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The implementation project, 5-5110, Implementation of Best Spall Repair Practices for Concrete Pavement, was initiated to assist TxDOT in using more durable repair practices and materials for concrete spalls, especially in CRCP pavements. In the related previous research project 0-5110, Best Practices for Concrete Pavement Spall Repairs, researchers discovered that TxDOT already had several technical tools in place to make it easier for district personnel to find and specify the most promising materials for their concrete spall repair projects.</td></tr>
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Implementing Best Concrete Pavement Spall Repairs

David Fowler
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Table of Contents

List of Figures

List of Tables

Chapter 1. Background for this Project

The Implementation Project, *5-5110, Implementation of Best Spall Repair Practices for Concrete Pavement*, was initiated to assist TxDOT in using more durable repair practices and materials for concrete spalls, especially in CRCP pavements. In the related previous research project *0-5110, Best Practices for Concrete Pavement Spall Repairs*, researchers discovered that TxDOT already had several technical tools in place to make it easier for district personnel to find and specify the most promising materials for their concrete spall repair projects. Some of these tools included Standard Specification Item 720, Repair of Spalling in Concrete Pavement, Departmental Materials Specification 6170, Polymeric Materials for Patching Spalls in Concrete Pavement, a draft specification for DMS -4655, Concrete Repair Materials, Special Specification 3408 from the Houston District in 1993 regarding Crack and Spall Repair (Elastomeric Patching Material) and Special Specification 3096 from 2004 entitled Fiber Reinforced Polymer Patching Material. The Construction Division Pavement and Materials Section- Chemical Branch had already developed extensive, well-conceived qualification testing program specifications, Tex-614-J, Testing Epoxy Materials and Tex-618-J, Testing Elastomeric Concrete. From these testing specifications, a list of currently approved materials is maintained.

Chapter 2. The Implementation Approach

These findings led the research team to develop training materials to assist TxDOT engineers in making improved spall repairs in concrete pavement spalls and to conduct training for key people to provide local technical expertise and trainers. Toward that end, a half-day training workshop was developed, and the training targets came from two select groups.

The first target group is the engineers who typically select the materials and repair techniques. Their decisions have often been based on initial material costs and the duration of closures with disruption to traffic. They do, however, understand life-cycle costing and labor-driven maintenance costs, so that training sessions have the objective of emphasizing the cost effectiveness of repairs that utilize more repair systems that last five or more years.

The second target group is comprised of maintenance supervisors who oversee the actual repairs on district concrete pavements using district manpower, and inspectors, who oversee the repairs to district concrete roadways by outside contractors. The focus of this session is how to properly store, handle, prepare, mix, place, and finish the repairs for safe and effective maintenance solutions.

In addition to the slide presentations, notebooks were provided to attendees. Each of the notebooks included the following handout information.

- Hard copy print-outs of the presentations
- Material selection summary method sheet
- Web links to TxDOT resources
- Printout of DMS -6170 Polymeric Materials for Patching Spalls in Concrete Pavement
- Printout for the latest draft of DMS-4655 Concrete Repair Materials
- Previous TxDOT job specifications for elastomeric patching projects
- The current list of prequalified concrete spall repair materials (by CST M&P-Chemical Branch)
- Guidelines for Concrete Spall Repair Procedures
- Contact information for TxDOT trainers
- CD for the final report on the research project (for more details than the presentation could show)
- CD for both training sessions.

The training was given in Austin at The University of Texas J. J. Pickle Research Campus Commons Building to a group of engineers, including the project's advisory panel and key personnel from the Division Offices. Comments were solicited and collected from attendees, and these were implemented into the next set of training sessions.

Chapter 3. Implementation, Conclusions and Recommendations

It became obvious that busy periods of construction and post-flood maintenance activities took priority over voluntary training regarding a specialized problem that most districts (those without large urban regions) did not have to deal with. Consequently, scheduling the training with interested districts proved difficult. In the summer of 2007 the Lubbock District used the implementation handout materials from the first pilot training to hold their own training sessions without any further assistance from the implementation team. The last training sessions, as a formal part of this implementation project, were given in Fort Worth District's TransVision Center at 9:30 A.M. (Engineers) and 11:00 A.M. (Maintenance Supervisors and Inspectors) on January 8, 2008.

Recommendations from this project are for TxDOT to continue joint efforts by the Maintenance Division, Construction Division Pavement and Materials Section (Chemical and Concrete Branches), and Research Technology and Implementation Office to get full implementation. Interested personnel from larger urban districts like Houston, Dallas, Ft. Worth, Lubbock, Amarillo, El Paso, Austin, San Antonio, and Waco should meet at least annually to discuss successful or upcoming projects and updated materials lists and quality assurance field evaluation concerns for maintaining concrete pavements.

Appendix A: Repair Manual for Best Spall Repairs in Concrete Pavements

This repair manual is divided into three main sections that address specific considerations for the repair of spalls in concrete pavements. The first section is geared toward familiarizing TxDOT engineers, specifiers, and other interested personnel with modern spall repair materials and methods, as well as the design concepts supporting their use on your concrete pavement. It is intended to provide a better understanding of why these relatively unfamiliar materials work so much better than the temporary filling with asphaltic materials.

The second section provides information regarding TxDOT's existing procedures and specifications related to the repair of concrete pavement spalls. It includes procedural specifications, material specifications, testing specifications, and a list of preapproved materials. The goal of this section is to assist in selecting and specifying proper repair methods and material.

The last section is a basic manual to provide guidance for maintenance and inspection personnel. It presents general rules for storage, mixing, placement, return to traffic, and disposal of materials after the repair is completed.

Section 1. Repair material concepts

Background

Concrete pavements are designed to be a cost effective solution for a long service life (30-plus years) under heavy traffic conditions. Long before the end of the service life, however, distress symptoms such as cracking and spalling often begin appearing in the pavement (Figures A1 and A2). Without proper repair of these symptoms, they may rapidly develop into advanced symptoms such as punch-outs or faulting that can seriously reduce the service life. Since labor and traffic control represent the largest costs in repairing spalls in TxDOT concrete roadways, there has been a recent emphasis on longer lasting repairs in concrete pavements. Installing cold-patch bituminous material or lowest-bid, rapid-setting cementitious repair products into concrete spalls is no longer a cost effective strategy.

Figure A1. Beginning spall

Figure A2. Widespread shallow spalling

Rigid pavement spall repair methods and related materials

The goal in spall repairs is to restore the surface for a smooth ride and permanently seal the spalls and associated cracking to prevent water and salt intrusion into and through the concrete where it will cause problems in the pavement and in the base. The sealing prevents or stalls any further erosion and later related pumping due to surface water intrusion into the base.

The critical requirements for concrete spall repair materials are as follows:

Materials Requirements

- General Requirement
  - Carry traffic within 3 hours of placement
  - Resistance to weather and abrasion
  - Skid resistant surface
  - Reflective finish; color to match concrete
  - Placing temperature of 10°C (52°F) and above
- Chemical resistance to:
  - Deicers
  - Motor oil
  - Sodium chloride solution
  - Hydraulic brake fluid
- Physical Requirements
  - Working time of at least 5 min. to 60 min. (from mixing until loss of bond ability and workability, whichever ends first)
  - Wet bond strength to concrete 100 psi minimum
  - Resilience 90 %
  - Compressive strength 200 psi
  - Thermal/stiffness compatibility- can show no delamination or cracking after nine cycles of ASTM C 884

Compressive strength and flexural strength evaluations were made of the most successful products, and the results are shown in Figures A3 and A4. Other tests were conducted, as well, but the results from those tests are discussed in the next section.

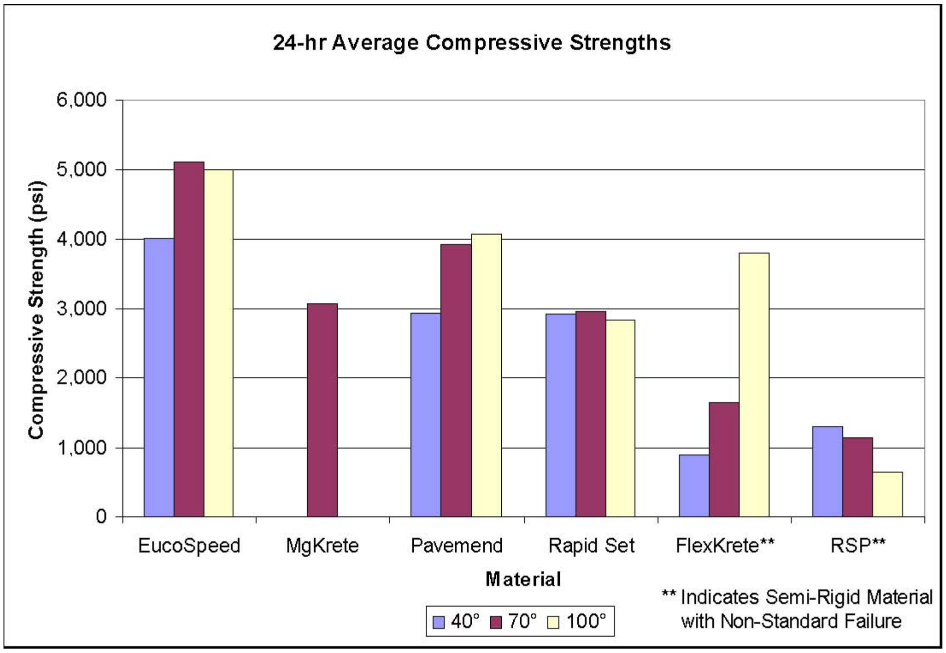

Figure A3. 24-hr compressive strength results for the repair materials studied.

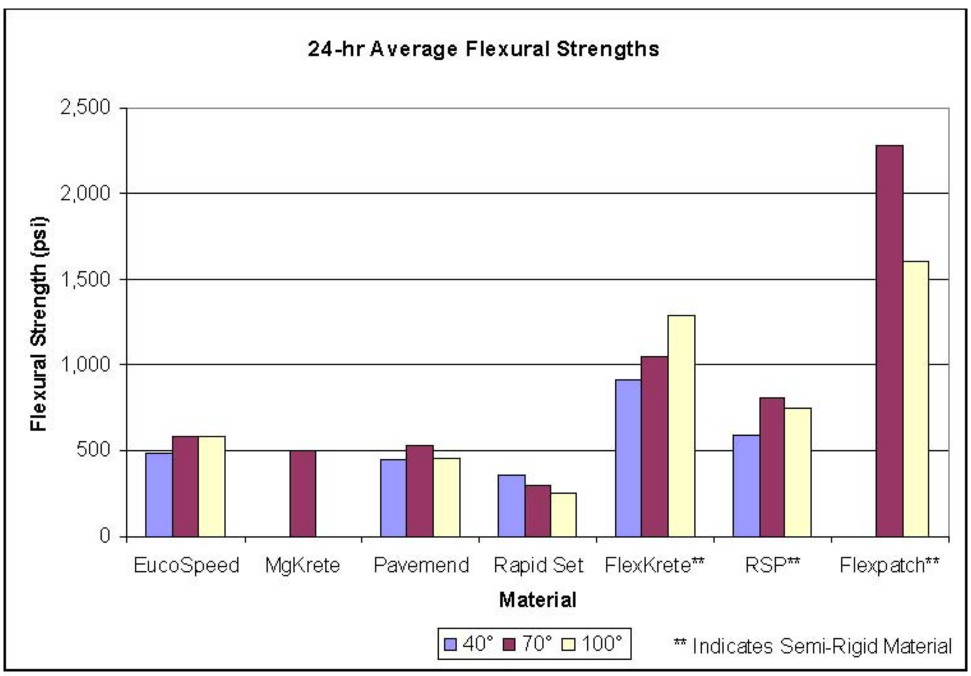

Figure A4. 24-hr flexural strength results for the repair materials studied.

Why elastomeric materials perform better

Laboratory and field evaluations both confirmed that low modulus materials were more durable for repairing concrete. This was apparent even thought the COTE for the polymer repair materials were much higher than for the concrete substrate.

Several commercially available materials that had been reported by TxDOT districts and other state DOTS as being successful were evaluated in the laboratory. The modulus of elasticity (E) is shown in Figure A5.

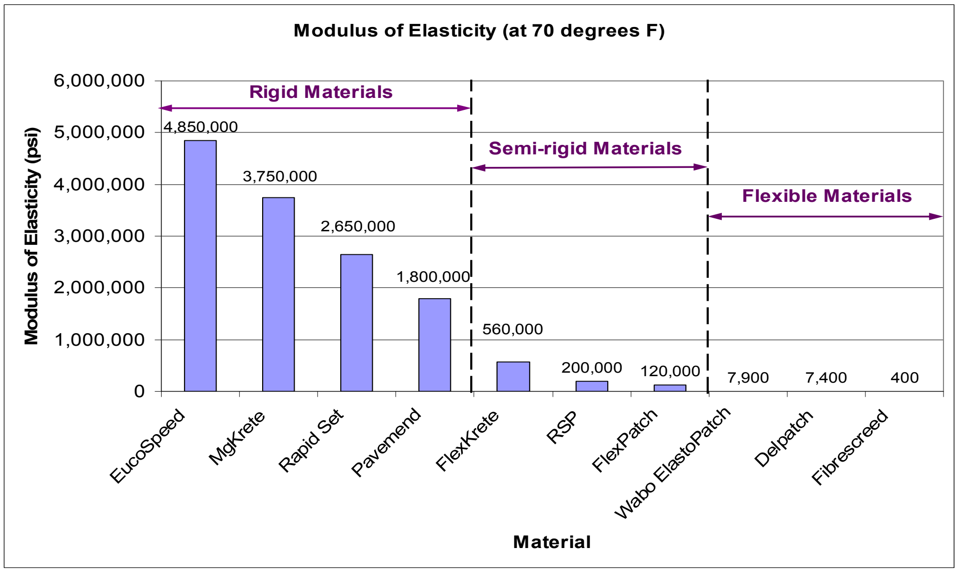

Figure A5. Modulus of elasticity for repair materials used in study.

Laboratory evaluations indicated that the COTE for rigid materials was comparable to normal concrete. Semi-rigid and flexible materials, however, exhibited COTE values that were 3 to 10 times the values of normal concrete (Figure A6).

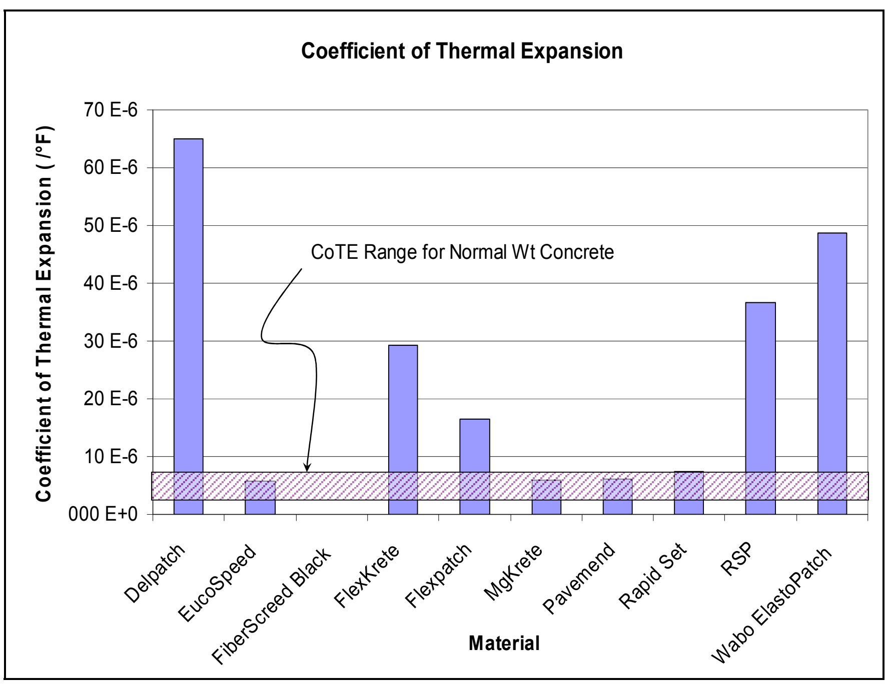

Figure A6. COTE for repair materials used in the study.

The modulus of elasticity and coefficient of thermal expansion may be the two most important properties for repair materials. The coefficient of thermal expansion (COTE) has the units of in./in./°F, and this translates to unit strain per °F. If the COTE, for example, is 6x10-6 in./in./ °F, and the temperature is increased 1°F, a one-inch-long piece of concrete would expand $6x10^{-6}$ in./in./ °F x 1 in. x 1 deg. = 6x10-6 in. However, if that piece of concrete was held between two pieces of concrete so that it couldn't expand, it would have the same effect as letting it expand and then pushing it back to the original position. That would require force as a result of stress.

From Figure A7, the relationship between stress, strain and E is shown. The stress due to restraint against thermal movement can be calculated by multiplying COTE by E (COTExE) (Fig. A8). For normal Portland cement concrete, the stress can be found for a 1°F temperature change as follows for concrete made with limestone and siliceous river gravel:

- For limestone aggregate concrete, the E is 3 to $4.5x10^6$ and the COTE is 4 to 5x 10^{-6}. The stress is COTExE = 12 to 22 psi/°F.
- For siliceous river gravel concrete, the E is 4 to $5x10^6$ and the COTE is 6 to 7x 10^{-6}. The stress is COTExE = 24 to 35 psi/°F.

For the polymer concrete repair materials the E is much lower and the COTE is much higher. Normally when materials with high values of COTE are used, it is assumed that the thermal expansion and contraction will likely cause failure when repeated temperature cycles occur. But the low E helps to offset the high COTE for the polymer materials. The following simplified calculations illustrate the difference in stresses produced by a 30°F temperature drop for two repair materials, assuming that the repair material is bonded at each end and unbonded at the bottom. A more accurate, but also much more complicated determination is discussed in Choi et al (1996).

- MgKrete, a magnesium phosphate. For a 30°F temperature change, a COTE = $6x10^{-6}$ in./in./ °F, and E = $3.7x10^6$, the stress is 666 psi. From Fig. A7 the flexural strength is about 500 psi which is an indication of the tensile strength which is less than the tensile stress of 666 psi; the repair would most likely crack.
- Delpatch, a polyurethane PC. For a 30°F change, a COTE COTE = $65x10^{-6}$ in./in./ °F, and n E = 7400 psi, the stress is 14 psi. The tensile bond strength ranges from 50 to 100 psi, so the Delpatch would be unlikely to fail.

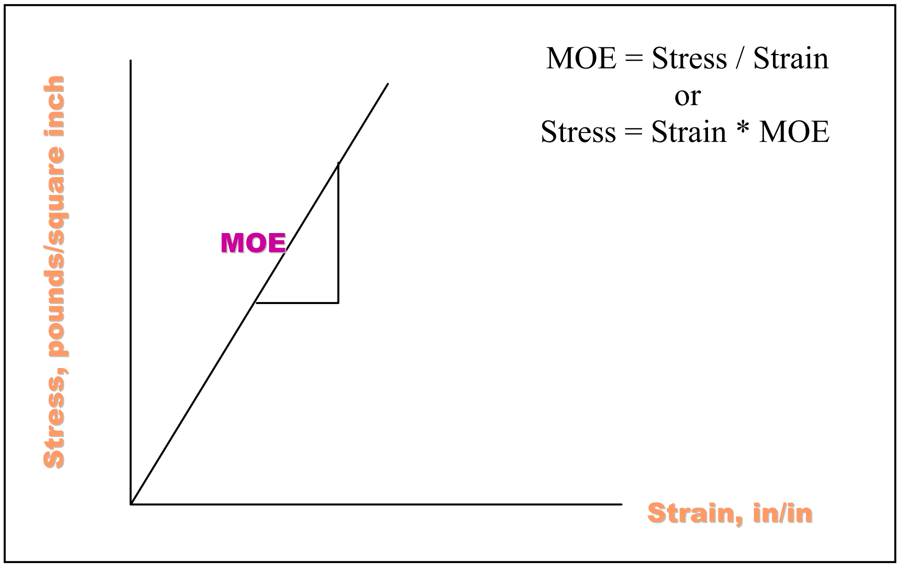

Figure A7. Stress-Strain Diagram

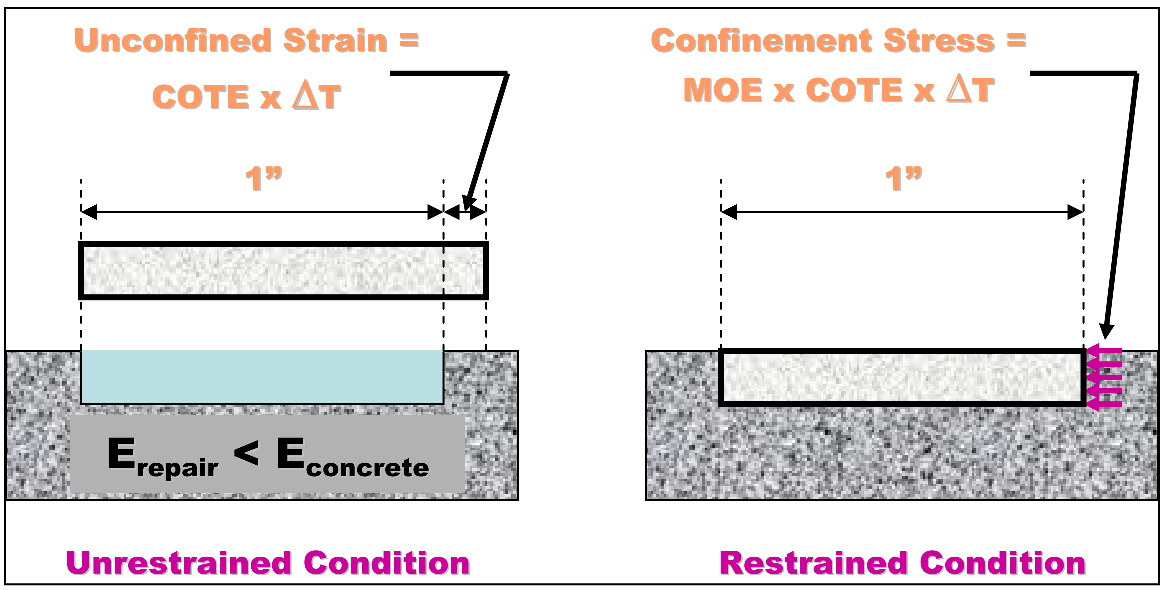

Figure A8. Modulus and COTE at Work

What Have We Learned about COTE and E?

Materials with low modulus of elasticity tend to develop lower stresses due to thermal changes. Field tests, as discussed in the next section, confirm that repair materials with the lowest product of COTE x E perform at a higher level, based on observed stresses. Figure A9 shows the value of COTExE for the materials tested. Materials with a value of about 15 or less showed the best performance. Even though the coefficient of thermal expansion for some of the polymer concretes may be as much as 10 times greater than concrete, the modulus is about 1/400 or 1/500 of concrete, the stress produced is much smaller and the repair material is much less likely to fail when shrinkage or thermal change occurs

- From the field tests we have learned that the polymers that had low E performed the best.
- Materials that had a COTE x E less than 10 psi/deg F seemed to perform better than the rigid materials that had a COTE x E greater than 10.
- Does that mean that hydraulic cements are never good repair materials?
    - Probably not, but the research in this study did not identify any that performed nearly as well.

Figure A9 shows the stress product of COTE x Modulus for all the materials evaluated in the research project
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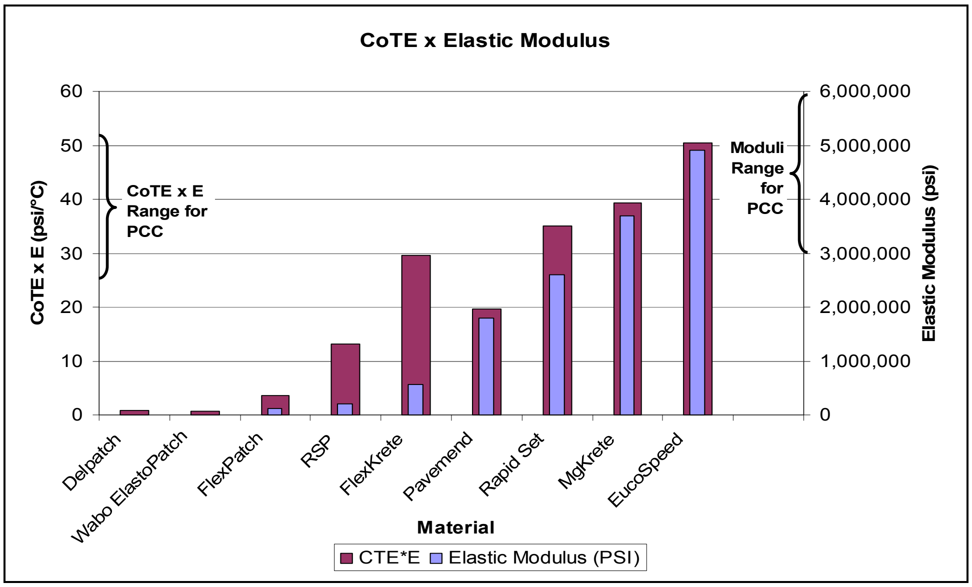

Figure A9. Stress product of COTE x Modulus for repair materials

Field Tests

Houston Field Evaluation

Cores were taken from repairs in Houston made with three different products: WaboCrete, Fibrescreed, and Delpatch (Figure A10), Tension bond tests were performed to measure the bond strength of the material to the concrete.

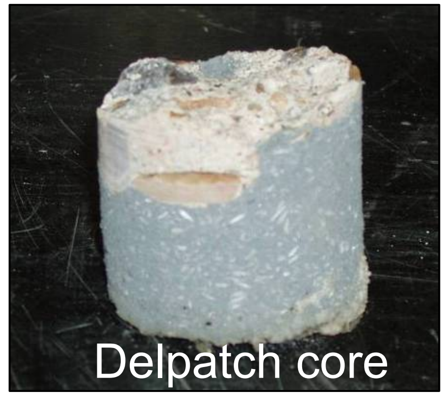

Figure A10. Delpatch core examination

Results were inconclusive due to the limited field samples available for testing, and the failure modes. (Only one material failed at the bond line)

However, visual evaluation of many repairs over a period of about six years in Houston indicates that the low modulus repair materials, particularly urethanes, have performed extremely well.

In many, even most cases, the crack at the bottom of the spall has not reflected through the urethane repair material after several years in place.

I-35 Alvarado Field Evaluation

In the summer of 2005, five repair materials were placed in tracks made in fresh concrete when the pavement was placed over 10 years ago. The tracks had originally been repaired with a repair material that slowly spalled. The five materials included three magnesium phosphates (MgKrete, Pavement, and EucoSpeed), an epoxy polymer concrete (FlexPatch) and a polyurethane polymer concrete (Delpatch). The materials were placed by manufacturer's representatives to insure that the placement was performed properly. Follow up evaluations were made a year after placement. The conclusions from the evaluations were:

- The magnesium phosphates developed significant cracking and spalling (Figs. A11 to A13). The EucoSpeed had finer cracks than the others. MgKrete was clearly the poorest performer of all materials tested at the site. The poor performance of these materials is due to the evolution of high exothermic curing temperatures, high modulus and low ductility.
- The polyurethane polymer concrete, Delpatch, clearly outperformed all other materials (Fig 13). This has been confirmed in the Houston District where repairs have been in place for 5 years or more and show no signs of distress. The excellent performance is due to the very low modulus, high elongation and excellent bond.
- FlexPatch, which is an epoxy polymer concrete, looked very good except for one transverse crack in about 100 lin. ft. of repair and continuous cracks along the boundary which may result in eventual failure within (Figure A14).

Cracking in rigid repairs Boundary cracks in rigid Severe cracking in rigid Surface spalling in rigid

Reflective cracking in rigid Blisters, cracks in rigid Severe spalling in rigid

Figure A11. Magnesium phosphates in Alvarado exhibited many durability problems at an early age.

Epoxy in very good cond. 1 transverse crack/100 ft Polyurethane was best

Figure A12. Polymers in Alvarado performed much better than magnesium phosphates after one year

Section 2. TxDOT Concrete Spall Repair Specifications and Selection Procedures

For the polymer-based repair materials TxDOT has developed a Standard Specification for Repair Spalling in Concrete Pavement (Item 720). There is also a TxDOT departmental material specification, "Polymeric Materials for Patching Spalls in Concrete Pavement" (DMS 6170) and polymer testing protocols (Tex -614-J and Tex-618-J) with acceptance criteria for finding commercially available materials meeting these requirements. An updated listing, "polyptch," (for polymer patching) of manufacturer's products that have already met these requirements in TxDOT CST M&P labs is available online at the TxDOT website.

Finally, CST M&P is finishing a new materials specification (DMS 4655) for rigid repair materials. A list of tests and acceptance criteria will be incorporated into the DMS and the most recent listing of prequalified rigid materials for this spall repair applications will be available online similar to the "polyptch" site.

Spall Repair Specifications

Elastomeric materials are different from asphaltic or portland cement concrete repair materials. Things that need to be spelled out are acceptable storage temperature range, safety and handling equipment and clothing (boots, rubber gloves, goggles), spill cleanup, mixing and finishing equipment, environmental constraints (precipitation and temperature), clean up chemicals, and environmentally responsible disposal of waste and clean up materials. Most of this information can be collected from the MSDS and product technical information, but contacting the company's technical representative could save time.

The procedure for making a spall repair follows the usual procedures for repair:

1. For surface preparations, make a saw cut at least one-half inch deep around the perimeter of the repair and remove all unsound concrete from the spall area. , using a light, e.g. 15-lb. chipping hammer to keep from damaging the sound concrete that could lead to later delamination. If the depth of the repair reaches the level of the reinforcing, examine the steel for corrosion. If the steel is corroded, the concrete must be removed to a depth of about one inch below the steel and the steel must be cleaned of corrosion to prevent delamination of the new repair material.
2. Clean and dry the substrate surface that is to be repaired with sandblasting and compressed air. Care should be taken to have an oil filter on the air compressor to prevent the surface to be contaminated. (Prime the surface if required by the manufacturer.)
3. Mix small batches according to manufacturer's recommendations very close to the repair.
4. Place material into spall and screed even with the grade of the surrounding pavement.
5. Return to traffic once the material exhibits manufacturer-specified characteristics

Repair materials for spalls in concrete pavements in Texas typically include the following types.

- Polymer concretes- polyurethanes, epoxies, thermosetting unsaturated vinyl ester
- Magnesium phosphates
- Hydraulic cement
- Polymer modified bitumen

Material Selection Process

The process of selecting the materials is shown in (Figure A13). The first consideration is whether the repaired area is to be overlaid any time soon. If an overlay is anticipated, the spalls are normally sawed out into rectangular areas at least down to the reinforcement or more typically full-depth. The cutout areas are removed, retaining or restoring any reinforcement, and filled with a rigid cementitious repair material that has a coefficient of thermal expansion (COTE) very close to that of the substrate concrete. Because the modulus of both repair material and substrate are very high, and so are the compressive strengths, it is important to minimize the thermally induced stresses from dissimilar material as much as possible. COTE values for repair materials must be established in a commercial testing lab and verified by TxDOT CST M&P lab. Because the volumes are so much larger, material costs for full-depth or half depth cut-out repairs play a larger part in the overall project cost, and rigid cementitious repair materials generally cost much less than the polymer-based repair materials.

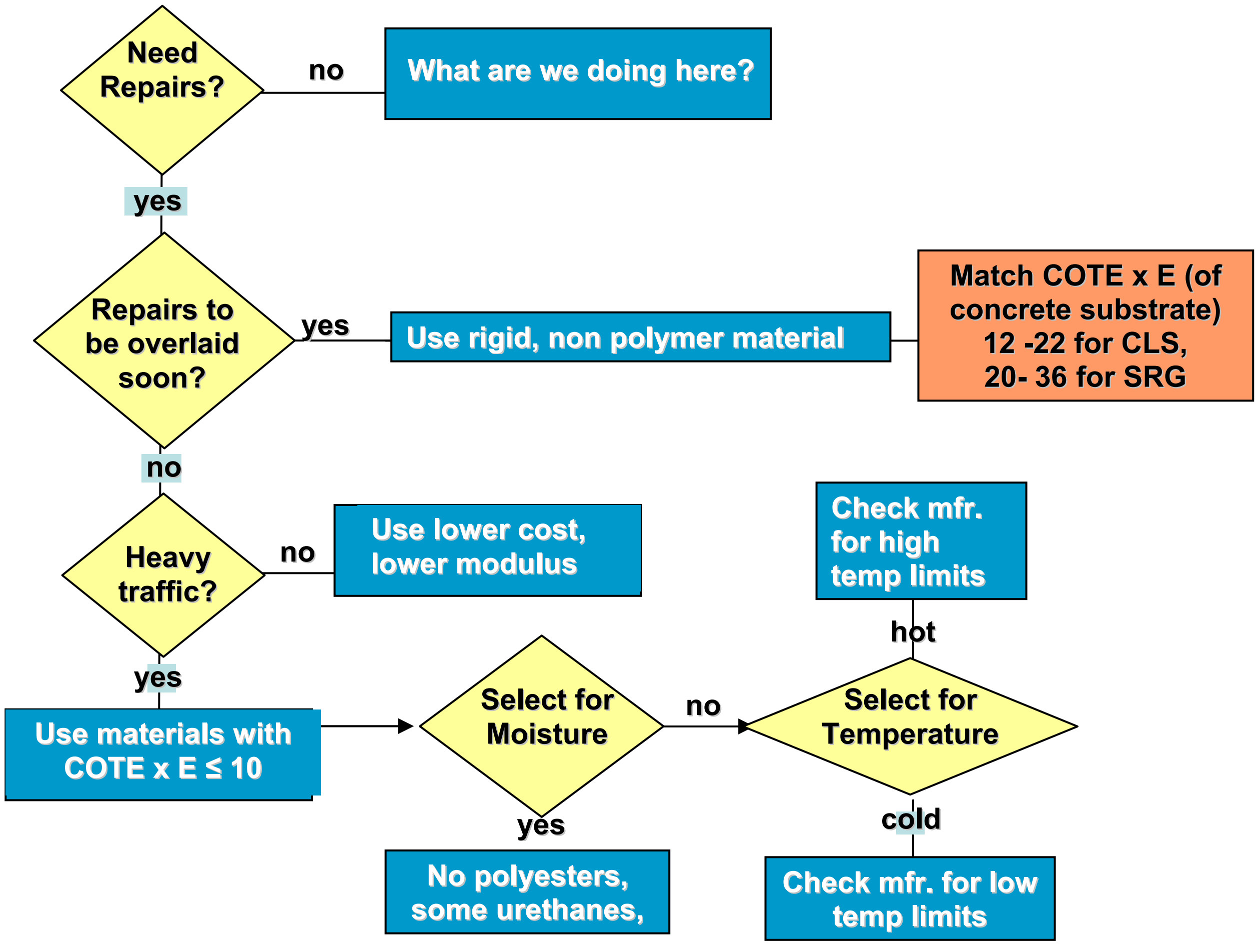

Figure A13. Material selection process

If no overlay is planned for the repair area, an elastomeric flexible polymer-based material is recommended for all shallow spalls (less than half the pavement depth). Some shallow edge sawing will still be required to avoid feather-edging the repair material. Also, high traffic lanes, particularly by trucks, make the more expensive longer durability materials a more cost-effective option. Low traffic volume roads might allow the consideration of a less expensive option.

The next consideration is the COTE of the repair material with respect to the pavement. For the elastomeric materials the COTE will be much higher than the substrate. The lower modulus of elasticity helps to offset the higher COTE as discussed in Section 1. It is recommended the product of COTE x modulus, E, be less than about 10 lbs/in^2°F. The lower modulus materials deform much more under load, but rutting is not a problem (Figure A14).

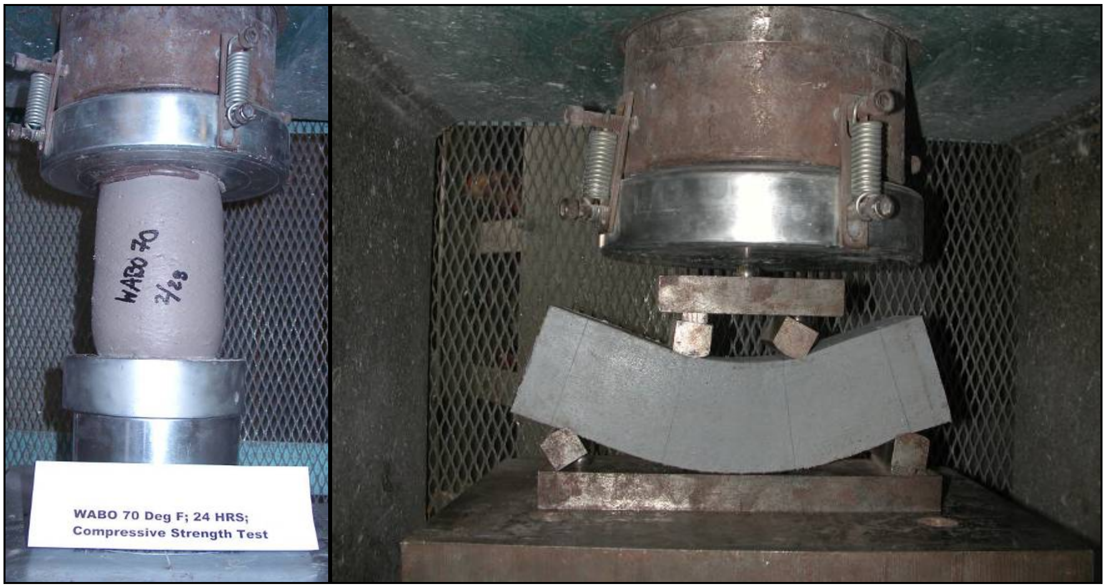

Figure A14. Flexible materials are typically too easily deformed to test under concrete test methods. This material is still within elastic limits.

The final consideration should be temperature and moisture constraints at the time of placement. Even though some epoxy-based systems are much less sensitive to the presence of moisture than other elastomeric repair materials, all polymer-based materials will have better bond strength to dry substrate surfaces. The epoxies actually chemically bond to the surface of the concrete, while the rest mechanically bond to surface voids and irregularities. Moisture blocks the full access of the polymer to reduce or prevent complete mechanical bonding.

Temperature is important because it significantly affects both the working time and the time to traffic, much more than for portland cement. Most manufacturers give working time and time to traffic based on room temperature, and those times may be reduced significantly as the ambient temperature increases, and conversely increase as temperatures are lowered. However, most manufacturers either produce slightly different formulations targeted for a pre-specified temperature range, or they can provide additives to retard or accelerate their mixtures. TxDOT CST M&P maintains a list of pre-approved materials that they have tested and passed based on the acceptance criteria. It probably is important to note here that working times less than 15 minutes are normally not practical. Similarly, allowable time to traffic may be no more than three or four hours, and temperatures could easily result in increased times.

Section 3. Guidelines for Repair Procedures

The following guidelines are provided to summarize good practices associated with successful repair techniques. Since many of the requirements are specific for certain material types, it is important to determine the manufacturer's requirements before the final product is selected. In some cases, because of time or seasonal temperature constraints, particular requirements for a given product might preclude its use in the spall repair project under consideration.

Preparation for spall repairs begins by removing unsound concrete and cleaning contaminants from the spalled area. This may require chipping with a light jack hammer or bush-milling. Nearly all materials also require that the edges be well defined by saw cutting to avoid feathered edges that often ravel. The edges are typically sawed at least ½ in. deep before sandblasting. The area to be saw cut should generally be in a rectangular shape as shown in Figure A15. Other preparation measures are:

- Clean steel reinforcing (If rust is present) - When the depth of the spall is such that rebars are exposed, repair material manufacturers may recommend or require that the rebars be cleaned (sandblasted, shot blasted or wire brushed) down to clean white-metal. This is particularly true for hydraulic cement repair materials, such as Rapid Set, Euco Speed, Pavemend, and MGKrete.
- Prime the surface (If required by manufacturer) - Some of the materials require that a primer be applied to the cleaned spall before it is filled with their repair material to improve the bond to the concrete For the materials previously discussed, priming is required by:
    - Fibrescreed
    - Delpatch
    - FlexKrete
    - Wabo ElastoPatch
    - Flexpatch (only if repair is less than 1 in. deep).
- Reestablish joint for rigid materials- It is recommended that the joint be reestablished in the surface of any rigid repair materials over existing cracks or joints (Figure A15) by saw cutting or by insertion of a joint material.

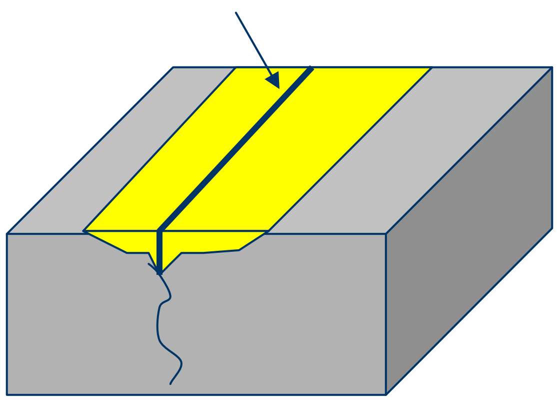

Figure A15. Re-establishing the joint

It is important to keep in mind that different materials have different properties and different requirements. Temperature and moisture compatibility are two important considerations for repair materials.

- **Temperature**
    - Cool temperatures retard and slow down cure times, and if return to traffic time is important and the repairs will take place during cool weather, the manufacturer may be able to provide an accelerator to speed the curing process.

- Warmer temperatures accelerate cure time and could prevent sufficient working time. Some manufacturers have retarders available to provide longer working times during hot weather.

- **Moisture**
  - Most materials develop higher bond strengths to dry surfaces.

Types of Repair Materials

- **Polymeric** (polyurethane, vinyl esters, epoxy). These resins start out as pourable liquids that will cure into hardened binders. For repairs, the resins are mixed with curing agents, sometimes called hardeners or initiators, and then with aggregates, usually sand and sometimes pea gravel. The key is to get the resin systems to harden at just the right speed. The working time must allow enough time for complete mixing, placing into the spall and finishing to a smooth surface flush with the surrounding concrete. At the same time traffic control costs and return-to-traffic criteria constraints require that the material cure sufficiently for trafficking in a very short period after the end of working time. Retarders and accelerators can often be added to help control the working and curing times. Some epoxy systems are custom batched at the factory to accommodate a specific ambient temperature range.

  This type of repair material is called polymer concrete, which simply means aggregates glued together with polymers, or plastics. Polymer concrete is very durable, water tight, and wear resistant. It bonds very well to dry aggregates and dry concrete—but this is important—usually the aggregate and concrete need to be dry. Some epoxies and polyurethanes can bond to wet surfaces and possibly even damp aggregate, but the manufacturer should be consulted if the repairs are to be made under these surface conditions.

  Some polymer concretes are very flexible, so that they have the ability to stretch considerably more than rigid materials without breaking (think of chewing gum). This makes them better for repairs than a very brittle material which cracks easily. Most of the polymer concretes considered for repairing pavement spalls are very ductile, but still hard enough to wear well. Generally speaking, the more resin-rich repair matrix gives more elastomeric properties, and filling the matrix with more clean, dry sand or coarse aggregate makes it more rigid. It is important to note that polymers cost much more than portland cement, but their ability to bond and stay in the repair without cracking may make them very cost effective. So, initial material costs in a labor intensive job may not be nearly as important for repairs as for new construction.

  Polymer concrete brand names used in this study included:

  - **FlexKrete**—Vinyl Ester
  - **FlexPatch**—Epoxy
  - **Delpatch**—Polyurethane
  - **Wabo ElastoPatch**—Polyurethane
  - **RSP**—Polyurethane

- **Modified Bitumen.** This binder system, basically asphalt upgraded with polymers, requires special equipment to heat the bitumen, similar to making hot mix. That renders it a material available for large jobs. It does not have the strength or wear resistance of most of the other repair materials, but it has remained in the spall where it has been applied.
- **Fibrescreed**. A hot applied synthetic polymer modified resin and bitumen compound containing mineral fillers, chopped fibers, sand and graded granite aggregate.
- **Rapid Setting HydraulicCement.** These systems are similar to normal portland cement concrete, grouts or mortars. They cost considerably more but they set much more quickly to accommodate early return-to-traffic times. Because they are brittle, edge sawing is typically required. One well known brand is:
  - **Rapid Set**—Chemically, this material is 33% calcium sulfo-aluminate and 67% di-calcium silicate.
- **Magnesium phosphate.** This binder system is a special chemical that reacts with water and sets very quickly in a rigid binder system. It is mixed with aggregate very similar to portland cement. In hot weather, it must be retarded or it will set faster than it can be placed and finished. It rapidly cures to a relatively brittle material. Commercially available magnesium phosphates include:
  - **EucoSpeed**
  - **Pavemend**
  - **MGKrete**

Instructions for mixing and placing individual repair materials that were evaluated in this research project are as follows:

- **Delpatch:**
  - Mix 3000ml part "A" component with 1500ml part "B" component for 10 seconds. Add pre-bagged aggregate and mix an additional minute.
  - Pour material into spall.
  - Texture surface with trowel.
- **FlexKrete:**
  - Mix 1gallon of Flexkrete with 1.2 oz of catalyst. Mix for 30-60 seconds. Add 3 to 4 gallons of sand and mix thoroughly for 2 minutes.
  - Pour material into spall.
  - Trowel into place.
- **Wabo Elasto Patch:**
  - Mix part "A" component with "B" in a 1:1 ratio for 2 minutes. Add packaged aggregate and mix an addition 2 minutes until well blended.
  - Pour material into spall.

- **FlexPatch:**
  - Mix prepackaged part “A” component with “B” for 3 minutes. Slowly stir in part “C” component (aggregate) until well blended.
  - Pour material into spall.
  - Finish with steel trowel.
- **RSP:**
  - Place aggregate into spall area.
  - Mix part “A” component with “B” component in 1:1 ratio.
  - Pour material over aggregate in spall.
  - Apply sand to top of repair.
- **EucoSpeed:**
  - Add 0.4–0.5 gallons of water to 50 lb bag of material. Mix for 2 minutes. May extend with an additional 30 lbs of pea gravel; mix an additional minute.
  - Pour material into spall.
  - Trowel material, broom finish.
- **Pavemend 15:**
  - Add 1.0 gallon of water to 45 lb bucket of material. Mix until temperature has reached 95 degrees.
  - Pour material into spall.
- **Rapid Set:**
  - Add 3–5 quarts of water for each 60 lb bag of material. Mix for 2 minutes. Mix 1–3 minutes until of uniform consistency.
  - Pour material into spall.
  - Trowel, float or broom finish.
- **FibreScreed:**
  - Material placed by contractor with proper equipment.
  - Place packaged material in machine.
  - Once material at proper temperature (375-380 degrees) apply to spall area in 2-in. lifts. Add ¾-in. bulking stone with each lift. Continue until flush with surface.
  - Apply top coat for skid resistance.

Table A1 is provided for quick reference regarding the type and times for each or the materials evaluated in this research project.

Table A1. Set time and time to traffic for materials tested

Material:	Initial Set Time (minutes)	Return to traffic	Type
Wabo ElastoPatch	22	1 hr	Elastomeric Polyurethane
Delpatch	60	1 hr	Elastomeric Polyurethane
RSP	6	1 hr	Elastomeric Polyurethane
Fibrescreed	**	15 min – 1 hr	Visco-Elastic Polymer-modified bitumen
FlexKrete	8	1.5 hrs	Semi-Rigid Vinyl Ester
FlexPatch	63	1 – 2 hrs	Semi-Rigid Epoxy
RapidSet	24	1 hr	Rigid Hydraulic Cement
EucoSpeed	17	1 hr	Rigid Magnesium Phosphate
Pavemend	13	1.5 hrs	Rigid Magnesium Phosphate
MG Krete	?	?	Rigid Magnesium Phosphate

** Not chemically activated, temperature controlled

Keep in mind that many products have additional additives which can speed up, and slow down working times and set times. Some companies also produce different formulations for different temperatures which effect critical times.

Training workshops were conducted during the Improved Repairs for Spalls implementation phase. In these workshops TxDOT personnel were trained to be designated regional trainers, who could be available on demand from other interested TxDOT personnel. In this way engineers, inspectors, and maintenance personnel without prior experience with these materials and methods could be advised and assisted in making the best selection of repair strategies and in performing the repairs most effectively. A list of TxDOT contacts who attended the workshop training is shown below. Additionally, CDs with the full presentation and workshop notebooks filled with pertinent reference materials are available through TxDOT's Office of Research and Technology Transfer (RTT).

References

Al-Negheimish, A.I. "Bond Strength, Long-Term Performance and Temperature-Induced Stresses in Polymer Concrete – Portland Cement Concrete: Composite Members." Ph.D. Dissertation. The University of Texas at Austin. August 1988.

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Choi, D., Fowler, D.W. and Wheat, D.L., "Thermal Stresses in Polymer Concrete Overlays," *American Concrete Institute Special Publication #SP166,* Properties and Uses of Polymers in Concrete, pp. 93-122, November 1996.

Zalatimo, Jamal-Aldin. "Analysis, Design, Construction and Durability of Polymer Concrete Overlays." Ph.D. Dissertation. The University of Texas at Austin. May 1993. pp 63-74.

Appendix B: Texas Standard Specifications 2004 (ITEM 720)—Repair of Spalling in Concrete Pavement

720.1. Description. Repair spalling and partial-depth failures in concrete pavement.

720.2. Materials. Furnish either rapid-set concrete or polymeric patching material unless otherwise shown on the plans.

A. **Rapid-Set Concrete.** Provide concrete that meets DMS-4655, "Rapid-Hardening Cementing Materials for Concrete Repair."

Use a packaged blend of hydraulic cement, sand, and gravel (maximum size 3/8 in.) which requires the addition of water and has a maximum shrinkage of 0.15% in accordance with ASTM C 928. Do not use chlorides, magnesium or gypsum to accelerate setting time. Before spall repair operations, demonstrate that the mixture achieves flexural strength of at least 425 psi in 5 hr., a minimum compressive strength of 5,100 psi in 7 days, and 6,300 psi in 28 days. Test in accordance with Tex-418-A and Tex-448-A.

B. **Polymeric Patching Material.** Provide polymeric patching material that meets DMS-6170, "Polymeric Materials for Patching Spalls in Concrete Pavement," and matches the color of the pavement.

720.3. Equipment. Furnish equipment in accordance with Item 429, "Concrete Structure Repair," or as approved.

720.4. Work Methods. Repair areas as shown on the plans or as directed. Dispose of debris off the right of way in accordance with federal, state, and local regulations.

A. **Hydraulic Cement Concrete Material.** Saw at least 1 1/2 in. deep around repair area before concrete removal, unless otherwise directed, providing a vertical face around the perimeter of the repair area. Provide a uniform rough surface free of loose particles and suitable for bonding. Remove concrete to a depth of 1 1/2 in. or the depth of deteriorated concrete, whichever is greater. Use chipping hammers not heavier than the nominal 15-lb. class or hydro-demolition equipment for the removal of concrete below 1 1/2 -in. depth. Mix, place, and cure in accordance with manufacturer's recommendations. Do not place concrete if the air temperature is below 40°F. Screed concrete to conform to roadway surface. Provide a rough broom finish.

B. **Polymeric Patching Material.** Submit for approval a statement from the manufacturer identifying the recommended equipment and installation procedures. Remove the deteriorated concrete to the dimensions shown on the plans or as directed. Dry and abrasive-blast the repair area to ensure it is free from moisture, dirt, grease, oil, or other foreign material that may reduce the bond. Remove dust from the abrasive blasting operation. Apply primer to the repair area. Reapply primer if conditions change before placing patching material. Mix, place, and cure in accordance with manufacturer's recommendations. Begin placement of material at the lower end of sloped areas. Screed polymeric patching material to conform to the roadway surface. Provide a non-skid finish with a notched trowel.

720.5. Measurement. This Item will be measured as follows:

A. Hydraulic Cement Concrete Material. By the cubic foot of concrete repair material placed.

B. Polymeric Patching Material. By the gallon of polymeric patching material placed.

720.6. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Spalling Repair" of the type (Hydraulic Cement; Polymeric, Flexible; or Polymeric, Semi-rigid) specified. This price is full compensation for sawing, chipping, milling, cleaning, abrasive-blasting, repairing spalled concrete pavement, disposal of materials, materials, equipment, labor, tools, and incidentals.

Appendix C: DMS-6170, Polymeric Materials for Patching Spalls in Concrete Pavement

Overview

Effective Date: August 2004 (refer to 'Archived Versions' for previous versions).

This Specification governs the quality monitoring program (QMP) for polymeric material for patching spalls in concrete pavement, and describes prequalification, quality monitoring requirements, disqualification and requalification, sampling and testing, and material requirements.

Material Description

Concrete patching material is a thermosetting polymer-based material mixed with aggregate to form a mortar used for patching spalls in concrete pavement.

- Type I is a flexible material with high resilience properties. This material is not intended for use in areas where a concrete asphalt overlay is anticipated.
- Type II is a semi-rigid material with a high compressive strength. The rigidity of this material is preferred when the concrete pavement will be repaved with a concrete asphalt overlay.

Prequalification

Material Producer List

The Materials and Pavements Section of the Construction Division (CST/M&P) maintains a material producer list (polyptch) of all materials conforming to the requirements of this program. Materials appearing on the material producer list require no further testing unless deemed necessary by the engineer. To obtain a place on the material producer list the producer must be accepted into the QMP.

The material will be prequalified as a complete binder and aggregate system; thus, the list will include the binder and aggregate specified by the manufacturer. The Contractor, supplier, or producer cannot substitute any of the components without prior notice to and approval of CST/M&P.

Materials not appearing on the material producer list require project specific testing and approval before use. Refer to 'Project Specific Testing.'

Prequalification Requests

Submit a written request to the Texas Department of Transportation, Construction Division, Materials and Pavements Section (CP51), 125 E. 11th Street, Austin, Texas 78701-2483, to prequalify your products. Include the following information in the request:

- Company name,
- Physical and mailing addresses,

- Contact person and telephone number, and
- Material type.

Performance History

CST/M&P will only accept into the QMP those materials that are determined by the Director of CST/M&P to have an established performance history and compliance with this Specification. Therefore, prospective producers or suppliers may be required to install their material at a test location. The Department must approve test sections before installation. Provide materials and installation for the test site at no cost to the Department. CST/M&P will monitor the test location for a minimum period of 12 mo. unless the material fails prematurely.

Prequalification Procedures

After the producer submits a request for QMP prequalification, CST/M&P will use the following procedure to prequalify the material:

- Producer will provide a laboratory test report that contains data showing compliance of the material in accordance to the requirements in 'Material Requirements."
- Producer will submit a minimum of 1 sample (amount of binder components equal to 1 gal. of mixed material and corresponding aggregate) for consideration of each type of patching material.
- CST/M&P will test each sample according to the tests outlined in 'Material Requirements.' CST/M&P will determine if there is an adequate correlation between the producer and CST/M&P test results. CST/M&P will reject the material if a correlation is not established or if the material does not meet the requirements.

CST/M&P will place materials meeting all requirements in the quality monitoring program. After acceptance, any changes in formulation or composition must be reported to CST/M&P. Material changes require resubmission for prequalification.

Quality Monitoring Requirements

The prequalification periods are from January 1st to June 30th and July 1st to December 31st of every year. During each prequalification period, the producer must provide 1 prequalification sample, and monthly quality control testing reports.

Monthly Quality Control Reports

The Department requires that all producers in the QMP perform quality control testing on their material. The Department requires that producers submit monthly quality control testing reports to CST/M&P for every prequalified material. The report must reflect the test data from each batch of prequalified material produced during that month regardless of the destination of the material. The monthly report must contain the following information:

- Type of patching material,
- Date of manufacture,

- Batch number, and
- QM test results.

QM tests are those listed in 'Material Requirements.' Producers must submit reports by the first business day of every month. If no prequalified material is produced for a particular month, then submit a report stating no material was produced.

Prequalification Sample

Submit a sample of each prequalified material for every prequalification period at least 1 mo. before the beginning of the prequalification period to allow sufficient time for testing. Any material not submitted on time may be delayed in posting on the material producer list.

Random Testing and Auditing

The Department reserves the right to conduct random sampling of prequalified materials for testing, and perform random audits of test reports. Department representative may sample material from the manufacturing plant, the project site, and warehouse. Maintain a complete record of all test reports for the previous and current calendar year. CST/M&P reserves the right to inspect and approve the laboratory where the quality control testing is performed to ensure that all criteria for equipment and procedure compliance are met. CST/M&P reserves the right to test samples to verify compliance with "DMS-6170, Polymeric Materials for Patching Spalls in Concrete Pavement."

Disqualification and Requalification

A producer may be disqualified and removed from the quality monitoring program if 1 of the following infractions occurs:

- Material tested by CST/M&P fails to meet the requirements stated in this Specification
- The producer fails to properly submit complete monthly quality control testing reports or prequalification samples to CST/M&P or
- The producer fails to report changes in the formulation or composition of the material to CST/M&P.

If a material is disqualified, the producer will not be allowed to supply material to the Department for a period of 6 mo., or as determined by the Director of CST/M&P. After this time has expired, the producer must requalify to regain QMP status. Disqualification will only apply to the patching material type corresponding to the infraction.

To requalify after the 6-mo. disqualification period, the producer must submit a written request to CST/M&P. Include with the request a test report from an independent laboratory with data that certifies that the material meets the requirements in 'Material Requirements.' After receiving the request and test data, all requirements in 'Prequalification Procedures' will apply.

Sampling and Testing

The Department will sample in accordance with "Tex-734-I, Sampling Epoxy," and will test in accordance with 'Material Requirements.'

Costs of sampling and testing are normally borne by the Department; however, the costs to sample and test materials failing to conform to the requirements of this Specification are borne by the Contractor or supplier. This cost will be assessed at the rate established by the Director of CST/M&P and in effect at the time of testing.

Amounts due the Department will be deducted from monthly or final estimates on Contracts or from partial or final payments on direct purchases by the State.

Project Specific Testing

Materials not appearing on the material producer list require project specific testing and approval before their use. Submit samples to CST/M&P with a certified test report from an independent laboratory with test data verifying that the material meets the requirements stated within this Specification. This material must not be used until testing is complete and material is approved.

Material Requirements

General Requirements

Both types of concrete pavement patching material have the following properties:

- The patching material is able to carry traffic within 3 hr. of placement or as directed by the Engineer.
- Concrete patching material is resistant to weather and abrasion.
- The aggregate type used in the patching material will be those specified by the manufacturer.
- The patching material has a skid-resistant finish (e.g., tining, broadcast sand).
- The patching material has a nonreflective finish with similar color tone to concrete, and
- Concrete patching material must be placed at substrate temperatures of 10°C (50°F) and rising.

Chemical Resistance

Manufacturers must submit a certified report indicating compliance to the following requirements for chemical resistance (Table C1).

Table C1: Chemical Resistance

Chemical	Effects
Deicers	None
Motor Oil	None
Sodium Chloride Solution (5%)	None
Hydraulic Brake Fluid	None
Standard: ASTM "D 471, Standard Test Method for Rubber Property-Effect of Liquids." 25°C (77°F) after 22 hr.	

Submit report before the material is accepted into the QMP. It is not required as a part of the monthly quality control reports, unless requested by CST/M&P.

Physical Requirements

Tables C2 and C3 present physical requirements for Type I and Type II.

Table C2: Type I

Test	Method	Requirements
Gel Time, min.	"Tex-614-J, Testing Epoxy Materials"	5 minimum – 60 maximum
Wet Bond Strength to Concrete, psi	"Tex-618-J, Testing Elastomeric Concrete"	100 minimum
Compressive Strength 24 hr. psi	ASTM "C 579, Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings and Polymer Concretes," Method B	200 minimum
Compressive Stress @ 0.1 in., 7 days, psi	"Tex-618-J, Testing Elastomeric Concrete"	200 minimum
Resilience, %	"Tex-618-J, Testing Elastomeric Concrete"	90 minimum
Thermal Compatibility One cycle is 8 hrs. @ 60°C followed by 16 hrs. @ -21°C Determine results after 9 cycles.	ASTM "C884/ C884M, Standard Test Method for Thermal Compatibility Between Concrete and an Epoxy-Resin Overlay," with modifications	No delamination or cracking

Table C3: Type II

Test	Method	Requirements
Gel Time, min.	"Tex-614-J, Testing Epoxy Materials"	1 minimum – 60 maximum
Wet Bond Strength to Concrete, psi	"Tex-618-J, Testing Elastomeric Concrete"	250 minimum
Compressive Strength 24 hr. psi	ASTM "C 579, Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings and Polymer Concretes," Method B	2,000 minimum
Compressive Stress @ 0.1 in., 7 days, psi	"Tex-618-J, Testing Elastomeric Concrete"	2,000 minimum
Resilience, %	"Tex-618-J, Testing Elastomeric Concrete"	65 minimum
Thermal Compatibility One cycle is 8 hrs. @ 60°C followed by 16 hrs. @ -21°C. Determine results after 9 cycles.	ASTM "C884/ C884M, Standard Test Method for Thermal Compatibility Between Concrete and an Epoxy-Resin Overlay," with modifications	No delamination or cracking

Packaging and Labeling

Package reactive components in airtight containers and protect from light and moisture. Package aggregates to protect them from moisture. Include instructions for mixing and application of the material, and include all safety information and warnings regarding contact with the components.

Labels must include the following information:

- Type of material
- Resin or hardener components
- Brand name
- Name of manufacturer
- Ratio of components to be mixed by volume
- Unique batch number
- Date of manufacture and
- Expiration date.

Appendix D: Section 9, Tex-614-J, Testing Epoxy Materials

Overview

Effective Date: August 2002 (refer to 'Archived Versions' for previous versions).

This method covers various test procedures for epoxy materials specified under the TxDOT Material Specification "DMS-6100, Epoxies and Adhesives." The test to be performed will depend upon the requirements set forth for each particular material.

This test includes the following test procedures:

- Compression Strength
- Viscosity
- Gel Time
- Tensile Bond
- Thixotropy
- Adhesive Shear Strength
- Impact Strength
- Wet Strength
- Wet Pull-out Strength
- Grind
- Bonding of fresh Portland cement concrete to cured Portland cement concrete.
- Hiding Power.

Component Ratios

The weight per liter/gallon of each component will be determined according to ASTM D 1475. For all tests performed on the mixed epoxy, the proper weight ratio of resin and hardener components shall be determined based on the weight per liter/gallon and the specified volume ratio.

Procedures

Following are the test procedures for the above epoxy materials.

Compression Strength

The following apparatus is required:

- 25.4 mm (1 in.) I.D. PVC tubing, by 50 mm (2 in.) in length for molding

- machine lathe
- constant-rate-of crosshead testing apparatus as described in the 'Apparatus' section of ASTM D 695.

The following procedure describes the compression strength test.

Compression Test	
Step	**Action**
1	Mix epoxy components according to producers' recommendations.
2	Form three cylindrical epoxy specimens with the dimensions of 0.025 m (1 in.) diameter and 0.05 m (2 in.) in height. NOTE: The area of a 0.025 m (1 in.) diameter specimen is 1.96 x 10^{-3} m^2 (0.785 in. ^{2}).
3	Allow specimen to cure in air for 48 hours at 25 ºC (77 ºF).
4	Remove epoxy specimen from mold.
5	Using a lathe or other apparatus, trim top and bottom sides of epoxy specimen to a flat true surface.
6	Test specimen at a rate of 1.3 mm (0.05 in.) per minute.
7	Record compression strength at failure or at 2.5 mm (0.1 in.) crosshead travel, whichever occurs first.
8	Report results in kPa (psi).

Use the following calculation to determine compression strength (C_S).

$$C_S = 1\,000\, L / \pi r^2 \text{, kPa} \quad (C_S = L / \pi r^2 \text{, psi})$$

Where:

- C_S = Compression strength, kPa (psi)
- L = load in Newtons (lbs.)
- Π = 3.14
- r = radius of the specimen in meters (in.)

Viscosity

The following apparatus is required:

- Brookfield Synchro-lectric viscometer of suitable range
- Friction top cans, 480 mL (1 pt.) and 950 mL (1 qt.)
- Thermometer, range 19 to 27 °C (66 to 80 °F), 0.2 division (ASTM F 17 thermometer)
- Spatula, 19 mm x 114 mm (0.75 in. x 4.5 in.) blade
- Balance, with minimum capacity of 2000 g, which meets the requirements of Test Method "Tex-901-K, Verifying the Calibration of Weighing Devices used for Laboratory Testing"

• Stopwatch.

The following procedure describes the viscosity test.

Viscosity Test	
Step	**Action**
1	♦To determine the viscosity of each component, place the resin or hardener in a container of such size that at least 25 mm (1 in.) clearance is provided between the bottom and sides of the spindle and the container, when the spindle is immersed to the proper depth in the liquid. ♦The temperature for all viscosity determinations is 25 ± 0.5 °C (77 ± 1 °F).
2	When making a viscosity determination, attach the proper spindle to the lower end of the motor shaft. With disc type spindles, first immerse the spindle in the liquid at an angle to eliminate air bubbles, then screw onto the shaft.
3	Adjust the height to bring the liquid level to the indention in the spindle.
4	Level the instrument, set the speed control at 2.0 rad/sec, and start the motor.
5	Allow the spindle to rotate for approximately two minutes before taking a reading. NOTE: The spindle used should result in a scale reading between 20 and 80.
6	Convert the scale reading obtained to viscosity in poises by multiplying by the factor supplied by Brookfield for the combination of spindle and speed used.
7	For Type II epoxy, calculate the percent difference by subtracting one component reading from the other, then divide by the smaller reading and multiply by 100.
8	To determine the viscosity of mixed epoxy, weigh a total quantity of 400 g resulting from measuring the proper amount of resin and hardener component into a 480 mL (1 pt.) can.
9	Mix the proper proportioned components with a spatula for three minutes.
10	An initial temperature of 24 °C (76 °F) is recommended.
11	Check the temperature, then insert the proper spindle and begin the test at Step 2, above. Take the viscosity reading five minutes after initiation of mixing.

The following procedure describes the stability test after 14 day heat aging at 120 °C (248 °F) for Epoxy Types II, V, VII, and VIII.

Stability Test	
Step	**Action**
1	Place resin and hardener in oven at 120 °C (248 °F) for 14 days.
2	Remove epoxy from oven and bring material temperature to 25 ± 1 °C (77 ± 2 °F)
3	Mix a total of 400 g epoxy into a 480 mL (1 pt.) can for three minutes.
4	When making a viscosity determination, attach the proper spindle to the lower end of the motor shaft. With disc type spindles, first immerse the spindle in the liquid at an angle to eliminate air bubbles, then screw onto the shaft.
5	Adjust the height to bring the liquid level to the indention in the spindle.
6	Level the instrument, set the speed control at 2.0 rad/sec, and start the motor.
7	Allow the spindle to rotate for approximately two minutes before taking a reading. NOTE: The spindle used should result in a scale reading between 20 and 80.
8	Convert the scale reading obtained to viscosity in poises by multiplying by the factor supplied by Brookfield for the combination of spindle and speed used.
9	Take the viscosity reading five minutes after initiation of mixing.

Gel Time

The following apparatus is required:

- Thermometer, range 19 to 27 °C (66 to 80 °F) (ASTM F 17 thermometer)
- Metal ointment can, 170 g size
- 480 mL (1 pt.) can with friction lip removed (for Type X only)
- Metal spatula with 19 mm x 114 mm (0.75 in. x 4.5 in.) blade
- Wooden block, minimum thickness of 25 mm (1 in.)
- Glass stirring rod
- Round wooden toothpick
- Stopwatch.

The following procedure describes the gel time test.

Gel Time Test

Step	Action
1	Ensure that the ambient and initial temperature of adhesive components is 25 ± 1 °C (77 ± 2 °F).
2	Weigh 100 g total of adhesive components into a 170 g metal ointment can.
3	Start the stopwatch and mix the two components for three minutes with a metal spatula.
4	During the mixing, scrape the sides and bottom of the can periodically.
5	♦Place the can with the mixed adhesive on a wooden block. ♦Allow mixed material to sit for 2 minutes.
6	This procedure is for gel time specification for between 6 and 20 minutes. ♦Insert toothpick in center of mixed material. ♦Probe every minute until material gels.
7	Record time elapsed as gel time.
8	For gel time specification above 20 minutes, ♦Probe the mixed adhesive every 2 minutes with a glass stirring rod, starting 16 minutes from the initiation of mixing until center of material gels.

The following procedure describes the gel time test specifically for Epoxy (Type X).

Gel Time Test For Epoxy (Type X)

Step	Action
1	Bring the coating components (resin and hardener) to 25 ± 1 °C (77 ± 2 °F).
2	Weigh a total of 300 g of material into a 480 mL (1 pt.) can.
3	Start the stopwatch and mix the two components for 5 minutes with a metal spatula.
4	Place the can on a wooden block. Allow mixed material to sit for 35 minutes
5	Probe mixed material every 5 minutes with a glass stirring rod until it gels.
6	Record the time at which the material gels in the container as the gel time.

Tensile Bond

The following apparatus is required:

- Metal spatula with 19 mm x 114 mm (0.75 in. x 4.5 in.) blade
- Metal ointment can, 85 g
- Mortar briquettes
- Cold cabinet or room, capable of maintaining 4 ± 1 °C (40 ± 2 °F)
- Constant Rate of Extension (CRE) apparatus as described in the "Apparatus" section of ASTM D695.

Prepare Mortar Briquettes prior to tensile bond testing. The following apparatus is required:

- Cement (Type III)
- Washed river sand aggregate sieved though a No.4 sieve
- Molds as described in ASTM C190
- Metal shims, 1in square
- Rubber stomper
- Humidity cabinet
- Constant temperature water bath set to 25 °C (77 °F).

The following procedure describes preparing mortar briquettes

Preparing Mortar Briquettes	
Step	**Action**
1	♦Obtain molds as described in ASTM C 190. ♦Place a shim in the center of the mold and coat the inside of the molds in release material. ♦Set the mold on top of an ungreased sheet of glass.
2	Use washed river sand sieved through a No. 4 sieve for aggregate.
3	♦Use 1-part cement to 3 parts sand by weight by measuring 750 g of sand and 250 g of cement. ♦Thoroughly mix sand and cement, and create a crater in the center.
4	♦Measure 125 mL (4.2 fl. oz) of water. ♦Pour water into the center of the crater.
5	♦Scoop material from the sides into the crater over the top of the water within 30 seconds of adding water. ♦For the next 30 seconds, trowel the dry mortar around the outside of the cone over the remaining mortar for the absorption of water.
6	Complete the operation with continuous, vigorous mixing, squeezing, and kneading with the hands for 1.5 minutes.
7	♦Fill the molds with concrete on both sides of the shim. Compact the concrete using the following procedure: ♦Press the mortar firmly with the rubber stomper, applying the force 12 times to each briquette. The force should measure approx. 15 to 20 lb. ♦Add more mortar and compact again till mold is complete. ♦Heap more mortar above the mold and smooth it off with a trowel.
8	Place the mold with the briquettes in a humidity cabinet and cure for 24 hours.
9	After 24 hours, remove the briquettes from the mold and immerse them in a 25˚C (77 ˚F) water bath for six days.
10	Allow briquettes to dry before use.

The following procedure describes the tensile bond test.

Tensile Bond Test	
Step	**Action**
1	Ensure that the initial and ambient temperature of adhesive components is 25 ± 1 °C (77 ± 2 °F).
2	Sandblast each face of the mortar briquette as described under the 'Adhesive Shear Strength' procedure. NOTE: Do not touch bonding faces after sandblasting.
3	Clean the bonding faces of 3 sets of briquettes with compressed air.
4	Weigh a total of 50 g of adhesive components in a 85 mL (3 fl. oz.) can and mix with a metal spatula for 3 minutes.
5	Immediately coat the faces of the briquettes with the adhesive by placing a small amount on each face, then spread the material uniformly and place the faces together with light pressure.
6	Remove the excess adhesive from the edges of the bonded area and stand upright. Allow the briquette to remain undisturbed until time for testing.
7	No more than 10 minutes, shall elapse during preparation of the specimens. For Type II no more than six minutes.
8	Allow 6 hours, to elapse between initiation of mixing and testing. For Type II allow 2 hours
9	Test the briquettes for tensile strength and record the load at break using a crosshead speed of 0.05 in/sec.

Thixotropy—Epoxy (Types I and II)

The following apparatus is required:

- Forced-draft oven, capable of maintaining 49 ± 1 °C (120 ± 2 °F)
- Smooth, clean metal plate 76 mm x 152 mm (3 in. x 6 in.), approximately 2.5 mm (0.1 in.) thick
- Steel form 76 mm x 152 mm x 2.5 mm (3 in. x 6 in. x 0.1 in.) thick with 51 mm x 102 mm (2 in. x 4 in.) cut-out in center
- Metal spatula, approximate size: 19 mm x 114 mm (0.75 in. x 4.5 in.) blade
- Metal container, preferably a 85 g ointment can.

The following procedure describes the thixotropy test.

Thixotropy Test	
Step	**Action**
1	In each of two metal containers add enough resin or hardener to produce approximately 50 g of adhesive, when combined.
2	Scribe a mark across the 76 mm (3 in.) dimension of a plate to correspond with one end of the epoxy panel to be formed.
3	Place the metal containers, steel plate, form and spatulas in the oven at 49 ± 1 °C (120 ± 2 °F) for 30 minutes.
4	Remove the cans and a spatula from the oven.

NOTE: Steps 5-11 must be performed in 22 minutes.	
5	Transfer the resin to the hardener can and mix with a heated spatula for one minute.
6	Remove the steel plate and form from the oven and place them on a horizontal surface with two or three sheets of paper or a piece of thin cardboard under the steel plate.
7	Place a 100 mil steel form over the plate so that the work is aligned with one of the 51 mm (2 in.) sides of the cut out.
8	Pour an excess of mixed adhesive immediately into the form.
9	Use a spatula to screed adhesive on the top surface of the form.
10	Slowly lift the form upward.
11	Place the steel plate and epoxy panel with the 102 mm (4 in.) dimension of the epoxy panel vertically, scribed end down, in the oven at 49 ± 1 °C (120 ± 2 °F) for a minimum of 2 hours.
12	After the adhesive has hardened, remove from oven and measure the outer edges and the center point of the panel for the amount of sag at the bottom edge of the panel from the scribed line.
13	Report the average to the nearest 0.03 mm (0.001 in.).

Thixotropy – Epoxy (Type III)

- The following apparatus is required:
- Same as for types I and II with the following additions and modifications:
- Thermometer, range 19 to 27 °C (66 to 80 °F) (ASTM F 17 thermometer)
- Thickness gauge, capable of measuring 0.02 mm (0.0008 in.)
- Metal form, 76 mm x 152 mm x 1.3 mm (3 in. x 6 in. x 0.05 in.) thick with a 51 mm x 102 mm (2 in. x 4 in.) cut- out in center.

The following procedure describes thixotropy at 25 °C (77 °F).

Thixotropy at 25°C (77°F)	
Step	**Action**
1	Bring the ambient and material temperature to 25 ± 1 °C (77 ± 2 °F).
2	♦Weigh a total of 50 g of adhesive components. ♦Mix for three minutes.
3	Place a 50-mil steel form over the plate so that the work is aligned with one of the 51 mm (2 in.) sides of the cut out.
4	Apply it to a smooth, clean steel plate to form a panel of epoxy material 51 mm x 102 mm (2 in. x 4 in.) in length, and 1.3 mm (0.05 in. [50 mils]) in thickness.
5	♦After pouring the epoxy into the form, screed the excess epoxy even with the top of the form. ♦Remove form.
6	After forming the epoxy material, stand the panel in a vertical position on its short edge, for a minimum of 4 hours.
7	♦Before taking each epoxy reading, zero out the thickness gauge by measuring the thickness of steel plate next to the 4 readings on each side. ♦Start measuring the epoxy thickness at 13 mm (0.5 in.) from the top and sides, then read down 25.4 mm (1 in.) apart and 13 mm (0.5 in.) from side.
8	Average all readings and report.

The following table describes thixotropy procedure at 49 °C (120 °F).

	Thixotropy at 49°C (120°)F
Step	**Action**
1	In each of two metal containers, add enough resin and hardener to produce 50 g of material, when combined.
2	Place all the apparatus and epoxy in the oven at 49 °C (120 °F) for approximately one hour or until they all have reached 49 °C (120 °F).
3	Remove from oven and mix epoxy for one minute.
4	Place a 50 mil steel form over the plate so that the work is aligned with one of the 51 mm (2 in.) sides of the cut out.
5	Apply it to a smooth, clean steel plate to form a panel of epoxy material 51 mm x 102 mm (2 in. x 4 in.) in length, and 1.3 mm (0.05 in. [50 mils]) in thickness.
6	♦After pouring the epoxy into the form, screed the excess epoxy even with the top of the form. ♦Remove form
7	After forming the epoxy material, stand the panel in a vertical position on its short edge, for a minimum of 2 hours.
8	♦Before taking each epoxy reading, zero out the thickness gauge by measuring the thickness of steel plate next to the 4 readings on each side. Start measuring the epoxy thickness at 13 mm (0.5 in.) from the top and sides, then read down 25.4 mm (1 in.) apart and 13 mm (0.5 in.) from side. ♦Average all readings and report.

Thixotropy—Epoxy Type X

The following apparatus is required:

- Thermometer, range 19 to 27 °C (66 to 80 °F) (ASTM F 17 thermometer)
- Thickness gauge, capable of measuring 0.03 mm (0.001 in.)
- Smooth steel plates 127 mm x 203 mm x 2.5 mm (5 in. x 8 in. x 0.1 in.)
- Adjustable film former, such as a Boston Bradley draw-down gauge

- Metal ointment can, preferable 170 g
- Metal spatula, 19 mm x 114 mm (0.75 in. x 4.5 in.).

The following procedure describes thixotropy for epoxy (Type X).

Thixotropy Test for Epoxy Type X	
Step	**Action**
1	Bring the ambient and material temperature to 25 ± 1 °C (77 ± 2 °F).
2	Determine the average thickness to the nearest 0.03 mm (0.001 in.) of a 51 mm x 102 mm (2 in. x 4 in.) area on a smooth, clean 127 mm x 203 mm (5 in. x 8 in.) steel plate.
3	Locate areas 76 mm (3 in.) from the top and 25 mm (1 in.) from the bottom along the 203 mm (8 in.) dimension, and 38 mm (1.5 in.) from each side along the 127 mm (5 in.) dimension of the plate, and take eight readings.
4	Weigh a total of 100 g of combined material Stir the two components of the epoxy coating for five minutes.
5	Use a film former with a path at least 76 mm (3 in.) wide and the opening set at approximately 16 mils.
6	Use approximately half of the mixed materials; apply two lines of equal amounts, one at top and other at center of the steel plate.
7	Draw a wet film down the length of the steel plate.
8	After forming the epoxy film, stand the steel panel in a vertical position on its short edge. NOTE: Make sure that no more than 10 minutes elapse between the mixing time and the placing of the steel in the vertical position. Let stand overnight.
9	Clean the blade with trichlorethylene.
10	After the epoxy has hardened, measure the average thickness of coating covering the 51 mm x 102 mm (2 in. x 4 in.) are of the steel plate, and take eight random readings.
11	Determine the average cured coating thickness by subtracting the average steel panel thickness from the average of total panel plus coating thickness.

Adhesive Shear Strength

The following apparatus is required:

- Steel specimens 25 mm x 165 mm x 1.6 mm (1 in. X 6.5 in. X 0.064 in.)
- Sandblasting machine
- Garnet blasting abrasive, 36 mesh
- Constant Rate of Extension (CRE) apparatus as described in the "Apparatus" section of ASTM D695.25 kN (5,000 lbs.) cell.

The following procedure describes Adhesive Shear Strength.

Adhesive Shear Strength	
Step	**Action**
1	Follow the procedure outlined in ASTM D 1002-99.
2	Prepare the surfaces of the individual pre-cut specimens by blasting to white metal.
3	Clean blasted ends with compressed air.
4	Cure the test specimens for 7 days at 21 to 27 °C (70 to 80 °F) prior to testing.

Impact Strength

The following apparatus is required:

- Machined steel plate, 152 x 152 x 13 mm (6 x 6 x 0.5 in.)
- Steel pipe, 51 mm (2 in.) inside diameter, approximately 1 m (3 ft.) in length
- Steel ball, 454 ± 10 g

The following test procedure describes impact strength.

Impact Strength	
Step	**Action**
1	Weigh a total of 200 g of material and mix for 3 minutes.
2	♦Cast 3 disks of material 70 mm (2.75 in.) in diameter and 9.5 mm (3/8 in.) thick. ♦Carefully tap disks on countertop to level material and remove bubbles. NOTE: If ointment can lids are used, the lids can be peeled away from the epoxy after approximately 24 hours.
3	Cure the disks for 7 days at 21 to 27 °C (70 to 80 °F).
4	Grind or machine the plane surfaces of the disks flat and parallel. Be careful not to heat the disks above 49 °C (120 °F) when machining or grinding.
5	Smooth the specimens with No. 180 grit sandpaper.
6	Blow clean the disks with oil-free compressed air.
7	Make sure ambient temperature and specimens temperature is 21 to 27 °C (70 to 80 °F). NOTE: Be certain that the thickness of the finished disks is 8 ± 0.5 mm (0.30 ± 0.02 in.).
8	Place the finished specimens on a machined steel plate securely attached to a concrete slab.
9	Drop a 454 g ball onto the center of the disks from an initial height of 1.5 m (5 ft).
10	Use the section of pipe as a guide for the ball. NOTE: Do not allow the ball to strike the disk after rebounding from the test drop.
11	Increase the height by 152 mm (6 in.) for each successive drop until the specimen fails by cracking or shattering to a maximum height of 7 ft.
12	Record the height of drop at which failure occurs in Joules (ft.-lbs.).
13	Test a minimum of three specimens.
14	Report the average to the nearest 0.7 joule (0.5 ft.-lb.).

Wet Strength (for Types II and IV)

The following apparatus is required:

- Metal spatula with 19 mm x 114 mm (0.75 in. X 4.5 in.) Blade
- Metal ointment can, 170 g
- Mortar briquettes
- Water bath, capable of maintaining 38 ± 1 °c (100 ± 2 °f)
- Water bath, capable of maintaining 23 ± 1 °c (73 ± 2 °f)
- Constant Rate of Extension (CRE) apparatus as described in the "Apparatus" section of ASTM D695.

The following procedure describes wet strength for epoxy (Types II and IV).

Wet Strength for Epoxy (Types II and IV)	
Step	**Action**
1	Prepare a minimum of three briquettes as described in the 'Tensile Bond' procedure.
2	Allow the briquettes to cure for one day at 21 to 27 °C (70 to 80 °F).
3	Immediately transfer the briquettes to an oven at 49 ± 1 °C (120 ± 2 °F) for two days.
4	Immerse the cured specimens in a distilled or deionized water bath maintained at 38 ± 1 °C (100 ± 2 °F) for seven days.
5	Remove specimens and place them in a distilled or deionized water bath at 23 ± 1 °C (73 ± 2 °F) for one hour.
6	Use the CRE for the tensile load test.
7	Record the load at failure.
8	Test one more set of specimens if any of the tested briquettes fail in the mortar at strengths below 1862 kPa (270 psi).

The following procedure describes Wet Strength for Epoxy Type IX.

Wet Strength for Epoxy Type IX	
Step	**Action**
1	Prepare a minimum of three briquettes as described in the 'Tensile Bond' procedure.
2	Soak each half of the test mortar specimens in a distilled or deionized water bath at 21 to 27 °C (70 to 80 °F) for 24 hours.
3	Remove the specimens and blow the bonding faces dry with oil-free compressed air.
4	Weigh a total of 50 g mixed material and mix for 3 minutes.
5	Immediately coat the faces of the briquettes with the mixed material by placing a small amount on each face, then spread the material uniformly and place the faces together with light pressure.
6	♦Remove the excess material from the edges of the bonded area and stand upright. ♦Allow the briquette to remain undisturbed for 24 hours.
7	Allow the briquettes to cure for one day at 21 to 27 °C (70 to 80 °F).
8	Immediately transfer the briquettes to an oven at 49 ± 1 °C (120 ± 2 °F) for two days.
9	Immerse the cured specimens in a distilled or deionized water bath maintained at 38 ± 1 °C (100 ± 2 °F) for seven days.
10	Remove specimens and place them in a distilled or deionized water bath at 23 ± 1 °C (73 ± 2 °F) for one hour.
11	Use the CRE for the tensile load test.
12	Record the load at failure.
13	Test one more set of specimens if any of the tested briquettes fail in the mortar at strengths below 1862 kPa (270 psi).

Wet Pull-out Test

The following apparatus is required:

- Grade 60 #3 rebar, 760 mm (30 in.) in length
- 150 mm x150 mm (6 in. x 6 in.), 8 in.(min.) height 22.3 ± 2.2 kN (5,0000 ± 500 lbs.) compression rated, concrete cylinder
- Water bath at 25 ± 2 °C (77 ± 3 °F)

- 150 mm x 13 mm dia. (6 in. x 5/8 in. dia.) carbide tip masonry drill-bit
- Hammer drill
- Constant Rate of Extension (CRE) tensile testing apparatus, with a 44,500 N (10,000 lb.) capacity.

The following outlines the procedure for wet pull-out strength.

Wet Pull-out Test	
Step	**Action**
1	♦Drill a hole, 90 mm (3.5 in.) in depth, concentrically located on the flat surface of the concrete cylinder. ♦Remove debris and dust from the hole using moisture-free compressed air
2	Weigh a total of 50 g of combined epoxy and mix for 3 minutes.
3	♦Place epoxy in hole. ♦Ensure rebar fits without binding.
4	Insert the rebar the entire depth of the hole.
5	Rotate the rebar several times to insure that an adequate coating of the epoxy is transferred on to the rebar and to avoid air pockets in the epoxy material.
6	Repeat steps 3 to 5 as necessary until hole is filled.
7	Remove excess epoxy from the surface of the cylinder. NOTE: To insure a valid test, the rebar must remain plumb and centrally located in the hole.
8	After a 24-hour curing period at 25 ± 2 °C (77 ± 3 °F) in air, totally submerge block into the water-bath in an upright position for an additional six days.
9	After a total curing period of seven days, pull the rebar to failure using the CRE tensile testing apparatus at a rate of 5.0 mm (0.2 in.) per minute.

Grind—Epoxy X

The following apparatus is required:

- Metal spatula, 19 mm x 114 mm blade (0.75 in. x 4.5 in.)
- Metal ointment can, 85 g
- Hegman Scale on a wide track grind gauge.

The following procedure describes the grind for epoxy (Type X).

Grind – Epoxy (Type X)	
Step	**Action**
1	Weight 10 g of the resin component.
2	Add 20% by weight xylene and stir into a homogenous mixture.
3	Pour a portion of the mixture on to the grind gauge.
4	Use the gauge bar to pull down the material over plate.
5	Read immediately.
6	North scale must read 4 minimum.
7	Record results.

Bonding of Fresh Portland Cement Concrete to Cured Portland Cement Concrete (Type V only)

The following apparatus is required:

- Metal spatula with 19 mm x 114 mm blade (0.75 in. x 4.5 in. blade)
- Metal ointment can, 85 g
- Mortar briquettes
- Sand and cement to prepare mortar as described in ASTM C 190 (Discontinued 1991)
- Briquette molds (ASTM C 190 [Discontinued 1991])
- Constant Rate of Extension (CRE) apparatus as described in the "Apparatus" section of ASTM D695.

The following procedure describes bonding test.

Bonding Test	
Step	**Action**
1	Prepare three briquettes as described in the 'Tensile Bond' procedure.
2	In a metal ointment container, mix a total of 50g of adhesive with a spatula for three minutes.
3	Apply the adhesive to the cut faces of the prepared briquette halves.
4	Prepare new mortar as described in the 'Tensile Bond' procedure.
5	Mold the new mortar against all three briquettes to form a complete briquette.
6	Cure the complete briquette for seven days, according to ASTM C 190 (Discontinued 1991).
7	Pull each specimen using the CRE.
8	Record kPa (psi) at failure.

The following procedure describes bonding test for Type VIII only.

Bonding Test	
Step	**Action**
1	Prepare three briquettes as described in the 'Tensile Bond' procedure.
2	Prepare new epoxy mixture by mixing 1 part epoxy to 6.35 parts of sand by weight (washed river sand, passing a No. 4 sieve [0.187 in.]).
3	Mold the new mortar against all three briquettes to form a complete briquette.
4	Cure the complete briquette for seven days, according to ASTM C 190 (Discontinued 1991).
5	Pull each specimen using the CRE.
6	Record kPa (psi) at failure.

Hiding Power

The following apparatus is required:

- Black and white paper charts
- Film former, draw down gauge, 5 mil
- Vacuum platter or other suitable device
- Reflectance Measurement Instrument.

The following procedure describes Hiding Power:

Hiding Power	
Step	**Action**
1	Bring the ambient and material temperature to 25 ± 1 °C (77 ± 2 °F).
2	Weigh a total of 50 g of material and mix for 5 min.
3	Using equal amounts of mixed material, make 2 lines on each color to the width of the draw down gauge.
4	Draw a wet film down at 2.4 in/sec on the paper chart.
5	Place draw down horizontally in a well-ventilated dust free location.
6	Allow to dry overnight.
7	♦Measure the reflectance at three random points on each color. ♦Record
8	Calculate the contrast ratio by dividing the reflectance on white substrate (Yw) into the reflectance on black substrate (Y)

Appendix E: Section 13, Tex-618-J, Testing Elastomeric Concrete

Overview

Effective Date: August 2002 (refer to 'Archived Versions' for earlier versions).

The method includes procedures for preparing and testing elastomeric concrete specimens as specified under "DMS-6140, Elastomeric Concrete for Bridge Joints." Tests are performed on binder components alone, and on the complete mixture of binder and aggregate. Refer to DMS-6140 for a description of the two types of elastomeric concrete and the tests performed on each type.

- Tests on Elastomeric Binder Only
  - Impact Strength
  - Tensile Strength
  - Tensile Stress
  - Ultimate Elongation
  - Tear Resistance.
- Tests on Complete Elastomeric Concrete
  - Wet Bond Strength to Concrete
  - 24-hour Compressive Strength
  - Compressive Stress
  - Resilience.

Preparing Samples

The following describes the required steps to prepare samples.

Preparing Samples

Step	Action
1	♦Allow material to stabilize at a temperature of 25 ± 2 °C (77 ± 4 °F). ♦Measure components in the ratios specified by the manufacturer. ♦Convert volume ratios to weight ratios using the gallon weight of the components.
2	Thoroughly mix the components. For tests that use aggregate, make sure the aggregate is mixed well with the binder.
3	Use Teflon or lubricant coated metal as mold surface.
4	Pour binder mixtures into molds as soon as possible after thorough mixing. NOTE: To minimize entrained air during mixing, use physical means or pass a soft flame over the surface.
5	Allow specimens to cure sufficiently so they will not be damaged by removal from molds.

Procedures

Impact Strength

The following apparatus is required:

- Discs with a 64 ± 1 mm (2.50 ± 0.05 in.) diameter and a 9.5 ± 0.3 mm (0.37 ± 0.01 in.) thickness
- Sanding lathe
- Water bath capable of maintaining 0 °C (32 °F)
- Pipe no more than 4.5 feet in height and 2 inches in diameter
- 1 pound steel ball no more than 2 inches in diameter.

The following describes the impact strength test.

Impact Strength	
Step	**Action**
1	Obtain at least three discs with a 64 ± 1 mm (2.50 ± 0.05 in.) diameter and a 9.5 ± 0.3 mm (0.37 ± 0.01 in.) thickness. NOTE: Lining the discs with release grease helps.
2	Using the weight mixing ratios, measure out sufficient binder material to fill the three discs. ♦ Thoroughly mix the material and pour into the discs. ♦ Set the discs aside to cure.
3	After seven days cure at 25 ± 2 °C (77 ± 4 °F), sand flat the faces of the disc, and immerse the specimen in ice water to condition it to 0 °C (32 °F).
4	Remove the specimen from the ice water, towel dry, and place them on a dry machined steel plate.
5	♦ Immediately after placing on the plate, drop a one-pound steel ball onto the center of the specimen from a height of 1.5 m (5 ft.). ♦ Use the pipe for a better aim.
6	Increase the drop height in 152 mm (0.5 ft.) intervals until the specimen fails by cracking.
7	Report the average value of three specimens in Joule (ft./lb.).

Tensile Strength

The following apparatus is required:

- Tensile specimen mold conforming to ASTM D 638, Type IV with dimension WO of 25 mm (1 in.)
- Dial gauge or caliper
- Tensile testing machine, constant-rate-of-extension (CRE) type, with automatic recording conforming to the requirements of ASTM D 76
- Testing clamps with 25 mm x 50 mm (1 in. x 2 in.) serrated jaws, and appropriate clamping power to prevent slipping or crushing.

The following describes the tensile strength test.

Tensile Strength	
Step	**Action**
1	♦Perform the tensile strength test according to ASTM D 638-84 using the Type IV specimen with dimension WO of 25 mm (1 in). ♦This corresponds to Die C of ASTM D 412.
2	♦Using the weight ratios, measure a sufficient amount of the binder components to fill the mold. ♦Thoroughly mix the components, and pour into the mold. ♦Cast at least three specimens. ♦Remove any entrained air using a soft flame or physical methods.
3	Perform test after seven days of curing at 25 ± 2 °C (77 ± 4 °F). Carefully remove the specimen from the mold. Remove excess material and smooth the edges.
4	Measure the thickness and width of the specimen neck with a dial gauge or caliper and determine the cross-sectional area.
5	♦Use an initial test machine jaw separation of 51 mm (2 in) and a cross-head speed of 51 mm (2 in.) per minute. ♦Calibrate and set an extensiometer on the sample with an initial gage length of 25 mm (1 in.).
6	Load the specimen to failure and use the maximum load to determine the tensile strength.
7	♦Report the average results from the three specimens in MPa (psi). ♦Discard any with obvious flaws.

Tensile Stress

Perform this test according to the methods of “Tensile Strength” using the same specimens.

Tensile Stress is measured at 13 mm (1/2 in.) elongation based on cross-head travel. Report the average result from the three specimens in MPa (psi).

Ultimate Elongation

Perform this test according to the methods of 'Tensile Strength' using the same specimens.

Determine ultimate elongation from initial gage length and the final amount of extension at failure. Calculate the ultimate elongation as a percent of the original gage length. Report the average result from the three specimens.

Tear Resistance

The following apparatus is required:

- Tensile testing machine, constant-rate-of-extension (CRE) type, with automatic recorder
- Testing clamps with 25 mm x 50 mm (1 in. x 2 in.) serrated jaws, and appropriate clamping power to prevent slipping or crushing
- Stamping die conforming to ASTM D 624, Die C
- Dial gauge or calipers to measure thickness.

The following describes the tear resistance test.

Tear Resistance	
Step	**Action**
1	♦Obtain a mold of a sheet measuring 4.5 in. x 6.5 in. with a 0.063 in. thickness. ♦Using the weight ratios, measure out a sufficient amount of binder components to fill the mold. ♦Thoroughly mix the components and pour into the mold. Remove entrained air using a soft flame or physical methods. ♦Let the sheet cure at 25 ± 2 °C (77 ± 4 °F).
2	♦Once the sheet of material has sufficiently cured, stamp the specimens for Tear Resistance test using the Die C specimen of ASTM D 624. ♦Stamp at least four specimens. ♦Sand the specimens to remove irregularities and provide true surfaces.
3	Continue the test after a total of seven days cure at 25 ± 2 °C (77 ± 4 °F)
4	Determine the thickness of the specimen at the point of tear with a dial gauge or caliper.
5	Use an initial test machine jaw separation of 51 mm (2 in.) and a cross-head speed of 51 mm (2 in.) per minute.
6	♦Measure the maximum load as the specimen is tearing. ♦Record the average of the four specimens in N/m (lb./in.).

Wet Bond Strength to Concrete

The following apparatus is required:

- tensile testing machine, constant-rate-of-extension (CRE) type, with automatic recorder conforming to the requirements of ASTM D 76
- briquette mold as described in ASTM C 190 (discontinued 1991)
- water bath capable of maintaining 25 °C (77 °F).

The following describes the wet bond strength to concrete test.

Wet Bond Strength to Concrete	
Step	**Action**
1	For wet bond strength to concrete test, obtain mortar briquette halves prepared according to 'Set Time Test' of Test Method "Tex-614-J, Testing Epoxy Materials."
2	Using the same molds used to make the briquettes, place a briquette half in the mold. Make sure the surface of the briquette is clean. NOTE: If recommended by the manufacturer, coat the side of the briquette with primer. Let the primer dry.
3	♦Using the weight ratios, measure sufficient binder and aggregate to fill the three briquette halves. ♦Thoroughly mix the three components. ♦Fill the other half of the briquette molds with complete elastomeric concrete. ♦Make at least three specimens.
4	Let the briquettes cure for 5 days in air at 25 ± 2 °C (77 ± 4 °F).
5	Immerse the specimens in 25 ± 2 °C (77 ± 4 °F) water for two days in a horizontal position.
6	Remove the specimens from the water, blot dry, and subject them to tensile loading while still damp
7	♦Determine the average tensile breaking stress based on a 25 mm2 (1 in.2) cross-sectional area. ♦Record the average of the three specimens in MPa (psi).

24-hour Compressive Strength

- Perform test as described in ASTM C 579.
- Form three specimens and cure for 24 hours at 25 ± 2 °C (77 ± 4 °F).
- Compress samples in a compression machine, and measure the maximum load.
- Calculate stress from max load and report the average of the three specimens in MPa (psi).

Compressive Stress

The following apparatus is required:

- compression testing machine, constant-rate-of-extension (CRE) type, with automatic recorder conforming to the requirements of ASTM D 76
- molds to cast 2 in. cubes
- dial gauge or calipers.

The following describes the compressive stress test.

Compressive Stress	
Step	**Action**
1	♦Obtain molds to cast three 51 mm (2 in.) cubes. ♦Line the inside of the molds with release grease.
2	♦Using the weight mixing ratios, measure sufficient binder and aggregate material to fill the three cubes. ♦Thoroughly mix the three specimens.
3	♦Pour the mixture into the molds in two lifts and tamp the material after each lift. ♦Screed off any excess material on top of the blocks. ♦Cure specimen for seven days at 25 ± 2 °C (77 ± 4 °F).
4	Using a dial gauge or caliper, determine the original height of the specimen within 0.03 mm (0.001 in.) without a load.
5	Place the specimen in the compression machine, zero the dial gauge, and apply a 445 N (100 lb.) load.
6	♦Load the specimen at a rate of 4 mm/min. (0.15 in./min.) until deflection of 2.5 mm (0.10 in.) is reached. ♦Record load at 2.5 mm (0.10 in.).
7	♦Calculate the compressive stress based on the original 2580 mm^2 area (4 in. ^{2}). ♦Report the average of the three specimens in MPa (psi).

Resilience

- The resilience test is a continuation of the 'Compressive Stress' test.
- After removal of the load, allow the specimen to recover for five minutes.
- Re-measure the height, and calculate the resilience as a percentage of recovered height:

$$Resilience = \frac{s + f - i}{s}$$

where:

- s = max displacement of cross-head (2.5 mm or 0.1 in.)
- f = final height of cube
- i = initial height of cube

Report the average of the three specimens.

Appendix F: Prequalified Products List for Polymeric Materials for Patching Spalls in Concrete Pavement

From "polyptch" website, ftp://ftp.dot.state.tx.us/pub/txdot-info/cmd/mpl/polyptch.pdf

General

The following products have met the requirements of DMS-6170, "Polymeric Materials for Patching Spalls in Concrete Pavement."

The Department reserves the right to conduct random sampling of prequalified materials for testing and to perform random audits of test reports. Department representatives may sample material from the manufacturing plant, the project site, and the warehouse. CST/M&P reserves the right to test samples to verify compliance with DMS-6170, "Polymeric Materials for Patching Spalls in Concrete Pavement."

Figure F1: Material/Producer List 1 02/29/08

Prequalified Producers of Polymeric Patching Materials

Type	Product Name	Producer	Contact Information	Lab Number	Tested	Expires
Type I	Delpatch	DS Brown	Ben Jacobus 300 E. Cherry St. North Baltimore, Ohio 45872 419-257-1600	J08480015	01/31/08	12/31/08
Type I	ElastoPatch	Crafco	Vern Thompson Chandler,AZ (800) 528-8242	J07481294		12/31/07
Type II	FlexKrete 102	FlexKrete Technologies	Roy Perrin McKinney, TX 972-964-8707	J07480319	02/21/07	12/31/07
Type II	Flexpatch*	Silicone Specialists Inc. 99242	Richard Waters Ft. Worth, TX 817-731-7890	J07482018	12/19/07	12/31/08
Type II	Pavesaver	DS Brown	Ben Jacobus 300 E. Cherry St. North Baltimore, Ohio 45872 419-257-1600	J07482185	01/31/08	12/31/08

*Materials should arrive prepackaged with a two component binder and aggregate.

Appendix G: Rigid Repair Materials (DMS 4655)

It must be noted that this is a draft that has not been finally approved. By the time this document is published it is expected that a finalized DMS will be available at the TxDOT website, http://www.txdot.gov/services/construction/material_specifications/dms_series.htm?series=4000

Effective Date: draft

3.1.1 Description**. This Specification governs the prequalification procedure, packaging, and material properties of inorganic cementing material for concrete repair. Polymeric materials are covered by DMS-6170, "Polymeric Materials for Patching Spalls in Concrete Pavement."**

3.1.2 Units of Measurements**. The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.**

3.1.3 Material Producer List**. The Materials and Pavements Section of the Construction Division (CST/M&P) maintains the Material Producer List (MPL) of all materials that meet the requirements of this Specification. Use materials that appear on the MPL, titled Concrete Repair Materials, for Department projects.**

Use material not on the MPL only after testing or when approved by the Engineer.

The Department reserves the right to randomly sample and evaluate prequalified materials for conformance to this Specification and to perform random audits of documentation. Department representatives may sample material from the manufacturing plant, the project site, and the warehouse.

3.1.4 Material Restrictions. **Use of recycled aggregate is not allowed.**

3.1.5 Prequalification.

Requests. **Prospective producers interested in submitting their product for prequalification must submit a written request to: Texas Department of Transportation, Construction Division, Materials and Pavements Section (CP51), 125 E. 11th Street, Austin, TX 78701-2483.**

Include the following information in the request:

- Company name,
- Physical and mailing addresses,
- Application classification(s) listed under 4655.7, and
- Contact person and telephone number.

Requirements. **Manufacturers requesting prequalification must meet the following requirements.**

- Test all concrete repair materials with results meeting the minimum material requirements of this Specification for the requested material application classification.
- Provide an independent laboratory test report from a laboratory audited and inspected by the Cement Concrete Research Laboratory, certifying compliance of the material to this Specification.
- Submit a minimum of approximately 100 pounds of concrete repair material to the Texas Department of Transportation, Construction Division, Materials and Pavement Section (CP 51), 9500 Lake Creek Parkway, Austin, Texas 78717.
- Provide manufacturer's certification and lot number for submitted sample.
- Provide technical data sheets typically accompanying product with printed instructions for mixing and application.
- Provide a current MSDS for the material.
- State if material is used neat or extended. If extended, submit all additional material and sourcing information needed except water.
- State the curing protocol (recommended or required) for field application.
- State if bonding agent is required. If required, submit bonding agent and a current Material Safety Data Sheet (MSDS) for the bonding agent.
- To maintain pre-approved status, submit annual notarized certifications stating that the product has not been altered since the product was originally submitted for approval.

All materials submitted for prequalification tests are at no cost to the Department.

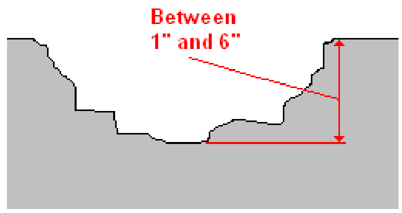
3.1.6 Packaging and Labeling**. Prepackage material in plastic lined or coated bags or other suitable moisture-resistant container. Repair material packaging must indicate the brand name, date of manufacture, lot number, and mixing/placing instructions. The repair material supplier must provide the Contractor and Engineer with a copy of the manufacturer's certificate for each lot number and shipment sent to the jobsite.**

3.1.7 Application Classifications**. A concrete repair material may be prequalified for multiple application classifications if desired. All diagrams are prior to surface preparation.**

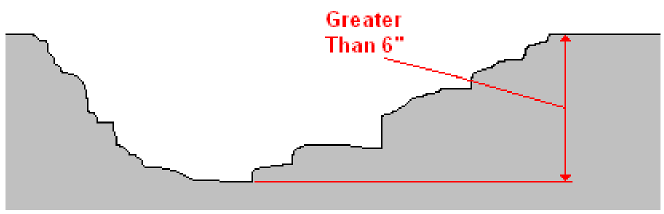
Ultra-rapid Repairs

Rapid Repairs

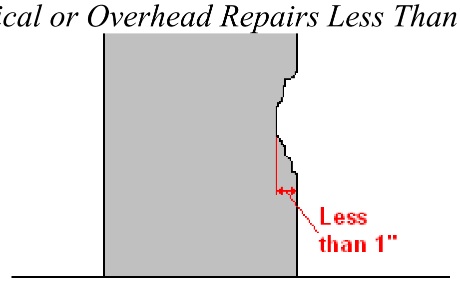
Horizontal Repairs Between 1 in. - 6 in.



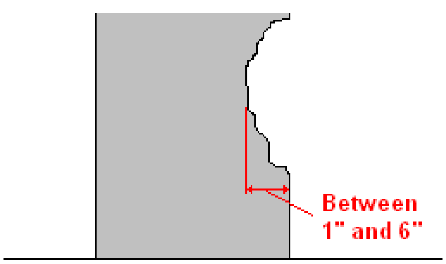
Horizontal Repairs Greater Than 6 in.

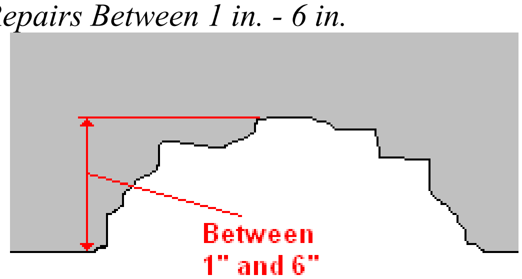


Vertical or Overhead Repairs Less Than 1 in.



Vertical or Overhead Repairs Between 1 in. - 6 in.





Concrete Pavement Spall Repair

General Purpose Repairs

Standard Repairs (Non-rapid)

Structural Concrete Repairs

Non-structural Concrete Repairs

3.1.8 Material Properties**. The following lists the material properties for each application classification listed in 4655.7.**

Ultra-rapid Repairs

Table A

Property	**Requirement**	**Test Method**
Splitting Tensile Strength, psi, min.	400 at 24 hours	ASTM C 496
Slant Shear, psi, min.	2,000 at 1 day	ASTM C 882[1]
Shrinkage, %, max.	0.07 at 28 days	ASTM C 157[2]
Coefficient of Thermal Expansion, micro strain /°F, max.	6.0[3] at 28 days	Tex-428-A
Compressive Strength using 4"x8" cylinders, psi, min.	2,000 at 2 hours 3,000 at 4 hours	ASTM C 39

[1]Standard substrate concrete used in test procedure has the following properties:

- Maximum Water/Cementitious Ratio: 0.45
- Maximum Nominal Aggregate Size: 3/4 in.
- Compressive Strength at 28 days: 3,600 psi
- Coefficient of Thermal Expansion at 28 days: 6.0 micro strain/°F

[2]Modified as follows:

Use 3"x3"x11.25" specimens. Demold at 3 ± 1/4 hours and take initial length reading. Store the specimens in a drying room (73°F and 50% relative humidity); at no point should the specimens be placed in water after they are demolded. Take readings at 1 day, 3 days, 7 days, 14 days, and 28 days.

[3]unless otherwise specified on plans

Rapid Repairs

Horizontal Repairs Between 1 in. - 6 in.

Table B2

Property	Requirement	Test Method
28-day Permeability, coulombs, max.	2,000 at 28 days OR 0.12 % by mass in top 1 inch	ASTM C 1202 OR AASHTO T 259
Splitting Tensile Strength, psi, min.	400 at 28 days	ASTM C 496
Slant Shear, psi, min.	2,000 at 3 days	ASTM C 882[1]
Shrinkage, %, max.	0.07 at 28 days	ASTM C 157[2]
Coefficient of Thermal Expansion, micro strain /°F, max.	6.0[2]at 28 days	Tex-428-A
Modulus of Elasticity, ksi, max.	5,000[3] at 28 days	ASTM C 469
Absorption, %, max.	9.0 at 28 days OR -0.07 at 28 days	ASTM C 497 Section 7, Method A OR ASTM C 157 (28-day soak)
Compressive Strength using 4”x8” cylinders, psi, min.	2,000 at 6 hours 3,000 at 24 hours 4,000 at 28 days	ASTM C 39
Freeze/Thaw Resistance[4]	90% at 300 cycles	ASTM C 666, Procedure A

[1]Standard substrate concrete used in test procedure has the following properties:

- Maximum Water/Cementitious Ratio: 0.45
- Maximum Nominal Aggregate Size: 3/4 in.
- Compressive Strength at 28 days: 3,600 psi
- Coefficient of Thermal Expansion at 28 days: 6.0 micro strain/°F

[2]Modified as follows:

- Use 3”x3”x11.25” specimens. Demold at 3 ± 1/4 hours and take initial length reading. Store the specimens in a drying room (73°F and 50% relative humidity); at no point should the specimens be placed in water after they are demolded. Take readings at 1 day, 3 days, 7 days, 14 days, and 28 days.

[3]unless otherwise specified on plans

[4]when required by plan note

Horizontal Repairs Greater Than 6 in.

Table B3

Property	Requirement	Test Method
28-day Permeability, coulombs, max.	1,500 at 28 days OR 0.09 % by mass in top 1 inch	ASTM C 1202 OR AASHTO T 259
Splitting Tensile Strength, psi, min.	400 at 28 days	ASTM C 496
Slant Shear, psi, min.	2,000 at 3 days	ASTM C 882[1]
Shrinkage, %, max.	0.07 at 28 days	ASTM C 157[2]
Coefficient of Thermal Expansion, micro strain /°F, max.	6.0[2] at 28 days	Tex-428-A
Modulus of Elasticity, ksi, max.	5,000[3] at 28 days	ASTM C 469
Absorption, %, max.	9.0 at 28 days OR -0.07 at 28 days	ASTM C 497 Section 7, Method A OR ASTM C 157 (28-day soak)
Compressive Strength using 4"x8" cylinders, psi., min.	2,000 at 6 hours 3,000 at 3 days 4,000 at 28 days	ASTM C 39
Freeze/Thaw Resistance[4]	90% at 300 cycles	ASTM C 666, Procedure A

[1]Standard substrate concrete used in test procedure has the following properties:

- Maximum Water/Cementitious Ratio: 0.45
- Maximum Nominal Aggregate Size: 3/4 in.
- Compressive Strength at 28 days: 3,600 psi
- Coefficient of Thermal Expansion at 28 days: 6.0 micro strain/°F

[2]Modified as follows:

- Use 3"x3"x11.25" specimens. Demold at 3 ± 1/4 hours and take initial length reading. Store the specimens in a drying room (73°F and 50% relative humidity); at no point should the specimens be placed in water after they are demolded. Take readings at 1 day, 3 days, 7 days, 14 days, and 28 days.

[3]unless otherwise specified on plans

[4]when required by plan note

Vertical or Overhead Repairs Less Than 1 in.

Table B4

Property	Requirement	Test Method
Slant Shear, psi. min.	2,000 at 3 days	ASTM C 882[1]
Shrinkage, %, max.	0.04 at 28 days	ASTM C 157[2]
Coefficient of Thermal Expansion, micro strain /°F, max.	6.0[2] at 28 days	Tex-428-A
Modulus of Elasticity, ksi, max.	5,000[3] at 28 days	ASTM C 469
Absorption, %, max.	9.0 at 28 days OR -0.04 at 28 days	ASTM C 497 Section 7, Method A OR ASTM C 157 (28-day soak)
Compressive Strength, using 4"x8" cylinders, psi, min.	3,600 at 28 days	ASTM C 39

[1]Standard substrate concrete used in test procedure has the following properties:

- Maximum Water/Cementitious Ratio: 0.45
- Maximum Nominal Aggregate Size: 3/4 in.
- Compressive Strength at 28 days: 3,600 psi
- Coefficient of Thermal Expansion at 28 days: 6.0 micro strain/°F

[2]Modified as follows:

- Use 3"x3"x11.25" specimens. Demold at 3 ± 1/4 hours and take initial length reading. Store the specimens in a drying room (73°F and 50% relative humidity); at no point should the specimens be placed in water after they are demolded. Take readings at 1 day, 3 days, 7 days, 14 days, and 28 days.

[3]unless otherwise specified on plans

Vertical or Overhead Repairs Between 1 in. - 6 in.

Table B5

Property	Requirement	Test Method
28-day Permeability[1], coulombs, max.	1,500 at 28 days OR 0.09 % by mass in top 1 inch	ASTM C 1202 OR AASHTO T 259
Slant Shear, psi, min.	2,000 at 3 days	ASTM C 882[2]
Shrinkage, %, max.	0.07 at 28 days	ASTM C 157[3]
Coefficient of Thermal Expansion, micro strain /°F, max.	6.0[4] at 28 days	Tex-428-A
Modulus of Elasticity, ksi, max.	5,000[4] at 28 days	ASTM C 469
Absorption, %, max.	9.0 at 28 days OR -0.07 at 28 days	ASTM C 497 Section 7, Method A OR ASTM C 157 (28-day soak)
Compressive Strength, using 4"x8" cylinders, psi, min.	3,600 at 28 days	ASTM C 39
Freeze/Thaw Resistance[5]	90% at 300 cycles	ASTM C 666, Procedure A

[1]only required for areas in contact with water

[2]Standard substrate concrete used in test procedure has the following properties:

- Maximum Water/Cementitious Ratio: 0.45
- Maximum Nominal Aggregate Size: 3/4 in.
- Compressive Strength at 28 days: 3,600 psi
- Coefficient of Thermal Expansion at 28 days: 6.0 micro strain/°F

[3]Modified as follows:

Use 3"x3"x11.25" specimens. Demold at 3 ± 1/4 hours and take initial length reading. Store the specimens in a drying room (73°F and 50% relative humidity); at no point should the specimens be placed in water after they are demolded. Take readings at 1 day, 3 days, 7 days, 14 days, and 28 days.

[4]unless otherwise specified on plans

[5]when required by plan note

Concrete Pavement Spall Repair. ***Refer to Item 720 "Repair of Spalling in Concrete Pavement," unless otherwise specified on plans.***

General Purpose Repairs

Table B7

Property	Requirement	Test Method
Compressive Strength, using 4”x8” cylinders, psi, min.	4,000 at 28 days	ASTM C 39
Initial Set, minutes, min.	45	ASTM C 266 or ASTM C 403
Final Set, hours, min.	4	ASTM C 266 or ASTM C 403

Standard Repairs (Non-rapid)

Structural Repairs

Table C1

Property	Requirement	Test Method
28-day Permeability, coulombs, max.	1,000 at 28 days OR 0.12 % by mass in top 1 inch	ASTM C 1202 OR AASHTO T 259
Splitting Tensile Strength, psi, min.	500 at 28 days	ASTM C 496
Slant Shear, psi, min.	2,200 at 28 days	ASTM C 882[1]
Shrinkage, %, max.	0.04 at 28 days	ASTM C 157[2]
Coefficient of Thermal Expansion, micro strain /°F, max.	6.0 at 28 days	Tex-428-A
Modulus of Elasticity, ksi, max.	5,500 at 28 days[3]	ASTM C 469
Absorption, %, max.	9.0 at 28 days OR -0.04 at 28 days	ASTM C 497, Section 7, Method A OR ASTM C 157 (28-day soak)
Compressive Strength using 4”x8” cylinders, psi, min.	5,000 at 28 days	ASTM C 39

[1]Standard substrate concrete used in test procedure has the following properties:

- Maximum Water/Cementitious Ratio: 0.45
- Maximum Nominal Aggregate Size: 3/4 in.
- Compressive Strength at 28 days: 3,600 psi
- Coefficient of Thermal Expansion at 28 days: 6.0 micro strain/°F

[2]Modified as follows:

Use 3”x3”x11.25” specimens. Demold at 24 ± 1/2 hours and take initial length reading. Store the specimens in a drying room (73°F and 50% relative humidty); at no point should the specimens be placed in water after they are demolded. Take readings at 3 days, 7 days, 14 days, and 28 dayss.

[3]unless otherwise specified on plans

Non-structural Concrete Repairs

Table C2

Property	Requirement	Test Method
28-day Permeability, coulombs, max.	,1,500 at 28 days OR 0.09 % by mass in top 1 inch	ASTM C 1202 OR AASHTO T 259
Splitting Tensile Strength, psi, min.	500 at 28 days	ASTM C 496
Slant Shear, psi, min.	2,000 at 28 days	ASTM C 882[1]
Shrinkage, %, max.	0.04 at 28 days	ASTM C 157[2]
Coefficient of Thermal Expansion, micro strain /°F, max.	6.0 at 28 days	Tex-428-A
Modulus of Elasticity, ksi, max.	3,500 at 28 days	ASTM C 469
Absorption, %, max.	9.0 at 28 days OR -0.04 at 28 days	ASTM C 497, Section 7, Method A OR ASTM C 157 (28-day soak)
Compressive Strength using 4"x8" cylinders, psi, min.	4,000 at 28 days[3]	ASTM C 39

[1]Standard substrate concrete used in test procedure has the following properties:

- Maximum Water/Cementitious Ratio: 0.45
- Maximum Nominal Aggregate Size: 3/4 in.
- Compressive Strength at 28 days: 3,600 psi
- Coefficient of Thermal Expansion at 28 days: 6.0 micro strain/°F

[2]Modified as follows:

- Use 3"x3"x11.25" specimens. Demold at 24 ± 1/2 hours and take initial length reading. Store the specimens in a drying room (73°F and 50% relative humidty); at no point should the specimens be placed in water after they are demolded. Take readings at 3 days, 7 days, 14 days, and 28 days.

[3]unless otherwise specified on plans

3.1.9 Disqualification**. The Department may disqualify and remove materials from the MPL if there is any change in cement or admixtures of a particular repair material or if the material at any time is found to not meet the requirements listed above. The material must be requalified for acceptance.**

The manufacturer may resubmit their product for requalification consideration, after following the procedures stated in 'Prequalification Requirements.'

3.1.10 Charge for Failing Samples. **Costs of testing are normally borne by the Department. However, the costs of re-sampling and re-testing materials that previously failed to conform to the requirements of this Specification will be borne by the producer. The Director of CST/M&P will establish the rate of sampling and testing costs of failing material in effect at the time of testing.**

Appendix H: Early Successful Special Specification for Polymer Patching

1993 Specifications CSJ's 0050-09-062 & 0912-71-880

SPECIAL SPECIFICATION
3408

Crack and Spall Repair (Elastomeric Patching Material)

1. **Description**. This Item shall govern for the furnishing and installation of elastomeric patching material for the repair of random cracks and spalls in existing Portland cement concrete pavement in accordance with the requirements herein and the details shown on the plans.

2. **Materials.** The repair material shall be an elastomeric patching material consisting of a fluid polyurethane base or binder with sand and with or without fiberglass aggregate system to provide a product that mixes in 5 minutes or less, flows readily, adheres to concrete, and requires no external application of heat for curing. This material shall be Delpatch (TM) and Delcrete (TM) Elastomeric Concrete as manufactured by D. S. Brown Company, or equal, as approved by the Engineer.

The materials shall meet the physical properties indicated in Table H1:

Table H1: Physical Properties

Binder Only			
Test		**Test Method**	**Specification**
Original Properties (after conditioning at 100 F for 7 days)	Tensile Strength, psi Tensile Stress,	TEX-618-J TEX-618-J	1,100 Min. 500 Min.
	psi Elongation, % Hardness,	TEX-618-J ASTM D2240	200 Min. 90 + 3 A
	Durometer D		
Tensile Properties (after oven aging 7 days @ 158 F ASTM D573	Tensile Strength, psi Tensile Stress, psi Elongation, %	TEX-618-J TEX-618-J TEX-618-J	1,100 Min. 500 Min. 200 Min.
	Hardness,	ASTM D2240	90 + 3 A
	Durometer D		

Properties for the binder and aggregate shall be submitted by the Manufacturer to the Engineer for approval.

The size of the aggregate and binder to aggregate ratio shall meet one of the following mix types:

Type 1. The aggregate shall consist of fine silica sand passing the No. 30 sieve size. The composition of the mix shall be approximately 15 lb. of aggregate per 1 gallon of binder.

Type 2. The aggregate shall consist of fine silica sand passing the No. 6 sieve size. The composition of the mix shall be approximately 30 to 40 lb. of aggregate per 1 gallon of binder.

Type 3. The aggregate shall consist of sand of the size selected by the Manufacturer. The composition of the mix shall be approximately 60 lb. of aggregate per 1 gallon of binder.

The type of mix required for the project shall be as indicated on the drawings.

The elastomeric patching material shall be gray in color. The material shall be kept dry and above freezing temperatures. During hot weather the material shall be kept in the shade and/or as directed by the Manufacturer.

3. Construction Methods. Prior to beginning operations, the Contractor shall submit a statement from the elastomeric concrete manufacturer showing the recommended equipment and installation procedures to be used. All equipment and procedures will be subject to approval by the Engineer.

The use of any equipment which damages dowels, reinforcing steel, concrete, base, subbase or subgrade shall be discontinued, and the joint and/or crack shall be cleaned by other methods which do not cause such damage.

(A) Crack and Spall Preparation. At the time of sealing, the crack or spall shall be free of all debris, dirt, dust, saw cuttings or other foreign material.

The cracks shall be cleaned by a method approved by the Engineer. Unless otherwise shown on the plans, hand tools, air guns, power routers, abrasive blasting equipment or other equipment may be used to clean the cracks.

Unsound concrete shall be removed to the dimensions indicated on the plans or as directed by the Engineer. Prior to application of the elastomeric patching material, the surface shall be dry and shall be sandblasted to ensure it is free from dirt, grease, oil, laitance or other foreign material which may reduce the bond between the elastomeric patching material and the existing concrete pavement. There shall be no dust from the sand blasting operation in the area to be repaired.

(B) Primer. After sandblasting, a primer supplied by the manufacturer shall be applied to the area to be repaired and allowed to cure for a minimum of 30 minutes before placing the elastomeric patching material. The primer shall be re-applied if 6 hours pass prior to introduction of the elastomeric patching material, or if a rain occurs.

(C) Application. Elastomeric concrete components shall be weighed and mixed in accordance with the manufacturer's recommendations. The material shall be placed into the area to be repaired within 4 minutes of the initial mixing. If there is a sloped condition in the roadway, placement shall begin at the lower end. Upon initial cure, a notched trowel shall be used to provide a non-skid finish to the surface. An experienced manufacturer's representative or agent of the manufacturer shall be present during the installation of the elastomeric patching material.

4. **Measurement.** This Item will be measured by the mixed gallon of elastomeric patching material, complete in place, of the type specified.

5. **Payment.** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Crack and Spall Repair Type 1", "Crack and Spall Repair Type 2" or "Crack and Spall Repair Type 3". This price shall be full compensation for furnishing all materials; for all routing and chipping, removal of loose concrete and cleaning; furnishing and installing "Elastomeric Patching Material and Primer"; and for all manipulations, labor, equipment, tools and incidentals necessary to complete the work.