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Slab Stabilization

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TECH BRIEF

This document is a brief technical summary of the MoDOT case study ***Slab Stabilization Case Study for Missouri*** *which is included in a larger report,* ***Concrete Repair Best Practices: A Series of Case Studies****, Publication no. cmr 17-013, November 2017.*

Introduction

This Tech Brief summarizes a case study on slab stabilization in the lead State of Missouri. Best practice specifications and experience from Missouri, Georgia, contractors, and research studies are also included. Slab stabilization technology has improved over the years through better procedures and materials to provide a restoration of support of slabs that have experienced pumping and erosion leading to transverse joint and crack faulting, cracking, and roughness.

Slab stabilization (also called undersealing and subsealing) is the pressure insertion of a highly flowable material beneath the slab or stabilized base to restore the support beneath transverse and longitudinal joints that has been eroded away. Erosion is caused by repeated heavy axle load deflections, poor joint load transfer efficiency (LTE), excess free water, and erodible materials in the base, subbase, and subgrade. Slab stabilization is not used to significantly raise the slab (this is called slab jacking) but primarily to restore support.

Pre-Slab Stabilization Considerations

The first key to successful slab stabilization is to limit usage to the slab locations where deflection testing indicates loss of support. Missouri and Georgia use load deflection testing at slab corners to determine if erosion and loss of support have developed. Many slab corners do not develop loss of support along a project. The presence of joint faulting is an obvious sign that erosion has occurred and loss of support is developing, particularly beneath the leave corner but possibly on the approach side as well. Faulting typically occurs at transverse joints without dowels and at working transverse cracks due to poor joint or crack LTE and high differential deflections.

The key indicator that is measured in Missouri and Georgia is the slab corner deflection along the project. The corner deflection at three Falling Weight Deflectometer (FWD) load levels can be used to determine if there is significant loss of support beneath the joint or crack that needs to be restored. This can be accomplished 1 to 3 years ahead of construction. The rapid void detection procedure is used in Missouri and is more fully explained in the 1993 AASHTO Guide, Part III, Chapter 3, Section 3.5. (AASHTO, 1993)

Figure 1 shows the concept for a specific transverse joint loaded at the corner from a Missouri project.

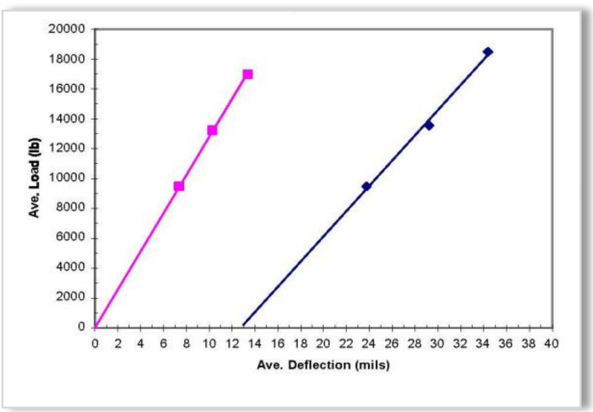

Figure 1. FWD load versus corner deflection before and after undersealing. Note that "after" undersealing the deflection vs. load line goes through the origin indicating restored support).

The "Before Undersealing" plot does not extend through the origin but along the "Deflection" axis, indicating a loss of support beneath the slab/stabilized base (e.g., high deflection for a given load). Once the joint has been injected with material (polyurethane, in this project), the post-stabilization (or undersealing) FWD load-deflection plot extends directly through the origin, indicating that the loss of support has been filled and full support has been restored with a much lower deflections. Missouri DOT concluded that, "The FWD is an efficient tool to use for void detection under PCC pavement slabs, assuming the rapid void detection procedure is correct. Plotting the linear trend for load-versus-deflection before and after undersealing is simple. The assumptions about linearity, within the 9,000 to 16,000 (lb) range, appear to be accurate based on the plots." (Missouri DOT, 2004)

Utilizing an effective material may also reduce future erosion and joint faulting through increasing the LTE, and this would be a significant long-term advantage. Projects in Texas and Pennsylvania have also shown significant increase of joint LTE after slab stabilization with polyurethane.

A large issue related to slab stabilization is the material quantities needed to stabilize the slabs along a project. A few projects have been over pumped, resulting in rising of slabs and sometimes resulting in cracking. However, too little material will not fill all the voids, and loss of support will still exist. The optimum amount of material required is what ensures that slab corner deflections are back to normal and that the load versus deflection line extends near the 0,0 origin of the plot.

The various companies that perform slab stabilization work have their own ways of estimating quantities needed based on their extensive experience. Research conducted in the 1980s under National Cooperative Highway Research Program (NCHRP) Project 1-21 also derived a procedure to estimate cementitious grout quantities based on FWD deflection tests previously described and adopted by AASHTO. (AASHTO, 1993).

Slab Stabilization Specifications and Construction

The second key to successful slab stabilization is effective specifications and procedures. Missouri specifies slab lift measuring equipment that measures to 0.001 inch. Maximum lift allowed is 0.125 inches during undersealing. The contractor must provide the slab stabilization hole pattern. Drilled hole diameter is a maximum of 1.5 inches. Holes are drilled through the slab only and not into the aggregate base. Proof of full slab stabilization includes material seeping from adjacent joints and cracks, vertical slab movement, or other visual indications.

The third key to successful slab stabilization is use of the best materials available to fill the voids beneath the slab/stabilized base. Three types have been used over the years:

- **Cementitious grouts** were used extensively in the 1970s onward by agencies such as Georgia. These materials include water, cement, fly ash, and soil that flow under pressure beneath slabs and stabilized base courses to restore support. Usage of cementitious grout has been phased out in recent years due to its erosion potential.
- **Asphalt cement** commonly used for slab stabilization must have a low penetration and a high softening point. It must also have a viscosity suitable for pumping when heated to temperatures from 400 to 450 °F. A few agencies, including Missouri, allow the use of asphalt cements for slab stabilization. Due to the extremely high temperatures there is some safety concern.
- **Expansive, high-density, two-component, water-resistant polyurethane material** is the primary slab stabilization material used today. It is pressurized through a mixing nozzle where the two components combine at 120 °F and begin to set in 30 seconds. Ninety percent strength is achieved within 3 minutes, and ultimate strength is achieved in 24 hours. The material can flow into very fine voids and expands about six times its liquid size, forcing its way into smaller or larger voids.

Comments from interviews on comparing cementitious grout to polyurethane indicated that the process control is better using the recommended injection hole pattern. By injecting polyurethane in smaller holes grouped together every 4 feet or so, there seems to be more uniform coverage across the slab bottom. Cementitious grout slurry was usually forced through one or two larger holes, and the material didn't always flow where it should have, sometimes creating voids as the slab lifted. The success of grout slurry stabilization was more dependent on the skill of the practitioner. Another factor is getting the consistency of the grout just right—it cannot be too stiff or too watery, whereas the polyurethane chemical ratios are relatively easy to achieve, and liquid asphalt requires the right temperature range.

Inspection/Acceptance

Inspection of a slab stabilization project is the fourth key to success and should focus on injecting the optimum amount of material injected into the holes. Too little injected material and support will not be restored. Too much injected material and the slab will lift excessively, perhaps leading to cracking (this was identified as the major concern for inspection). Both Missouri and Georgia have specific limitations on the allowable amount of slab lifting. There are two key inspection points:

- Lifting of the slab is the key test to ensure that too much material is not injected into the hole. Missouri and Georgia have specification limits for controlling the amount of slab lift.
- Post-stabilization load-deflection testing of the slab corners along the project is the key to ensure that sufficient material has been injected. If the load versus deflection plot shows the line passing close to the origin, the joint will pass inspection. If not, the contractor would need to return and inject materials into the slab again.

Performance & Survival of Slab Stabilization

Missouri. The typical service life of slab stabilized jointed reinforced concrete pavement (mostly at working transverse cracks) in Missouri was estimated by experienced staff of the State at 5-10 years. A contractor who has conducted many concrete pavement restoration projects estimates life of slab stabilization using polyurethane injection material as 10-15 years.

Georgia. When performed according to the specifications for cementitious grout, the support to jointed plain concrete pavement non-doweled joints was restored for 5+ years (no dowel bar retrofit at transverse joints).

The use of dowel bar retrofit at transverse joints and working cracks in addition to slab stabilization may be required to prevent future joint and crack faulting where truck traffic is heavy.

Summary of Slab Stabilization

Four key aspects of successful slab stabilization were identified:

- Limit usage to the slab locations where deflection testing indicates loss of support exists.
- Detail and effectiveness of the specifications for slab stabilization.
- Material that is used to pump beneath slabs and how well the deflections are reduced at the slab corners and how long the material will maintain full support without pumping and eroding. The polyurethane material is currently being used very successfully to restore support and this material may also have some ability to reduce future erosion and pumping if properly placed.
- Inspection/acceptance procedures and their effectiveness. The use of deflection equipment to test the undersealed joints for load support and elimination of voids is highly recommended. Reduction of voids beneath the slab through deflection testing is proof that support has been restored for acceptance. If a joint or working crack still indicates loss of support, it can be redone and then retested to ensure compliance.

References

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Availability—This Tech Brief is available from the MoDOT Innovation Library at http://www.modot.org/services/or/byDate.htm