CP ROAD MAP
shaping the future of concrete pavement

www.cproadmap.org

APRIL 2011

ROAD MAP TRACK 6
Innovative Concrete Pavement Joint Design, Materials, and Construction

AUTHOR
Peter C. Taylor
National Concrete Pavement Technology Center

SPONSOR
FHWA
Pooled Fund Study TPF-5(224)

MORE INFORMATION
Peter C. Taylor
National Concrete Pavement Technology Center
515-294-9333
ptaylor@iastate.edu

Moving Advancements into Practice (MAP) Briefs describe innovative research and promising technologies that can be used now to enhance concrete paving practices. MAP Brief 6-1 provides information relevant to Track 6 of the CP Road Map, Innovative Concrete Pavement Joint Design, Materials, and Construction.

The Long-Term Plan for Concrete Pavement Research and Technology (CP Road Map) is a national research plan developed and jointly implemented by the concrete pavement stakeholder community. Publications and other support services are provided by the Operations Support Group and funded by TPF-5(185).

MAP Brief 6-1 is available at: http://www.cproadmap.org/publications/ MAPbrief6-1.pdf

"Moving Advancements into Practice"

MAP Brief 6-1:

Describing promising technologies that can be used now to enhance concrete paving practices

Preventing Joint Deterioration in Concrete Pavements A Summary of Current Knowledge

Introduction

Premature deterioration of concrete at joints in pavements has been reported in a number of locations in northern states. The pavements affected include state highways, city and county streets, and parking lots. Not all roadways exhibit deterioration at the joints, but the problem is common enough that a focused research effort is in progress to find preventative measures. The causes behind joint deterioration are not fully understood. In the interim, however, this document describes some of the factors that may be contributing to its occurrence and provides guidelines on how the risks may be reduced.

Occurrence

Joint deterioration is generally observed initially in longitudinal joints, followed by transverse joints, and is most common in pavements ranging in age from 5 to 15 years old. The distress is often initially observed as shadowing (Figure 1), because microcracking near the joints traps water; later, the joint exhibits significant loss of material (Figure 2).

Figure 1. Typical shadowing

Figure 2. Loss of material

Mechanisms

To date, no single mechanism has been found that accounts for all reported occurrences of joint deterioration. Investigations thus far have revealed two separate causes that are currently being investigated: 1) freezing-related deterioration caused by concrete saturation and 2) mechanical deterioration.

In the first and more common form of deterioration, typical characteristics are as follows:

- Concrete that has been saturated for longer periods (Figure 3) has a significantly higher risk of distress, regardless of the source of water.
- Many distressed pavements have been found to have marginal air void systems.
- A variety of potentially aggressive de-icing salts may have been used on these surfaces.
- Once damage starts, it progresses rapidly.

Water that is trapped in a joint will result in longer periods of saturation and thus provide greater risk of freezing-related damage. Water can be trapped behind a failed seal, above a non-cracked joint, or in the joint if the base layer is impermeable.

Figure 3. Evidence of concrete saturation

Researchers have also observed that if the longitudinal joint is cut deeper than the transverse, water in the deeper cut will not have a route to drain out of. In addition, work at Purdue has shown that high concentrations of some salts (used as de-icers) attract water, and thus slow or prevent drying of concrete surfaces that are in contact with them. This is particularly relevant in joints that will tend to act as reservoirs where salt may become concentrated while the pavement surface drains off.

Data from Purdue have shown that increasing the air content slows the rate of saturation of concrete, thus helping to reduce the risk of damage. In addition, requirements for and performance of the air void system are likely to have changed with changing chemical composition of the concrete system, particularly the air entraining admixtures.

In the second, mechanical, form of deterioration (Figure 4), typical characteristics are as follows:

- Damage is normally narrow and shallow, and may be on only one side of the joint.
- Damage starts near the edge of the slab and propagates along the joint rather than outward.
- The cracks often appear around aggregate particles rather than through them, indicating that the first damage may have occurred in the first few hours after placing.

It is likely that poor maintenance of the sawing equipment and/or inappropriate sawing practices are leading to damage around the saw cut that may not be visible initially, but will be exercised and opened up by weathering. Such damaged areas will also tend to act as water traps, thus leading to accelerated freezing-related distress, as described above.

Prevention

Until the causes of the problem have been fully understood, the following recommended approaches are likely to reduce the risk of failure.

In new construction:

1. Use concrete mixtures that are well proportioned using appropriate materials.
   - Use a w/cm between 0.38 and 0.45
   - Select and proportion appropriate supplementary cementitious materials to reduce concrete permeability
   - Choose durable aggregates
   - Select graded aggregate combinations that will make it easier to handle and consolidate the mixture

Figure 4. Typical mechanical distress

Figure 5. Example of damage occurring in a slab that has not cracked out

2. Pay attention to the air void system.
   - Before construction begins, assess the amount of air that may be lost during handling and adjust the mixture accordingly.
   - Monitor the air content carefully and periodically assess the air void system behind the paver.
   - Do not accept air contents that are below the recommended minima.
   - Avoid air void systems that are close to the limits as it may be that the current limits are inappropriate for current conditions and materials.
3. Ensure that fresh concrete is well cured
4. Allow water to leave the hardened concrete. For example:
   - Ensure that the saw cuts initiate a crack so that water can get away (Figure 5), for instance make sure the longitudinal saw cuts are at least T/3 in depth.
   - Ensure that the base has some permeability to allow water to drain away from the joints. Care must be taken to ensure that the load carrying capacity is not compromised and that pumping is prevented.
   - Pay attention to design and construction of drainage systems including requirements to prevent clogging.

Mitigation / Repair

In existing pavements that are beginning to show shadowing, the following measures can be used to mitigate or repair the deterioration.

1. Apply surface sealants to the faces of and near existing joints to reduce ingress of water into the concrete
   - Siloxane-based materials have a proven history of reducing permeability of concrete systems. These materials are sprayed on and will have to be re-applied periodically —probably about every 5 to 7 years.
   - Other sealant types are being investigated.

2. Consider limiting the type of deicing salts to sodium chloride.
3. Partial / full depth repairs of the joints may be required if the serviceability of the pavement is compromised. In some cases it is reported that the damage is through the full depth of the pavement meaning that a full depth repair is required. Damage limited to the top 1/3 to top 1/2 of the depth may be addressed using a partial depth repair.
4. Pay attention to maintenance of drainage systems including regular inspection and cleaning.
5. Consider retrofitting edge-drains to improve drainage.

Additional details on prevention methodologies are provided in an implementation guide published by the South Dakota Department of Transportation, which can be accessed at http://www.state.sd.us/Applications/HR19ResearchProjects/Projects/SD2002-01_Implementation_Guide_Final.pdf

A future MAP brief will address repair techniques for existing pavements in more detail.

Future Work

A Pooled Fund study sponsored by the States of South Dakota, New York, Minnesota, Iowa, Indiana, Wisconsin, and Michigan; FHWA; and the pavement construction industry has been established to fund joint deterioration research.

Work is underway at Iowa State University, Michigan Technological University, and Purdue University to investigate these mechanisms, both in the laboratory and in the field. The goal of this work is to understand the causes, and particularly to understand why some pavements are distressed and others nearby are untouched. Based on this understanding, guidelines for good practice to prevent the problem will be developed.

For more information, contact Peter C. Taylor, Associate Director, National Concrete Pavement Technology Center, 515-294-9333, ptaylor@iastate.edu or visit http://www.cptechcenter.org.