Improving Joint Durability in Concrete Pavements
A Summary of Current Knowledge

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Introduction

Premature deterioration of concrete at pavement joints has been reported in a number of locations in northern states. The pavements affected include state highways, city and county streets, and parking lots. While not all roadways are distressed, the problem is common enough that a focused research effort is in progress to find preventative measures.

The causes behind joint deterioration are not yet 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.

Distress in a longitudinal joint on a city street

Occurrence

Typically, joint deterioration is initially observed in longitudinal joints, followed by transverse joints, and is most common in pavements ranging from 5 to 15 years old. The distress is first observed as shadowing, as microcracking near the joints traps water, and is later exhibited as significant loss of material (see photos below).

Typical shadowing

Loss of material

Mechanisms

To date, no single mechanism has been found that accounts for all of the reported occurrences of joint deterioration. A number of mechanisms have been suggested, but none has been universally accepted as dominant. The common characteristics among distressed pavements are as follows:

- Pavements that are saturated for longer periods are at significantly higher risk, regardless of the source of water.
- Many distressed pavements were 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.

Experts agree that water is the common factor in most deterioration mechanisms. Water that is trapped behind a failed seal or above a non-cracked joint will result in longer periods of saturation and lead to greater risk of freezing-related 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 and changing de-icing procedures and materials. It is likely that the problem is an issue with the paste rather than with the aggregates.

Finally, it has also been reported that some mixtures may have eroded during early-entry sawing, leaving voids below the backer rod.

An example of damage occurring below the backer rod

Distress in longitudinal and transverse joints

Water ponding at joints

Localized damage on each side of a joint

Prevention

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

In new construction:

- 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.
- Ensure that fresh concrete is well cured.
- 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 minimum.
- Make provisions to allow water to leave the hardened concrete.
  - It has been reported that water is being trapped below backer rods (see photo below). Consider limiting joint sawing to 1/16 to 1/8 in. wide and not installing sealants or backer rods.
  - Ensure that saw cuts initiate a crack that allows water to get away—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 means are available to prevent or remove clogging.
  - Pay attention to design and construction of drainage systems.

Mitigation / Repair

In existing pavements that are beginning to show shadowing, the following techniques may help mitigate distress.

- 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. They will have to be replaced periodically—approximately every 5 to 7 years.
  - Other sealant types are being investigated.
- Consider limiting the type of deicing salts to sodium chloride.
- Partial / full depth repairs of the joints may be required if the serviceability of the pavement is compromised. In some cases, damage has been reported through the full depth of the pavement, meaning that a full depth repair is required.
- Pay attention to maintenance of drainage systems, including regular inspection and cleaning.
- Consider retrofitting edge-drains to improve drainage.

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

A forthcoming National CP Tech Center technical brief will address repair techniques for existing pavements in more detail.

Future Work

A pooled fund study sponsored by state DOTs, FHWA, and the pavement construction industry has been established further research the causes of joint distress and to develop effective guidelines on how it may be prevented. The work plan for this project is being finalized but the tasks planned include the following:

- Develop a list of potential mechanisms
- Conduct in-depth interviews of stakeholders in states that have reported joint distress
- Develop a database of parameters from sites where distress is observed
- Test samples taken from selected sites
- Reproduce distress in laboratory samples (to develop an accelerated test or verify a theory)
- Identify failure mechanisms
- Develop prevention and mitigation methods
- Train practitioners on prevention and mitigation methods

The research for this project will be conducted at Purdue University and Michigan Technological University.

More information

If you have joint deterioration in your area, please contact Peter Taylor, National Concrete Pavement Technology Center, 515-294-9333, ptaylor@iastate.edu.

Additional information is available online at http://www.cptechcenter.org.