Research Record

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Evaluating pavement patching materials

Polymers and Elastomeric concretes

Common knowledge about concrete pavements:

- •Eight to ten percent of all pavement spall repairs fail within one year.
- •Fifty percent of all pavement repairs fail within the first five years.

Of course, the statements stated above do vary depending on the initial condition of the pavement. But the *statement* that cannot be contested is that failures are a part of pavements.

Engineers at MDOT, and particularly at the Materials and Technology (M&T) Division at Lansing, are always looking for newer and better ways to patch highways and bridge decks with best possible results. The most important factors that researchers look for in new patching materials are quickest and safest installation of patching material leading to longest possible durability.

Peter Emmons in his article *Selecting concrete repair materials for long-term durability based on available test data*, writes, "concrete requires repair and/or protection when damage, defects or deterioration cause disintegration, spalling, cracking, deflection, settlement or leakage. Successful repairs must address the issues of constructability, engineering and aesthetics. The best repairs are those that first address the long-term needs of engineering and durability followed by the short-term needs of constructability."

The search for newer and better concrete patching materials is an old one. But what is new is the addition of polymers, and specifically elastomeric concretes, to the list of concrete repair materials.

A Bit of History

Enter Polymers

Defense technology percolating to civilian use is not new. What is new with polymers (and especially elastomeric concretes) is their speed of adoption and enthusiastic reception within the various DOTs. The study of polymers started with the U.S. Air Force searching for better ways to address the problem of bomb damaged runways (BDR). The goals of the improved BDR systems were structural soundness, flushness with surrounding pavement, and rapid accomplishment within any environment. The materials research section of the BDR study brought into focus polymer concretes, because their performance promised to satisfy stringent structural requirements and satisfy the full range of test conditions.

However, the studies found one major problem with practically all polymers -incompatibility with water or wet aggregates and concrete. One conclusion from the study, conducted by BDM/Batelle Columbus laboratories, which tested polyurethane and acrylic polymer concrete at extreme temperatures (-20' F to 105˚F), indicated that surface water on aggregate significantly reduced (40 to 60 percent) the flexural strength of these polymers. However, the 400-psi flexural criterion was met under all conditions. BDM mitigated the moisture compatibility problem in polyurethane polymer concretes by several modifications to the chemical formulation.

At the same time that polymers were grabbing the attention of engineers at the various DOTs they were also being successfully tested in building applications. Compared to Portland Cement, polymer concretes, in some studies, showed improved flexural, compressive, and tensile properties. Additionally, polymer concretes offered improved damping characteristics and good protection against corrosive environments.

Lab Studies and Field Trials: A Brief Sketch

MDOT Concrete Pavement Restoration

For over 25 years, MDOT has conducted several studies to develop effective maintenance procedures for concrete pavements including partial-depth repairs of spalls. Based on experimental work conducted in the spring of 1985, the Federal Highway Administration HPR program and was approved in October 1986. The main objective of this research project, begun in 1987, was to evaluate the field performance of various repair techniques, and to determine the merit of restoring and extending service life of concrete pavements. The restoration procedures that were tested included full-depth lane repairs, partial-depth spall repairs, routing and resealing of transverse cracks, resawing and resealing of joints. Developments from this project included incorporation of most of the full-depth lane repair procedures and recognition of a need for a more uniform rating system for pavements.

The Strategic Highway Research Program (SHRP) Study

This SHRP study, also known as the H-106 partial-depth spall repair experiment, was one of the most extensive partial-depth patching studies ever undertaken. The primary aim of this study, begun in March 1991, was to determine the most cost-effective materials and procedures for placing high-quality, long-lasting partial-depth patches in concrete pavements. The ability to place long-lasting patches quickly offers two major advantages: first, the amount of time crews are exposed to traffic is decreased, and second, serviceability of the pavement is increased. A secondary objective of the SHRP study was to identify material tests related to patch performance.

The study and field tests were conducted in over 1600 partial-depth patches at test sites located in four climatic regions – wet-freeze, dry-freeze, wet-nonfreeze, and dry-nonfreeze. Eleven rapid-setting materials were selected for this study: five new polymers and two elastomeric concretes.

The patches were placed using different combinations of the materials and five patch-preparation procedures. Field performance was monitored five times over eighteen months.

Elastomeric Concretes

M&T Lab Study

Testing procedures: With this background and history in place, and spurred by the successful trial installations and study comparing elastomerics and high-end polymer modified cementitious products on I-94 near Port Huron in September 1994, M&T technical personnel began a lab study to determine the physical properties of ten polymer concrete materials (eight of which were elastomeric concretes) for use in the preventive maintenance of roadways and bridge decks.

The pretesting procedures started March of 1994, when 12 bond blocks, of steel, concrete, and hot-dipped galvanized, were cast for thermal compatibility tests. In January of 1995, 101.6 mm by 203.2 mm concrete cylinders and wear track slabs (to be used as substrate slabs) were cast and cured. The blocks and the cylinders were cured for 28 days and then air dried, while the slabs were wet cured for 7 days and then air dried. All surfaces that were

Projects involving Elastomeric Concretes

Elastomeric concretes have been used in a number of projects to repair spalls and patch highways and bridge decks. The following list outlines the major projects undertaken by MDOT over the past couple of years.

Installation of Chemtron CP2010 on the US-31 Bascule Bridge and repair of spalls around steel support structures.

Percol Elastic Cement partial width replacement of expansion joints on I-94 over Black River, Port Huron, MI performed in November 1995. The elastomeric concrete was used as a header to replace existing devices that were in extremely poor shape.

Roadware Sylcrete elastomeric concrete repairs on I-69 Southbound, Charlotte, MI.

Spall repairs over one of the busiest sections of road in MI (I-75 over Fourteen Mile Road) with Percol elastic cement. The repairs are performing well and are being inspected twice a year and evaluated for durability and overall performance.

Transverse faulted crack repairs with Percol elastic cement on I-75 at Vreeland Road, Monroe, MI. This experimental installation showed that the elastic cement could neither withstand movements between slabs nor return some integrity to the faulted slabs.

Simple spall repair on the Blue Water Bridge, Port Huron, MI with Percol Elastic Cement resulting in faster opening to traffic.

Replacement of a severely deteriorated joint on a bridge on the I-275/I-696 Interchange with Percol Elastic cement.

Spall and joint repair over six miles on the three lanes of heavily traveled I-75 (Monroe to Silbey Road) Highway. The elastomeric concrete (Percol) was also used along faulted transverse cracks to allow for movement at the crack.

A cooperative study involving Michigan State University on I-96 Eastbound over Doan Creek, Webberville, MI involving the installation of a recycled PET material and Delcrete in several spall repair locations.

to be bonded were sand blasted except the hot-dipped galvanized samples which were cleaned with acetone.

The actual lab study began on January 3, 1995. The study had to improvise and modify some of the standard ASTM tests due to the fact that there were not many standards and test methods for polymer concretes.

The ten materials chosen were either previously used as bridge expansion joint headers or were found through extensive literature search. The ten polymer products tested were: Silispec PNS 900, Flexcon, Jeene PC92M, Delcrete, Percol Elastic Cement, Chemtron CP2010, Flexolith, Thoro XPC 95, Wabocrete, Sylcrete.

Results: The conclusions drawn from the lab and field studies indicated that polymer concretes (with one exception) outperformed all portland cement-based fast set materials. Researchers also found that even though preparation of repair areas was still critical, polymer concretes were a lot more forgiving of "bad" preparation. That is, slight oversights in the preparation of the site would not adversely affect the performance of the polymers. Results suggest that if a Qualified Products List be required, testing criteria should include the flexural strengths, tensile strength, and elongation of the polymer concrete, while the most important criteria should be successful field installations of the products to observe their behavior under live traffic conditions. Also, the most economical and easiest products to install were the systems that were pumped from bulk units and flooded over pre-placed aggregate. Percol elastic cement, Chemtron CP2010 and Roadware Sylcrete, all elastomeric concretes, proved to be very efficient repair materials.

A close look at two types of elastomeric concretes: D.S. Brown Delcrete Elastomeric Concrete and Percol Elastic Cement

Delcrete is a free-flowing, two-part polyurethane based elastomeric concrete that is mechanically mixed on-site in small batches. It has the capability to bond to a variety of surfaces, including steel and concrete. It has been used extensively in bridge deck replacement joints. The D.S Brown Company regards Delcrete as an excellent concrete because of "its outstanding flow and cure characteristics without [application of] external heat and because it has excellent low temperature flexibility." Other factors that make this an excellent choice for long lasting repairs are**:** >2000 psi tensile strength, 98% resilience, non-brittle over extreme temperature ranges, ambient cure system, and resistance to multitude of chemicals

Percol Elastic Cement is another elastomeric concrete that is a rapid curing, flexible adhesive binder used with aggregates and/or sand for repairing and resurfacing Portland concrete surfaces. It is mixed in a static mixing nozzle from bulk units and flooded over a preplaced aggregate. The aggregates and binder are applied separately and with cure time at two minutes, it is truly a fast-set repair material. Some other advantages of this excellent repair material are that it requires no priming, has a high flash point, contains no peroxides or heavy metals, and is odorless.

Advantages of elastomerics: A question of money

When polymers were first introduced for roadway patching, they proved to be very effective *but* expensive. The initial cost of using polymers, and especially elastomerics, is still quite high, but this high initial cost may be offset by a significant decrease in lower life-cycle costs.

The list of projects involving elastomeric concretes indicates that elastomeric concretes are being used in spall repair, cracked and joint spall repairs, partial width replacement of joints, and many more diverse applications. Added to this impressive list of applications are its advantages over other types of repair materials, particularly portland cement-based materials. Elastomeric concretes have no portland cement component. They offer the twin advantages of superior bonding over other types of concretes and significantly higher elasticity with proper installation and good construction methods. Additionally, there is no need to chip out concrete below re-bar as these materials do not depend on the mechanical bond with the re-bar as part of the repair. Most elastomerics also have high tensile strength and are non-brittle over extreme temperature ranges.

They have fast cure times, which result in faster open-to-traffic times. Using elastomeric concretes, thus, translates to reduced closure costs, since most repair jobs using elastomerics can be opened to traffic within two hours. This also decreases labor costs since workers spend less time at the job. Less closure time of the roadway also means increased safety for the driving public and workers.

New material, new way of thinking

"Using polymers (and elastomeric concretes) for pavement patching would require a change in thinking, from the conventional reactive approach, to a newer proactive one," said Doug Branch, Supervisor, M&T Materials Investigations.

"The whole concept of elastomeric concrete repairs is based on the repairs lasting a minimum of five years," said Tom Miller, M&T Engineering Technician.

This "change in thinking" is crucial to MDOT's new focus in the preventive maintenance program, wherein basically sound pavements are preferentially repaired to increase service life.

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Editor .... Susan Sanders

Research Writer/Editor .... A. "Kris" Krishnaswamy

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