By Tom Kuennen, Contributing Editor

Taming Disruptive Cracks to Preserve Pavements

Understand the type and cause of the cracks you mend, or you may waste scarce dollars and time.

Cracking is the bane of pavements, whether of asphaltic concrete or portland cement concrete.

Asphalt pavement can crack from the top-down and from the bottom-up. It can alligator-crack, longitudinal-crack, thermal-crack, and fatigue-crack.

Concrete pavements expansion-crack, D-crack, transverse-crack, fault and even blow-up under thermal stress. And both asphalt and concrete overlays reflection-crack.

While the hot-mix asphalt (HMA) establishment long has been focused on rutting — also called pavement deformation — cracking also forms such a threat to asphalt pavements that research on both rutting and cracking took the lion's share of funds for the Strategic Highway Research Program (SHRP). The program is a five-year, $150 million research effort, mostly funded by the states, that was completed in 1993. Although, its principal product was the current Superpave system of design specifications, cracking was studied intensively.

A product of research

In SHRP project H-105, *Innovative Materials and Equipment for Pavement Surface Repair*, the researchers conducted a massive literature review and a nationwide survey of highway agencies to identify potentially cost-effective repair and treatment options.

The information and findings from that study then were used in the subsequent field experiments conducted under SHRP project H-106, *Innovative Materials Development and Testing*. In project H-106, many different test sections were installed and evaluated to determine the cost-effectiveness of maintenance materials and procedures.

Test sections were installed at 22 sites throughout the United States and Canada between March 1991 and February 1992, under the supervision of SHRP representatives. The researchers collected installation and productivity information at each site and periodically evaluated the experimental repairs and treatments through the end of 1992. The first version of this manual was prepared in October 1993 and was based on this work effort.

Materials and Procedures for Sealing and Filling Cracks in Asphalt-Surfaced Pavements: Manual of Practice (to see, Google FHWA-RD-99-147) was the product of this research.

"Cracks are inevitable, and neglect leads to accelerated cracking and potholing, further reducing pavement serviceability," the Federal Highway Administration (FHWA) says in its Manual of Practice. "The problem of cracks is handled in many ways, ranging from pavement maintenance activities, such as surface treatments and crack filling, to full-scale pavement rehabilitation projects, such as resurfacing."

Maintenance departments bear most of the burden of dealing with cracks, FHWA said. Departments with sufficient funding are often responsible for adding a few more years of serviceable life to deteriorated pavements through preventive or routine maintenance — or both.

"Two of the more common options exercised by maintenance departments are crack sealing and crack filling," FHWA says. "These operations have been conducted for many years, generally on a routine basis. However, only in the last two decades has their potential benefits as preventive maintenance tools been realized. With proper and timely application, crack sealing

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BETTER Roads

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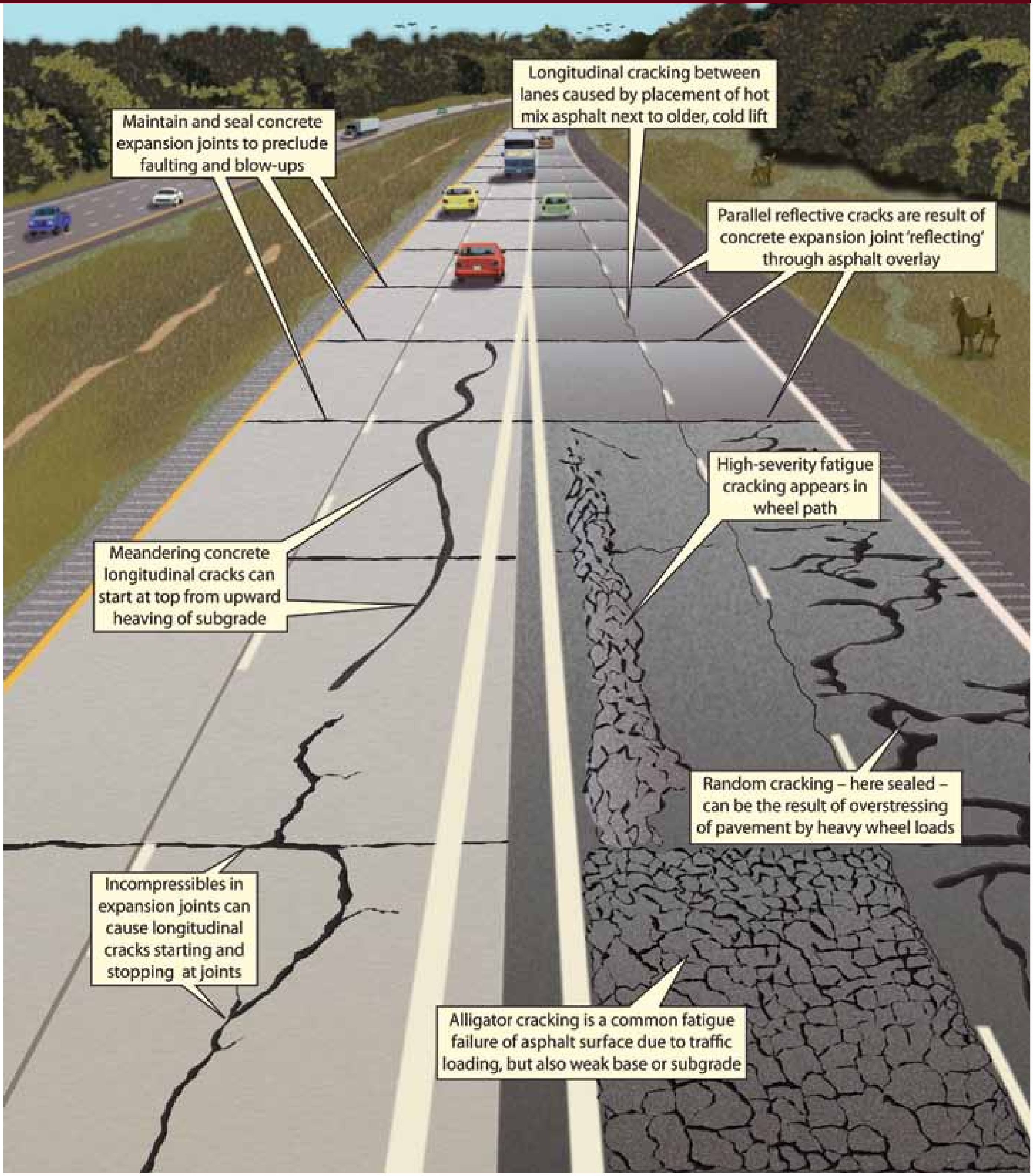

and filling can extend pavement life past the point where the cost-benefit of added pavement life exceeds the cost of conducting the operation."

Working versus non-working cracks

Cracks in either asphalt or concrete pavements will be either "working" or "moving" with loads or stresses, or nonworking or static. For example, asphalt reflective cracking takes place when existing "working joints" and cracks in the overlaid portland cement concrete pavement propagate up through the asphalt overlay.

To ensure good bond, rout deep random cracks and clean with compressed air or hot lance prior to filling

Photo courtesy of Crafco, Inc.

Crack treatment is the placement of materials into the cracks of pavement surfaces in order to prevent the intrusion of water and foreign objects that may damage the pavement structure, SAUS Scott Zinke and James Mahoney, Connecticut Transportation Institute of the University of Connecticut.

Working cracks must be tackled more aggressively than non-working cracks, they write. "Crack treatment involves two types of action: crack sealing and crack filling," Zinke and Mahoney wrote in 2006.

Crack sealing, they write, is the placement of specialized treatment materials above or into working cracks using unique configurations to prevent the intrusion of water and incompressibles.

Crack filling, on the other hand, is the placement of more conventional treatment materials into non-working cracks to substantially reduce infiltration of water and to reinforce the adjacent pavement.

Working cracks — defined as having movement in excess of 3 m (0.12 inch) will require a material that has a greater capacity for adhesion and cohesion failure due to the increased pavement movement, they write. Transverse cracks — cracks perpendicular to the direction of traffic, typically considered to be working cracks

– are often targeted for crack sealing.

Non-working cracks are defined by the FHWA as cracks where little movement is occurring between crack edges. Most longitudinal cracks – cracks parallel to the direction of traffic – are considered to be non-working cracks and are often targeted for crack filling.

Types of asphalt cracking

In its important publication, *Distress Identification Manual for the Long-Term Pavement Performance Manual* (to view, Google FHWA-RD-03-031), FHWA categorizes types of cracking for asphalt pavements, jointed concrete pavement, and continuously reinforced concrete pavements.

Asphalt cracking includes the following:

Fatigue cracking or bottom-up cracking results from stresses propagated to asphalt pavement foundations cause foundation cracks to work their way upward through the pavement.

It's found in pavements subjected to repeated traffic loadings, like wheel paths, and can be a series of interconnected cracks. It develops into many-sided, sharp-angled pieces, usually less than 0.3 meter (12 inches) on the longest side, characteristically with a chicken wire/alligator pattern, in later stages.

Low-severity fatigue cracking is an area of cracks with no or only a few connecting cracks; the cracks are not spalled or sealed; pumping of base materials out the cracks is not evident. In moderate fatigue cracking the interconnected cracks form a complete pattern, cracks may be slightly spalled and may be sealed, and pumping is not evident. High-severity fatigue cracking is an area of moderately or severely spalled interconnected cracks forming a complete pattern, pieces may move when subjected to traffic, cracks may be sealed, and pumping may be evident.

Block cracking is a pattern of cracks in asphalt that divides the pavement into approximately rectangular pieces. The rectangular blocks will range from approximately 0.1 square meter to 10 square meters (1 to 10 square feet) in size. It's also categorized into low, moderate and high levels of severity.

Edge cracking in asphalt applies only to pavements with unpaved shoulders, FHWA said. Crescent-shaped cracks or fairly continuous cracks, which intersect the pavement edge and are located within 0.6 meter (2 feet) of the pavement edge, adjacent to the shoulder. It includes longitudinal cracks outside of the wheel path and within 2 ft of the pavement edge.

Longitudinal cracking in asphalt describes cracks predominantly parallel to pavement centerline. Location within the lane (wheel path versus non-wheel path) is significant. Any wheel path longitudinal crack that meanders and has a quantifiable area is considered as fatigue cracking, while a non-wheel path longitudinal crack may have a variety of causes.

Longitudinal cracking between lanes of asphalt likely is the result of failure to obtain compaction on a cold joint between two lifts of asphalt, where a fresh lift of hot mix is placed against a cooled mix.

Reflective cracks at joints appear in asphalt overlays over joints in concrete pavements. The reflection cracking may consistently mirror the slabs beneath, although knowing the slab dimensions beneath the asphalt surface will confirm such reflective cracking.

Transverse cracking in asphalt describes non-reflective cracks that are predominantly perpendicular to pavement centerline.

Thermal cracking appears as transverse cracks perpendicular to the pavement's centerline or direction of placement. Like all cracks it allows infiltration of water into the pavement and cause a rough ride. It's attributed to shrinkage of the asphalt surface due to bitterly cold temperatures, which causes separation of the pavement, especially when the asphalt binder has hardened or become brittle.

Overheating of liquid asphalt in the plant – which causes premature aging of the binder as needed hydrocarbons are driven off by the excessive heat – also can lead to asphalt thermal cracks. That's why in 2008 and 2009 Crow

For application longevity, *fill routed, cleaned cracks with quality sealant and allow to cure prior to any overlay.*

Photo courtesy of Crafco, Inc.

Wing County, Minn., has tested warm mix asphalt on certain county roads, as it attempts to fight low-temperature thermal cracking and raveling via placement of a lift mixed at substantially lower temperatures.

Top-down asphalt cracking

While bottom-up cracking appears to be the propagator of fatigue cracking, so-called top-down cracking also is getting new recognition in the United States, and appears to have multiple causes.

In Florida, surface cracks in the wheel paths are attributed to radial shear forces under truck tires, with wide-base tires causing the highest tensile stresses. Other research from Colorado and Pennsylvania indicates the primary cause is mix segregation caused by the paver at mix placement. Elsewhere it's attributed to hardening of the liquid asphalt binder resulting in high thermal stresses in the asphalt cement binder, and low-stiffness in the friction course.

When top-down cracking is encountered, the therapy is that same as that of bottom-up cracking, and that's prompt filling, says Tim Aschenbrener, P.E., project development branch manager, headquarters office, Colorado DOT. "Because the location will be segregated, it will have high voids and hold water," he says. "We have our maintenance personnel fill the cracks quickly to prevent water ingress, because these are the kind of cracks that can deteriorate very rapidly. They are generally located near or right in the wheel path."

Cracks in jointed concrete and CRCP

FHWA-RD-03-031 also describes cracks in jointed concrete pavements, including corner breaks, durability cracking ("D" cracking), longitudinal cracking, and transverse cracking.

- **Corner breaks** refer to portions of the slab separated by cracks, which intersect the adjacent transverse and longitudinal joints, describing approximately a 45-deg angle with the direction of traffic. The length of the sides is from 1 ft to one-half the width of the slab on each side of the corner.
- **D- or durability cracking** describes a closely spaced crescent-shaped hairline-cracking pattern. It occurs adjacent to joints, cracks or free edges, initiating in slab corners. There may be dark coloring of the cracking pattern and surrounding area, FHWA said.
- **Longitudinal cracking** describes cracks that are mostly parallel to the pavement centerline, and are attributed to subgrade heaving that pushes upward against the rigid slab and cracks it.

Longitudinal cracks in concrete may be the result of the wrong placement or timing of sawed construction joints, loss of foundation support from inadequate compaction, stabilization or water entry; or reflection cracking from a stabilized base, propagated upward through the concrete layer, report Youn su Jung, Thomas J. Freeman, and Dan G. Zollinger in Texas Transportation Institute's *Guidelines for Routine Maintenance of Concrete Pavement (March 2008)*.

Transverse cracking includes cracks that are predominantly perpendicular to the pavement centerline. Transverse cracks in jointed concrete pavements may result from improper joint design, with excessive slab length that may result in excessive tensile stresses in the slab and lead to transverse cracking, or improper joint construction by failing to saw joints soon enough or deep enough, Jung, Freeman and Zollinger write. Optimum spacing of joints will eliminate much transverse cracking.

▲ ***When random cracks get to be too much,*** *it may be time to renovate pavement with a mill-and-overlay.*

Photo courtesy of Wirtgen America, Inc.

Improper slab design or construction resulting in inadequate slab thickness or inadequate material strength may lead to transverse cracks, they added, as well as expansive soils, frost heave, or loss of foundation support.

Blow ups are localized upward movements of the pavement surface at transverse joints or cracks, often accompanied by shattering of the concrete in that area, thought to be caused by stresses in the pavement due to expansion from ambient heating.

Cracks in continuously reinforced concrete pavement (CRCP) mirror those for JCP, that is, durability or D-cracking, longitudinal cracking, and transverse cracking.

Cracks come first

Both working and non-working cracks need to be dealt with promptly. Among the bad practices is waiting too long – that is, waiting for damage to develop – before corrective measures are applied, said Larry Galehouse, P.E., executive director, National Center for Pavement Preservation at Michigan State University.

"The No. 1 fault of agencies is that they may wait until a problem develops before they address it," Galehouse says. "If the structure is good we can keep water out of the pavement. With pavement preservation techniques we will improve their performance and extend their life.

"For very good PCC pavements we can reseal joints and for PCC and HMA, cracks," Galehouse tells *Better Roads*. "We can seal edges to avoid edge drops between driving lanes and shoulders, something that's not done enough."

In its *Roadway Maintenance Surface Treatment Strategies* guidelines, the California Department of Transportation (Caltrans) says much the same thing for both contracted maintenance and that done by state forces. "Experience has shown when proper preparation has been done in areas scheduled for surface treatments (either by contract or by state forces), the life of the surface treatments can be greatly extended and helped in reducing life-cycle cost," Caltrans says. "It is critical that all necessary preparation work such as crack filling, pothole repair, patching, leveling, digouts, etc., be done prior to surface treatments being placed."

Caltrans calls crack filling and sealing "our first line of defense in roadway maintenance." Caltrans recommends cracks 1/4 inch or wider be filled or sealed before rainfall seasons or before maintenance surface treatments, such as fog seals, sand seals, slurry seals, chip seals or maintenance overlays are applied. ❖