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Effective Long-Lasting Partial Depth Joint Repairs for Challenging Conditions

NRRA PREVENTIVE MAINTENANCE TEAM

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As Portland cement concrete (PCC) pavements age, longitudinal and transverse joints can exhibit signs of distress as a result of traffic loading, climatic variations, materials-related issues, and construction defects. Although only small areas are often involved, the joint distress can substantially disrupt traffic flow and increase pavement roughness, sacrificing consumer ride comfort. When immediate action is required, temporary repairs are often made using readily available materials, such as cold mix or other asphalt materials. These temporary materials are often replaced with more permanent materials to reestablish the integrity and functionality of the concrete pavement. The goal of this project is to provide a guide for agencies to establish an effective joint repair program. The final report reviews the background information explaining why this research was performed, summarizes the findings from previous similar research studies, details how the patches were constructed and how they performed, and provides a Product Matrix that includes installation requirements, equipment needed, along with the life expectancy of the products to compare and guide the reader through product selection.

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Effective Long-Lasting Partial Depth Joint Repairs for Challenging Conditions

Final Report

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LIST OF ABBREVIATIONS

Below are the abbreviations for each patch type.

- CL: Centerline
- CLJ: Centerline Joint
- FL: Full Length
- CP: Corner Patch
- WP: Wheel Path
- ML: Mid-Lane
- MLJ: Mid-Lane Joint

Please refer to Figure 4.1 for orientation of each patch type.

EXECUTIVE SUMMARY

As Portland cement concrete (PCC) pavements age, longitudinal and transverse joints can exhibit signs of distress as a result of traffic loading, climatic variations, materials-related issues, and construction defects. Although only small areas are often involved, the joint distress can substantially disrupt traffic flow and increase pavement roughness, sacrificing consumer ride comfort. When immediate action is required, temporary repairs are often made using readily available materials, such as cold mix or other asphalt materials. These temporary materials are often replaced at a later date with more permanent materials to reestablish the integrity and functionality of the concrete pavement.

This research project is being conducted to review alternative patch materials for PCC partial depth repairs and monitor whether these alternative materials last longer than the frequently used cold mix and other asphalt patches.

To conduct this research, distresses were made manually within the PCC pavement along the old I-94 westbound at the Minnesota Road Research Facility (MnROAD). This report details the distresses that were patched, what products were used, how they were mixed, and how they were applied. The report also details a literature review that was performed to better understand the various patching materials, installation procedures, and previous research projects that have been completed on this topic.

MnDOT research and district personnel, material suppliers, and Braun Intertec personnel were onsite during the preparation and installation process to document the procedures required or used by each product. Documentation included equipment needed for preparation and the installation process, and manufacturer guidelines or recommendations for installation of each product.

In addition, this report provided updates on the condition of the patches after three years of service. The conditions of the patches were rated on a scale of 0 to 4, with 0 being a failed patch and 4 being a patch with no signs of distress. Discussion of the patch conditions along with photos of the patches were included in this report. A matrix summarizing each material used, its installation process, and performance over the last three years was also included as part of this report.

CHAPTER 1: OBJECTIVES

Joint distress can range from minor spalling that requires no immediate action to major distresses that can affect large areas of pavement and significantly disrupt traffic. When immediate action is required, temporary repairs are often made using readily available materials, such as cold mix or other asphalt materials. These temporary materials are often replaced at a later date with more permanent materials to reestablish the integrity and functionality of the concrete pavement.

When longer-lasting materials are used in the initial joint repairs, the impact to travelers is that additional costs for temporary materials and subsequent removals are eliminated. Different material types are available for longer-term repairs, which vary widely in cost, required skill level for satisfactory placement, and time needed before opening to traffic. The performance of each of these materials can also vary widely making selection and installation of permanent repairs challenging.

The objective of this project is to provide a guide for National Road Research Alliance (NRRA) members and other agencies to establish an effective partial depth repair program for concrete pavements. The final report reviews the background information explaining why this research was performed, summarizes the findings from previous similar research studies, details how the patches were constructed and how they performed, and provides a Product Matrix that includes installation requirements, equipment needed, along with the life expectancy of the products to compare and guide the reader through product selection.

CHAPTER 2: PROJECT BACKGROUND

The NRRA Preventive Maintenance team selected the original westbound lanes of I-94 that are adjacent to the MnROAD Facility to perform this research project. This portion of I-94 was originally constructed in 1973 with a 9-inch thick concrete pavement and skewed 27-foot spaced transverse joints. A total of 15 test sections consisting of three contiguous panels and two transition panels, one at either end, were prepared. Seven different patch types were created as shown in Figure 4.1. Sixteen different proprietary products were supplied by vendors for evaluation. Additionally, asphalt patching mix was used in two of the 15 sections.

MnDOT Research, MnDOT District, material suppliers, and Braun Intertec Corporation (Braun) personnel were onsite during the preparation and installation process to document the procedures required and/or used for each product. Documentation included equipment needed for preparation and installation process, and manufacturer guidelines or recommendations for the installation of each product.

The distresses were created on September 27, 2017, and patches were installed between September 27 and October 11, 2017. Westbound I-94 traffic was placed on the partial depth patch sections beginning November 2, 2017 and remained there intermittently throughout the research project. Traffic is not usually placed on the old I-94 westbound section during winter months or while research and other MnROAD events are occurring. As such, the patches did not endure regular snowplowing during the winter months for this research project. Snowplow blades often catch on loose pavement material, especially patches, resulting in material loss.

Traffic data was only available through May 11, 2020. The final site visit was performed on August 12, 2020. As such, the traffic counts are likely slightly higher than reported below.

In total, the partial depth patch section carried traffic for 242 days between the installation date and May 11, 2020. In that time, nearly 6 million passenger cars and 1.25 million heavy commercial trucks drove over the partial depth patches. The traffic data is broken down into further detail in Table 2.1.

An annual review of the patch conditions was performed each year, for three years after installation. The first review was completed on June 20, 2018 by MnDOT and Braun personnel. It was noted that the patches were still in good condition after the winter months. The reviewers were curious how the patches would perform during the summer months when traffic is higher. Additionally, waiting to review patch conditions until later in the year would put the review closer to a whole year between installation and condition review. As such, the patches were reviewed again on September 15, 2018. The patch conditions were noted to have deteriorated since the June 20 review. This theory was tested again during the second-year review. A review of the patch conditions was done on May 17, 2019 and again on September 27, 2019. The patches were noted to have shown more deterioration over the summer months during higher traffic, than during winter months when traffic is low. The final annual review was completed on August 27, 2020.

Patch condition ratings from the annual reviews that took place in August and September were used to track the patch performance. The patch conditions were rated as described in Section 4.2. After the final review was completed, each product's performance over three years was summarized, as shown in Figure 4.6. A matrix was also developed to compare each product's performance, along with installation and other details. The Product Matrix is included in Chapter 5.

Table 2.1 Traffic Data between Patch Installation and Final Review

Lane	Dates	Total Number of Passenger Cars	Total Number of Heavy Commercial Trucks	WIM Measured CESALs
Driving	Installation (11/2/17) to Year 1 Review (8/27/18)	667,123	185,948	254,516
	Year 1 Review (10/1/18) to Year 2 Review (9/16/19)	1,417,522	426,697	405,948
	Year 2 Review (10/14/19) to Final Review (5/11/20)	508,820	165,456	228,961
	Total (11/2/17 to 5/11/20)	*2,593,465*	*778,101*	*889,425*
Passing	Installation (11/2/17) to Year 1 Review (8/27/18)	908,868	63,909	55,239
	Year 1 Review (10/1/18) to Year 2 Review (9/16/19)	1,840,328	341,351	157,753
	Year 2 Review (10/14/19) to Final Review (5/11/20)	617,861	66,398	61,490
	Total (11/2/17 to 5/11/20)	*3,367,057*	*471,658*	*274,482*

CHAPTER 3: LITERATURE REVIEW

3.1 INTRODUCTION

3.1.1 Partial Depth Repair

Partial depth repair (PDR) is the removal and replacement of deteriorated or spalled concrete in the upper portion of concrete pavements. Spalling is defined as cracking, breaking, or chipping away of concrete at joints and cracks, which is often caused by incompressible materials that accumulate in these openings. The incompressible materials hinder slab movement induced by thermal variations, thus resulting in high compressive stresses at joints and cracks. Spalling may occur at other locations on a pavement slab due to reasons such as snowplowing, poor construction practices and popouts (ACPA, 2004). Interestingly, the spalling experienced in Texas has been generally associated with the use of certain type of siliceous river gravel, which tends to exhibit higher elastic modulus, higher coefficient of thermal expansion (CTE) and weaker bonding (Folliard et al., 2006; Markey et al., 2006).

Spalling allows the ingress of water and more incompressible materials. It propagates under the influence of environmental and traffic factors, and if proper repair is delayed, particularly for pavements located in a wetter and colder climate, the distress could progress rapidly to minimize structural integrity, safety and ride quality. PDR replaces deteriorated concrete, restores ride quality, prevents further deterioration and provides a reservoir for resealing of joints and cracks (ACPA, 1989).

Due to the detrimental effects of spalling, some highway agencies spend substantial budget on spall repairs, estimated to be in excess of one billion dollars annually in the United States (Kuo et al., 1999). Increasing budget constraints and stricter requirements to minimize traffic delays and safety hazards have necessitated the need for better materials and installation techniques for rapid construction of long-lasting repairs. It is believed that about 8 to 10 percent of spall repairs fail within a year, and about half of all pavement repairs fail within five years (MDOT, 1996). However, with optimal timing of repairs, proper selection of materials and good construction practices, it is possible to produce PDRs that could last 10 to 15 years or longer (Frentress and Harrington, 2012).

The primary objective of this literature review was to synthesize effective practices for producing long-lasting PDRs. The review focused on applications and limitations of PDR; material and construction considerations; and field performance of PDRs. To achieve the above stated objective, over 30 publications compiled from transportation research databases, industry associations, university research centers and state departments of transportation (DOT) libraries, were reviewed.

3.1.2 Applications and Limitations

Historically, recommendations have limited the use of PDRs to the upper third of the pavement (e.g., Patel et al., 1993; Wilson et al., 1999a; ACPA, 2004). However, it is becoming common to use PDR to

treat distresses that extend as deep as one-half of the slab thickness. For instance, Minnesota, Wisconsin, Michigan, Kansas, Missouri, Colorado and South Dakota have successfully utilized PDR to correct distresses that extended to one-half of the slab (Frentress and Harrington, 2012). Because most repair materials cannot accommodate high stresses induced by movements across working joints, cracks, load transfer devices and reinforcing steel, PDR is suitable for treating distresses located within the top one-third to one-half of the slab thickness (Smith et al., 2014). The following distresses have been successfully remedied with PDRs (Frentress and Harrington, 2012; Smith et al., 2014):

- Spalling caused by accumulation of incompressible materials in joints
- Spalling caused by poor construction practices, such as poor consolidation, inadequate curing, over-finishing, weak concrete, clay balls and inadequate reinforcing steel cover
- Spalling caused by freeze-thaw as a result of inadequate air void system
- Localized areas of deterioration or scaling limited to the upper one-third to one-half of the slab thickness and of sufficient size and depth to warrant repair
- Non-working longitudinal and transverse cracks

Despite the utility of PDR, it is ineffective in treating spalling caused by dowel bar misalignment; working cracks resulting from shrinkage, fatigue, or foundation movement; durability cracking (D-cracking); and material-related issues such as alkali-silica reactivity, alkali-carbonate reactivity and ettringite formation (Frentress and Harrington, 2012; Smith et al., 2014).

Pavement coring is recommended for ascertaining the depths of deterioration to enable a suitable repair option to be selected. Locations where deteriorations reach the depth of dowel bars are candidates for a full depth repair (Wilson et al., 1999a; Smith et al., 2014). To minimize the risk of premature failures, PDRs may be undertaken before overlay construction (Wilson et al., 1999a).

3.2 MATERIAL CONSIDERATIONS

Proper material considerations are essential for producing long-lasting PDRs. Poor material selection and design has been found to cause patch failures within two to three years (ACPA, 2006). Wilson et al. (1999a) identified the following common material-related causes of premature PDR failures:

- Incompatibilities between the climatic conditions during repair installation and the materials
- Thermal incompatibility between the repair material and the existing concrete
- Extreme climatic conditions during the service life of the repairs
- Inadequate cure time prior to opening repairs to traffic
- Incompatibility between the joint bond breaker and the joint sealant material

The selection of a repair material for a particular project could be challenging, since many factors need consideration, including allowable lane closure time; environmental conditions; material properties, particularly shrinkage characteristics, CTE, curing time, compatibility between repair material and

existing concrete; project size and funding; and performance requirements (Frentress and Harrington, 2012; Smith et al., 2014). Regardless, cost-effective materials that provide maximum benefits should be selected. The following subsections discuss some essential properties of repair materials, benefits and drawbacks of various material types and a framework for evaluating and approving new materials.

3.2.1 Material Properties

To shorten lane closure times, traffic loading is permitted when patches have gained minimum strength to sustain loads. Most highway agencies use flexural strength to determine traffic-opening times for full depth repairs (FDRs), since most of FDR structural failures are caused by high tensile stresses at the bottom of slabs (Frentress and Harrington, 2012). However, Frentress and Harrington (2012) recommended using compressive strength at opening as a criterion for selecting PDR mixtures, since PDRs mostly experience compressive stress; tensile stress is accommodated by the existing concrete.

There is no consensus on minimum strength requirements for opening PDRs to traffic. This is not surprising because several material, traffic and environmental factors influence such a criterion. Frentress and Harrington (2012) noted that, since PDRs are confined and supported by the underlying concrete, the minimum compressive strength requirement at opening should be lower (typically 1,600 to 1,800 psi) than that for conventional FDRs (typically 3,000 psi or higher). They also noted that higher opening compressive strengths (e.g., 3,000 psi) may increase the risk of short-term failures than lower opening strengths (e.g., 1,600 to 1,800 psi); the higher the opening strength, the higher the complexity of the repair material composition.

Table 3.1 shows the opening strength requirements of some agencies. By using the HIPERPAV software to analyze typical concrete mixtures constructed in Virginia, Elfino et al. (2013) recommended a minimum opening compressive strength of 1,600 psi, provided a maturity meter was used to monitor in-situ strength. They suggested the recommended opening strength could reduce cement quantities in repair mixtures compared with the current requirement of 2,000 psi. Similarly, Collier et al. (2018), after reviewing several opening strength requirements, suggested Louisiana Department of Transportation and Development reduce their current minimum compressive strength specification of 3,000 psi to 2,000 psi in order to increase durability, while minimizing construction costs and lane closure times. They also recommended adoption of the maturity method for monitoring in-situ strength.

Table 3.1 PDR Opening Strengths (Frentress and Harrington, 2012; Elfino et al., 2013; Collier et al., 2018)

State	Flexural Strength (psi)	Compressive Strength (psi)
New York	--	1,527
Kansas	300	1,800
Missouri	--	1,600
Michigan	300	1,800
Minnesota	500	3,000
Colorado	--	2,500
Nebraska	--	3,625
Virginia	--	2,000
Louisiana	--	3,000

There seems to be a trend toward specifying lower opening compressive strengths for PDRs and using a maturity meter to monitor in-situ strength gain, particularly if very early opening is required (e.g., 4-hour curing time). For instance, the Virginia DOT allows the use of maturity meters to monitor in-situ strength, in order to facilitate rapid decision-making on traffic-opening times (Elfino et al, 2013).

Drying shrinkage and CTE of repair materials also impact the performance of PDRs; the greater the difference in these properties between the repair material and the existing concrete, the greater the risk of debonding (Smith et al., 2014). Emmons et al. (1993) indicated that most repair materials have greater shrinkage potential than conventional concrete, hence a repair material that is restrained in a patch could induce tensile stress as high as 1,000 psi.

Apart from possessing desirable strength and shrinkage characteristics, PDR materials should also be able to withstand deterioration from freezing and thawing. Therefore, freeze-thaw durability is an important material characteristic that needs consideration. Rapid strength-gain materials, although allow for early opening to traffic, are often prone to durability-related distresses owing to their reduced curing times and slower long-term strength gain (Van Dam et al., 2005; Frentress and Harrington, 2012). Using high-quality materials and construction techniques, reducing the water-to-cement ratio and increasing aggregate volume but maintaining workability are some suggested measures for achieving early-strength without adversely affecting durability (Van Dam et al., 2005).

Flowability, rate of strength gain, water and chloride ion impermeability and ability to develop strong bond with the existing concrete have also been identified as essential material characteristics that influence the long-term performance of repair concrete materials (Deshpande, 2006). Several laboratory test methods are available for evaluating the mechanical, durability and dimensional stability properties of cementitious repair materials. Table 3.2 shows examples of such tests.

Table 3.2 Laboratory Test Methods for Evaluating Cementitious Repair Materials

Property	Test Method
Compressive strength	ASTM C 39
Drying shrinkage	ASTM C 157
Restrained shrinkage	ASTM C 1581
Slant-shear bond strength	ASTM C 882 (modified by ASTM C 928)
Tensile bond strength	ASTM C 1583
Modulus of elasticity	ASTM C 469
Coefficient of thermal expansion	ASTM C 531
Freeze-thaw resistance	ASTM C 666

3.2.2 Material Types

PDR materials may be categorized as cementitious, polymer-based and bituminous materials. Bituminous materials are mostly used for temporary, emergency-type repairs, although some proprietary products may provide longer service lives. Research (e.g., Wilson et al., 1999a) shows that bituminous patches may perform well for three to four years, but rapidly deteriorate afterward. The rest of the review focuses on cementitious and polymer-based repair materials.

3.2.2.1 Cementitious Materials

Regular PCC mixtures are commonly used for PDRs. Mixtures containing Type III Portland cement or Type I Portland cement plus a set-accelerator are installed to open to traffic quickly. Table 3.3 summarizes some benefits and drawbacks of cementitious repair materials.

Table 3.3 Cementitious Materials (Patel et al., 1993; Frentress and Harrington, 2012; Smith et al., 2014)

Category	Benefits	Drawbacks
Portland cement concrete	• Type I cement mixtures install easily • Type I cement rich mixtures gain strength rapidly in warm weather • Type III cement mixtures set faster, allowing quicker opening to traffic	• Type I cement rich mixtures gain strength slowly in cold weather; they may need insulation layers • Difficult to place Type III cement mixtures properly
Gypsum-based concretes	• Gain strength rapidly; can open to traffic in one hour • Applicable in non-freezing conditions • Not affected by deicing agents	• May not perform well under moisture or in a freezing weather • Free sulfates in typical gypsum mixtures facilitate steel corrosion • Dry conditions are needed to install
Magnesium phosphate concretes	• Set very quickly to yield high early-strength, impermeable material • Bond well to clean and dry surfaces	• Small amounts of excess water can cause considerable strength loss • Not compatible with certain types of limestone aggregate
High alumina concretes	• Gain strength rapidly, with good bonding capability on dry surfaces • Exhibit high freeze-thaw damage resistance and very low shrinkage • Applicable in low-temperature conditions	• Strength loss may occur over time due to a chemical conversion process during curing or later • Conversion test can evaluate mix designs to ascertain if converted strength exceeds specified strength

3.2.2.2 Polymer-Based Concretes

Polymer resin, aggregate and a set initiator are the major constituents of polymer-based concretes. They have faster setting times than most cementitious materials and may be sensitive under certain field conditions (Frentress and Harrington, 2012). Aggregate is added to enhance thermal compatibility with the existing concrete, provide a wearing surface and improve economy (Patel et al., 1993). Table 3.4 presents some benefits and drawbacks of polymer-based concretes.

Table 3.4 Polymer-Based Materials (Patel et al., 1993; Frentress and Harrington, 2012; Smith et al., 2014)

Category	Benefits	Drawbacks
Epoxy concretes	• They are impermeable and have excellent bonding properties	• They must be thermally compatible with existing concrete to prevent patch failure (epoxies have higher CTE) • Deep repairs should be placed in multiple lifts to control heat generation • Not suitable to patch spalls caused by steel corrosion; adjacent sound concrete may deteriorate quickly
Methyl methacrylate (MMA) concretes	• Provide high compressive strength and good bonding • Can be installed over a wide temperature range (40 to 130°F)	• Many are volatile and may pose a health hazard from prolonged exposure
Polyester-styrene concretes	• Have similar properties as MMAs • Generally cost less	• Slower rate of strength gain than MMAs
Polyurethane concretes	• They have very quick setting times (90 seconds) • They are very flexible	• High CTE and large initial shrinkage • Many are moisture-intolerant, but some manufacturers exempt their products

3.2.2.3 Miscellaneous Patching Materials

There is a continual search for innovative repair materials that provide cost-effective repair solutions. For instance, Parker and Shoemaker (1991) evaluated the potential benefits of incorporating steel fibers and anchors in rapid-setting cementitious repair materials. The anchors were U-shaped No. 4 reinforcing bars inserted in holes drilled in the slabs and filled with a rapid-setting polyester grout. The anticipated benefits of the anchors were bonding enhancement between the new and old concrete and load support after bond failure. While the inclusion of the anchors did not improve patch performance, patches constructed with steel fiber-reinforced PCC exhibited better performance. The superior performance was attributed to the larger tensile strength and ductility of the fiber-reinforced concrete, which enabled the patches to better resist cracking. Also, it was thought that the steel fiber improved resistance to shrinkage and microcracking during curing.

Some product manufacturers recommend adding pea gravel to their products, a process known as extension. Deshpande and Olek (2008) conducted laboratory evaluation of four commercial rapid-setting repair materials extended with pea gravel of nominal aggregate size of 9.5 mm. Both fresh properties (slump and setting time) and hardened properties (compressive strength, slant shear strength, cracking susceptibility, drying shrinkage and freeze-thaw durability) were considerably affected by the extension; the extended products did not necessarily exhibit the properties of rapid-setting repair materials required by ASTM C 928. Also, an additional amount of water was necessary for all the extended products to exhibit the desired workability.

Some newly proposed rapid-setting repair materials incorporate waste materials, such as fly ash and silica fume (e.g., Ghazy et al., 2016; Mohammadi et al., 2014). Song et al. (2017) formulated a rapid-setting repair material comprising fly ash, blast furnace slag and rice husk ash. Wang and Lomboy (2016) developed, for rapid repair applications, a mortar mix formula which incorporated Type I Portland cement, river sand, Class F fly ash, silica fume, limestone fines and a high-range water reducer. The mortar exhibited better self-consolidation, freeze-thaw durability and chloride ion impermeability than the commercial concrete repair product used as a control. Also, the compressive strength and modulus of rupture at one day were comparable to those of a conventional pavement concrete mixture at 28 days. However, the mortar exhibited higher autogenous shrinkage and slightly lower free drying shrinkage; the addition of micro-steel fibers slightly reduced the shrinkage. Further investigation into the fatigue and shrinkage cracking behavior of the mortar mix was recommended. Field trials will also help to evaluate the material's performance under service conditions.

The search for newer and better repair materials and construction techniques is set to continue, and it is important an effective framework exists for an objective evaluation of potential products and their installation techniques. Section 3.2.5 presents a simple framework for evaluating new repair materials.

3.2.2.4 Accessory Materials

Bonding agents, curing materials and joint bond breakers are accessory materials that may be needed in the PDR construction process. These materials are briefly discussed below.

Bonding Agents

The bond strength between the repair and the existing concrete has a major impact on patch performance and, for early-opening-to-traffic patches, early development of bond strength is critical. Surface preparation, surface moisture condition, bonding agents, compressive strength of the repair material, curing and the presence of cracking all affect bond strength (Santos et al., 2012).

A bonding agent may not be required for some proprietary patch materials. However, the use of sand-cement grout as a bonding agent for cementitious repair materials is widely practiced. Two parts of Type I cement to one part of water and one part of sand is a popular grout recipe; however, Kansas DOT specifies a more fluid grout, comprising one part of Type I cement to three parts of water, meant to promote bonding, moisten and cool the repair area (Frentress and Harrington, 2012).

Riding and DonJuan (2014) concluded, from laboratory and field studies, that a water-to-cement ratio of one provided the best balance between workability, bond strength and wait time between grouting and material placement. A dried-out grout hinders bonding; hence, removal by sandblasting and re-application is required (Smith et al., 2014). Epoxy bonding agents have been used for both cementitious and proprietary repair materials to reduce lane closure times (Frentress and Harrington, 2012).

Curing Materials

PDRs are prone to rapid moisture loss because of their high surface-area-to-volume ratio (ACPA, 1989). Proper curing will help to maintain adequate moisture and temperature condition to facilitate strength

gain, while minimizing shrinkage cracking. Frentress and Harrington (2012) identified the following characteristics of some common categories of curing compounds:

- Water-based curing compounds are readily available, but their water-retention properties reduce their caliber
- Linseed oil curing compounds provide good curing and help prevent shrinkage cracking
- Waxed-based curing compounds are very good and help to prevent shrinkage cracking
- Poly alpha methylstyrene has high solid content and requires constant mixing. If mixed properly, it provides good curing and significantly reduces shrinkage cracking.

ASTM C 309 and AASHTO M 148 provide specifications for most curing compounds. White-pigmented curing compounds create a sealing membrane that controls moisture loss; allow heat of hydration to escape, and provide curing for several days until worn out by traffic; the white color reflects solar radiation to check excessive heat development (Tyson, 1977; Van Dam et al., 2005). In hot weather, applying a white-pigmented curing compound (e.g., poly-alpha-methylstyrene) as soon as the bleed water evaporates is an effective curing method (Frentress and Harrington, 2012; Smith et al., 2014).

Moist burlap and polyethylene sheeting may also be used for curing, although they may not be the most effective method to use in hot weather because shrinkage cracking can occur from rapid moisture loss when the sheeting and burlap are removed to allow for traffic operations (Tyson 1977). Insulation blankets are effective for curing in cold weather as they retain the heat of hydration, thereby ensuring early strength development (Whiting et al., 1993; Smith et al., 2014). It is preferable to use insulating blankets in conjunction with curing compounds, since blankets alone do not significantly reduce the risk of plastic shrinkage (Whiting et al., 2005). It is advised not to place blankets just after applying a curing compound (Whiting et al., 2005).

Manufacturers of proprietary repair materials may recommend curing procedures for their products. Some highway agencies specify curing compound application rates that are 1.5 to 2 times typical rates as a precaution to prevent shrinkage cracking (Frentress and Harrington, 2012; Smith et al., 2014).

Joint Bond Breakers

Patches installed at joints or cracks, if they bond to the adjacent slab, often experience excessive compressive stresses due to slab movement. A compressible joint bond breaker prevents such undesirable bonding and relieve compressive stresses; the joint breaker also prevents the patch material from entering the joint or crack to hinder slab movement (Frentress and Harrington, 2012).

For best performance, a joint bond breaker must be nonabsorbent, closed cell, chemically inert, compressible with good recovery, compatible with joint sealant and heat resistant, if it is used with hot-poured sealants (Patel et al., 1993). Polyurethane, polystyrene, or polyethylene strips, and fiberboards have been frequently used as bond breakers to reduce the risk of joint patch failures (Patel et al., 1993). Because of the relatively high rigidity of fiberboard, it provides the most benefit at the lane-shoulder joint, where greater support is needed (Patel et al., 1993). Waxed cardboards fit well into irregular cracks, while maintaining their rigidity for placement of the repair material (Frentress and Harrington, 2012). It is noted that certain proprietary repair products have sufficient compressibility to tolerate joint movements without the need for a joint bond breaker (Smith et al., 2014).

As a good construction practice, a joint bond breaker should be scored (Figure 3.1) at an appropriate depth prior to installation and, upon curing of the patch material, the top strip of the bond breaker is removed to create a joint sealant reservoir (Wilson et al., 1999a). As Figure 3.2 shows, it is recommended bond breakers extend 1.0 inch (25mm) below and 3 inches (75 mm) beyond the repair boundaries to prevent the patch material from flowing into the joint during placement (Wilson et al., 1999a).

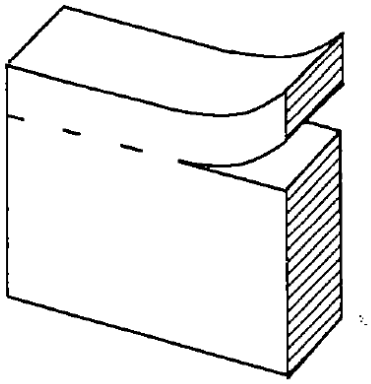

Figure 3.1 Scored Joint Bond Breaker (Wilson et al., 1999a)

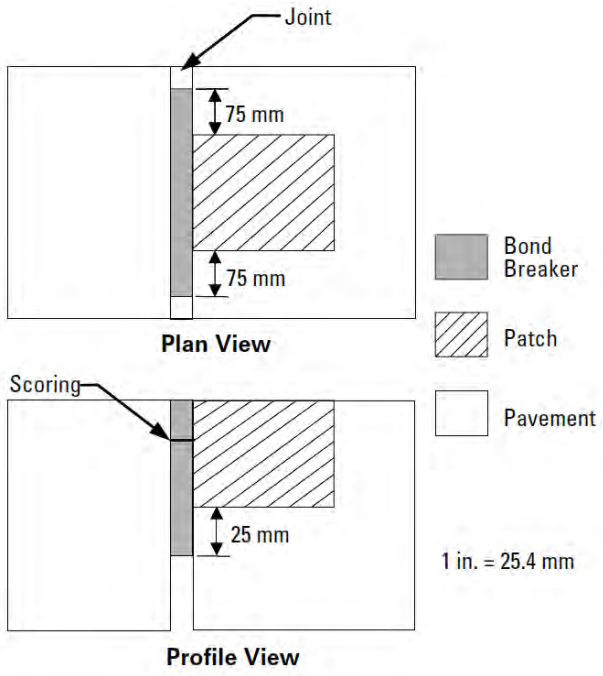

Figure 3.2 Joint Bond Breaker (Wilson et al., 1999a, as reproduced by Smith et al., 2014)

3.2.3 Material Evaluation Methodology

The proliferation of repair materials calls for an effective approach for their objective evaluation and adoption. Figure 3.3 shows a simple framework for evaluating new repair products (Tyson, 1977). Minimum material property values are established, based on laboratory testing or empirical experience. Products without sufficient verifiable test data to prove performance claims are screened out. If verifiable test data or an agency's test results indicate that product has good potential, it is accepted for field trials. It is important to differentiate between material- and construction-related failures. Products that distinguish themselves in field trials may be adopted for general use, but satisfactory long-term performance must justify their continual use.

Several products may exhibit satisfactory performance in the field trials and a decision must be made regarding which product should be selected for a particular project. As previously discussed, several factors influence the selection of a repair material. In addition to the factors already discussed, it may also be useful to utilize a production chart that shows relationships between the approximate number of patches that could be installed, using a certain product, and the available lane closure time (Tyson, 1977). Such a chart will be useful, during project planning, to estimate overall lane closure time, provided the number of patches is known.

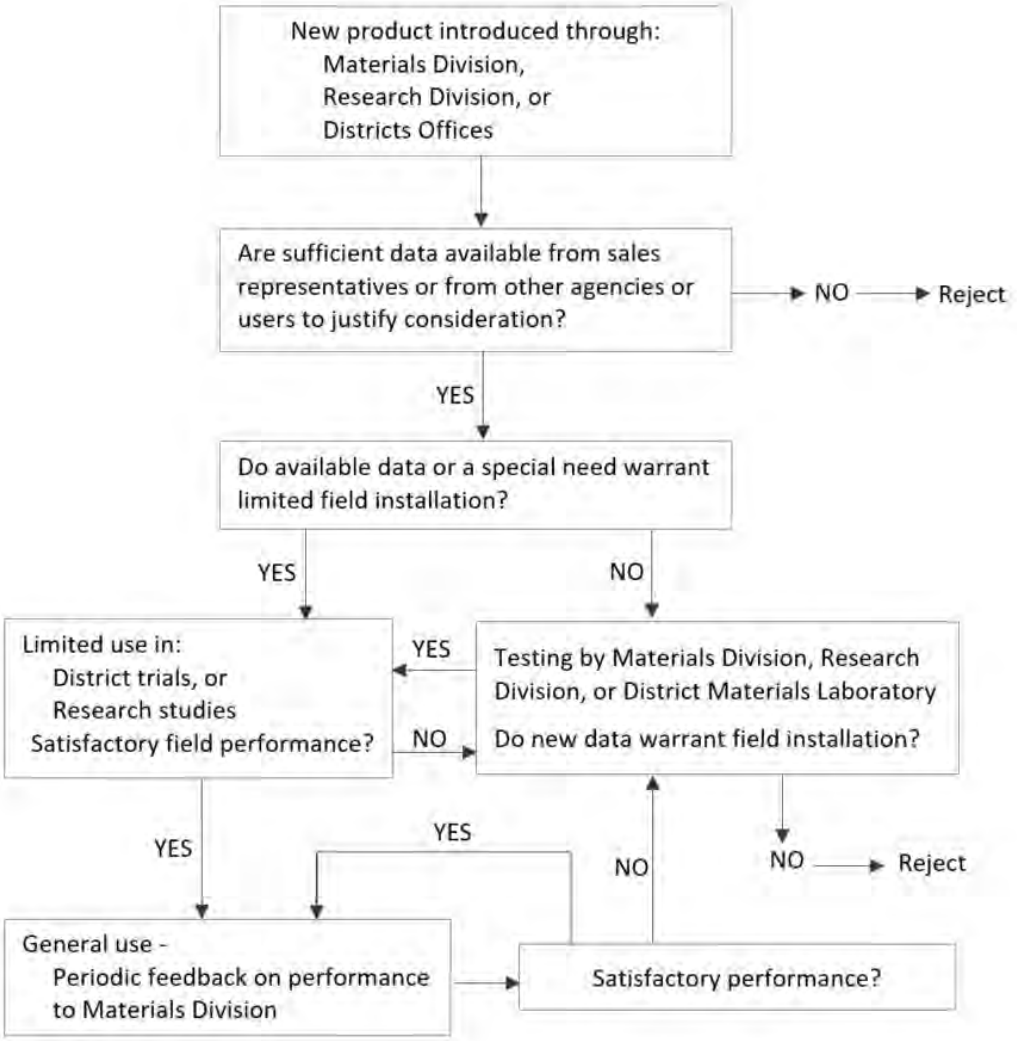

Figure 3.3 Methodology for New Product Evaluation (adapted from Tyson, 1977)

3.3 CONSTRUCTION CONSIDERATIONS

Tyson (1977) suggested that joint spall repairs be considered not later than the time when visual survey indicates 20 percent of the joints need PDRs. Best practices for constructing PDRs have been documented in various manuals (e.g., Patel et al., 1993; Wilson et al., 1999a; Frentress and Harrington, 2012; ACPA, 2004; ACPA, 2006). The performance of proprietary repair materials depends heavily on construction procedures, hence the manufacturer's instructions must be consulted to ensure proper installation. The construction of PDRs consists primarily of the following activities.

3.3.1 Repair Area Demarcation

It is widely recognized that a zone of unsound concrete, with no visual indication of distress, exists around the limits of visibly deteriorated areas. Numerous studies (e.g., Whiting et al., 1993; Chen et al., 2006) have highlighted the importance of including this zone in the repair boundaries. Tapping the pavement slabs with a steel rod or ball peen hammer, as well as dragging a metal chain, and listening to the nature of the resulting sound (a clear ringing sound indicates sound concrete; a dull sound indicates weak concrete) is a popular technique for determining the existence and extent of unsound concrete near spalls and joints that should be removed. Commercial sounding devices may also be used.

Repair limits should extend two to six inches beyond the identifiable unsound areas suggested by the sounding test to ensure all delaminated concrete is removed (Patel et al., 1993; Whiting et al., 1993; Frentress and Harrington, 2012). Square or rectangular repair boundaries with vertical faces improve the aesthetics of patched areas and minimize cracking associated with thin edges (ACPA, 1989; Chen et al., 2006). While it is generally recommended that patches should be at least two inches deep for stability reasons, recommended minimum length and width vary from 10 to 15 inches and from 4 to 10 inches, respectively (Patel et al., 1993; Frentress and Harrington, 2012). Deteriorated areas less than a foot apart are best repaired as one patch area and, where several small spalls are present at a joint, it is proper to patch the entire joint length (Patel et al., 1993). Some proprietary material manufacturers recommend suitable patch dimensions.

3.3.2 Deteriorated Concrete Removal

Methods for removing deteriorated concrete include saw-and-chip (saw-and-patch), cold-milling, chipping (chip-and-patch), clean-and-patch, sandblasting, airblasting and waterblasting. Each method has its benefits and drawbacks, which will not be fully discussed here. The Strategic Highway Research Program (SHRP)/Federal Highway Administration (FHWA) study (Wilson et al., 1999b), which explored cost-effective materials and procedures for constructing PDRs, found the chip-and-patch method to be more cost-effective. Also, a Texas study (Chen et al., 2006) noted that either the chip-and-patch or saw-and-patch could provide satisfactory results, if the repair boundaries were properly identified.

Cold-milling yields tapered edges, which may be considered as a drawback. Although tapered edges are prone to cracking, those produced by cold-milling have performed satisfactorily (ACPA, 1989). The clean-and-patch is mostly used for emergency repairs under adverse conditions, while sandblasting and airblasting are effective for cleaning repair areas after concrete removal, in order to get rid of loose particles and contaminants (Wilson et al., 1999a). Equipment availability, contractor expertise, allowable lane closure time, environmental conditions and project specifications dictate the selection of concrete removal methods. Regardless of the selected method, it must ensure:

- Complete and uniform removal of deteriorated concrete to correct dimensions
- Rough surfaces that promote interlock between the repair material and the existing concrete
- Saturated surface dry and freshly exposed concrete, with no significant damage

3.3.3 Joint Bond Breaker Installation

As previously mentioned, joint bond breakers relieve compressive stresses and prevent the repair material from flowing into joints or cracks to impede slab movement. A key recommendation of the SHRP/FHWA partial depth spall repair study (Wilson et al., 1999b) was related to joint restoration. A bond breaker must span the entire vertical face of joints that is exposed during concrete removal. In a Virginia study in which over 10,000 partial depth patches were installed along mostly transverse joints on 400 miles of jointed concrete interstate pavement lanes, Tyson (1977) reported that a large number of the patch failures resulted from lack of joint bond breaker or failure to install a bond breaker to cover the full depth of the patches; the lower portions of the patches were in contact with the adjacent slabs, exposing them to destructive effects of slab movements. Figure 3.2 illustrated a recommended installation procedure for joint bond breakers.

3.3.4 Bonding Agent Application

The clean, freshly exposed concrete must be thoroughly coated with a suitable bonding agent, ensuring that excess material does not collect in pockets. Typically, a soft-brittle brush is used to apply epoxy-based bonding agents, while stiff-brittle brush works best for cement-based grouts; spraying is recommended for large repair areas (Frentress and Harrington, 2012; Wilson et al., 1999a).

It is crucial to apply a bonding agent just prior to placing the repair material; if the agent sets before the repair material is installed, it should be removed by sandblasting and reapplied (Smith et al., 2014). In a study to evaluate the effect of bonding agent application on PDR performance, Riding and DonJuan (2014) found cementitious grouts exhibited higher shear and tensile strengths if the repair material was placed before the grout had cured for more than 15 minutes; the bond strength started to decrease once curing had passed 15 minutes. Another significant finding was that adequate bond strength was obtained if the repair material was placed on a substrate concrete in saturated surface dry condition.

3.3.5 Mixing, Placement and Consolidation

Using proper mixing equipment and ensuring correct mixing proportions and duration are prerequisites for producing a good quality repair mixture. Warm water may be used for mixing if ambient air temperature is below 55^{o}F, and ice water at higher ambient temperatures (Wilson et al., 1999a). Excessive mixing of rapid-setting materials will reduce the available for installation, while adding water later could adversely affect strength (Wilson et al., 1999a).

Small drum mixers, paddle-type mixers, mortar mixers and Jiffy mixers are typically used; however, the size of a project may not warrant the use of high-volume mixing equipment (e.g., ready-mix trucks).

It is not recommended to place cementitious and most proprietary repair materials at ambient air temperatures below 40°F (Wilson et al., 1999a). For instance, the Virginia DOT prohibits placing cementitious materials when air temperature is below 40°F; the temperature of the material at the time of placement must range from 70 to 95°F, unless otherwise approved (Elfino et al., 2013). Although some polymer-based concretes may be installed in cold weather, better performance results when they are installed under favorable conditions (Wilson et al., 1999a). Also, some polymer-based concretes, such as epoxies and methyl methacrylates, should be installed in maximum lift thickness of 2 inches due to their considerable heat of hydration; the time lag between lifts is often recommended by manufacturers (Wilson et al., 1999a). To avoid segregation, aggregate-containing patch materials should be placed with a shovel, slightly overfilling the patch area to compensate for volume reduction from consolidation (Wilson et al., 1999a).

Consolidation of repair mixtures using internal vibrators, vibrating screeds or manual tools will release trapped air to produce a dense material with improved durability and bonding characteristics. Poor consolidation often creates voids at the interface of the repair material and the underlying concrete, which could cause failures in less than a year (Tyson, 1977). Tools used for consolidation must be of an appropriate size and capacity for working in the repair area. Some best consolidation practices are summarized below (Wilson et al., 1999a; Smith et al., 2014):

- Holding vibrators at 15 to 30 degrees to the vertical and moving them through the entire fresh repair material according to a well-defined pattern
- Avoiding moving the repair material with vibrators to prevent segregation
- Determining adequacy of consolidation by observing when the material no longer settles, the release of air bubbles ceases, and a smooth layer of mortar appears on the surface

3.3.6 Finishing, Curing and Sealing

Finishing operations must be properly timed to prevent the trapping of concrete bleed water. Patches should be worked from the center toward the boundaries to pinch the patch material against the existing concrete in order to promote bonding (Wilson et al., 1999a; Frentress and Harrington, 2012). Overworking the concrete surface is strongly discouraged, so that the surface does not become brittle; susceptible to abrasion, freeze-thaw damage and chemical attack (Van Dam et al., 2005). Saw overcuts at the patch corners are typically filled with grout or joint sealant to prevent the ingress of moisture (Wilson et al., 1999a). Coating the boundaries of cementitious patches with a sand-cement grout will minimize moisture intrusion, which could cause delamination if it becomes frozen (ACPA, 1989; Whiting et al., 1993; Smith et al., 2014).

Some apply a textured finish to the patches (e.g., using a broom) in order to match the texture of the existing concrete; however, this practice has little effect on the overall skid resistance of the pavement (Wilson et al., 1999a).

As noted previously, properly curing the patch material prevents rapid moisture loss, thereby minimizing the risk of shrinkage cracking and scaling, while maximizing strength gain. Late or inadequate curing must be avoided, as it can reduce the ultimate strength of PDRs by up to 40 percent (Frentress and Harrington, 2012).

The PDR construction process typically ends with joint restoration, which may be accomplished in two ways. If a scored bond breaker was installed prior to placing the repair material, the tear-off strip is removed to create a reservoir for a joint sealant (Figure 3.4). Another approach is to timely saw the full depth of the PDR plus ¼ inch, sandblast and airblast the saw cut, followed by inserting a closed-cell backer rod and applying a joint sealant (Wilson et al., 1999a; Frentress and Harrington, 2012). The SHRP manual entitled *Materials and Procedures for Repair of Joint Seals in Concrete Pavements* (Evans and Romine, 1993) provides more information on joint sealing.

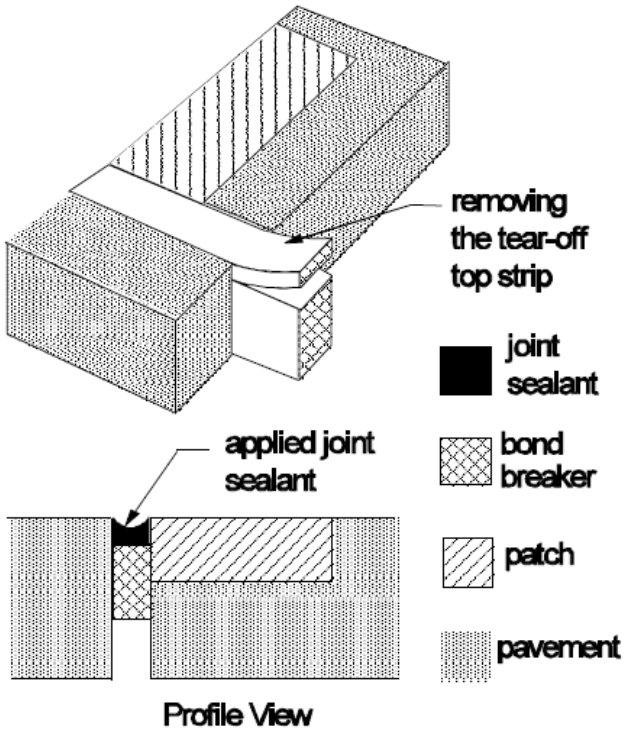

Figure 3.4 Joint Restoration Using Scored Bond Breaker (Wilson et al., 1999a)

3.4 PATCH PERFORMANCE

Wilson et al. (1999a) reviewed several documents which indicated 80 to 100 percent of well-constructed PDRs performed well after 3 to 10 years of service. Existing pavement condition, construction quality, material characteristics, traffic loading and environmental factors all influence the performance of PDRs. For instance, Parker and Shoemaker (1991) observed that PDRs constructed during warm weather (over 70°F) performed better than those constructed during cold weather. The list below shows common construction-related causes of PDR failures (Wilson et al. 1999a; Frentress and Harrington, 2012; Smith et al., 2014):

- Inappropriate use of repair techniques and materials
- Failure to remove all deteriorated material or square the patch area
- Inadequate cleaning of the patch area
- Insufficient consolidation; inadequate or improper curing
- Poor bonding between the patch material and existing concrete
- Failure to properly restore joints
- Variability in patch material quality
- Incompatibility in thermal expansion between patch material and existing concrete

In a MnROAD study (Burnham et al., 2016) conducted between 2011 and 2014 to evaluate the field performance of 22 repair materials (16 cementitious, 3 polymer-based, 3 bituminous), a total of 93 partial depth joint patches were constructed on an 18-year old pavement that had developed material-related joint distresses. Some interesting findings from the study are summarized below:

- About 59 percent of the patches were in good condition (some random cracks, limited material loss) after three years in service
- Location seemed to have had little effect on performance: 61 percent of the PDRs installed near the centerline were in good condition versus 67 percent of those in loaded areas
- Although many of the slower setting repair products exhibited a higher survivability, they were considered unsuitable for early-opening-to-traffic applications.

Similarly, the SHRP/FHWA partial-depth spall repair study (Mojab et al., 1993; Wilson et al., 1999b), which began in 1991, evaluated 11 rapid-setting cementitious, polymer-based, bituminous repair materials and five repair methods (saw-and-patch, chip-and-patch, mill-and-patch, waterblast-and-patch, and clean-and-patch). A total of 1,607 partial-depth patches were constructed on moderate- to high-volume four-lane highways located in four climatic regions: wet-freeze, wet-nonfreeze, dry-freeze and dry-nonfreeze. Field performance was monitored for 51 to 87 months, depending on the site. Major distresses observed on the cementitious and polymer-based patches included spalling, cracking, faulting and debonding (Wilson et al., 1999b). It was recommended the required service life of PDRs should influence the selection of repair materials and construction methods. Smith et al. (2014) cited several sources to develop the guidelines in Table 3.5 for addressing common PDR construction-related problems.

Table 3.5 Construction-Related Problems and Suggested Solutions (Smith et al., 2014)

Problem	Typical Causes	Typical Solutions
Deterioration found to extend beyond the original repair boundaries	• This is an unforeseen problem because the true amount of deterioration is not known until the concrete is removed	• Extend the limits of the repair area to encompass all of the deterioration • If the deterioration extends significantly deeper than one-third to one-half of the slab thickness, FDR should be placed
Repair failures associated with inadequate compression relief provision	• Compression relief is not provided • Compression relief material is not deep or wide enough to accommodate joint movement below repair • Compression relief does not extend to end of repair area	• Replace the repair, making sure to provide adequate compression relief
Dowel bar exposed during concrete removal	• Concrete deterioration extends deeper • Improper concrete removal techniques	• FDR should be used instead of the planned PDR
Reinforcing steel exposed during concrete removal	• If the steel is located in the upper third of the slab, exposing it is likely unavoidable • If steel is exposed below the upper third of the slab, either the concrete deterioration extends deeper or improper concrete removal techniques were used	• If the steel is in the upper third of the slab, the steel should be removed to the edges and the placement of the repair material should continue as planned • If the exposed steel is below the upper third of the slab, FDR should be used instead of the planned PDR
Repair material flows into joint or crack	• The joint insert is not extending far enough into the adjacent joint/ crack and below repair • There is an incorrectly selected insert size for the joint/crack width	• Either remove and replace the repair, or mark the joint for sawing as soon as it can support a saw without raveling the mix • If repair material is allowed to infiltrate a crack, it should be removed and replaced
Shrinkage cracking and surface scaling due to improper finishing and/or curing	• These issues are common when the repair material is not cured properly or adequately or if extra water is added to the surface during finishing	• Minor scaling and shrinkage cracking are typically not major issues; the repair must be monitored for additional deterioration • If excessive scaling and cracking is observed, the repair must be replaced
Repair cracking or debonding of repair material	• Joint insert is not used or used improperly • Inappropriate joint insert dimensions • Repair area was not cleaned immediately prior to grouting or concrete placement • Grout dried out before placing concrete • Curing compound is not adequate • Repair material is shrinkage susceptible • Repair material was placed under adverse environmental conditions	• If the repair fails prematurely due to one of these causes, replace the repair • It is important to determine the cause of the premature failure to avoid repetition

3.5 SUMMARY AND CONCLUSIONS

The literature review synthesized several effective practices for producing long-lasting PDRs. The review focused on the applicability and limitations of PDRs, material and construction considerations, and field performance of PDRs. Based on this review, the following summary and conclusions are presented:

- PDRs have been successfully used to treat spalling distresses within the top one-third to one-half of the slab thickness, except for those caused by dowel bar misalignment; working cracks caused by shrinkage, fatigue, or foundation movement; durability cracking; and material-related problems such as alkali-silica reactivity and alkali-carbonate reactivity.
- PDR materials may be categorized as cementitious, polymeric, or bituminous. In recent times, new repair materials have been proposed, some incorporate waste products, such as fly ash, blast furnace, slag silica fume and rice husk ash. An effective framework must exist for objectively evaluating new materials, as they become available.
- Curing, strength, shrinkage, thermal compatibility, bonding and freeze-thaw durability are some important characteristics that should be considered in the selection of repair materials.
- Minimum compressive strength requirement for opening PDRs to traffic varies. For example, the requirements of the nine DOTs cited in this review ranged from 1,527 to 3,625 psi. However, there seems to be a shift toward specifying lower opening strengths, as well as using the maturity concept to monitor in-situ strength, especially if very early opening is required.
- Bonding agents, curing compounds and joint bond breakers are accessory materials often needed for PDRs; their careful selection and application will enhance PDR performance.
- Many construction-related factors have been associated with premature PDR failures. However, research shows that well-constructed PDRs could perform well after 3 to 10 years of service. Several best practices for preparing repair areas; mixing, placing and consolidating repair materials; finishing and curing; as well as restoring joints were discussed in the literature review.

CHAPTER 4: CONSTRUCTION AND PATCH PERFORMANCE

4.1 DISTRESS DESIGN

The distress areas were created on September 27, 2017, which was a sunny day with an average temperature of about 60 degrees Fahrenheit. A rotary head milling machine was used to create the distress areas (distress). The process of milling was more aggressive than anticipated and created much larger areas – both in width and depth – than would typically receive partial depth patching. As such, some of the material providers did not have enough material on-hand to patch all the distresses in a test cell. Some of the test cells contain two different patch materials to accommodate for the lack of product. The layout of patch materials used for each distress within each test cell are described in detail in Section 4.3.

Each distress was air blasted to remove the loose rubble left after the milling process. Several distresses were then sandblasted. However, due to a restricted time window and for the sake of streamlining the installation of the patches, not all of the distresses were sandblasted. Section 4.3 details which distresses were sandblasted in the observations of each individual cell. A final cleaning with a traditional leaf blower was performed in each distress before patch material was placed.

The figure below provides the typical patching types and locations within a test cell. Note that the order of the patching types varies within each cell, but each cell contains all types. The actual order of the patching types for each test cell are shown in Section 4.3.

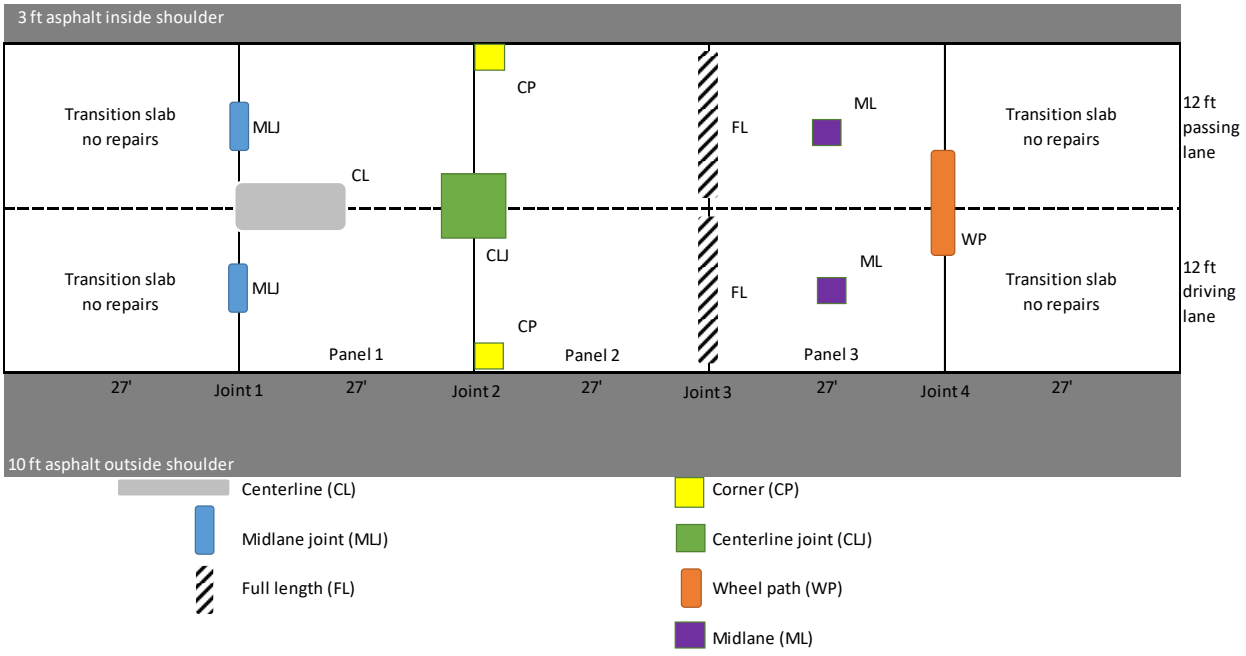

Figure 4.1 Typical Layout of Patching Types for PCC Partial-Depth Repair Study

4.2 CONDITION RATING SCALE AND SERVICE LIFE

MnDOT and Braun personnel developed a rating scale to use when reviewing the patch conditions. The rating scale is a modified version of the rating system used in the research project performed at MnROAD between 2011 and 2014 (Burnham et al., 2016). Patch conditions were reviewed during August and September each year. This scale is based on whether the original patch still exists and if so, what condition it is in. The scale ranges from 0 to 4, with 0 meaning the patch has failed and has been replaced, and 4 meaning the patch is intact and shows no signs of distress. Although the rating scale is only being used to review the cementitious and polymeric proprietary products, all of the patches were reviewed. The intention is to compare the "patch life" for typical HMA patches versus the proprietary product patches.

Note that shrinkage cracks were not considered a distress in these annual reviews. Shrinkage cracks are not identified in MnDOT's Pavement Distress Identification Manual; however, they are common in concrete pavements. Shrinkage cracks are hairline cracks at the surface that develop during the setting and curing of concrete and typically do not extend through the entire depth of the patch or slab. As such, these cracks were not considered to decrease the integrity of the patches.

Table 4.1 depicts the details of the rating scale. The ratings of the patches within each test cell are discussed in Section 4.3 and included in Appendix A with the corresponding patch photos.

Table 4.1 Patch Condition Rating Scale

Rating	Patch Condition Description
4	Excellent; 100% of patch is intact, only shrinkage cracks present
3	Good; distresses (cracking and debonding) exist, but 100% of original patch is in place
2	Fair; less than 50% of the original patch is gone/been replaced
1	Poor; over 50% of the original patch is gone/been replaced
0	Failed; original patch no longer exists

The figures below show examples of patches with each condition rating. During each annual review, the condition of each individual patch was noted. The ratings were then averaged for each different proprietary product. An average patch rating for each product year to year is included in the Product Matrix in Chapter 5.

Figure 4.2 Patch Condition Rating = 4 [No Distress]

Figure 4.4 Patch Condition Rating = 2 [Linear cracks and <50% material loss]

Figure 4.3 Patch Condition Rating = 3 [Linear cracks]

Figure 4.5 Patch Condition Rating = 1 [Linear cracks and >50% material loss]

The yearly average patch condition ratings for each proprietary product were then plotted in a graph to estimate how long each product will last. This graph is shown in Figure 4.6. Discussions between MnDOT and Braun personnel determined that a patch's service life ends when the patch condition drops below a condition rating of about 1.5 on the scale developed for this research. This 1.5 rating suggests that a patch has lost about 50 percent or more of its material, which is typically when patches get repaired or replaced. Using the existing average patch condition ratings for each product, we were able to estimate

how long it would take for each product to deteriorate to a condition rating of 1.5. The service life of each product is summarized in Section 4.3 and in the Product Matrix in Chapter 5.

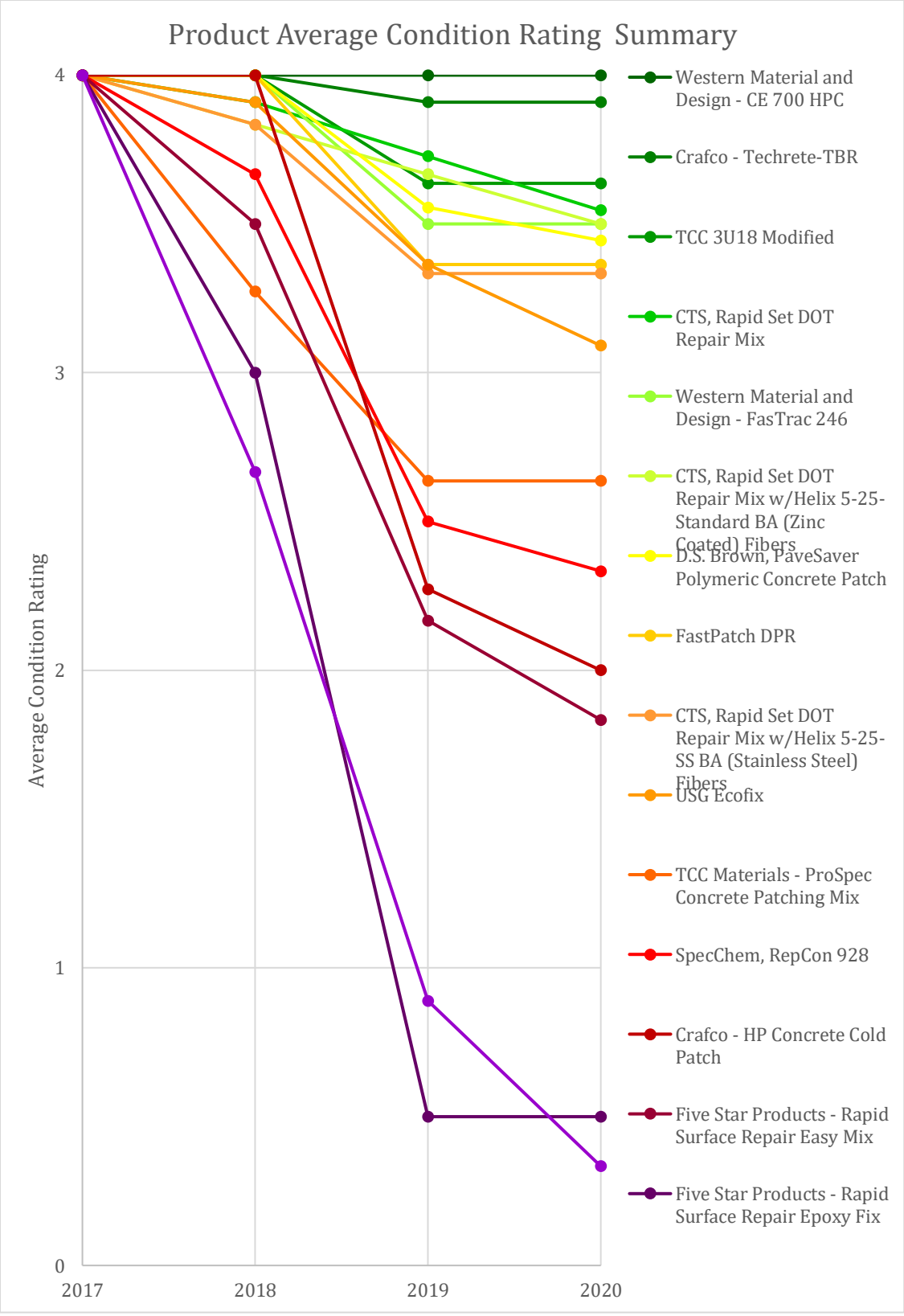

Figure 4.6 Product Average Condition Rating Summary

4.3 INSTALLATION AND PATCH PERFORMANCE DETAILS

The patches were installed on September 27, September 28, October 4, and October 11, 2017. The weather during installation was generally sunny with average temperatures between 55- and 60-degrees Fahrenheit. During the installation process, it was decided to document how the material was installed, not necessarily what the best practices are. The Material Technical Data Sheets (MTDS) were reviewed to determine any best practices for each product and to determine more detailed information on the installation techniques and preparation needed of the patch.

It was observed that the patch materials came in a variety of packaging. There may be options for bulk quantities for larger repair projects. Some were contained in bags that are not waterproof while some were contained in buckets or waterproof materials. However, it should be noted that many of the materials are available in different sizes or quantities. The MTDS were reviewed for “shelf life” and storage requirements of each material. These items may play a role in deciding the appropriateness of each material for storage at maintenance facilities.

It was also noted that some materials required a mixer other than the standard revolving drum mixer that most maintenance crews currently utilize. Several products preferred and some required a mortar or shearing mixer. A few of the products could be mixed with a simple drill mixer with a paddle attachment. The mixing procedures are detailed in the sections below. The MTDS were also reviewed for any Standard Operating Procedures (SOP) for mixing each product as some suppliers were involved in mixing the product.

The curing time also varied amongst products. The MTDS provide generalized timeframe at varying temperatures along with the curing procedures for each material. The re-establishment of the joint was a large topic of discussion during the installation. Some suppliers utilized foam board or cardboard or a combination thereof. Some suppliers requested that their patches be sawed. It was observed during the installation that the foam board or cardboard was difficult to use, as it would routinely float in the material and needed to be weighted down. The sawing time to establish joints in the patches for some of the materials may have been too long to minimize the potential for cracking.

Figures 4.7 through 4.27 detail the patches and products placed in each cell. Below each layout figure is a discussion about the installation process of that product and the condition ratings of the patch materials throughout the research project.

4.3.1 Cell 94001 – CTS, Rapid Set DOT Repair Mix

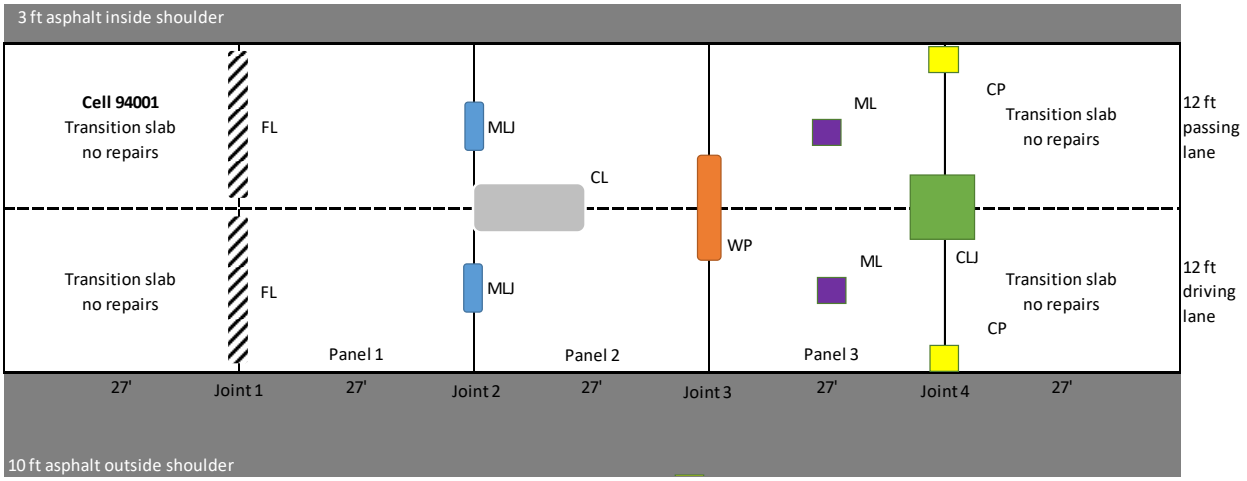

Figure 4.7 Patch Layout for Cell 94001 – CTS, Rapid Set DOT Repair Mix

The driving and passing lane were both sandblasted for this cell. Rapid Set DOT repair mix is a bagged product, 55 pounds. Approximately one 5-gallon bucket of 3/8-inch granite chips was added for each bag of mix added to the mixer, along with approximately 5 quarts of water per bag. The mixture was mixed for 3 minutes in a revolving drum mixer to provide the consistency desired. The mixture was then placed into a wheelbarrow and transported to the patches. The passing lane FL joint was mixed in a wheelbarrow and had a higher water-to-cementitious ratio than the other patches. The material was finished with traditional concrete tools. The patches were pre-wetted before placing material. Foam board was used to re-establish joints and patches were cured with plastic sheeting. The time to install the patch material will depend on the size of the distress area, number of batches required, number of crew members, and other such factors; however, installation of a single batch would generally take about 30 minutes to install. The curing time for this material is approximately 1 hour.

Over the last three years, the patches have developed shrinkage cracks and some minor linear cracks and material loss. The linear cracks and material loss developed at the CLJ and WP locations. The average patch rating for Cell 94001 during each annual review are listed below.

- First Year Review – 3.9
- Second Year Review – 3.7
- Third Year Review – 3.5

The patches are generally in good to excellent condition. The estimated patch life for this product is over five years.

This product was also used in the research project performed at MnROAD between 2011 and 2014 (Burnham et al., 2016).

4.3.2 Cell 94002 – SpecChem, RepCon 928 and Hot Mix Asphalt

4.3.2.1 94002 (A) – SpecChem, RepCon 928

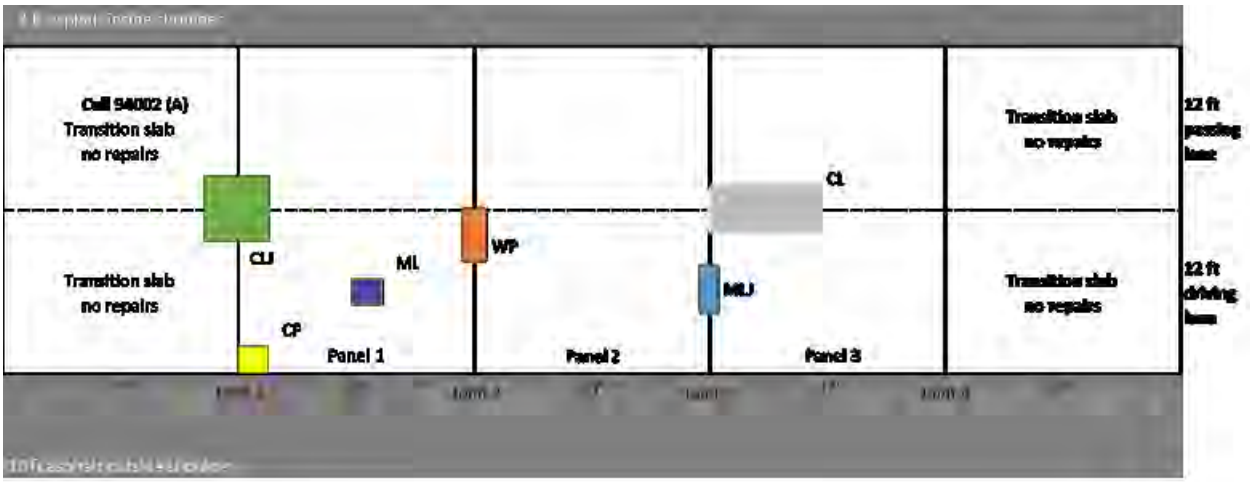

Figure 4.8 Patch Layout for Cell 94002 (A) – SpecChem, RepCon 928

The driving and passing lane were both sandblasted for this cell. RepCon 928 is a bagged product, 50 pounds. Approximately 2.5 quarts of water per bag were added in the mixer and mixed for 3 minutes in a revolving drum mixer. The mixture was then placed into a wheelbarrow and transported to the patches. The material was finished with traditional concrete tools. The patches were pre-wetted before placing material. Foam board was used to re-establish some joints while others were sawed, and patches were cured with plastic sheeting. Some cracking was noted in some patches the next day. The time to install the patch material will depend on the size of the distress area, number of batches required, number of crew members, and other such factors; however, installation of a single batch would generally take about 30 minutes to install. The curing time for this material is approximately 3 hours.

Over the last three years, the patches have developed linear cracks and some material loss. All of the distress locations developed linear cracks. Material loss was noted at the CL, CLJ, and WP locations. The average patch rating for Cell 94002(A) during each annual review are listed below.

- First Year Review – 3.7
- Second Year Review – 2.5
- Third Year Review – 2.3

The patches are generally in fair to good condition. The estimated patch life for this product is about 3.8 years.

4.3.2.2 94002 (B) – Hot Mix Asphalt

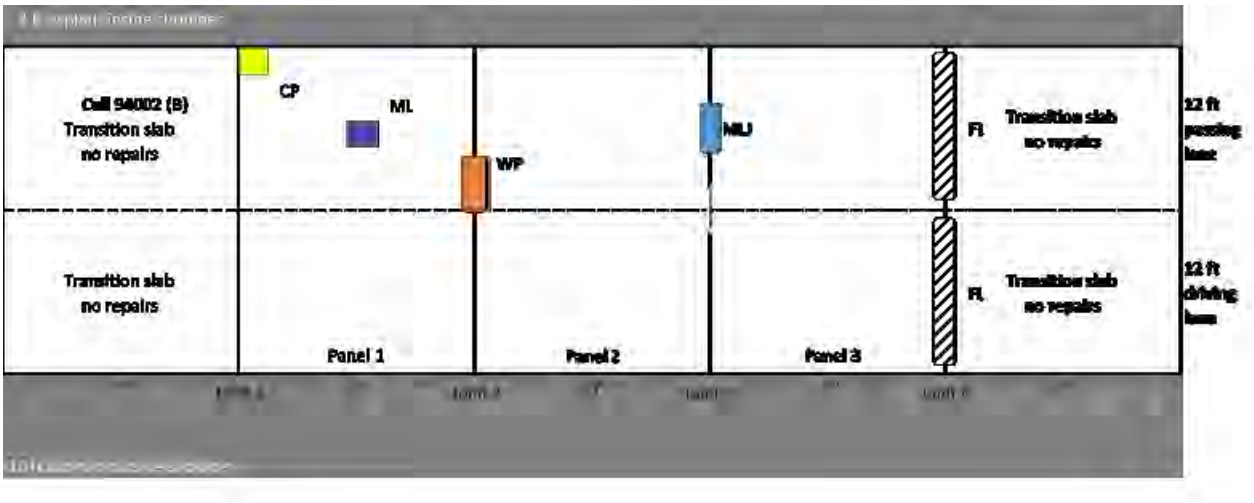

Figure 4.9 Patch Layout for Cell 94002 (B) – Hot Mix Asphalt

The passing lane CP, ML, WP, and MLJ and both FL patches were completed with HMA due to the amount of product required for the patches. The HMA material was installed similarly to the procedure described for Cells 94014 and 94015, which were all HMA material.

The HMA patches in Cell 94002 (B) have developed cracking and material loss. Most of the patches have required repairs. The HMA patches were not rated for condition during this research.

4.3.3 Cell 94003 – Western Material and Design (2 products)

4.3.3.1 94003 (A) FasTrac 246

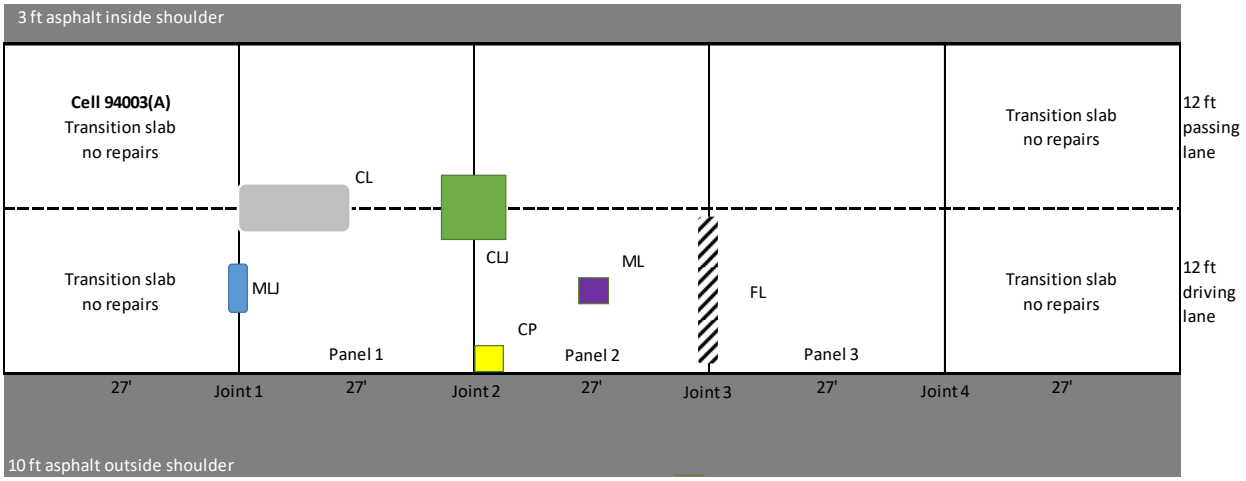

Figure 4.10 Patch Layout for Cell 94003 (A) – Western Material and Design, FasTrac 246

The driving lane and passing lane were both sandblasted. FasTrac 246 is a bagged product, 60 pounds. Approximately 2 quarts of water per bag were added in the mixer. The supplier utilized their own mixer which was a "screw" type mixer. The mixer attached to the front of a skid steer and was used to mix as well as place the concrete in the patches. The material was finished with traditional concrete tools. The patches were pre-wetted before placing material. Foam board was used to re-establish some joints while others were sawed. The patches were cured with plastic sheeting. The time to install the patch material will depend on the size of the distress area, number of batches required, number of crew members, and other such factors; however, installation of a single batch would generally take about 30 minutes to install. The curing time for this material is approximately 1 1/2 to 3 hours, depending on weather conditions.

Over the last three years, the patches have developed shrinkage cracks and linear cracks. Linear cracks developed at the CL, CLJ, and FL locations. The average patch rating for Cell 94003(A) during each annual review are listed below.

- First Year Review – 4.0
- Second Year Review – 3.5
- Third Year Review – 3.5

The patches are generally in good to excellent condition. The estimated patch life for this product is over five years.

4.3.3.2 94003 (B) CE 700 HPC

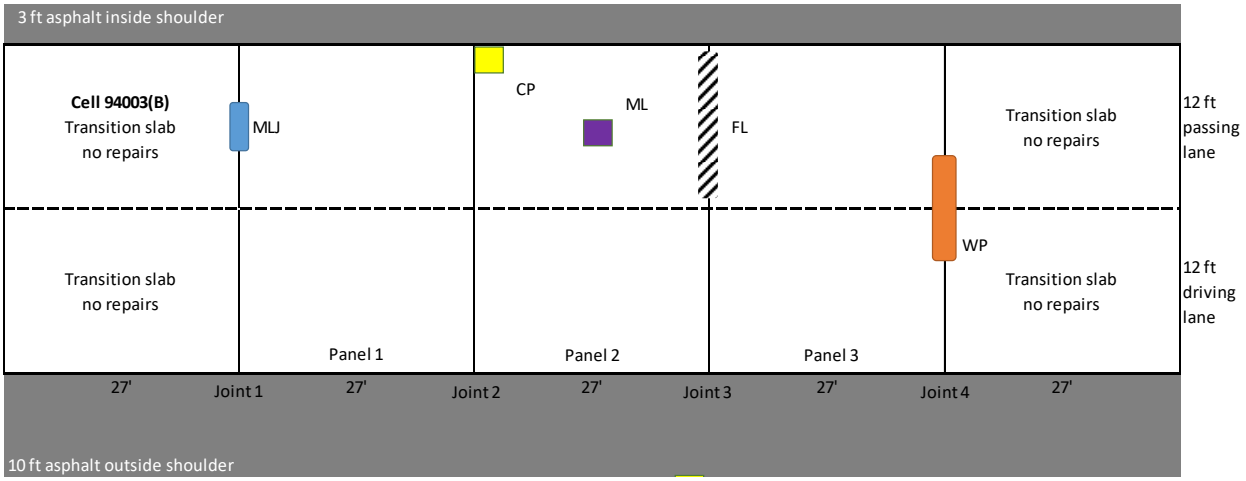

Figure 4.11 Patch Layout for Cell 94003 (B) – Western Material and Design, CE 700 HPC

The passing lane was sandblasted with the exception of the FL and WP repairs. The driving lane for the WP repair was sandblasted. CE 700 HPC is a 3-part system. Before mixing, the material was heated to approximately 70 to 80 degrees Fahrenheit. Part A (liquid polymer, 4 gallons) and Part B (liquid polymer, 4 gallons) are poured into the mixer and mixed for approximately 3 minutes. Then Part C (aggregate, 12 50-pound bags) was added. The supplier utilized their own mixer which was a "screw" type mixer. The mixer attached to the front of a skid steer and was used to mix as well as place the concrete in the patches. The material is finished with traditional concrete tools. Aggregate was broadcast onto the surface for added slip resistance. Cardboard was used to re-establish joints. The patches were not pre-wetted and were not cured. The time to install the patch material will depend on the size of the distress area, number of batches required, number of crew members, and other such factors; however, installation of a single batch would generally take about 30 minutes to install. Although this product does not require any curing methods, traffic should not be permitted onto the patch for approximately 1 1/2 to 5 hours, depending on weather conditions.

Over the last three years, the patches have not developed any distresses. The average patch rating for Cell 94003(B) during each annual review are listed below.

- First Year Review – 4.0
- Second Year Review – 4.0
- Third Year Review – 4.0

The patches are in excellent condition. The estimated patch life for this product is over five years.

4.3.4 Cell 94004 – D.S. Brown, PaveSaver Polymeric Concrete Patch and Crafco, HP Concrete Cold Patch

4.3.4.1 94004 (A) – PaveSaver Polymeric Concrete Patch

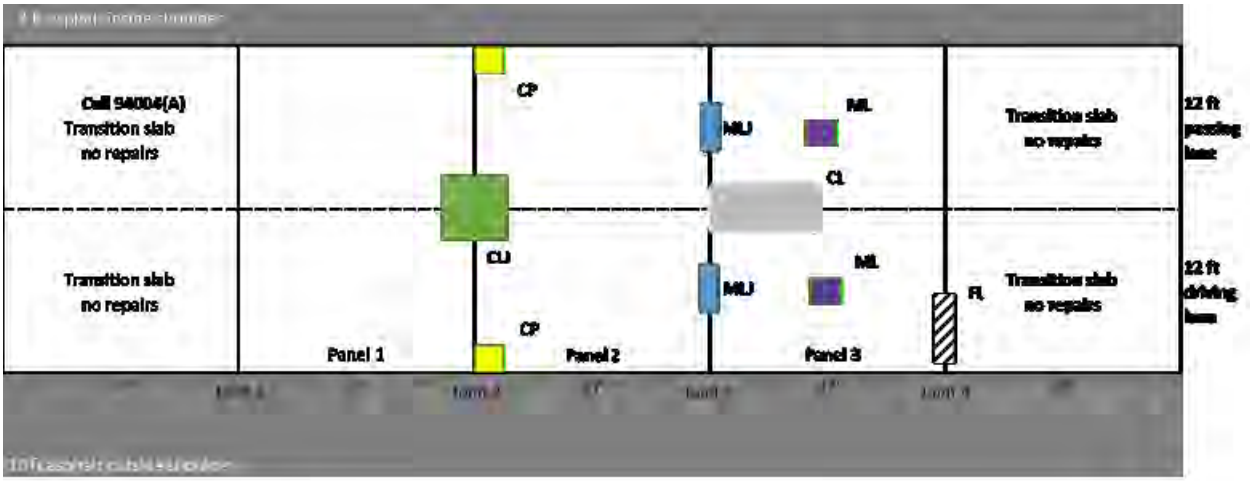

Figure 4.12 Patch Layout for Cell 94004 (A) – D.S. Brown, PaveSaver Polymeric Concrete Patch

The driving lane was sandblasted for all repairs while the passing lane was sandblasted only for the CL and ML repairs. PaveSaver Polymeric Concrete Patch is a 3-part system. Part A (1-gallon gray liquid) and Part B (1-gallon clear liquid) were poured into a 5-gallon bucket and mixed with a drill mixer with a paddle attachment for 3 minutes. The paddle mixer was placed towards the bottom of the bucket to minimize the introduction of air into the mixture. Part C (aggregate, 2 50-pound bags) was then placed into the bucket while mixing continued until the desired consistency was achieved. The material was poured from the bucket into the patch. The material was finished with traditional concrete tools. Cardboard was used to re-establish joints. The patches were not pre-wetted and were not cured. The time to install the patch material will depend on the size of the distress area, number of batches required, number of crew members, and other such factors; however, installation of a single batch would generally take less than 30 minutes to install. Although this product does not require any curing methods, traffic should not be permitted onto the patch for approximately 3 hours.

Over the last three years, the patches have developed some shrinkage cracks, linear cracks and material loss. Linear cracks developed at the CLJ, FL, Passing CP, and Passing MLJ locations. The FL location experienced some material loss. The average patch rating for Cell 94004(A) during each annual review are listed below.

- First Year Review – 4.0
- Second Year Review – 3.6
- Third Year Review – 3.4

The patches are generally in good to excellent condition. The estimated patch life for this product is over five years.

4.3.4.2 94004 (B) – Crafco, HP Concrete Cold Patch

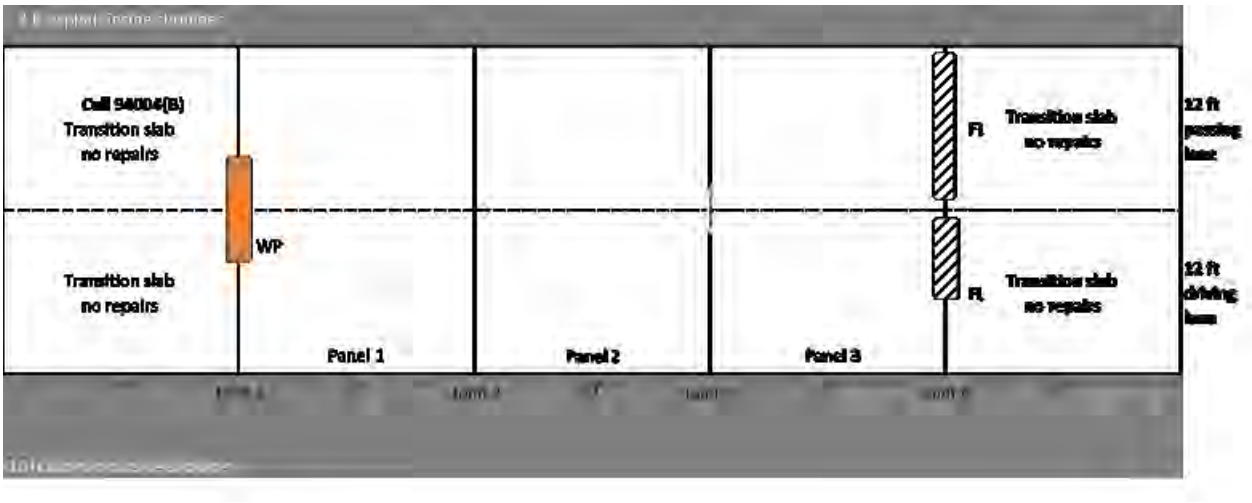

Figure 4.13 Patch Layout for Cell 94004 (B) – Crafco, HP Concrete Cold Patch

The WP, passing lane FL, and about half of the driving lane FL repairs were patched with the Crafco, HP Concrete Cold Patch, due to a lack of PaveSaver materials. The HP Concrete Cold Patch material was placed similarly to the procedure described for Cell 94009.

The patch condition summary is discussed in the Cell 94009 section of this report.

4.3.5 Cell 94005 – Willamette Valley Company, FastPatch DPR

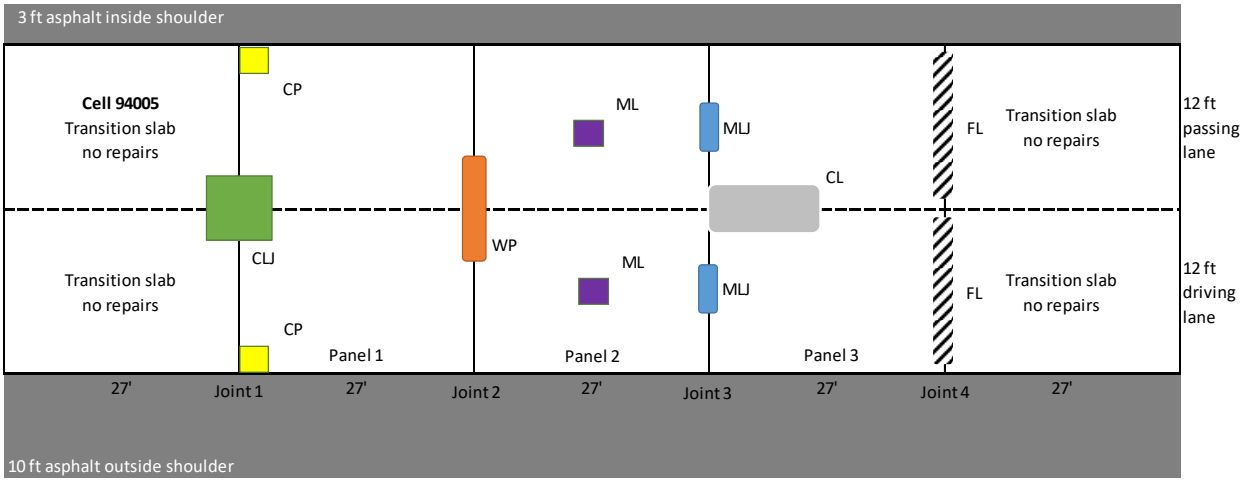

Figure 4.14 Patch layout for Cell 94005 – Willamette Valley Company, FastPatch DPR

The driving lane was sandblasted for all repairs and the passing lane was sandblasted for the CLJ and CL repairs. FastPatch is a 3-part system wholly contained in a 5-gallon bucket. Part A (11 liters) and Part B (6 liters) are packaged in separate packets inside the bucket while Part C (2.5 liters) is "loose" aggregate in the bucket. The mixing required a drill with a paddle attachment. Part A was added to Part C while mixing for 2 minutes then Part B was added while mixing for an additional 2 minutes. The material was poured from the bucket into the patch. The material is finished with traditional concrete tools. Foam board was used to re-establish the joints. Aggregate was broadcast onto the surface for added slip resistance. The patches were not pre-wetted and were not cured. The time to install the patch material will depend on the size of the distress area, number of batches required, number of crew members, and other such factors; however, installation of a single batch would generally take less than 30 minutes to install. Although this product does not require any curing methods, traffic should not be permitted onto the patch for approximately 1 hour.

Over the last three years, the patches have developed some linear cracks. Linear cracks have developed at the CL, Driving CP, both FL, both MLJ, and WP locations. The average patch rating for Cell 94005 during each annual review are listed below.

- First Year Review – 4.0
- Second Year Review – 3.4
- Third Year Review – 3.4

The patches are generally in good to excellent condition. The estimated patch life for this product is over five years.

4.3.6 Cell 94006 – Five Star Products (2 Products) h

4.3.6.1 94006 (A) Rapid Surface Repair Easy Mix

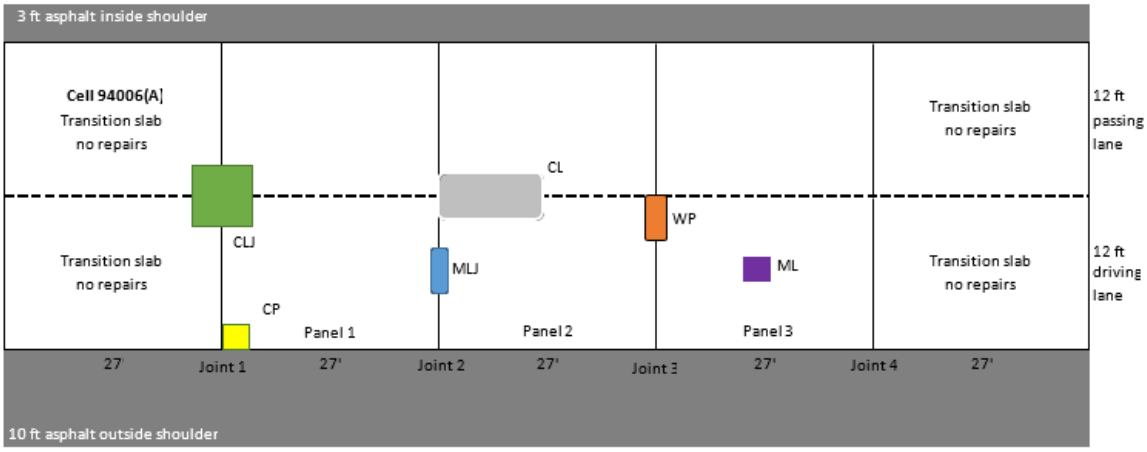

Figure 4.15 Patch Layout for Cell 94006 (A) – Five Star Products, Rapid Surface Repair Easy Mix

The driving lane was sandblasted along with the passing lane for the CL repair. Rapid Surface Repair Easy Mix is a 3-part system. Part A (1.21 liters) and Part B (1.21 liters) are poured into a 5-gallon bucket and mixed using a drill with a paddle attachment for approximately 30 seconds. Part C (50-pound aggregate bag) was added and mixed until the desired consistency was achieved. The material was poured from the bucket into the patch. The material is finished with traditional concrete tools. The patches were heated with a propane torch before placing the material. It was observed that the patches were most likely too large for this material, at least in the provided material sizes. It was difficult to place the material in more than one lift as the previous lift typically hardened before the second lift could be mixed. The time to install the patch material will depend on the size of the distress area, number of batches required, number of crew members, and other such factors; however, installation of a single batch would generally take less than 30 minutes to install. Although this product does not require any curing methods, traffic should not be permitted onto the patch for approximately 30 minutes.

Over the last three years, the patches have developed linear cracks and material loss at all of the patch locations. The average patch rating for Cell 94006(A) during each annual review are listed below.

- First Year Review – 3.5
- Second Year Review – 2.2
- Third Year Review – 1.8

The patches are generally in poor to fair condition. The estimated patch life for this product is about 3.4 years.

4.3.6.2 94006 (B) Rapid Surface Repair Epoxy Fix*

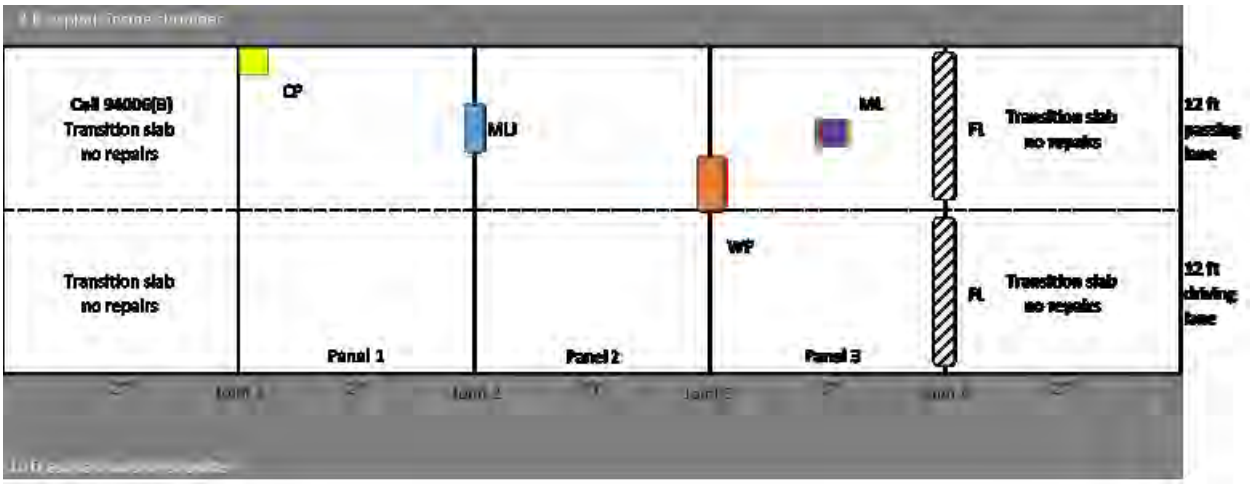

Figure 4.16 Patch Layout for Cell 94006 (B) – Five Star Products, Rapid Surface Repair Epoxy Mix

The passing lane was not sandblasted for these repairs. Rapid Surface Repair Epoxy Mix is a 3-part system. The 3/8-inch granite chips were placed into the patch. The supplier provided a dispensing system contained in a cargo van. The system mixed Part A and Part B together and dispensed the mixed product onto the granite chips. The mixture filled in the voids in the aggregate to fill the patch. The patches were heated with a propane torch before placing the material. Foam board was used to re-establish joints. Aggregate was broadcast onto the surface for added slip resistance. The patches were not cured. The time to install the patch material will depend on the size of the distress area, number of batches required, number of crew members, and other such factors; however, installation of a single batch would generally take about 30 minutes to install. Although this product does not require any curing methods, traffic should not be permitted onto the patch for approximately 40 minutes.

Over the last three years, the patches have experienced significant material loss. All patches, except for the Passing CP location, have been completely replaced. The average patch rating for Cell 94006(B) during each annual review are listed below.

- First Year Review – 3.0
- Second Year Review – 0.5
- Third Year Review – 0.5

The patches are generally failed. Based on our review, the patch life for this product is less than two years.

*Note: This product is no longer in production.

4.3.7 Cell 94007 – TCC Materials, ProSpec Concrete Patching Mix

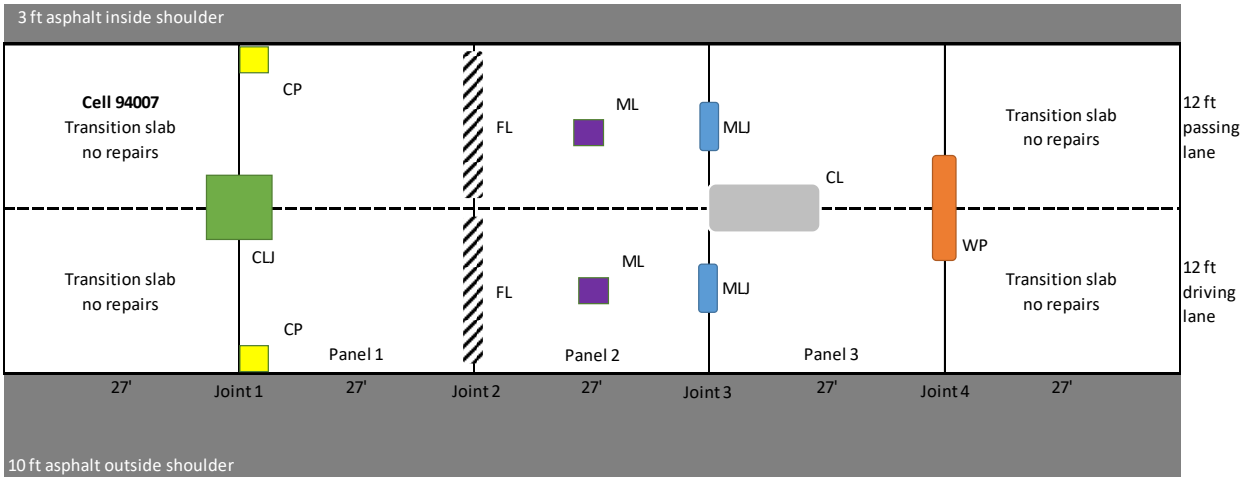

Figure 4.17 Patch Layout for Cell 94007 – TCC Materials, ProsSpec Concrete Patching Mix

The driving lane was sandblasted along with the passing lane for the CLJ and CL repairs. ProSpec Concrete Patching Mix is a bagged product, 50 pounds. Approximately 3 quarts of water was added to the mixture per bag. The mixer required for this product was a paddle or mortar mixer. A revolving drum mixer was not suitable. Mixing continued for 2 to 3 minutes until the desired consistency was obtained. The mixture was then placed into a wheelbarrow and transported to the patches. The material was finished with traditional concrete tools. Foam board was used to re-establish joints. The patches were pre-wetted before placing material and curing was completed using plastic sheets. The time to install the patch material will depend on the size of the distress area, number of batches required, number of crew members, and other such factors; however, installation of a single batch would generally take about 30 minutes to install. The curing time for this material is approximately 24 hours.

Over the last three years, the patches have developed shrinkage cracks, linear cracks, and some material loss. The Driving ML location has failed. Material loss was noted at the Passing FL, Passing MLJ, and WP locations. The average patch rating for Cell 94007 during each annual review are listed below.

- First Year Review – 3.3
- Second Year Review – 2.6
- Third Year Review – 2.6

The patches are generally in fair to good condition. The estimated patch life for this product is about 4.8 years.

4.3.8 Cell 94008 –Aqua Patch Road Materials, Aqua Patch and TCC Materials, ProSpec Concrete Patching Mix

4.3.8.1 94008 (A) – Aqua Patch Road Materials, Aqua Patch

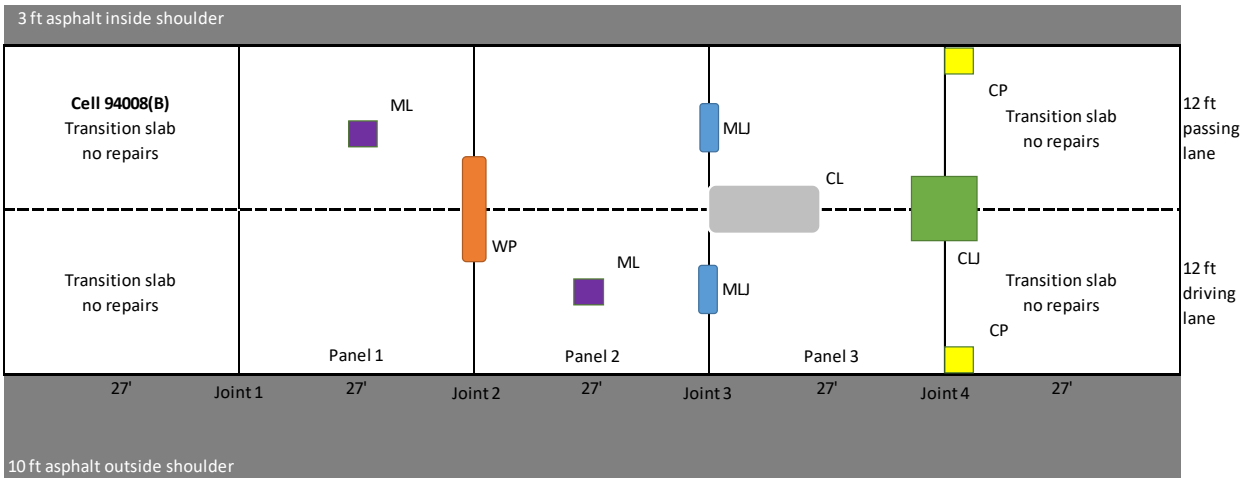

Figure 4.18 Patch Layout for Cell 94008 (A) – Aqua Patch Road Materials, Aqua Patch

The driving lane was sandblasted along with the passing lane for the CL and CLJ repairs. Aqua Patch is a bagged product, 50 pounds. There is no mixing or finishing required. The material is placed into the patch, water added, and tamped down. The time to install the patch material will depend on the size of the distress area, number of batches required, number of crew members, and other such factors; however, installation of a single batch would generally take less than 15 minutes to install. Although this product does not require any curing methods, traffic should not be permitted onto the patch for approximately 4 to 6 hours, depending on weather conditions.

Over the last three years, the patches have experienced significant material loss. Most patches have been completely replaced, except for the Driving ML and Passing CP locations, which have both experienced material loss. The average patch rating for Cell 94008(A) during each annual review are listed below.

- First Year Review – 2.7
- Second Year Review – 0.9
- Third Year Review – 0.3

The patches are generally failed. Based on our review, the patch life for this product is less than two years.

4.3.8.2 94008 (B) – TCC Materials, ProSpec Concrete Patching Mix

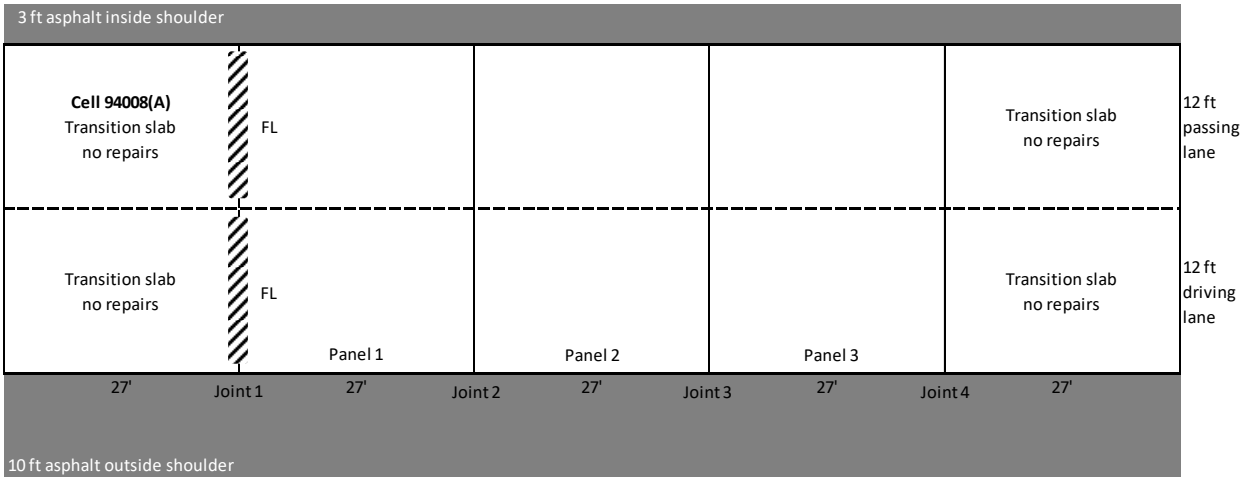

Figure 4.19 Patch Layout for Cell 94008 (B) – TCC Materials, ProSpec Concrete Patching Mix

The driving lane was sandblasted for the FL repair. The procedures for mixing and placing are the same as described for the material as used in Cell 94007.

The patch conditions for this product are summarized in the Cell 94007 section.

4.3.9 Cell 94009 – Crafco, HP Concrete Cold Patch

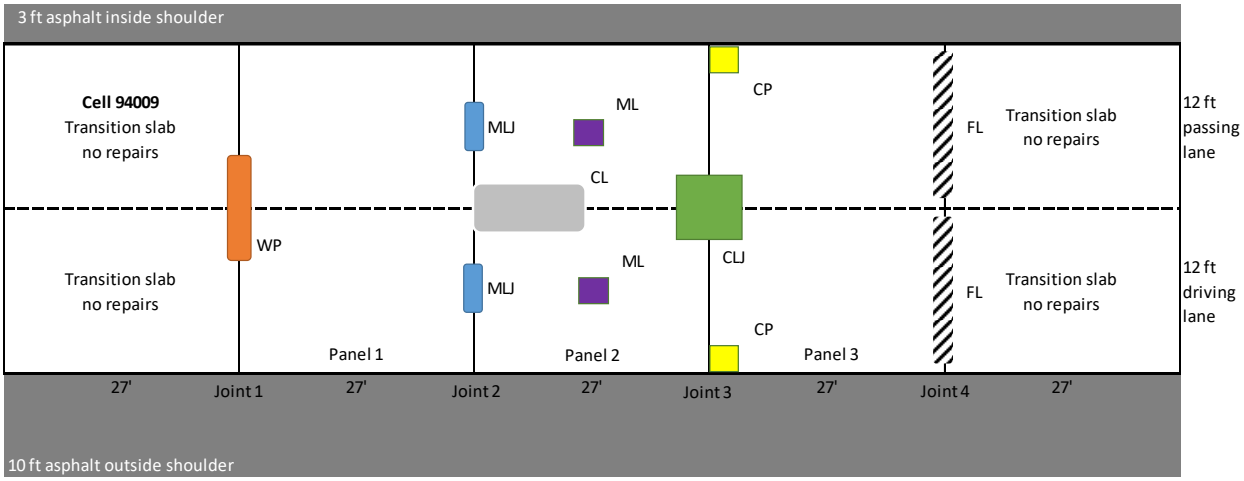

Figure 4.20 Patch Layout for Cell 94009 – Crafco, HP Concrete Cold Patch

The driving lane was sandblasted along with the passing lane for the CL and CLJ repairs. HP Concrete Cold Patch is a bagged product, 50 pounds. The material was placed in 2-inch lifts in patches where required. Each lift was compacted via a hand tamper. The final layer was placed approximately 1/2 inch above the top of the patch and hand tamped. It was noted during the annual reviews that the patches became depressed and were overlaid with HMA to re-level the surface. Depending on the depth of the patch, material may need to be placed thicker than 1/2 inch above the surface. There is no finishing of the material required. A bond breaker or Portland cement was used on the surface. The supplier then proceeded to drive back and forth over the product for final compaction. The time to install the patch material will depend on the size of the distress area, number of batches required, number of crew members, and other such factors; however, installation of a single batch would generally take less than 30 minutes to install. The patch area can be opened to traffic immediately after installation is complete.

Over the last three years, the patches have developed linear cracks. The patches have also compacted and become depressed. As such, the CL, both CP, Driving FL, both MLJ, and WP locations have been overlaid with HMA to re-level the patch to the existing surface. The average patch rating for Cell 94009 during each annual review are listed below.

- First Year Review – 4.0
- Second Year Review – 2.3
- Third Year Review – 2.0

The patches are generally in fair condition due to being overlaid. The estimated patch life for this product is about 3.2 years. However, the patches may last longer if enough material is placed in the patch to begin with.

4.3.10 Cell 94010 – Crafco, Techrete-TBR

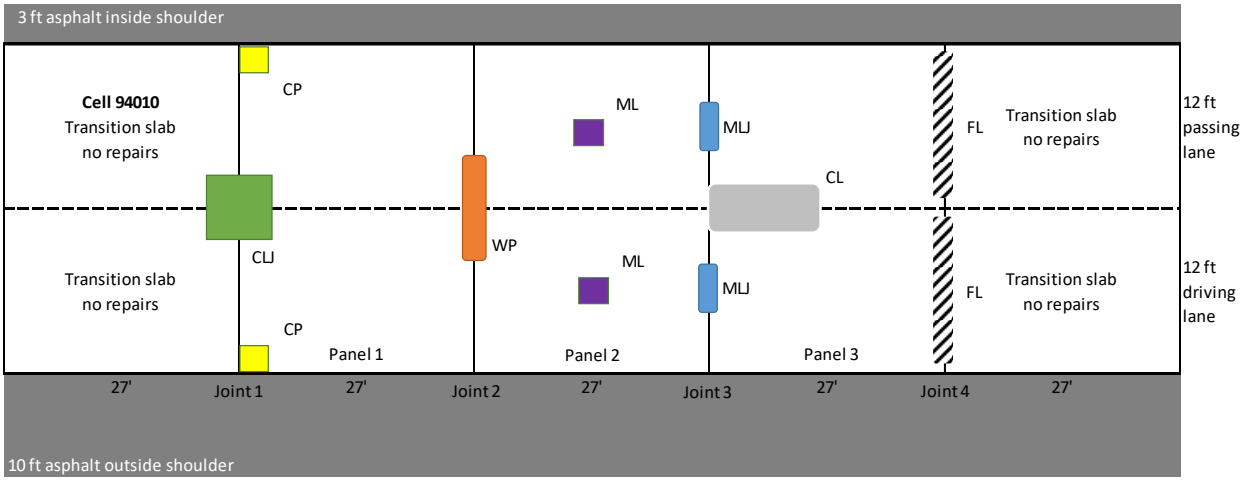

Figure 4.21 Patch Layout for Cell 94010 – Crafco, Techrete-TBR

Sandblasting was performed for all patches in the driving lane, and the passing lane CLJ. Techrete-TBR is a hot applied flexible mastic sealant. The material is in melt-able bags weighing 35 pounds, and heated and mixed in a melter to approximately 400 degrees Fahrenheit. The melter used in this application was a Crafco Patcher II. It was reported that most MnDOT districts have an approved melter that can be used for the Techrete-TBR patches. The melter is placed directly over the patch and the material moves down the shoot into the patch. Although sandblasting is not required, it is preferred. A primer is applied to each distress and dried before material is placed. There is no need to re-establish joints as the material should move with the slab. For deeper patches, material can be placed in two lifts. The first layer should "set" before the second lift is placed. The edges are finished with a heated tool, similar to a float used for traditional concrete finishing. An aggregate can be broadcast onto the surface for slip resistance although none was broadcast during the placement. The time to install the patch material will depend on the size of the distress area, number of batches required, number of crew members, and other such factors; however, installation of a single batch would generally take about 30 to 60 minutes to install. Although this product does not require any curing methods, traffic should not be permitted onto the patch until the material has cooled, approximately 1 hour, depending on weather conditions.

Over the last three years, the patches have developed some shrinkage cracks. The average patch rating for Cell 94010 during each annual review are listed below.

- First Year Review – 4.0
- Second Year Review – 3.9
- Third Year Review – 3.9

The patches are generally in good to excellent condition. The estimated patch life for this product is over five years.

4.3.11 Cell 94011 – TCC Materials, 3U18 Modified

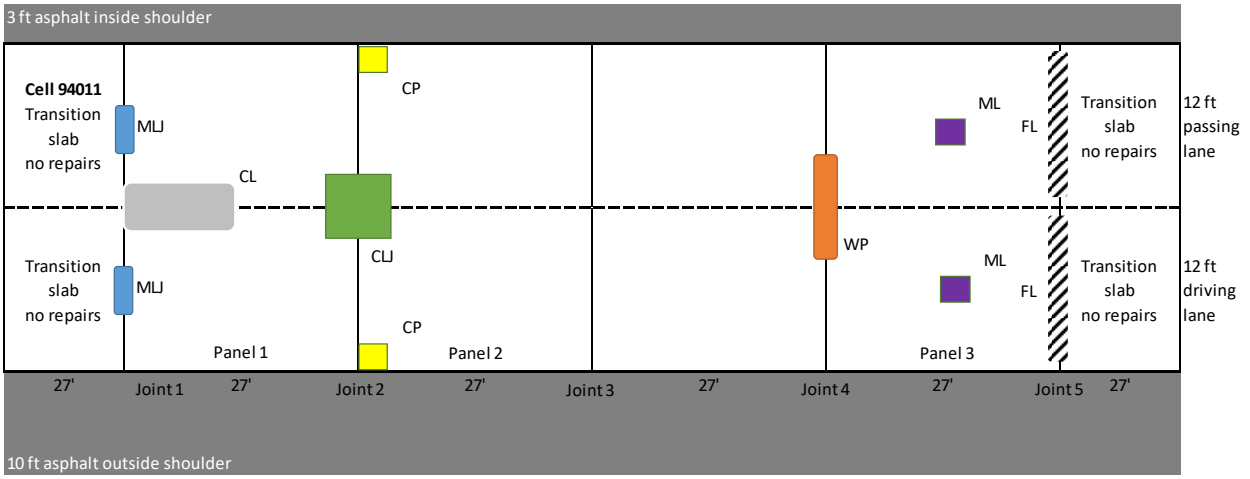

Figure 4.22 Patch Layout for Cell 94011 – TCC Materials, 3U18 Modified

The driving and passing lane were sandblasted. 3U18 Modified is a bagged product, 50-pound bags. Water was added to the product until an approximate 10-inch slump was achieved continuing the mixing for approximately 6 minutes. MnDOT also added two admixtures; one was reported to be an accelerating admixture, and the second was a water reducer. A revolving drum mixer was utilized to mix the product. The mixture was then placed into a wheelbarrow and transported to the patches. The material was finished with traditional concrete tools. The patches were saw cut to re-stablish joints. The patches were pre-wetted before placing material and curing was completed using plastic sheets. The time to install the patch material will depend on the size of the distress area, number of batches required, number of crew members, and other such factors; however, installation of a single batch would generally take about 30 minutes to install. The curing time for this material is approximately 24 hours.

Over the last three years, the patches have developed some shrinkage cracks and minor linear cracks. Linear cracks developed at the CLJ, both CP, and Driving FL locations. The average patch rating for Cell 94011 during each annual review are listed below.

- First Year Review – 4.0
- Second Year Review – 3.6
- Third Year Review – 3.6

The patches are generally in good to excellent condition. The estimated patch life for this product is over five years.

This product was also used in the research project performed at MnROAD between 2011 and 2014 (Burnham et al., 2016).

4.3.12 Cell 94012 – USG Ecofix

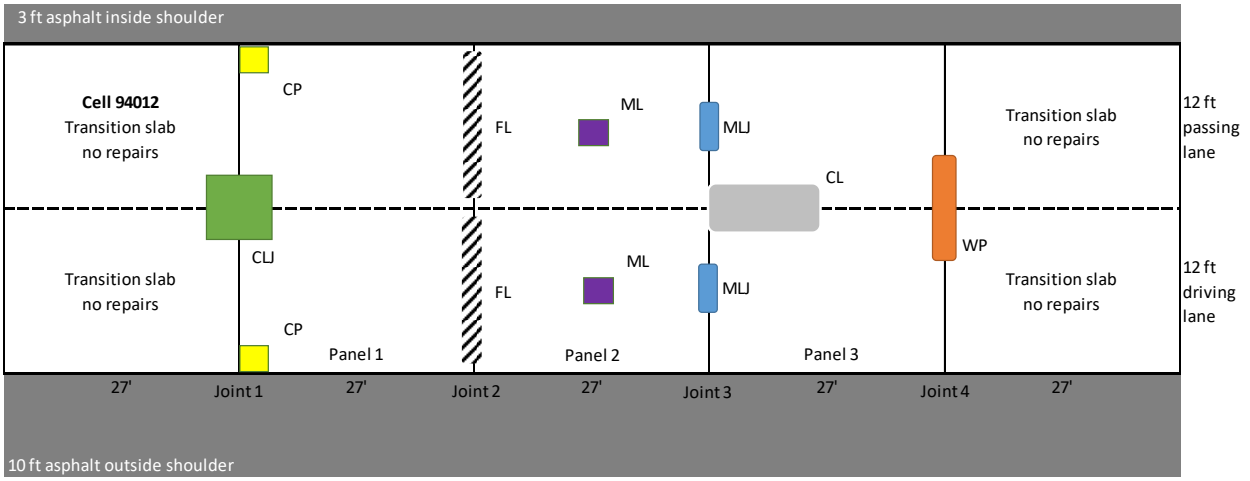

Figure 4.23 Patch Layout for Cell 94012 – USG Ecofix

The driving and passing lane were sandblasted. USG Ecofix is a bagged product, 50 pounds. Approximately 32.5 pounds of 3/8-inch granite chips and approximately 2.25 quarts of water were added per bag. The mixture was mixed in a revolving drum mixer for 2 to 3 minutes until the desired consistency was obtained. The mixture was then placed into a wheelbarrow and transported to the patches. The material was finished with traditional concrete tools. The patches were pre-wetted and saw cutting was utilized to re-establish the joints. The patches were cured with plastic sheets. The time to install the patch material will depend on the size of the distress area, number of batches required, number of crew members, and other such factors; however, installation of a single batch would generally take about 30 minutes to install. The curing time for this material is approximately 1 hour.

Over the last three years, the patches have developed shrinkage cracks and some minor linear cracks and material loss. The Passing CP location failed. The CLJ and Driving FL locations experienced material loss. The average patch rating for Cell 94012 during each annual review are listed below.

- First Year Review – 3.9
- Second Year Review – 3.4
- Third Year Review – 3.1

The patches are generally in good to excellent condition. The estimated patch life for this product is about five years.

4.3.13 Cell 94013 – CTS, Rapid Set DOT Repair Mix and Helix Steel Fibers (2 fiber products)

4.3.13.1 94013 (A) – CTS, Rapid Set DOT Repair Mix and Helix 5-25-Standard BA (Zinc Coated) Fibers

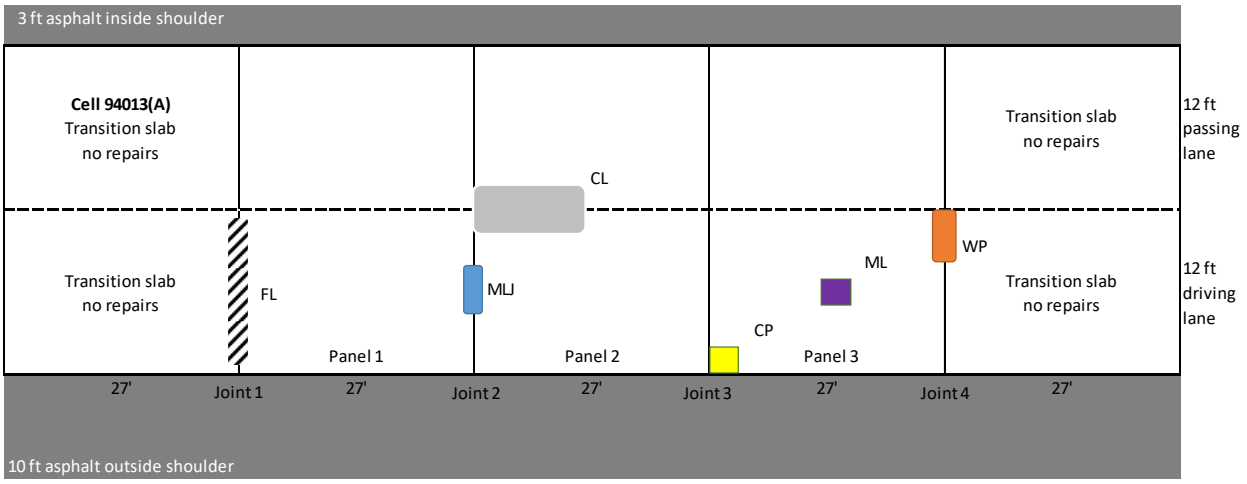

Figure 4.24 Patch Layout for Cell 94013 (A) – CTS, Rapid Set DOT Repair Mix and Helix 5-25-Standard BA (Zinc Coated) Fibers

The driving and passing lane were sandblasted. The material is a bagged product, 55 pounds, that was used in cell 94001. Approximately one 5-gallon bucket of 3/8-inch granite chips were added for each bag of material in the mixer along with approximately 5 quarts of water per bag. Helix zinc coated fibers were added to the mixture at the rate of 2 pounds per bag. The fiber was added to the granite chips and mixed before addition of the bagged product. Everything was mixed for approximately 3 minutes in a revolving drum mixer to provide the consistency desired, and then placed into a wheelbarrow and transported to the patches. The material was finished with traditional concrete tools. The distresses were pre-wetted before placing material. Foam board was used to re-establish joints and patches were cured with plastic sheeting. The time to install the patch material will depend on the size of the distress area, number of batches required, number of crew members, and other such factors; however, installation of a single batch would generally take about 30 minutes to install. The curing time for this material is approximately 1 hour.

Over the last three years, the patches have developed some minor linear cracks and material loss at the Driving MLJ and WP locations. The average patch rating for Cell 94013(A) during each annual review are listed below.

- First Year Review – 3.8
- Second Year Review – 3.7
- Third Year Review – 3.5

The patches are generally in good to excellent condition. The estimated patch life for this product is over five years.

4.3.13.2 94013(B) - CTS, Rapid Set DOT Repair Mix and Helix 5-25-SS BA (Stainless Steel) Fibers

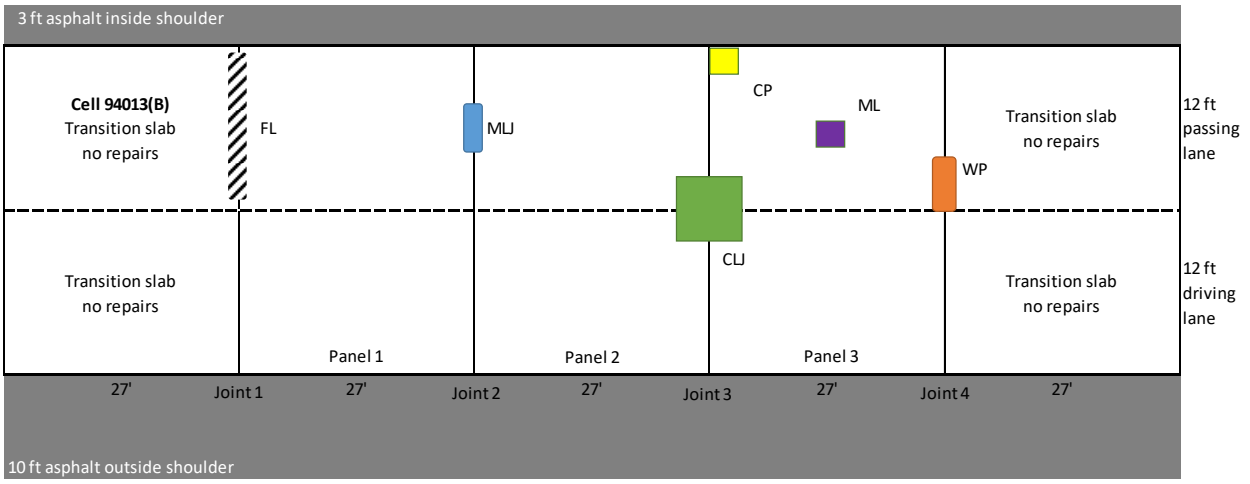

Figure 4.25 Patch Layout for Cell 94013 (B) – CTS, Rapid Set DOT Repair Mix and Helix 5-25-SS BA (Stainless Steel) Fibers

The driving and passing lane were sandblasted. The mixing procedures were the same as for Cell 94013 (A) with the difference being the utilization of stainless-steel fibers instead of zinc coated.

Over the last three years, the patches have developed linear cracks at the CLJ, CP, FL, and MLJ locations. The average patch rating for Cell 94013(B) during each annual review are listed below.

- First Year Review – 3.8
- Second Year Review – 3.3
- Third Year Review – 3.3

The patches are generally in good to excellent condition. The estimated patch life for this product is over five years.

4.3.14 Cell 94014 and 94015 – Hot Mix Asphalt

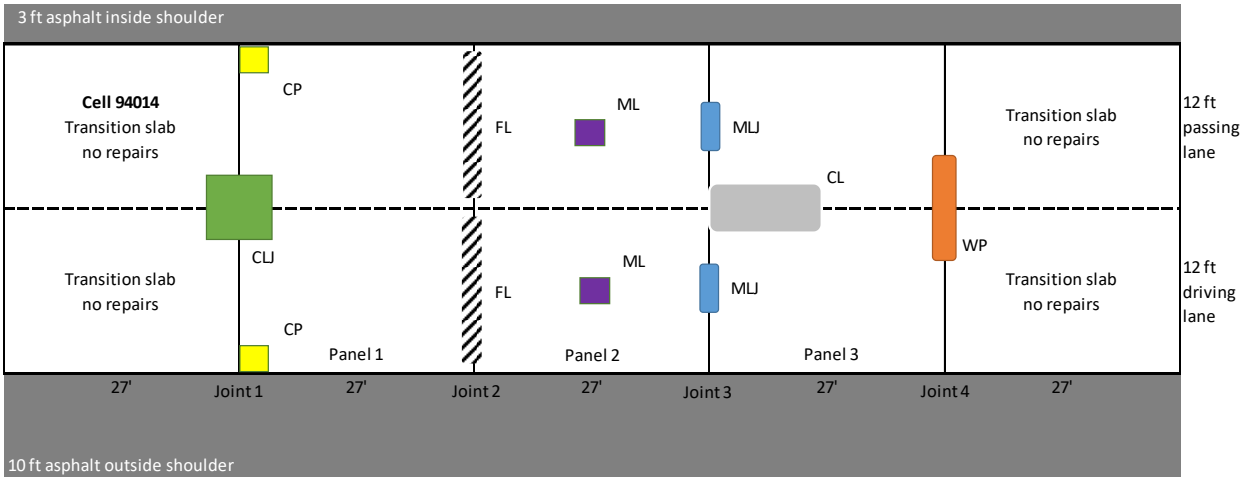

Figure 4.26 Patch Layout for Cell 94014 – Hot Mix Asphalt

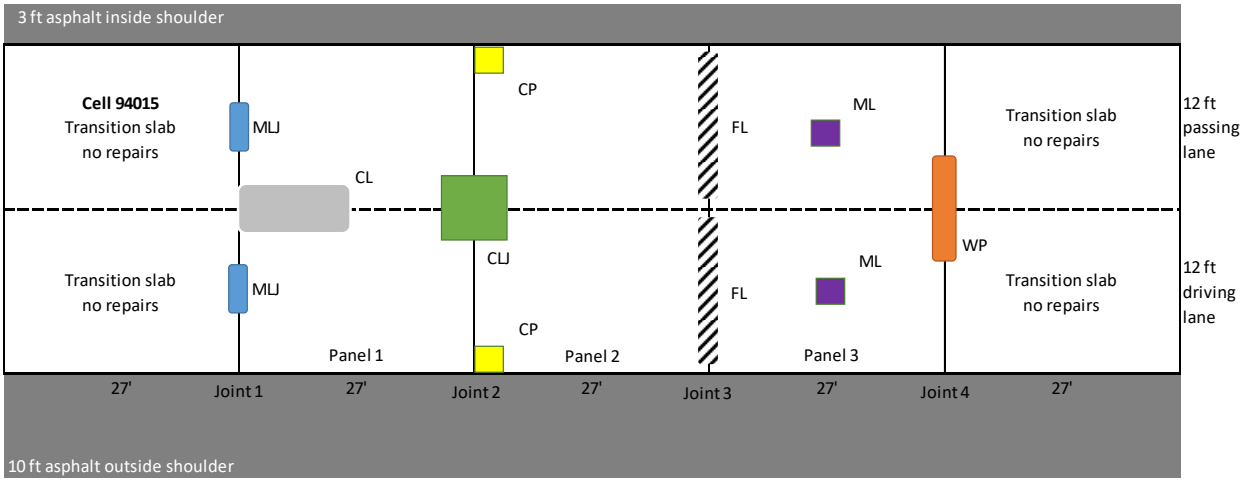

Figure 4.27 Patch Layout for Cell 94015 – Hot Mix Asphalt

The Hot Mix Asphalt was provided by District 3 and installed by MnROAD personnel. All patches were tack coated prior to mix placement. Compaction was achieved utilizing a small drum roller. The time to install the patch material will depend on the size of the distress area, number of batches required, number of crew members, and other such factors; however, installation of a single batch would generally take less than 30 minutes to install. Traffic can be permitted on the patch area immediately after installation is complete.

The HMA patches in Cells 94014 and 94015 have developed cracking and material loss. Most of the patches have required repairs. The HMA patches were not rated for condition during this research.

CHAPTER 5: SUMMARY AND CONCLUSION

This research project was performed to provide a guide for NRRA members and other agencies to establish an effective partial depth repair program for concrete pavements. The research focused on the findings from previous similar research studies, constructing and monitoring the performance of patches comprised of various products, and providing a guide that summarizes each product, including installation requirements, and equipment needed, along with the life expectancy of the partial depth repairs. The following summary and conclusions were made from this research project.

5.1 PATCH PREPARATION

Section 3.3.2 discusses the importance of removing deteriorated concrete and debris from the distress areas and properly cleaning the area before installing the patch material. For this research project, after the distresses were manually created, each distress was cleaned using the "airblasting" method with a traditional leaf blower immediately before the patch material was installed. Some distresses were also cleaned using the "sandblasting" method after the distresses were created. However, due to time constraints, not all of the distress areas were cleaned using both methods.

It was noted during the annual condition reviews that the patches were performing better at the locations where sandblasting was used. Sandblasting the distress areas likely removed more loose material and debris than the traditional leaf blower. As such, the patch material had a stronger bond to the pavement. The average condition ratings for the patches that were sandblasted were consistently higher than patches that were not sandblasted. Table 5.1 shows a comparison of the condition ratings over the last three years.

Table 5.1 Comparison of Patch Preparation Conditions

Annual Review Year	Sandblasted Average Condition Rating	Not Sandblasted Average Condition Rating
2018 (First Year)	3.8	3.6
2019 (Second Year)	3.2	2.4
2020 (Third Year)	3.0	2.3

Based on these results, proper cleaning of the distress area prior to installing the patch material will increase the performance of the patch.

5.2 TRAFFIC

The patches were installed in fall 2017. Westbound I-94 traffic was placed on the partial depth patch sections beginning November 2, 2017, and remained there intermittently throughout the research project. However, traffic was not placed on the old I-94 westbound section during the winter months. As such, the patches did not endure traffic or regular snowplowing during the winter months for this research project. Snowplow blades often catch on loose pavement material, especially patches, resulting

in material loss. Table 5.2 shows the dates that old westbound I-94 was closed to traffic over the three winters this research project took place.

Table 5.2 Winter Dates Old Westbound I-94 was Closed to Traffic

Time Period	Dates Old Westbound I-94 was Closed to Traffic
First Winter	November 22, 2017, to March 11, 2018
Second Winter	December 4, 2018, to March 17, 2019
Third Winter	November 27, 2019, to February 18, 2020

An annual review of the patch conditions was performed each year for three years after installation. The first review was completed on June 20, 2018, by MnDOT and Braun personnel. It was noted that the patches were still in good condition after the winter months. The reviewers were curious how the patches would perform during the summer months when traffic is higher. As such, the patches were reviewed again on September 15, 2018. The patch conditions were noted to have deteriorated since the June 20 review. This theory was tested again during the second-year review. A review of the patch conditions was done on May 17, 2019, and again on September 27, 2019. The patches were noted to have shown more deterioration over the summer months during higher traffic than during winter months when traffic is lower. Table 5.3 summarizes the differences in average condition ratings between these reviews.

Table 5.3 Difference in Average Condition Rating Based on Time of Year

Time Period	Beginning Average Condition Rating	Ending Average Condition Rating	Difference in Average Condition Rating
First Winter (Fall 2017 to Spring 2018)	4.0	3.9	0.1
First Summer (Spring 2018 to Fall 2018)	3.9	3.7	0.2
Second Winter (Fall 2018 to Spring 2019)	3.7	3.5	0.2
Second Summer (Spring 2019 to Fall 2019)	3.5	3.0	0.5

Based on these findings, the drop in average condition rating was higher over the summer than over the winter. This suggests that traffic affects the performance of the patches more than weather and environmental effects.

Note that it is likely the patches would have deteriorated more over the winter if traffic were allowed on the roadway and snowplowing had been performed.

5.3 PATCH LOCATION

During the research project, the question arose about whether the patch location affected the patch performance. It was anticipated that patches within the wheel paths and along the transverse joints would deteriorate faster than patches located mid-panel and away from joints.

After the annual condition reviews were completed, it was noted that the mid-lane (ML) and corner patch (CP) locations generally had the highest average ratings over the three years. The average condition ratings for the ML and CP locations were consistently higher than the overall average condition ratings for this research. Conversely, the wheel path (WP) patch locations generally had the lowest average ratings over the three years. The average condition ratings were consistently lower than the overall average condition ratings for this research.

Table 5.4 Comparison of Condition Ratings Based on Patch Location

Annual Review Year	Average Overall Condition Rating	Average CP Condition Rating	Average ML Condition Rating	Average WP Condition Rating
2018 (First Year)	3.7	3.9	3.9	3.4
2019 (Second Year)	3.0	3.2	3.4	2.4
2020 (Third Year)	2.8	3.0	3.2	2.3

These findings show that the location of the patch may affect patch performance. The ML and CP patches were the smallest patches and were not within the traffic wheel path. The ML patches were also located mid-panel, not along a joint. The WP patches were within the traffic wheel path and ran along the intersection of the transverse and longitudinal joints of the panels.

5.4 LONG-LASTING PRODUCTS

Based on our annual reviews and rating scale, certain materials involved in this research would be considered “long-lasting” because they lasted three years and, as of this writing, were still performing well. An estimated service life of each product was calculated based on the annual condition ratings. A terminal serviceability for a patch was set to a rating of 1.5, which based on the rating scale, would mean that the patch had about 50 percent material loss. A patch lasting longer than three years was considered long-lasting for this research. Based on the terminal serviceability and the condition ratings from each annual review, an estimated service life was calculated for each product. While some products still did not show any deterioration during the final annual review, it was decided that the maximum expected life of any patch was about five years. As such, the maximum estimated service life for this research was five years. Table 5.5 summarizes the products that were considered “long-lasting” and their estimated service life.

Table 5.5 Summary of "Long-Lasting" Products

Product Name	Estimated Service Life (years)
Crafco, HP Concrete Cold Patch	3.2
Crafco, TechCrete-TBR	>5
CTS, Rapid Set DOT Repair Mix	>5
CTS Rapid Set DOT Repair Mix with Helix 5-25-SS BA Fibers	>5
CTS Rapid Set DOT Repair Mix with Helix 5-25-Standard BA Fibers	>5
DS Brown, PaveSaver Polymeric Concrete Patch	>5
Five Star Products, Rapid Surface Repair Easy Mix	3.4
SpecChem, RepCon 928	3.8
TCC Materials, 3U18 Modified	>5
TCC Materials, ProSpec Concrete Patching Mix	4.8
USG, Ecofix	5.0
Western Material and Design, CE 700 HPC	>5
Western Material and Design, FasTrac 246	>5
Willamette Valley Company, FastPatch DPR	>5

For this research project, 14 of the 16 products used were considered "long-lasting" patches and 9 of the 16 were estimated to last longer than 5 years.

5.5 PRODUCT MATRIX

This research is not meant to determine one "best product" but rather compares various products. Figure 5.1 is a Product Matrix that summarizes each of the products used in the research project and details pertaining to the estimated service life, installation and curing, shelf life, and packaging. Agencies should use the Product Matrix as a guide to determine which products will best suit their needs and abilities. Things to consider may include ease of installation/time to install, curing time, shelf life/storage, crew experience, and available equipment.

Product Matrix														
Product	Condition Rating After Installation**			Estimated Service Life to 1.5 Rating	Installation Process							Open to Traffic	Packaging	Shelf Life
	1 Year After	2 Years After	3 Years After		General Ease	Preparation	Mixing	Placing	Finishing	Establish Joints	Curing			
Aqua Patch Road Materials, Aqua Patch	2.7	0.9	0.3	2.7 Years	Easy	None	None	Place material in patch, add water, tamp down	None	No	None	4 to 6 hours	50lb bags	6 months
Crafco, HP Concrete Cold Patch	4	2.3	2	3.2 Years	Easy	None	None	Place material in 2-inch lifts, hand-tamp, add extra material on top and drive over for final compaction	Bond breaker or PCC	No	None	Immediate	50lb bags	1 year
Crafco, TechCrete-TBR	4	3.9	3.9	>5 Years	Requires Melter	Primer applied to patch area	Melter to heat and mix material to 400F	Pour from melter to patch area	Heated tool similar to float	No	None	1 hour	35lb melt-able bags	2 years
CTS, Rapid Set DOT Repair Mix	3.9	3.7	3.5	>5 Years	Typical	Pre-wetted patch area	Revolving drum mixer	Wheelbarrow	Traditional tools	Foam Board	Plastic sheeting	1 hour	55lb bags	1 year
CTS, Rapid Set DOT Repair Mix with Helix 5-25-SS BA Fibers	3.8	3.3	3.3	>5 Years	Typical	Pre-wetted patch area	Revolving drum mixer	Wheelbarrow	Traditional tools	Foam board	Plastic sheeting	1 hour	55lb bags	1 year
CTS, Rapid Set DOT Repair Mix with Helix 5-25-Standard BA Fibers	3.8	3.7	3.5	>5 Years	Typical	Pre-wetted patch area	Revolving drum mixer	Wheelbarrow	Traditional tools	Foam board	Plastic sheeting	1 hour	55lb bags	1 year
DS Brown, PaveSaver Polymeric Concrete Patch	4	3.6	3.4	>5 Years	Easy	None	5-gallon bucket and drill mixer with paddle attachment	5-gallon bucket	Traditional tools	Cardboard	None	3 hours	3-part system, liquid in gallons, aggregate in 50lb bags	Not Specified
Five Star Products, Rapid Surface Repair Easy Mix	3.5	2.2	1.8	3.4 Years	Easy	None	5-gallon bucket and drill mixer with paddle attachment	5-gallon bucket	Traditional tools	Foam board	None	30 minutes	3-part system, liquid in liters, aggregate in 50lb bags	1 year
Five Star Products, Rapid Surface Repair Epoxy Fix*	3	0.5	0.5	2.7 Years	Epoxy System	Heat patch area with propane torch	Dispensing system contained in a cargo van	Aggregate placed into patch area, dispensing system poured mixture over aggregate to fill voids	None	Foam board	None	40 minutes	3-part system, liquid in gallons, aggregate in 50lb bags	2 years
SpecChem, RepCon 928	3.7	2.5	2.3	3.8 Years	Typical	Pre-wetted patch area	Revolving drum mixer	Wheelbarrow	Traditional tools	Foam board or sawcut	Plastic sheeting	3 hours	50lb bags	1 year
TCC Materials, 3U18 Modified	4	3.6	3.6	>5 Years	Typical	Pre-wetted patch area	Revolving drum mixer	Wheelbarrow	Traditional tools	Sawcut	Plastic sheeting	24 hours	50lb bags	1 year
TCC Materials, ProSpec Concrete Patching Mix	3.3	2.6	2.6	4.8 Years	Typical	Pre-wetted patch area	Paddle or mortar mixer	Wheelbarrow	Traditional tools	Foam board	Plastic sheeting	24 hours	50lb bags	1 year
USG, Ecofix	3.9	3.4	3.1	5 Years	Typical	Pre-wetted patch area	Revolving drum mixer	Wheelbarrow	Traditional tools	Sawcut	Plastic sheeting	1 hour	50lb bags	1 year
Western Material and Design, CE 700 HPC	4	4	4	>5 Years	Typical	Heat material to 80F	Screw-type mixer attached to skid steer, or paddle or mortar mixer	Skid steer or wheelbarrow	Traditional tools	Cardboard	None	1.5 to 5 hours	3-part system, polymer in gallons, aggregate in 50lb bags	2 years
Western Material and Design, FasTrac 246	4	3.5	3.5	>5 Years	Typical	Pre-wetted patch area	Screw-type mixer attached to skid steer, or paddle or mortar mixer	Skid steer or wheelbarrow	Traditional tools	Foam board or sawcut	Plastic sheeting	1.5 to 3 hours	60lb bags	1 year
Willamette Valley Company, FastPatch DPR	4	3.4	3.4	>5 Years	Easy	None	5-gallon bucket and drill mixer with paddle attachment	5-gallon bucket	Traditional tools	Foam board	None	1 hour	5-gallon buckets	1 year
Hot Mix Asphalt	NA	NA	NA	About 2 Years	Typical	Tack Coat	None	Place material into patch area	Compaction with small drum roller	No	None	Immediate	NA	NA

**Product is no longer in production*
***Condition Rating Scale based on 0 to 4 scale, described in Table 4.1*

Figure 5.1 Product Matrix

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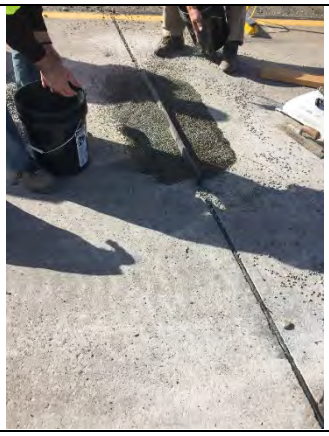
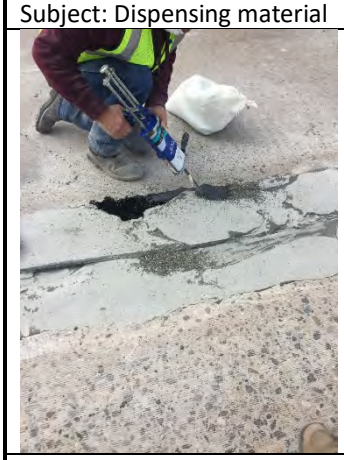
APPENDIX A1: INSTALLATION PHOTOS

	
Photograph: Milled Patch	Photograph: Air Blasting
Subject: General patch conditions after milling	Subject: Process of air blasting removing rubble
	
Photograph: Air Blaster Patch	Photograph: Sand Blasting
Subject: General patch conditions after air blasting	Subject: Process of sand blasting (performed after air blasting.
	
Photograph: Sand Blasted Patch	Cell/Product: 94001 – CTS, Rapid Set DOT Repair Mix
Subject: General patch conditions after sand blasting	Subject: Mix Consistency

	
Photograph: 94001 – CTS, Rapid Set DOT Repair Mix	Photograph: 94001 – CTS, Rapid Set DOT Repair Mix
Subject: Placing mixture	Subject: Weighing down foam board
	
Photograph: 94002 SpecChem, Repcon 928	Photograph: 94003 (A) Western Material and Design, FasTrac246
Subject: Finished Product	Subject: Mixer
	
Photograph: 94003 (A) Western Material and Design, FasTrac246	Photograph: 94003 (A) Western Material and Design, FasTrac246
Subject: Inside of Mixer	Subject: Concrete placement

	
Photograph: 94003 (B) Western Material and Design, CE700 HPC	Photograph: 94003 (B) Western and design, CE700HPC
Subject: Heating materials prior to placement	Subject: Part A and Part B Mixing
	
Photograph: 94003 (B) Western Material and Design, CE700 HPC	Photograph: 94004 D.S.Brown, PaveSaver Polymeric Concrete
Subject: Material Placement	Subject: Part A and Part B mixing
	
Cell/Product: 94004 D.S., PAveSaver Polymeric Concrete	Cell/Product: 94005 Willamette Valley Company, FastPatch
Subject: Finishing Material	Subject: Finishing Product

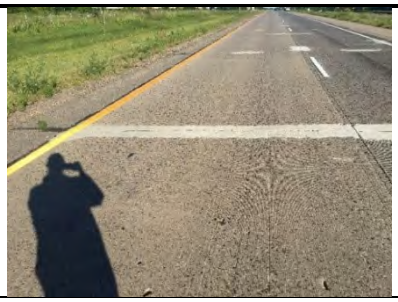
	
Photograph: 94005 Willamette Valley Company, FastPatch	Photograph: 94006(A) Five Star, Rapid Surface Repair Easy Mix
Subject: Final Product (Right Side has aggregate broad cast)	Subject: First lift had set up
	
Photograph: 94006 (B) Five Star, Rapid Surface Repair Epoxy Fix	Photograph: 94006 (B) Five Star, Rapid Surface Repair Epoxy Fix
Subject: Dispensing material	Subject: Broad Casting Aggregate onto surface
	
Photograph: 94006 (B) Five Star, Rapid Surface Repair Epoxy Fix	Photograph: 94007 TCC Materials, ProSpec Concrete Patch
Subject: Small application of previous patch	Subject: Paddle Mixer

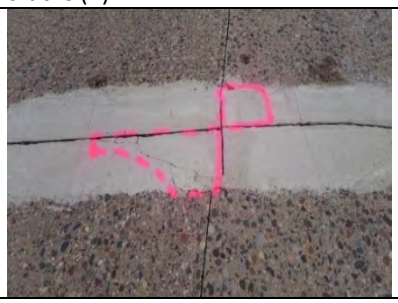
	
Photograph: 94007 TCC Materials, ProSpec Concrete Patch	Photograph: 94008 (8) Aqua Patch Road Material, Aqua Patch
Subject: Material being placed	Subject: Patch Material the day after placement
	
Photograph: 94009 Crafco HP Concrete Cold Patch	Photograph: 94009 Crafco HP Concrete Cold Patch
Subject: Spreading Material	Subject: Patch material the day after placement (noTraffic)
	
Photograph: 94010 Crafco Techcrete-TBR	Photograph: 94010 Crafco Techcrete- TBR
Subject: Crafco Patcher (Melter and Mixer)	Subject: Finishing tool heater

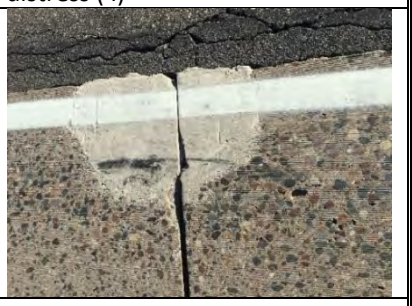
.3 	
Photograph: 94010 Crafco Techrete-TBR	Photograph: 94010 Crafco Techrete-TBR
Subject: Primed Patch	Subject: Placed Patch Material
	
Photograph: 94010 Crafco Techcrete- TBR	Photograph: 94011 3U18M
Subject: Finishing patch material	Subject: Placing and finishing material
	
Photograph: 94012 USG Ecofix	Photograph: 94013 CTS, Rapid Set and Helix Fiber
Subject: Material mixing in revolving drum	Subject: Fibers and aggregate mixing

	
Photograph: 94013 CTS, Rapid Set and Helix Fiber	Photograph: 94013 CTS, Rapid set and Helix Fiber
Subject: Mixing of bagged product, aggregate, and fibers	Subject: Finishing of products with steel fibers

APPENDIX A2: ANNUAL CONDITION PHOTOS

		
Cell/Product/Location: 94001 – CTS, Rapid Set DOT Repair Mix – Passing FL		
2018 Condition (Rating): Shrinkage cracks (4)	2019 Condition (Rating): Shrinkage cracks (4)	2020 Condition (Rating): Shrinkage cracks (4)
No photo		
Cell/Product/Location: 94001 – CTS, Rapid Set DOT Repair Mix – Driving FL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage and linear cracks (3)	2020 Condition (Rating): Shrinkage and linear cracks (3)
No photo		
Cell/Product/Location: 94001 – CTS, Rapid Set DOT Repair Mix – Passing MLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks (4)	2020 Condition (Rating): Shrinkage cracks (4)
No photo		
Cell/Product/Location: 94001 – CTS, Rapid Set DOT Repair Mix – Driving MLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks (4)	2020 Condition (Rating): Shrinkage cracks (4)

No photo		
Cell/Product/Location: 94001 – CTS, Rapid Set DOT Repair Mix – CL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks (4)	2020 Condition (Rating): Shrinkage cracks (4)
No photo		
Cell/Product/Location: 94001 – CTS, Rapid Set DOT Repair Mix – WP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage and linear cracks (3)	2020 Condition (Rating): Shrinkage and linear cracks, <50% patch gone (2)
No photo		
Cell/Product/Location: 94001 – CTS, Rapid Set DOT Repair Mix – Passing ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks (4)	2020 Condition (Rating): Shrinkage cracks (4)
No photo		
Cell/Product/Location: 94001 – CTS, Rapid Set DOT Repair Mix – Driving ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks (4)	2020 Condition (Rating): Shrinkage cracks (4)

		
Cell/Product/Location: 94001 – CTS, Rapid Set DOT Repair Mix – CLJ		
2018 Condition (Rating): Linear cracks (3)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Shrinkage and linear cracks, <50% patch gone (2)
No photo		
Cell/Product/Location: 94001 – CTS, Rapid Set DOT Repair Mix – Passing CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94001 – CTS, Rapid Set DOT Repair Mix – Driving CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks (4)	2020 Condition (Rating): Shrinkage cracks (4)
		
Cell/Product/Location: 94002(A) – SpecChem, RepCon 928 – CLJ		
2018 Condition (Rating): Linear cracks (3)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks, <50% patch gone (2)

No photo		
Cell/Product/Location: 94002(A) – SpecChem, RepCon 928 – Driving CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks (3)
No photo		
Cell/Product/Location: 94002(A) – SpecChem, RepCon 928 – Driving ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks (3)
		
Cell/Product/Location: 94002(A) – SpecChem, RepCon 928 – Driving WP		
2018 Condition (Rating): Linear cracks (3)	2019 Condition (Rating): Linear cracks, >50% patch gone (1)	2020 Condition (Rating): Linear cracks, >50% patch gone (1)
No photo		
Cell/Product/Location: 94002(A) – SpecChem, RepCon 928 – Driving MLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks (3)

No photo		
Cell/Product/Location: 94002(A) – SpecChem, RepCon 928 – CL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks, <50% patch gone (2)	2020 Condition (Rating): Linear cracks, <50% patch gone (2)
No photo		
Cell/Product/Location: 94002(B) – HMA – Passing CP		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A
No photo		
Cell/Product/Location: 94002(B) – HMA – Passing ML		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A
No photo		
Cell/Product/Location: 94002(B) – HMA – Passing WP		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A

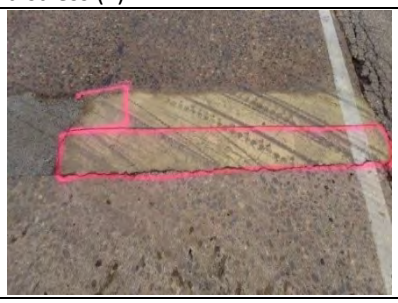
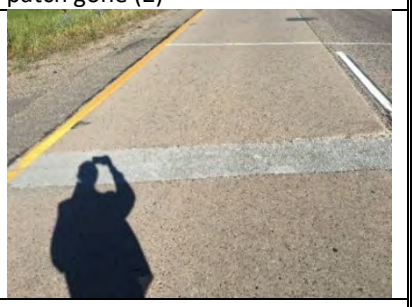
No photo		
Cell/Product/Location: 94002(B) – HMA – Passing FL		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A
No photo		
Cell/Product/Location: 94002(B) – HMA – Driving FL		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A
No photo		
Cell/Product/Location: 94003(A) – Western Material and Design, FasTrac 246 – CL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks (3)
No photo		
Cell/Product/Location: 94003(A) – Western Material and Design, FasTrac 246 – Driving MLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks (4)	2020 Condition (Rating): Shrinkage cracks (4)

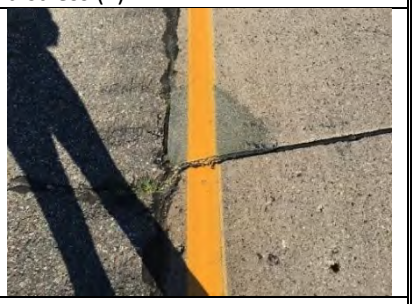
No photo		
Cell/Product/Location: 94003(A) – Western Material and Design, FasTrac 246 – CLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks, debonded (3)	2020 Condition (Rating): Shrinkage and linear cracks, debonded (3)
No photo	No photo	
Cell/Product/Location: 94003(A) – Western Material and Design, FasTrac 246 – Driving CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94003(A) – Western Material and Design, FasTrac 246 – Driving ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks (4)	2020 Condition (Rating): Shrinkage cracks (4)
No photo		
Cell/Product/Location: 94003(A) – Western Material and Design, FasTrac 246 – Driving FL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage and linear cracks (3)	2020 Condition (Rating): Shrinkage and linear cracks (3)

No photo		
Cell/Product/Location: 94003(B) - Western Material and Design, CE 700 HPC – Passing MLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo	No photo	
Cell/Product/Location: 94003(B) - Western Material and Design, CE 700 HPC – Passing CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94003(B) - Western Material and Design, CE 700 HPC – Passing ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94003(B) - Western Material and Design, CE 700 HPC – Passing FL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)

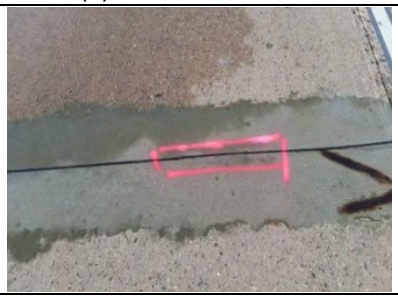
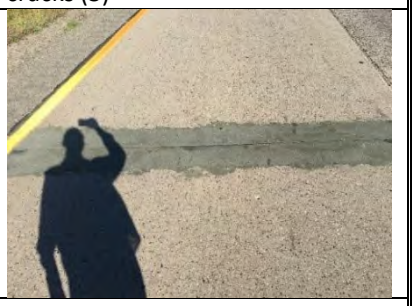
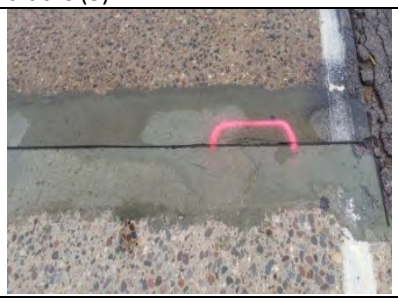
No photo		
Cell/Product/Location: 94003(B) - Western Material and Design, CE 700 HPC – WP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94004(A) – DS Brown, PaveSaver Polymeric Concrete Patch – CLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks (3)
No photo		
Cell/Product/Location: 94004(A) – DS Brown, PaveSaver Polymeric Concrete Patch – Passing CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Debonded (3)	2020 Condition (Rating): Debonded (3)
No photo		
Cell/Product/Location: 94004(A) – DS Brown, PaveSaver Polymeric Concrete Patch – Driving CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)

No photo		
Cell/Product/Location: 94004(A) – DS Brown, PaveSaver Polymeric Concrete Patch – CL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94004(A) – DS Brown, PaveSaver Polymeric Concrete Patch – Passing MLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Debonded (3)	2020 Condition (Rating): Debonded (3)
No photo		
Cell/Product/Location: 94004(A) – DS Brown, PaveSaver Polymeric Concrete Patch – Driving MLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94004(A) – DS Brown, PaveSaver Polymeric Concrete Patch – Passing ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)

No photo		
Cell/Product/Location: 94004(A) – DS Brown, PaveSaver Polymeric Concrete Patch – Driving ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94004(A) – DS Brown, PaveSaver Polymeric Concrete Patch – Half of Driving FL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks, debonded (3)	2020 Condition (Rating): Linear cracks, <50% patch gone (2)
No photo		
Cell/Product/Location: 94004(B) – Crafco, HP Concrete Cold Patch – WP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks, patch depressed (3)	2020 Condition (Rating): Linear cracks, depressed patch, <50% patch gone (2)
No photo		
Cell/Product/Location: 94004(B) – Crafco, HP Concrete Cold Patch – Passing FL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks, patch depressed (3)	2020 Condition (Rating): Linear cracks, depressed patch, <50% patch gone (2)

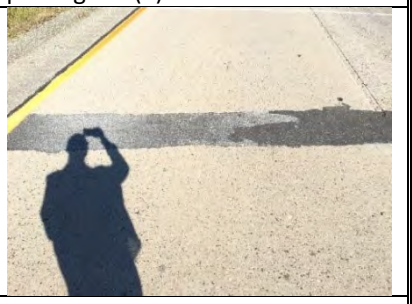
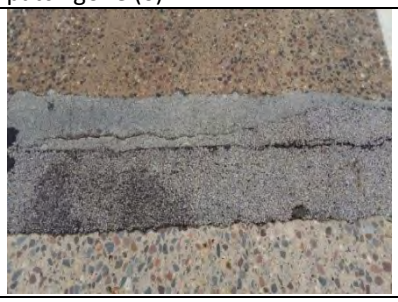
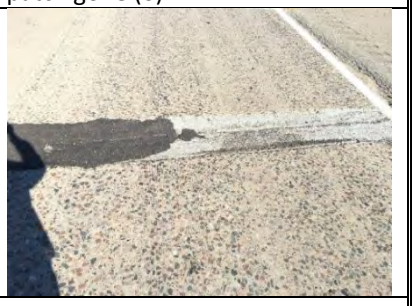
No photo	No photo	
Cell/Product/Location: 94004(B) – Crafco, HP Concrete Cold Patch – Half of Driving FL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks, patch depressed (3)	2020 Condition (Rating): Linear cracks, depressed patch, <50% patch gone (2)
No photo		
Cell/Product/Location: 94005 – Willamette Valley Company, FastPatch DPR – CLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94005 – Willamette Valley Company, FastPatch DPR – Passing CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94005 – Willamette Valley Company, FastPatch DPR – Driving CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks (3)

No photo		
Cell/Product/Location: 94005 – Willamette Valley Company, FastPatch DPR – WP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks (3)
No photo		
Cell/Product/Location: 94005 – Willamette Valley Company, FastPatch DPR – Passing ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94005 – Willamette Valley Company, FastPatch DPR – Driving ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94005 – Willamette Valley Company, FastPatch DPR – CL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Debonded (3)	2020 Condition (Rating): Debonded (3)

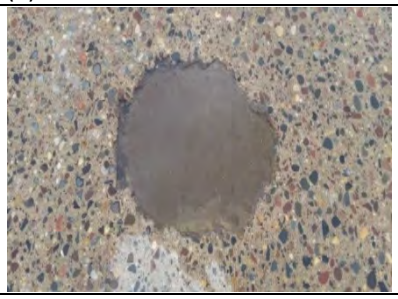
No photo		
Cell/Product/Location: 94005 – Willamette Valley Company, FastPatch DPR – Passing MLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks (3)
No photo		
Cell/Product/Location: 94005 – Willamette Valley Company, FastPatch DPR – Driving MLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks (3)
No photo		
Cell/Product/Location: 94005 – Willamette Valley Company, FastPatch DPR – Passing FL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks (3)
No photo		
Cell/Product/Location: 94005 – Willamette Valley Company, FastPatch DPR – Driving FL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks (3)

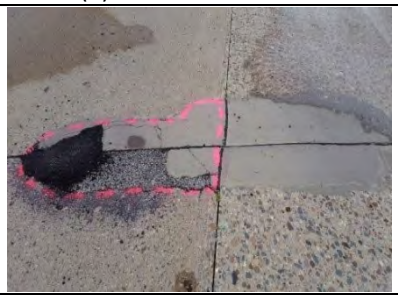
No photo		
Cell/Product/Location: 94006(A) – Five Star Products, Rapid Surface Repair Easy Mix – CLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): >50% patch gone (1)	2020 Condition (Rating): Linear cracks, >50% patch gone (1)
No photo		
Cell/Product/Location: 94006(A) – Five Star Products, Rapid Surface Repair Easy Mix – Driving CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks (3)
No photo		
Cell/Product/Location: 94006(A) – Five Star Products, Rapid Surface Repair Easy Mix – CL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks, <50% patch gone (2)
		
Cell/Product/Location: 94006(A) – Five Star Products, Rapid Surface Repair Easy Mix – Driving MLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear Cracks, <50% patch gone (2)	2020 Condition (Rating): Linear cracks, <50% patch gone (2)

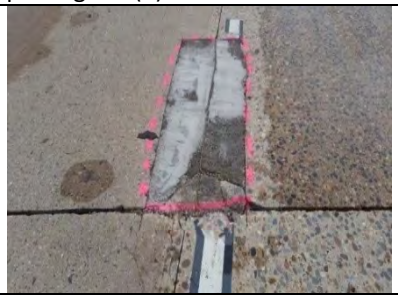
		
Cell/Product/Location: 94006(A) – Five Star Products, Rapid Surface Repair Easy Mix – Driving WP		
2018 Condition (Rating): >50% patch gone (1)	2019 Condition (Rating): >50% patch gone (1)	2020 Condition (Rating): Linear cracks, >50% patch gone (1)
No photo		
Cell/Product/Location: 94006(A) – Five Star Products, Rapid Surface Repair Easy Mix – Driving ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks, <50% patch gone (2)
No photo		
Cell/Product/Location: 94006(B) – Five Star Products, Rapid Surface Repair Epoxy Fix – Passing CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks (3)
		
Cell/Product/Location: 94006(B) – Five Star Products, Rapid Surface Repair Epoxy Fix – Passing MLJ		
2018 Condition (Rating): > 50% of patch repaired (1)	2019 Condition (Rating): 100% patch gone (0)	2020 Condition (Rating): 100% patch gone (0)

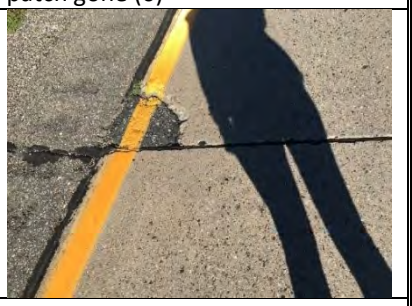
		
Cell/Product/Location: 94006(B) – Five Star Products, Rapid Surface Repair Epoxy Fix – Passing WP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): 100% patch gone (0)	2020 Condition (Rating): 100% patch gone (0)
No photo		
Cell/Product/Location: 94006(B) – Five Star Products, Rapid Surface Repair Epoxy Fix – Passing ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): 100% patch gone (0)	2020 Condition (Rating): 100% patch gone (0)
		
Cell/Product/Location: 94006(B) – Five Star Products, Rapid Surface Repair Epoxy Fix – Passing FL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): 100% patch gone (0)	2020 Condition (Rating): 100% patch gone (0)
		
Cell/Product/Location: 94006(B) – Five Star Products, Rapid Surface Repair Epoxy Fix – Driving FL		
2018 Condition (Rating): >50% patch gone (1)	2019 Condition (Rating): 100% patch gone (0)	2020 Condition (Rating): 100% patch gone (0)

		
Cell/Product/Location: 94007 – TCC Materials, ProSpec Concrete Patching Mix – CLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks, debonded (3)	2020 Condition (Rating): Shrinkage cracks, debonded (3)
No photo		
Cell/Product/Location: 94007 – TCC Materials, ProSpec Concrete Patching Mix – Passing CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks (3)
No photo		
Cell/Product/Location: 94007 – TCC Materials, ProSpec Concrete Patching Mix – Driving CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
		
Cell/Product/Location: 94007 – TCC Materials, ProSpec Concrete Patching Mix – Passing FL		
2018 Condition (Rating): <50% patch gone (2)	2019 Condition (Rating): Linear cracks, >50% patch gone (1)	2020 Condition (Rating): Linear cracks, >50% patch gone (1)

No photo		
Cell/Product/Location: 94007 – TCC Materials, ProSpec Concrete Patching Mix – Driving FL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks (4)	2020 Condition (Rating): Shrinkage cracks (4)
		
Cell/Product/Location: 94007 – TCC Materials, ProSpec Concrete Patching Mix – Passing ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Debonded (3)	2020 Condition (Rating): Debonded (3)
No photo		
Cell/Product/Location: 94007 – TCC Materials, ProSpec Concrete Patching Mix – Driving ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): 100% patch gone (0)	2020 Condition (Rating): 100% patch gone (0)
No photo		
Cell/Product/Location: 94007 – TCC Materials, ProSpec Concrete Patching Mix – CL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks (3)

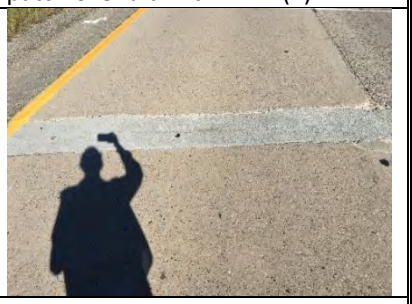
		
Cell/Product/Location: 94007 – TCC Materials, ProSpec Concrete Patching Mix – Passing MLJ		
2018 Condition (Rating): <50% patch gone (2)	2019 Condition (Rating): Linear cracks, <50% patch gone (2)	2020 Condition (Rating): Linear cracks, <50% patch gone (2)
No photo		
Cell/Product/Location: 94007 – TCC Materials, ProSpec Concrete Patching Mix – Driving MLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks (4)	2020 Condition (Rating): Shrinkage cracks (4)
		
Cell/Product/Location: 94007 – TCC Materials, ProSpec Concrete Patching Mix – WP		
2018 Condition (Rating): <50% patch gone (2)	2019 Condition (Rating): Linear cracks, <50% patch gone (2)	2020 Condition (Rating): Linear cracks, <50% patch gone (2)
		
Cell/Product/Location: 94008(A) – Aqua Patch Road Materials, Aqua Patch – Passing ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): <50% patch gone (2)	2020 Condition (Rating): 100% patch gone (0)

		
Cell/Product/Location: 94008(A) – Aqua Patch Road Materials, Aqua Patch – WP		
2018 Condition (Rating): Linear cracks, <50% patch gone (2)	2019 Condition (Rating): 100% patch gone (0)	2020 Condition (Rating): 100% patch gone (0)
No photo		
Cell/Product/Location: 94008(A) – Aqua Patch Road Materials, Aqua Patch – Driving ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): <50% patch gone (2)	2020 Condition (Rating): >50% patch gone (1)
No photo		
Cell/Product/Location: 94008(A) – Aqua Patch Road Materials, Aqua Patch – CL		
2018 Condition (Rating): Linear cracks (3)	2019 Condition (Rating): 100% patch gone (0)	2020 Condition (Rating): 100% patch gone (0)
No photo		
Cell/Product/Location: 94008(A) – Aqua Patch Road Materials, Aqua Patch – Passing MLJ		
2018 Condition (Rating): Linear cracks, <50% patch gone (2)	2019 Condition (Rating): >50% of patch gone (1)	2020 Condition (Rating): 100% patch gone (0)

		
Cell/Product/Location: 94008(A) – Aqua Patch Road Materials, Aqua Patch – Driving MLJ		
2018 Condition (Rating): Linear cracks, <50% patch gone (2)	2019 Condition (Rating): 100% patch gone (0)	2020 Condition (Rating): 100% patch gone (0)
No photo		
Cell/Product/Location: 94008(A) – Aqua Patch Road Materials, Aqua Patch – CLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): 100% patch gone (0)	2020 Condition (Rating): 100% patch gone (0)
No photo		
Cell/Product/Location: 94008(A) – Aqua Patch Road Materials, Aqua Patch – Passing CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks, <50% patch gone (2)	2020 Condition (Rating): Linear cracks, <50% patch gone (2)
		
Cell/Product/Location: 94008(A) – Aqua Patch Road Materials, Aqua Patch – Driving CP		
2018 Condition (Rating): >50% patch gone (1)	2019 Condition (Rating): >50% patch gone (1)	2020 Condition (Rating): 100% patch gone (0)

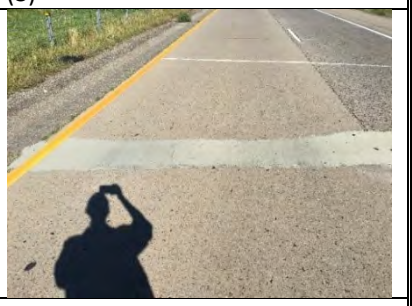
		
Cell/Product/Location: 94008(B) – TCC Materials, ProSpec Concrete Patching Mix – Passing FL		
2018 Condition (Rating): <50% patch gone (2)	2019 Condition (Rating): Linear cracks, >50% patch gone (1)	2020 Condition (Rating): >50% patch gone (1)
		
Cell/Product/Location: 94008(B) – TCC Materials, ProSpec Concrete Patching Mix – Driving FL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage and linear cracks (3)	2020 Condition (Rating): Linear cracks (3)
No photo		
Cell/Product/Location: 94009 – Crafco, HP Concrete Cold Patch – WP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): >50% patch overlaid with HMA (1)	2020 Condition (Rating): >50% patch overlaid with HMA (1)
No photo		
Cell/Product/Location: 94009 – Crafco, HP Concrete Cold Patch – CL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): >50% patch overlaid with HMA (1)	2020 Condition (Rating): >50% patch overlaid with HMA (1)

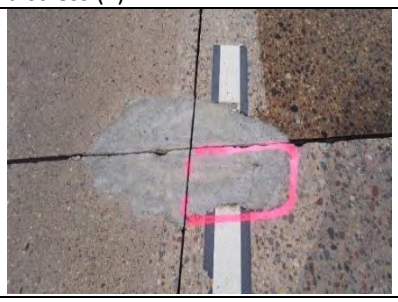
No photo		
Cell/Product/Location: 94009 – Crafco, HP Concrete Cold Patch – Passing MLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): >50% patch overlaid with HMA (1)	2020 Condition (Rating): >50% patch overlaid with HMA (1)
No photo		
Cell/Product/Location: 94009 – Crafco, HP Concrete Cold Patch – Driving MLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): >50% patch overlaid with HMA (1)	2020 Condition (Rating): >50% patch overlaid with HMA (1)
No photo		
Cell/Product/Location: 94009 – Crafco, HP Concrete Cold Patch – Passing ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94009 – Crafco, HP Concrete Cold Patch – Driving ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)

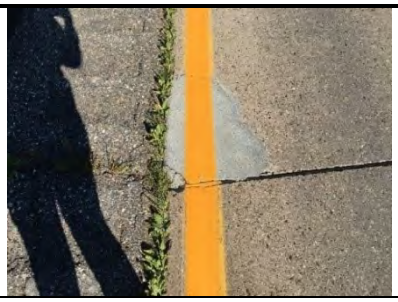
No photo		
Cell/Product/Location: 94009 – Crafco, HP Concrete Cold Patch – CLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracking, patch depressed (3)	2020 Condition (Rating): Linear cracks, depressed patch (3)
No photo		
Cell/Product/Location: 94009 – Crafco, HP Concrete Cold Patch – Passing CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): >50% patch overlaid with HMA (1)	2020 Condition (Rating): >50% patch overlaid with HMA (1)
No photo		
Cell/Product/Location: 94009 – Crafco, HP Concrete Cold Patch – Driving CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracking, patch depressed (3)	2020 Condition (Rating): >50% patch overlaid with HMA (1)
No photo		
Cell/Product/Location: 94009 – Crafco, HP Concrete Cold Patch – Passing FL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracking, patch depressed (3)	2020 Condition (Rating): Linear cracks, depressed patch (3)

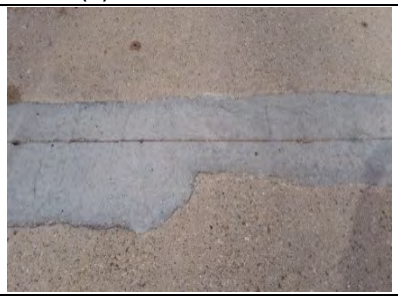
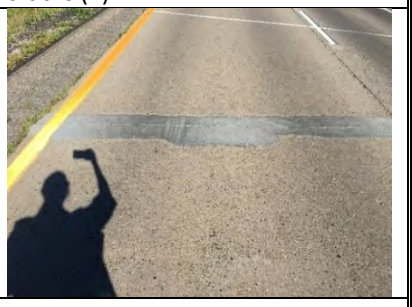
No photo		
Cell/Product/Location: 94009 – Crafco, HP Concrete Cold Patch – Driving FL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracking, patch depressed (3)	2020 Condition (Rating): Linear cracks, depressed patch, <50% patch gone (2)
		
Cell/Product/Location: 94010 – Crafco, Techrete-TBR – CLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks (4)	2020 Condition (Rating): Shrinkage cracks (4)
No photo		
Cell/Product/Location: 94010 – Crafco, Techrete-TBR – Passing CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94010 – Crafco, Techrete-TBR – Driving CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)

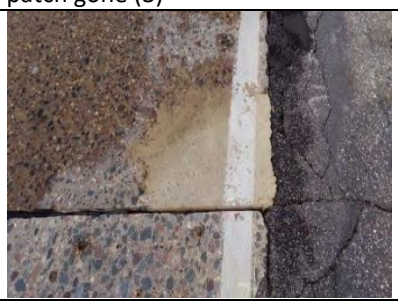
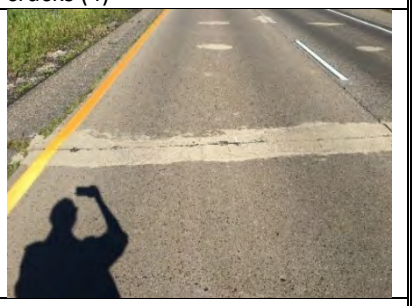
		
Cell/Product/Location: 94010 – Crafco, Techrete-TBR – WP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94010 – Crafco, Techrete-TBR – Passing ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94010 – Crafco, Techrete-TBR – Driving ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94010 – Crafco, Techrete-TBR – CL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)

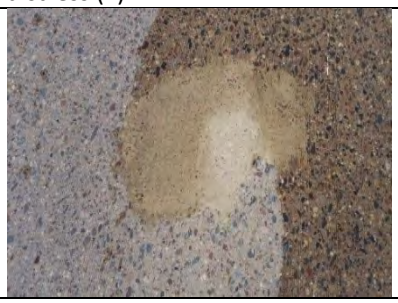
No photo		
Cell/Product/Location: 94010 – Crafco, Techrete-TBR – Passing MLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94010 – Crafco, Techrete-TBR – Driving MLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Debonded (3)	2020 Condition (Rating): Debonded (3)
No photo		
Cell/Product/Location: 94010 – Crafco, Techrete-TBR – Passing FL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94010 – Crafco, Techrete-TBR – Driving FL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)

No photo		
Cell/Product/Location: 94011 – TCC Materials, 3U18 Modified – CL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94011 – TCC Materials, 3U18 Modified – Passing MLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94011 – TCC Materials, 3U18 Modified – Driving MLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
		
Cell/Product/Location: 94011 – TCC Materials, 3U18 Modified – CLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks, debonded (3)	2020 Condition (Rating): Linear cracks, debonded (3)

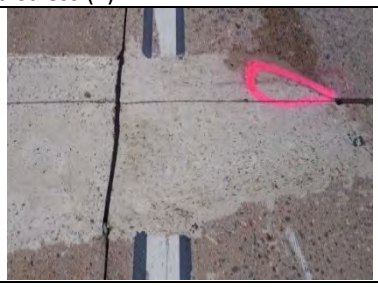
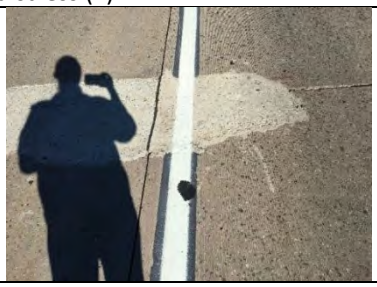
No photo		
Cell/Product/Location: 94011 – TCC Materials, 3U18 Modified – Passing CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks (3)
No photo		
Cell/Product/Location: 94011 – TCC Materials, 3U18 Modified – Driving CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks (3)
		
Cell/Product/Location: 94011 – TCC Materials, 3U18 Modified – WP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks (4)	2020 Condition (Rating): Shrinkage cracks (4)
No photo		
Cell/Product/Location: 94011 – TCC Materials, 3U18 Modified – Passing ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks (4)	2020 Condition (Rating): Shrinkage cracks (4)

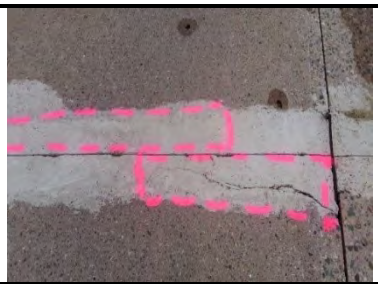
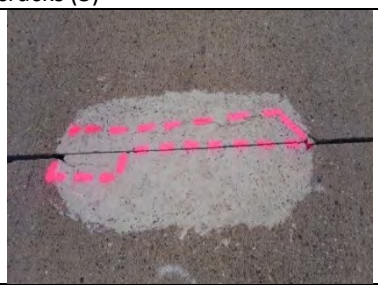
No photo		
Cell/Product/Location: 94011 – TCC Materials, 3U18 Modified – Driving ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks (4)	2020 Condition (Rating): Shrinkage cracks (4)
No photo		
Cell/Product/Location: 94011 – TCC Materials, 3U18 Modified – Passing FL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks (4)	2020 Condition (Rating): Shrinkage cracks (4)
No photo		
Cell/Product/Location: 94011 – TCC Materials, 3U18 Modified – Driving FL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks, debonded (3)	2020 Condition (Rating): Shrinkage cracks, debonded (3)
		
Cell/Product/Location: 94012 – USG, Ecofix – CLJ		
2018 Condition (Rating): Linear cracks (3)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks, <50% patch gone (2)

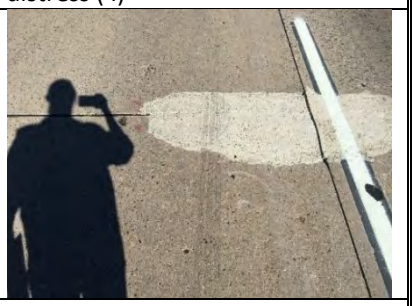
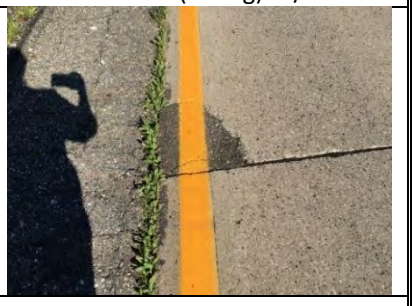
No photo		
Cell/Product/Location: 94012 – USG, Ecofix – Passing CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): >50% patch gone (3)	2020 Condition (Rating): 100% patch gone (0)
No photo		
Cell/Product/Location: 94012 – USG, Ecofix – Driving CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks (4)	2020 Condition (Rating): Shrinkage cracks (4)
No photo		
Cell/Product/Location: 94012 – USG, Ecofix – Passing FL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks, debonded (3)	2020 Condition (Rating): Shrinkage cracks, debonded (3)
No photo		
Cell/Product/Location: 94012 – USG, Ecofix – Driving FL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage and linear cracks (3)	2020 Condition (Rating): Linear cracks, <50% patch gone (2)

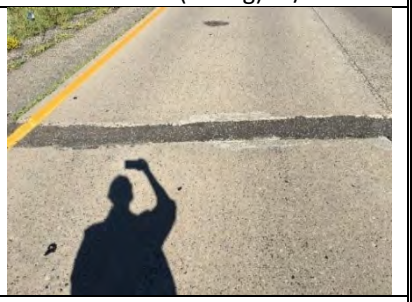
No photo		
Cell/Product/Location: 94012 – USG, Ecofix – Passing ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94012 – USG, Ecofix – Driving ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94012 – USG, Ecofix – CL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94012 – USG, Ecofix – Passing MLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)

No photo		
Cell/Product/Location: 94012 – USG, Ecofix – Driving MLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94012 – USG, Ecofix – WP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks (3)
No photo		
Cell/Product/Location: 94013(A) – CTS, Rapid Set DOT Repair Mix w/Helix 5-25-Standard BA (Zinc Coated) Fibers – Driving FL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94013(A) – CTS, Rapid Set DOT Repair Mix w/Helix 5-25-Standard BA (Zinc Coated) Fibers – CL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)

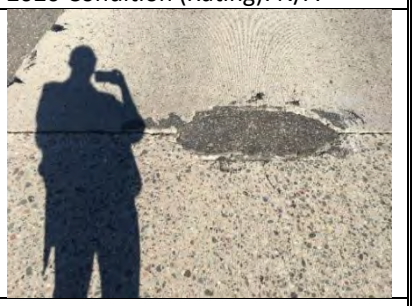
No photo		
Cell/Product/Location: 94013(A) – CTS, Rapid Set DOT Repair Mix w/Helix 5-25-Standard BA (Zinc Coated) Fibers – Driving MLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks, <50% patch gone (2)
No photo		
Cell/Product/Location: 94013(A) – CTS, Rapid Set DOT Repair Mix w/Helix 5-25-Standard BA (Zinc Coated) Fibers – Driving CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94013(A) – CTS, Rapid Set DOT Repair Mix w/Helix 5-25-Standard BA (Zinc Coated) Fibers – Driving ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
		
Cell/Product/Location: 94013(A) – CTS, Rapid Set DOT Repair Mix w/Helix 5-25-Standard BA (Zinc Coated) Fibers – Driving WP		
2018 Condition (Rating): Linear cracks (3)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks (3)

No photo		
Cell/Product/Location: 94013(B) – CTS, Rapid Set DOT Repair Mix w/Helix 5-25-SS BA (Stainless Steel) Fibers – Passing FL		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks (3)
No photo		
Cell/Product/Location: 94013(B) – CTS, Rapid Set DOT Repair Mix w/Helix 5-25-SS BA (Stainless Steel) Fibers – Passing MLJ		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage and linear cracks (3)	2020 Condition (Rating): Linear cracks (3)
		
Cell/Product/Location: 94013(B) – CTS, Rapid Set DOT Repair Mix w/Helix 5-25-SS BA (Stainless Steel) Fibers – CLJ		
2018 Condition (Rating): Linear cracks (3)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks (3)
No photo		
Cell/Product/Location: 94013(B) – CTS, Rapid Set DOT Repair Mix w/Helix 5-25-SS BA (Stainless Steel) Fibers – Passing CP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Linear cracks (3)	2020 Condition (Rating): Linear cracks (3)

No photo		
Cell/Product/Location: 94013(B) – CTS, Rapid Set DOT Repair Mix w/Helix 5-25-SS BA (Stainless Steel) Fibers – Passing ML		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): No distress (4)	2020 Condition (Rating): No distress (4)
No photo		
Cell/Product/Location: 94013(B) – CTS, Rapid Set DOT Repair Mix w/Helix 5-25-SS BA (Stainless Steel) Fibers – Passing WP		
2018 Condition (Rating): No distress (4)	2019 Condition (Rating): Shrinkage cracks (4)	2020 Condition (Rating): Shrinkage cracks (4)
No photo		
Cell/Product/Location: 94014 – HMA – CLJ		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A
No photo		
Cell/Product/Location: 94014 – HMA – Passing CP		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A

No photo		
Cell/Product/Location: 94014 – HMA – Driving CP		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A
No photo		
Cell/Product/Location: 94014 – HMA – Passing FL		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A
No photo		
Cell/Product/Location: 94014 – HMA – Driving FL		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A
No photo		
Cell/Product/Location: 94014 – HMA – Passing ML		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A

No photo		
Cell/Product/Location: 94014 – HMA – Driving ML		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A
No photo		
Cell/Product/Location: 94014 – HMA – CL		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A
No photo		
Cell/Product/Location: 94014 – HMA – Passing MLJ		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A
No photo		
Cell/Product/Location: 94014 – HMA – Driving MLJ		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A

		
Cell/Product/Location: 94014 – HMA – WP		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A
No photo		
Cell/Product/Location: 94015 – HMA – CL		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A
No photo		
Cell/Product/Location: 94015 – HMA – Passing MLJ		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A
		
Cell/Product/Location: 94015 – HMA – Driving MLJ		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A

		
Cell/Product/Location: 94015 – HMA – CLJ		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A
No photo		
Cell/Product/Location: 94015 – HMA – Passing CP		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A
No photo		
Cell/Product/Location: 94015 – HMA – Driving CP		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A
No photo		
Cell/Product/Location: 94015 – HMA – Passing FL		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A

No photo		
Cell/Product/Location: 94015 – HMA – Driving FL		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A
No photo		
Cell/Product/Location: 94015 – HMA – Passing ML		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A
No photo		
Cell/Product/Location: 94015 – HMA – Driving ML		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A
No photo		
Cell/Product/Location: 94015 – HMA – WP		
2018 Condition (Rating): N/A	2019 Condition (Rating): N/A	2020 Condition (Rating): N/A

APPENDIX B: MATERIAL TECHNICAL DATA SHEETS

DOT REPAIR MIX

High Performance Concrete Repair Material

PRODUCT DATASHEET

DESCRIPTION: Rapid Set® DOT REPAIR MIX is a high performance, fast setting, multi-purpose repair material. Durable in wet environments, DOT REPAIR MIX is a blend of Rapid Set hydraulic cement, high performance additives and ASTM C33 concrete sand. DOT REPAIR MIX is non-metallic and no chlorides are added. Mix DOT REPAIR MIX with water to produce a flowable, quality repair material that is ideal where fast strength gain, high durability and low shrinkage are desired. DOT REPAIR MIX is ready for traffic and loading within 1 hour.*

USES: Use DOT REPAIR MIX for concrete repair, highway repair, dowel bar retrofit, construction of pavements and bridges, parking decks and ramps, sidewalks and steps, joint repair and formed work. DOT REPAIR MIX contains an air-entraining admixture, in some geographical regions, for freeze thaw durability.

ENVIRONMENTAL ADVANTAGES: Use DOT REPAIR MIX to reduce your carbon footprint and lower your environmental impact. Production of Rapid Set cement emits far less CO_2 than portland cement. Contact your Rapid Set representative for LEED values and further environmental information.

APPLICATIONS: Apply DOT REPAIR MIX in thicknesses from 1/2" to 4" (1.2 cm to 10.2 cm). For thicker applications, DOT REPAIR MIX can be extended with up to 100% clean, dry coarse aggregate (up to 3/4") conforming to ASTM C33.

SURFACE PREPARATION: For repairs, application surface shall be clean, sound and free from any materials that may inhibit bond such as oil, asphalt, curing compound, acid, dirt and loose debris. Mechanically abrade surface and remove all unsound material. Apply DOT REPAIR MIX to a thoroughly saturated surface with no standing water.

MIXING: The use of a power driven mechanical mixer, such as a mortar mixer or a drill-mounted mixer, is recommended. Organize work so that all personnel and equipment are in place before mixing. Use clean potable water. **DOT REPAIR MIX may be mixed using 3 to 4.5 quarts (2.8 L to 4.3 L) of water per 55-lb (25 kg) bag. Use up to 5 quarts (4.7 L) when extended with dry coarse aggregate. Use less water to achieve higher strengths.** Place the desired quantity of mix water into the mixing container. While the mixer is running, add DOT REPAIR MIX. Mix for the minimum amount of time required to achieve a lump-free, uniform consistency (usually 1 to 3 minutes). Do not retemper.

PLACEMENT: DOT REPAIR MIX may be placed using traditional construction methods. Organize work so that all personnel and equipment are ready before placement. Place, consolidate and screed quickly to allow for maximum finishing time. Use a method of consolidation that eliminates air voids. On flat work, do not install in layers; install full depth sections and progress horizontally. Do not wait for bleed water. Apply final finish as soon as possible. DOT REPAIR MIX may be troweled, floated or broom finished. The working time for DOT REPAIR MIX is 10 to 25 minutes at 70°F (21°C). To extend working time, use Rapid Set® SET Control® retarding admixture from the Rapid Set® Concrete Pharmacy® or use cold mix water. Do not install on frozen surfaces. DOT REPAIR MIX may be applied in temperatures ranging from 45°F to 90°F (7°C to 32°C).

OVERVIEW

Highlights:

- Fast: Ready for traffic and loading in 1 hour
- Durable: Formulated for long life in critical applications
- Structural: For repair and new construction
- Extendable: Add rock for large placements
- Easy To Use: Mix to fluid or stiff consistency
- Multi-Purpose: Use for concrete repair, highway repair, dowel bar retrofit, construction of pavements, bridges, parking decks, ramps, sidewalks, steps, joint repair, formed work and more

Conforms to:

- ASTM C928
- California Test No. 551

MasterFormat® 2016

03 01 30	Maintenance of Cast-in-Place Concrete
03 01 40	Maintenance Of Precast Concrete
03 01 50	Maintenance of Cast Decks and Underlayment
03 01 70	Maintenance of Mass Concrete

Manufacturer:

CTS Cement Manufacturing Corp.
11065 Knott Ave., Suite A
Cypress, CA 90630
Tel: 800-929-3030 | Fax: 714-379-8270
Web: www.CTScement.com
E-mail: info@CTScement.com

DOT REPAIR MIX High Performance Concrete Repair Material

CURING: Water cure all Rapid Set® DOT REPAIR MIX installations by keeping exposed surfaces wet for a minimum of 1 hour. Begin curing as soon as the surface starts to lose its moist sheen. When experiencing extended setting time due to cold temperature or the use of retarder, longer curing times may be required. The objective of water curing shall be to maintain a continuously wet surface until the product has achieved sufficient strength.

COLD WEATHER: Environmental and material temperatures below 70°F (21°C) may delay setting time and reduce the rate of strength gain. Lower temperatures will have a more pronounced effect. Thinner sections will be more significantly affected. To compensate for cold temperatures, keep material warm, use heated mix water, and follow ACI 306 Procedures for Cold Weather Concreting.

WARM WEATHER: Environmental and material temperatures above 70°F (21°C) may shorten setting time and increase the rate of strength gain. Higher temperatures will have a more pronounced effect. To compensate for warm temperatures, keep material cool, use chilled mix water and follow ACI 305 Procedures for Hot Weather Concreting. The use of Rapid Set® SET Control® retarding admixture from the Rapid Set® Concrete Pharmacy® will help offset the effects of high temperatures.

YIELD & PACKAGING: DOT REPAIR MIX is available in 55 lb (25 kg) bags. One 55 lb (25 kg) bag of DOT REPAIR MIX will yield approximately 0.5 ft^3. When extended 60% by weight with quality coarse aggregate, yield is approximately 0.7 ft^3. When extended 100% by weight with quality coarse aggregate, yield is approximately 0.9 ft^3.

SHELF LIFE: DOT REPAIR MIX has a shelf life of 12 months when stored properly in a dry location, protected from moisture, out of direct sunlight, and in an undamaged package.

USER RESPONSIBILITY: Before using CTS products, read current technical data sheets, bulletins, product labels and safety data sheets at www.CTScement.com. It is the user's responsibility to review instructions and warnings for any CTS products prior to use.

WARNING: DO NOT BREATHE DUST. AVOID CONTACT WITH SKIN AND EYES. Use material in well-ventilated areas only. Exposure to cement dust may irritate eyes, nose, throat, and the upper respiratory system/lungs. Silica exposure by inhalation may result in the development of lung injuries and pulmonary diseases, including silicosis and lung cancer. Seek medical treatment if you experience difficulty breathing while using this product. The use of a NIOSH/MSHA-approved respirator (P-, N- or R-95) is recommended to minimize inhalation of cement dust. Eat and drink only in dust-free areas to avoid ingesting cement dust. Skin contact with dry material or wet mixtures may result in bodily injury ranging from moderate irritation and thickening/cracking of skin to severe skin damage from chemical burns. If irritation or burning occurs, seek medical treatment. Protect eyes with goggles or safety glasses with side shields. Cover skin with protective clothing. Use chemical resistant gloves and waterproof boots. In case of skin contact with cement dust, immediately wash off dust with soap and water to avoid skin damage. In case of skin contact with wet concrete, wash exposed skin areas with cold running water as soon as possible. In case of eye contact with cement dust, flush immediately and repeatedly with clean water, and consult a physician. If wet concrete splashes into eyes, rinse eyes with clean water for at least 15 minutes and go to the hospital for further treatment.

PROPOSITION 65 WARNING: This product contains chemicals known to the State of California to cause cancer and birth defects or other reproductive harm. Please refer to the SDS and www.CTScement.com for additional safety information regarding this material.

LIMITED WARRANTY: CTS CEMENT MANUFACTURING CORP. (CTS) warrants its materials to be of good quality and, at its option, will replace or refund the purchase price of any material proven to be defective within one (1) year from date of purchase. The above remedies shall be the limit of CTS's responsibility. Except for the foregoing, all warranties expressed or implied, including merchantability and fitness for a particular purpose, are excluded. CTS shall not be liable for any consequential, incidental, or special damages arising directly or indirectly from the use of the materials.

TYPICAL PHYSICAL DATA

Neat Bag (3.0 to 4.5 quarts)	60% Extension (3.5 to 4.75 quarts)	100% Extension (3.5 to 5.0 quarts)
Yield		
0.5 ft^3	0.7 ft^3	0.9 ft^3
Compressive Strength		
ASTM C109 Mod.	ASTM C39	ASTM C39
1 hr* 3300 psi	1 hr* 2800 psi	1 hr* 2500 psi
3 hrs 5000 psi	3 hrs 4600 psi	3 hrs 4200 psi
24 hrs 7000 psi	24 hrs 6800 psi	24 hrs 6500 psi
7 days 7500 psi	7 days 7200 psi	7 days 7000 psi
28 days 9500 psi	28 days 9000 psi	28 days 8500 psi
Flexural Strength, ASTM C78		
4 hrs 450 psi	4 hrs 400 psi	4 hrs 400 psi
7 days 700 psi	7 days 650 psi	7 days 600 psi
28 days 900 psi	28 days 850 psi	28 days 800 psi
Modulus of Elasticity, ASTM C469		
7 days 4,400,000 psi	7 days 4,100,000 psi	7 days 3,900,000 psi
28 days 5,100,000 psi	28 days 4,500,000 psi	28 days 4,000,000 psi
Slant Shear Bond Strength, ASTM C882 per C928		
1 day 1500 psi	1 day 1200 psi	1 day 1100 psi
7 days 2000 psi	7 days 1800 psi	7 days 1700 psi
Splitting Tensile Strength, ASTM C496		
7 days 700 psi	7 days 500 psi	7 days 390 psi
28 days 900 psi	28 days 600 psi	28 days 415 psi
Resistance of Concrete to Rapid Freezing and Thawing, ASTM C666 Procedure A		
Durability factor 300 Cycles: 95%	Durability factor 300 Cycles: 95%	Durability factor 300 Cycles: 95%
Scaling Resistance, ASTM C672 per C928		
Scaling of material at 25 cycles: 0.05 lb/ft^2	Visual rating at 25 cycles - 2	Visual rating at 25 cycles - 1
Length Change, ASTM C157 modified per ASTM C928		
Air Cure: -0.08% Water Cure: 0.02%	Air Cure: -0.07% Water Cure: 0.01%	Air Cure: -0.05% Water Cure: 0.05%
*Data obtained at flow consistency of 105 by ASTM C1437 at laboratory conditions	*Data obtained at slump consistency at 6" by ASTM C143 at laboratory conditions	*Data obtained at slump consistency at 6" by ASTM C143 at laboratory conditions

*After final set
Results will vary depending on aggregates and jobsite conditions

REPCON® 928

GREENCONSCIOUS

Polymer-modified rapid setting concrete repair mortar with corrosion inhibitor

DESCRIPTION

RepCon® 928 is a single component, polymer modified, fiber reinforced, rapid setting concrete repair mortar with corrosion inhibitor for use on concrete floors, highway pavements, bridge decks and other applications requiring early resumption of traffic or use. RepCon® 928 is formulated to meet the requirements of ASTM C928 Packaged, Dry, Rapid Hardening Cementitious Material for Concrete Repair and AASHTO T260. RepCon® 928 incorporates the latest in polymer technology offering superior durability, performance and ease of application without liquid activators for horizontal and vertical form & pour applications.

FEATURES/BENEFITS

- One component, dry-polymer modified. Just add water.
- Fiber-reinforced for added flexural strength
- Air entrained for excellent freeze-thaw durability
- Natural concrete-gray color
- Suitable for horizontal and formed vertical application
- Takes foot traffic in 1 hour after set
- Long work time for hot weather applications (available in fast-set version **RepCon® 928 FS**)

APPLICATION

Surface Preparation: The concrete must be sound and free of all foreign material, including oil, grease, dust, laitance or other surface contaminants. For maximum durability, saw cut the perimeter of the repair 1/8" deeper than the depth of the repair, creating a notched, reinforced edge. Mechanically abrade the surface by an engineered approved method in accordance with ICRI 310.2 Guideline to a minimum CSP 5. **All concrete surfaces to be repaired must be in a saturated-surface-damp (SSD) condition with no standing water on the surface**.

Priming/Scrub Coat: Thoroughly clean all exposed steel reinforcing of rust and coat with **SpecPrep SB.**
Prepared concrete must be SSD and primed with a spray or brush coat of **SpecPrep SB** and the repair mortar applied wet on wet or up to the recommended open time (see **SpecPrep SB** technical data sheet).
As an alternative, apply a scrub coat of the properly mixed repair mortar by scrubbing a thin layer into the predampened substrate with a stiff brush. Place the repair mortar immediately before the bond coat dries.

Mix 4.75 - 5.25 pints (depending on desired consistency) of clean water per 50 pound bag of material.
Mix with a low speed drill or mortar mixer. Add recommended amount of clean water into the container, followed by slowly adding the RepCon® 928 powder.
Mix 2-3 minutes. Mix only what can be applied within the setting period. Depending on the area dimensions, RepCon® 928 can be applied in applications from 1" to 6" in a lift without extension.
Deep Applications: For repair applications over 2", RepCon® 928 can be extended with clean, SSD, 3/8" aggregate up to 60% by weight (30lbs) and mixed an additional 2 min. Choose a clean (free of organic material) well-graded 3/8" aggregate. Aggregate should be predampened prior to mixing with RepCon® 928. The total mixing water for the batch shall be reduced by the amount of free water found in the aggregate. This extension will add approx 0.18 cu-ft to the unit yield and should be placed within 15-20 min.

Placement: Trowel, or screed RepCon® 928 firmly into the prepared area, ensuring intimate contact with the bonding surface. Finish RepCon® 928 level with the surrounding concrete and allow to take an initial set. After the initial set, when RepCon® 928 is surface hard, finish by hand trowelling. Excessive troweling is not required.

Finishing/Curing: Finish the repair material to the desired texture to best match the surrounding concrete. Do not add additional water to the surface during finishing.

TYPICAL TEST DATA

Test Data based on 5.0 pints water	
Set Time at 70°F (ASTM C-266)	
Initial Set	40 min
Final Set	45 min
Compressive Strength (ASTM C-109)	
3 hours	3200 psi
1 day	6100 psi
7 days	8250 psi
28 days	9,625 psi
Bond Strength (ASTM C-882 modified)	
7 days	2545 psi
Flexural Strength (ASTM C-348)	
7 days	750 psi
28 days	1150 psi
Freeze-Thaw Resistance (ASTM C 666)	
Procedure A (300 cycles)	99% Durability Factor
Yield	
Yield Per Bag	.42 cu-ft

SPECCHEM
Solution to Service

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Kansas City, MO 64108
www.specchemllc.com 866.791.8700

Lightly spray SpecFilm as a finishing aid on this and any other polymer modified mortars to assist in finishing. RepCon® 928 is self-curing under most conditions. In severe drying conditions, use an ASTM C-309 compliant, water based SpecChem curing compound.

SPECIFICATIONS/COMPLIANCE

ASTM C-928 (Rapid Hardening Mortar)
AASHTO T-260

PACKAGING

- 50 lb bag
- 3,000 lb SuperSack

Coverage: approx 20 sq-ft @ 1/4”

SHELF LIFE

Shelf life of unopened bags stored in a dry facility is 12 months. Excessive temperature differential and/or high humidity can shorten the shelf life expectancy. Store in a cool, dry area away from direct sunlight.

LIMITATIONS/PRECAUTIONS

Minimum thickness for horizontal repairs subjected to heavy or severe traffic is 1/2”. Do not retemper after initial mixing. Do not add other cements or additives to this product. RepCon® 928 is a fast setting product, so mixing equipment should be cleaned with water as soon as possible. Use only potable water for mixing.
Application range 55°F to 85°F. Please consult SpecChem for special instructions on any application outside this temperature range.

Adverse Weather Application: In adverse temperatures, follow ACI recommendations for hot/cold weather concreting practices. For optimum results, condition material to between 65 ^{o}F and 85^{o}F.
Application in cold weather should follow procedures outlined in ACI 306. Heating the repair area, using warm water for mixing, and tenting or insulating the patch area after application will increase strength development. Do not use direct, unvented heat on the patch after installation. Do not allow repairs to freeze until the material has reached a minimum of 1000 psi compressive strength.
Caution: Contains Portland Cement and sand. Cement will cause irritation. Avoid contact. A dust respirator, safety goggles, and rubber gloves are recommended. Avoid prolonged contact with clothing. In case of contact with eyes, immediately flush with water for at least 15 minutes. Get prompt medical attention. Do not wear contact lenses when working with this product. DO NOT take internally. Keep out of reach of children.

Avoid hazards by following all precautions found in the Material Safety Data Sheet (MSDS), product labels, and technical literature. Please read this information prior to using the product.

CLEAN UP

Tools and equipment may be cleaned with water before RepCon® 928 hardens.

WARRANTY

NOTICE-READ CAREFULLY
CONDITIONS OF SALE
SpecChem offers this product for sale subject to and limited by the warranty which may only be varied by written agreement of a duly authorized corporate officer of SpecChem. No other representative of or for SpecChem is authorized to grant any warranty or to waive limitation of liability set forth below.
WARRANTY LIMITATION
SpecChem warrants this product to be free of manufacturing defects. If the product when purchased was defective and was within use period indicated on container or carton, when used, SpecChem will replace the defective product with new product without charge to the purchaser. SpecChem makes no other warranty, either expressed or implied, concerning this product. There is no warranty of merchantability. NO CLAIM OF ANY KIND SHALL BE GREATER THAN THE PURCHASE PRICE OF THE PRODUCT IN RESPECT OF WHICH DAMAGES ARE CLAIMED.
INHERENT RISK
Purchaser assumes all risk associated with the use or application of the product.

SPECCHEM
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Kansas City, MO 64108
www.specchemllc.com *866.791.8700*

FasTrac 246 Concrete

Rapid-setting concrete

Description

FasTrac 246 Concrete is a one-component, shrinkage compensated, proprietary blend of cements, aggregates, and performance enhancing chemical additives. This rapid setting concrete is mixed with water on site, used for large-scale horizontal concrete repairs, and form and pour vertical applications that require high early-strength gain.

Features/Benefits

- Very rapid setting; allows structures to be opened to vehicular traffic in 3 hours
- Non-gypsum based with volume stability
- Excellent resistance to freeze/thaw with outstanding durability
- Shrinkage compensation minimizes cracking from drying shrinkage

Yield
Approx. 0.45-cu.ft. /60 lb. bag when mixed with the recommended amount of water.

Packaging
60# bag
3,000 lb bulk bags

Shelf Life
12 mos. properly stored

Storage
Store and transport in clean, dry conditions.

Application Temperature Range
40° F to 90° F

Where to Use
- Airport runways
- Concrete slab replacement
- Repair of bridges
- Parking decks
- Horizontal concrete surfaces
- Interior or exterior

How to Apply

Surface Preparation (See ICRI guidelines)

1. Concrete must be sound and fully cured (28 days).
2. Saw cut the perimeter of the area being patched into a square with a minimum depth of 1" (25 mm).
3. Remove all unsound concrete and roughen the surface to min. 1/4" profile amplitude.
4. Remove all laitance, oil, grease, curing compounds, and other contaminants that could prevent adequate bond.
5. The concrete substrate should be saturated surface-dry (SSD), without standing water, before application.
6. Apply the mixed material onto the prepared saturated surface-dry (SSD) substrate by trowel or screed. Ensure proper consolidation of the mortar and compaction around reinforcing steel. Minimum application thickness is 1” based on a 3/8” max. coarse aggregate. Finish the completed repair, as required, taking care not to overwork the surface.

Reinforcing Steel
Remove all oxidation and scale from the exposed reinforcing steel in accordance with ICRI Technical Guideline No. 03730 “Guide for Surface Preparation for the Repair of Deteriorated Concrete Resulting from Reinforcing Steel Corrosion.”

Mixing
Mix with required amount of cool, potable water for desired application characteristics, from 2.19 to 2.48 U.S. qts (2.07 to 2.34L) per 60lbs. (27.2kg) bag. Conduct field trials to verify proper slump, (approx 8”) yield and a thoroughly mixed product.

Working time- Approx. 15-25 min

Set time- min. at 72° F (22° C) ASTM C 191
Initial 20-30 minutes
Final 30-40 minutes

V07Sep.17

FasTrac 246 Concrete pg 2 of 3

Curing
Cure immediately after finishing. Use a curing compound that complies with ASTM C 309. In extreme heat, keep the patches covered and damp.

Clean Up
Clean tools and equipment with clean water immediately after use. Cured material must be removed mechanically.

Health and Safety
Make certain the most current versions of product data sheet and MSDS are being used

Risks
Product contains portland cement and sand (crystalline silica); it can cause skin and eye irritation. Ingestion or inhalation of dust may cause tract irritation. This contains free respirable quartz, which has been listed as a suspected human carcinogen by NTP and IARC. Repeated or prolonged overexposure to free respirable quartz may cause silicosis or other serious and delayed lung injury.

Precautions
KEEP OUT OF THE REACH OF CHILDREN. Prevent contact with skin and eyes. Prevent inhalation of dust. DO NOT take internally. Use only with adequate ventilation. Use impervious gloves, eye protection and if the TLV is exceeded or is used in a poorly ventilated area, use NIOSH/MSHA approved respiratory protection in accordance with applicable federal, state and local regulations.

First Aid
In case of eye contact, flush thoroughly with water for at least 15 minutes, and seek medical attention. In case of skin contact, wash affected areas with soap and water. If the irritation persists seek medical attention. Remove and wash contaminated clothing. If inhalation causes physical discomfort, remove to fresh air. If the discomfort persists, breathing difficulty occurs, or if swallowed seek medical attention. Refer to Material Safety Data Sheet (MSDS) for further information.

Proposition 65
This product contains material listed by California as known to cause cancer, birth defects, or other reproductive harm.

VOC Content
0 lbs/gal or 0 g/L

Limited Warranty Notice
Every reasonable effort is made to apply exacting standards both in the manufacture of “FasTrac 246 Concrete” product and in the information, which we issue concerning these products and their use. We warrant our products to be good quality and will replace or, at our election, refund the purchase price of any products proved defective. Satisfactory results depend not only on quality products, but also upon many factors beyond our control. Therefore, except for such replacement or refund, Western Material and Design, LLC makes no warranty or guarantee, express or implied, including warranties of fitness for a particular purpose or merchantability, respecting its products, and Western Material and Design, LLC shall have no other liability with respect thereto. Any claim regarding product defect must be received in writing within one year from the date of shipment. No claim will be considered without such written notice or after the specified time interval. User shall determine the suitability of the products for the intended use and assume all risks and liability in connection therewith. Any authorized change in the printed recommendations concerning the use of our products must bear the signature of the Western Material and Design, LLC technical manager.

FasTrac 246 Concrete pg 3 of 3

Technical Data, Conforms to ASTM C928

Property (Test Method)	**Result**
Compressive Strength (ASTM C39)	
3 hrs	4080 psi
1 day	5620 psi
7 days	7280 psi
28 days	8420 psi
Bond Strength (ASTM C882)	
3hrs	1240 psi
1 day	1310 psi
7 days	1620 psi
28 days	1840 psi
Length Change (ASTM C157, Mod. by C928)	
Air Cure	-0.032%
Water Cure	0.06%
Resistance to Scaling (ASTM C672)	
Visual Rating	0
Scaled Material	0.0 lbs/ft^2

CE700 HPC

CE700 HPC

TECHNICAL DATA

Shelf Life:	2 years in original unopened container.
Condition material to:	65^{0}F – 85^{0}F (18^{0}C – 29^{0}C) before using.
Mix Ratio (Polymer)	1:1 by volume
Mix Ratio (Polymer with aggegate)	4-gallon mixed polymer to 300 Lb aggregate
Viscosity (Polymer)	1,200 cps @ 77°F
Gel Time (60 g Polymer)	20 minutes
Tack Free Time (73ºF)	3 hours
Tensile Properties (Polymer only, ASTM D638), 7 day cure Tensile Strength: Tensile Elongation:	 2,000 psi (13.8 MPa) 40%
Slant Shear Bond Strength (ASTM C882) 2 day cure: 14 day cure:	 1,500 psi (10.3 MPa) 2,000 psi (13.8 MPa)
Compressive Strength (ASTM C579) 3 hour cure: 24 hour cure:	 1,200 psi (8.3 MPa) 5,000 psi (34.5 MPa)
Bond Strength (ASTM C1583/ACI 503R)	500 psi (3.4 MPa), 100% substrate failure
Flexural Strength (ASTM D790)	3,000 psi (23.4 MPa)
Shrinkage on Cure (ASTM D2566)	0.2%
Thermal Compatibility (ASTM C884)	Pass
Water Absorption (Binder only, ASTM D570)	0.2% (24 hr)
Chloride Ion Permeability (AASHTO T277)	0.0 coulomb

MINIMUM CURING TIME:

TEMPERATURE (^{0}F)	**60**	**65**	**70**	**75**	**80**
MINIMUM CURING TIME (HRS)	**5**	**4**	**3.5**	**3**	**2**

APPLICATION

SURFACE PREPARATION:
Prepare surface in accordance with ICRI Technical guideline no. 03732. Surface must be clean and sound. Surface must be free of standing water. Remove curing compounds-laitance , grease, rubber and any foreign matter or unsound surface. For best results, shot blasting, sandblasting and scarifying are the preferred methods of preparation. (¼" – CSP 5, 6 or 7). Remove rust from exposed reinforcing steel. Have all necessary equipment near area to permit rapid and continiuus placement. All bagged aggregates and liquid resins should be stored in a clean, cool, dry environment. Remove all unsound concrete and establish a sound concrete foundation.
MIXING: Prefered method is to use automated installation equipment. When mixed and applied manually, mix only the amount of material that can be used within its pot life. Proportion each liquid component carefully into a clean pail. Mix thoroughly for 3 minutes with a Jiffy mixer on low speed (400-600rpm). Scrape the sides and bottom of the container. To prepare a repair mortar, slowly add 300 lbs. of the engineered aggregate to every 4-gal of mixed epoxy. Mix only until all aggregate is wetted out. Volumetric mixers may be utilized to increase production or the FasTrac 750 Concrete Mixer.
INSTALLATION and FINISHING: use CE700 HPC liquid polymer part only as a primer when necessary. Place CE700 HPC with a vibratory strike off screed. Standard hand tools can also be used for small patches. CE700 HPC can be finished to the designed roughness. Broadcast aggregate and lightly roll it into CE700 HPC to further improve friction.

LIMITATIONS

Minimum substrate temperature is 50^{0}F (10^{0}C). Do not thin. Solvents will prevent proper cure. Material is a vapor barrier after cure.

CLEAN UP

Collect with absorbent material. Flush area with water. Dispose of in accordance with local, state and federal disposal regulations. Uncured material can be removed with CE Clean or approved solvent. Cured material can only be removed mechanically.

HANDLING PRECAUTIONS

Refer to the Safety Data Sheet for FasTrac CE700 HPC before using.

WARRANTY

LIMITED WARRANTY

All information provided by Western Material & Design, LLC (WMD) concerning WMD products, including but not limited to, any recommendations and advice relating to the application and use of WMD products, is given in good faith based on WMD's current experience and knowledge of its products when properly stored, handled and applied under normal conditions in accordance with WMD's instructions. In practice, the differences in materials, substrates, storage and handling conditions, actual site conditions and other factors outside of WMD's control are such that WMD assumes no liability for the provision of such information, advice, recommendations or instructions related to its products, nor shall any legal relationship be created by or arise from the provision of such information, advice, recommendations or instructions related to its products. The user of the WMD product(s) must test the product(s) for suitability for the intended application and purpose before proceeding the full application of the product(s). WMD reserves the right to change the properties of its products without notice. All sales of WMD product(s) are subject to its current terms and conditions of sale.

Prior to each use of any WMD product, the user must always read and follow the warnings and instructions on the product's most current Technical Data Sheet, product label and Safety Data Sheet which are available at www.WMD.com. Nothing contained in any WMD materials relieves the user of the obligation to read and follow the warnings and instruction for each WMD product as set forth in the current Technical Data Sheet, product label and Safety Data Sheet prior to product use.

WMD warrants this product for one year from date of installation to be free from manufacturing defects and to meet the technical properties on the current Technical Data Sheet when used in accordance with the written instructions. User determines suitability of product for intended use and assumes all risks. Buyer's sole remedy shall be limited to the purchase price or replacement of product exclusive of labor or cost of labor

NO OTHER WARRANTIES EXPRESS OR IMPLIED SHALL APPLY INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. WMD SHALL NOT BE LIABLE UNDER ANY LEGAL THEORY FOR SPECIAL OR CONSEQUENTIAL DAMAGES. WMD SHALL NOT BE REPSONSIBLE FOR THE USE OF THIS PRODUCT IN A MANNER TO INFRINGE ON ANY PATENT OR ANY OTHER INTELLECTUAL PROPERTY RIGHTS HELD BY OTHERS.

D.S. BROWN
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www.dsbrown.com

PaveSaver™ Polymeric Concrete Patch

Pavements

Bridge the World with Leading Infrastructure Solutions

300 East Cherry Street • North Baltimore, OH 45872 | Telephone: 419.257.3561 • Fax: 419.257.2200 | www.dsbrown.com

Top and Center images: Highway Spall Repair, Highway 99, Fort Bend County, TX.

Dowel Bar Retrofit.

PaveSaver™ Polymeric Concrete Patch

General

PaveSaver™ is a new generation of non-shrink epoxy-based elastomeric concrete featuring an ideal balance for both flexibility and strength. This unique combination provides an excellent long-term patching solution for repairing cracks and spalls on airfield, bridge decks, bridge expansion joint headers, and highway pavements.

PaveSaver™ Advantages

1. **High-load bearing capacity** – Handles the weight of C-4s, 747s and heavy truck traffic.
2. **Outstanding anti-spalling properties** – PaveSaver™ is a long-term solution for high-performance pavement repairs.
3. **Impact resistant** – Under bitterly cold conditions, PaveSaver™ withstands heavy impact and resists shattering, unlike conventional concrete and imitation epoxy-based materials.
4. **High compressive strength** – PaveSaver™ can handle heavy psi pressure before deflecting.
5. **Chemical resistant** – PaveSaver™ resists commonly used chemicals such as ASTM Oil #1, ASTM Fuel A, Ethylene Glycol, Freon, Isopropyl Alcohol, JP-4 Jet Fuel, Silicone Grease, Sodium Chloride, Mineral Oil, Trisodium Phosphate and Potassium Acetate.
6. **Easy to install** – PaveSaver™ is semi self-leveling and has a rapid cure time. This minimizes expensive downtime and allows for the return of traffic often within 3 hours after final pour. It also protects work crews by minimizing exposure to heavy traffic. PaveSaver™ can be mixed in 5-gallon buckets or in approved mortar mixers for high volume applications.
7. **Flexibility** – Cement, phosphate, and most other high early strength repair materials prematurely fail because they are rigid. Rigid repair materials installed in rigid pavement require that the materials have similar coefficient of expansion. Most do not and, as a result, destroy the patch and the surrounding concrete. PaveSaver™ utilizes a unique epoxy chemistry to provide a flexible patch that will deflect as surrounding concrete expands and contracts.

PaveSaver™ Airfield Repair Application

PaveSaver™ Bridge Expansion Joint Header Application

PaveSaver™ Polymeric Concrete Patch Physical and Performance Properties

Test Method	Property Tested	Requirements	Results
ASTM C501	Abrasion Resistance	Weight Loss H-22 Grams 1.0 Max.	Pass
ASTM C531	Linear Shrinkage	Negligable	Pass
ASTM C579 Method B	Compressive Strength	PSI @ 4 Hours 1500 Min. PSI @ 24 Hours 4500 Min.	Pass Pass
ASTM C882	Bond Strength	PSI of 2500 Min.	Pass
ASTM C884	Thermal Compatibility	No delamination or cracking	Pass
AASHTO T-277	Chloride Ion Permeability	Coulombs, 1.0 Max	Pass

PaveSaver™ meets and/or exceeds ASTM C881 Type III (Mortar) and the following physical property requirements

Test Method	Property Tested	Requirements	Results
ASTM C579 Method B	Compressive Strength	PSI @ 4 Hours 1500 Min. PSI @ 24 Hours 4500 Min.	Pass Pass
Tex-614-J	Gel Time	1 Minute Min. - 60 Minutes Max.	Pass
Tex-618-J	Wet Bond Strength to Concrete	PSI of 350 Min.	Pass
Tex-618-J	Compressive Strength	PSI of 3000 Min. @ 0.1 in. for 7 days	Pass
Tex-618-J	Resilience	75% Min.	Pass
ASTM C884	Thermal Compatibility	No delamination or cracking	Pass

Area Preparation

Saw cut, chip, or mill area to be repaired, leaving only sound concrete. Carefully sandblast all areas which will be in contact with PaveSaver™. The repair area must be clean and dry and the substrate must be a minimum temperature of 40°F (5°C). The minimum age of hardened concrete for bonding should be 5-7 days.

Materials/Equipment

Jiffy style mixing attachment, heavy-duty drill, clean and dry mixing bucket, spatula, bucket scrapers, and finishing trowels.

A D.S. Brown approved mortar mixer may be used for large projects.

Storage Conditions

Store at 40°- 95°F (5°- 35°C). For best results, condition material to 65°- 85°F (18°- 29°C) before using.

Mixing and Placing

Step 1

Pour premeasured amounts of Part A and B liquids into the mixing bucket. Using a spatula, thoroughly scrape the sides and bottoms of the cans to get as much of the resin liquids as reasonably possible into the mixing bucket. Failure to do this could result in irregular color or a dry mix.

Step 2

Place Jiffy type mixer at bottom of pail to avoid introducing air and thoroughly mix on low-speed (300 rpm) for 3 minutes. The material should have a uniform consistency with no visual color streaks.

Step 3

Slowly add component C (aggregate) to the mixed liquid components.

Step 4

Mix thoroughly until all aggregate is wetted out.

Step 5

Immediately place mortar. Thoroughly compact and trowel finish the surface.

Step 6

For repairs along existing joints, the joints should be maintained by the use of forming materials or saw cutting method.

1.0 Cubic Foot Unit of PaveSaver™

Packaging

1.0 cubic foot unit (.028 cubic meter)
(7.48 mixed gallons)
One can Part A (1 gallon gray liquid)
One can Part B (1 gallon clear liquid)
Two 50 lb. bags Aggregate

Technical

Data Sheet

Willamette Valley Company

www.wilvaco.com

800.333.9826

Partnering through service, innovation, and integrity

FastPatch DPR Kit

Distressed Pavement Repair

DESCRIPTION

FastPatch DPR is an easy-to-apply, long-lasting repair material for distressed pavement. It is supplied in complete, ready-to-use kits with a polymer blend of recycled and renewable materials. Each kit comes with two color options of Gray or Black, and topping sand to blend repair areas with the surrounding pavement. It can be applied in warm conditions, or in cooler conditions with the aid of FastPatch Kicker accelerator, to form a permanent repair that is quickly ready for traffic.

WHERE TO USE

- **Roadways**–spalls, wheel path areas, approaches and departures
- **Parking Lots**–holes, walkways, broken areas
- **Warehouses**–floors, spalls, loading areas
- **Sidewalks**–trip hazards, walkways, "repair instead of replace"

FEATURES AND BENEFITS

- **Easy-to-Apply**—Mix with cordless drill, pour, & finish in minutes
- **Lasting Repair**—Excellent adhesion & absorbs impact
- **Open to Traffic Quickly**—Reduce traffic interruptions
- **Recycled & Renewable Materials**—Sustainable sources
- **Odorless**—100% solids & suitable for indoor applications
- **Freeze-Thaw Resistant**—Long term repair for colder climates

PACKAGING

5-gallon pail

COLORS

Gray or Black

YIELD

3 US gal (11 Liters)*

SHELF LIFE

1 year when properly stored.

STORAGE

Store and ship this product in a clean, dry, low-humidity, shaded or covered environment at 60-90° F (15-32° C).

*Depending on application method

TECHNICAL INFORMATION

Typical Properties and Parameters:

VOC, lbs/gal (g/L), ASTM D 2369	0
Service Temperature, ° F (° C)	-30 to 170 (-34 to 77)
Work-life min., 70° F (21° C)	9 minutes
Adhesion, ASTM D 7234	> 400 psi, 100% substrate failure
Application Temp ° F (° C)	40 to 105 (4 to 40)
Application Method	Mechanical mix & pour
Recommended Thickness	> 1/4 in. (0.635 cm)
Recommended Repair Area	< 16 ft2 (1.49m2).

Set Time (with Aggregate):

Temp. °F (°C)	Set Time (min.)	With Optional FastPatch Kicker (1 oz.)
110 (40)	7	3
75 (21)	30	18
40 (10)	80	40

APPLICATION

PAVEMENT PREPARATION

1. Pavement must be structurally sound (200psi or greater according to ASTM D7234), clean (ASTM D4258), and dry (less than 5%, ASTM E1907).
2. Moisture or oil in repair areas will result in poor adhesion. Apply product only if surface is dry and ambient temperature is 5° F (3° C) above dew point.
3. Remove all contaminants (e.g., oil, dust, sand, moisture) from surface for proper adhesion.
4. For maximum adhesion, profile surface according to ICRI Guide 03732, to a minimum of CSP 3, by abrasive blasting.
5. Shape spall perimeter into a square by saw cut, 1-3 inches (2.54-7.6 cm) deep. Hammer repair area and remove debris. Remove all loose rebar. Exposed non-moving rebar can remain. Maximum recommended repair size is less than 16 ft^2 (1.49m^2).
6. Use a minimum 120 PSI continuously dry compressed air to blow out loose debris, dirt and dust prior to applying product. Moist pavement can be torched dry. If moisture returns immediately after torching, stop and do not install FastPatch in this area.
7. Use a steel bristle brush to remove dirt on vertical and horizontal pavement surfaces. Use a minimum 120 PSI continuously dry compressed air to blow out repair area, prior to applying product.
8. As necessary, plug all gaps or joints surrounding the repair area with foam.
9. Protect surrounding surfaces to the repair area with tape to prevent contamination.
10. Priming all surfaces with POLYPrime is recommended to strengthen bonding surface and maximize adhesion. Refer to primer TDS sheets for detailed instructions.
11. Honor all moving joints or moving cracks in the repair area by saw-cutting after FastPatch has cured or installing form board during application. Joints or cracks without movement do not require honoring. Contact manufacture for more details.

OTHER MATERIALS

1. Previously installed polymer materials must be tested to determine best method of preparation for acceptable adhesion. Typically, methods will include solvent cleaning, abrading, and vacuuming surfaces.
2. Avoid installing FastPatch on bare ground, dirt, grass or other non-structural surfaces. Applications surfaces must be dry.

PROCESSING

1. Precondition Kits to 70°F (21°C) for 24 hours before use.
2. For colder temperature conditions, use FastPatch Kicker to shorten cure time. Kits can be heated up to 100°F (38°C) to speed cure at colder temperatures. Kits can be cooled 50°F to extend work time in warmer conditions.
3. Overly cold kits will not flow or level properly, and cure time will be slow. Overly hit kits will shorten work time.
4. Check that primed surfaces are ready for application before mixing and applying FastPatch.
5. Protect surfaces around the repair area with tape to prevent contamination of surrounding surface.
6. Place mixing station a short distance from the application area.
7. Wear gloves and safety glasses while mixng and applying material.
8. Attach a clean, "eggbeater–style" mixing paddle to a mechanical drill with a minimum of 500RPM.
9. Use entire kit and do not divide.

APPLICATION

1. Remove contents of FastPatch kit and leave aggregate in the bucket.
2. Open Part A package and pour over aggregate. Mix 2 minutes.
3. OPTION 1: For gray, mix Part B with aggregate mixture.
   OPTION 2: For black, add BLACK pigment to aggregate mixture then add Part B.
   OPTION 3: For speeding system, add FastPatch Kicker to aggregate mixture then add Part B. FastPatch Kicker is sold separately, and recommended in cold weather.
   OPTION 4: For extending kit yield up to 3.5 gallons (14L), 1.5 gallons (6L) of 3/8" (1 cm) pea gravel may be added to aggregate mixture. Up to half bag of excess topping sand may be added to kit to improve slope application.
4. Mix for 2 minutes. Scrape sides and bottom while mixing. MATERIAL WILL NOT SET IF POORLY MIXED. Signs of poor mixing include dark swirls and tacky material that does not solidify.
5. Immediately pour in area. Level to surrounding surface.
6. After 10 minutes, sprinkle NATURAL or BLACK topping sand to match surrounding surfaces.
7. Material is typically ready for traffic in 1-hour at 70°F (21°C). Colder temperatures will slow cure. Warmer temperatures will speed cure.

SKID RESISTANCE: It is the responsibility of the Applicator to ensure product meets minimum skid resistance requirements. Refer to the agency or end-user friction management policy or specifications to determine minimum skid resistance and test method requirements. Aggregate (Sand, pumice, flint) can be added topically at the gel stage or Fastpatch can be ground, sanded or abraded to achieve any necessary skid resistant texture.

CLEANING & MAINTENANCE

Clean equipment with POLYQuik® Cleaner or acetone immediately after use. Cured material must be removed mechanically.

HEALTH AND SAFETY

Before handling, you should become familiar with the Material Safety Data Sheet (MSDS) regarding the risks and safe use of this product. To obtain an MSDS please call 800 333 9826 or send an email to: msds@wilvaco.com.

WILLAMETTE VALLEY COMPANY
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DIVISIONS

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Revision Date: September 2014

Rapid Surface Repair Easy Mix™

Fast Turnaround Surface Repair for Roads & Bridges

PRODUCT DESCRIPTION

Five Star® Rapid Surface Repair Easy Mix is a self-leveling, low viscosity, two-part liquid polyurethane-hybrid polymer. When supplemented with its proprietary blended aggregate, this product is used to repair and rehabilitate concrete and asphaltic concrete pavements. The enhanced polymer is high performance, rapid setting, and can be used to make an impact and traffic resistant polymer concrete that can be used at temperatures down to 0°F (-18°C). Within minutes of placement, durable, long-lasting repairs are able to handle vibration, heavy traffic, and thermal movement.

ADVANTAGES

- No priming required to bond to concrete, asphalt, steel or wood
- Waterproof, chemically resistant membrane protects substrates from freeze-thaw spalling
- Use neat or with aggregate
- Stops further corrosion of reinforcing steel
- Traffic ready in as little as 30 minutes*
- Very low odor
- Make repairs year round — can be used in temperatures down to 0°F (-18°C)

USES

- Expansion joint and bridge header reconstruction
- Control joint filler
- Repair cracks, potholes, spalls
- Resurface runways, walkways, floors, and parking lots

PACKAGING AND YIELD

Five Star® Rapid Surface Repair Easy Mix is packaged in either .64 gal. (2.42 L) kits containing .32 gal. (1.21 L) “A” & .32 gal. (1.21 L) “B” and 50 lbs. of aggregate yielding approximately .41 ft^3 (.011 m^3) per kit, or in 55 gal. (208.2 L) "A" & 55 gal. (208.2 L) "B" drums. Aggregate for the drum kits is sold separately. When mixed with 172 bags of aggregate (50 lb.), drum kits will yield 70.4 ft^3 (2.0 m^3).

SHELF LIFE

One year in original unopened packaging when stored in dry conditions; high relative humidity and temperature will reduce shelf life.

**Traffic time dependent upon air and substrate temperature.*

TYPICAL PROPERTIES AT 77°F (25°C)	
Mix Ratio by Volume	(1) Part A : (1) Part B
Viscosity @ 77°F (25°C) - mixed	60 cps
Gel Time, Neat	2 to 3 minutes
Working time with Aggregate	Approx. 5 minutes
Cured	
Color	Dark Grey
Cure Time (reopen to traffic)	30 minutes
Hardness, Durometer D, ASTM D-2240	70
Tensile Strength, ASTM D-412	3,000 psi (20.7 MPa)
Compressive Strength, ASTM C-579B	
1 hour	2,000 psi (13.8 MPa)
1 day	6,000 psi (41.3 MPa)
7 days	7,000 psi (48.2 MPa)
28 days	8,000 psi (55.1 MPa)
Elongation, ASTM D-638	10 - 15%
Bond Strength, ASTM C-882	2,000 psi (13.8 MPa)

The data shown above reflects typical results based on laboratory testing under controlled conditions. Reasonable variations from the data shown may result. Test methods are modified where applicable.

PLACEMENT GUIDELINES

SURFACE PREPARATION

1. Prepare concrete surfaces to a minimum CSP-4 (Concrete Surface Profile per ICRI Technical Standard 03732. Ensure surfaces are clean, sound and rough prior to repair.
2. For overlays, cut keyway channel (groove) using concrete saw equipped with dry cut diamond blade around perimeter of area to be resurfaced. Keyway channel (groove) depth shall be a minimum of 1/2 inch (12.7 mm). Surfaces adjacent to a vertical plane (such as curbs, walls, tanks, etc.) shall have keyway channels cut approximately 4 – 6 inches (101.6 - 152.3 mm) back from vertical plane towards the interior of area to be resurfaced. Keyway channel shall be 1/2 inch (12.7 mm) deep by 1/2 inch (12.7 mm) wide.
3. For overlays, chip 2 inch (50.8 mm) wide taper back from interior edge of keyway channel at all termination edges (i.e., drains, doors, etc.). Using bush hammer or chipping gun equipped with a 1 – 2 inch (24.4 - 50.8 mm) wide spade blade, chip a 2 inch (50.8 mm) wide taper back from edge of interior keyway channel (groove) inward towards the area being resurfaced. Taper shall match depth of keyway channel at its deepest point, which is the edge of the keyway, and taper out to 0 inches at its most shallow point, 2 inches (50.8 mm) towards the interior of the area to be resurfaced.
4. For crack filling, route out as necessary to a maximum 1/2 inch wide by 1/2 inch deep.
5. Vacuum dust and dirt from all surfaces.
6. Surfaces must be completely dry and free of moisture prior to installation.

MIXING INSTRUCTIONS: Mix ratio is 1:1 by volume. Mix a small sample and test prior to actual placement. Larger mix volumes can generate significant exotherm. Mix Components A & B thoroughly with drill and paddle for 30 seconds then add aggregate. Continue mixing for 30 seconds until aggregate is completely wetted.

NOTE: PRIOR TO APPLICATION, READ ALL PRODUCT PACKAGING THOROUGHLY. *For more detailed placement procedures, refer to Five Star® Design-A-Spec™ installation guidelines or call Five Star Products' Engineering and Technical Service Center at 1-800-243-2206.*

CLEAN-UP: Clean tools immediately after use with xylene or MEK.

CONSIDERATIONS

- Product should be stored at 50–80°F (10–27°C).
- Product may be installed between 0–100°F (-18–37°C). For temperatures above or below these limits please consult Five Star Products' Engineering and Technical Service Center at 1-800-243-2206.
- Keep material out of sun or hot areas prior to applying, as this may cause working time to be diminished and could cause poor appearance and/ or adhesion.

CAUTION

This product may cause skin and eye irritation. Do not inhale vapors. Provide adequate ventilation. Protect against contact with skin and eyes. Wear rubber gloves, long sleeve shirt, goggles with side shields. In case of contact with eyes, flush repeatedly with water and contact a physician. Areas of skin contact should be promptly washed with soap and water. Do not take internally. Keep product out of reach of children. **PRIOR TO USE, REFER TO SAFETY DATA SHEET**.

For worldwide availability, additional product information and technical support, contact your local Five Star® distributor, local sales representative, or call Five Star Products' Engineering and Technical Service Center at 1-800-243-2206.

SKU / PRODUCT CODE	DESCRIPTION	#UNITS/PALLET	UNIT SIZE
30928	Five Star® Rapid Surface Repair Easy Mix Kit	120	Resin (A): 0.32 gal (1.2 L) Hardener (B): 0.32 gal (1.2 L) Aggregate (C): 50 lb. (22.7 kg) bag
30931	Five Star® Rapid Surface Repair Easy Mix Drums	4 drums	Resin (A): 55 gal (208.2 L) Hardener (B): 55 gal (208.2 L) Aggregate not included
30929	Five Star® Rapid Surface Repair Easy Mix Aggregate	60	50 lb. (22.7 KG) Bag

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Specifications Subject to Change.
For most current version of datasheet, go to FiveStarProducts.com

ISO 9001:2008 CERTIFIED

Rapid Surface Repair EpoxyFix™

Concrete and Asphalt Pavement Repair

PRODUCT DESCRIPTION

Five Star® Rapid Surface Repair EpoxyFix™ is a unique, low viscosity, two-part liquid, epoxy-hybrid polymer. When supplemented with aggregates, this product is used to repair and rehabilitate concrete and asphaltic concrete pavements. The enhanced polymer is high performance, rapid setting, has a high tolerance for moisture, and can be used to make a resilient polymer concrete. Fast curing, durable, long -lasting repairs are able to handle vibration, heavy traffic, and thermal movement.

ADVANTAGES

- High moisture tolerance
- Superior bond strength
- No priming required to bond to concrete, asphalt or steel
- Traffic ready in as little as 35-40 minutes[1]
- No toxic fumes during application.
- Use any clean, locally sourced stone (does not need to be kiln-dried)
- Make repairs, resurface pavements and apply protective coating year round — hot or cold.
- No VOCs

USES

- Control joint filler
- Spall and pothole repairs on concrete and asphalt pavement
- General concrete patching where flexibility is required
- Surface repairs on roads, bridges, runways, industrial floors, parking lots
- Expansion joint and bridge header reconstruction

PACKAGING AND YIELD

Five Star® Rapid Surface Repair EpoxyFix™ comes packaged in:

- 10 gal. (37.9 L) kits: 5 gal. (18.9 L) "A" & 5 gal. (18.9 L) "B"
- 100 gal. (379.0 L) kits: 50 gal. (189.0 L) "A" & 50 (189.0 L) gal. "B"

Typically, one cubic foot repair requires 3.2 gallons (12.1 liters) of liquid.

SHELF LIFE

Two years in original unopened packaging when stored in dry conditions; high relative humidity and temperature will reduce shelf life.

[1]Traffic time dependent upon air and substrate temperature and depth of application.

TYPICAL PROPERTIES AT 70°F (21°C)	
Mix Ratio	(1) Part A : (1) Part B
Viscosity @ 73°F	Part A: 1,600 cps / Part B: 500 cps
Specific Gravity	Part A: 1.15 / Part B: 1.08
Cured	
Color	Clear to Amber/Assumes Color of Aggregate
Specific Gravity, ASTM D-792	1.08 g/cc
Hardness, Durometer D, ASTM D-2240	55 +/- 5
Tensile Strength, ASTM D-412	800 psi (5.5 MPa)
Compressive Strength, ASTM C-579B[2]	2,800 psi (19.3 MPa)
Elongation at Break, ASTM D-638	95%
Bond Strength, ASTM C-882	Concrete Failure

[2]With commercially available dried 3/8" crushed stone.

The data shown above reflects typical results based on laboratory testing under controlled conditions. Reasonable variations from the data shown may result. Test methods are modified where applicable.

PLACEMENT GUIDELINES

SURFACE PREPARATION

1. Prepare concrete surfaces to a minimum Concrete Surface Profile (CSP) 4 to 5 in accordance with ICRI Technical Standard 310.1R (International Concrete Repair Institute) guidelines. As an alternative, roughen concrete surfaces to coarse aggregate exposure. Blow out all repair areas thoroughly with oil free compressed air, removing all dust, debris and bond inhibiting substances. Vertical saw-cut surfaces should be sandblasted and clean.
2. All surfaces should be visibly dry prior to placement. Surfaces may be damp but best adhesion is to dry surfaces, use a torch or heat gun to dry excessively wet areas.
3. For optimum performance, liquid components should be conditioned to between 70-90°F (21-32°C) prior to use. Aggregate should be heated to a minimum 90°F (32°C) and a maximum 140°F (60°C).

MIXING: NOTE: Mix ratio is 1:1 by volume. Material may be mixed through a self-dispensing injection unit such as plural component dispensing/mixing equipment. For machine installed product refer to your operator's manual and/or consult Five Star Products' Engineering and Technical Service Center at 1-800-243-2206 for specifics.

HAND MIX INSTRUCTIONS: Five Star® Rapid Surface Repair EpoxyFix™ may be used for small repairs. Measure exactly equal amounts by volume of components A & B. Mix together for 1 to 2 minutes depending on volume and temperature. Remember, as material quantities increase, heat generated by the product increases and the pot life of mixed product will decrease respectively. Place material IMMEDIATELY after mixing.

AUTOMATED DISPENSING METHOD: Five Star® RSR EpoxyFix™ products are applied using heated liquid polymer dispensing systems and utilize an Automated Dispensing Method (ADM) for fast cure times that shorten return to traffic time considerably. Part A and Part B liquids are heated to 145-150°F (63-66°C) using drum/band heaters, then pumped, blended by static mixer and applied directly into the aggregate. This heating method lowers the viscosity of the liquids to around 100cps and allows for a higher rate of dispensing and relatively low power usage for the pumps.

APPLICATION

1. Repair areas should have aggregate pre-placed at thicknesses of 1 to 4 inches per lift. Use 3/8" aggregate.
2. The liquids are dispensed using a Five Star® FAST-CAT (dispensing/mixing injection equipment) via a static mixer through pre-placed aggregate or poured in place. Placement must be continuous to prevent cold joints. Continue applying liquids through aggregate until liquids can be seen puddling on top surfaces of aggregate and aggregate no longer accepts liquids. For multiple lifts, pre-place additional aggregate immediately, spread and level and continue applying liquids through the next layer of aggregate. Repeat as necessary depending upon thickness of repair.
3. A topping sand or similar may be broadcast on top for skid resistant surfaces. Remove excess once material hardens.

NOTE: PRIOR TO APPLICATION, READ ALL PRODUCT PACKAGING THOROUGHLY. *For more detailed placement procedures, refer to Five Star® Design-A-Spec™ installation guidelines or call Five Star Products' Engineering and Technical Service Center at 1-800-243-2206.*

CLEAN-UP: Clean tools immediately after use with xylene or MEK.

CONSIDERATIONS

- Product should be stored at 60 - 110°F (15 - 43°C), and conditioned to a minimum of 70°F (21°C) prior to installation.
- Product may be installed between 40 - 110°F (4 - 43°C). For temperatures above or below these limits please consult Five Star Products' Engineering and Technical Service Center at 1-800-243-2206.
- Minimum substrate temperature 40°F (4°C) and rising with conditioned materials.
- Colder temps will reduce strength gain and time to traffic.
- For temperatures below 40°F (4°C), use Five Star® RSR EpoxyFix™ LT.

CAUTION

This product may cause skin and eye irritation. Do not inhale vapors. Provide adequate ventilation. Protect against contact with skin and eyes. Wear rubber gloves, long sleeve shirt, safety goggles. In case of contact with eyes, flush repeatedly with water and contact a physician. Areas of skin contact should be promptly washed with soap and water. Do not take internally. Keep product out of reach of children. **PRIOR TO USE, REFER TO SAFETY DATA SHEET**.

For worldwide availability, additional product information and technical support, contact your local Five Star® distributor, local sales representative, or you may call Five Star Products' Engineering and Technical Service Center at 1-800-243-2206.

SKU / PRODUCT CODE	DESCRIPTION	# UNITS/PALLET	UNIT SIZE
30936	Five Star® Rapid Surface Repair EpoxyFix™ Kit (Part A & B)	36 (18 kits)	Resin (A): 5 gal (18.9 L) Hardener (B): 5 gal (18.9 L)
30939	Five Star® Rapid Surface Repair EpoxyFix™ Drums (Part A & B)	4 (2 kits)	Resin (A): 50 gal (189.3 L) Hardener (B): 50 gal (189.3 L)
17620	Five Star® 3/8" Crushed Stone Aggregate	60	50 lb. (22.7 kg) Bag
17630	Five Star® 6-10 Broadcast Sand	60	50 lb. (22.7 kg) Bag

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Specifications Subject to Change.
For most current version of datasheet, go to FiveStarProducts.com

ISO 9001:2008 CERTIFIED

ProSpec® Concrete Patching Mix

1. PRODUCT NAME
ProSpec® Concrete Patching Mix

2. MANUFACTURER
Akona® Manufacturing, LLC, a TCC Materials® company
(Akona® Manufacturing is a licensed manufacturer of ProSpec®)
2025 Centre Pointe Blvd, Suite 300
Mendota Heights, MN 55120 USA

Phone: 1.651.688.9116
Fax: 1.651.688.9164
Internet: tccmaterials.com

3. PRODUCT DESCRIPTION
ProSpec® Concrete Patching Mix is a dry mixed combination of Portland Cement and aggregates that is proportioned and manufactured according to MnDOT specification 3105 for grade 3U18. When mixed according to specifications with water and admixtures, it is an ideal mixture for repairing concrete pavement, industrial floors, and structural concrete.

Features and Benefits
- Pre-blended concrete mixture
- High compressive strength
- Excellent durability
- Freeze/thaw resistant (when used with Air Entraining Admixture and water reducing admixture)
- Plasticized

*Call TCC Materials for state DOT approvals

Uses
- Full and partial depth repairs
- Roads and highways
- Parking structures
- Industrial floors
- New construction

SAFETY
READ THE SAFETY DATA SHEET (SDS) BEFORE USING THIS PRODUCT. SDS information is available on our website: tccmaterials.com or contact TCC Materials® at 651-688-9116 (7:30 AM to 4:00 PM, M-F, Central US Time).

CAUTIONS
Read complete cautionary information printed on product container prior to use.

This Product Data Sheet has been prepared in good faith on the basis of information available at the time of publication. It is intended to provide users with information about and guidelines for the proper use and application of the covered ProSpec® brand product(s) under normal environmental and working conditions. Because each project is different, neither ProSpec® nor TCC Materials® can be responsible for the consequences of variations in such conditions, or for unforeseen conditions.

4. TECHNICAL DATA
Complies with ASTM C387

Typical Values • ProSpec Concrete Patching Mix		
	Mixed with water only	Mixed with Air Entraining Admixture and water reducing admixture
Unit Weight	147.2 lb.ft3	145.8 lb/ft3
Air Content	3.1%	5.9%
Slump	1 in. (25 mm)	1 in. (25 mm)
Water/Cement Ratio	0.385	0.345
Initial Set (hr:min)	~ 3:00	3:15
Final Set (hr:min)	~ 4:40	4:15
Compressive Strength ASTM C 39 (Moist Cured)		
24 hours	4,400 psi (30.3 MPa)	5,230 psi (36 MPa)
3 days	6,150 psi (42.4 MPa)	7,170 psi (49.4 MPa)
7 days	7,090 psi (48.9 MPa)	8,290 psi (57.1 MPa)
28 days	7,820 psi (53.9 MPa)	8,390 psi (57.8 MPa)
Flexural Strength ASTM C 78 (Moist Cured)		
7 days	840 psi (5.8 MPa)	1,035 psi (7.1 MPa)
28 days	1,060 psi (7.3 MPa)	1,055 psi (7.3 MPa)
Rapid Chloride Permeability ASTM C 1202		
RCP 28 day	2,400 C	1,191 C
RCP 56 day	1,174 C	1,153 C

Test results obtained under controlled laboratory conditions. Reasonable variations can occur due to atmospheric and job site conditions.

LEED® Eligibility[1]

- Regional Materials (MR-c4, MR-c5)

Packaging

50 lb. (22.7 kg.) bag (BOM #126198)

Shelf Life

12 months from the date of manufacture when stored in the original, unopened container, away from moisture, under cool, dry conditions and out of direct sunlight.

Commercial Approvals

- Meets MNDOT specification 3105 for Grade 3U18 patching mixes

5. INSTALLATION

Preparation

All materials should be conditioned to 50°-75°F (10°-24°C) 24 hours prior to installation. Proper surface repair preparation is crucial to achieving a successful application.

1. Roughen surface and remove all unsound concrete. Clean area and remove grease, oil, paint, and any other foreign materials that will inhibit performance.
2. All concrete surfaces must be fully cured, structurally sound and non-flexing.
3. The surface should be saturated with water, Saturated Surface Dry (SSD) with no puddling of water, prior to placement.

Note: It is the responsibility of the installer/applicator to ensure the suitability of the product for its intended use.

Job Mockups

The manufacturer requires that when its ProSpec® products are used in any application or as part of any system that includes other manufacturers' products, the contractor and/or design professional shall test all the system components collectively for compatibility, performance and long-term intended use in accordance with pertinent and accepted industry standards prior to any construction. Written documentation of the tests performed shall be satisfactory to the design professional and contractor. Test results must include the means and methods of application, products used, project-specific conditions being addressed, and standardized tests performed for each proposed system or variation.

Mixing

Mixture should be placed within 60 minutes of batching. For best results use a concrete drum mixer or a paddle mixer. For concrete that will be exposed to freezing and thawing, use an Air Entraining Admixture meeting ASTM C260, such as ProSpec Liquid Air Entraining Admixture, and use a High Range Water Reducing Admixture meeting ASTM C494 Type F. Admixtures should be dosed based on manufacturer's recommendations and should be verified with test batches. Concrete should obtain 1 in. (25 mm) maximum slump and 6.5% air and should not use more than 4.75 pints of water per 50 lb. bag. Use of less water will result in higher compressive strength.

1. Start with a clean mixer that has been wetted down but does not have any standing water.
2. Place water and admixtures into mixer according to guidelines listed above. Mixing the admixtures thoroughly into the mix water will help evenly disperse them and aid with mixture consistency.
3. Place desired number of bags in the mixer. Always use full bags only. Do not exceed mixer capacity
4. Mix 3-5 minutes to a uniform, lump free consistency
5. Maintain water content, admixture dosages and mixing time from batch to batch to ensure product consistency.

If concrete mixture will be placed in an interior application, water reducer and air entrainment are not required for concrete durability. In that case, use the same mixing steps as listed above, but Maintain water and mixing time consistency among batches. but use 4-5 pints of water per bag (adjust water content to get 1 in. (25 mm)" slump).

Application

Apply only when air and substrate temperatures are between 50°–90°F (10°-32°C) within 24 hours of application and placement, and when rain is not forecast 24 hours after.

1. Shovel or place mixture immediately into pre-dampened prepared area. Application should be between 1½ in. (38 mm) to full depth.
2. Once the mixture has been compacted and spread to completely fill forms or patch, strike off with a straight board or screed, moving the edge back an forth with a saw-like motion. Use a darby or bull float to level any ridges and fill voids left by the screed.
3. Concrete shall be used and placed in final position within 1 hour after initial mixing or discarded at that time under normal temperatures. Warm temperatures will accelerate set.
4. Allow the concrete to reach initial set, wait for all water to evaporate from the surface before finishing with a trowel or broom. Can be open to foot traffic in 6 hours, wheeled traffic in 24 hours.
5. Do not retemper Concrete Patching Mix. Do not overwork the concrete mixture.

Curing

Always follow industry standard practices for finishing and curing concrete patches as described in ACI Manual of Concrete Practice.

Refer to:
ACI 308 Standard Practice for Curing Concrete

Cleaning

Use clean potable water to clean all tools immediately after use. Dried material must be mechanically removed. Use a waste water hardener (e.g. Conglez™ or similar product) for cementitious waste disposal.

Limitations

- Apply only to surfaces that are fully cured, frost free and above 50°F (10°C) and below 90°F (32°C) within 24 hours of application and 48 hours thereafter.
- Shade and protect patch in windy and/or hot weather conditions.
- During weather warm conditions, keeping mixing water and material cool should assist in maintaining open time of the product. During cold weather conditions, the use of warm mixing water and warming surfaces should accelerate set times.
- Do not over-work, over-water, retemper or overmix.
- Do not bridge over existing expansion or control joints.
- Do not mix more concrete than can be placed in 1 hour.
- ProSpec® Concrete Patching Mix should be installed in accordance with local building code provisions and all applicable ASTM standards.

Coverage

50 lb. (22.7 kg) bag yields approximately 0.45 cu. ft. (12.7 L) at a flowable consistency.

6. AVAILABILITY

To locate ProSpec® products in your area, please contact:

Phone: 1.651.688.9116
Website: tccmaterials.com

7. WARRANTY

Seller warrants that its product will conform to and perform in accordance with the product specifications. The foregoing warranty is in lieu of all other warranties, expressed or implied, including, but not limited to those concerning merchantability and fitness for a particular purpose. Because of the difficulty in ascertaining and measuring damages hereunder, it is agreed that Seller's liability to the Buyer shall not exceed the total amount billed and billable to the Buyer for the product hereunder.

8. MAINTENANCE

Not applicable.

9. TECHNICAL SERVICES

Technical Assistance:
Information is available by calling TCC Materials®
(hours 7:30 AM to 4:00 PM, M-F, CST):

Phone: 1.651.688.9116
Fax: 1.651.688.6164
Web: tccmaterials.com

Technical and Safety Literature:
To acquire technical and safety literature, please visit our website at: tccmaterials.com.

10. FILING SYSTEM

Division 3

[1] ProSpec® products can contribute to LEED® credits within the Material Resource, (Recycled Content & Regional Materials) and Indoor Environmental Quality (Low Emitting Materials).

Data Sheets are subject to change without notice. For the latest revision, check our website at tccmaterials.com

TCC MATERIALS
SPEC BLENDED CONSTRUCTION PRODUCTS®
2025 Centre Pointe Blvd, Suite 300,
Mendota Heights, MN 55120

REV 01/17

AQUA PATCH

Save money by eliminating repeat repairs!

Fast - Traffic-ready immediately

Easy - Just add water

Environmentally friendly

Permanent - As hard as hot mix asphalt

Convenient - Use in Winter or Summer, rain or shine!

U.S. Patented

Doing the job right - the first time, is now faster and easier than ever!

AQUA PATCH saves time and money while delivering a superior, permanent repair to asphalt and concrete surfaces. This cold-mix, water-activated product is environmentally friendly. It sets up quickly and is traffic-ready immediately.

Unlike other asphalt patching solutions, AQUA PATCH provides a permanent solution, using revolutionary organic renewable additives, so you don't have to continually repair the same trouble spot, or replace a temporary fix with a permanent solution.

Don't let weather interfere with your production schedule. You can use AQUA PATCH all year round, in all types of weather, hot or cold, wet or dry. Rain and moisture actually helps accelerate the process.

AQUA PATCH is traffic-ready immediately after compaction, so road repairs don't tie up traffic as long.

AQUA PATCH comes ready to use and application is quick and easy. Simply clear debris from the repair area, apply AQUA PATCH, add water and tamp it down. Fast, easy and permanent!

Environmentally friendly
AQUA PATCH is water activated, environmentally friendly and non-toxic. No hydrocarbon leaching or evaporation.

1. Apply AQUA PATCH

2. Add water

3. Tamp down

AQUA PATCH

Permanent Asphalt/Concrete Repair Solution

AQUA PATCH is a cold-mix, permanent repair solution for asphalt and concrete applications that reacts with water to harden quickly, being traffic-ready immediately. The proprietary hardening agent is environmentally friendly and renewable.

Instant Strength Development

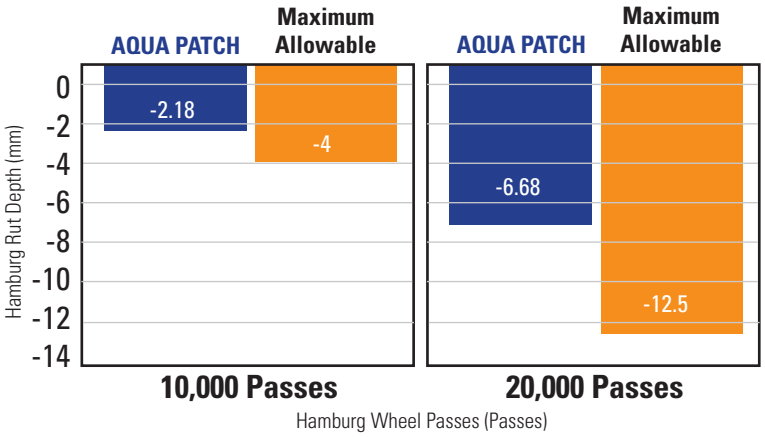
Applications:

- Asphalt road patching
- Concrete road repairs
- Pothole repairs
- Driveways, walkways and parking lots
- Utility cuts and manhole repairs
- Bridge joints

Benefits:

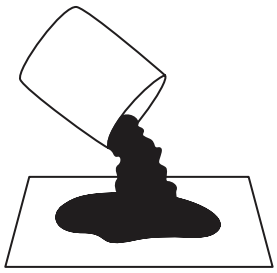
- Easy - pour, add water and tamp
- Durable - as hard as hot mix asphalt
- Fast & hard - traffic-ready immediately
- Saves money - eliminates repeat repairs
- Environmentally friendly
- Can be sealed with a seal coat immediately after one hour cure.

Hamburg Wheel Tracking Test (AASHTO T324)

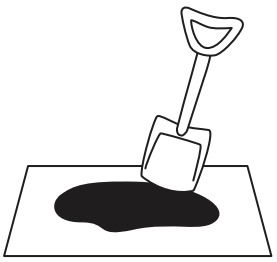


1. Remove loose debris and clean the area to be patched.

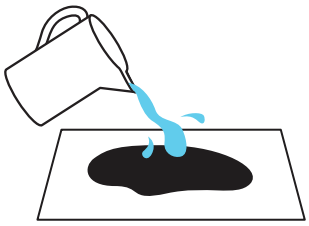
2. Pour AQUA PATCH in the hole.



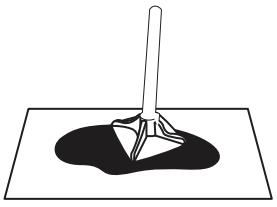
3. Spread and level. If deeper than 2 inches, apply in two layers.



4. Pour water over AQUA PATCH evenly. Excess water does not damage the material, or undermine the repair.



5. Compact into a smooth finish.



AQUA PATCH

AquaPatchAsphalt.com • 844-869-8873

CRAFCO INC
AN ERGON COMPANY
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www.crafco.com

PRODUCT DATA & INSTALLATION INSTRUCTIONS

HP CONCRETE COLD PATCH

PART NO. 34969

October 2013

READ BEFORE USING THIS PRODUCT

GENERAL Crafco HP Concrete Cold Patch is a unique, gray color, cold applied, single component patching material used for repairing potholes, spalls, cracks and other confined voids and distresses over 1 inch wide and greater than ½ inch deep, in portland cement concrete pavement, slab and deck surfaces. It can be used to repair roads, highways, streets, airport pavements, parking lots, bridge and parking decks, sidewalks, walkways and floors. HP Concrete Cold Patch is composed of a specially designed thermoplastic binder and a unique aggregate composition that produces an easy to use durable patching material that is a gray color like portland cement concrete. HP Concrete Cold Patch can be used in most weather conditions and will adhere in cold and damp conditions. Unlike most other concrete patching materials, no mixing, heating or special installation equipment is required. HP Concrete Cold Patch is the easiest to use and has the fastest installation of all types of concrete patching materials. To use, HP Concrete Cold Patch is simply removed from the bag, placed into the prepared area to be patched, leveled and then compacted. The patch is then ready for traffic immediately after compaction. No additional curing time is needed.

PROPERTIES Properties of Crafco HP Concrete Cold Patch are as follows:

Compacted In Place Unit Weight	125 pcf
Compacted In Place Density	2.0
Weight per Bag	50 lbs
Volume per Bag	0.40 cu ft
Workability	30 to 100F
Aggregate Size	100% passing 3/8 inch
Aggregate Durability	40% maximum Loss
Binder Coating Durability	95% minimum

INSTALLATION The repair area is to be swept clean of all loose debris and blown clean before applying patching material. The repair area surfaces can be damp but should not have free moisture present during installation. The HP Concrete Cold Patch is removed from the bag and placed into the prepared repair area. For best performance, HP Concrete Cold Patch should be applied at least ½ inch in thickness. For repairs from ½ inch to 2 inches thick, apply product in a single layer and compact. Repairs deeper than 2 inches should be filled in layers, from 1 to 2 inches thick, with compaction of each layer. The final layer should be placed approximately ¼ to ½ inch above the surface, and then be compacted to surface level with a hand or mechanical tamper or multiple passes from a vehicle tire. Compaction should be sufficient to produce firm material in the repair. Following compaction, any excess patch material is then cleaned up and the repair area can be opened to traffic. Just after installation and compaction, HP Concrete Cold Patch will be a malleable material that will not be dislodged by traffic. Over time the surface will harden. If needed at warm temperatures, initial surface tack can be reduced with a light sprinkle application of portland cement, calcium carbonate powder, or fine sand over the compacted surface. HP Concrete Cold Patch should be installed when pavement temperatures are between 30 and 100F. If applying when pavement temperatures are below 30F, the repair area can be warmed to at least 30F using a torch or heat lance. To improve workability when installing product at colder temperatures, product can be stored in a warmer area not exceeding 90F prior to use, and bags can be dropped on the ground to loosen the material, if needed.

STORAGE Pallets and bags of HP Concrete Cold Patch should be kept intact and stored under cover. Shelf life of properly stored product in unopened pallets and bags is up to 1 year. To maintain workability, leftover HP Concrete Cold Patch from an opened bag should be placed in an airtight container such as a pail or bucket with a tight fitting lid.

PACKAGING Packaging consists of individual 50 pound plastic bags which are stacked on standard 40 by 48 inch pallets. Each pallet contains 56 bags, producing a pallet weight of 2800 lbs. Palletized units are protected from the weather using a plastic pallet cover, and a minimum of two layers of six month u.v. protected stretch wrap. Pallets are labeled with the product name, part number, lot number and net product weight.

WARRANTY CRAFCO, Inc. warrants that CRAFCO products meet applicable specifications at time of shipment. Techniques used for the preparation of the areas to be repaired are beyond our control as are the use and application of the product; therefore, Crafco shall not be responsible for improperly applied or misused product. Remedies against Crafco, Inc., as agreed to by Crafco, are limited to replacing nonconforming product or refund (full or partial) of purchase price from Crafco, Inc. All claims for breach of this warranty must be made within three (3) months of the date of use or twelve (12) months from the date of delivery by Crafco, Inc. whichever is earlier. There shall be no other warranties expressed or implied. For optimum performance, follow Crafco recommendations for product installation.

CRAFCO® INC
PRESERVATION PRODUCTS PAVEMENT
Delivering Confidence Through Innovation, Quality and Value Since 1976

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www.crafco.com

PRODUCT DATA SHEET

TECHCRETE™-R / TECHRETE™-TBR

PART NO. 34952 (Type R)
PART NO. 34953 (Type TBR)

NOVEMBER 2015

READ BEFORE USING THIS PRODUCT

GENERAL TechCrete is gray in color, aesthetically suitable in all concrete pavements, and is used in sealing wide cracks and joints, and repairing a large variety of pavement distresses in Portland Cement Concrete Pavement and Asphalt Concrete Pavement. Pavement distresses appropriate for TechCrete include but are not limited to: A) Cracking (Corner breaks, Longitudinal and transverse cracking), B) Joint Deficiencies (Spalling of longitudinal and transverse joints), C) Surface Defects (Map cracking and scaling, Popouts), and D) Miscellaneous distresses (Blowups, Faulting of transverse joints and cracks, Lane-to-shoulder dropoff, Lane-to-shoulder separation, and Patch/Patch deterioration). TechCrete is used in highway, street, road, parking lot, bridge decks, airport taxiways and runways, and other pavement surfaces. The unique design features of TechCrete produce an impervious, impact-resistant; load-bearing, flexible repair that withstands vehicle traffic, aircraft, movement and climatic conditions.
VOC = 0 g/l.

TechCrete-R ("TC-R") and TechCrete-TBR ("TC-TBR") are hot-applied, flexible mastic sealant compounds made of polymer-modified synthetic resin containing fibers, fillers, fines and high quality aggregate. TC-R and TC-TBR are supplied in powder / granular form in meltable bags. To use, bags of TC-R or TC-TBR are placed in an approved melter (Crafco Patcher I or II) where it is mixed and heated to the required installation temperature range. Heated TC-R or TC-TBR is then poured into the prepared pavement section and leveled as described in the Installation Instructions. The repair is then covered with a specific surfacing aggregate (Crafco Part No. 33374) or a surfacing aggregate specified in the project plan and approved by Crafco. The repair is allowed to cool and solidify prior to opening to traffic.

Read all information prior to using TC-R or TC-TBR: 1) Product Data Sheet, 2) Safety Data Sheet, 3) Installation Instructions, and 4) Patcher Equipment Safety Manual.

TechCrete is supplied as TechCrete-R and TechCrete-TBR.

Product	Recommended Use
TechCrete-R ("TC-R") Part Number 34952 Contains ideal pre-measured, pre-mixed combination of proprietary binder and fine aggregate designed to provide all the benefits of TechCrete. TC-R contains smaller aggregate than TC-TBR and is used in shallow repairs where neat edge feathering is required.	**Wide Cracks and Joints** TC-R is designed to treat wide cracks and joints with a minimum width of 1.5 inches (38 mm) and up to 4 inches (100 mm) wide and up to full-depth repairs. **Surface Defects and Miscellaneous Distresses** TC-R is designed for treating most other distresses as partial-depth repairs less than to 0.75 inch (20 mm) deep.
TechCrete-TBR ("TC-TBR") Part Number 34953 Contains ideal pre-measured, pre-mixed combination of proprietary binder and aggregate designed to provide all the benefits of TechCrete. TC-TBR contains larger aggregate than TC-R and is used in larger and deeper repairs- a minimum of 1.5-inch depth (38 mm) is required to install	**Wide Cracks and Joints** TC-TBR is designed to treat wide cracks and joints greater than or equal to 2 inches (50 mm) wide and up to full-depth repairs. **Surface Defects and Miscellaneous Distresses** TC-TBR is designed for treating most other distresses as partial-depth repairs from 0.75 to 8 inches (20 to 200 mm) deep, recognizing that the minimum application depth is 1.5 inches (38 mm). For deeper repairs, while not required, TechCrete-R & TBR can be bulked with additional aggregate - contact your Crafco representative.

SPECIFICATION CONFORMANCE Specification limits for TC-R and TC-TBR are as follows:

PARAMETER	TechCrete-R	TechCrete-TBR
Color	Gray	Gray
Form	Powder	Powder
Specific Gravity (ASTM D2726 Modified)	2.08	2.03
Binder Content (ASTM D6307 Method A), %	15 – 25	15 – 25
Aggregate Passing the 0.625 inch (ASTM D5444), % Retained on the No. 16, % Passing the No. 4 Sieve, %	-- -- 100 minimum	100 minimum 55 minimum --
Flow (ASTM D5329 Modified), 5 h 140˚F(60˚C), mm	5 maximum	5 maximum
Tensile Test (Briquette) (AASHTO T140 Modified TTM5) at 20˚F (-7˚C), 3 specimens, pounds.	50 – 200 (222 – 890 N)	50 – 200 (222 – 890 N), at least 2 out of 3 fail between grips
Tensile Adhesion, (ASTM D5329 Modified), psi (kPa)	12 psi (83 kPa) minimum, 0.5 inches (12 mm) minimum elongation	12 psi (83 kPa) minimum, 0.5 inches (12 mm) minimum elongation
Impact Testing (ASTM D2794, 2 inch (50 mm) diameter, 1 inch (25 mm) thick specimen, 0.625 inch (16 mm) impact dart	No cracking, chipping or separation at 6 ft·lb (8.1 N·m) at 20ºF (-7ºC)	No cracking, chipping or separation at 6 ft·lb (8.1 N·m) at 20ºF (-7ºC)
Flexibility, Lab Standard Conditions (ASTM D3111)	No Cracking or Loss of Aggregate Adhesion	No Cracking or Loss of Aggregate Adhesion
Minimum Application Temperature	375˚F (190˚C)	375˚F (190˚C)
Maximum Heating Temperature	400˚F (204˚C)	400˚F (204˚C)
Shelf Life	2 years	2 years

INSTALLATION Prior to use, the user must read and follow Installation Instructions for TC-R or TC-TBR to verify proper product selection, heating methods, pavement preparation procedures, application geometry, usage precautions and safety procedures. These instructions are provided with each shipment.

PACKAGING TC-R and TC-TBR are packaged in meltable bags each containing approximately 35 +/- 2 pounds (15.8 +/- 1 kg) of product. Bags are stacked and stretch wrapped on pallets containing approximately 2700 lb (1225 kg). Pallets are weighed and the product is sold by net weight. Each 35 lb bag of TC-R fills a void ~ 0.27 cu ft (0.008 cu m). Each TC-R pallet fills a void ~20 cu ft (0.59 cu m). Each 35 lb bag of TC-TBR fills a void ~ 0.28 cu ft (0.008 cu m). Each TC-TBR pallet fills a void ~21 cu ft (0.59 cu m).

WARRANTY CRAFCO, Inc. warrants that CRAFCO products meet applicable ASTM, AASHTO, Federal or State specifications at time of shipment. Techniques used for the preparation of the cracks and joints prior to sealing or filling are beyond our control as are the use and application of the products; therefore, Crafco shall not be responsible for improperly applied or misused products. Remedies against Crafco, Inc., as agreed to by Crafco, are limited to replacing nonconforming product or refund (full or partial) of purchase price from Crafco, Inc. All claims for breach of this warranty must be made within three (3) months of the date of use or twelve (12) months from the date of delivery by Crafco, Inc. whichever is earlier. There shall be no other warranties expressed or implied. **For optimum performance, follow Crafco recommendations for product installation.**

Air-Entrained Concrete Patching Mix

Portland Cement Concrete Patch Mix with Water Reducer and Air

Product Description

TCC Materials® Air-Entrained Concrete Patching Mix (3U18M) is ideal for repairing concrete pavement, bridge decks, industrial floors, concrete parking lots and garage decks. When mixed with water, this pre-blended mixture of cement, aggregate and special additives will produce a high-strength concrete repair material that is extremely durable and works well in harsh environments. **Additionally, when used with TCC Fast-Set Liquid Activator surfaces can be reopened to traffic within four to five hours under typical conditions.**

Air-Entrained Concrete Patching Mix is a modified version of TCC Concrete Patching Mix which has been designed to meet the requirements of MNDOT specification 3105 *"Bagged Portland Cement Concrete Patching Mix 3U18*".

When/Where to Use

Use for full and partial depth repair of concrete pavements, parking structures, bridge deck repair, industrial floors, new slab construction, formed concrete work, and grouting.

Advantages

- Excellent flowability and workability
- Durable patching material
- High compressive strength mix
- Pre-blended mixture
- Freeze/thaw and salt resistance properties
- Includes water reducer for improved strength, durability and workability
- Air entrained concrete patch

Typical Yield

50 lb. (22.7 kg) bag will yield approximately 0.375 cubic feet (wet). 72 bags will cover approximately 1 cubic yard.

Packaging

50 lb. (22.7 kg) bags

Helpful Items:

Surface Preparation

Surface to be repaired should be clean, sound, and free from any materials that may inhibit bond such as oil, asphalt, curing compounds, acids, dirt and loose debris. Roughen surface and remove all unsound concrete. Immediately prior to placement the repair surface shall be thoroughly saturated with no standing water. For optimal bond in partial-depth repair applications, apply a cement/water slurry to the repair surface immediately prior to placing the patch. Slurry must still be damp when patch is placed.

Mixing and Application

Place the desired number of bags of mix into the mixer. Use full bags only and do not exceed mixer capacity. Add clean, potable water to mix. Total water should be approximately 3-4 pints per 50 lb. bag. Water content may vary based on desired slump and ambient temperature. **When using with TCC Fast-Set Liquid Activator refer to mixing instructions on the Activator Data Sheet instead of the standard instructions here.** Mix initially for about 3 minutes. Let the mix stand for 3 minutes. Mix again for about 2 minutes. Designed slump is about 4-6". Targeted air content is 6.5% (±1.5%). Do not add additional additives unless noted above. After placement, follow industry practices for curing concrete patches.

Technical Data	
Tests Performed	*Air Entrained Concrete Patching Mix*
Compressive Strength, psi (ASTM C39)	
1 day	4,040
3 day	5,230
7 day	6,160
28 day	6,930
Tensile Strength, psi (ASTM C496)	
7 day	460
28 day	550

Shelf Life	One year in original, unopened bags
Storage Conditions	Store dry at 40-95°F (4°C –35° C). Condition material to 65-75° F before using.
Color	Gray
Batching Method	Per ASTM C387

Warning

This product contains Portland cement. Contact with cement, freshly mixed concrete, or mortar can cause sever burns. The cementitious materials mixed onsite are alkaline in nature and on contact with water may irritate the eyes and skin. If contact with eyes occurs, flood eyes repeatedly with clean water and see a physician immediately. Do not rub eyes. Wash hands thoroughly after handling or before eating. Do not take internally. This product may contain silica. Inhaled silica dust may cause respiratory or other health problems.

Warranty

Seller warrants that its product will conform to and perform in accordance with the product specifications. The foregoing warranty is in lieu of all other warranties, express or implied, including, but not limited to, those including merchantability and fitness for a particular purpose. Because of the difficulty in ascertaining and measuring damages hereunder, it is agreed that, the sellers liability to the buyer at no point for any particular project shall exceed the total purchase price of said product.

WARNING: INJURIOUS TO EYES!

KEEP OUT OF REACH OF CHILDREN!

2025 Centre Point Blvd, Suite 300 Mendota Heights, MN 55120 | P 651.686.9116 | F 651.688.9164 | www.tccmaterials.com

USG ECOFIX™ RAPID REPAIR PATCH

Innovative polymer-modified cementitious infrastructure repair material

- Next generation technology for infrastructure repair applications
- Environmentally sustainable – high recycled content, low embodied energy, low carbon footprint
- Sets rapidly in about 30 minutes; provides rapid repair and return to service one hour after set
- Ideal for concrete pavement repairs on expressways, roads, ramps, bridges, parking lots, and industrial concrete floors
- Superior bond to concrete substrates without bonding primers
- Versatile—product can be placed in a variety of environmental conditions including hot, humid, and cold weather conditions
- Extremely water durable
- Extremely durable even under the most severe environmental conditions — freezing and thawing, salt application, and heavy traffic
- Suitable for full depth repairs, partial depth repairs, and on-grade applications
- May assist in obtaining LEED® credits and achieving local, state, and state DOT's sustainability objectives
- Meets ASTM C928 standard specification
- NTPEP-tested (Project No. 15-01-010)

DESCRIPTION

USG EcoFix™ Rapid Repair Patch is a high-performance, air-entrained, rapid-setting, eco-friendly cementitious mortar for use in infrastructure repair applications. Whether used neat or with aggregate, USG EcoFix Rapid Repair Patch provides superior working properties and excellent water and freeze-thaw resistance. In addition, USG EcoFix Rapid Repair Patch is a highly dimensionally stable product and provides excellent resistance to sulfates and salt-scaling.

Due to its special chemical composition, USG EcoFix Rapid Repair Patch develops excellent bond to concrete substrates without requiring a bonding primer. The product's 65% recycled content in the cementitious binder, low embodied energy, and low carbon footprint makes it an environmentally sustainable material. USG EcoFix Rapid Repair Patch may also assist in obtaining various LEED credits for the project.

USG EcoFix Rapid Repair Patch meets the ASTM C928 Standard Specification for Packaged, Dry, Rapid-Hardening Cementitious Materials for Concrete Repair.

LIMITATIONS

1. Keep all raw materials at temperatures above freezing (32 °F (0 °C)). The application, neat or aggregate, must be at temperatures above 32 °F (0 °C).
2. Consult a United States Gypsum Company representative or the structural design engineer on record for use in new structural construction.
3. Contact USG (800-874-4968) for below-grade and vertical applications.

SURFACE PREPARATION

Consult *ICRI Guideline No. 310.2 Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlay* for surface preparation equipment and methods. Mark off damaged areas and make a 2 in. vertical cut with a concrete saw or other suitable equipment around the perimeter of the damaged area. Break out all material within the cut area and clean all debris from the hole. A structurally sound base is essential for ensuring a good repair job. Ensure that the application surface is clean, sound, and free from contaminants that may inhibit bond such as oil, wax, asphalt, acid, curing compound, dirt and loose debris. It is important to have the damaged areas prepared prior to mixing USG EcoFix Rapid Repair Patch. Note - the existing concrete does not require a bonding primer. Lightly dampen the surrounding concrete, especially in hot weather conditions. Apply USG EcoFix Rapid Repair Patch to saturated surface dry (SSD) substrate with no standing water.

For on-grade full depth or partial depth repairs, please follow the procedures as outlined by the U.S. Department of Transportation Federal Highway Administration. These procedures are available at the following weblinks: Full Depth Repair - http://www.fhwa.dot.gov/pavement/concrete/full.cfm; Partial Depth Repair -http://www.fhwa.dot.gov/pavement/concrete/repair00.cfm.

NOTE Per ACI CT-13 ACI Concrete Terminology Standard, saturated surface dry (SSD) is defined as the condition of an aggregate particle or other porous solid when the permeable pores are filled with water and no water is on the exposed surfaces.

EQUIPMENT

Use a standard concrete mixer for mixing the material. Per *ICRI Guideline No. 320.5R Pictorial Atlas of Concrete Repair Equipment*, the acceptable concrete mixers include: Type A Horizontal Shaft Mixer, Type B Tumble Mortar Mixer, and Type D Pan-Type Mortar Mixer. The batch size will be controlled by the size of the mixer. However, due to the rapid setting behavior of USG EcoFix Rapid Repair Patch, the total mix should be limited to a quantity that can be mixed and placed in about 15 minutes. Do not use high shear mixers that tend to entrap excessive amounts of air in the material. Ensure that all equipment is properly cleaned prior to mixing.

TYPICAL MIXING PROPORTIONS

USG EcoFix Rapid Repair Patch is a pre-sanded cementitious powder packaged in 50 lb. bags. The pre-sanded material can be used neat or extended with clean 3/8" to 1/2" aggregate and a measured amount of water.

Neat Mix
– 50 lb. USG EcoFix Rapid Repair Patch
– 2.25 quarts potable water

Extended Mix
– 50 lb. USG EcoFix Rapid Repair Patch
– 32.5 lb. clean aggregate (3/8" to 1/2" maximum aggregate size)
– 2.25 quarts potable water

For an extended mix, use only 3/8" to 1/2" clean, saturated surface dry (SSD) aggregates meeting ASTM C33 specification. When using wet aggregate, adjust water quantity for the aggregate moisture content. **Because USG EcoFix Rapid Repair Patch is pre-sanded, do not add any field sand to the mixture.**

The batch may be scaled up as long as the mixer capacity is not exceeded. Maintain the leading edge in workable consistency to ensure proper homogeneity of poured material from successive batches. Note that the material has a manufactured set time of about 25 to 35 minutes.

MIXING PROCEDURES

1. Introduce measured amount of water to mixer.
2. Add half the amount of aggregate into mixer (for mixes with aggregate extension).
3. Add USG EcoFix Rapid Repair Patch into mixer with mixer operating.
4. Slowly add the remainder of the aggregates into mixer (for mixes with aggregate extension).
5. Mix for three minutes. Then, if necessary, add more water in small amounts during additional mixing to obtain desired fluidity. See *USG EcoFix Products – Mixing Proportions Chart* (IG5132) for additional mixing information.
6. Mix until lump free, but not for more than six minutes.
7. Dump batch and immediately deliver the mixed material to the prepared pavement area. For an area that requires more than one batch, material should preferably be poured in layers. Clean mixer by adding water and allowing mixer to run. Dispose cleaning water in accordance with local storm water regulations before starting another batch.
   Note Prior to placing USG EcoFix Rapid Repair Patch, the area to be repaired should be wetted with water to minimize water withdrawal from the material. The substrate must be in saturated surface dry condition and there should be no freestanding water in the cavity to be patched.
8. Level the USG EcoFix Rapid Repair Patch to the surrounding pavement with an appropriate screeding device, and before set, broom finish if necessary. If a smooth finish is desired, trowel lightly before set.
9. Allow USG EcoFix Rapid Repair Patch to develop strength for a minimum of one hour after set. After this time, traffic can resume over the patched area.

YIELD

USG EcoFix Rapid Repair Patch is available in 50 lb. multiwall paper bags with a 3-mil thick polyethylene liner. The 50 lb. bag material when mixed with specified amount of water has a yield of about 0.42 cu.ft. The 50 lb. bag material when extended with 32.5 lb. aggregate and mixed with specified amount of water has a yield of about 0.62 cu.ft.

PRECAUTIONS

1. Do not overwater or overmix.
2. Do not add additional sand to USG EcoFix Rapid Repair Patch.
3. Do not add additional cement, fly ash, or other chemical or mineral admixtures to the product.
4. Do not use reactive aggregates that can potentially cause alkali-silica reaction.
5. Damaged pavement must be completely removed, and the cavity cleared free of debris. Provide at least a vertical cut at the perimeter of the prepared area. Do not trowel EcoFix Rapid Repair Patch to a thin, feathered edge.
6. Do not permit USG EcoFix Rapid Repair Patch mix to freeze before set has taken place. If USG EcoFix Rapid Repair Patch is to be used at or near freezing temperatures, the following is recommended.

   (a) Keep materials and equipment as warm as possible.

   (b) Keep mortar and adjacent pavement above 32 °F (0 °C) until USG EcoFix Rapid Repair Patch has set.
7. Under hot, windy conditions, use of an approved concrete curing membrane may be required to prevent surface dry out.
8. If USG EcoFix Rapid Repair Patch is being used to patch an area adjacent to non-concrete materials such as control or expansion joints, a bonding agent approved by appropriate government regulatory agencies and used in accordance with manufacturer's recommendations is suggested.
9. Determine that the patch has set for at least one hour before allowing traffic to resume over patched area.
10. Do not leave material in mixer for longer than 15 minutes. If excessive buildup is detected on the equipment, clean prior to the next batch mixing.

TECHNICAL DATA

PROPERTIES	TESTING STANDARD	NEAT MATERIAL FROM BAG USG EcoFix: 50 lb. Water: 2.25 quart	MATERIAL WITH AGGREGATE EXTENSION USG EcoFix: 50 lb. Aggregate (3/8" to 1/2"): 32.5 lb. Water: 2.25 quarts
Setting Time	ASTM C191/ AASHTO T131	25-35 min.	25-35 min.
Length Change	ASTM C157 (modified per ASTM C928)	**Air cure at 28 days** -0.10% **Water cure at 28 days** +0.02%	**Air cure at 28 days** -0.05% **Water cure at 28 days** +0.01%
Compressive Strength (2" Cubes)	ASTM C109[1]	**2 hours** 2500 psi **3 hours** 3500 psi **4 hours** 4000 psi **24 hours** 6500 psi **7 days** 8500 psi **28 days** 10500 psi	**2 hours** 2500 psi **3 hours** 3500 psi **4 hours** 4000 psi **24 hours** 6000 psi **7 days** 8000 psi **28 days** 10000 psi
Compressive Strength (3"×6" Cylinders)	ASTM C39[1]/ AASHTO T22[1]	**2 hours** 2500 psi **3 hours** 3000 psi **4 hours** 3500 psi **24 hours** 5500 psi **7 days** 7000 psi **28 days** 8000 psi	**2 hours** 2500 psi **3 hours** 3000 psi **4 hours** 3500 psi **24 hours** 5000 psi **7 days** 6500 psi **28 days** 7500 psi
Direct Bond Strength to Concrete Substrate (ICRI CSP 5 Surface Profile Substrate)	ASTM C1583	**28 days** > 250 psi	**28 days** > 300 psi
Bond Strength to Concrete Substrates	ASTM C882 (modified per ASTM C928)	**24 hours** >2500 psi **7 days** >3500 psi	**24 hours** >2500 psi **7 days** >3000 psi
Freeze-Thaw Resistance	ASTM C666/ AASHTO T161 (Procedure A) ASTM C215	1200 Cycles **Relative Dynamic Modulus** >95%	1200 Cycles **Relative Dynamic Modulus** >95%
Salt Scaling Resistance	ASTM C672	Excellent No significant weight loss (<0.10 lb/sq. ft. after 75 cycles)	Excellent No significant weight loss (<0.10 lb/sq. ft. after 75 cycles)
Chloride Permeability	ASTM C1202/ AASHTO T277	Permeability Class - Low	Permeability Class - Very Low
Thermal Compatibility	ASTM C884	PASS (no delamination)	PASS (no delamination)
Yield (50 lb. Dry Powder)	ASTM C1107	0.42 cu.ft.	0.62 cu.ft.

1. Samples dry cured at 50% relative humidity and 75 °F (24 °C) temperature

STORAGE AND USE

When properly used, USG EcoFix Rapid Repair Patch is easy to work with. Keep indoors at temperatures between 65 °F – 75 °F (18 °C – 24 °C) and 45% – 55% RH. Do not stack more than two pallets high. Keep from drafts. Rotate stock. USG EcoFix Rapid Repair Patch should be used within one year of the manufacturing date located on the package. Always follow handling and use directions and safety warnings on the package.

SUBMITTAL APPROVALS

Job Name	
Contractor	Date

PRODUCT INFORMATION
See usg.com for the most up-to-date product information.

LEED INFORMATION
For the most up-to-date information on LEED rating systems, project certification and the U.S. Green Building Council, please visit usgbc.org.

DANGER
Causes skin irritation. Causes serious eye damage. May cause an allergic skin reaction. Harmful if swallowed. Avoid breathing dust. Wash thoroughly after handling. Wear protective gloves/protective clothing/eye protection. Use only in a well-ventilated area, wear a NIOSH/MSHA-approved respirator. If swallowed, inhaled, or skin irritation occurs get medical attention. If on skin: Wash with plenty of water. If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses and continue rinsing. Do not eat drink or smoke when using this product. Contaminated work clothing should not be allowed out of the workplace. Wash contaminated clothing before reuse. Dispose of in accordance with local, state, and federal regulations. For more information call Product Safety: 800-507-8899 or see the SDS at usg.com.
KEEP OUT OF REACH OF CHILDREN.

NOTE
The information in this document is subject to change without notice. USG Corp. assumes no responsibility for any errors that may inadvertently appear in this document. Consult your USG Company sales office or representative for information.

NOTICE
We shall not be liable for incidental or consequential damages, directly or indirectly sustained, nor for any loss caused by application of these goods not in accordance with current printed instruction or for other than the intended use. Our liability is expressly limited to replacement of defective goods. Any claim shall be deemed waived unless made in writing to us within thirty (30) days from date it was or reasonably should have been discovered.

SAFETY FIRST!
Follow good safety/industrial hygiene practices during installation. Wear appropriate personal protective equipment. Read SDS and literature before specification and installation.

800 USG.4YOU
800 (874.4968)
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Manufactured by
United States Gypsum Company
550 West Adams Street
Chicago, IL 60661

IG1932-USA-ENG/rev. 1-18

USG
IT'S YOUR WORLD. BUILD IT.®

DOT REPAIR MIX

High Performance Concrete Repair Material

PRODUCT DATASHEET

DESCRIPTION: Rapid Set® DOT REPAIR MIX is a high performance, fast setting, multi-purpose repair material. Durable in wet environments, DOT REPAIR MIX is a blend of Rapid Set hydraulic cement, high performance additives and ASTM C33 concrete sand. DOT REPAIR MIX is non-metallic and no chlorides are added. Mix DOT REPAIR MIX with water to produce a flowable, quality repair material that is ideal where fast strength gain, high durability and low shrinkage are desired. DOT REPAIR MIX is ready for traffic and loading within 1 hour.*

USES: Use DOT REPAIR MIX for concrete repair, highway repair, dowel bar retrofit, construction of pavements and bridges, parking decks and ramps, sidewalks and steps, joint repair and formed work. DOT REPAIR MIX contains an air-entraining admixture, in some geographical regions, for freeze thaw durability.

ENVIRONMENTAL ADVANTAGES: Use DOT REPAIR MIX to reduce your carbon footprint and lower your environmental impact. Production of Rapid Set cement emits far less CO_2 than portland cement. Contact your Rapid Set representative for LEED values and further environmental information.

APPLICATIONS: Apply DOT REPAIR MIX in thicknesses from 1/2" to 4" (1.2 cm to 10.2 cm). For thicker applications, DOT REPAIR MIX can be extended with up to 100% clean, dry coarse aggregate (up to 3/4") conforming to ASTM C33.

SURFACE PREPARATION: For repairs, application surface shall be clean, sound and free from any materials that may inhibit bond such as oil, asphalt, curing compound, acid, dirt and loose debris. Mechanically abrade surface and remove all unsound material. Apply DOT REPAIR MIX to a thoroughly saturated surface with no standing water.

MIXING: The use of a power driven mechanical mixer, such as a mortar mixer or a drill-mounted mixer, is recommended. Organize work so that all personnel and equipment are in place before mixing. Use clean potable water. **DOT REPAIR MIX may be mixed using 3 to 4.5 quarts (2.8 L to 4.3 L) of water per 55-lb (25 kg) bag. Use up to 5 quarts (4.7 L) when extended with dry coarse aggregate. Use less water to achieve higher strengths.** Place the desired quantity of mix water into the mixing container. While the mixer is running, add DOT REPAIR MIX. Mix for the minimum amount of time required to achieve a lump-free, uniform consistency (usually 1 to 3 minutes). Do not retemper.

PLACEMENT: DOT REPAIR MIX may be placed using traditional construction methods. Organize work so that all personnel and equipment are ready before placement. Place, consolidate and screed quickly to allow for maximum finishing time. Use a method of consolidation that eliminates air voids. On flat work, do not install in layers; install full depth sections and progress horizontally. Do not wait for bleed water. Apply final finish as soon as possible. DOT REPAIR MIX may be troweled, floated or broom finished. The working time for DOT REPAIR MIX is 10 to 25 minutes at 70°F (21°C). To extend working time, use Rapid Set® SET Control® retarding admixture from the Rapid Set® Concrete Pharmacy® or use cold mix water. Do not install on frozen surfaces. DOT REPAIR MIX may be applied in temperatures ranging from 45°F to 90°F (7°C to 32°C).

OVERVIEW

Highlights:

- Fast: Ready for traffic and loading in 1 hour
- Durable: Formulated for long life in critical applications
- Structural: For repair and new construction
- Extendable: Add rock for large placements
- Easy To Use: Mix to fluid or stiff consistency
- Multi-Purpose: Use for concrete repair, highway repair, dowel bar retrofit, construction of pavements, bridges, parking decks, ramps, sidewalks, steps, joint repair, formed work and more

Conforms to:

- ASTM C928
- California Test No. 551

MasterFormat® 2016

03 01 30	Maintenance of Cast-in-Place Concrete
03 01 40	Maintenance Of Precast Concrete
03 01 50	Maintenance of Cast Decks and Underlayment
03 01 70	Maintenance of Mass Concrete

Manufacturer:

CTS Cement Manufacturing Corp.
11065 Knott Ave., Suite A
Cypress, CA 90630
Tel: 800-929-3030 | Fax: 714-379-8270
Web: www.CTScement.com
E-mail: info@CTScement.com

DOT REPAIR MIX High Performance Concrete Repair Material

CURING: Water cure all Rapid Set® DOT REPAIR MIX installations by keeping exposed surfaces wet for a minimum of 1 hour. Begin curing as soon as the surface starts to lose its moist sheen. When experiencing extended setting time due to cold temperature or the use of retarder, longer curing times may be required. The objective of water curing shall be to maintain a continuously wet surface until the product has achieved sufficient strength.

COLD WEATHER: Environmental and material temperatures below 70°F (21°C) may delay setting time and reduce the rate of strength gain. Lower temperatures will have a more pronounced effect. Thinner sections will be more significantly affected. To compensate for cold temperatures, keep material warm, use heated mix water, and follow ACI 306 Procedures for Cold Weather Concreting.

WARM WEATHER: Environmental and material temperatures above 70°F (21°C) may shorten setting time and increase the rate of strength gain. Higher temperatures will have a more pronounced effect. To compensate for warm temperatures, keep material cool, use chilled mix water and follow ACI 305 Procedures for Hot Weather Concreting. The use of Rapid Set® SET Control® retarding admixture from the Rapid Set® Concrete Pharmacy® will help offset the effects of high temperatures.

YIELD & PACKAGING: DOT REPAIR MIX is available in 55 lb (25 kg) bags. One 55 lb (25 kg) bag of DOT REPAIR MIX will yield approximately 0.5 ft^3. When extended 60% by weight with quality coarse aggregate, yield is approximately 0.7 ft^3. When extended 100% by weight with quality coarse aggregate, yield is approximately 0.9 ft^3.

SHELF LIFE: DOT REPAIR MIX has a shelf life of 12 months when stored properly in a dry location, protected from moisture, out of direct sunlight, and in an undamaged package.

USER RESPONSIBILITY: Before using CTS products, read current technical data sheets, bulletins, product labels and safety data sheets at www.CTScement.com. It is the user's responsibility to review instructions and warnings for any CTS products prior to use.

WARNING: DO NOT BREATHE DUST. AVOID CONTACT WITH SKIN AND EYES. Use material in well-ventilated areas only. Exposure to cement dust may irritate eyes, nose, throat, and the upper respiratory system/lungs. Silica exposure by inhalation may result in the development of lung injuries and pulmonary diseases, including silicosis and lung cancer. Seek medical treatment if you experience difficulty breathing while using this product. The use of a NIOSH/MSHA-approved respirator (P-, N- or R-95) is recommended to minimize inhalation of cement dust. Eat and drink only in dust-free areas to avoid ingesting cement dust. Skin contact with dry material or wet mixtures may result in bodily injury ranging from moderate irritation and thickening/cracking of skin to severe skin damage from chemical burns. If irritation or burning occurs, seek medical treatment. Protect eyes with goggles or safety glasses with side shields. Cover skin with protective clothing. Use chemical resistant gloves and waterproof boots. In case of skin contact with cement dust, immediately wash off dust with soap and water to avoid skin damage. In case of skin contact with wet concrete, wash exposed skin areas with cold running water as soon as possible. In case of eye contact with cement dust, flush immediately and repeatedly with clean water, and consult a physician. If wet concrete splashes into eyes, rinse eyes with clean water for at least 15 minutes and go to the hospital for further treatment.

PROPOSITION 65 WARNING: This product contains chemicals known to the State of California to cause cancer and birth defects or other reproductive harm. Please refer to the SDS and www.CTScement.com for additional safety information regarding this material.

LIMITED WARRANTY: CTS CEMENT MANUFACTURING CORP. (CTS) warrants its materials to be of good quality and, at its option, will replace or refund the purchase price of any material proven to be defective within one (1) year from date of purchase. The above remedies shall be the limit of CTS's responsibility. Except for the foregoing, all warranties expressed or implied, including merchantability and fitness for a particular purpose, are excluded. CTS shall not be liable for any consequential, incidental, or special damages arising directly or indirectly from the use of the materials.

TYPICAL PHYSICAL DATA

Neat Bag (3.0 to 4.5 quarts)	60% Extension (3.5 to 4.75 quarts)	100% Extension (3.5 to 5.0 quarts)
Yield		
0.5 ft^3	0.7 ft^3	0.9 ft^3
Compressive Strength		
ASTM C109 Mod.	ASTM C39	ASTM C39
1 hr* 3300 psi	1 hr* 2800 psi	1 hr* 2500 psi
3 hrs 5000 psi	3 hrs 4600 psi	3 hrs 4200 psi
24 hrs 7000 psi	24 hrs 6800 psi	24 hrs 6500 psi
7 days 7500 psi	7 days 7200 psi	7 days 7000 psi
28 days 9500 psi	28 days 9000 psi	28 days 8500 psi
Flexural Strength, ASTM C78		
4 hrs 450 psi	4 hrs 400 psi	4 hrs 400 psi
7 days 700 psi	7 days 650 psi	7 days 600 psi
28 days 900 psi	28 days 850 psi	28 days 800 psi
Modulus of Elasticity, ASTM C469		
7 days 4,400,000 psi	7 days 4,100,000 psi	7 days 3,900,000 psi
28 days 5,100,000 psi	28 days 4,500,000 psi	28 days 4,000,000 psi
Slant Shear Bond Strength, ASTM C882 per C928		
1 day 1500 psi	1 day 1200 psi	1 day 1100 psi
7 days 2000 psi	7 days 1800 psi	7 days 1700 psi
Splitting Tensile Strength, ASTM C496		
7 days 700 psi	7 days 500 psi	7 days 390 psi
28 days 900 psi	28 days 600 psi	28 days 415 psi
Resistance of Concrete to Rapid Freezing and Thawing, ASTM C666 Procedure A		
Durability factor 300 Cycles: 95%	Durability factor 300 Cycles: 95%	Durability factor 300 Cycles: 95%
Scaling Resistance, ASTM C672 per C928		
Scaling of material at 25 cycles: 0.05 lb/ft^2	Visual rating at 25 cycles - 2	Visual rating at 25 cycles - 1
Length Change, ASTM C157 modified per ASTM C928		
Air Cure: -0.08% Water Cure: 0.02%	Air Cure: -0.07% Water Cure: 0.01%	Air Cure: -0.05% Water Cure: 0.05%
*Data obtained at flow consistency of 105 by ASTM C1437 at laboratory conditions	*Data obtained at slump consistency at 6" by ASTM C143 at laboratory conditions	*Data obtained at slump consistency at 6" by ASTM C143 at laboratory conditions

*After final set
Results will vary depending on aggregates and jobsite conditions

HELIX™

Micro-Rebar

Data Sheet

Product: Helix 5-25

Description:

The unique, twisted design of Helix allows for efficient tensile stress re-distribution within the concrete prior to concrete cracking. The result is a significant increase in the concrete's strain capacity and pre-crack properties. Unlike rebar and other forms of reinforcement, Helix provides proactive reinforcement which engages the concrete before large cracks form.

Applications:

- Structural Walls
- Structural Floors
- Foundations
- Beams/Columns
- Shotcrete
- Paving
- Precast
- Rebar Replacement

Geometry:

Length: 25 mm (1.00 in)
Diameter: 0.50 mm (0.02 in)
25,307 fibers/kg (11,500 fibers/lb)

Approvals:

Uniform ES Evaluation Report 0279
www.helixsteel.com/technical
www.iapmoes.org

Tensile Strength:

Tensile Strength: 246.5 ksi minimum
(1700 Mpa minimum)
Material: High Carbon Steel Wire

Meets Specifications:

ACI 318
ACI 360
ASTM A820-Type I

Coating:

Coating: Electroplated Zinc

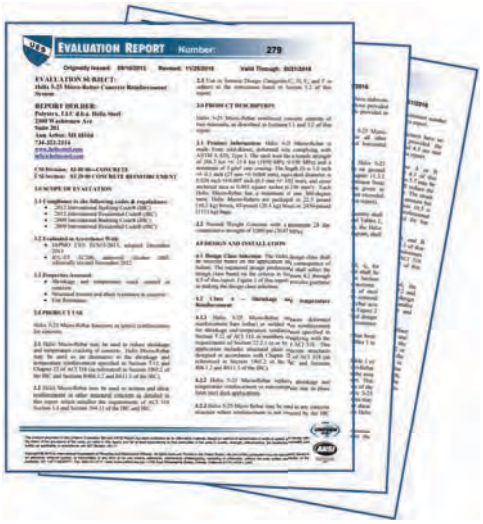
For more information, visit **www.helixsteel.com** or call 734-322-2114.
Helix Steel - 2300 Washtenaw Ave, Suite 201, Ann Arbor, MI 48104

Made in USA

HELIX™ Micro-Rebar Data Sheet

Dosing Instructions:

Mixing should be done in accordance with ASTM C94 and the mixing instructions below. The dosages of Helix added to the mix should be noted on the batch documentation in accordance with Uniform Evaluation Service ER 279 Section 5.15. and verified using the procedure in ER 279 Appendix A.


EVALUATION REPORT Number: 279

Mixing Instructions:

Ready Mix Plants (Dry) - TRUCK MIXER

To prevent Helix from clumping (small cluster of Helix), rigorously follow the procedures below: (1) Add a minimum of 20 gallons (75 liters) of the mix water into the drum. (2) With the drum at full charging speed, add the Helix into the truck drum. (3) Turn truck drum at charging speed for six minutes immediately prior to the addition of mix into truck. (4) Add the sand, aggregate and cement (or concrete) in the normal manner.

Ready Mix Wet (Central Mix)

(1) For dosages below 15 lb/cyd (9kg/m3) follow dry procedures with 7 gallons (27 liters) of water in the drum.
(2) For higher dosage please use the Site Batching instructions below.

Site Batching Into Mix Trucks (Loaded Truck at Construction Site)

(1) Set the drum to charging speed. (2) Sift Helix through a 2"x 2" (50mm x 50mm) Mesh or use Helix Dosing Unit (contact Helix to order). The dosing unit breaks up clumps and ensures Helix goes into the truck at a controlled rate (about 1 box per minute). When Helix is added at this stage, it must enter the mixer clump free. (3) When adding Helix, it may collect on any residual concrete on the interior surfaces of the hopper. Push the Helix into the drum avoiding clumps. Adding a slipper y lining, such as PVC sheeting, to the hopper may help avoid these buildups. (4) Mix at charging speed for 5 minutes (60 revolutions) after Helix is added.

Pan Mixer/Drum Mixer

(1) Set the mixer to the proper speed. (2) Add Helix at a rate of 45-60 seconds per 45 lbs (20 kgs). (3) Helix should be added with the aggregates. (4) Mix at max speed for 5 minutes after Helix is added.

Approvals:

Uniform ES Evaluation Report 0279
www.helixsteel.com/technical
www.iapmoes.org

Meets Specifications:

ACI 318
ACI 360
ASTM A820-Type I

For more information, visit **www.helixsteel.com** or call 734-322-2114.
Helix Steel - 2300 Washtenaw Ave, Suite 201, Ann Arbor, MI 48104

Made in USA

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