REPORT 2013 - 11

VERMONT AGENCY OF TRANSPORTATION

Materials & Research Section
Research Report

ASSESSMENT OF TECHCRETE A CONCRETE REPAIR MATERIAL AND JOINT SEALANT

Report 2013 – 11

December 2013

Assessment of TechCrete
a Concrete Repair Material and Joint Sealant

Initial Report 2013 – 11

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Reporting on Work Plan 2008-02

STATE OF VERMONT
AGENCY OF TRANSPORTATION

MATERIALS & RESEARCH SECTION

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16. Abstract

Joint sealing and resealing is a commonly performed concrete pavement maintenance activity that serves two purposes. First, it minimizes water infiltration; second, it prevents intrusion of solid materials in the joints. There are many sealants available for resealing concrete joints including hot-poured, rubberized asphalt sealants and silicone sealants. According to a Federal Highway Administration technology brief, “the hot-poured, rubberized asphalt sealants are less expensive than silicone materials but generally have shorter life expectancies (typically, 4 to 8 years for hot-poured sealants and 5 to 10 for silicone sealants) [1].

In the fall of 2007, the City of Winooski resealed some of the pavement joints located along US Route 2 and 7 as part of their periodic preventative maintenance work, with a new hot-poured product, TechCrete, manufactured by Crafco. According to Crafco, this flexible material is a hot-poured product for concrete repairs, which provides high tensile strength and high compressive resistance. It is comprised of a combination of several resins, polymers, and aggregate. In addition, it has proven to provide a long-term life span in most applications. According to the manufacturer, once the material has properly cured, the materials will not de-bond or crack while remaining flexible during the expansion and contraction of the adjacent concrete slabs. Additionally, the affected lane can be open to traffic within one hour of application.

In 2008, Crafco contacted VTrans to have TechCrete added to the Approved Products list. This study is an evaluation of the product. VTrans selected the Winooski site and a site in South Burlington where a concrete pavement was placed in 1997 that exhibited similar deterioration, to conduct a field evaluation of the product.

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ABSTRACT

Joint sealing and resealing is a commonly performed concrete pavement maintenance activity that serves two purposes. First, it minimizes water infiltration; second, it prevents intrusion of solid materials in the joints. There are many sealants available for resealing concrete joints including hot-poured, rubberized asphalt sealants and silicone sealants. According to a Federal Highway Administration technology brief, "the hot-poured, rubberized asphalt sealants are less expensive than silicone materials but generally have shorter life expectancies (typically, 4 to 8 years for hot-poured sealants and 5 to 10 for silicone sealants) [1].

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INTRODUCTION

With a growing number of highway infrastructure in need of reconstruction or rehabilitation and ever increasing construction costs, State Agencies are seeking out cost effective methods of increasing the service life of pavements. Pavement preservation, according to the American Association of State Highway and Transportation Officials (AASHTO), is a planned strategy of the application of cost-effective treatments to an existing roadway system and its appurtenances that preserves the system, retards future deterioration, and maintains or improves the functional condition of the system without significantly increasing structural capacity [2]. The application of a preventative maintenance treatment at the proper time provides a cost effective alternative that typically extends the time when a more extensive corrective treatment is needed.

Portland cement concrete (PCC) pavements deteriorate over time due to a lack of uniform support from underlying substrates or uneven distribution of traffic loading often resulting in distresses such as faulting, cracking, spalling, scaling, and materials deterioration. Many of these distresses allow water penetration through the concrete slab creating an ideal environment for freeze/thaw damage. In addition, chloride constituents introduced from winter maintenance practices corrodes reinforcing, thereby reducing structural strength and exacerbating the rate of cracking.

Specifically, PCC pavements contain both transverse and longitudinal joints that must be maintained regularly to prevent premature failure. Spalling is a common occurrence along concrete pavement joints, especially on exterior surfaces that are exposed to freeze and thaw cycles. Joint sealing prevents incompressible materials from being lodged in the joint space as well as reducing water infiltration. Sealant materials must be able to withstand repeated expansion and compression as the pavement slabs expand and contract with temperature and moisture changes. However, some joint sealants are unable to withstand daily temperature variations and associated movements resulting in additional cracking, and need for repair. Crafco Inc. produces a concrete repair material known as TechCrete that is reportedly a long-term solution for distressed concrete pavement preservation. TechCrete [3] is a polymer-modified resin with aggregate blend that is ideal for repairing multi slab joint deterioration. According to the manufacturer, the material allows traffic to resume within one hour of application.

The objective of this study was to examine the ease of concrete joint repair, initial performance, long-term durability, and cost effectiveness. The experimental sealant material was utilized on two concrete pavement rehabilitation projects in the towns of Winooski and South Burlington in the summer and fall of 2009. The following report documents the material specifications, installation, and initial performance.

PROJECT LOCATION AND SUMMARY

In association with the federally approved Workplan, WP-2008-2-Modified-2, TechCrete was applied to portions of two construction projects in the towns of Winooski and South Burlington. During the design process, the PCC pavements within each project were surveyed for suitability. Areas of accelerated deterioration along and between the PCC pavement joints on these projects were selected for TechCrete application and assessment. All other joints were to be repaired with a standard hot poured joint sealer in compliance with the "2006 Standard Specifications for Construction", item 524.11 [5].

Winooski

In 1989, a portion of US Route 2 and US Route 7 in Winooski was replaced with reinforced concrete pavement by VTrans in the Winooski M 5100(8) project. From the City of Burlington, the project began just north of the bridge over the Winooski River to just north of Maple Street in Winooski, approximately between mile markers 0.045 to 0.264. This project was to solve a problem with ripples forming in the pavement due large trucks coming to a stop at each intersection, thereby shoving the pavement ahead.

The joints in concrete pavements typically require resealing at about 6 to 8 years of service life. The joints in Winooski were not maintained within this timeframe. The lack of timely repair may have contributed to significant leakage of surface water into the joints and subsequent deterioration of the concrete within the joints.

In 2002, VTrans repaired the joints in the Winooski STP 2131(1)S project, with common concrete repair methods using details similar to those used for TechCrete shown in this report. For this type of repair, the work was done too late to prevent continual damage to the concrete. In addition, the patching concrete proved to be incompatible with the in situ concrete pavement. Since completion, much of the joint repair has experienced additional spalling and cracking, thereby reopening the joints to water and salt infiltration.

In 2005, the City of Winooski underwent a redevelopment project that significantly changed the roadway configuration into a large oval traffic circle. This work required removing portions of the concrete pavement.

In October of 2008, selected joints were repaired by a private contractor using a new more flexible material, TechCrete. A representative from Crafco, the supplier, was present to provide guidance with the material's application. Once the cracks were properly prepared, TechCrete was then placed into the repair areas according to the manufacture's specifications.

After this successful pilot test of the material, the Agency amended the repaving project, Winooski STP 2617(1)S, by adding the repair of the deteriorating joints with TechCrete. The material was applied to the deteriorated joints along US Route 7/2 and West Allen Street. According to the project plans, work was to be performed under "the Route 7 portion of the project involves the repair of deteriorated concrete joints using a self-adhesive polymer product." Specifically, the experimental material was applied along US Route 7 between mile marker (MM) 0.045 and 0.264 for a total length of 0.219 miles. Figure 1 shows the project area. The 2010 AADT, or average annual daily traffic, on US Route 7 for this section of roadway is shown in Table 1; trucks comprise nearly 6% of this traffic stream. This section of roadway has grades that range from 6.46% at the beginning of the project; slightly decreases to 6.02% at the start of the traffic circle; then increases to 9.00% just north of the West Allen Street and ends with 7.77% at Maple St.

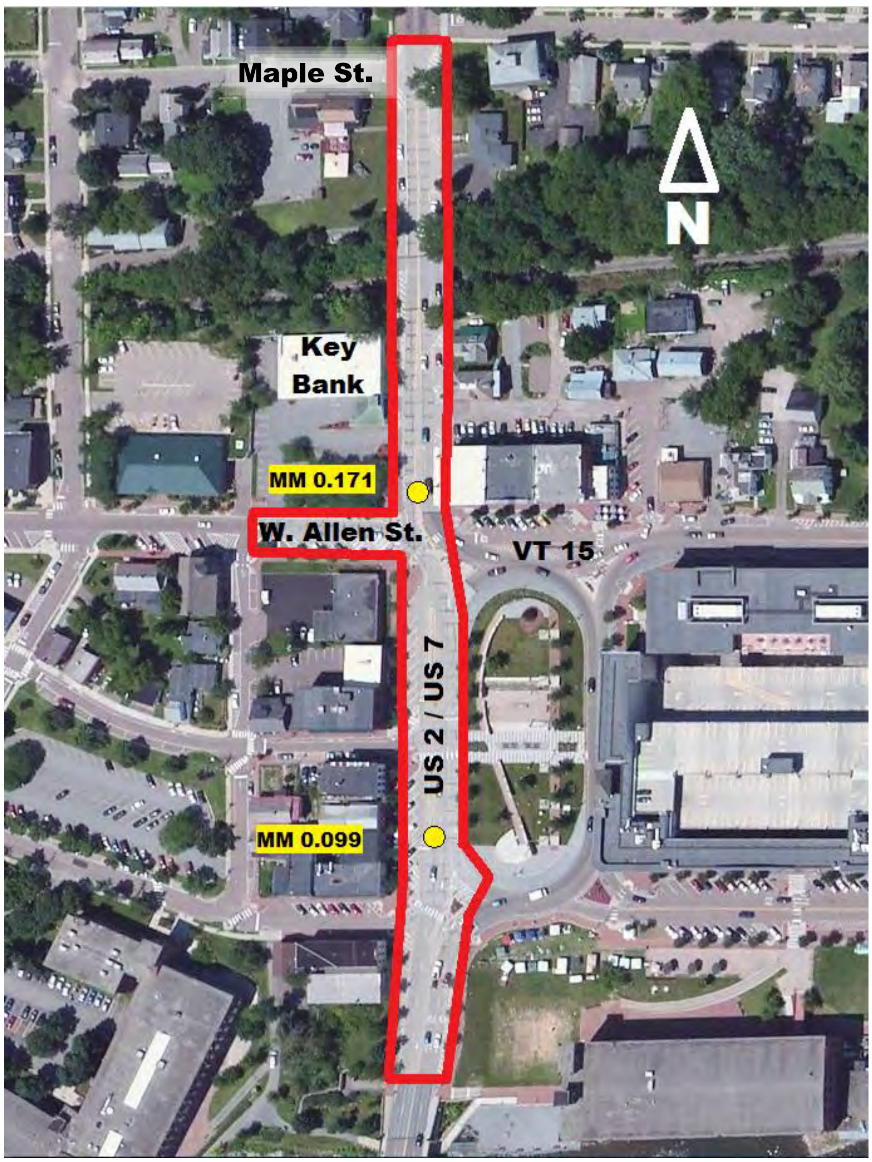

Figure 1 Winooski Project Site, US Route 2/7 and West Allen Street

Table 1 AADT within Winooski TechCrete repairs

MM Range	AADT
0.000 to 0.099	25,600
0.099 to 0.171	21,400
0.171 to 0.439	10,600

Specific repair locations for this project were specified by the design consultant, Dubois and King, and joint repair utilizing the TechCrete material was referenced in the plans' special provisions. Dubois and King estimated that approximately 136,000 lbs of TechCrete would be needed to repair all of the PCC pavement joints.

Burlington-South Burlington

The original intersection of I-189 and US Route 7 was constructed as part of the Interstate I-189 construction project in 1962. At the time, I-189 intersected US Route 7 with an overpass, and a series of ramps. In 1990, the intersection was reconstructed as part of the so-called "Southern Connector" project (So. Burlington-Burlington MECG M5000(1)) that would extend I-189 to the City of Burlington. This reconstruction made I-189 an underpass with newly constructed ramps.

Similar to the phenomenon that developed at intersections on US Route 7 in Winooski, the pavement began to form ripples as heavy trucks came to a stop at the US Route 7 and Ramp 'C' intersection, as well as more southerly intersections. In 1997, VTrans began a project (Burlington City CM-NH 9621(1)) to reconstruct a portion of US Route 7 at the intersection with Ramp 'C' as well as a portion of the ramp, with reinforced concrete pavement as was done in the Winooski reconstruction completed in 1989. Since then, the concrete joints at this location began to deteriorate as well.

During the same time of the Winooski repair project in 2009, TechCrete was also used to seal the deteriorated cracks as a part of the NH 2726(1)S and STP 2727(1)S projects, located at the intersection of US Route 7 and Ramp 'C' of I-189. The NH project consisted of the I-189 exit ramp and US 7 south of the ramp, while the STP portion is the section of US 7 north of the ramp. According to the project plans, work to be performed included "cold planing and resurfacing of the existing highway with a shim/leveling course and wearing course, resealing/repair of the concrete pavement, new pavement markings, vehicle detector loops, sidewalk ramps, new signs, and incidental items". Figure 2 shows the extent of the repair project.

The 2010 AADT was 33,600 for the National Highway system (NHS) portion of the project and 37,300 for the STP (non-NHS) portion, relatively high AADTs for Vermont; the nearest vehicle classification recorder indicated that 3% of these vehicles are trucks. The grades on US Route 7 in the repair area begins with a negative 0.52% then flattens out near the intersection with the ramp, then proceeds northerly with a positive 1.30% from the intersection. The grades on the ramp begin at 2.92% at the beginning of the repair, then tapers down to 2.02% at the intersection. The design plans specified the use of TechCrete on 38 locations along US Route 7 and 35 locations on Ramp "C."

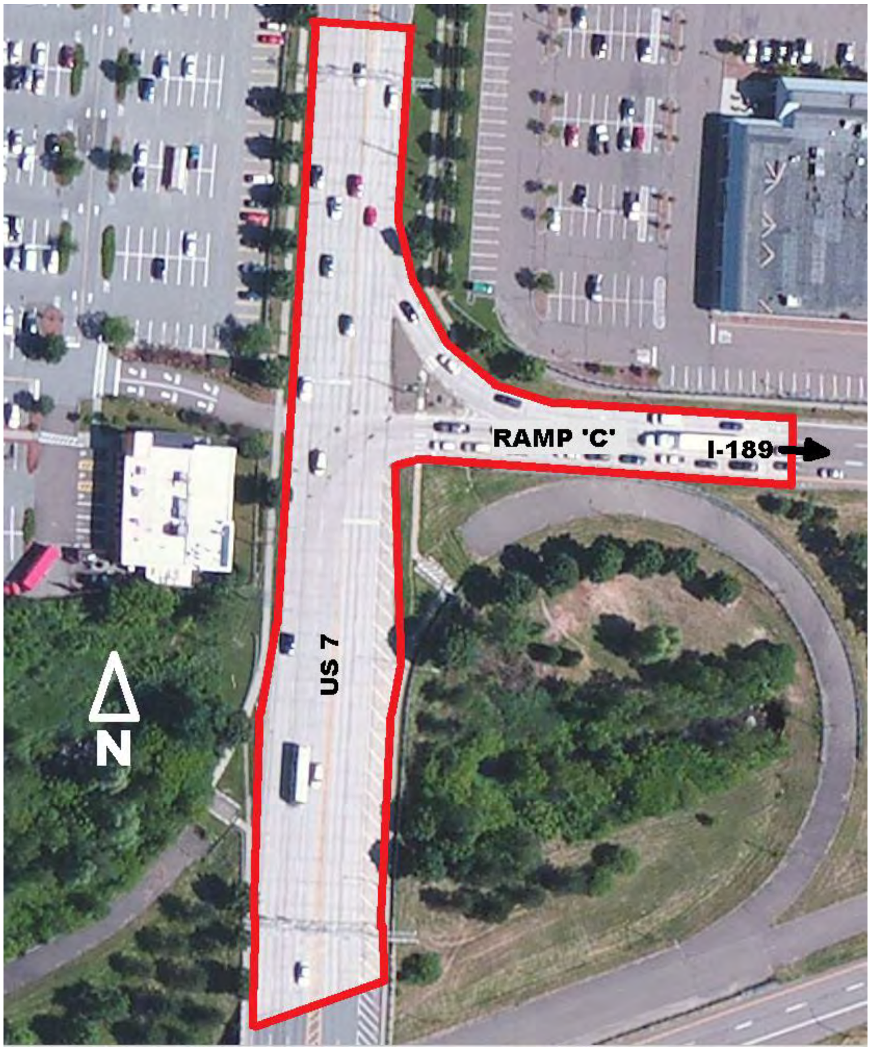

Figure 2 South Burlington Project Site, US Route 7 and I-189 Ramp 'C'

Specific repair locations were identified by the design consultant, Clough Harbour & Associates LLP. Joint repair utilizing the TechCrete material was referenced in the plans' special provisions. The design consult estimated that approximately 11,000 pounds of TechCrete would be needed to complete the extent of the repairs for these two Burlington projects.

MATERIAL DESCRIPTION

TechCrete produced by Crafco Inc., of Chandler, Arizona, is a flexible and high tensile strength hot pour product intended for concrete repair. It is comprised of a combination of several resins, polymers, and aggregates. Reportedly, the material has a high compressive resistance. TechCrete has proven to provide a long-term life span in most applications. According to the manufacturer, once it is in place, the material will not de-bond or crack, and will contract and expand along with the adjacent PCC pavement. The expected service life of TechCrete, according to product representatives should be a minimum of ten years for standard applications in most conditions.

Prior to application, any defective concrete pavement (spalled, cracked, and any other damaged areas) had to be removed to a minimum width of 4" centered over the joint to a depth of at least 2". This is shown in Figure 3. The joint then needed to be cleaned, dried, and primed. Crafco's specifications for the placement of TechCrete, provides proper temperatures for mixing and set times. According to these specifications, TechCrete must be melted in a mixer/heater to a minimum temperature of 375°F without exceeding the set upper limit of 428°F, within a maximum time limit of 6 hours.

Upon meeting the specified temperature, the material is placed into the prepared joints in two lifts with a maximum lift of 2" on the final course. The surface is then leveled with a heated iron and any air bubbles are allowed to expel. An optional layer of dry aggregate chipping may be placed on top of the surface if desired. TechCrete can be opened to traffic in approximately one hour after placement, weather and ambient temperature dependant. If traffic needs to be allowed over the repairs sooner, the TechCrete may be cooled with the use of water once initial set is reached.

INSTALLATION

Though the prepared joint was required to be a minimum width of 4" per the project plans, a minimum of two inches of sound concrete was to be removed on either side of the joint; therefore, requiring a wider excavated area in most places. Once the joints were cleared of the required concrete, a 1" by 1" chamfer was cut on each edge of the joint using a grinding saw to eliminate the weak point between the concrete and TechCrete. Final limits of removed concrete were at the discretion of the Resident Engineer at the time each of the individual repairs were underway. TechCrete was then place per the manufacturer's recommendations, as previously described. Further, the material was placed one inch outside the edge of the chamfer. As stated within the contract, all work for this project was performed as night work due to the large volume of traffic that was present during daytime hours in both locations.

To determine which joints needed to be repaired for this project, professional judgment was employed by Project Engineers in their evaluation of the site prior to final design. An example of a selected joint in need of repair is shown in Figure 4. Per project specifications and contract, the installation of TechCrete was originally proposed to be limited to an 80-day project, with as many joints being repaired as possible in the timeframe, weather permitting. Additional days were to be added when needed to complete the necessary repairs. The time limit required a prioritization of cracks that would eventually be repaired. The 80 days was inclusive of both the Winooski and Burlington sections of concrete that needed to be repaired.

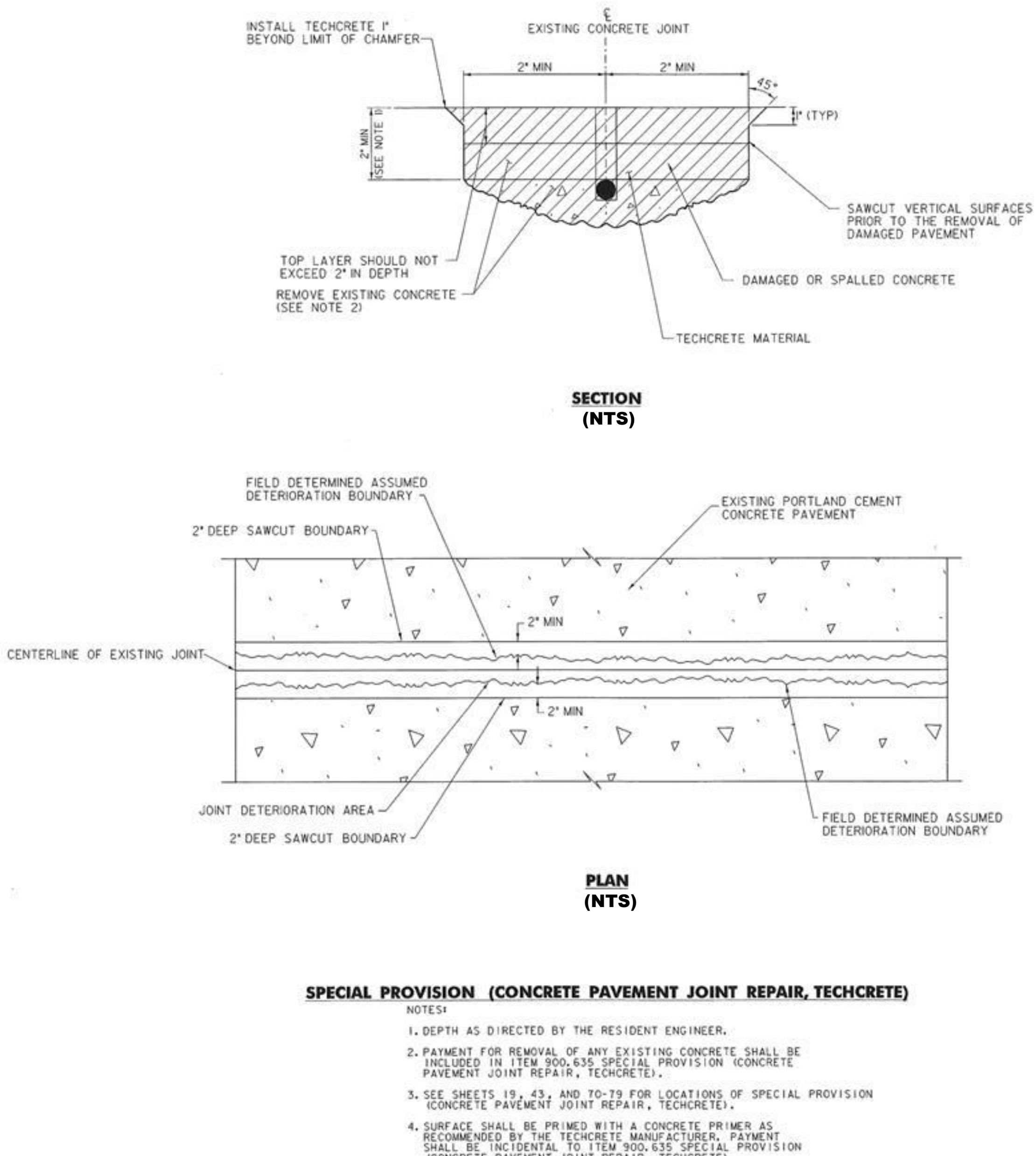

Figure 3 Vermont Agency of Transportation developed standard for TechCrete work

Winooski Installation

Installation in Winooski began on the evening of Tuesday, June 16 2009. Pike Industries was the prime contractor for all three projects, while Nicom Coatings Corporation was the subcontractor; responsible for performing all TechCrete related activities as well as all joint repairs. In addition to this standard personnel, a Crafco sales and technical representative was on hand on the first night to provide guidance. Research personnel were also onsite the first night to observe the installation. The following section details the steps taken during this first night of work, which was duplicated on all subsequent nights, to perform joint repair.

Figure 4 Typical concrete joint deterioration prior to repair

General Installation Details

Once repair limits were identified, the damaged portions of concrete and joint filler from previous repairs were removed. This was accomplished by first cutting around the edges with a saw. This can be seen in Figure 5, along with the rest of the process.

The damaged concrete was broken apart using a 60 lb. jackhammer. Pieces were removed by shovel and hand, and then any dust was swept away with a broom. High points continued to be broken up with the jackhammer. After the depth of removed damaged concrete was deemed satisfactory, the edges of the repair joints were beveled. Pressurized air was used to aid in the cleaning of surfaces. After the repair sections were blasted with pressurized air, any remaining debris was swept away. Once the sections were clean, a compatible bituminous priming solution for concrete, manufactured by Laybond Products LTD, was painted onto the exposed concrete joint.

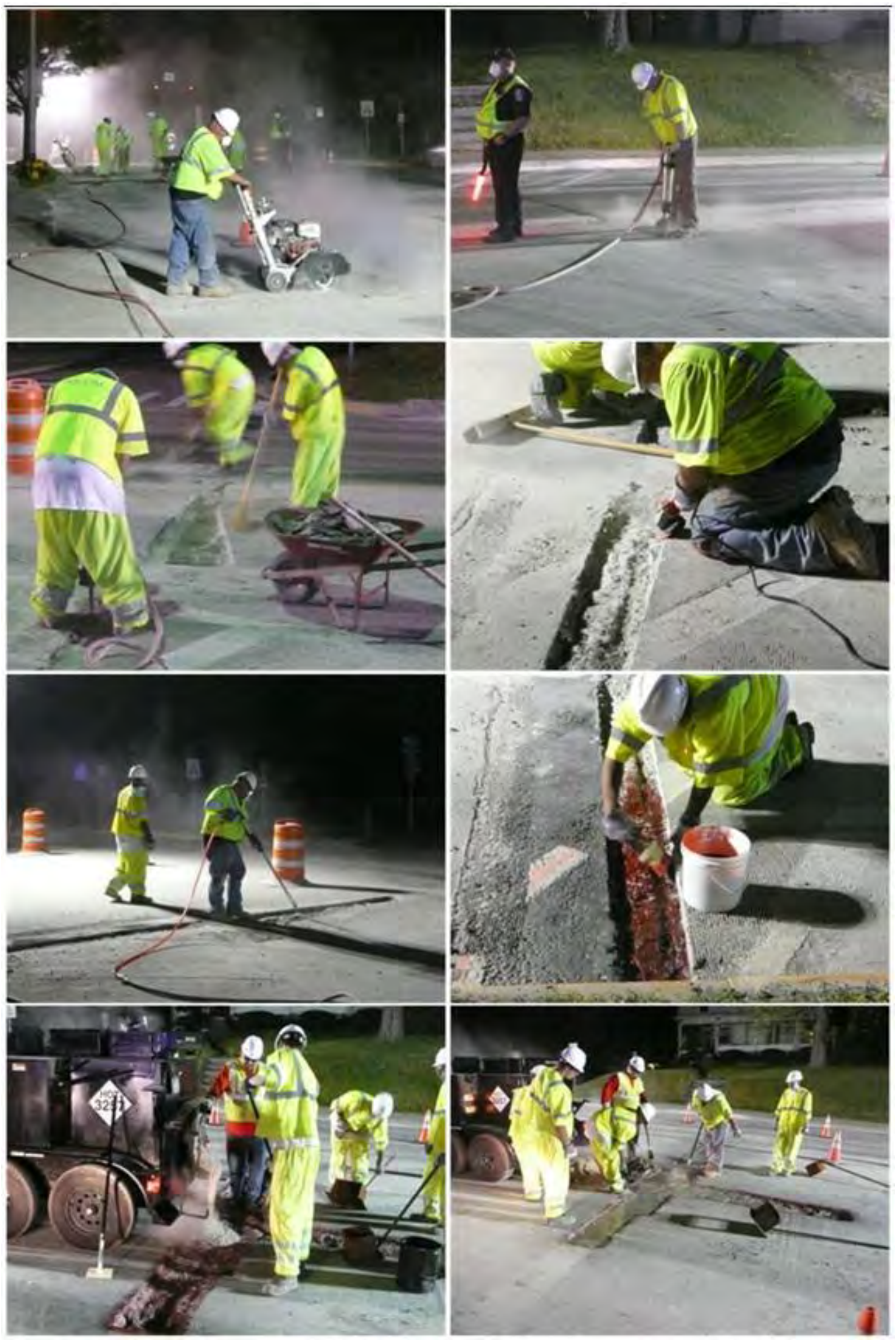

Figure 5 Typical construction sequencing for concrete joint repair with TechCrete

Following the preparation of the joints, the TechCrete material was ready to be placed. A mixing and melting unit, the Craftco Patcher II, was brought to the work site attached to a work truck. The mixing unit was loaded to capacity with the bags containing the repair material. The melting unit was started at approximately the same time as the crew started saw cutting the joints. In accordance with the manufacture's recommendation, TechCrete was heated to the minimum temperature and within the maximum time limits.

Installation of the TechCrete began at approximately 1:45am, as seen in Figure 5. The temperature of the concrete before the TechCrete was placed was measured at 70°F and the contractor maintained the kettle temperature below the maximum. The temperature of the TechCrete two minutes after being placed was 379°F.

The first joint fill was completed by the Crafco representative to demonstrate the process to the contractor. Since the depth of the removed concrete was substantial, this site required a two-lift application, as did all the other sites whose depth was greater than 2" [3]. The repair of the remaining three prepared joints was completed by Nicom Coatings Corporation personnel. Supervision was provided by the Crafco representative. After the TechCrete for all four joints was placed, the repair material was allowed to cool to 150°F. This process took approximately one hour. Once set, the second lift was placed, level to the top of the existing concrete. The repair material was manually delivered to the joints with buckets as the locations of the joints made it impossible to back the kettle trailer in without driving over already setting test sites. All repair material was distributed using rakes and then leveled with a heated flat iron. By the time the exposed joints were filled and repaired, material started to set at 4:30am. This allowed the TechCrete repairs to cool enough for traffic to be allowed on the section of road prior to 7:00am.

Installation on the Winooski project continued throughout the summer, with final placement occurring on October 5.

Installation Problems

The Winooski portion on US 7 poses a large problem for the installation of a flowable material: the steep grade that encompasses a large portion of the PCC roadway. In conjunction with the chamfer on the upper edges of each joint, the repairs on the steepest section of road (approximately 9.0%) allowed the TechCrete to slowly ooze out of the joints and down the sloping concrete surface, giving an appearance of cooling lava. Additional material had to be placed into the upper elevations of each joint to ensure the higher part of the repair section was adequately filled, while at the same time allowing the material to cool enough to solidify at the lower part to keep the material overflow to a minimum. The chamfer further decreased the height of the 'berm' that would hold the TechCrete in place. The schematic shown in Figure 6 attempts to depict this phenomenon, while Figure 7 shows a picture of an overfilled joint after cooling.

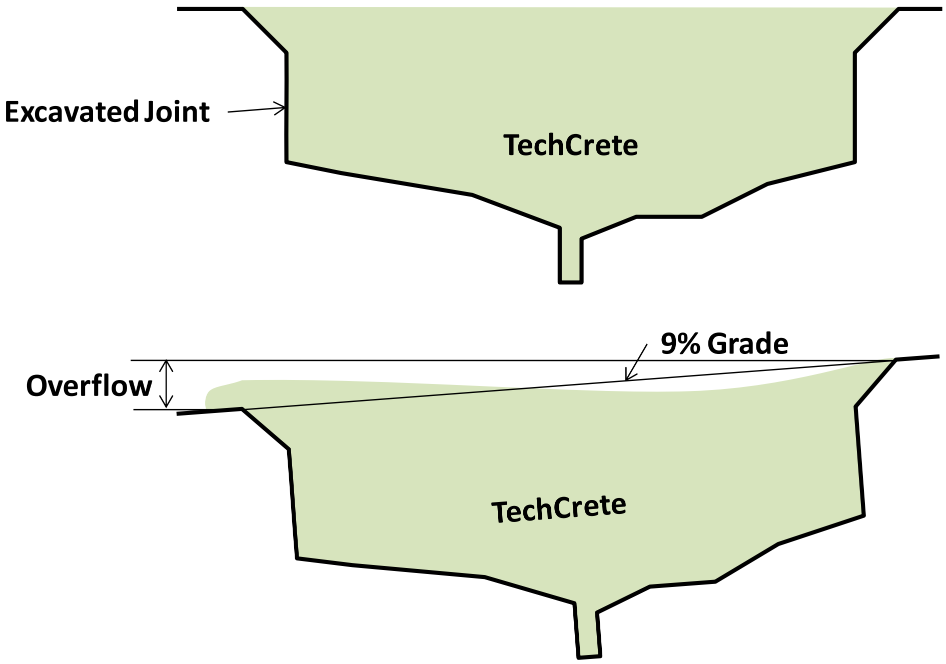

Figure 6 Schematic of difficulty when placing TechCrete on a large grade


Figure 7 Excessive placement of TechCrete on an inclined joint

As can be seen in the figure, the TechCrete in this joint repair was overfilled and had begun to flow down the grade before cooling and solidifying. Once cooled, the excess material can easily be picked up as demonstrated. All joints that exhibited this overfilling had to be repaired afterward to prevent damage to the material itself and the concrete. A snowplow hitting the material could have damaged one or all of the repair material, the surrounding concrete, or the snow plow itself.

It was stated by the contractors that, in addition to the chamfer, another obstacle in providing satisfactory results with the material on steeper grade repairs was the Resident Engineer's desire to have enough aggregate present and visible at the low end of the joint, therefore additional material had to be placed in order to achieve this. According to Crafco representatives, while these aspects make the job slightly more challenging, with the appropriate amount of care and deliberateness, they could have been overcome easily. The result would be the delivery of a satisfactory product throughout its placement, with no further repairs necessary. According to Crafco, the product has been used on steeper grades than this location with perfect success. The Resident Engineer, at one point during installation, asked Nicom to try to reduce the temperature of the TechCrete in the kettles, which aided with the material placement, as the material was somewhat more viscous and cooled quicker. Fewer problems may have been encountered had the subcontractor taken a pause and decided on further alterations to their placement procedure once these issues were discovered, rather than continuing with placement the same process for the remainder of the project. Measures such as having water on hand would have allowed the subcontractor to cool the material more quickly.

In an effort to repair the worst of the joint repairs on the steepest grade, Nicom, attempted three techniques. The first method was to cut the excess material away with a knife/blade. This method was quickly determined to be ineffective. The second method was to use a grader to plane the material away flush with the concrete pavement. This method was slightly more effective, however the TechCrete material proved to be too tough in most cases for the grader to plane the material effectively; it was a very uneven plane even when the grader was able to remove material. According to the daily work report:

> *September 21, 2009: "Nicom crew attempting to perform repairs to TechCrete material. Two methods were used: heated ice scraper tools and the recessed pavement grinding machine. These methods were slow and not very effective at achieving the ¼" reveal desired. Scraper method proved to be the least damaging to the TechCrete, but was painfully slow."*
>
> *October 4, 2009: TechCrete was attempted to be repaired using a grader.*
>
> *October 5, 2009: "…worked with a propane torch and a scraper starting at the Key Bank, working uphill on the SB parking lane. The resulting TechCrete product wasn't pretty, but it was less of a plow obstacle and may ride a little better."*

The third method attempted was to heat up the material and a scraper with a propane torch and scrape the material off, as described above for October 5th. This was very similar to the method of applying the material at installation, where a hot iron was used to apply and smooth out the TechCrete. The actual use of a hot iron was the repair method suggested by Crafco. Once the three methods were attempted the third alternative was chosen as the preferred method, numerous joints were repaired once again, most of them being located adjacent and around the Key Bank area. Figure 8 shows a before and after comparison of one of the joints.

Figure 8 Side by side comparison of an overfilled joint (left) and the same joint after removal of material (right)

The image on the left of Figure 8 is a joint prior to repair, with a considerable amount of extra TechCrete having been placed into the joint. The right-hand side shows the same joint after a heated iron had been used to remove material and smooth out the remainder. The joint is virtually non-distinguishable as being the same one; its appearance is far different after repair. The extra material has been removed as well as possible and the markings from the iron are still visible. The joint is now much more effective, as it does not act as a speed bump as traffic moves across it, nor is it an obstacle for a snowplow.

Burlington Installation

The installation of TechCrete on the Burlington portion of the project occurred in the same manner as the Winooski portion, with the exception of a much faster timetable due to fewer repairs being necessary. The Burlington repairs occurred between August 30, 2009 and September 18, 2009. Research was onsite on one of the final days of production, September 16. Processes and installation methodologies appeared to be identical with little, if any, change or improvement. An image from the installation, along with the hot iron described in previous sections is shown in Figure 9.

Figure 9 Hot iron used during TechCrete placement for leveling

After the completion of the installations, no joint repairs were noted as being in serious need of further repair, unlike what happened with Winooski. Even on the steepest grade (2.92%) on ramp "C" (albeit, not as steep of a grade as Winooski) there was little or no evidence of the same flowing patterns.

PAVEMENT MARKINGS

A considerable amount of thought went into what type of retroreflective pavement markings to use on these projects. Durable markings that would adhere to both PCC and the TechCrete material were desired. Permanent marking tape was chosen as the best alternative for the concrete; however, tape markings required recessing. Recessing requires grinding the surface of the pavement down to a certain depth. Grinding of the TechCrete material; however, was discouraged, since it would 'gum up' the grinder due to the polymer-based material, which has a rubbery consistency.

The solution that was decided upon was to grind the concrete, but not the TechCrete. Where in contact with the TechCrete, the tape would have a much higher profile, thus creating a spot much more susceptible to traffic wear and snowplow damage. It was decided that the tape would be cut on both sides of the TechCrete repairs. If damage or delamination were to occur over the repair material and tape was pulled off, only a foot or two of tape would be lost (between cuts) rather than losing a much longer strip of tape measuring in the tens of feet. Pictures of both the cuts and profile views of the tape can be seen in Figure 10 and Figure 11.

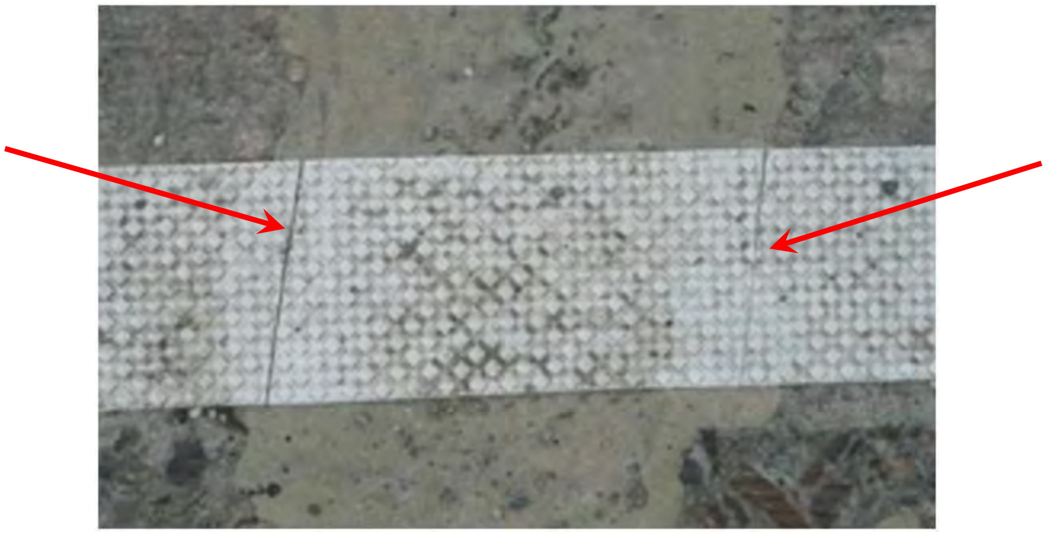

Figure 10: Durable pavement marking tape laid over both PCC and TechCrete. Please note the knife cuts on either side of the TechCrete

During site visits performed on January 26, 2010, approximately 4 months after project completion, the condition of the pavement markings was assessed. At the Winooski location, several lengths of tape had delaminated from the concrete pavement. The tape remained in place where it was applied to the TechCrete material. As predicted, the tape on the TechCrete constituted a high spot and was indeed subject to increased wear, as can be seen in Figure 14. The tape adhesive to TechCrete interface created a much stronger bond than the bond created with the concrete. Figure 13 shows a section of road, in front of a business driveway, where all tape has been pulled off of the concrete pavement while the sections on the TechCrete still remain, even though they are higher and present more of a plowing obstacle.

FINAL CONSTRUCTION

A meeting was held on February 17, 2010, between Construction and Pavement Management, with Research present, to determine what follow up work would need to be completed to close out the project. Pavement Management personnel, following the completion of the TechCrete and hot poured joint sealer installations in the fall of 2009, went out and surveyed the area. The survey revealed that a small portion of the overall repair work was either deficient in material, needed some repair or needed to be completely redone. These troubled areas were noted on project "as-built" plans.

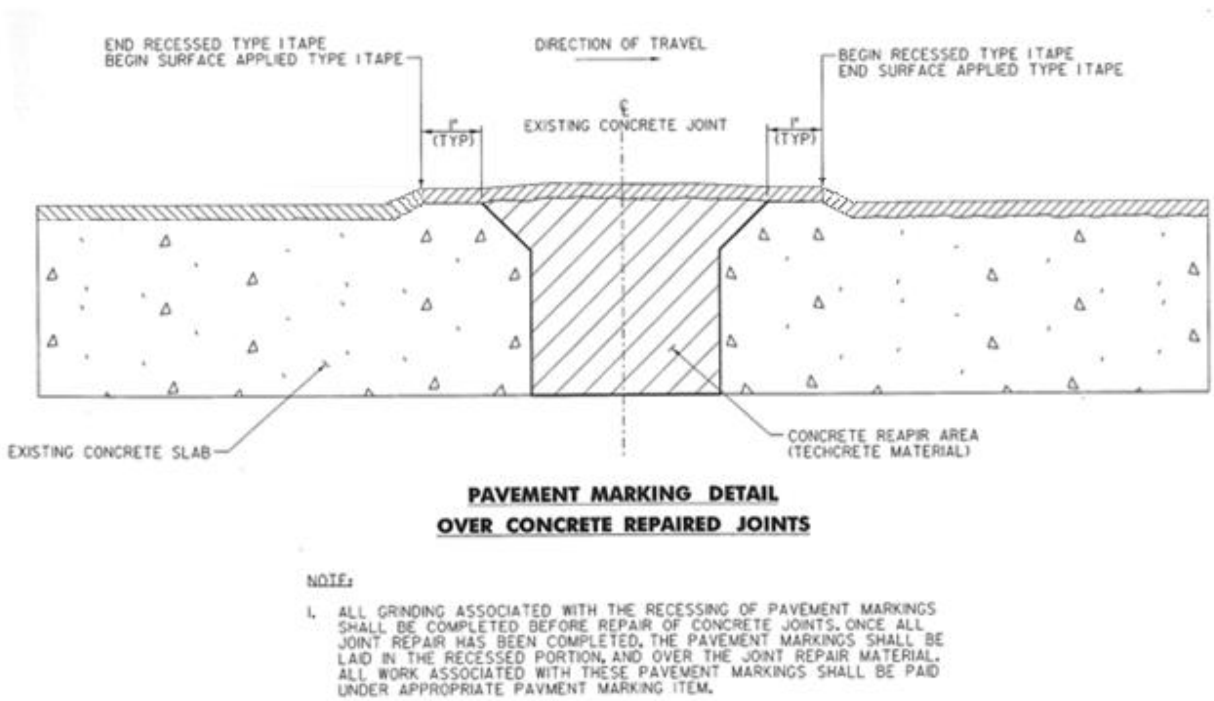

Figure 11: Pavement marking detail from the project plans

During this meeting, it was decided that several joints that had been repaired with TechCrete needed to be reworked. It was decided that the bulk of the necessary TechCrete repairs were at the Winooski location. Very little reworking of the material was necessary at the Burlington location. In addition, similar work was requested on the hot poured joint sealer in some areas as well. A meeting was held between Agency, Pike Industries, and Nicom personnel at a later date to finalize the specifics of how and when the repairs would take place.

The required reworking and repairs occurred over a three-night period between June 21 and June 23, 2010. This entailed more reworking of the higher spots with a hot iron, removal of some material on high spots, and adding material on some under filled joints. Most of the repairs occurred on joints that are adjacent to the Key Bank building, just north of West Allen St., where the roadway was the steepest. This was where most of the placement difficulties as noted earlier, occured.

PERFORMANCE

Site visits were performed on January 26th, 2010 (both locations) and February 17th, 2010 (Winooski) to assess the damage present, if any, following the onset of snow plowing activities during the winter, approximately 4 and 5 months following project completion respectively. At the time of these site visits, no visible TechCrete damage could be seen. This was unexpected, given that after the repairs were performed on the steep grade, there were some high spots still present. The material appears to have held up very well to the plows. An image of the same joint as presented side by side earlier is shown in Figure 12. No visible damage can be seen, with only slight wear evident on the higher ridges from traffic.

Prior to the 2008 pilot project with TechCrete, the concrete repair of 2002 had deteriorated significantly; with lengths of the concrete joint repair being fragmented. Figure 4 in this report gives an example of the state of that repair. Over the years since the repair, Winooski used asphalt patching material to seal the joints in places. In comparison, TechCrete has maintained a monolithic longitudinal integrity, and has maintained its position within the joint.

Figure 12: Condition of joint following first winter season

The traffic marking tape on the project has not performed as well as the TechCrete material has. As previously stated, it was assumed that the portions of tape that were placed on the TechCrete would be the most susceptible to plow and traffic damage because of their higher profile when compared with the recessed tape on the concrete surface. Countering these assumptions, what was discovered was that most of the tape damage resulted from delamination from the concrete surface. Several long and short lengths of tape detached from the concrete. The reasons for this are unknown, but should not be completely due to snow plowing as the tape was recessed. The plow would only be able to catch and edge or corner of the tape and pull it up, if it had not been initially adhered to the concrete. Images of the tape deficiencies can be seen in Figure 13 and Figure 14. Figure 13 shows a portion of tape soundly adhered to the TechCrete, but completely missing up and down station from the repair, with only a short segment of the tape detached from the concrete. Most marking damage was present at the Winooski portion of the project, with little damage on US 7 in Burlington.

Figure 13: Tape markings adhered to TechCrete but not to the concrete

The tape markings on the TechCrete were slightly worn. In all locations where tape was placed on TechCrete, the tape remained in place; no tape has delaminated from TechCrete. What has happened is that the tape has worn down, especially on the highest spots, due to plow and traffic wear. Figure 14 below shows tape wear on the TechCrete, with the highest portion of the repair being at the bottom of the picture.

Site visits have been made following each passing winter. Each site visit showed that the TechCrete repair material was performing well and was intact in all locations as of early 2013. The quality of the concrete around the TechCrete repairs, however, has deteriorated drastically in some areas, as can be seen in Figure 15 below, from 2011, and Figure 16 from 2013. Some corner areas have spalled considerably around the TechCrete; the TechCrete shows no signs of damage or deterioration in these areas. The reason for such rapid deterioration of these corner areas of the concrete has not been determined.

Figure 14: Tape wear over the higher points on the TechCrete repair

Figure 15 Condition of some repair areas following the second winter of service life (2011).

COST ANALYSIS

The bid price of TechCrete for this project was $6.25 per pound of material, which included the concrete removal and joint preparation. The density of TechCrete is reported as being 134.65 lbs per cubic foot. According to Table 2, the total amount of material used was 235,524 lbs. The typical joint during construction was about 4 inches deep. Assuming the concrete was removed at an average depth of 4" on all joints, the total repair area was 583.01SY total for both projects. Considering there was a certain amount of material that was carved off and discarded, the above area would need to be reduced. Assuming that about 1% of the

TechCrete material was discarded, the total repair area may have been around 570SY. The total cost for the TechCrete Application was $1.47 million.

Figure 16 Condition of some repair areas following the fourth winter of service life (2013).

In 2002, the concrete repair used item 580.10, Concrete Repair on Superstructures, Class I for thin repairs of 3” or less and item 580.11, Concrete Repair on Superstructures, Class II for deeper repairs. Since the repairs using TechCrete were predominately 4” depths, the cost for the Class II repairs will be used for comparison. Recent Agency estimates in 2013 suggest the current price for Class II Repair is $585 per square yard. Adjusting for 2009 dollars, the price for Class II concrete repair would have been about $538.38 per square yard. The cost of the repair using conventional methods would have been about $306,876.60 or 21% of the TechCrete costs, without considering the materials long-term effectiveness.

The concrete repair of 2002 in Winooski proved to extend the life of the concrete pavement by 5 or 6 years. In 2008, the City of Winooski began seeking means to repair the deteriorated repair of the joints. In 2009, the Agency worked with Winooski in repairing the joints with TechCrete. By 2013, 4 years later, the joint repair material is maintaining its integrity, though the supporting in situ concrete is continuing to deteriorate.

As seen in Table 2, the initial estimated quantities were substantially lower than the final quantities used. This was primarily due to the extent of repairs that were needed. The repairs required greater depths of concrete removal than originally thought. Another ancillary reason for the overrun on the Winooski portion of the project was the extra material placed into the joints to counter the difficulty with the steep slopes.

Table 2 Cost comparison of estimated versus actual usage costs

Project	Estimate (lbs)	Actual (lbs)	Difference (lbs)
Winooski	136,400	213,756	77,356
Burlington	9,470	19,028	9,558
Burlington	1,530	2,740	1,210
Total	147,400	235,524	88,124

SUMMARY AND RECOMMENDATIONS

Test sites continue to be observed periodically to assess wear and durability at these locations. The number of joints that need substantial repair, the type of repairs that TechCrete is recommended for, is substantial.

The project showed that TechCrete is a viable option for both repairing and sealing joints in concrete pavement that have deteriorated over time. As effective as the material proved to be overall; factors need to be considered for its deployment in future joint repair projects. Steep slopes need specific attention to avoid the placement troubles that were experienced in Winooski. Future contractors and project engineers need to consider the process used in placing TechCrete so that it stays in the void, rather than ooze out as it did north of West Allen Street. The contractor may consider employing rapid cooling methods such as applying cool water or ice to the freshly placed material. As shown in this project, placing TechCrete at lower temperatures provided some relief.

TechCrete proved to be a much more expensive repair method when compared with typical concrete repair. This project was the first placement of TechCrete within an Agency project. Costs typically are higher when new technology is introduced. In the ensuing years of further observations, the Agency will evaluate the products effectiveness in increasing the time between repairs. To the date of this report, observations are showing that the TechCrete material is exceeding the life span that the Agency experienced with typical concrete repair. It remains bonded to the in situ base concrete and is maintaining its structural integrity throughout the entire length of each patch.

A factor learned from the results of this work was that patching deteriorated concrete does not correct the flaws of the in situ concrete pavement. In each case, first with the concrete patching in 2002 and then with the TechCrete patching in 2009, the base concrete of the pavement continued to deteriorate away from the patch, suggesting a currently unexplained phenomenon is underway within the original concrete pavement placement. Patching in both instances has proven to add life to the pavement structure.

Since the project was completed, a new specification was submitted and accepted for item 780.05 Polymer Concrete Repair Products. The new specification requires that these types of products be listed in the Approved Products List in order to be used. TechCrete has been approved by the New Products Committee and placed on the APL.

REFERENCES

1. "Concrete Pavement Rehabilitation and Preservation Treatments", FHWA-IF-06-005, Concrete Pavement Technology Program (CPTP), Washington DC, November, 2005

2. "Pavement Preservation: A Road Map for the Future", FHWA-SA-99-015, Forum held October 26-28, 1998, Kansas City, MO. FHWA 1999.

3. "Concrete Repair Products, TechCrete the Flexible Solution for Concrete Repair" and Product Data Sheet TechCrete, Part Number 34952 and 34953, Crafco Inc., 2008.

4. "Assessment of TechCrete, a Concrete Repair Material and Joint Sealant", Work Plan for Research Investigation, Work Plan No. WP-2008-2-Modified-2, Vermont Agency of Transportation, Jason P. Tremblay, M.S., E.I., December 4, 2008.

5. Vermont Agency of Transportation. Standard Specifications for Construction. 2006.

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STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS AND RESEARCH SECTION

WORK PLAN FOR RESEARCH INVESTIGATION
Assessment of TechCrete, a Concrete Repair Material and Joint Sealant
Work Plan No. WP-2008-2-Modified-2

OBJECTIVE OF STUDY:

With a growing number of highway infrastructure in need of reconstruction or rehabilitation and ever increasing construction costs, State Agencies are seeking out cost effective methods of increasing the service life of pavements. Pavement preservation, according to the American Association of State Highway and Transportation Officials (AASHTO), is a planned strategy of the application of cost-effective treatments to an existing roadway system that preserves the system, retards future deterioration and maintains or improves the functional condition of the system without significantly increasing structural capacity. The application of a preventative maintenance treatment at the proper time provides a cost effective alternative that typically extends the time when a corrective (or reactive) treatment is needed.

Portland cement concrete (PCC) pavements deteriorate over time due to a lack of uniform support from underlying substrates or uneven distribution of traffic loading often resulting in distresses such as faulting, cracking, spalling and scaling. Many of these distresses allow water penetration through the concrete slab creating an ideal environment for freeze/thaw damage. In addition, chloride constituents introduced from winter maintenance practices corrodes reinforcing, thereby reducing structural strength and exacerbating the rate of cracking.

Specifically, PCC pavements contain both transverse and longitudinal joints that must be maintained regularly to prevent premature decay. Spalling is a common occurrence along concrete pavement joints, especially on exterior surfaces that are exposed to freeze and thaw cycles. Joint sealing prevents incompressible materials from getting lodged in the joint space as well as water inflitration. Sealent materials must be able to withstand repeated expansion and compression as the pavement slabs expand and contract with temperatue and moisture changes. However, some joint sealents are unable to withstand daily temperature variations and associated movements resulting in additional cracking and need for repair. Crafto Inc. produces a concrete repair material known as TechCrete that is reportedly a long-term solution for distressed concrete pavement preservation. Product literature indicates that it is a polymer modified resin with aggregate blend that is ideal for repairing multi slab repairs. In addition, it can be open to traffic within one hour of application.

The purpose of this study is to examine and evaluate the constructability, overall performance and cost effectiveness of the TechCrete concrete repair material. Research personnel will assess the product's durability in high traffic locations. Efforts will be made to provide a comparative analysis with regards to performance and cost of the experimental products versus standard joint sealant methods, no treatment of concrete joints, and full concrete replacement.

LOCATIONS:

TechCrete produced by Crafco Inc. will be applied to two city projects. The description of each location is as follows.

Burlington and South Burlington

The first location is the Burlington City Project, NH 2726(1)S and STP 2727(1)S, located at the intersection of I-189 (ramps "C" and "H") and US Route 7 in the towns of Burlington and South Burlington. According to the project plans, work to be performed includes "cold planing and resurfacing of the existing highway with a shim/leveling course and wearing course, resealing/repair of the concrete pavement, new pavement markings, vehicle detector loops, sidewalk ramps, new signs, and incidental items". The AADT, or average annual daily traffic is 33,600 for the NH portion of the project and 37,300 for the STP portion, relatively high AADT for Vermont. The current plans specify the use of TechCrete on 38 locations along US Route 7 and 35 locations on ramps identified as "C" and "H" as shown on associated plan sheets.

Areas of accelerated deterioration along and between pavement joints were selected for application and assessment. Specific locations were identified by the design consultant, Clough Harbour & Associates LLP and joint repair utilizing the TechCrete material will be referenced in the plans' special provisions. All other joints will be repaired with a standard hot poured joint sealer in compliance with the "2006 Standard Specifications for Construction", item 524.11. It should be noted that TechCrete may be applied to additional pavement joints at the discretion of the Resident Engineer during construction.

Winooski

The second location is in the City of Winooski, project STP 2617(1)S on US Route 7 and VT Route 15. All TechCrete material will be used on the US Route 7 portion of the project, as this is the portion with concrete pavement, which extends from mile marker 0.045 to 0.264 for a total length of 0.219 miles. According to the project plans "work to be performed under the Route 15 portion of this project includes cold planing, resurfacing with a leveling course and wearing course, pavement markings, guardrail, improvements, and incidental items. The Route 7 portion of the project involves the repair of deteriorated concrete joints using a self-adhesive polymer product." The AADT on US Route 7 is as follows: 12,800 for MM 0.045 to 0.079; 15,000 for MM 0.079 to 0.159; and 11,500 for MM 0.159 to 0.264.

Repair locations were identified by the design consultant, Dubois and King, and will be repaired in an identical manner to the Burlington project.

MATERIAL:

TechCrete produced by Crafco Inc. is a flexible and high tensile strength hot pour product for concrete repair. It is comprised of a combination of several resins, polymers, and aggregates. Reportedly, it has a high compressive resistance and has proven to provide a long term life span in most applications. According to the manufacturer, once it is in place, the material will not de-bond or crack, but will move with the pavement and can be open to traffic within one hour. The expected service life of TechCrete is reported as being a minimum of 10 years.

Prior to application, any defective PCC pavement must be removed. In addition, a minimum of 4” 2” 4” width on either side of the joint must be removed, cleaned, dried, and primed. The TechCrete substrate must be melted in a mixer/heater to a minimum temperature of 375°F (190°C) without exceeding the safe heating temperature of 428°F (220°C). Once heated to the correct temperature it is poured into the cut area in two lifts with a maximum lift of 2” on the final course. The surface is then leveled with a heated iron and any air bubbles are allowed to expel. An optional layer of dry aggregate chipping may be placed on top of the surface if desired.

COST:

The reported cost of TechCrete is $1.47 per pound of material. The density of TechCrete is reported as being 134.65 lbs per cubic foot. According to the estimate prepared by the designer for the Burlington project, a total of 10,350 pounds will be used, assuming a cutting depth of 4” on all joints, which would amount to a total of 77 ft3 of repairs. This will be a minimum amount and could possibly increase. At this rate, a total material cost would be a minimum of $15,214.50 plus labor and equipment.

For the Winooski project, the it has been estimated that 135,000 pounds of TechCrete will be needed to complete the repairs, equating to 1000 ft3. According to the project estimate, the cost of material and labor will be $5.00 a pound for a total of $675,000, installed. Utilizing the same $1.47 cost per pound as above, this results in a total material cost of $198,450 for this project and $213,664.50 total for both locations.

SURVEILLANCE AND TESTING:

The experimental joint sealant will be monitored during placement in accordance with our Standard Specifications as well as with the manufacturer’s specifications. Designated test sections will be visually inspected on a periodic basis throughout the duration of the study. The evaluation shall include the following per location:

1. A preconstruction site visit will be conducted to characterize the current condition of the pavement slabs. This will include an assessment of the pavement joints in areas designated

for the future application of both the conventional joint sealant and Techcrete. All observations will be recorded along with photo documentation.

2. At the time of the application, temperature, relative humidity, precipitation/cloud cover, wind condition, ambient air, and pavement temperatures will be recorded. All surface preparation and application procedures will be monitored closely. Any problems encountered during application of the conventional and experimental sealants will be documented. Reported curing times will be verified by Research personnel.

3. Four test sections will be selected on experimental repairs as well as four on standard joint sealer sections. These specific sites will be extensively tracked, along with general observations and conditions of the entire project.

4. Site inspections will be completed at least annually after the installation to monitor for the appearance of cracks in the test sites. As freeze/thaw cycles will be the most detrimental to the effectiveness of the material, investigations will preferably occur during the springtime months. Observations about the general performance and appearance of this test area will be recorded, along with comments detailing the differences and similarities between the TechCrete and the other joint sealer used.

STUDY DURATION:

The project will be under evaluation for the length of time required to obtain valid conclusions on the performance and effectiveness of the concrete repair material, but not less than five years.

REPORTS:

An initial report will be prepared after initial installation is complete. Interim reports will be prepared and submitted as needed but not less than biennially. A final report will be published once the evaluation is complete, but not sooner than 5 years after installation.

Reviewed by: ______________________________

William Ahearn, P.E.
Materials and Research Engineer
Date:

Approved by Material and Research (WEA)
Approved by Federal Highway Administration (CPJ)