Project Summary

Texas Department of Transportation

0-5444: Rehabilitation Procedures for Longitudinal Cracks and Joint Separation in Concrete Pavement

Background

Longitudinal cracking and longitudinal joint separations in concrete pavements accelerate structural deterioration of the pavement, reducing ride quality, and in severe cases can become a safety hazard to motorists. This research evaluated the effectiveness of different repair techniques to prevent or slow down such failures. The research also developed guidelines, recommendations, and specifications for repair and for new construction.

What the Researchers Did

Researchers used several methods to determine which practices worked best, including:

- a literature search and survey of DOT practices,
- field site evaluations,
- laboratory simulations, and
- a Finite Element Modeling (FEM) specification review.

What They Found

Causes of longitudinal cracking in concrete pavements included:

- base problems (soft, non-uniform support, inadequate compaction, inadequate base thickness, and dry granular base wicking moisture from concrete),
- low concrete strength,
- late or shallow saw cutting,
- more than three lanes tied together,
- lack of attention to detail during construction, and
- traffic load fatigue.

Four repair methods studied yielded these findings:

- Cross stitching is the most common method used in other states. However, the cross stitching is found to be more effective to fix the small crack or minor longitudinal joint separation.
- Slot stitching is similar to dowel bar retrofit (DBR) for transverse joints.
- The stapling repair method was developed to provide positive mechanical anchorage between separated slabs.
- The headed bar is a new conceptual design.
- Field studies in Fort Worth, Rosenberg, and Houston show that current methods of design for transverse steel and tie bars should be altered.
- Longitudinal joint separations were likely caused by a combination of three phenomena: 1) dynamic loading from heavy truck traffic, 2) tie bar corrosion, and 3) poor joint sealing.
- Load transfer effeciencey (LTE) tended to decrease as joints widened. Repair guidelines, then, cannot be solely based on joint or crack width.
- Data from unrepaired longitudinal joints and cracks indicated sensor deflection to be independent of crack/joint width.

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Project Completed: 8-31-08

- Longitudinal joints showed decreasing LTE with increasing deflection. In practical terms, this means that the cost of repairing a pavement increases as overall pavement quality worsens. The most efficient and cost-effective approach is to make repairs as soon as possible.
- Base type and condition affect the overall performance of joints and cracks, but may not strongly affect LTE. High quality repair materials that will remain flexible over time and effectively seal joints and cracks should be an important part of any repair strategy.
- No direct correlation was found between subgrade modulus value and pavement condition, in DCP field studies.
- More DCP tests need to be run in more locations, in multiple places at each location, and during different times of the year to accurately conclude if there is a correlation between subgrade modulus values and pavement conditions.
- Repair bars should be placed as close to mid-depth in the slab as possible.
- Low-modulus grout around steel tie bars is not beneficial for shear performance, but works well for tension or flexure, provided it has good tensile characteristics.
- Cross stitching is still not a proven method because of field performance problems and lack of conclusive lab data.
- Cross stitching and slot stitching methods performed better in shear loading than stapling.
- Stapling performed best in flexure type loading.
- Headed bars offered no advantage over conventional rebar.
- Separated joints and cracks should be repaired as soon as possible, and before wide separations occur. Wide joints contribute to high concrete stresses, high bending stresses in the repair bars, and lower stiffness (load transfer efficiency).
- Bond strength is the most important material property for shear loading.
- Bond and tensile strength are the most important material properties for tension or flexure loading.

Analytical Finite Element Modeling (FEM) was conducted to determine the elastic distribution of stress in concrete for three repair methods under consideration. Researchers found that: 1) shear-type loading simulations indicated that slot stitching would probably perform best in the field, and 2) cross stitching was shown to produce the highest stresses.

What This Means

Researchers developed repair and new construction procedures for longitudinal cracking and joint separations in concrete pavements, and tie bar and transverse steel designs were developed. Researchers believe the most important conclusions are:

- Saw cut longitudinal warping joints at 1/3 the pavement depth as soon as the wet sheen evaporates from the pavement surface, regardless of coarse aggregate type.
- Saw cut depth should be checked for acceptance.
- Use No. 6 multi-piece tie bars in new construction.
- Include tolerances for tie bar depth in the Standards.
- Cross stitching should only be used to repair tight cracks/separations. Slot stitching should be used for wider cracks/separations, and is used to restore load transfer, prevent separations, and improve performance of longitudinal joints and wide cracks.
- Under-seal should be injected under low pressure into the voids under faulted slabs to re-establish uniform support for the slabs before retrofitting tie bars.
- Transverse steel spacing should be 3 ft or more, regardless of slab widths.

For More Information:

0-5444-1 Interim Repair Guidelines for Longitudinal Cracking and Joint Separations

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