck transverses them.

while simultaneously, the water under the slab is being squeezed forward of the truck axle and pushed beneath the right-hand slab as in Figure 2.

The footprint of the tire on the pavement is about 1 ft long. As the axle comes to within 6 in. of the joint at the end of the slab, the tire begins a transition of load from the left slab to the right slab while traveling approximately 1 ft to the beginning of the second slab. During this transition, which lasts approximately one-hundredth of a second, the vertical applied load on the end of the first slab almost instantly drops to zero. At the same time, the vertical applied load on the beginning of the second slab suddenly rises

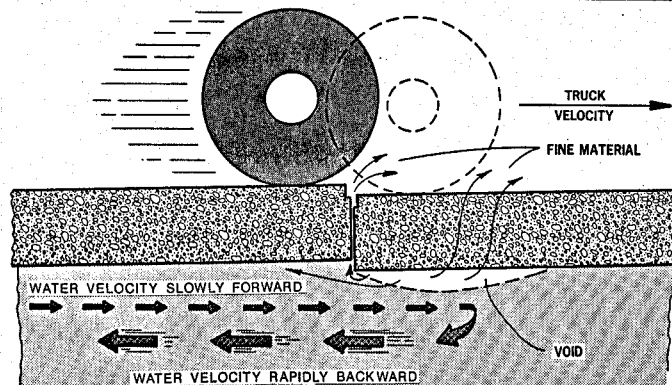


Figure 2. Soil-bearing water being pumped forward, then back under first slab, causing a void beneath the second slab.

from zero to its maximum value at B within one-hundredth of a second, thereby rapidly expelling the just-accumulated water backward under the end of the first slab. That slab, now unloaded, recovers from its deflected position, creating a void. Note that although the same load rolls over points A and B at the same speed, the rate of load application at B is about 20 times the rate at A. The ability of the rapidly flowing water to move particles of soil is substantially enhanced by its increase in velocity since the largest particle size able to be moved by a stream of water is proportional to the square of the water's velocity. That is, if the velocity doubles, the size of particle that can be moved is quadrupled. Pieces up to 1/8-in. in diameter have been found to move in this manner.

As a result of the high rate of loading and previous forward water flow, significant quantities of water are rapidly ejected back from under the end of the second slab, carrying more soil with them than they carried when they came forward, producing the void shown in Figure 2. Simultaneously, a portion of the water with finer materials in it may be squeezed up through the transverse and shoulder joints, removing more material from beneath the pavement, as shown in Figures 3 and 4. The void created under the pavement slab provides an opportunity for further saturated fine material under the shoulders to move inward under the slab as shown in Figure 3. This process, continually repeated with the passage of numerous trucks, in the long run results in a subsidence of the shoulders near the joint, progressive lowering of the right-hand slab relative to the left-hand slab, and eventually cracking of the pavement (Fig. 2).

As a practical measure, what can pavement designers and builders do to prevent this phenomenon, given the inevitability of heavy axle loads? Modern high-traffic roads are designed for trucks, so we must concentrate on controlling the other two principal conditions responsible for joint faulting. The first condition is lack of joint load transfer, although pavements on local roads carrying low-truck volumes may function satisfactorily for many years without load

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transfer. The second condition is poor sub-slab drainage. Ideally, we would like to design our pavement joints to be rigidly interlocked vertically and transversely, but be free to expand and contract longitudinally, i.e., in the direction of the roadway. Such an arrangement is best achieved by installing longitudinally oriented, 1-1/4-in. diameter steel dowels spaced 12 in. apart across the transverse joints and by providing tie-bars for connecting the concrete lane slabs together and concrete shoulders (if present) to the main roadway slabs.

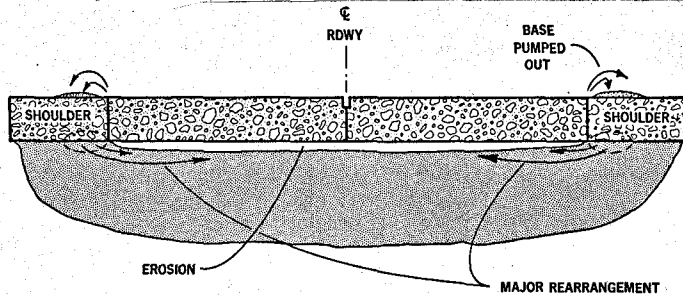


Figure 3. Material can move from under the shoulders to the void beneath the slab.

While the adoption of such positive load transfer devices is certainly useful in helping to prevent pumping and faulting, it is by no means a panacea. The true villain is the water under the slab trapped there by base materials that are not drainable, and that contain erodable particles fine enough to be moved about readily. If, through a system of perfect seals, we could prevent the entry of moisture under the slab, we would have solved the problem for the dry material

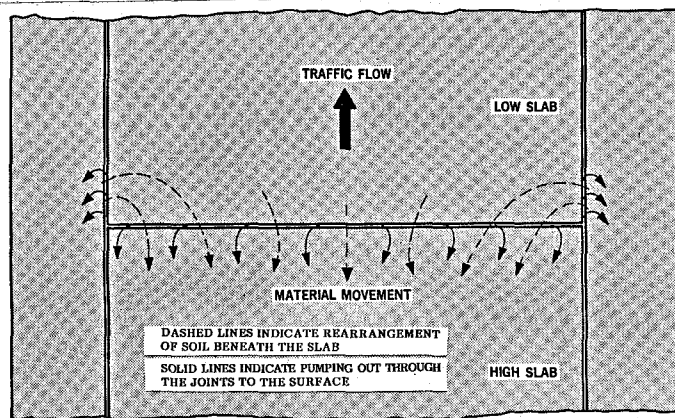


Figure 4. Fines are pumped up through the shoulder joints and pavement transverse joints, as well as material rearrangement beneath the slab.

could not be pumped. But there are no perfect seals, so we concentrate our efforts on the rapid removal of penetrating moisture to prevent saturated base conditions from occurring. To achieve this, we often employ a drainage course consisting of an open graded, crushed material with large voids through which any free standing water will drain rapidly. This is known as an open graded drainage course (OGDC) and when used in conjunction with positive load transfer devices provides our best insurance against pavement pumping and joint faulting.

-John O'Doherty

TECHADVISORIES

The brief information items that follow here are intended to aid MDOT technologists by advising or clarifying, for them, current technical developments, changes or other activities that may affect their technical duties or responsibilities.

SPECIFICATION UPDATE

Dense-Graded Aggregate Produced by Crushing Portland Cement Concrete, 8.02(5), dated 8-11-87. This new specification deletes the prohibition of 20 Series aggregates coarser than the 3/8-in. sieve, produced by crushing portland cement concrete, in bituminous top course mixtures. Also, a paragraph was added requiring the use of Michigan Test Method (MTM) 110 in cases where there is a restriction on the amount of deleterious material in the aggregate.

Prohibiting Disposal of Surplus and Unsuitable Material, 2.08(1c), dated 11-18-87. This specification, which replaces the special provision dated 11-15-84, is intended to reduce problems associated with regulating agencies, contractors, and various "interested parties" in the crossing of wetlands on Department projects. A description of unsuitable material was added to the opening paragraph and a provision for relocation of material, at the contractor's expense, when it has been disposed of by the contractor in a wetland or floodplain without a valid permit was added.

Concrete Barrier and Glare Screen, 6.12(1), dated 10-15-87. This new specification requires that "barrier surfaces exposed to traffic shall have a uniform, smooth-textured finish, similar to one resulting from a metal finishing tool or a broom with soft bristles." This revision is intended to prevent errant vehicles from climbing the barrier.

Bushings for Pins and Link Plates, 5.04(9c), dated 8-24-87. This revision deletes the Duralon Journal Bushing and adds the Dixon CJ Bushing because of its superior quality and durability. Also, the maximum allowable clearance between the pin and the bushing was increased from 0.010 in. to 0.015 in. to alleviate fit problems in the field.

Pins and Link Plates for Redundant Bridges, 5.04(18) and for Non-Redundant Bridges, 5.04(19), both dated 8-19-87. These specifications, which replace the special provisions dated 9-29-86, specify the requirements for new pins and link plates as replacements in existing bridges.

Delineator Reflectors, 8.26(4a), dated 07-13-87. This specification is revised to permit use of delineators with either a plastic housing or no housing as an alternate to delineators with aluminum housing; also, the reflective lens is specified to have a nominal area of 7 sq in. rather than minimum area of 7 sq in. The changes were made to bring our specification into line with the current technology.

Galvanized Steel Conduit, 8.25(4a), dated 9-25-87. This new specification brings the standard specification in conformance with the current Federal specification.

PERSONNEL CHANGES

Ken Lambert, formerly working for District 1, Escanaba office, has joined the Testing Laboratory as the Traveling Bituminous Mix Inspector for Districts 1 and 2. **Bob Pena** and **Dick Endres**, formerly assigned to M&T under the Engineer Development Program, have now become permanent members of the Division. Bob is currently working in the Pavement Management Group, while Dick has been assigned to the Environmental area of the Geotechnical Support Unit. **Loid Hawkins**, a familiar face in and around the Division for many years, has joined the Central Material Control area of the District Support Section, having been previously assigned to the Jackson, District 8 office. We expect major contributions to our quality assurance programs by each of these technologists, and we welcome them to the Division.

This document is disseminated as an element of MDOT's technical transfer program. It is intended primarily as a means for timely transfer of technical information to those MDOT technologists engaged in transportation design, construction, maintenance, operation, and program development. Suggestions or questions from district or central office technologists concerning MATES subjects are invited and should be directed to M&T's Technology Transfer Unit.

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