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North Carolina Department of Transportation

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Material Property and Quality Control Specifications for Elastomeric Concrete Used at Bridge Deck Joints

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16. Abstract

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- Capital Services, 112 Morris Road, Schenectady, NY 12304 – Mr. Tom Meacham
- E-poxy Engineered Materials, LLC, 10 Broadway, Albany, NY 12202
- Kinedyne Corporation, Buffalo, NY
- R.J. Watson, Inc., 78 John Glenn Drive, Amherst, NY 14228 – Mr. Marc D. Stafford
- Watson Bowman Acme Corp., Amherst, NY

Executive Summary

Elastomeric concrete has been used in bridge expansion joint construction for over two decades. However, the North Carolina Department of Transportation (NCDOT) does not currently have a quality control program addressing elastomeric concrete. The purpose of this research was to determine the minimum requirements in order to ensure satisfactory long-term performance and to develop a quality control program, including field sampling and testing during installation. There were two main phases to the research performed within this study. The first phase dealt with identification of critical material properties to establish a prequalification program. A total of eleven products were obtained and lab-mixed to determine the effects of varying polymer and aggregate types. This phase would also provide a baseline for material property values throughout the remainder of the research. In the second phase, site visits were made to fresh installations throughout North Carolina to obtain sample elastomeric concrete mixed in the field. Those sites were later revisited to obtain material from the same expansion joint after at least 4 months in service. When revisited, samples were obtained through means of coring. Cored sample test data could then be compared to the fresh sampling data to determine changes in physical properties with time. Older existing joints (over 5 years in-service life) were also identified and sampled to determine the physical property changes associated with long-term cyclic loading and environmental weathering. The following table displays the proposed minimum requirements determined in this study, in comparison to the existing NCDOT requirements.

Testing Method	Existing NCDOT Min. Requirements	Proposed Min. Requirements
Binder Tensile Strength (psi)	800	1000
Binder Tear Strength (lb/in)	90	200
Binder Ultimate Elongation (%)	150	150
Compressive Strength (psi)	2800	2200
5% Deflection Resilience	-	95
Splitting Tensile Strength (psi)	-	625
Bond Strength (psi)	450	450
Impact Resistance (ft-lbs)	7	-
Durometer Hardness	-	50

The research performed within this study presents a foundation for establishing a comprehensive quality control/assurance program for elastomeric concrete used in the state of North Carolina. Prequalification specifications are also presented, in addition to installation recommendations.

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1 INTRODUCTION AND LITERATURE REVIEW

1.1 Elastomeric Concrete – The Product

Polymeric materials have been successfully used by the construction industry for several decades. For close to 20 years, fiber reinforced polymer (FRP) composites have revolutionized the infrastructure repair and retrofit industry. More recently, polymeric materials have been used for elastomeric concrete as pavement patching materials (Michigan DOT, 1996). Similar materials are also being used as bridge joint headers with either armored or armorless design. The ease of application and quick setting/curing time allows elastomeric concrete to be an excellent header material for both new construction and joint replacement projects, where quick reopening of bridge lanes to traffic is critical. In new construction, elastomeric concrete is utilized as a nosing material for bridge and parking deck expansion joint construction. In replacement projects, the material is used for joint spall and crack repairs, partial width replacements, and many other applications.

By definition, elastomeric concrete consists of a two-component polymeric binder and an aggregate system, forming a mortar to be used in patching or nosing (e.g. in bridge joint headers) (Texas DOT, 2001). The polymeric binder can be epoxy or polyurethane, while the aggregate system is comprised of kiln dried sand and/or stone aggregate. Similarly to FRP composites, the elastomeric concrete is developed and marketed as a system, making the application process more uniform. Furthermore, several manufacturers are developing complete bridge joint systems, specifying not only the elastomeric concrete header, but also the joint sealant. Elastomeric concrete is typically used as the bridge joint header material in Evazote seal joint systems, which accommodate small movement ranges. A major advantage of these complete joint systems is the guaranteed material compatibility between individual components, allowing for a more realistic system evaluation by DOTs across the country.

Each product comes with technical data sheets listing features, mixing procedures, and limitations of that particular product. Depending on the product, elastomeric concrete should not be installed under certain temperatures, typically between 35 ˚F and 45 ˚F (Polyset Company). Manufacturers also warn that the material should not be installed in a wet environment. The Michigan Department of Transportation has studied the effect of moisture on elastomeric concrete. This study took place while the material was still in its early developmental stages. They proved that one major problem resurfaced with practically all polymers: incompatibility with water or wet aggregates and concrete (MDOT, 1996). One conclusion from the study indicated that surface water on the aggregate reduced the flexural strength of the polymers by 40 to 60 percent when tested at extreme temperatures (-20 °F to 105 °F).

1.2 Bridge Joint Header Types

Evazote seal joints are compression seal systems consisting of elastomeric concrete nosing material that is placed within a full depth (2¼" x 5½") blockout. Once elastomeric concrete has cured, an Evazote seal is placed along the length of the joint. They are typically bonded into place with a two component modified epoxy adhesive, which is applied on the inside of the elastomeric concrete surface (unarmored) or the steel railing (armored).

According to the NCDOT Structure Design Unit Design Manual, evazote joint seals are used at both interior bents and end bents, with a permissible maximum joint opening of 3½" normal to the centerline of the joint. The design manual also discusses the cases where joints shall be armored. For projects with a design average daily truck traffic (ADTT) of 2500 or more, and all bridges on the national highway system (NHS) regardless of ADTT, the Evazote joint seal shall be armored from gutter line to gutter line. (North Carolina Department of Transportation, 2007). Figure 1-1 shows a cut-section view of a typical expansion joint with elastomeric concrete serving as the nosing material within the concrete blockout. The left side displays an unarmored joint and the right side displays an armored joint, both incorporating the typical Evazote neoprene seal.

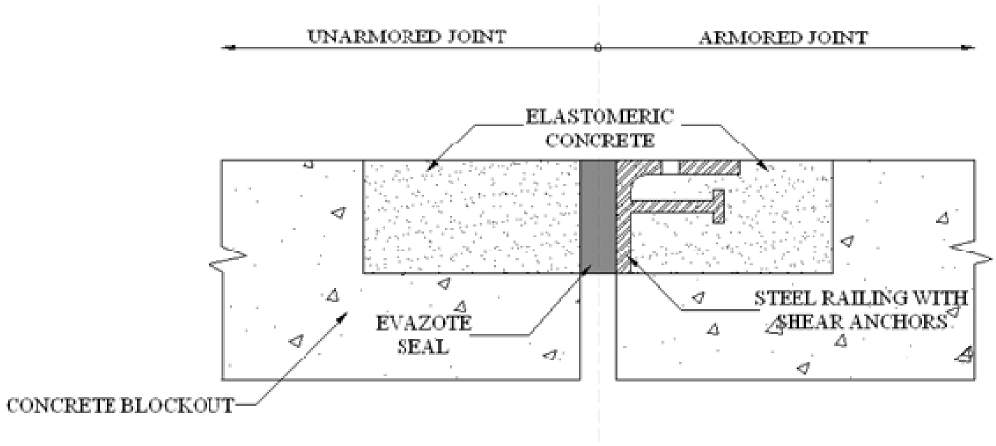

Figure 1-1. Half plan of a typical armored and unarmored expansion joints

1.3 Product Performance

It has proven effective as a nosing material when used in conjunction with unarmored and armored expansion joints, which can be attributed to a number of factors. First, it has very good bond strength characteristics to both steel and concrete.

When considering expansion joint headers, another key factor is resilience. The resilience of elastomeric concrete allows for expansion, contraction, and load dissipation to occur without considerable spalling taking place. Spalling can be defined as deterioration over time that can lead to fragments of a material becoming loose. Spalling of the nosing material not only takes away from the aesthetics of the bridge, but also creates cracks and voids, which can house water and other foreign objects.

Water can ultimately degrade the nosing material especially in regions which are subject to harsh freeze-thaw cycles. Similarly, deicing salts can penetrate the spalled areas of the nosing material, and can ultimately leak down to the substructure, prematurely degrading many of the substructure components. Prior to elastomeric concrete, Portland cement concrete served as the header material. The brittle properties of this concrete led to significant levels of spalling, proving that normal concrete was an undesirable header material. Previous research indicates that poorly consolidated Portland cement concrete produces low strength concrete possessing air pockets in which water can collect and freeze, ultimately resulting in spalling (Distlehorst & Wojakowski, 2005).

In September of 1994, MDOT technical personnel began a study of 10 polymer concrete materials (eight of which were elastomeric concrete) for use in the preventive maintenance of roadways and bridge decks.

The conclusions drawn from the studies indicated that all of the polymer concretes (with the exception of one material) outperformed all Portland cement-based fast set materials.

Elastomeric concrete is also an ideal material for replacing failed expansion joints due to its quick curing time. Within 3 hours of the complete placement, lane closures can be reopened in most applications. This benefit can cut down on costs due to traffic control as well as direct labor hours in the field. Placements typically do not take more than four to five hours, and can be successfully installed by following the product manufacturer's instructions. Due in part to its quick curing time, elastomeric concrete possesses a high viscosity, which ultimately affects the workability during placement. Perhaps the most challenging obstacle in the installation process is ensuring that the armored angles (when used) are mounted at the right elevation with respect to the surrounding concrete deck. All in all, elastomeric concrete provides a simple means for constructing an expansion joint, when compared to other types of bridge joints. The ease of mixing and placement has made elastomeric concrete a promising option, which field employees can appreciate.

1.4 Development of Testing Methods

Presently, a set of comprehensive testing methods does not exist for elastomeric concrete. Therefore, many state departments, testing agencies, and manufacturers have had to modify existing standards which are traditionally reserved for concretes, rubbers, and plastics. Over the years, there have been only few studies performed to identify the most critical properties and minimum requirements of elastomeric concrete. The earliest requirements can be dated back to 1990, in R.J. Watson's (Watson, 1990) review of elastomeric concrete in the field. After completing the study, the minimum requirements of cured elastomeric concrete were summarized as shown in Table 1-1.

Table 1-1. Minimum material property requirements (Watson, 1990)

[redacted]

Four years later, in September of 1994, MDOT technical personnel began a study of ten polymer concrete materials (eight of which were elastomeric concrete) for use in the preventive maintenance of roadways and bridge decks. The ten polymer concrete products were lab-mixed and tested in accordance with modified ASTM specifications. The study did not mention all of the testing which took place, but concluded by suggesting that the required testing criteria should include the flexural strength, tensile strength, and elongation of polymer concrete. Minimum requirement values were not derived in the study. MDOT researchers found that although preparation of repair areas was still critical, polymer concretes were much more forgiving of "bad" preparation.

To develop a specification for elastomeric concrete used in bridge expansion dam headers, Jeff Zell

Consultants, Inc. (JZC) prepared a comprehensive report for the Pennsylvania Department of Transportation (Jeff Zell Consultants, Inc., 2007). Three elastomeric concrete products were evaluated based on existing testing protocols, as well as incorporating additional testing methods to better determine the properties of interest. JZC researched the tests performed by the various departments of transportation on elastomeric concrete, and found that there were a total of eight reoccurring tests, those being:

1. Compressive strength
2. Tensile strength
3. Bond strength to concrete
4. Elongation
5. Tear resistance
6. Hardness
7. Brittleness by impact
8. Resilience

Ultimately, JZC was unable to develop a set standard of minimum requirements for elastomeric concrete, concluding that the unique composition of each of the three elastomeric concrete materials considered, made it difficult to adopt standard testing methods and minimum acceptable values. JZC recommended selecting particular elastomeric concrete products based on site/design specific factors, including the loading and environmental conditions. The document also noted that great care must be taken during the installation process, as most of the problems (spalling, delamination, etc...) associated with the use of elastomeric concrete could be linked to conditions existing before or occurring during installation of the product. Both of the lab studies previously mentioned recommended observation of successful field installations to determine their behavior under live traffic conditions, in addition to evaluation of field specimens after exposure to simulated weather and loading conditions.

1.5 Field Performance

R. J. Watson (Watson, 1990) noted that the earliest installations of hot-applied elastomeric concrete date back to 1979 in New York State. In the early days of elastomeric concrete, the Nevada Department of Transportation, Ontario Ministry of Transportation, and the Louisiana Department of Transportation were the first to experiment with this emerging material (Watson, 1990). Those agencies found this new product to be effective and ultimately led to other states utilizing elastomeric concrete in bridge joint headers. Watson addressed the typical strip seal systems of the day which were combined with the field mixed elastomeric concrete as the nosing material. These strip seal systems featured a metal rail edge, which was manufactured from structural steel. The metal railing runs the length of the joint, placed at the center of the blockout. This is a construction method still seen in today's strip seal installation techniques. Watson documented many tasks to consider when preparing and installing the joint, including a list of tools proving useful, methods for accelerating cure times, and tips for installing the preformed elastomeric strip sealing element.

Watson listed the following installation problems:

- contaminated blockout area,
- poor consolidation underneath the edge rail,
- improper mixing procedures,
- poor quality concrete or asphalt in bond area,
- inadequate elastomeric concrete material.

Watson also discussed the effects of moisture on the bond strength of the elastomeric concrete to the steel and concrete substrates. Four field installations were monitored on a twin set of structures in 1985, and were inspected four years later. Out of the four installations performed, one joint was installed as it rained. When inspected four years later, the joint that was not installed according to manufacturer guidelines showed signs of bond failure. Given that the same installation crew and product type was used on all four joints, indicates that the moisture was most likely the source of the problem.

Kuo and Ortega (2001a and 2001b) tested several elastomeric concrete materials in an accelerated wear testing project focused on bridge expansion joints. The objective of this project, funded by Florida DOT, was to establish the life expectancy of wear for over 40 joint systems, based on an accelerated test method utilizing a wheeled testing apparatus traveling at 10-12 mph around a test bed. Some systems performed up to an estimated 10-year service life, while others would remain functional up to an equivalent of 20-year service life, under the same loading and environmental conditions.

In June 2005, The Kansas Department of Transportation released a document (Distlehorst and Wojakowski, 2005) which focused on joint systems including both traditional concrete and elastomeric concrete header materials. Two types of elastomeric concrete were placed on bridges in Wichita in 1991, consisting of cold-mixed and hot-mixed elastomeric concrete. The elastomeric concrete and the adjacent concrete header materials of two joints were surveyed annually for ten years, examining the rut depth, extent of spalling, and the general condition of the joints. Compressive and tensile lab tests of field-cast specimens were taken during the initial placement of the two joints. The lab testing and annual surveys determined that elastomeric concretes reduced spalling at bridge expansion joints. Although elastomeric concretes developed distress, their use reduced spalling at the bridge expansion joints when compared to the traditional concrete headers.

1.6 Project Objectives

The project described in this report, undertaken in July 2006, was initiated to evaluate elastomeric concrete as a nosing material within bridge expansion joint headers in North Carolina. The project consisted of two research phases: to determine the minimum requirements to ensure long-term performance-based contract specifications; and to develop a quality control program, including field sampling and testing during elastomeric concrete installation.

Elastomeric concrete has been a leading bridge joint header material, for more than 2 decades, within many of the Departments of Transportation throughout the country. As a result, a growing number of bridge designers and construction companies in North Carolina have began selecting elastomeric concrete for its use within expansion joint header dams. This relatively new material presents a reasonably simple means of constructing an expansion joint; however, its service life can be seriously reduced if the proper procedures are not followed. Therefore, it is imperative that field installations are performed correctly in order to ensure long lasting joint service lives. With regards to elastomeric concrete bridge joint headers, the North Carolina Department of Transportation (NCDOT) expects these materials (evaluated as individual components rather than as part of a joint system): to provide a transition zone between the concrete bridge deck and flexible joint material in both new and retrofit applications; and to have an easy installation procedure.

Table 1-2 displays the NCDOT minimum requirements of cured elastomeric concrete at 14 days. These current NCDOT specifications were evaluated to determine if these minimum requirements are reliable measures of the physical properties of field-mixed elastomeric concrete.

The purpose of this report is to present an analysis of elastomeric concrete so as to determine a quality control program for the North Carolina Department of Transportation (NCDOT). Currently, the NCDOT has a list of minimum requirements which all installed products must satisfy, and in addition, manufacturers must also provide written certification that their products meet these specifications.

Table 1-2. Current NCDOT elastomeric concrete specifications

Concrete Properties	Test Method	Minimum Requirement
Bond Strength to Concrete	ASTM D5420	450
Brittleness by Impact (ft-lb)	Ball Drop	7
Compressive Strength (psi)	ASTM D695	2800

Binder Properties (without aggregate)	Test Method	Minimum Requirement
Tensile Strength (psi)	ASTM D638	800
Ultimate Elongation	ASTM D638	150%
Tear Resistance (lb/in)	ASTM D624	90

The first phase of the project focused on the identification of existing standards throughout the country, in order to determine critical material properties. Currently, there are no standard testing methods set forth for elastomeric concrete; although an American Society for Testing and Materials (ASTM) D04.34.12 Task Group has been recently drafting such a document, the effort was halted as no consensus could be reached between committee members. Subsequently, all acquirable elastomeric concrete products currently on the market were obtained and mixed in a highly-controlled lab environment. All specimens were prepared according to the implemented standard testing methods. The results from the lab-mixing were used to develop revised acceptance criteria, based on the existing NCDOT minimum requirements. The critical material properties identified in this phase served as a benchmark for the remainder of the research. The values generated would serve as the benchmark for establishing the prequalification of elastomeric concrete, as well as providing a baseline for the field phase.

The second phase of the project involved the field monitoring of installation and replacement procedures. Fresh-mixed samples were obtained from 12 sites across the state. All sites at which fresh samples were obtained were revisited to collect coring samples. Twelve "older" existing sites were also visited for coring purposes, to determine the physical properties of joints performing in an acceptable manner. Fresh sampling and coring visits were made to each region of the state; however, due to the limited number of elastomeric concrete installations in the coastal and western regions, determining the varying effects of weather, salinity, and deicing chemicals was not feasible. The values obtained from the field would then be compared with the newly proposed acceptance criteria from phase one, which would determine if the proposed values were consistent with typical field performance.

A research methodology was set forth in the original proposal that divided the project into four distinct tasks. These tasks were:

- Identify critical material properties and perform a thorough evaluation of elastomeric concrete materials currently available on the market by means of material testing.
- Develop acceptance criteria for armorless and armored bridge joint headers.
- Evaluate new and existing field applications to confirm proposed acceptance criteria.

2 BENCHMARK INVESTIGATIONS

2.1 Department of Transportation Specifications

Before laboratory testing could begin, a thorough understanding of the material was needed. By performing a review of acceptance criteria of other states/agencies, the research team was able to define the scope of work better and also avoid possible drawbacks. An exhaustive search of other states' transportation departments was conducted in order to determine which states have used elastomeric concrete, and if so, what their quality control program consisted of. This was done through the use of internet searches, e-mail, and phone conversations.

This effort had limited success due to lack of available information. Most state transportation departments do not have this information on their website. For this reason, emails and phone conversations were more effective than simply searching internet websites. It seems that elastomeric concrete is not being used in several states. For the states that are using elastomeric concrete, there is not a very structured quality assurance program (if any).

Once contact was made with a state's department of transportation, it usually took several days and sometimes weeks of conversing and writing with different people in order to find the information desired. The information obtained was compiled and included in Appendix A, along with a survey which contains several questions considered to be critical to this research program.

Appendix B provides more details from a few selected states' elastomeric concrete specifications. From this information, several levels of specifications can be identified, as follows:

1. *Comprehensive specifications* – providing a complete package on elastomeric concrete. As an example, TexDOT in Section 5 DMS-6140 provides a quality monitoring program (QMP), as well as specifications for material requirements (MR). The QMP provides information on the prequalification program, which requires manufacturers to: provide test results showing compliance with MR; and provide elastomeric concrete samples to TexDOT for independent material evaluation. Successful materials then remain on an approved list for 6 months as a system. Other requirements could be requested by the engineers, but as rule, the materials have to be re-qualified every six months, or if they have been modified or reformulated.

The MR section in the same TexDOT specification provides a list of minimum acceptable levels for a wide range of material properties for two types of elastomeric concrete systems: Type I system is a semi-flexible and more resilient material, as compared to the Type II system, which is a higher strength semi-rigid system. However, no clear guideline is provided in this document on which system should be used for what conditions.

For both of these material types, detailed lists of requirements are provided for both the binder material only, then for the binder and aggregate mixture (i.e. the final product). It is important to note that in addition to a few ASTM standards, these provisions primarily reference two TexDOT test specification, Tex-614-J and Tex-618-J; which for the most part, represent modified/customized ASTM standards.

Finally, similarly to other states (e.g. Tennessee, and Kansas), TexDOT also provides a list of pre-qualified elastomeric concrete materials, identifying the product manufacturer, and the qualification expiration date.

2. *Prescriptive specifications* – providing acceptable material properties. North Carolina's specification on elastomeric concrete, for example, provides a list of requirements for the binder and the elastomeric concrete, separately. Furthermore, additional general requirements and an overall material description are also included for these materials.

As another example, the GDOT specification (Section 449) is also provided in Appendix B. These specifications divide header materials into epoxy concrete, and elastomeric concrete categories, with no clear indications on when to specify these two header material types. Similarly to the TexDOT practice, this section also references a GDT 111 test method, in addition to an AASHTO standard test.

Furthermore, the same GDOT specification includes a separate section on header construction requirements. These requirements emphasize the importance of the manufacturer's involvement in the construction process, including installer training and providing representation during header installation. Additional requirements are provided pertaining deck surface preparations, header material mixing methods, acceptable weather conditions, and minimum curing times before allowing traffic to open.

3. *General specifications* – providing only general statements on elastomeric concrete. At the most, these "specifications" contain a definition or material description; and maybe a list of prequalified products and/or materials.

Similarly to the wide range of material properties and test methods published by elastomeric concrete manufacturers, as it can be seen from the data presented here, state DOT specifications vary greatly between comprehensive documents to simple general statements.

It is clear that elastomeric concrete has great potential in bridge joint headers. Most of the states adopted this material for both joint retrofit and new construction. Many material systems are currently available; however, the industry does not have a clear guideline to follow with reference to acceptable material performance and test methods. To fill this gap, state DOTs offer special provisions or specifications (with a wide range of details), some offer a well-defined QA/QC protocol including elaborate prequalification programs. Some of the states modify existing ASTM standards, or developed new test methods in order to better evaluate elastomeric concrete materials.

Appendix C includes a sample of state specifications, providing a snapshot of provisions from selected states. The material was mostly gathered from state DOT web sites, followed by specific inquires, as was necessary.

2.2 Manufacturer Specifications

Another search was conducted in order to determine how many different elastomeric concrete products are being produced at the time the research project was conducted. Once the various producers were located, they were contacted and asked both for material data sheets and also samples of their material for testing purposes. All of the companies seemed eager to send all of the information requested; however, it took quite longer than expected to receive all of the material samples, and even longer to receive answers to more specific test-related questions. All of the products which were lab tested are shown below, organized by manufacturer, in no particular order:

1. R J Watson
    - Tron-Flex
2. Watson Bowman Acme
    - WaboCrete 2
3. Chase Corporation
    - Ceva Crete
    - E-Crete No. 57
    - Pro-Crete Plus
    - Pro-Crete NH
4. Polyset
    - Ply-Krete
    - Ply_Krete HT
    - Ply_Krete HS
    - Ply_Krete LV
5. D S Brown
    - Delcrete

In order to identify the available critical material properties of elastomeric concrete, a master table has been prepared. This two-page table is provided in Appendix C, and summarizes the properties published by:

- The ASTM D04.34.12 Task Group
- Capital Services
- D.S. Brown
- E-Poxy Engineered Materials
- Kinedyne
- R.J. Watson
- Watson Bowman Acme

It is clear from this table that about 45 material properties are being reported for elastomeric concrete. Most of these properties reference ASTM and AASHTO standard test specifications, others follow in-house or state-specific DOT test procedures. Some of the test data was developed under standard conditions; however, a large part of the data was produced under special (environmental and/or test) conditions, making a direct comparison of material properties even harder.

Most of these test data have been produced in research and development (R&D) programs by the manufacturers, and a great number of the selected test and environmental conditions appear to be rather subjective. State funded elastomeric concrete evaluation is almost non-existent, although a few states did develop special test protocols to evaluate these materials.

2.3 Review of Available Testing Methods

After researching and reviewing the various companies and state departments, a list of the more relevant test methods was developed during the first phase of the research. The standards which were considered for this project are listed as follows (as described by ASTM, where applicable), although not all of them were performed:

1. **Compressive Properties of Rigid Plastics - ASTM 695 – 02a**
   Scope: Determination of the mechanical properties of unreinforced and reinforced rigid plastics, including high-modulus composites, when loaded in compression at relatively low uniform rates of straining or loading. Report compressive strength and speed of testing.

2. **Tensile Properties of Plastics - ASTM D 638 – 03**
   Scope: Determination of the tensile properties of unreinforced and reinforced plastics in the form of standard dumbbell-shaped test specimens when tested under defined conditions of pretreatment, temperature, humidity, and testing machine speed. Report speed of testing, tensile strength, and percent elongation.

3. **Apparent Shear Strength of Single-Lap-Joint Adhesively Bonded Metal Specimens by Tension Loading - ASTM D 1002 – 01**
   Scope: This test method covers the determination of the apparent shear strengths of adhesives for bonding metals when tested on a standard single-lap-joint specimen and under specified condition of preparation and test.

4. **Vulcanized Rubber and Thermoplastic Elastomers - Tension - ASTM D 412 - 98a**
   Scope: Tensile tests measure the force required to break a specimen and the extent to which the specimen stretches or elongates to that breaking point. The data is often used to specify material, to design parts to withstand application forces and as a quality control check of materials.

5. **Rubber Property – Compression Set - ASTM D 395 – 03**
   Scope: Compression set testing is used to determine the ability of elastomeric materials to maintain elastic properties after prolonged compressive stress. The test measures the somewhat permanent deformation of the specimen after it has been exposed to compressive stress for a set time period. This test is particularly useful for applications in which elastomers would be in a constant pressure/release state.

6. **Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers - ASTM D 624 – 00E1**
   Scope: This test method describes procedures for measuring a property of conventional vulcanized rubber and thermoplastic elastomers called tear strength. Report tear strength based on ultimate load and median thickness.

7. **Rubber Property – Durometer Hardness - ASTM D 2240 – 03**
   Scope: Determines indentation hardness of substances classified as thermoplastic elastomers, vulcanized rubber, elastomeric materials, cellular materials, gel-like materials, and some other forms of plastics. Report means of testing, description of test specimens, and hardness values.

8. **Water Absorption of Plastics - ASTM D 570 – 98**
   Scope: Covers determination of the relative rate of absorption of water by plastics when immersed. This test method is intended to apply to the testing of all types of plastics, including cast, hot-molded, and cold-molded resinous products, and both homogeneous and laminated plastics. Report time of immersion and percentage of water absorbed.

9. **Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear - ASTM C 882-99**
   Scope: This test method covers the determination of the bond strength of epoxy-resin-base bonding systems for use with Portland-cement concrete. This test method covers bonding hardened concrete to hardened or freshly-mixed concrete.

10. **Compressive Strength of Hydraulic Cement Mortars - ASTM C 109/C 109M – 02**
    Scope: This test method covers determination of the compressive strength of hydraulic cement mortars, using 2” cube specimens.

11. **Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials - ASTM G 154 - 00a^{E1}**
    Scope: This practice covers the basic principles and operating procedures for using fluorescent UV light, and water apparatus intended to reproduce the weathering effects that occur when materials are exposed to sunlight (either direct or through window glass) and moisture as rain or dew in actual usage. This practice is limited to the procedures for obtaining, measuring, and controlling conditions of exposure. A number of exposure procedures are listed in an appendix: however, this practice does not specify the exposure conditions best suited for the material to be tested.

12. **Impact Resistance – ASTM D 5420-04**
    Scope: *(modified)* Specimens will be conditioned for prescribed test temperatures for a specific amount of time. A one pound steel ball will be dropped through a vertical 10 foot guide tube onto the center of the specimen. Drops will be made immediately after moving the specimen from the exposure condition. The initial drop will be that of 5’ followed by drops of ½’ increments until the specimen cracks. At least 3 specimens will be tested at each temperature for each mix.

13. **Shrinkage - ASTM C 157/C 157M-06.**
    Scope: This standard test is mainly used to determine the percent of shrinkage which occurs in hardened hydraulic cement mortar and concrete specimens. The shrinkage measured is not induced by temperature or any outside force.

14. **Sieve Analysis of Fine and Coarse Aggregates – ASTM C 136-96a**
    Scope: this test method is used to determine the particle size distribution of a sample containing fine and coarse aggregates. Report total percentage of material passing each sieve to nearest whole number.

15. **Indirect Tensile Test – AASHTO T 322-03**
    Scope: This standard provides procedures for determining the creep properties of hot-mix asphalt at various loading times, tensile strength and Poisson’s ratio using the indirect tensile test.

3 SAMPLE PREPARATION AND TESTING

The test methods selected here focus on the aggregate, cured binder, and finally cured elastomeric concrete (EC). The ten methods which were followed during Phase I of the project on the products are listed as follows:

1. Sieve Analysis (Aggregate)
2. Tensile Properties of Plastics (Binder)
3. Tear Strength of Conventional Vulcanized Rubber and Thermoplastic (Binder)
4. Compressive Properties of Rigid Plastics (EC)
5. Splitting Tensile Strength (EC)
6. Rubber Property – Durometer Hardness (EC)
7. Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear (EC)
8. Impact Resistance (EC)
9. Water Absorption of Plastics (EC)
10. Shrinkage (EC)

One of the most difficult tasks in fabricating the specimens was finding a way to release the specimen from the mold without damaging the specimen, especially the binder samples. A release gel made by Dow Corning was used on the molds in order for the specimens to be removed from the molds without causing any damage to the specimens. In order for the materials to be tested according to the governing specifications, various molds and die cutters had to be fabricated and/or purchased. Once the (binder and EC) specimens had cured for a minimum of seven days, testing would take place. The following sections provide a detailed description of the sample preparation and test procedures followed.

3.1 Product Mixing And Specimen Fabrication

Great effort was made to ensure that all of the products were mixed following the manufacturers' instructions and under the most optimum laboratory conditions. New mixing buckets and containers were used for each batch, and the mixing drills and molds were thoroughly cleaned after each use. In order to be more efficient, and to allow remixing a batch if necessary, the batches were mixed in smaller batches using the proper weight ratios obtained from each manufacturer.

The preparation of all of the products followed the same general steps:

1. Open binder containers and slowly stir containers separately for approximately 20-30 seconds to offset any settling which may have taken place in the container during storage/shipment
2. Weigh out the exact amount needed from parts A, B and C (as applicable)
3. Binder Only:
    a. Mix binder parts together for a specified time in a clean container
    b. Pour mixed binder into mold and let the specimens sit for 24 hrs
4. Binder and Aggregate:
    a. Mix binder parts together for specified time in a clean 5 gallon bucket (20-30 sec)
    b. Slowly pour in aggregate while continuously mixing for the specified amount of time and until a uniform mix is reached (2-3 min)
    c. Place mixed elastomeric concrete in molds and let the specimens sit for 24 hrs

5. Remove samples from molds, and allow a curing time of a minimum of 7 days before testing

Figure 3-1 shows the binder being mixed first with a small power drill. Figure 3-2 shows the aggregate being slowly poured into the binder while mixing with a larger power drill ensuring a much more consistent mix.

Figure 3-1. Binder mixing

Figure 3-2. Aggregate being added to binder

3.2 Sieve Analysis

It is well known that cured concrete can have very different characteristics and mechanical properties depending the type, size and gradation of the aggregate used. It was obvious that all of the products which were to be tested had different sizes and types of aggregate used to form the elastomeric concrete. The research team decided that by performing a sieve analysis, some insight could be gained as to the advantages and disadvantages of using different aggregate types to form the elastomeric concrete, as well as its effect on test specimen aspect ratio and results.

The test method used conformed to that of ASTM C 136-96a. The sieve sizes used were: 200, 100, 50, 40, 16, 8 and 4. A representative sample was taken for each product and placed in an oven at approximately 230° F for a 24 hour period in order to ensure a constant mass. The sample was then weighed and placed on the sieve stack and put in a mechanical sieve shaker. Each sample was in the shaker for approximately ten minutes. The samples were then removed and the percentage retained on each sieve was calculated by subtracting the percentage which passed a certain sieve from 100 percent - from this, the Fineness Modulus was found for each product.

3.3 Tensile Properties of Plastics

The tensile strength of binder is considered to be a property which can determine the overall usefulness of the product. In addition, tensile strength has been found to be in almost all of the DOT's requirements and in most of the manufacturers' material data sheet. Even though elastomeric concrete will not experience pure tensile stresses when used as a bridge joint header, the tensile strength of the binder is a great indication of the chemical bond capacity of the binder.

After careful consideration, specimen type III for non-rigid plastics from ASTM D 638–03 was used for testing. This type was chosen because the specimens were considered to be non-rigid and the ideal thickness of the specimens fell between the range of 0.28" and 0.55". In addition, most of the manufacturers and contacted DOTs were using this same specimen type.

For these tensile specimens (as well as for the tear specimens), a 12"x12"x3/8" mold was fabricated using a thick plexiglass and perimeter steel bars attached to a flat piece of plywood (see Figure 3-3). The specimens were created by pouring freshly mixed binder into the mold prepared with form release agent. Once the binder had set for a day, the material was removed from the mold, resulting in a 3/8" thick sheet. A steel die conforming to the dimensions of specimen type III was purchased and used to cut five or six tensile (and later tear) specimens for each product. Once the specimens had been cured, they were each measured using a digital caliper with an accuracy of 0.0005" at three different locations.

The procedure used for testing the tensile property of the elastomeric concrete binder followed the procedure outlined in ASTM D 638 – 03. The speed of testing used was 2 in/min. Pads made out of the leftover binder sheet were used to line the grips in the machine to keep the gripping mechanism from pinching the actual specimen and causing premature failure within the gripping zone. The tensile strength was then calculated by taking the maximum load and dividing it by the smallest recorded cross-sectional area. In addition, the elongation percentage was calculated by taking the gauge length recorded at rupture and dividing it by the original gauge length and multiplied by 100.

Figure 3-3. Mold used to prepare the binder (tensile and tear) specimens

3.4 Tear Strength of Conventional Vulcanized Rubber and Thermoplastic

Similarly to the tensile test, the tear strength of a product is considered to relate to the overall strength of the material as it also suggests the quality of the chemical bond in the binder of the elastomeric concrete. Due to the repetitive nature of the dynamic loading from vehicles traveling across the bridge, a tear could possibly be produced in the material – and it is believed that a poor tear resistance of the binder should be an indicator of the EC's future performance.

The procedure used for testing followed the procedure found in ASTM D 624 – 00E1. Specimen type C was used for fabrication of the specimens. Again, this proved to be the obvious type due to the fact that most manufacturers and DOTs which were evaluating tear strength were using this specimen type. The specimens were created following the same procedure as the tensile strength specimens, but using a type C die. Only five specimens are required, but whenever possible, extra samples were created in case a retest was necessary. Specimen dimensions were then recorded, and tested in the same MTS apparatus as the tensile tests. Once testing was completed, the tear strength for each product was calculated, and the results tabulated.

3.5 Compressive Strength

Three different specimen types were used for testing the compressive strength of EC. The first two types are governed by ASTM 695 – 02a, which covers the determination of the mechanical properties of unreinforced and reinforced rigid plastics when loaded in compression at relatively low uniform rates of straining or loading. As some of the EC materials utilized coarser aggregates, it was decided to consider a third sample type as well, the 2" cube, used to evaluate the compression strength of mortar.

- 0.5"(width) x 0.5"(thickness) x1" (length) prisms
- 0.5" (diameter) x 1" (length) cylinders
- 2" cubes; Figure 3-4 shows elastomeric concrete cast in the cube molds.

Figure 3-4. Compression specimens cast in 2” cube molds

All specimens were cured for a minimum of seven days at room temperature prior to testing. The following steps were taken during compressive testing procedure:

1. Specimens would then be placed in testing apparatus, carefully centered to avoid eccentricity, and loading would begin at a rate of 0.05” per minute.
2. At 5% deflection, the specimens were unloaded and three height measurements were taken to the nearest .001 in. The 5% deflection heights were compared to the original heights to provide a measure of the resilience of each specimen. 5% deflection loads were also recorded to determine the 5% deflection compressive strength.
3. Specimens would then be placed back in the loading apparatus and the loading process would resume.
4. Loading would occur until peak load values saw drops of approximately 30 %.

As the ASTM states, many plastic materials will continue to deform in compression until a flat disc is formed, without any well-defined fracturing. In this case, compressive strength can have no real meaning. This is much the case of elastomeric concrete because a specimen can be flattened until aggregate to aggregate interaction is the source of the compressive strength, rather than the composite material itself. For this reason, the 30% peak drop off value was used throughout compression testing.

3.6 Splitting Tensile Strength

Tensile strength of concrete is typically measured indirectly by a splitting tensile test or a flexural test. For this particular research, tensile strength was determined through the use of the splitting tensile test, followed in accordance with ASTM D 3967 – 05. The permissible thickness/diameter aspect ratio is between 0.2 and 0.75. As this method was developed primarily for Portland-cement concrete, and first used by JZC for elastomeric concrete, the influence of thickness/diameter ratio was unknown. Therefore, without trying to establish a complete correlation throughout the entire range, two different specimen types were tested for all the available EC materials: one with a 1.5”/2.5” ratio, and the other with a 1.5”/3.0” ratio, respectively. All specimens were cast within a 2.5” or 3” inside diameter PVC pipe, then saw-cut to the proper thickness with a radial arm saw using a (dry) diamond blade.

Finally, the specimens were placed between the bearing strips so that the load was applied along its diameter as shown in Figure 3-5. These bearing strips ensured that tensile failure occurs rather than compressive failure because the areas of load application are in a state of triaxial compression. Therefore, the bearing strips allow the specimens to withstand much higher compressive stresses than would be indicated by a uniaxial compressive strength test result. A load rate of 2" per minute was used in the testing process. At failure, the maximum load was recorded.

Figure 3-5. Splitting tensile strength specimen in loading apparatus

3.7 Durometer Hardness

Indentation hardness of elastomeric concrete was tested by a Type D Durometer in accordance with ASTM D 2240 – 03. The Type D Durometer, as stated in the ASTM, is commonly used for hard rubber, thermoplastic elastomers, harder plastics, and rigid thermoplastics. This test method is commonly used by DOTs as a quality check to test the hardness of the binder alone. The Durometer used is shown in Figure 3-6.

Figure 3-6. Durometer used for hardness testing

To begin the test, the indentor guard is removed so that the measurement tip is left exposed. The instrument was then placed between the thumb and middle finger with the index finger resting on the mounting knob. With the instrument and specimen in place, the Durometer is pushed down with a steady, even pressure for one full second, at which point the reading is recorded. This step is repeated four more times at different locations, and all five recordings are averaged. It was noted within the ASTM that any readings below 20 or above 90 are not considered reliable and should be discarded; however, readings outside of this range did not take place over the course of these experiments.

3.8 Slant Shear Bond Strength

The bond strength of elastomeric concrete to conventional concrete was tested is accordance with ASTM C 882 – 99. First, the base concrete material was prepared using a high strength mix of over 7000 psi. By doing this, the research team was able to ensure that the failure would occur in the elastomeric concrete, or at the interface between the elastomeric concrete and the Portland cement concrete. 3" x 6" cylinders were then filled approximately half full of fresh mixed concrete. The concrete specimens were then immediately set at a position so that the concrete cured as a half cylinder at an angle of 30 degrees from the vertical. The concrete half cylinders cured for a minimum of twenty-eight days in a curing chamber. Once the specimens were removed from the curing chamber, they were set out at room temperature for seven days so that any surface moisture could dry. Although some states test the wet bond application, this practice was not followed in this research as virtually all manufacturers require a dry concrete surface prior to EC placement.

After the concrete half cylinders were completely cured and dry, the diagonal surface was sandblasted to remove any loose particles from the concrete surface. Each surface was also grinded to remove any course aggregate protruding through the bonding surface (unintentionally aiding the slant shear resistance of the concrete-EC interface). The next phase of the specimen preparation consisted of applying the elastomeric primer (supplied with the elastomeric concrete) to the surface of the concrete half cylinders, prior to mixing the elastomeric concrete. The half cylinder would then be placed back in a 3" x 6" cylinder and the freshly mixed elastomeric concrete would be placed in the remainder of the cylinder. Figure 3-7 shows the finished slant shear specimen.

Figure 3-7. Slant shear specimen

The slant shear test would consist of the specimen being placed in compression apparatus, and loaded until shearing occurred along the bonding surface. The bond strength was calculated by dividing the ultimate load carried at failure by the area of the bonded surface, i.e. 14.13 in^2.

3.9 Impact Resistance

In order to determine the impact resistance of the cured EC, the ball drop test was performed, as described in ASTM D 5420-04. The testing apparatus consisted of a vertically suspended PVC pipe 2" in diameter, with holes cut for a ball stop at 6" increments as seen in Figure 3-8.

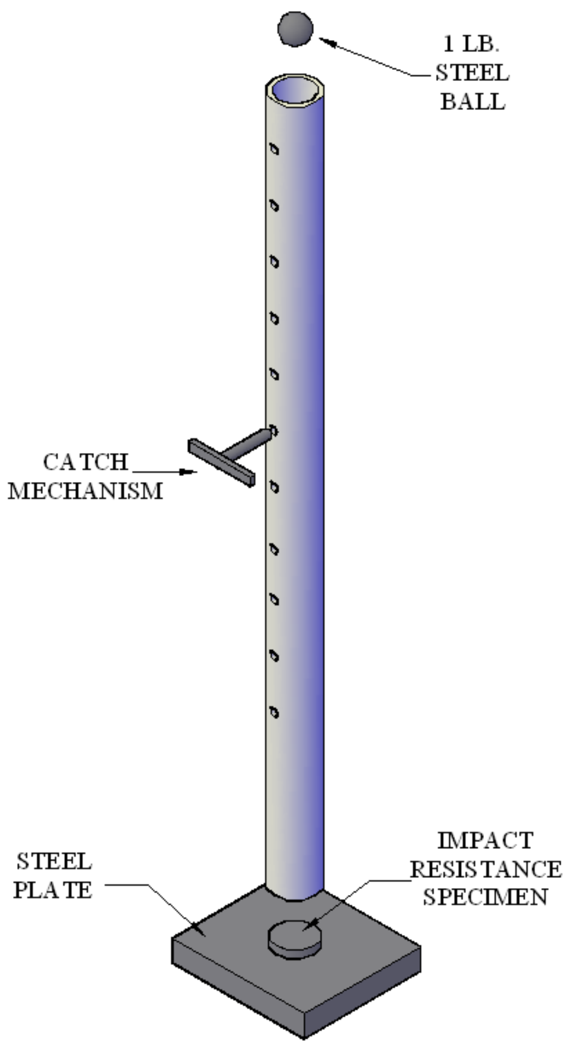

Figure 3-8. Impact resistance apparatus

All impact resistance specimens were first cast within a 2.5" diameter PVC pipe, and subsequently saw-cut into discs having a thickness of 0.375". Two different specimen sets were used, consisting of conditioned and unconditioned specimens. Conditioned specimens were placed in an ice bath at a temperature of 32 ^{0}F for 24 hours prior to testing. Unconditioned specimens were stored under room temperature until testing.

During testing, the elastomeric concrete discs were placed on a steel plate underneath the vertically suspended pipe, then a 1 lb steel ball (no more than 2 inches in diameter) was dropped from the ball stop (catch mechanism) starting at 5', moving up in 6" increments up to 10' until cracking occurred. As soon as the specimens first experience cracking the test stopped, and the maximum height recorded as the impact resistance.

3.10 Water Absorption of Plastics

Although water absorption may seem to be a minor property of a material when compared to compressive or tensile strength, the resistance to water absorption of an elastomeric concrete product can be vital to its performance as a bridge joint header. Since the material will be continuously exposed to the weather, the research team felt that this could be a very important property to check. If a product were to absorb enough water, failure of the bridge joint header could occur due to freeze/thaw cycles, which are prominent in the western parts of the state of North Carolina.

The EC specimens were created by placing a freshly mixed elastomeric concrete batch into a PVC pipe which was lined with the previously mentioned Dow Corning release agent. The PVC pipe was approximately 12" long and had an inside diameter of 2". Once the mix had cured for seven days, the pipe was cut into 1/8" thick disks. Instead of using three specimens, as the ASTM states, six specimens were used for each product to ensure that a reliable test result was obtained.

The testing method followed the procedure described in ASTM D 570 – 98. The specimens were placed in an oven with a temperature of 122 °F for a 24 hour period. Once the specimens were removed from the oven, they were immediately weight to the nearest .001 gram. The specimens were then fully immersed in distilled water, taking precautions to ensure that each specimen was resting on its edge and not touching any other specimen. The immersed specimens were kept at room temperature, approximately 73 °F for a 24 hour period. The specimens were then removed from the water, surface dried with a dry cloth and immediately weighed to the nearest .001 gram. The percentage of water absorption was found by dividing the difference in weight by the original weight and multiplying it by 100.

3.11 Shrinkage

It is common to observe movement in non-homogeneous mixtures by either expansion or contraction produced from causes other than outside forces and temperature. Typical concrete with Portland cement experiences shrinkage as it cures and the moisture is hydrated or evaporated from the material. Clay masonry however, expands as moisture is absorbed into the kiln-dried bricks. This can become a serious issue in building materials. If there is excessive expansion or contraction in a building material, cracks and spalling could occur leading to water damage and armor corrosion, or possibly structural failure through delamination or spalling.

As there are no specific shrinkage test methods for EC, the procedure used here was adapted from ASTM

C 157/C 157M-06 developed for concrete. Immediately after the elastomeric concrete was mixed, it was placed in manufactured molds specific to this test. The molds were lined with Dow Corning release gel to aid in the de-molding of the specimens (see Figure 3-9). Once the specimens had set for a 24 hour period, they were de-molded and placed in an environment chamber with a temperature of 73°F and the relative humidity set to 50%. The specimens were allowed to cure for a total of seven days. After the specimens had cured for seven days, they were measured using a digital length comparator. The length was measured and recorded approximately every week for several months.

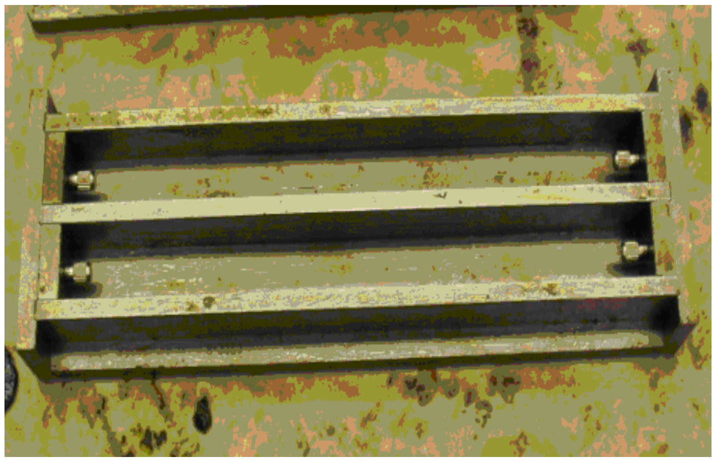

Figure 3-9. Shrinkage molds

3.12 Testing Equipment

It is important to note that throughout the testing process, all tests were performed consistently on the same equipment. All compressive, bond, tensile and tear strength tests were performed with a MTS testing system (as seen in Figure 3-10), while the tensile-splitting tests were performed using a Universal Testing Machine (UTM).

Both of these equipment were fully calibrated, and had force or displacement controlled loading capabilities. Force and deformation was recorded by the built-in data acquisition system, which later was retrieved and imported into MS Excel for further analysis.

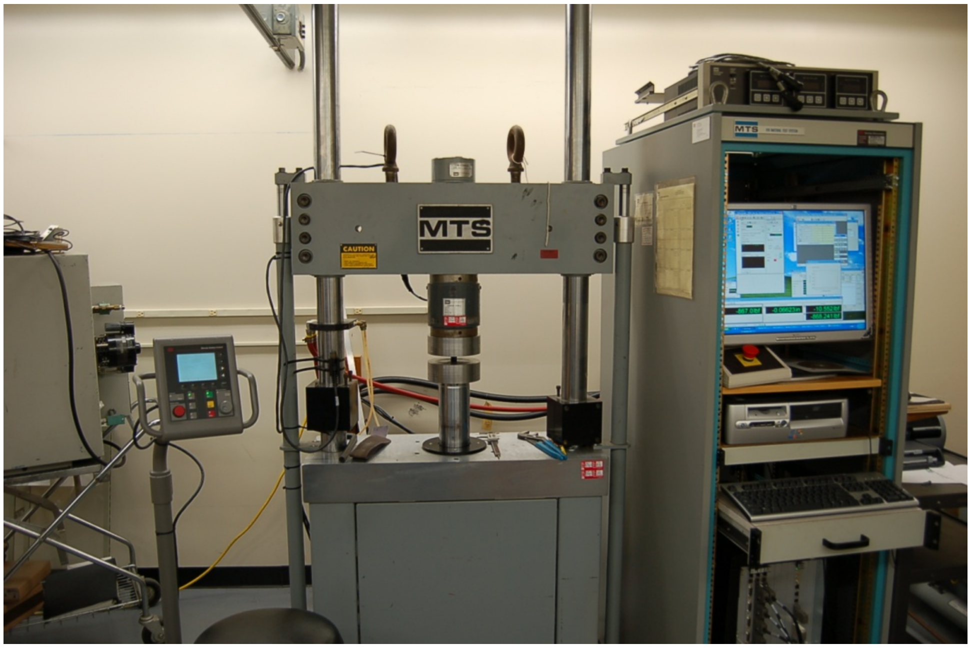

Figure 3-10. MTS system with an EC compression specimen being tested

4 LABORATORY-MIXED EC TEST RESULTS AND ANALYSIS

In this chapter, first the test results are presented by method (the same data is also summarized by each material type, see Appendix D), followed by data analysis, and finally, initial recommendations for a elastomeric concrete quality control and assurance program.

4.1 Aggregate Sieve Analysis

From the sieve analysis, information about the particle distribution and average particle size of each product was obtained. The particle distribution for each product was found by plotting the percent passing versus the sieve diameter. While most of the products' aggregate had a poor gradation, some products were better graded, for example Wabocrete 2 and ProCrete NH. While the products varied somewhat in their particle size distribution, most of them had the same average particle size of about 0.4mm. E-Crete 57 and Delcrete had an average particle size of 0.3 mm, which was significantly smaller than the rest of the products. The fineness modulus of ProCrete NH and TronFlex were the two largest with 5.34 and 5.01 respectively.

4.2 Binder Tensile Strength

Table 4-1 shows the binder tensile strength results, as well as the ultimate elongation in percentage. The last 2 columns in the table show the binder tensile properties reported by each manufacturer. It is important to note that for 7 out 11 materials the published tensile capacity values are higher than the lab results, a trend that is not only evident from the ultimate elongation values as well, but from most of the test methods performed in this project and presented in this chapter. However, even these lower-than-published values are clearly larger than the performance of a Portland cement paste, proving that a polymer-based material is more suitable as a bridge joint header primarily due to its tensile properties.

Table 4-1. Binder tensile strength results

	Lab Mix		Man.'s Data	
Product	psi	%	psi	%
Ply-Krete	521	122	900	175
Ply-Krete HT	991	113	775	160
Ply-Krete HS	1167	45	1750	150
Ply-Krete LV	1777	61	2200	60
E-Crete 57	376	46	775	160
Ceva Crete	1028	63	950	150 min
WaboCrete II	2128	248	1000	200 min
ProCrete NH	1556	57	2250	60 min
ProCrete Plus	1208	127	1700	150 min
DelCrete	967	82	600	200 min
Tron-Flex	224	190	1500	250 min
Lab Average =	1086	105		

4.3 Binder Tear Strength

Table 4-2 shows the tear strengths for each binder. As it can be seen from this table, unlike the tensile results, each of the lab mix values are higher that the published data, when those are available. Although the tear strength results apparently have no correlation to their tensile capacities, the values could be important qualitatively, indicating that a brittle material is likely to be more susceptible to premature failure due to cracking and spalling.

Table 4-2. Binder tear strength results

	Lab Mix	Man.'s Data
Product	pli	pli
Ply-Krete	375	150
Ply-Krete HT	447	--
Ply-Krete HS	415	165
Ply-Krete LV	484	200
E-Crete 57	379	--
Ceva Crete	564	--
WaboCrete II	582	100
ProCrete NH	566	200
Procrete Plus	641	165
DelCrete	456	100
Tron-Flex	152	--
Lab Average =	460	

4.4 EC Compressive Strength and Resilience

As stated earlier, three different specimen types were used to test the products in compression: 2” cubes, 1” x 0.5”x 0.5” prisms, and 1”x0.5” cylinders. Table 4-3 shows the laboratory tested compression strengths for each product (for the three specimen types) with their corresponding manufacturer’s published data. Judging from the test results, there is not one specimen type that is definitively better than the others, and no clear trend can be observed. However, the average values across all products are comparable. By comparing the ultimate compression results alone, six of the eleven products tested at a higher compressive strength with the cubes, four products tested higher with the cylinders, and only one product tested higher with the prisms. On the same note, similarly to the tensile test results, very few (actually one single) values confirm published results, where those are available.

In addition to the ultimate compressive strength, the standard deviation was also computed for all of the test results for a particular product. A high standard deviation implies that the results are widely dispersed, while a low standard deviation shows that the results are tightly grouped around the mean. By comparing the two specimen types which gave the highest compressive results (cube and cylinder types), 8 of the 11 products had a lower standard deviation with the cube type than the cylinder type. This shows that by using the cube specimen type to test compressive strength, more precise and consistent results can be obtained.

Since the prism specimen type only had one product which showed a higher compressive strength, it is obviously not the ideal specimen type to use for this test. Considering that the cube not only produced a higher compressive strength on the average, but also had a lower standard deviation overall, it is clear that the 2" cube specimen type is the most consistent type to use for this testing procedure. In addition, it is also the most practical type to fabricate, as the cube molds are already in use for testing mortars. On the other hand, the prism and cylinder types recommended by ASTM D 695 were developed for rigid plastics, without the presence of reinforcement or aggregate.

Table 4-3. EC compressive strength results

	Lab Mix (psi)				Manufacturer's Data	
Product	cube	prism	cylinder	*cube	psi	*psi
Ply-Krete	1166	1321	1469	641	2800	--
Ply-Krete HT	2335	2059	3205	2335	3000	--
Ply-Krete HS	3239	2966	2867	1884	4600	3500
Ply-Krete LV	2745	3314	3543	2146	4000	--
E-Crete 57	1771	1286	1756	996	3000	--
Ceva Crete	2792	2584	2366	1809	4000	--
WaboCrete II	1468	1551	1945	512	2200	1200
ProCrete NH	3210	2063	2332	3059	4200	--
Procrete Plus	3060	2210	2189	1121	4350	3000
DelCrete	1839	1355	1390	598	--	800
Tron-Flex	830	922	784	564	--	--
Lab Average =	2223	1966	2168	1424		
* indicates stress at 5% deflection						

In addition to determining the ultimate compressive strength of each product, a 5% deflection compressive strength was established for each product as well (see Table 4-3). That is to say, each specimen was loaded until it was at 95% of its original height. As stated earlier, with materials such as elastomeric concrete tested in compression, a true ultimate compressive strength is hard to obtain due to the fact that for many products there is not an obvious failure in the specimen.

The cause for this type of behavior was due to the ductile nature of the material tested. Because elastomeric concrete is a combination of a polymeric (epoxy or polyurethane) binder mixed with aggregate, the majority of the compressive strength is provided by the aggregate. By using a set deflection, such as 5%, as a control point, the testing results can become more consistent and comparable. A 5% deflection compressive strength would allow for elastomeric products of different material properties to be equally evaluated, and in some cases, the 5% deflection compressive strength was the ultimate strength of the material.

Another benefit of testing the 5% compression strength is that by doing so, none of the specimens reached failure, allowing for the resilience to be evaluated. Because of the nature of the material and the application for which it will be used, the resilience ability was believed, early in the project, to be a key factor in determining which product would be more appropriate for use. However, as shown in Table 4-4, all of the products had a resiliency of 96% or more. Therefore, after extensive testing, due to the high values for all the products, the results are inconclusive, and resiliency was no longer considered to be a controlling factor in determining the suitability of a product for use as a bridge joint header.

Table 4-4. EC resilience results

Product	Lab Mix %	Man.'s Data %
Ply-Krete	98.2	--
Ply-Krete HT	99.0	90
Ply-Krete HS	96.8	--
Ply-Krete LV	97.2	--
E-Crete 57	99.6	90
Ceva Crete	96.7	--
WaboCrete II	99.9	--
ProCrete NH	97.4	--
Procrete Plus	98.4	--
DelCrete	98.9	95
Tron-Flex	99.8	--
Lab Average =	98.4	

4.5 EC Split Cylinder Tensile Strength and Comparison

Throughout this project the research team tried to understand whether elastomeric concrete is (and should behave as) more like concrete, or as a reinforced polymer. This challenge is also evident from the lack of a clear industry standard for evaluating elastomeric concrete – clearly shown from the master table provided in Appendix C: no less than 45 different test methods, or variations of the same method, are being used to report elastomeric concrete material properties. As no tensile tests have been reported for cured EC (except for the JZC report in 2007), based on experience with traditional concrete, it was decided that the split cylinder tensile test would be useful.

Table 4-5 shows the results of the split cylinder tensile tests with an average strength of 566 psi (a value that could be higher if one ignores the first and the last two values). It is evident from this table that higher binder tensile strength yield higher split tensile strength – a trend that is also true when considering the compressive strength of the EC. A common method in estimating the tensile strength of concrete is by using the square root of the compressive strength multiplied by a factor of 6.4. In concrete this estimate has a large scatter, primarily due to variations in aggregate, composition of cement paste, test method, etc…

In order to establish a similar relationship, Table 4-5 also includes the above-mentioned factor for all three compression test specimen type. Interestingly, all three specimen types yielded an average factor of about 12, with a coefficient of variation around 25%, a result that is better than the test method individually, suggesting a decent correlation between compressive and split tensile strength. The factor 12 is significantly higher than the 6.4 used in concrete, which is primarily due to the very high tensile strength and ultimate elongation of the polymeric binder. Although this relationship can be further refined by using a larger pool of test results, it is clear that this factor could be used as a starting point for elastomeric concrete materials. Furthermore, when more (performance based) design guidelines will be developed for elastomeric concrete, this table can be used to select a more suitable bridge joint header in function of estimated tensile stresses.

Table 4-5. EC split tensile test results and comparisons

Product	EC Split Tensile	EC Compression			Binder Tensile			
	psi	cube	prism	cylinder	psi	cube	prism	cylinder
Ply-Krete	340	1166	1321	1469	521	9.9	9.3	8.9
Ply-Krete HT	626	2335	2059	3206	991	13.0	13.8	11.1
Ply-Krete HS	702	3239	2966	2867	1167	12.3	12.9	13.1
Ply-Krete LV	876	2745	3314	3543	1777	16.7	15.2	14.7
E-Crete 57	589	1771	1286	1756	376	14.0	16.4	14.1
Ceva Crete	615	2792	2584	2366	1028	11.6	12.1	12.6
WaboCrete II	581	1468	1551	1945	2128	15.2	14.8	13.2
ProCrete NH	804	3210	2063	2332	1556	14.2	17.7	16.6
Procrete Plus	528	3060	2210	2189	1208	9.6	11.2	11.3
DelCrete	310	1839	1355	1390	967	7.2	8.4	8.3
Tron-Flex	258	830	922	784	224	9.0	8.5	9.2
Lab Avg. (psi)	566	2223	1966	2168	1086	12.1	12.8	12.1
Std. Dev. (psi)	198	854	761	822	583	2.9	3.2	2.6
COV (%)	35	38	39	38	54	24	25	22

4.6 Hardness

The hardness test results can be seen in Table 4-6. As stated in ASTM D 2240-05, this method is an empirical test, with no simple relationship to other basic material properties. Therefore, these test results should only be used as a quick and simple evaluation to ensure that a given batch of elastomeric concrete has been adequately cured – this would require further tests to establish a "soft" relationship between curing rate and hardness. The hardness test could be a test performed in the field to ensure that the elastomeric concrete has reached a state of hardness which would allow for the movement of traffic over the expansion joint without damaging the bridge headers.

Table 4-6. EC hardness test results

Product	Lab Mix	Man.'s Data
	--	--
Ply-Krete	61.6	45
Ply-Krete HT	60	59
Ply-Krete HS	61	45
Ply-Krete LV	63	45
E-Crete 57	62	59
Ceva Crete	53	--
WaboCrete II	61	40
ProCrete NH	54	50
Procrete Plus	48	40
DelCrete	45	50
Tron-Flex	52	85
Lab Average =	57	

4.7 Bond Strength

Since bond failure is one of the main causes for elastomeric concrete to fail as a bridge header, the bond test was highly anticipated as a determining factor for the effectiveness of different products as bridge joint headers. All of the specimens had proper failure mode, which occurred at the interface between the Portland cement concrete and the elastomeric concrete. In addition, all of the individual product test results were fairly consistent within the test set, and were also higher than all the published results by the manufacturers. However, one should note that most manufactures did not list a test method for their product's bond strength, and depending on whether a dry or a wet bond test was performed, the results might not be directly comparable. Table 4-7 shows all the results for the bond strength testing. To fully understand the importance of bond versus splitting tensile strength, and the possible failure modes, one should also consider the stress field in a header, and investigate the effects of vertical (truck) and horizontal (thermal and truck breaking) loads on the bridge joint header – perhaps through finite element analysis, a task that was outside of this project's scope.

Table 4-7 EC bond strength

Product	Lab Mix psi	Man.'s Data psi
Ply-Krete	604	500
Ply-Krete HT	877	250
Ply-Krete HS	1244	500
Ply-Krete LV	1254	500
E-Crete 57	263	250
Ceva Crete	621	500
WaboCrete II	648	--
ProCrete NH	1140	500
ProCrete Plus	668	550
DelCrete	414	400 (pli)*
Tron-Flex	256	--
Lab Average =	726	
* indicates a modified procedure was used		

4.8 Impact Resistance and Temperature

This test was mainly designed to test the brittleness of a material. Almost all of the products either met or exceeded their related manufacturer's data when they were tested at room temperature (70 °F). In order to distinguish the different products, the research team decided to test the specimens at freezing temperature (32 °F), since western North Carolina experiences these temperatures during the colder seasons. As it can be seen in Table 4-8, the temperature did have a significant effect on some of the products, while others were unaffected. This information could be important when specifying elastomeric concrete in the western part of the state. However, before a stronger correlation can be made between material temperature and behavior, more significant exposure and durability tests are recommended.

Table 4-8. Impact resistance of EC

Product	Lab Mix ft-lb (32°)	Lab Mix ft-lb (70°)	Man.'s Data ft-lb
Ply-Krete	6.7	10	--
Ply-Krete HT	8.7	10	--
Ply-Krete HS	8.2	9	10
Ply-Krete LV	5.0	6	--
E-Crete 57	8.9	10	--
Ceva Crete	7.9	10	7 +
WaboCrete II	9.4	10	7+
ProCrete NH	5.2	7	10+
Procrete Plus	5.6	9	7+
DelCrete	10.0	10	10+
Tron-Flex	9.5	10	--
Lab Average =	8	9	

4.9 Water Absorption

While the water absorption test results were comparable with the existing published data, they were somewhat inconclusive due to the fact that almost all of the results were less than one percent. Because the percentages were so low, the water absorption for all of the products tested was considered to be negligible, which was somewhat expected considering that the binder is a polymer. Table 4-9 shows the results of the water absorption testing.

Table 4-9. Water absorption results

Product	Lab Mix %	Man.'s Data %
Ply-Krete	0.13	--
Ply-Krete HT	0.28	< 1
Ply-Krete HS	0.70	--
Ply-Krete LV	0.27	--
E-Crete 57	0.00	< 1
Ceva Crete	1.14	--
WaboCrete II	0.41	--
ProCrete NH	1.74	--
Procrete Plus	0.43	--
DelCrete	0.55	--
Tron-Flex	0.26	--
Lab Average =	0.54	

4.10 Shrinkage

The shrinkage test results were so low (less than ½ % in 2 months, after which the tests were stopped) that they are considered negligible.

4.11 Moisture Resistance

All moisture-induced damage specimens were conditioned in accordance with AASHTO T 283-03, entitled, “Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage.” To begin the process, specimens were first divided into three subsets. The first subset consisted of dry specimens that were not conditioned in any way to serve as the control for not only the moisture induced damage testing, but also the remainder of the durability testing. The remaining two subsets were comprised of specimens that were subjected to vacuum saturation within water, as well as vacuum saturation within a 3% sodium chloride water solution. Sodium chloride was selected to serve as a characteristic deicing agent. Both subsets of specimens were placed in a vacuum saturation chamber containing a minimum of 1” water or sodium chloride solution above their top surface. A vacuum of absolute pressure (22 Hg partial pressure) was then applied for 10 minutes.

Afterward, the vacuum was removed while specimens were left submerged for 10 more minutes. Next, each specimen was placed inside a leak-proof plastic film. The wrapped specimen was then placed in a sealed plastic bag containing 10 +/- 0.5 mL of water. Afterward, the bagged specimen was placed in a freezer at a temperature of 0 +/- 5 ˚F for 16 hours. Specimens were then placed in a hot bath containing water at 140 +/- 5 ˚F for 24 hours with at least 1” water above their surface. Finally, the plastic bag and film were removed from each specimen, and each was placed in a water bath at 77 ˚F for 2 hours +/- 10 minutes. Specimens were subsequently removed and tested.

After careful review of the results (shown in Table 4-10), it appears that moisture can have a considerable effect on the performance of elastomeric concrete. When compared to their baseline counterparts, the H20 and sodium chloride specimens both see significant decreases in strength, although sodium chloride doesn’t seem to play a major role in the degradation process. Ply-Krete and Pro-Crete Plus seem to be the most susceptible to damage, and again it is important to note that both products are typically heated. For the most part, E-Crete #57 seemed to show the greatest resistance to conditioning throughout the moisture-induced damage testing phase.

Table 4-10. Moisture induced damage

Ply-Krete						
Conditioning	Variable	Compressive Strength (psi)	Tensile Splitting Strength (psi)	Tensile Splitting Strength H20/Dry Ratio	Impact Resistance (ft-lbs)	Hardness
MID	Dry	2273	565	66.02%	7.33	56
MID	H_20	1576	373		6.5	42
MID	Cl	1665	504	-	6.67	40

Pro-Crete NH						
Conditioning	Variable	Compressive Strength (psi)	Tensile Splitting Strength (psi)	Tensile Splitting Strength H20/Dry Ratio	Impact Resistance (ft-lbs)	Hardness
MID	Dry	3125	1191	94.04%	5.5	54
MID	H_20	2953	1120		5.5	41
MID	Cl	2584	1188	-	5.5	41

Pro-Crete Plus						
Conditioning	Variable	Compressive Strength (psi)	Tensile Splitting Strength (psi)	Tensile Splitting Strength H20/Dry Ratio	Impact Resistance (ft-lbs)	Hardness
MID	Dry	2209	625	62.72%	5.5	53
MID	H_20	1180	392		5.5	41
MID	Cl	1096	401	-	5.5	45

E-Crete #57						
Conditioning	Variable	Compressive Strength (psi)	Tensile Splitting Strength (psi)	Tensile Splitting Strength H20/Dry Ratio	Impact Resistance (ft-lbs)	Hardness
MID	Dry	2439	836	93.42%	8.33	58
MID	H_20	2333	781		9.5	40
MID	Cl	2518	772	-	9.17	41

4.12 Laboratory Mix Results Overview

4.12.1 Epoxy versus Polyurethane Binder

As previously stated, the binder for all of the products considered in this project fell into two main chemical types. Four of the products were polyurethane based and seven of them were epoxy based. Table 4-11 shows the chemical base for each products binder. In general, the epoxy-based products seemed to have a higher compressive and tensile strength, while the polyurethane-based products had a higher impact resistance. Additionally, the polyurethane based products had a higher overall ultimate elongation percentage. From this observation it seems that the polyurethane products may be somewhat more ductile while the epoxy based products are more brittle and have more compressive and tensile strength.

Table 4-11. Binder chemical base

Epoxy	Polyurethane
Ceva Crete	DelCrete
Ply-Crete	E-Crete #57
Ply-Crete HS	Wabo-Crete II
Ply-Crete HV	Tron-Flex
Ply-Crete LT	
Pro-Crete NH	
Pro-Crete Plus	

4.12.2 Comparison with Published Data

Since there has been no a set of national acceptance criteria for the use and maintenance of elastomeric concrete used in bridge joint headers, a set of control data must be established in order to progress towards developing a practical yet conservative quality control and assurance program. The scope of this project was specifically to develop such a program for the NCDOT. During the first phase of this project there were over 600 tests performed on 11 available elastomeric concrete products. While some of the test results were close to what was published by the manufacturers, other data proved to be significantly lower than expected. Compressive and tensile strengths were the two main material properties which were consistently lower than that of the manufacturers' published data. This particular trend has also been noted in other published studies as well, e.g. the PennDOT project by Jeff Zell Consultants, Inc. (2007).

There could be several reasons for this inconsistency. Some could be due to different test methods being used, different environmental conditioning during testing, human error or excessive pot life.

4.12.3 Comparison with NCDOT Specifications

One of the main goals of this project was to evaluate the current NCDOT requirements for elastomeric concrete and determine what changes would need to be made to produce an effective quality control program. The current NCDOT elastomeric concrete minimum requirements can be seen in Table 1-2. A table showing the laboratory tested products' results versus the NCDOT requirements can be seen in Table 4-12. If a product met the minimum requirement for a specific material property, a "√" was placed in the corresponding space

As it can be seen from this table not a single product satisfies all six requirements. Only two products satisfied the elongation requirement, while only four products satisfied the compression requirement. In addition, the tear strength requirement was met by all products. These results seem to suggest that elongation and compression requirements may be too conservative, while the tear requirement may not be conservative enough.

Table 4-12. Lab mixed material compliance with current NCDOT specifications

Product	Test Method					
	Binder Tensile	Binder Ult. Elongation	Binder Tear	EC Compression	EC Bond	EC Impact
Ply-Krete			√		√	√
Ply-Krete HT	√		√		√	√
Ply-Krete HS	√		√	√	√	√
Ply-Krete LV	√		√	√	√	
E-Crete 57			√			√
Ceva Crete	√		√		√	√
WaboCrete II	√	√	√		√	√
ProCrete NH	√		√	√	√	√
ProCrete Plus	√		√	√	√	√
DelCrete	√		√			√
Tron-Flex		√	√			√

4.12.4 Material Specifications

As previously mentioned, the current NCDOT requirements for elastomeric concrete may be too conservative in some areas. This is evident due to the fact that none of the tested products were able to meet all of the requirements and there are no widespread bridge joint headers failures throughout the state. In particular, for the elongation requirement, only 2 of the 11 products passed. There appears to be a trade off for elongation versus other properties, such as compressive strength. Additional testing and analysis may be required in order to determine the ideal elongation percentage.

The compression requirement appears to be too conservative as well. Judging from the comparison between compression strength, impact resistance, and tensile strength, using a compression strength of 2200 psi would be more practical as a minimum requirement.

Taking into account the averages of the laboratory tests for tensile and tear strength, both the tear resistance and tensile strength requirements appear to be too low. From the test results, the tear resistance requirement should be at a minimum 200 lbs/in. Furthermore, the required minimum for the tensile strength should be at a minimum 1000 psi.

Another suggestion would be to change the compression and elongation requirements. By lowering the requirement for compression to 2200 psi and the elongation percentage to 60%, at least 2 products out of the 11 tested would pass all of the requirements. With future testing and research, optimum values and criteria for the material properties of elastomeric concrete may become more evident.

5 Field Sampling

5.1 NCDOT Elastomeric Concrete Performance Survey

Prior to visits to being made to field installation, NCDOT provided the research team with a contact list containing the Area Bridge Construction Engineers and the Bridge Maintenance Engineers from each of the Divisions seen in Figure 5-1.

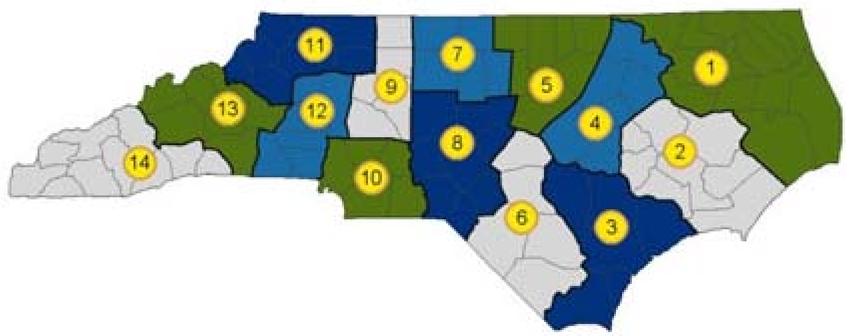

Figure 5-1. NCDOT Division Locations *(*NCDOT, 2008*)*

Each of those contacts were sent a small survey to get an idea of the typical problems were being encountered in the field. The results of this survey would indicate the sorts of problems that could be expected during field observations. The survey consisted of the following questions.

1. What is the most typical problem encountered in the field with regards to elastomeric concrete? (i.e. uniform mixture, bonder application)

2. Is there a preference for armored vs. unarmored joints? For instance, have you noticed fewer problems with one or the other? Installation? Spalling?

3. How does this material compare to other types of expansion joints? Easier installation? Life-span issues? Leaking?

A summary of the results from each of the respective survey questions follows:

1. Non-uniform mixture was noted as a very common problem, according to the majority of participants. There were noted cases where the mixture never set, remaining soft and eventually having to be removed. Some participants expressed that ambient temperature can be an issue at

the time of placement. On cold days the elastomeric concrete mix cools much faster, thus making it very difficult to finish.

2. Armored joints are required where ADTT counts exceed 2500, or if the route is located along the NHS. Armored joints were recognized as being more difficult to work with because inspectors can't see under the armor. This forces inspectors and engineers to rely on the contractor to properly consolidate the elastomeric concrete underneath the steel railing. Some participants had issues with this in the field, where the material was not placed directly under the armor, thus leaving a void. Some participants expressed that they had a preference for armored joints, and that it was simply a matter of correctly setting the angles, while others did not have a preference either way.

3. Although everyone agreed that the elastomeric joints were easier to install than most joint types, there seemed to be mixed reactions in regard to the service life of the joint. Most participants felt that the joints containing elastomeric joints performed well over time. A couple participants felt that other joints required tougher installation, but seemed to last longer.

5.2 Fresh Field Sampling

In order to observe fresh elastomeric concrete applications, field visits were made to a total of fourteen expansion joint placements, in which fresh samples were obtained for future testing. The field visits ranged from Asheville to Wilmington, while the majority of the fresh samples were obtained in the Piedmont region. Figure 5-2 shows a map of all the sites visited throughout the field phase of the project.

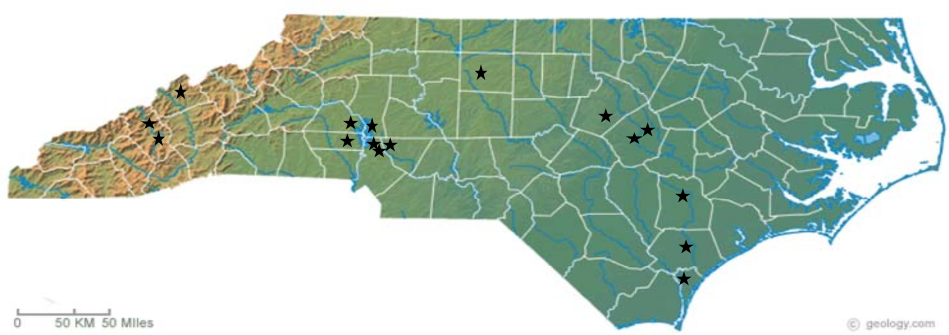

Figure 5-2. N.C. field sampling and coring locations (Geology.com, 2006)

The research team contacted NCDOT bridge maintenance engineers from each division looking to obtain information on any new applications or replacements. Contacts were called or e-mailed approximately every two weeks. The number of site visits was limited due to schedule conflicts, communication issues, and a lack of sufficient notices prior to construction. The remainder of the chapter will discuss the fresh sampling phase of the project.

At each site, the same set of prepared molds were taken out, based off previous calculations on the number of specimens needed for the compressive strength, bond strength, tensile splitting strength, impact-resistance, and hardness tests. The breakdown of the molds can be seen below in Table 5-1. All molds were primed with a release gel agent prior to obtaining samples. Some of the early site visits did not include slant shear testing, because it was not decided upon after some field sampling had already taken place. Figure 5-3 shows bond strength and compressive strength molds.

Table 5-1. Mold specimens used throughout field sampling

Testing Standard	Mold Type	Specimens
Compressive Strength	2" Cube Molds	6
Splitting Tensile Strength	2.5" Diameter PVC Pipe	6
Bond Strength	3" x 6" Cylinders	3
Impact Resistance	2.5" Diameter PVC Pipe	6

Figure 5-3. Bond strength and compression strength molds

During the field observation, many aspects were noted upon including the joint preparation, mixing process, placement procedures, and weather conditions. The first step at each location consisted of preparing the concrete within the blockout in which the elastomeric concrete would be in contact with. At each of the applications that were observed, the blockout was surface blasted in order to remove any foreign substances from the bonding surface. A total of two granular materials were used at each of the joints visited. Sand was used for the majority of the preparations, while black slag was used at some locations. In cases where armored joint systems were used, the self leveling apparatus (accompanied by the armored joint system) was set up prior to sandblasting. The self-leveling apparatus ensures that the joint will have no elevation change with respect to the surrounding concrete deck.

Once the blockout surface/armored system was deemed suitable for the fresh application, foam backer board was placed in the void between the concrete decks, as is seen in the unarmored joint in Figure 5-4. The foam backer board serves as a formwork for the elastomeric concrete within the blockout. Once the elastomeric concrete is cured, the foam board is removed and an Evazote seal in placed in the void. Some form of protective paper would also be taped down to each side of the joint to keep the surrounding concrete deck from being tarnished by the elastomeric concrete. Figure 5-4 shows a new construction joint completely prepared for placement.

Figure 5-4. New construction joint prepared for placement

With everything in place, the mixing would begin. A number of mixing techniques were observed, although the methodology was generally the same. Most of the visited locations followed the manufacturer directions, by first mixing the two-part primer supplied with the elastomeric concrete unit. In the majority of cases, the primer was applied with rubber gloves, which enabled workers to apply the primer evenly over the surface of the armored joint systems (where utilized), which have steel studs protruding every nine inches (approximate). Primer was also applied with brushes at some sites. With the primer applied to the blockout and armored systems, workers would begin mixing the two-part urethane-based or epoxy-based resins. At each site, there was some form of an assembly line that started with those opening cans of the two-part resin/hardener components. Once this binder was mixed, one worker would assist in opening the pre-bagged aggregate and dumping the mix for the worker who would perform the mixing.

The aggregate may or may not be heated based on the product. Elastomeric concrete that is not heated will possess a much lower viscosity than elastomeric concrete in which the aggregate is heated. This lower viscosity makes it much easier to pour the material into the joint, but top surface finishing is difficult. Alternatively, heating the aggregate will cut down on the curing time, also increasing the workability of the material with regard to the finishing process of the top surface. Mixing would take place long enough to ensure that no dry pockets of aggregate existed within the mix; however, at a few sites, it was observed that there were dry pockets of aggregate within the mix, which can have a considerable impact on a single expansion joint if this error is carried out throughout the remainder of the joint construction. These dry pockets can ultimately lead to voids within the mix. Figure 5-5 shows aggregate being heated within a concrete mixer, by means of a blow torch.

Figure 5-5. Aggregate being heated within concrete mixer

Once a bucket was completely mixed, a “runner” would take the bucket to those handling the trowels, at which point the elastomeric concrete would finally be placed into the joint. There were a few bridges that were visited that had a considerable change in elevation from one end of the joint to the other. In these cases, the pour would begin at the lower elevation and work up the joint. To assist in the finishing process, the trowels were heated so that the top surface of the elastomeric concrete could be leveled off smoothly. Figure 5-6 shows workers finishing the top surface of a joint with heated trowels, as a research student obtains fresh samples.

Figure 5-6. Top surface finishing as compressive specimens are obtained

Upon returning back to the lab, all field observations were documented within the field visit database. Figure 5-7 shows an example of the field-visit documentation. Each of the field data sheets can be found in Appendix E.

Elastomeric Concrete Research Field Trip Data

Site # 4

Location	Date (Month)	Date (Day)	Date (Year)	Weather Conditions
Wilmington - Martin Luther King and McCrae Rd.	4	29	2007	Night - About 60ºF

Placement Description	Heated Aggregate?	Product
Failure/Replacement	No	Pro-Crete NH

Failure Removal Procedure: Angle was lost on edge of elastomeric joint due to spalling. Evazote seal has also apart from the elastomeric concrete. One lane already completed, left hand lane to be replaced. Joint further up on same bridge will eventually need to be replaced. Failed joint is being sawed out. Jackhammer used to remove unwanted elastomeric concrete. Obtained samples of failed elastomeric concrete. Joint being completely cleaned for the new pour.

Placement Procedure: Workers cleaned joint of old elastomeric concrete, now cleaning surface with air gun. Will now put in formwork, pour elastomeric and allow to set, eventually returning to replace Evazote seal. Workers decided to remove foam finish pad. Plywood being used as formwork. Stakes added to ensure proper spacing for new foam sealer pad. First batch of non-heat aggregate was heated. This led to that first batch setting up quicker than normal. All batches after this used non-heated aggregate as the product

Other Comments: (3) - 2"x2"x2" cube samples obtained, (3) - 3"x6" cylinder samples obtained, Previous Evazote seal obtained, as well as removed elastomeric concrete joint.

Figure 5-7. Sample of field visit observation sheet

5.3 Cored Sample Sites

For each site at which fresh samples were obtained, coring samples were later acquired to determine how well the elastomeric concrete joint was performing over time. All joints were given a minimum of 4 months to cure from the time of the initial placement. A list of older existing joints was also compiled to determine the mechanical properties of the elastomeric concrete after long-term placement. Any bridge joints that were older than five years were considered to be “older” existing sites. Prior to making trips to the field, a set procedure was established within the lab for obtaining the cored specimens. Once the coring procedure was developed, field trips were ready to occur. The following section of this chapter will discuss the procedure used throughout the coring phase of the project.

5.3.1 Cored Sample Procedure

Prior to bridge coring taking place, the traffic services department within each division was contacted to set up traffic control, ensuring the safety of all parties involved. Upon arrival to the site, the first step would involve setting up an aluminum plate for the coring drill to adhere itself to (vacuum hold down system), just near the expansion joint. The coring equipment would subsequently be set in place with the 2.5” diameter diamond bit attached to obtain the tensile splitting and impact resistance specimens. With the coring drill securely in place, a water pump was hooked up to the side of the coring drill in order to cool the bit during the coring process. In the lab it was discovered that without water, the bit would reach high temperatures causing the binder within the elastomeric concrete sample to melt. It was determined that coring would not be feasible without the presence of water regardless of the product type. With all of the equipment set up, the coring would occur next, as is seen below in Figure 5-8.

Figure 5-8. Core sampling of an armored joint in the field

Coring was always performed on the shoulder, as close to the concrete traffic barriers as possible. Initially, the research team hoped to core in the tire path to determine the effects of cyclic loading;

however, NCDOT expressed concerns about the patching material debonding overtime due to the cyclic effects experienced in the tire path. Therefore, specimens were only obtained on the shoulder.

Drilling was performed in a gradual manner to prevent any form of damage to the cored specimens. There were two signals indicating that the full depth of the elastomeric concrete had been penetrated. The first being that a distinct difference in the drilling could be felt once the drill made contact with the underlying concrete. The drill would begin to shake much more once the concrete layer was reached. Also, the water that was being pumped down to the point of contact between the bit and the elastomeric concrete would turn light-grey indicating that the concrete had been struck by the bit. The drill would be slowly elevated once the drill completely penetrated the elastomeric concrete. Once the drilling bit was elevated back to its at-rest position, wedges were used to slowly loosen the specimens from the concrete as can be seen in Figure 5-9.

Figure 5-9. Removal of core samples

Once all of the specimens were “popped” out of the joint, the remaining debris and water were vacuumed out of the void. This would ensure that the patching material (ideally the same elastomeric concrete or a similar patching material) would not be affected by considerable moisture content within the joint.

5.3.2 Specimen Preparation

When all coring was complete, the cylindrical 2.5” and 3” specimens needed to be modified for the appropriate testing method. The 2.5” cores would be used for the tensile splitting strength and impact resistance specimens. These would simply need to be saw-cut to the correct dimensions using a dry cutting diamond blade, typically used for normal concrete. The tensile splitting specimens were cut into sections 1.5” thick, while the impact resistance specimens were cut into discs .375” thick. The 3” diameter cores would be used for compressive strength specimens and consisted of more complex cutting. In order to keep the dimensions of the compressive strength specimens constant from previous phase testing, 2” cubes would need to be rendered. The cubes were carefully produced by first cutting core specimens into 2” thick sections. A 2” x 2” template was used to define the cross-section on the top face of the cored specimen. The appropriate cuts were then made to create the cube specimen from the original cylindrical cored specimen.

5.3.3 Product Identification

Once cored specimens were obtained from the older existing bridges (> 5 years in-service), the product type needed to be identified. Upon identification, the older existing results could be compared to the results from the fresh sampling as well as the lab-mixed phase of the research. This would determine how well certain products were performing over time. The research team first contacted the NCDOT about determining what types of elastomeric concrete were used in the older joints; however there were no records of what type of product was used during installation. Contractors were also contacted in regards to the older existing coring bridge list, but again no records were kept about what type of product was used. This meant that the research team would have to attempt to properly identify the type of product used. There were a total of two products that proved identifiable upon inspection, those being E-Crete #57 and Delcrete. The E-Crete #57 mix is the only product comprised of sand as its aggregate, making it very easy to identify.

Similarly, Delcrete is the only material comprised of fine fiberglass shavings as its aggregate, again making it easy to identify. One joint material in Hickory was identified by a bridge maintenance engineer as Ceva Crete, which appeared to match another joint material from Hickory. Thus, the two joint materials from Hickory were identified as Ceva-Crete. The remaining elastomeric products that were considered throughout the project all appear nearly identical. Aggregate sizes were all identified as sieve size #40 or #50 in phase one of the research, making it very difficult to compare aggregate types. Visually, the polymeric binders appear identical, as all products share a black pigment. The remaining joints were identified based on the comparison of test results to the lab-mixed and fresh sample results.

5.4 Fresh and Cored Sampling Locations

Table 5-2 shows all of the site locations at which fresh samples were obtained. These same sites were visited months later and cored as well. The initial fresh sampling date is shown, as well as the date the same joint was revisited for coring. Each site was also assigned a form of identification, because the current bridge location maps do not display these newly constructed bridges and their respective bridge numbers.

A total of sixteen sites were visited during the fresh field sampling phase. In the case of the location identified as Fresh PR11, NCDOT bridge maintenance engineers contacted the research team to core an existing joint which had been placed weeks prior. Fresh samples were not obtained at the time of the placement therefore only cored values are shown. The joint was being removed due to a failure to apply the primer within the blockout prior to placement. In the case identified as Fresh MR4, fresh samples were obtained in the field but the samples never cured once returned to the lab. This is one particular problem that was noted after speaking with a number field engineers.

Similarly, Table 5-3 seen below, shows the “old” existing cored site locations. These sites were selected based on the relative age of the joint. These joints were selected based on their relative in-service life surpassing five years. Thus, fresh samples were not obtained at these locations. Bridge numbers were determined for these “older” existing bridges.

Table 5-2. Fresh and cored sample sites

Region	ID	City	General Location	Product	Fresh Placement Date	Date Core Specimens Obtained
Coastal Region	CR1	Wilmington	Martin Luther King Jr. and McCrae	ProCrete NH	4/29/2007	11/2/2007
Piedmont Region	PR1	Garner	Buffaloe Rd. and E-540	Ply-Krete	1/24/2007	12/6/2007
	PR2	Charlotte	WT Harris at Northlake Mall	Ply-Krete	11/2/2006	7/12/2007
	PR3	Charlotte	New I-485 over I-77	Ply-Krete	4/26/2007	7/17/2007
	PR4	Clayton	New Business 70	E #57	7/24/2007	12/6/2007
	PR5	Clayton	Clayton Bypass Off NC-42	Ply-Krete	7/25/2007	*
	PR6	Clayton	Clayton Bypass Off NC-42	Ply-Krete	7/26/2007	12/6/2007
	PR7	Denver	Optimist Club Church Rd.	Pro-Crete NH	5/21/2007	12/1/2007
	PR8	Denver	New 16 Off 150 (9+10)	Pro-Crete NH	6/6/2007	12/1/2007
	PR9	Denver	New 16 Off 150 (11+12)	Pro-Crete NH	6/7/2007	12/1/2007
	PR10	Statesville	I-77 to exit 49a onto US70E	E #57	**	9/20/2007
	PR11	Greensboro	I-40 and I-85 Bus. Near Market St.	Ply-Krete	9/29/2007	1/10/2008
Mountain Region	MR1	Canton	On 23/19 heading into Canton	E #57	9/11/2007	***
	MR2	Marshall	Meadows Town Rd.	ProCrete Plus	8/16/2007	12/18/2007
	MR3	Marshall	Meadows Town Rd.	ProCrete Plus	8/16/2007	12/18/2007
	MR4	Marshall	Meadows Town Rd.	ProCrete Plus	8/16/2007	12/18/2007

Note:

* Coring samples were not able to be obtained at PR5 due to small width of joint.

** No fresh samples were taken at Location PR10. Only cored specimens were obtained prior to being replaced.

*** Coring samples were not obtained at MR1 due to traffic control issues.

Table 5-3. “Old” core sampling sites

Region	Bridge Number	County	Product	"Old" Core Sampling Date	Approximate Age (Years)
Coastal Region	300429	Duplin	E #57	11/01/07	5 - 7
	670219	Pender	Pro-Crete Plus	11/01/07	5 - 7
Piedmont Region	590003	Mecklenburg	Del-Crete	01/07/08	5 - 7
	590922	Mecklenburg	Ply-Krete	01/07/08	5
	120082	Cabarrus	Ply-Krete	12/20/07	5
	120064	Cabarrus	Ply-Krete	12/20/07	5
	120046	Cabarrus	Ply-Krete	12/20/07	5
	170032	Catawba	Ceva-Crete	12/07/07	10 - 12
	480006	Iredell	Ceva-Crete	01/14/08	10 - 12
Mountain Region	430094	Haywood	Pro-Crete NH	12/18/07	5
	430090	Haywood	Pro-Crete NH	12/17/07	5
	430091	Haywood	Pro-Crete NH	12/17/07	5

Note: Product types not available from NCDOT or contractors. Product types shown were assigned based on appearance and relative strengths. Product types may not be correctly identified.

6 Field Results

Upon completion of all testing methods from the field and durability phases, the results from each phase were carefully analyzed to draw inferences about elastomeric concrete. Theses analyses took into account field procedures, field sampling results. The following section will provide an in-depth analysis of the field phase.

6.1 Field Observations

Throughout the duration of the fresh sample field visits, field procedures were closely monitored to determine the level of workmanship associated with each installation. There were some notable problems which arose and are listed below:

- In Charlotte, workers had to be reminded to apply the primer just as they began to place the first mix of elastomeric concrete in the block out. In many of the site visits, it was noted that the block out/armored angle were not completely covered by the primer, rather being applied in a lackadaisical manner.

- In Statesville, there were a series of 4-6 joints which had to be removed by the contractor due to the absence of the bonding primer prior within the blockout. Similarly, one joint in Clayton had to be replaced due to the absence of the bonding primer.

- In Wilmington, the workers heated Pro-Crete NH up to a temperature of 190 degrees F, which is a product that traditionally is not heated (No Heat). This led to the elastomeric concrete curing in the bucket before workers could place any material in the block out. The remainder of the header was correctly placed with non-heated aggregate product.

- In Denver, one joint was placed by the contractor after a hard rain, shortly after the rain had sub-ceded. The research team left as the rain began to fall, therefore samples were not obtained. All manufacturer specifications recommend very little, if any moisture on the bonding surface. This was confirmed by the MDOT report, as discussed in the literature review. Moisture will ultimately affect the bond strength and can have an effect on the flexural strength as well.

- Out of three samples taken in Marshall, one sample never fully cured in the lab. Pro-Crete Plus was used, which is to be heated uniformly. The product was heated on site, but may not have been heated thoroughly. Another reason for the sample not curing could have been attributed to faulty mixing ratios. When revisited for coring, the joint at which the uncured sample was obtained had cured without the need for a replacement. Therefore, a faulty mix may have been sampled.

- Out of all the fresh sample visits, the majority dealt with new construction sampling during the initial placement of the elastomeric concrete, although in Canton, elastomeric concrete was used to replace a failed bolt-down system. In Wilmington, an existing elastomeric joint was replaced after the metal railing of the armored joint began to bend in the tire path. This may have been attributed to the fresh material not being properly consolidated underneath the bottom surface of the steel angle, leaving a void for the steel to bend.

When coring "older" existing sites in the field, joints were noted for their general in-service condition. Out of the twelve sites which were visited, nearly all sites appeared to be in good condition. Minor spalling was noted at a few locations, while wearing was common in most of the joints.

6.2 Fresh Site Visits

Pro-Crete NH has the highest strength with regards to compression and tensile splitting strength, while E #57 displays the lowest overall compressive and tensile splitting strength. Pro-Crete NH also has the highest hardness, which directly corresponds to its high compressive and tensile splitting strengths. It would seem that the product with the highest hardness values would have the lowest impact resistance. The harder a material becomes, the more brittle it becomes, thus possessing a lower resistance to impact. The fresh field results of E #57 also support this theory. Ultimately, Pro-Crete contains larger aggregate than E-Crete #57, which contains sand. The larger aggregate may be the source of larger compressive strengths, whereas products containing smaller aggregate are more resilient.

Tables 6-1 and 6-2 show the comparison of lab-mixed values (LAB) and field-mixed (FM) values. This comparison provides insight into how well field-mixing procedures compare to lab-mixing within a controlled environment. Ply-Krete and Pro-Crete Plus both show substantial decreases in strength when transitioning from the lab to the field. Out of the four products which reoccurred throughout the field sampling stage, Ply-Krete and Pro-Crete Plus are the only two products which are typically heated. By observing the field-mixed values of Pro-Crete NH and E-Crete #57 (typically non-heated), it appears that these two products are much more similar to the lab-mixed specimens. The data shown in Tables 6-1 and 6-2 imply that heated products tend to have higher deviations from their lab-mixed counterparts. Heating aggregate increases the curing time and improves the finishing process; however, aggregate needs to be of a uniform heated temperature as recommended by the manufacturer. This extra step that is associated with some products provides the opportunity for flaws to occur in the mixing process, with the chance of non-uniformly heated aggregate becoming an issue. Non-heated products are, in a sense, simpler to mix, which leads to physical properties which are more parallel with values supplied by the product manufacturer.

Table 6-1. Compressive strength, tensile splitting strength, and impact resistance lab and field averages by product type

	Compressive Strength (psi)			Tensile Splitting Strength (psi)			Impact Resistance (ft-lbs)		
Product	LAB	FM	% Diff.	LAB	FM	% Diff.	LAB	FM	% Diff.
Ply-Krete	2336	1353	-42%	626	422	-33%	7.8	7.06	-9%
Pro-Crete NH	3210	3191	-1%	804	835	4%	5.2	6.08	17%
Pro-Crete Plus	3060	1687	-45%	528	523	-1%	5.6	5	-11%
E-Crete #57	1771	1155	-35%	589	477	-19%	8.9	10	13%

Table 6-2. Hardness and bond strength lab and field averages by product type

	Hardness			Bond Strength (psi)		
Product	LAB	FM	% Diff.	LAB	FM	% Diff.
Ply-Krete	60	54	-10%	877	295	-66%
Pro-Crete NH	53	55	4%	1140	585	-49%
Pro-Crete Plus	53	51	-4%	668	214	-68%
E-Crete #57	62	46	-26%	263	132	-50%

6.3 Fresh and Cored Sample Result Comparisons

A comparison of the fresh sampling values and the revisited coring values can be used to determine how the material is holding up over time. Tables 6-3 through 6-6 show the total testing results for all 15 sites which were visited during the fresh sampling phase. It is important to note that Clayton 2 was not cored due to the small width of the blockout, and Canton was not cored due to traffic control issues. Also, Statesville was solely visited for coring purposes prior to a failed joint being replaced. The remaining 12 sites are used for the analysis of sites at which both fresh and cored values were obtained. All sites are sorted based on the product used during installation.

Table 6-3. Ply-Krete fresh and cored sample performance by location

Ply-Krete												
Location	Compression Strength (psi)			Tensile Splitting Strength (psi)			Impact Resistance (ft-lbs)			Hardness		
	Fresh	Core	Δ	Fresh	Core	Δ	Fresh	Core	Δ	Fresh	Core	Δ
Buffaloe Rd	923	953	3%	289	458	58%	7.33	5.67	-23%	55	53	-4%
Clayton 2	2195	-	-	606	-	-	7.83	-	-	57	-	-
Clayton 3	2190	1446	-34%	608	614	1%	6.17	6.17	0%	58	51	-12%
Greensboro	872	1709	96%	387	505	30%	6	6	0%	49	46	-6%
I-77	1041	1081	4%	316	338	7%	8.5	5.33	-37%	52	47	-10%
Wt Harris	897	1172	31%	324	331	2%	6.5	7.67	18%	54	53	-2%
Mean	***1353***	***1272***	***-6%***	***422***	***449***	***6%***	***7.06***	***6.17***	***-13%***	***54***	***50***	***-8%***
Standard Deviation	*653*	*304*		*147*	*119*		*1.00*	*0.90*		*3.31*	*3.32*	
Manufacturer Data	**2800**			**N/A**			**N/A**			**45**		

Table 6-4. Pro-Crete NH fresh and cored sample performance by location

Pro-Crete NH												
Location	Compression Strength (psi)			Tensile Splitting Strength (psi)			Impact Resistance (ft-lbs)			Hardness		
	Fresh	Core	Δ	Fresh	Core	Δ	Fresh	Core	Δ	Fresh	Core	Δ
Denver 9&10	2994	2790	-7%	795	807	2%	6.83	5	-27%	54	54	0%
Denver 11&12	2709	2932	8%	951	988	4%	5	5	0%	57	53	-7%
Wilmington	3420	742	-78%	727	300	-59%	7.17	5.67	-21%	49	51	4%
Denver Opt.	3640	2333	-36%	869	972	12%	5.33	5	-6%	58	54	-7%
Mean	***3191***	***2199***	***-31%***	***835***	***767***	***-8%***	***6.08***	***5.17***	***-15%***	***55***	***53***	***-3%***
Standard Deviation	*418*	*1005*		*96*	*322*		*1.08*	*0.33*		*4.04*	*1.41*	
Manufacturer Data	**4200**			**N/A**			**10**			**50**		

Table 6-5. Pro-Crete Plus fresh and cored sample performance by location

Pro-Crete Plus												
Location	Compression Strength (psi)			Tensile Splitting Strength (psi)			Impact Resistance (ft-lbs)			Hardness		
	Fresh	Core	Δ	Fresh	Core	Δ	Fresh	Core	Δ	Fresh	Core	Δ
Marshall Jt. 1	1668	4351	161%	548	944	72%	5	5	0%	53	49	-8%
Marshall Jt. 2	1707	2291	34%	498	1154	132%	5	5	0%	48	53	10%
Mean	***1687***	***3321***	***97%***	***523***	***1049***	***101%***	***5***	***5***	***0%***	***51***	***51***	***1%***
Standard Deviation	*27*	*1457*		*35*	*148*		*0.00*	*0.00*		*3.54*	*2.83*	
Manufacturer Data	**4350**			**N/A**			**7**			**40**		

Table 6-6. E-Crete #57 fresh and cored sample performance by location

E-Crete #57												
Location	Compression Strength (psi)			Tensile Splitting Strength (psi)			Impact Resistance (ft-lbs)			Hardness		
	Fresh	Core	Δ	Fresh	Core	Δ	Fresh	Core	Δ	Fresh	Core	Δ
Canton	1177	-	-	600	-	-	9.17	-	-	48	-	-
Clayton 1	1133	1870	65%	354	710	101%	10	7.33	-27%	43	46	7%
Statesville	-	1661	-	-	387	-	-	5.33	-	-	46	-
Mean	***1155***	***1766***	***65%***	***477***	***549***	***101%***	***10***	***6***	***-27%***	***46***	***46***	***7%***
Standard Deviation	*31*	*148*		*174*	*228*		*0.59*	*1.41*		*3.54*	*0.00*	
Manufacturer Data	**3000**			**N/A**			**N/A**			**59**		

Figures 6-1 through 6-4 graphically depict the increases/decreases in strength between the fresh and cored samples, sorted by site location. The compressive and tensile splitting strengths show the greatest standard deviation out of the four tests performed on field specimens. Wilmington and Marshall Joint 1 show considerable deviations in compressive and splitting tensile strength when comparing the fresh and cored values. Hardness and impact strength remained reasonably constant.

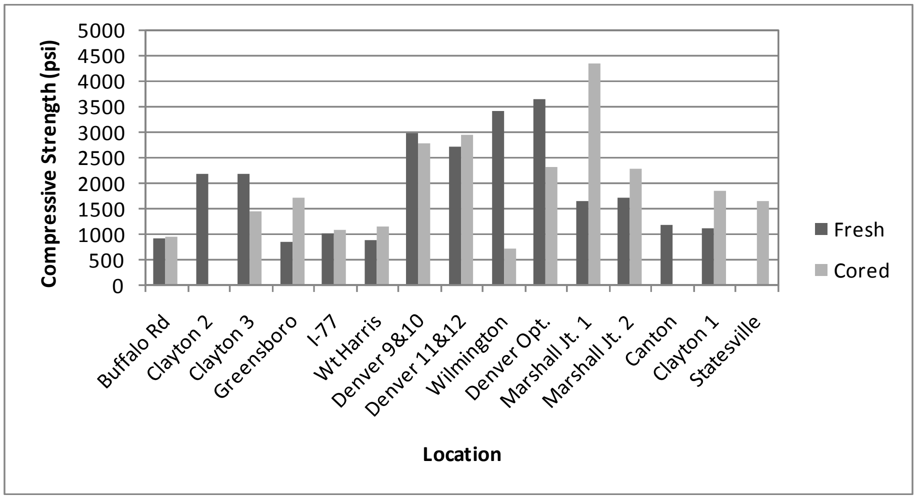

Figure 6-1. Fresh and cored compressive strength by site

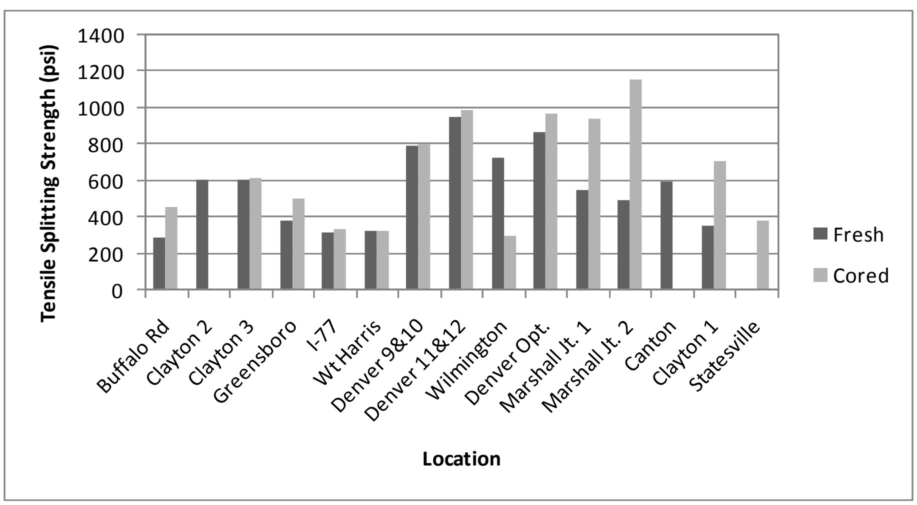

Figure 6-2. Fresh and cored tensile splitting strength by site

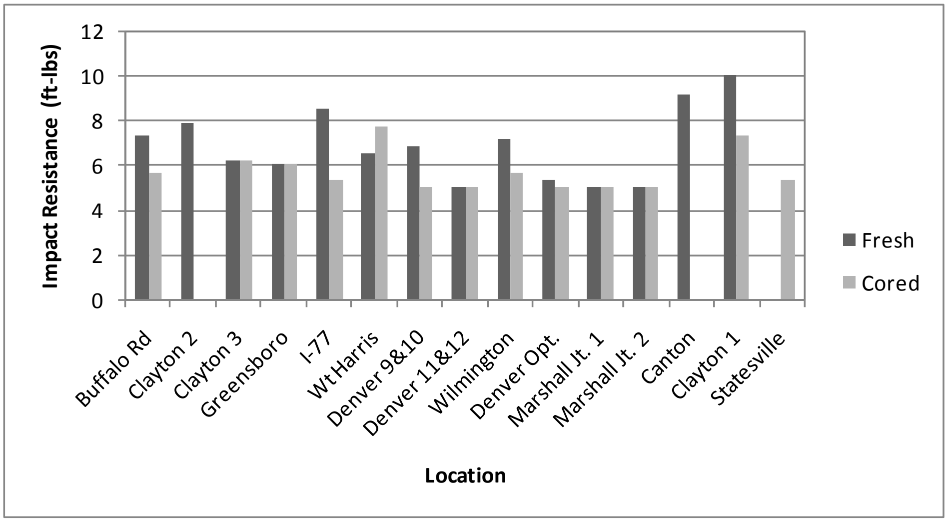

Figure 6-3. Fresh and cored impact resistance strength by site

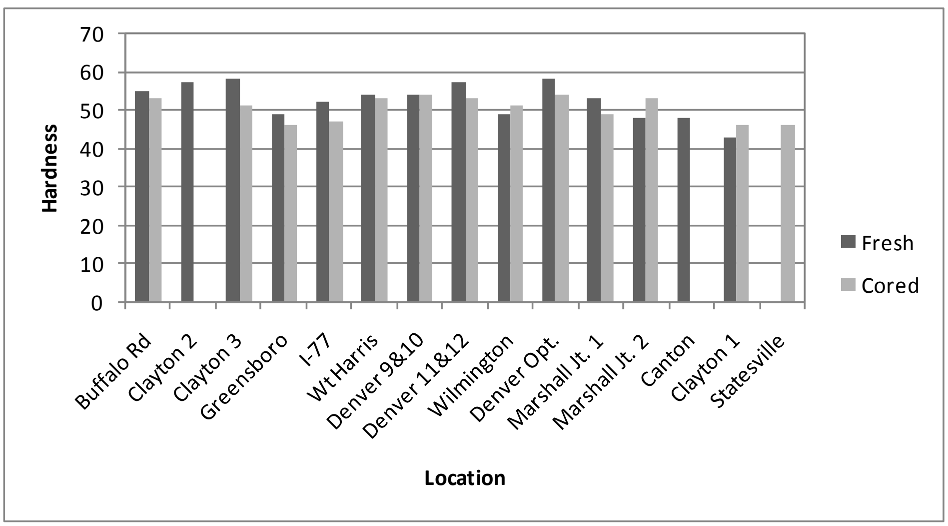

Figure 6-4. Fresh and cored hardness by site

It would seem that the fresh and cored sample testing results would remain fairly constant, considering each joint was cored four months to ten months later. It is expected that over some considerable period of time, strengths will see substantial declines due to impact loading, deck movements, and in-service weathering conditions. Table 6-7 shows the breakdown of the field fresh sites that were later revisited and cored to determine how well the elastomeric concrete was holding up over time. The table is based off the results shown above in Figures 6-1 through 6-4, incorporating 12 of 15 cases in which both fresh *and* cored samples were obtained. In the majority of the cases, compressive and tensile splitting strengths both saw an increase. In the majority of cases, impact resistance experienced a decrease, which correlates with the increase in compressive strength and tensile splitting strengths. Similarly, the hardness goes up

83% of the time, which is in agreement with the increases in compression and tensile splitting strengths, as well as the decrease in impact resistance. Therefore, it appears that with time the material continues to cure, thus becoming harder, which leads to the material becoming more brittle. Consequently, the compressive and tensile splitting strengths go up as the material cures.

Table 6-7. Fresh and cored sample summary

Test Method	Constant	Increase	Decrease
Compressive Strength	33%	42%	25%
Splitting Tensile Strength	42%	50%	8%
Impact Resistance	50%	8%	42%
Hardness	83%	8%	8%

Out of the 12 sites (in which fresh *and* cored samples were obtained) which were revisited, only 5 were open and subject to traffic loads, however no correlation exists between those joints which were live loaded and the decreases in strength seen in Table 6-7. Therefore, the reasons for the decrease in strength may be attributed to faulty mixing procedures or in-service environmental effects. Another possible reason for the decreases in strength may be due in part to the coring process. Despite the uniform procedure, the coring process may damage the material properties of elastomeric concrete.

6.4 Fresh Cored Samples

Pro-Crete Plus possesses the highest compressive and tensile splitting strengths, which are significantly higher than the fresh site visits. Pro-Crete Plus has aggregate which is typically heated during mixing, so this increase in strength may be attributed to the high temperatures experienced over the summer months after the initial placement. E #57 also saw a rise in compressive and tensile splitting strength. Pro-Crete NH tended to lose compressive and tensile splitting strength overtime, while Ply-Krete remained fairly consistent overtime. As for hardness, Ply-Krete fell slightly, which is in agreement with its increase in compressive and tensile splitting strength. The impact resistance of the products remained fairly constant with the exception of E #57, which saw a decrease in impact resistance along with an increase in compressive and tensile splitting strength.

6.5 Old Existing Cored Samples

A total of 12 older existing sites were visited to obtain core specimens. When compared to the fresh field and field fresh cored specimens, E #57 and Ply-Krete seem to develop strength overtime, assuming similar "initial" installations of elastomeric concrete. Pro-Crete Plus displayed high compressive and tensile splitting strengths, although the values were lower than the fresh samples values. This would contradict the theory that Pro-Crete Plus sees a significant increase in strength overtime; however, this statement stands valid only if the old existing joints were mixed in a nearly identical fashion to those fresh sample values. Pro-Crete NH tends to lose strength overtime, as demonstrated by the continual decrease in strength values. As for impact resistance, most products have very similar values with the exception of Delcrete, which tends to remain more resilient with time. Hardness also remains fairly constant in all the products. Tables 6-8 through 6-13 show the data obtained for each of the older existing joints which were cored, again listed by product.

Table 6-8. Ply-Krete old existing core performance by location

Ply-Krete				
Location	Compressive Strength (psi)	Tensile Splitting Strength (psi)	Impact Resistance (ft-lbs)	Hardness
Charlotte (I-485)	2104	510	5.00	51
Harrisburg 1	974	425	6.83	50
Harrisburg 2	2148	576	9.17	53
Harrisburg 3	975	346	6.83	50
Mean	***1550***	***464***	***7***	***51***
Standard Deviation	*665*	*100*	*1.71*	*1.43*
Manufacturer Data	2800	-	-	45

Table 6-9. Pro-Crete NH old existing core performance by location

Pro-Crete NH				
Location	Compressive Strength (psi)	Tensile Splitting Strength (psi)	Impact Resistance (ft-lbs)	Hardness
Lake Junaluska	1163	445	6.17	50
Little Fork Rd. 1	520	313	6.17	48
Little Fork Rd. 2	783	437	6.00	51
Wilmington, CR1*	1818	297	NA	50
Mean	***1071***	***373***	***6***	***50***
Standard Deviation	*563*	*79*	*0.10*	*1.19*
Manufacturer Data	4200	-	10	50

*specimens obtained from a failed joint sampled during replacement

Table 6-10. Pro-Crete Plus old existing core performance by location

Pro-Crete Plus				
Location	Compressive Strength (psi)	Tensile Splitting Strength (psi)	Impact Resistance (ft-lbs)	Hardness
Wilmington (117)	1644	540	5	52
Manufacturer Data	4350	-	7	50

Table 6-11. E-Crete #57 old existing core performance by location

E-Crete #57				
Location	Compressive Strength (psi)	Tensile Splitting Strength (psi)	Impact Resistance (ft-lbs)	Hardness
Wilmington (I-40)	2191	800	5.67	50
Manufacturer Data	3000	-	-	59

Table 6-12. Ceva-Crete old existing core performance by location

Ceva-Crete				
Location	Compressive Strength (psi)	Tensile Splitting Strength (psi)	Impact Resistance (ft-lbs)	Hardness
Old Shelby	1100	549	5.00	52
Hickory (I-40)	1357	507	5.17	48
Mean	***1228***	***528***	***5***	***50***
Standard Deviation	*182*	*30*	*0.12*	*2.83*
Manufacturer Data	4000	-	7	-

Table 6-13. Del-Crete old existing core performance by location

Del-Crete				
Location	Compressive Strength (psi)	Tensile Splitting Strength (psi)	Impact Resistance (ft-lbs)	Hardness
Charlotte (Graham)	1750	520	10.00	38
Manufacturer Data	-	-	10	50

Overall, it appears that field mixing is the source of lower strengths when compared to the values obtained when mixing products in a highly controlled environment. Two of the most important properties of the elastomeric concrete, compressive and bond strength, see a substantial drop off in values. Despite the mixing errors that may occur in the field, it appears that elastomeric concrete is developing strength with time, in this case, 4 months. This is supported by comparing the values between the field-mixed and fresh-cored phases. Despite increases in strength, traffic loads and weathering seem to degrade the material considerably when considering in-service lives of over 5 years. This is supported by comparing values from the old-cored and fresh-cored phases.

6.6 Comprehensive Data Analysis

The following section presents all of the testing results by product. Tables 6-14 through 6-19 display the complete results from each phase along with the current NCDOT specifications and data from the product manufacturer. From an observation of the current NCDOT specifications, it is quite evident that the specification values seem to be too high.

Table 6-14. Ply-Krete performance and specifications

Ply-Krete Performance vs. Specifications					
	Compressive Strength (psi)	Tensile Splitting Strength (psi)	Impact Resistance (ft-lbs)	Hardness	Bond Strength (psi)
NCDOT specifications	**2800**	*****	**7**	*****	**450**
Manufacturer data sheet	**2800**	******	******	**45**	**500**
Field - Fresh Mixed	1353	422	7.06	54	295
Field - Fresh-Cored	1272	459	6.51	50	-
Field - Old Cored	1550	464	7	51	-
Lab	2336	626	7.8	60	877

* No current specification available (binder and aggregate)
** Testing omitted from manufacturer data sheet

Table 6-15. Pro-Crete NH Performance and specifications

Pro-Crete NH Performance vs. Specifications					
	Compressive Strength (psi)	Tensile Splitting Strength (psi)	Impact Resistance (ft-lbs)	Hardness	Bond Strength (psi)
NCDOT specifications	**2800**	*****	**7**	*****	**450**
Manufacturer data sheet	**4200**	******	**10**	**50**	**500**
Field - Fresh Mixed	3191	835	6.08	55	585
Field - Fresh-Cored	2199	767	5.17	53	-
Field - Old Cored	1071	373	6	50	-
Lab	3210	804	5.2	53	1140

* No current specification available (binder and aggregate)
** Testing omitted from manufacturer data sheet

Table 6-16. Pro-Crete Plus performance and specifications

Pro-Crete Plus Performance vs. Specifications					
	Compressive Strength (psi)	Tensile Splitting Strength (psi)	Impact Resistance (ft-lbs)	Hardness	Bond Strength (psi)
NCDOT specifications	**2800**	*****	**7**	*****	**450**
Manufacturer data sheet	**4350**	******	**7**	**40**	**550**
Field - Fresh Mixed	1687	523	5	51	214
Field - Fresh-Cored	3321	1049	5	51	-
Field - Old Cored	1644	540	5	52	-
Lab	3060	528	5.6	53	668

* No current specification available (binder and aggregate)

** Testing omitted from manufacturer data sheet

Table 6-17. E-Crete #57 performance and specifications

E #57 Performance vs. Specifications					
	Compressive Strength (psi)	Tensile Splitting Strength (psi)	Impact Resistance (ft-lbs)	Hardness	Bond Strength (psi)
NCDOT specifications	**2800**	*****	**7**	*****	**450**
Manufacturer data sheet	**3000**	******	******	**59**	**250**
Field - Fresh Mixed	1155	477	10	46	132
Field - Fresh-Cored	1870	710	7.33	46	-
Field - Old Cored	1926	593	6	48	-
Lab	1771	589	8.9	62	263

* No current specification available (binder and aggregate)

** Testing omitted from manufacturer data sheet

Table 6-18. Ceva-Crete performance and specifications

Ceva-Crete Performance vs. Specifications					
	Compressive Strength (psi)	Tensile Splitting Strength (psi)	Impact Resistance (ft-lbs)	Hardness	Bond Strength (psi)
NCDOT specifications	**2800**	*****	**7**	*****	**450**
Manufacturer data sheet	**4000**	******	**7**	******	**500**
Field - Fresh Mixed	-	-	-	-	-
Field - Fresh-Cored	-	-	-	-	-
Field - Old Cored	1228	528	5	50	-
Lab	2792	615	7.9	53	621

* No current specification available (binder and aggregate)

** Testing omitted from manufacturer data sheet

\- No specimen obtained for particular phase/test

Table 6-19. Delcrete performance and specifications

Delcrete Performance vs. Specifications					
	Compressive Strength (psi)	Tensile Splitting Strength (psi)	Impact Resistance (ft-lbs)	Hardness	Bond Strength (psi)
NCDOT specifications	**2800**	*****	**7**	*****	**450**
Manufacturer data sheet	******	******	**10**	**50**	**400**
Field - Fresh Mixed	-	-	-	-	-
Field - Fresh-Cored	-	-	-	-	-
Field - Old Cored	1750	520	10	38	-
Lab	1839	310	10	53	414

* No current specification available (binder and aggregate)

** Testing omitted from manufacturer data sheet

\- No specimen obtained for particular phase/test

6.7 Comprehensive Results Vs. Existing NCDOT Specifications

In order to determine how the results of all the research phases compare to the existing NCDOT specifications, all the tested values from the 11 lab and 41 field cases were analyzed to determine the percentage passing each specification. The only three test specifications set forth for a complete mix by the NCDOT are for compressive strength, impact resistance, and bond strength. Table 6-20 shows the number of cases in which the existing NCDOT specifications were met with respect to each test method. Finally, Table 6-21 shows the number of test results collected from field samples compared to the proposed specifications.

Table 6-20. Lab and field results vs. current NCDOT specifications

Current NCDOT Specifications			
Test Method	Cases Satisfied	Cases Unsatisfied	Passing %
Compressive Strength (2800 psi)	8	44	15%
Impact Resistance (7 ft-lbs)	19	33	37%
Bond Strength (450 psi)	9	12	43%

Table 6-21. Field results vs. proposed NCDOT specifications

Proposed NCDOT Specifications			
Test Method	Cases Satisfied	Cases Unsatisfied	Passing %
Compressive Strength (2200 psi)	14	26	35
Spitting Tensile Strength (625 psi)	15	25	38
Hardness (50)	28	12	70

Clearly, the specified compressive strength of 2800 psi is much too high, with 8 cases passing out of the 52 cases analyzed. The impact resistance value of 7 ft-lbs also appears to be somewhat high, with a little over one-third of the 52 specimens passing. The bond strength specification seems to be a bit more realistic, with nearly half of the specimens passing. All in all, the existing specifications are too high, especially in the case of compressive strength and bond strength, which are two of the most important properties. Although impact resistance only passes 36% of the time, impact resistance does not appear to be one of the most important properties of elastomeric concrete, as the values remain fairly constant throughout all of the testing.

As for the field samples versus the proposed specifications, the results are more favorable (the field data included both freshly sampled materials and cored materials from both new and old applications).

6.8 Statistical Analysis

In order to further understand the data set of the entire research, statistical analyses were employed in order to determine the normal distributions and other significant values in regard to each testing method. This method would hopefully prove beneficial in determining any revisions to the existing NCDOT specifications.

In determining the minimum requirements, only lab and field-mixed results were considered. These two phases were used for determining the specification values because the current specification deals with freshly mixed products, rather than in-service elastomeric concrete. Many factors affect in-service elastomeric concrete including traffic loads and environmental weathering, thus these values were omitted from the analysis.

When considering the data from the hardness, impact resistance, and 5% deflection resilience results, both the lab and the field showed very small deviations from one another. Therefore, each test was analyzed as a whole, taking into account the entire data set. Table 6-22 shows statistics for the each of these tests. Upon examining the data from the lab and field-mixed samples, there were three test methods which possessed value sets that were more difficult to evaluate, in terms of identifying outliers. In Table 6-23, data sets are shown for the compressive, tensile splitting, and bond strengths in ascending order of strength. The data within the table was reduced to produce normal distributions that would portray each property, by eliminating outliers which were offsetting the distribution curve. After determining the normal distributions for each test method, the average values provided a better representation of each material property. The “normalized” data sets were then used to generate the minimum requirement values for the compressive, tensile splitting, and bond strength tests. The data reduced data sets were used to generate the graphical summaries shown in Figures 6-5 to 6-7.

Table 6-22. Statistics for impact resistance, hardness, and 5% deflection resilience

	Impact Resistance (ft-lbs)	Hardness	5% Deflection Resilience
Mean	7.2	54	97
Standard Deviation	1.7	4.8	1.55

Table 6-23. Data reduction used to obtain normal distributions

Compressive Strength (psi)		Tensile Splitting Strength (psi)		Bond Strength (psi)	
~~LAB~~	~~830~~	~~FIELD~~	~~289~~	~~FIELD~~	~~92~~
~~FIELD~~	~~872~~	~~LAB~~	~~291~~	~~FIELD~~	~~143~~
~~FIELD~~	~~897~~	~~FIELD~~	~~316~~	~~FIELD~~	~~171~~
~~FIELD~~	~~923~~	FIELD	324	~~FIELD~~	~~185~~
FIELD	1041	FIELD	354	~~FIELD~~	~~200~~
FIELD	1133	FIELD	387	FIELD	228
LAB	1166	LAB	396	LAB	256
FIELD	1177	LAB	425	LAB	263
LAB	1468	FIELD	498	FIELD	354
FIELD	1668	FIELD	548	FIELD	383
FIELD	1707	FIELD	600	FIELD	387
LAB	1771	FIELD	606	LAB	414
LAB	1839	FIELD	608	LAB	604
FIELD	2190	LAB	615	LAB	621
FIELD	2195	LAB	700	LAB	648
LAB	2335	LAB	705	LAB	668
FIELD	2709	LAB	717	~~LAB~~	~~877~~
LAB	2745	FIELD	727	~~LAB~~	~~1140~~
LAB	2792	LAB	764	~~FIELD~~	~~1188~~
FIELD	2994	FIELD	795	~~LAB~~	~~1244~~
LAB	3060	LAB	849	~~LAB~~	~~1254~~
LAB	3210	FIELD	869		
LAB	3239	LAB	894		
FIELD	3420	FIELD	951		
~~FIELD~~	~~3640~~	LAB	964		

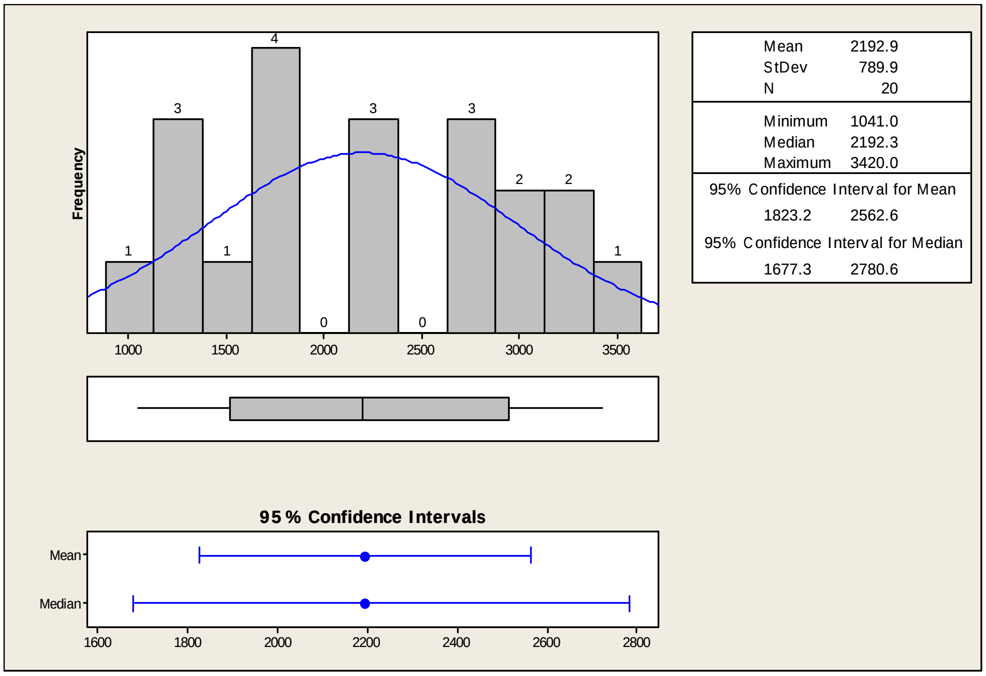

Figure 6-5. Graphical summary of compressive strength data from lab and field-mixed data

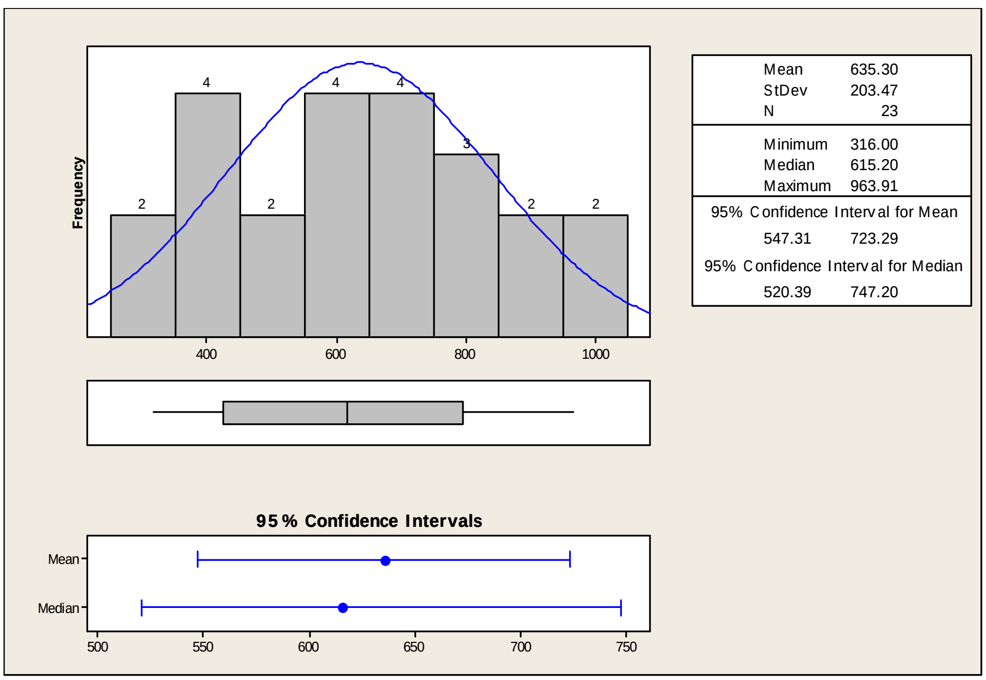

Figure 6-6. Graphical summary of tensile splitting strength from lab and field-mixed results

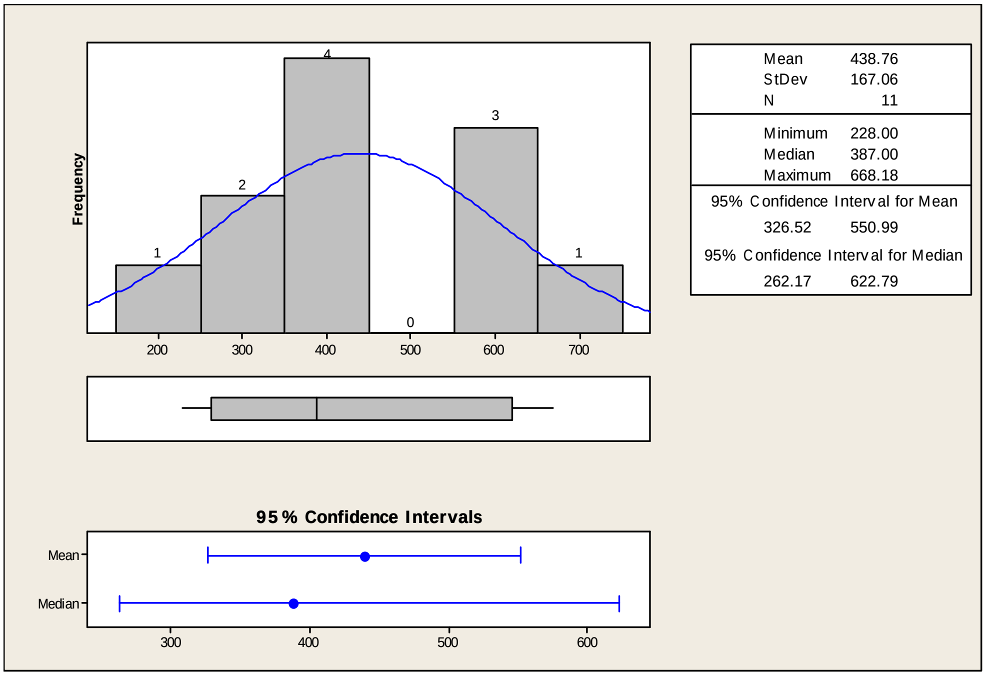

Figure 6-7. Graphical summary of bond strength from lab and field-mixed results

7 CONCLUSIONS AND RECOMMENDATIONS

Overall, elastomeric concrete provides a great alternative as a nosing material within bridge expansion joint headers. Its resilient properties present a material that reduces the effects of spalling, especially when compared to normal concrete. The majority of products possess physical characteristics that provide contractors with a promising nosing material. Ultimately, the performance of elastomeric concrete is dependent on many variables. The research performed within this study identified the following contributing factors:

- Product type
- Aggregate size
- Heated/non-heated aggregate
- Environmental conditions
- Surface preparation
- Mixing/placement workmanship
- Traffic volume

Out of the various factors listed above, workmanship is easily identified as the number one factor associated with the field performance of elastomeric concrete. Despite the simplicity involved in preparing expansion joints containing elastomeric concrete, it seems that most problems can be linked to the initial placement, which is concluded in three of the reports within the review of literature. This is quite evident when comparing the field-mixed values to the lab-mixed values. Lab-mixing is performed in a highly-controlled environment; however, the procedure is the same. The ultimate key in mixing elastomeric concrete is ensuring that the mixing ratios are in accordance with that recommended by the manufacturer. For the most part, this involves simply mixing two cans of binder-mix and pre-bagged aggregate. From field observations, the research team gathered that a great majority of contractors use their own forms of mixing, including “measuring cups” for the binder. These smaller portions ultimately alleviate the mixing process and cut down on the rush to place the quickly curing elastomeric concrete. All contractors should consult the manufacturer of their preferred elastomeric concrete, in order to ensure that the proper mixing ratios are maintained. A number of bridge maintenance engineers also indicated that non-uniform mixtures were a common problem. This implies that the polymeric binder and aggregate are being mixed too quickly, which leads to dry pockets within the mix.

Beyond the mixing process, it appears that many contractors place elastomeric concrete in the absence of the primer. This primer ensures that the proper bond strength is maintained throughout the life of a particular joint. This mistake can prove costly, as learned from many of the field observations. Along the course of the field research, many contractors were forced to remove the freshly placed elastomeric concrete, and replace it, being sure to apply primer to the blockout surface.

The following list summarizes typical installation problems which were encountered in the field, and could have negative long-term performance effects:

- Not applying primer to blockout prior to elastomeric concrete placement.
- Application of primer in a lackadaisical manner.
- Failure to maintain proper mixing ratios.
- Mixing two different products.
- Non-uniform mixtures, leading to dry pockets within mix.

- Not properly consolidating material under armored railing.

The product type can also affect the physical properties of a particular elastomeric concrete header. There are many types of products currently on the market, which possess many different characteristics. It is important to note that all manufacturer data sheets show that their respective product material properties surpass the minimum requirements set forth by each state department of transportation. These values appear misleading, when comparing to the lab, field, and even durability values. Products mixed within the lab and field rarely matched up to the values suggested by manufacturers (following the same standard testing methods).

In the selection of elastomeric concrete products, comes the question of workability. Some products require that aggregate be heated prior to mixing with the binder while others do not. Heated aggregates seem to improve the finishing process, as well as cut down on the curing time, but trends in the field-collected data show that those products which were heated showed much greater deviations from their lab-mixed counterparts. This may be attributed to non-uniform heating within the aggregate, which can lead to small volumes of the mix not curing properly, if at all. There were a few cases in which the research team was told about headers which never cured. These cases may have been due in part to non-uniformly heated aggregate or possibly cool temperatures in the field (below 45˚ F). Therefore, the research team does not recommend the use of elastomeric concrete products required to use heated aggregates, until a reliable and practical field solution is developed.

7.1 Recommended Testing Methods

Upon determining the critical material properties and developing a list of relevant standard testing methods, numerous tests were conducted to obtain lab and field results. After careful consideration of all those testing methods developed by the research team, the following tests were found to be the most important in regard to elastomeric concrete.

Binder only:

- Tensile Strength
- Tear Strength
- Elongation

Complete mix:

- Compressive Strength
- 5% Deflection Resilience
- Bond Strength
- Tensile Splitting Strength
- Durometer Hardness

The compressive strength and 5% deflection resilience of the elastomeric concrete ensures that the joint will be capable of supporting the live axle loads transmitted to the joint while remaining resilient to accommodate vertical and horizontal deck movements. Bond strength is also extremely important in the installation of elastomeric concrete as the nosing material. In the field, there were many cases where the primer was not applied to the blockout prior to placement. In all those cases, the joint had to be replaced. It is imperative that primer is applied to ensure a prolonged in-service life. The bond strength must be tested to ensure that a particular product will provide an adequate bond to the adjacent concrete and steel. Tensile splitting strength is recommended to be added to the specifications because it has been well established as the simplest and the most reliable method for determining the tensile strength of elastomeric concrete when completely mixed. Although durometer hardness testing is normally performed on uniform plastics and rubbers, the test presents a method for determining if a particular material has cured in the field. It was determined that in some cases, flawed field-mixing procedures led to joints which never fully cured. Hardness readings can be taken along the length of the joint to ensure that the material has indeed cured. Impact resistance does not appear to give any indication of how well a particular elastomeric header will behave. Products generally performed the same throughout this particular test, with variances being attributed to the varying aggregate types. Those products with finer aggregates (sand, fiberglass) outperformed products containing coarser aggregates, which is mostly likely due in part to the higher levels of polymer per volume of material. Ultimately, this particular method tests material properties that seem insignificant when compared to the other tests considered within in this study.

7.2 Proposed Minimum Requirement Values

After comparing the existing NCDOT requirements to the lab and field data, it was determined that the requirements were too high. This was especially apparent when comparing products that were mixed in the highly-controlled environment of the lab. Of the eleven products which were mixed, there were none that passed all of the minimum requirements. Therefore, nearly all field values (fresh and cored) failed the existing minimum requirements. After observing the results of the statistical analysis, the following numbers are proposed for the minimum requirements as shown in Table 7-1.

Table 7-1. Proposed minimum requirements

Testing Method	Minimum Requirement
Binder Tensile Strength (psi)	1000
Binder Tear Strength (lb/in)	200
Binder Ultimate Elongation (%)	150
Compressive Strength (psi)	2200
5% Deflection Resilience	95
Splitting Tensile Strength (psi)	625
Bond Strength (psi)	450
Durometer Hardness	50

These values come from the statistical analysis described above by eliminating outliers to determine an approximation of the normal distribution of each material property. Once the normal distributions were determined for each material property test method, the mean of each reduced data set was calculated. It is important to note that the 5% deflection resilience minimum requirement is listed for the test methods described in this study. Table 7-2 shows the current NCDOT minimum requirements in comparison to the newly proposed minimum requirements of a complete elastomeric concrete mix. It is clear from Table 7-3 that 3 products satisfy the new requirements except the binder ultimate elongation value, which might still be too conservative (and is related to the splitting tensile strength, for which the proposed new limit is being met by only 4 products). Binder ultimate elongation might not be as relevant to product long-term performance; however, without further durability tests the current minimum value should not be changed.

Table 7-2. Comparison of existing and proposed minimum requirements

Testing Method	Existing NCDOT Min. Requirements	Proposed Min. Requirements
Tensile Strength (psi)	800	1000
Tear Strength (lb/in)	90	200
Ultimate Elongation (%)	150	150
Compressive Strength (psi)	2800	2200
5% Deflection Resilience	-	95
Splitting Tensile Strength (psi)	-	625
Bond Strength (psi)	450	450
Impact Resistance (ft-lbs)	7	-
Durometer Hardness	-	50

Table 7-3. Lab mixed results compliance with proposed NCDOT specifications

Product	Binder Tensile	Binder Ult. El.	Binder Tear	EC Compr.	EC 5% Defl.	EC Split T.	EC Bond	EC Hardness
Ply-Krete			√		√		√	√
Ply-Krete HT			√	√	√	√	√	√
Ply-Krete HS	√		√	√	√	√	√	√
Ply-Krete LV	√		√	√	√	√	√	√
E-Crete 57			√		√			√
Ceva Crete	√		√	√	√		√	√
WaboCrete II	√	√	√		√		√	√
ProCrete NH	√		√	√	√	√	√	√
ProCrete Plus	√		√	√	√		√	
DelCrete			√		√			
Tron-Flex		√			√			√

7.3 Formulation of a Quality Control Program

7.3.1 Material Prequalification

The performance of elastomeric concrete ultimately begins with the product. Therefore, all products installed by contractors in the field must exhibit material properties that ensure long lasting performance in the field. As elastomeric concrete becomes more prevalent in bridge expansion joint construction, the need arises for prequalification of materials on the market. It is recommended that each year (or sooner if the elastomeric concrete material components or the installation procedure is changed), the NCDOT obtain products from the various elastomeric concrete manufacturers for prequalification testing. Product samples (aggregate, primer, and binder) should be provided by the manufacturer in order to mix the number of specimens for each testing method as shown in Table 7-4. Any products not passing the minimum requirements will be deemed unsuitable for use in the state of North Carolina.

Table 7-4. Prequalification testing methods and respective number of specimens

Testing Method	Standard	Number of Test Specimens
Tensile Strength	ASTM D 638	5
Ultimate Elongation	ASTM D 638	5
Tear Strength	ASTM D 624	5
Compressive Strength	ASTM D 695	6
5% Deflection Resilience	ASTM D 695	6
Splitting Tensile Strength	ASTM D 3967	6
Bond Strength	ASTM C 882	6
Durometer Hardness	ASTM D 2240	5

Detailed sample preparation and testing instructions are provided in Chapter 3 of this report. Furthermore, the recommended material specification for elastomeric concrete bridge joint headers is provided in Appendix F.

7.3.2 Quality Control - Inspection

In order to ensure elastomeric concrete is being properly mixed, fresh field samples should be obtained on site and subsequently tested, and the results compared to the minimum requirements. The following steps are suggested for each installation to ensure that all joints are installed in an effective manner; however, each product should ultimately be installed according to the manufacturer guidelines:

1. Prepare the concrete blockout surface and steel railing (armored joints) surfaces by abrasive blasting to remove any foreign debris. Foreign debris and dirt will ultimately affect the bond strength of the joint. In new construction, concrete within the block-out must cure for a minimum of 7 days and reach a compressive strength of

3000 psi. Also, do not place elastomeric concrete if the ambient air temperature is below 45°F. A manufacturer's representative should also be present during the first placement by a particular contractor.

2. In the case of armored joints, steel railing needs to be set up using the self-leveling apparatus prior to being sandblasted. Blast-cleaning anchor studs are not required; however, anchorage bars or studs and their welds shall be inspected visually. Any anchorage bars or studs that do not have complete attachment weld shall be replaced.

3. Blow header block-out with filtered air to remove laitance and debris from the sandblasting operation.

4. Place some form of a protective paper along the length of the joint with a width of approximately 3 feet to protect surface of concrete deck.

5. Place foam backer board in opening between bridge decks to serve as formwork for elastomeric concrete.

6. Mix Part A and Part B of elastomeric primer following the manufacturer's direction. Mixing should occur until marbling does not occur within the mix.

7. Apply primer to the concrete within the blockout, as well as to the steel railing where armored joints are utilized. In the case of armored joints, ensure that shear studs and the bottom surface of the railing have liberal amounts of primer.

8. Prepare to place elastomeric concrete within two hours after primer is applied, while primer remains tacky.

9. Mix Part A and Part B of the elastomeric concrete binder, using a power mixer. Again, mix within bucket until marbling does not occur. Be sure to mix proper ratios and components of the binder.

10. Add aggregate to binder mix. Mixing is complete when no dry pockets remain within the mix. Mixing should take place for approximately 1 minute. Again, be sure to add correct amount of aggregate to the binder.

11. Mixed elastomeric concrete can then be placed in the blockout. Material should be consolidated in blockout so that voids do not exist, using a method recommended by the manufacturer.

12. In case of armored joint application, material must reach the underside of the steel railing top plate. Failure to do so will lead to bonding failure, leading to cracks which water can infiltrate. Ultimately, voids below the angle can lead to bending of the steel angle in the wheel paths.

13. Heated trowels are recommended for finishing the top surface of elastomeric concrete nosing; however, some form of a ventilation mask is recommended to protect against the fumes generated by the thermal reaction between the heated trowel and elastomeric concrete.

14. It is suggested that the elevation of the top of the elastomeric concrete nosing exceed the top of the adjacent concrete deck by a small amount. Any excess material can be grinded down to provide a smooth transition between the concrete deck and the elastomeric concrete nosing. Elastomeric concrete should cure for a minimum of two days prior to grinding the surface.

7.3.3 Quality Control – Field Sampling

In order to cut down on the number of workmanship-related problems identified in this study, more stringent field supervision should be implemented. All installations should be carefully inspected to ensure proper performance of expansion joints containing elastomeric concrete. Satisfactory test results from routine fresh sampling by NCDOT inspectors or engineers will ultimately provide the best indication of how well a joint will perform over time.

When the results from fresh samples do not meet the minimum requirements, or when premature failure is being observed in a joint resulting from normal service conditions, elastomeric concrete core samples should be taken. However, due to the fact that the actual coring procedure somewhat disturbs the elastomeric concrete material and the elastomeric concrete continues to cure for a certain amount of time, the results from cored samples should be carefully evaluated, as the results often vary, with no special trend observed from one material to another (see Section 6.3).

a. *Field sampling and testing procedures – fresh material:*

During elastomeric concrete installation the Department should collect freshly mixed samples for independent testing. A minimum of one set of samples shall be collected for bridge joint or for each day's production.

The set of samples shall consist of:

- six 2 inch cube molds for 6 compression tests performed according to ASTM 695. Section 3.5 of this report presents detailed instructions for sample preparation and testing.
- three 3x6 inch cylinders for 6 splitting tensile tests (1.5 inch thick and 3 inch diameter slices, as recommended by ASTM 3967), and 5 durometer hardness tests (performed on the remaining slices, and following the specifications outlined in ASTM D2240, using a type D durometer). More details are provided in Sections 3.6 and 3.7, respectively.

The fresh samples shall be stored at the bridge site for at least 24 hours before shipping to the testing laboratory. Curing time varies from one material to another, and although in preparing the lab specimens a minimum of 7-day curing time was allowed, a 14-day curing period (at room temperature) is recommended to allow for variations in manufacturers' recommendations and field conditioning.

b. Field sampling and testing procedures – cored material:

As it was mentioned earlier, when the results of fresh samples do not meet the minimum requirements, or when an in-service bridge joint header prematurely fails under normal conditions, it might be necessary to core samples from the installed elastomeric concrete header.

The goal of the coring procedure is to obtain the same samples (number and size) as per fresh materials described earlier. However, in order to obtain the 2 inch cube samples required for the compression tests, 3 inch diameter cores are needed, and later cut to the proper size using a suitable radial arm or rock saw. Furthermore, as the thickness of most bridge joint headers is around 2-2.5 inches, it is necessary to core 6 cylinders to obtain all the tensile splitting test samples. Finally, the durometer hardness tests can be performed directly on the material in service, as no special sample preparation is required for the cured material.

Section 5.4.1 provides detailed description of the coring process, which is very similar to the sampling procedures of cured Portland-cement concrete. It is important to note that the holes should be patched using the same elastomeric concrete material, if available. If an older bridge joint header material cannot be identified, a non-shrink grout or a cold-patch asphalt material can be used.

7.4 Further Recommendations

After researching a number of state specifications for bridge joints, it is recommended that a watertight integrity test be implemented into the NCDOT elastomeric concrete specifications.

The integrity test shall take place at least five days after the joint system has been fully installed, with the full length of the joint being tested. The joint should be covered with flowing water for a minimum duration of 15 minutes, with concrete surfaces below the joint subsequently being inspected during the 15 minute period, and also 45 minutes after the supply of water has stopped, inspecting for any evidence of dripping water or moisture. If water leakage is found, the contractor should locate the leakage point and seal the leak. Another water integrity test shall be performed under the same conditions described above, after the leak has been sealed (NYSDOT, 2003). This test ensures that the expansion device is indeed watertight, which is one of the advantages of elastomeric concrete joints. With leakage being one of the main problems associated with expansion joints, this will provide an early indication any problems attributed to the installation process.

7.5 Future Work

In order to further understand the physical properties of elastomeric concrete, it will be necessary to complete future research. The following section presents possible directions for future studies:

- Provided that only concrete was considered in the bond strength studies presented in this report, future research should consider the bonding strength between steel railing and elastomeric concrete for the case of armored joints. Also, primer application should be investigated to determine the overall effects of the primer on the bond strength to concrete and steel. This would provide an indication of the total bond strength which is lost in the absence of primer.

- Physical property tests should also be performed in pre-determined time intervals to determine if elastomeric concrete picks up strength with time, as is the case with normal concrete. When considering strength with time, the data within this report led to inconclusive results.

- Various field factors at the time of placement should also be considered for its impact on the physical properties of elastomeric concrete. When considering site conditions, there are many variables which have not been tested for in previous studies, including the effects of temperature and humidity. Varying conditions could be simulated within a controlled lab environment, while mixing elastomeric concrete. These types of tests would determine if mixing ratios account for lower values, or if field conditions also play a role.

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In addition to the sources listed above, available elastomeric concrete specifications were reviewed from the following agencies:

- North Carolina DOT
- Texas DOT
- Georgia DOT
- Tennessee DOT
- Caltrans
- New York State DOT
- Kansas DOT.

Material references were obtained from representatives (or their corporate web pages) of the following elastomeric concrete manufacturers:

- D.S. Brown, 300 East Cherry Street, North Baltimore, OH 45872
- Capital Services, 112 Morris Road, Schenectady, NY 12304 – Mr. Tom Meacham
- E-poxy Engineered Materials, LLC, 10 Broadway, Albany, NY 12202
- Kinedyne Corporation, Buffalo, NY
- R.J. Watson, Inc., 78 John Glenn Drive, Amherst, NY 14228 – Mr. Marc D. Stafford
- Watson Bowman Acme Corp., Amherst, NY

APPENDIX A – Elastomeric Concrete Survey of Departments of Transportation

Table A-1. Survey questionnaire and data sheet

Name: (Last, First)

Date(s):

Time(s): (Start-End)

DOT: (State)

Position:

Experience: (With elastomeric concrete)

1. How did your DOT decide upon the minimum material requirements for elastomeric concrete?
2. What testing methods does your DOT require elastomeric manufactures to perform and do you feel they are all necessary? (Might could email specifics)
3. When installing elastomeric concrete in expansion bridge joint headers must an inspector be present?
4. Aside from minimum material requirements, what are your expectations for elastomeric concrete (i.e. Life expectancy)?
5. What do you find the life expectancy to be on elastomeric expansion bridge joint headers in (interviewee's state)?
6. What are the most common modes of failure for the elastomeric concrete you use?
7. What is the reasoning behind the failing elastomeric concrete?
8. How often do you conduct inspections and maintenances of the elastomeric concrete headers?
9. How do you determine when the elastomeric concrete headers should be replaced during the service life of a concrete bridge?
10. What type of bridge surface treatments do you typically use prior to installation? Why?
11. Are there any overall advantages of the product you use?
12. Are there any disadvantages?

Table A-2. State test methods and related ASTMs

State	Test Methods	Related ASTM's
Alabama	Impact strength	Not listed
	Tensile Strength	Not listed
	Tensile Stress	Not listed
Florida	Tensile Strength	D638(b,e)
	Compressive Strength	C579(e)
	Hardness	D2240(b,e)
	Bond Strength	C882(e)
Georgia	Tensile Strength	D638(b)
	Elongation	D638(b)
	Hardness	D2240(b)
Illinois	Compressive Strength	C579(e)
	Scaling Resistance	C672(e)
	Impact Resistance	D2444(e)
	Bond Strength	C884(e,b)
Kansas	Tensile Strength	D638(b)
	Elongation	D638(b)
	Tear Resistance	D624(b)
Massachusetts	Compression Strength	D695(e)
	Resilience	C579(e)
	Impact Resistance	D3209(e)
Michigan	Bond Strength	D638(b,e)
	Compression Strength	C579(b,e)
	Bond Strength	C882(e)
Nevada	Tensile Strength	D638(b,e)
	Tear Resistance	D624(e)
	Compressive Strength	D695(e)
New Mexico	Tensile Strength	D412(b)
	Hardness	D2240(b)
	Compression Strength	D395(e)
	Brittleness	D746(b)
	Ozone Resistance	D1149(b)
	Resistance to Salt & Oil	D471(b)
New York	Tensile Strength	D638(b,e)
	Tear Resistance	D624(b,e)
	Compression Strength	D695(b)
	Resilience	C579(e)
North Carolina	Tensile Strength	D638(b)
	Elongation	D638(b)
	Bond Strength	D638(e)
	Tear Resistance	D624(b)
	Compression Strength	D695(e)
Oklahoma	Tensile Strength	D638(e,b)
	Hardness	D2240(e)
	Viscosity	D2393(b)
Texas	Tensile Strength	D638-84(b)
	Tear Resistance	D624-81(e)
West Virginia	Tensile Strength	D638(b,e)
	Tear Resistance	D624(e)
	Hardness	D2240(b,e)

APPENDIX B – DOT SPECIFICATIONS

North Carolina **Specifications for Elastomeric Concrete (10-12-01)**

Description: Elastomeric concrete is a mixture of a two-part polymer consisting of polyurethane and/or epoxy, and kiln-dried aggregate
Manufacturer shall supply it as a unit
Use the concrete in the blocked out areas on both sides of the bridge deck joints as indicated on the plans

Requirements: Materials to comply with the following minimum requirements at 14 days

Elastomeric concrete properties

Bond strength to concrete:	min. 450 psi	ASTM D638
Brittleness by impact:	min. 7 ft-lbs	Ball Drop
Compressive strength:	min. 2800 psi	ASTM D695

Binder properties (w/o aggregates)

Tensile strength:	min. 800 psi	ASTM D638
Ultimate elongation:	min. 150%	ASTM D638
Tear resistance:	min. 90 lb/in	ASTM D624

Additional Requirements:

Use elastomeric concrete that resists water, chemical, UV, and ozone exposure, and withstands freeze-thaw
Furnish manufacturer's certification verifying that the materials satisfy all the requirements
Provide samples of elastomeric concrete to Engineer, if requested, to independently verify conformance with specs
Require manufacturer's rep to be present on site during installation of the elastomeric concrete

Georgia DOT **Section 449: Bridge Deck Joint Seals**

Use either epoxy concrete or elastomeric concrete for header material

1. Materials

Elastomeric Concrete:

Includes a 2-component elastomer and pre-bagged fillers
May use heat to accelerate curing and ensure good bond to concrete and steel
Compatible with the concrete and steel to which is bonded
Provides smooth riding surface across the joint
Can be mixed with normal equipment and placed between 45F and 100F

Requirements

Elastomeric concrete cured binder material (w/o filler??)

Before oven aging:		
Tensile strength:	min. 750 psi	ASTM D638
Elongation at break:	200-350%	ASTM D638
Hardness Type D durometer:	38±8	ASTM D2240
Compression set, 22 hrs. at max. 158F:	50%	ASTM D395 (meth B)
Tear Resistance	min. 150 lbs/in	ASTM D624 (2in/min)
Water Absorption	max. 1.2%	ASTM D270
Heat Shrinkage	max. 1.6%	ASTM D1299
Impact strength	min. 7 ft-lbs/min	GDT 111
Properties after oven aging at 158F for 72 hrs:		
Tensile strength:	min. 750 psi	ASTM D638
Elongation at break:	150-350%	ASTM D638
Hardness Type D durometer:	42±5	ASTM D2240
Impact strength	min. 7 ft-lbs/min	GDT 111

Elastomeric concrete binder material (with filler??)

Resilience at 5% deflection:	min. 80%	GDT 111
Bond strength to concrete:	min.* 375 psi	GDT 111
Wet bond strength to concrete:	min.* 250 psi	GDT 111
Pot life:	min. 5 minutes	GDT 111

*minimum psi or concrete failure

Epoxy Concrete:

Compatible with with all allowable joint seal materials, concrete and steel
Capable of providing a smooth riding surface across the joint
Can be mixed with normal equipment
Can be mixed and placed at temperatures above 55F
Use a 2-component rapid curing epoxy with aggregates that cures to a dense semi-flexible weather, abrasion, and impact - resistant epoxy concrete

Requirements

Epoxy concrete - epoxy only (before and after oven aging at 158F for 72 hours)

Tensile strength:	min. 900 psi	ASTM D638
Elongation at break	min. 40%	ASTM D638
Shore D hardness	45-75	ASTM D2240
Pot Life	max. 45 minutes	GDT 111

Epoxy concrete - epoxy mixed with aggregate

Compressive strength at 24 hours:	min. 2500 psi	ASTM C39 (3" cyl)
Resilience at 5% deflection:	min. 75%	GDT 111
Bond strength to concrete:	min.* 375 psi	GDT 111
Wet bond strength to concrete:	min.* 250 psi	GDT 111
Thermal compatibility:	no delamination	ASTM C884

*minimum psi or concrete failure

Aggregate used (supplied by the manufacturer, well-graded, clean, dry)

Gradation:	No. 4 sieve - 100% passing by weight	AASHTO T27
	No. 80 sieve - 0-5% passing by weight	AASHTO T27

2. Construction Requirements

<u>Header preparation:</u>

Remove loose, eroded, and unsound concrete from the surface within joint area
Provide horizontal bonding areas by cutting all angular areas of concrete blockouts
Immediately before placing of eopxy or elastomeric concrete, sandblast the concrete surfaces

<u>Construction:</u>

Use an installer trained by the manufacturer to install the <u>bridge deck joint sealing system</u>
A manufacturer's rep shall be present at the installation of the epoxy or elastomeric concrete headers
Install the joint system according to the manufacturer's recommendations, and the following:
~ do not perform any part of the installation in rainy weather, or if rain is expected w/in 1 hour of installation
~ ensure surfaces are completely dry before applying adhesive or primer
~ before adding the aggregate, thoroughly mix the two components (resin and hardener) of the epoxy mortar
~ mix the epoxy mortar in a mech. mortar mixer by combining 1 vol. of mixed epoxy and 3 vols. of aggregate
~ prime the surface, then place and finish the epoxy concrete w/in 1/2 hour of mixing
~ the epoxy mortar cure time is directly related to temperature, and use the following general guideline to estimate cure time: 40F-5hrs,50F-4hrs,60F-3hrs,70F-2.5hrs,80F-1.5hrs,90F-1hr, 100F-0.75hr
~ postpone installation if temp. is not 55F and rising. If can't postpone, use supplemental heat to complete the operation and reopen the lane. If suppl. heat has been used, make sure
~ allow the elastomeric concrete to to cool and solidify for at least an hour before opening to traffic
~ allow the epoxy concrete to cure for at least two hours before opening to traffic

Texas DOT

Section 5. DMS-6140, Elastomeric Concrete for Bridge Joint Systems

Provides Quality Monitoring Programs (QMP) and Material Requirements (MR)

2 types of elconc:

- **Type I:** fluid thermosetting binder (two-component, rapid curing elastomer) with aggregate forms a semi-flexible and resilient system
- **Type II:** two-component rapid curing liquid polymer combined with aggregate forms a semi-rigid and higher compressive strength material

QMP

Materials list approved by Constr. Division/Materials and Pavement Section (CD/MPS)
No further tests req'd for these materials unless requested by project engineer
Materials remain on the list for 6 months, after which resubmit materials for prequalification
Material list includes a bridge joint system: specific binder, aggregate and sealant to be used
No component substitutions allowed for a prequalified system unless allowed by the CD/MPS

Prequalification:

Producer provides lab test results (min. one sample per mat. style) showing compliance with TexDOT specs
Min. of one 1/2 gal sample of each elconc system to be considered will be provided to CD/MPS for evaluation
CD/MPS results should meet requirements of the specifications
Elconc is approved as a system, not as components
Adequate correlation should exist between CD/MPS test results and producer test data

Texas DOT **Section 5. DMS-6140, Elastomeric Concrete for Bridge Joint Systems (cont' d)**

MR Bond test to be performed with the corresponding elconc, instead of portland cement concrete (why???)

Properties:

after mixing, min 5 minutes working time at 80F
consistency should be self-leveling to moderately stiff flowable and hand-trowelable
elconc should support traffic in 3 hours
elconc should be resistant to chemicals, weather and abrasion
use aggregates specified by the manufacturer
elconc not to be placed at a temperature below 50F

Requirements

Type I - Binder only

Gel Time:	min. 5 minutes	Tex-614-J	Testing Epoxy Materials
Impact Strength:	min. 5 lb-ft	Tex-618-J	Testing Elastomeric Concrete
Tensile Strength:	min. 500 psi	Tex-618-J	
Tensile Stress:	max. 1000 psi	Tex-618-J	
Ult. Elongation:	min 100%	Tex-618-J	
Tear Resistance:	min. 80 lb/in	Tex-618-J	

Type I - Binder and aggregate mixture

Wet bond strength to concrete:	min. 225 psi	Tex-618-J
Compressive strength at 24 hours:	min. 750 psi	ASTM C579 Meth. B
Compressive stress:	min. 750 psi	Tex-618-J
Resilience:	min. 85%	Tex-618-J

Type II - Binder only

Gel Time:	min. 5 minutes	Tex-614-J	Testing Epoxy Materials
Tensile Strength:	min. 900 psi	Tex-618-J	Testing Elastomeric Concrete
Ult. Elongation:	min 40%	Tex-618-J	
Shore D hardness:	45-75	ASTM D2240	

Type II - Binder and aggregate mixture

Wet bond strength to concrete:	min. 225 psi	Tex-618-J
Compressive strength at 24 hours:	min. 2000 psi	ASTM C579 Meth. B
Compressive stress:	min. 2000 psi	Tex-618-J
Resilience:	min. 70%	Tex-618-J

Caltrans

Specifications from a specific contract's Special Provisions (dated 02/24/03)

Description: Elastomeric concrete is a mixture of a two-part (mixed 2:1 ratio) polyurethane material compounded with both fiberglass and sand specifically formulated to bond to concrete and steel

Requirements: Elastomeric concrete shall be flexible, have high load bearing capacity and be resistant to spalling and cracking
Use only polyurethane binders (use of epoxy not allowed) with sand and fiberglass or granite aggregate
A manufacturer's rep shall be present during all phases of mixing and placement of elastomeric concrete
Elastomeric concrete shall be mixed and placed at the job site
The mixed material shall have a pot life of at least 5 minutes
The material shall cure exothermally requiring no extra heat, at ambient temperatures of 45F or greater
The material shall set up and allow traffic no later than 2 hrs. after the final plecement

Elastomeric concrete properties (binder and aggregate) *

Compressive stress (5% defl.):	max. 1400 psi	ASTM D695
Resilience (5% defl.):	min. 95%	ASTM D695
Impact strength:	min. 10 lb-ft (no cracks)	Ball drop
Dry bond strength to concrete:	min. 400 psi	
Wet bond strength to concrete:	min. 250 psi	

* ASTM tests are ammended, or new test methods described

Polyurethane binder properties

After 7-day conditioning at 100F:		
Tensile strength:	min. 500 psi, max. 1500 psi.	ASTM D573 (D638)
Elongation:	min. 180%	ASTM D573 (D638)
Hardness Type D durometer:	90±3 A(??)	ASTM D573 (D2240)
After 7-day oven aging at 158F:		
Tensile strength:	min. 500 psi, max. 1500 psi.	ASTM D638
Elongation:	min. 180%	ASTM D638
Hardness Type D durometer:	90±3 (A??)	ASTM D573 (D2240)

Additional Requirements:

Contractor to submit for approval manufacturer's technical info for approval for each brand of elastomeric concrete
Elconc shall not be used until the Engineer has approved it, and the manufacturer's tech rep has instructed the Contractor and the Engineer on the surface preparation, mixing and application of elconc
Cleaning of concrete contact surfaces shall be done by sand blasting, by removing 1/8" of concrete
Concrete and reinforcement shall be free of rust, paint, greese, asphalt or other foreign materials
Surface temperatures of areas to be covered shall be between 45F and 90F
Elastomeric concrete shall be cured for at least 1 hour prior to opening the surface to public traffic.

NYSDOT **Engineering Instruction EI 05-027 from 08/04/05, effective for projects with letting beyond 01/12/06**
Standard Material Specification 701-11

General Specifications

Elastomeric concrete used as bridge header and patching material
Vendors must submit Materials Detail Sheets to the General Engineering Unit for approval
Vendor technical representatives must be present during all phases of el. conc. Installation
Use only el. conc. Appearing on the NYSDOT Approved List of Materials and Equipment
Use a product supplied by a single supplier - combining products are not permitted, unless approved by NYSDOT
Elastomeric concrete will be evaluated by NYSDOT/3rd party at 6-months intervals for 2 years,
to maintain the Approved List status

Construction Details

Have a manufacturer's rep on the project site during all phases of installation
The rep will present all quality-control equipment info (qualibration, competency) to the Engineer for approval
Supply MSDS and Material Detail sheets for all materials
Abrasive-blast clean all metal and concrete surfaces that come in contact with el. conc.
Measyre surface moisture content of the substrate before installation
Vacuum or air-blow clean contact surfaces
Adhere to approved Material Data sheet instructions for mixing, placement and finishing
Supply elastomeric concrete components and primers in prepackaged/premeasured containers, with instructions

Material Requirements

Resilience	min. 70%	ASTM C579-01
Compressive strength (at 5 hours)	min. 500 psi	ASTM C579-01 (modified)
Compressive strength (at 24 hours)	min. 2031 psi	ASTM C579-01 (modified)
Tensile Strength (at 7 days)	min. 145 psi	ASTM D638
Tear Resistance (at 7 days)	min. 40 lb/in.	ASTM D624
Pot Life	min. 5 minutes	Gardco GT-S Gel Timer

Kansas DOT **Special Provisions 90P&M-214: Elastomeric Concrete**

Prequalified Man./Products: (PQL-37)	Flexcon 2000	Bridgesaver, Inc.
	Delcrete	D.S. Brown
	Silspec 900 PNS	SSI
	Wabocrete	Watson Bowman Assoc.
	Wabocrete II	" " " " " " "

APPENDIX C – MATERIAL PROPERTIES

MATERIAL PROPERTY	ASTM D04.34.12 Task Group on	Capital Services [a]			D.S. Brown
	Elastomeric Concrete (12/08/98)	Pro-Crete	Pro-Crete Plus	Pro-Crete NH	Delcrete
Compressive Strength (ASTM D695) - psi	min. 1800 [b,g]	2800	4350	4200	
Compr. Str. @ 5% Strain (ASTM D695) - psi	min. 500 [b,g]		3000		min 800
Compressive Strength (New York DOT) - psi					
Resilience at 5% Deflection (ASTM D695) - %	min. 80 [b,g]				
Resilience at 5% Defl. (in-house method) - %					min 95
Tensile Strength (ASTM D638) - psi		900	1700	2250	min 1500 [b,d]
Tensile Stress (ASTM D638) - psi					min 500 [b,d]
Ultimate Elongation (ASTM D638) - %		175	150	60	min 200 [b,d]
Ultimate Elongation ~ Jaw Separation - %					
Ultimate Elongation ~ Bench Marks - %					
Tensile Shear Strength (ASTM D1002) - psi					
Tensile Strength (ASTM D412) - psi	min. 750 [b,g]				
Tensile Elongation (ASTM D412) - %	min. 100 [b,g]				
Comp. Set B after 22 hrs. 158F (ASTM D395) - %	max. 50 [b]				
Tear Resistance (ASTM D624) - lbs/in	min. 80 (using die C) [b]	165	165	200	
Tear Resistance (ASTM D638) - lbs/in					
Bond Strength (ASTM D638) - psi		550	550	500	
Dry Bond Strength to Concrete (in-house) - pli					400
Wet Bond Strength to Concrete (in-house) - pli					250
Bond Strength (ASTM C882) - psi	min. 390				
Adhesion Properties (ASTM C109)					
Bond to Concrete (or failure in concrete) - psi					
Hardness, Shore D (ASTM D2240)	approx. 40±5 [b]		40	50	90±3 A [b,d]
Hardness, Shore A (ASTM D2240)					
Hardness, Durometer (ASYM D2240)					
Hardness Change (ASTM D2240) - 7 days at 14F					
Brittleness by Impact (ball drop) - ft-lb		7+	7+	10+	>10 (at -20F)
Impact Resistance (ASTM D3209)	no cracks: 32F,-20F,14days/158F [g]				
Ozone Resistance (ATM D1149)					
U.V. Resistance (ASTM G53)					
Water Absorption (ASTM D570) - %					
Water Abs. 70 hrs. at 158F(ASTM D570) - %	max. 3				
Pot Life at 78F - minutes		45	45	18	5
Gel Time (AASHTO T-237) - minutes					
Gel Time (AASHTO T-237) - minutes					
Initial Set - hours					
Initial Cure - hours		8	8	1 to 3	
Vulcanized Cure at 175F - hours		2	2		
Open to Traffic - hours		3	4	2 to 4	2
Cure Time (open to traffic) - hours					
Cure Time (open to traffic) - hours					
Cure Time (open to traffic) - hours					
Full Chemical Cure - days					
Cure cycle (full cure at 150-170F) - hours					
Shelf Life (from date of manuf.) - years					

MATERIAL PROPERTY	E-Poxy Engineered Materials		Kinedyne	R.J. Watson [c]		Watson Bowman Acme
	Eva-Pox	Ceva-Crete	Dyne-Crete	Tron-Flex	Tron-Flex (at 73F)	Wabocrete II
Compressive Strength (ASTM D695) - psi	3000 (mod. B)	4000± [e]	4600±400			2200
Compr. Str. @ 5% Strain (ASTM D695) - psi			3500			1200
Compressive Strength (New York DOT) - psi					3770	
Resilience at 5% Deflection (ASTM D695) - %		75 [e]				95
Resilience at 5% Defl. (in-house method) - %						
Tensile Strength (ASTM D638) - psi	1000	950 [b,e]; 1500 [b,f]	1750±250			
Tensile Stress (ASTM D638) - psi		700 [b,e]; 850 [b,f]				
Ultimate Elongation (ASTM D638) - %	100	150 [b,e]; 75 [b,f]				
Ultimate Elongation ~ Jaw Separation - %			100±20			
Ultimate Elongation ~ Bench Marks - %			150±20			
Tensile Shear Strength (ASTM D1002) - psi		1350 [e]				
Tensile Strength (ASTM D412) - psi				1500 [b]	2500 [e]	1000 [b,e]
Tensile Elongation (ASTM D412) - %				min 250 [b]	260 [e]	200 [b,e]
Comp. Set B after 22 hrs. 158F (ASTM D395) - %						
Tear Resistance (ASTM D624) - lbs/in		165 [b,f]			100 [e]	100 [b,e]
Tear Resistance (ASTM D638) - lbs/in	90					
Bond Strength (ASTM D638) - psi						
Dry Bond Strength to Concrete (in-house) - pli						
Wet Bond Strength to Concrete (in-house) - pli						
Bond Strength (ASTM C882) - psi	500	500 [e]				
Adhesion Properties (ASTM C109)					no specifics provided	
Bond to Concrete (or failure in concrete) - psi					min 350	
Hardness, Shore D (ASTM D2240)			40			35-40 [b,e]
Hardness, Shore A (ASTM D2240)	85-95			85±5 [b]		
Hardness, Durometer (ASYM D2240)					90±3 [e]	
Hardness Change (ASTM D2240) - 7 days at 14F				max 10 pt [b]		
Brittleness by Impact (ball drop) - ft-lb		7+ [e]				
Impact Resistance (ASTM D3209)					no cracks: -32F,0F, 158F	no cracks: -20F,32F, 158F
Ozone Resistance (ATM D1149)				no cracks		
U.V. Resistance (ASTM G53)				excellent		
Water Absorption (ASTM D570) - %	0.35	0.35				
Water Abs. 70 hrs. at 158F(ASTM D570) - %						
Pot Life at 78F - minutes	20-30	20-30	40-50	20		
Gel Time (AASHTO T-237) - minutes					10-15 for 150 grams	10-15 for 150 grams
Gel Time (AASHTO T-237) - minutes					20-30 for 1 gallon	20-30 for 1 gallon
Initial Set - hours	1.5-2.0					
Initial Cure - hours	3	3.0-4.0				
Vulcanized Cure at 175F - hours		2				
Open to Traffic - hours						
Cure Time (open to traffic) - hours					1.0-1.5 at 70-90F	1.0-1.5 at 70-90F
Cure Time (open to traffic) - hours					1.5-2.0 at 50-70F	1.5-2.0 at 50-70F
Cure Time (open to traffic) - hours					2.0-3.0 at 40-50F	2.0-3.0 at 40-50F
Full Chemical Cure - days	7	7				
Cure cycle (full cure at 150-170F) - hours			2			
Shelf Life (from date of manuf.) - years	1				1	1

Notes:

[a] - properties not separated to binder versus elastomeric concrete

[b] - material properties for the binder only

[c] - two sets of material properties provided for the same brand name

[d] - properties are the same after 7-day 100F conditioning, and 7-day 158F oven aging

[e] - after 7-day cure

[f] - after 30-day oven (accelerated) cure

[g] - standard test modified based on draft ASTM document

APPENDIX D – Laboratory-Mix Test Results

Ply-Krete

Property	Units	Test Method	Test Results
Ply-Krete Manufacturers' Data Sheet			
Compressive Strength	psi	ASTM D 695	2800
Slant Shear Bond Strength	psi	Not Listed	500 (dry)
Slant Shear Bond Strength	psi	Not Listed	300 (wet)
Tear Strength	pli	Not Listed	150
Tensile Strength	psi	ASTM D 638	900
Elongation at Break	%	ASTM D 638	175
Hardness	-	ASTM D 2240	45

Property	Units	Test Method	Test Results	
Ply-Krete Test Results Summary				
Tensile Strength	psi	ASTM D 638		521.38
Elongation at Break	%	ASTM D 638		122
Hardness	--	ASTM D 2240		61.6
Tear Resistance	lbs/inch	ASTM D 624		375
Compressive Strength	psi	ASTM D 695		1166.31
5% Compressive Stress	psi	ASTM D 695		640.7
5% Resilience	%	ASTM D 695		98%
Impact Resistance	ft-lb	Ball Drop	32° F	6.7
			70° F	10
Water Absorption	%	ASTM D 570		0.13
Bond Strength	psi	ASTM C 882		604.20

Ply-Krete HT

Ply-Krete HT Manufacturer's Data Sheet			
Property	Units	Test Method	Test Results
Compressive Strength	psi	ASTM D 695	3000
Resilience @ 5% Δ	%	ASTM D 695	90 min.
Slant Shear Bond Strength	psi	Not Listed	250 min.
Tensile Strength	psi	ASTM D 638	775
Elongation at Break	%	ASTM D 638	160
Hardness	-	ASTM D 2240	59
Water Absorption	%	ASTM D 570	< 1

Ply-Krete HT Test Results Summary				
Property	Units	Test Method	Test Results	
Tensile Strength	psi	ASTM D 638	991	
Elongation at Break	%	ASTM D 638	113	
Hardness	--	ASTM D 2240	60.4	
Tear Resistance	lbs/inch	ASTM D 624	447	
Compressive Strength	psi	ASTM D 695	2335.15	
5% Compressive Stress	psi	ASTM D 695	2335.2	
5% Resilience	%	ASTM D 695	98.97	
Impact Resistance	ft-lb	Ball Drop	32° F	7.8
			70° F	9.7
Water Absorption	%	ASTM D 570	0.28	
Bond Strength	psi	ASTM C 882	876.86	

Ply-Krete HS

Ply-Krete HS Manufacturer's Data Sheet			
Property	Units	Test Method	Test Results
Compressive Strength	psi	ASTM D 695	4600
Compressive @ 5%	psi	ASTM D 695	3500
Slant Shear Bond Strength	psi	ASTM D624	500 (dry)
Slant Shear Bond Strength	psi	ASTM D624	350 (wet)
Tear Strength	pli	ASTM D624	165
Tensile Strength	psi	ASTM D 638	1750
Elongation at Break	%	ASTM D 638	150
Hardness	-	ASTM D 2240	45
Brittleness	ft-lb	Ball Drop	10

Ply-Krete HS Test Results Summary			
Property	Units	Test Method	Test Results
Tensile Strength	psi	ASTM D 638	1167
Elongation at Break	%	ASTM D 638	45
Hardness	--	ASTM D 2240	52.8
Tear Resistance	lbs/inch	ASTM D 624	415
Compressive Strength	psi	ASTM D 695	3239.23
5% Compressive Stress	psi	ASTM D 695	1883.6
5% Resilience	%	ASTM D 695	96.79
Impact Resistance	ft-lb	Ball Drop	32° F 8.2 70° F 8.7
Water Absorption	%	ASTM D 570	0.70
Bond Strength	psi	ASTM C 882	1243.93

Ply-Krete LV

Ply-Krete LV Manufacturer's Data Sheet			
Property	Units	Test Method	Test Results
Compressive Strength	psi	ASTM D 695	4000
Slant Shear Bond Strength	psi	Not listed	500 (dry)
Slant Shear Bond Strength	psi	Not listed	275 (wet)
Tear Strength	pli	Not listed	200
Tensile Strength	psi	ASTM D 638	2200
Elongation at Break	%	ASTM D 638	60
Hardness		ASTM D 2240	45

Ply-Krete LV Test Results Summary			
Property	Units	Test Method	Test Results
Tensile Strength	psi	ASTM D 638	1777
Elongation at Break	%	ASTM D 638	61
Hardness	--	ASTM D 2240	63
Tear Resistance	lbs/inch	ASTM D 624	484
Compressive Strength	psi	ASTM D 695	2745.29
5% Compressive Stress	psi	ASTM D 695	2145.5
5% Resilience	%	ASTM D 695	97.22
Impact Resistance	ft-lb	Ball Drop	32° F 5 70° F 6
Water Absorption	%	ASTM D 570	0.27
Bond Strength	psi	ASTM C 882	1253.93

E-Crete # 57

E-Crete 57 Manufacturer's Data Sheet

Property	Units	Test Method	Test Results
Compressive Strength	psi	ASTM D 695	3000
Resilience @ 5% Δ	% min.	ASTM D 695	90
Shear Bond Strength	psi min.	Not listed	250
Tensile Strength	psi	ASTM D 638	775
Elongation at Break	%	ASTM D 638	160
Hardness		ASTM D 2240	59
Water Absorption	%	ASTM D 570	< 1

E-Crete 57 Test Results Summary

Property	Units	Test Method	Test Results	
Tensile Strength	psi	ASTM D 638	376	
Elongation at Break	%	ASTM D 638	46	
Hardness	--	ASTM D 2240	62	
Tear Resistance	lbs/inch	ASTM D 624	379	
Compressive Strength	psi	ASTM D 695	1771.20	
5% Compressive Stress	psi	ASTM D 695	996.2	
5% Resilience	%	ASTM D 695	99.56	
Impact Resistance	ft-lb	Ball Drop	32° F	8.88
			70° F	10
Water Absorption	%	ASTM D 570	0.00	
Bond Strength	psi	ASTM C 882	262.68	

Ceva Crete

Ceva Crete Manufacturer's Data Sheet			
Property	Units	Test Method	Test Results
Compressive Strength	psi	ASTM D 695	4000
Bond Strength	psi	ASTM C-882	500
Tensile Strength	psi	ASTM D 638	950
Elongation at Break	% min.	ASTM D 638	150
Hardness		---	---
Brittleness by Impact	ft/lbs	---	7 +

Ceva Crete Test Results Summary				
Property	Units	Test Method	Test Results	
Tensile Strength	psi	ASTM D 638	1028	
Elongation at Break	%	ASTM D 638	63	
Hardness	--	ASTM D 2240	52.8	
Tear Resistance	lbs/inch	ASTM D 624	564	
Compressive Strength	psi	ASTM D 695	2791.52	
5% Compressive Stress	psi	ASTM D 695	1808.6	
5% Resilience	%	ASTM D 695	96.73	
Impact Resistance	ft-lb	Ball Drop	32° F	7.9
			70° F	10
Water Absorption	%	ASTM D 570	1.14	
Bond Strength	psi	ASTM C 882	620.52	

Wabo Crete II

WaboCrete II Manufacturer's Data Sheet

Property	Test Method	Test Results	
Tensile Strength	ASTM D 412	1000 psi	
Elongation at Break	ASTM D 412	200% min	
Hardness	ASTM D 2240	35 - 40	
Tear Resistance	ASTM D 624	100 lbs/inch	
Compressive Strength	ASTM D 695	2200 psi	
5% Compressive Stress	ASTM D 695	1200 psi	
5% Resilience	ASTM D 695	95%	
Impact Resistance	ASTM D 695	158° F	No Cracks
		32° F	No Cracks
		-20° F	No Cracks
Cure Time	Not listed	70-90° F	1-1.5 hr
		50-70° F	1.5-2 hr
		40-50° F	2-3 hr

WaboCrete II Test Results Summary

Property	Units	Test Method	Test Results	
Tensile Strength	psi	ASTM D 638	2128	
Elongation at Break	%	ASTM D 638	248	
Hardness	--	ASTM D 2240	52.8	
Tear Resistance	lbs/inch	ASTM D 624	582	
Compressive Strength	psi	ASTM D 695	1467.62	
5% Compressive Stress	psi	ASTM D 695	511.5	
5% Resilience	%	ASTM D 695	99.94	
Impact Resistance	ft-lb	Ball Drop	32° F	9.4
			70° F	10
Water Absorption	%	ASTM D 570	0.41	
Bond Strength	psi	ASTM C 882	648.08	

ProCrete NH

ProCrete NH Manufacturer's Data Sheet

Property	Units	Test Method	Test Results
Compressive Strength	psi	ASTM D 695	4200
Hardness		ASTM D 2240	50
Bond Strength	psi	ASTM D 638	500
Tensile Strength	psi	ASTM D 412	2250
Elongation at Break	%	ASTM D 412	60%
Tear Resistance	lb/in	ASTM D 624	200
Brittleness by Impact	ft-lbs	Ball Drop	10 +

ProCrete NH Test Results Summary

Property	Units	Test Method	Test Results
Tensile Strength	psi	ASTM D 638	1556
Elongation at Break	%	ASTM D 638	57
Hardness	--	ASTM D 2240	52.8
Tear Resistance	lbs/inch	ASTM D 624	566
Compressive Strength	psi	ASTM D 695	3209.67
5% Compressive Stress	psi	ASTM D 695	3059.3
5% Resilience	%	ASTM D 695	97.39
Impact Resistance	ft-lb	Ball Drop	32° F 5.2 70° F 7.2
Water Absorption	%	ASTM D 570	1.74
Bond Strength	psi	ASTM C 882	1140.32

ProCrete Plus

ProCrete Plus Manufacturer's Data Sheet			
Property	Units	Test Method	Test Results
Compressive Strength	psi	ASTM D 695	4350
Compressive Strength @ 5%	psi	ASTM D 695	3000
Hardness		ASTM D 2240	40
Bond Strength	psi	ASTM D 638	550
Tensile Strength	psi	ASTM D 412	1700
Elongation at Break	%	ASTM D 412	150% min
Tear Resistance		ASTM D 624	165
Brittleness by Impact	ft-lbs	---	7 +

ProCrete Plus Test Results Summary			
Property	Units	Test Method	Test Results
Tensile Strength	psi	ASTM D 638	1208
Elongation at Break	%	ASTM D 638	127
Hardness	--	ASTM D 2240	52.8
Tear Resistance	lbs/inch	ASTM D 624	641
Compressive Strength	psi	ASTM D 695	3059.72
5% Compressive Stress	psi	ASTM D 695	1120.9
5% Resilience	%	ASTM D 695	98.38
Impact Resistance	ft-lb	Ball Drop	32° F 5.6 70° F 9.3
Water Absorption	%	ASTM D 570	0.43
Bond Strength	psi	ASTM C 882	668.18

DelCrete

DelCrete Manufacturer's Data Sheet Binder and Aggregate			
Property	Test Method	Test Results	
Tensile Strength	ASTM D 412 (modified)	600 psi	
Elongation at Break	ASTM D 412 (modified)	25% min	
Hardness	ASTM D 2240	50	
Tear Resistance	ASTM D 624	100 lbs/inch	
5% Compressive Stress	ASTM D 695	800 psi	
5% Resilience	ASTM D 695	95% Min	
Impact Resistance	Tex-614-J (modified)	-20° F	> 10 ft.-lb No Cracks
Dry Bond Strength to Concrete, pli	ASTM C 190 (modified)	400, pli	
Wet Bond Strength to Concrete, pli	ASTM C 190 (modified)	250, pli	

Binder Only		
Property Original Properties 7 days @ 100° F	Test Method	Test Results
Tensile Strength	ASTM D 638	1500 psi
Tensile Stress	ASTM D 638	500, psi
Elongation at Break	ASTM D 638	200 Min
Hardness, Durometer D	ASTM D 2240	90±3 A

DelCrete Test Results Summary

Property	Units	Test Method		Test Results
Tensile Strength	psi	ASTM D 638		967.47
Elongation at Break	%	ASTM D 638		82
Hardness	--	ASTM D 2240		52.8
Tear Resistance	lbs/inch	ASTM D 624		456
Compressive Strength	psi	ASTM D 695		1839.21
5% Compressive Stress	psi	ASTM D 695		598.1
5% Resilience	%	ASTM D 695		98.92
Impact Resistance	ft-lb	Ball Drop	32° F 70° F	10 10
Water Absorption	%	ASTM D 570		0.55
Bond Strength	psi	ASTM C 882		414.20

Tron-Flex

Tron-Flex Manufacturer's Data Sheet			
Property	Units	Test Method	Test Results
Tensile Strength	psi	ASTM D 412	1500
Elongation at Break	% min.	ASTM D 412	250
Hardness		ASTM D 2240	85 ± 5

Tron-Flex Laboratory Testing Results				
Property	Units	Test Method		Test Results
Tensile Strength	psi	ASTM D 638		224.5
Elongation at Break	%	ASTM D 638		189.8
Hardness	--	ASTM D 2240		52.8
Tear Resistance	lbs/inch	ASTM D 624		151.6
Compressive Strength	psi	ASTM D 695		829.59
5% Compressive Stress	psi	ASTM D 695		564.4
5% Resilience	%	ASTM D 695		99.84
Impact Resistance	ft-lb	Ball Drop	32° F	9.5
			70° F	10
Water Absorption	%	ASTM D 570		0.26
Bond Strength	psi	ASTM C 882		256.45

APPENDIX E: FRESH FIELD DATA SHEETS

Elastomeric Concrete Research Field Trip Data

Fresh-Field Visits

Location	Date			Weather Conditions
	Month	Day	Year	
Charlotte - Harris Blvd. at Northlake Mall	11	2	2006	Sunny, Clear about 55ºF

Placement Description	Heated Aggregate?	Product
Initial Placement	Yes	Ply-Krete

Failure Removal Procedure:

Placement Procedure:

Workers sandblasted the area prior to placement occurring. Primer is also applied to this particular joint. Aggregate is heated according to manufacturer's instructions. Aggregate is placed in tumbler and heated using blow torch device. During placement, trowels are heated to ensure a smooth finish.

Other Comments:

Ply-Krete representatives present for demonstration with bridge construction employees. Workers had to be reminded to apply primer to blockout.

Figure E-1. Charlotte (Harris Blvd.) fresh-field data sheet

Elastomeric Concrete Research Field Trip Data

Fresh-Field Visits

Location	Date			Weather Conditions
	Month	Day	Year	
Raleigh - Buffaloe Rd. and E-540	1	24	2007	Sunny, slightly windy abou

Placement Description	Heated Aggregate?	Product
Failure/Replacement	Yes	Ply-Krete

Failure Removal Procedure:

Replacement not due to actual failure. Rollers traveled over joints and cracked the joint. Joint was removed in damaged areas and then replaced.

Placement Procedure:

Aggregate heated using blow torch device, which was hooked to a propane tank. Aggregate was then loaded in concrete mixer and heated with a blow torch. Heatiing makes for an easier finish, making it easier to work with.Trowels heated to precent clumping of material.

Other Comments:

Chris Harkins from B&G has used e.c. since 2000. Yet to replace any e.c. due to actual failure. Samples taken: 2" cube molds (3) and 3" x 6" cylinder molds (6)

Figure E-2. Raleigh (Buffaloe Rd.) fresh-field data sheet

Elastomeric Concrete Research Field Trip Data

Fresh-Field Visits

Location	Date			Weather Conditions
	Month	Day	Year	
Charlotte - I-77 at Northlake	4	26	2007	Partly cloudy, about 75ºF

Placement Description	Heated Aggregate?	Product
Initial Placement	Yes	Ply-Krete

Failure Removal Procedure:

Placement Procedure:

Cleaning joint by sandblasting. Using "Black Betty", does not contain silica dust. Heating trowels to increase workability. Aggregate also heated in tumbler. Aggregate heated to 130ºF, shot with heat gun.

Other Comments:

Two people talked to on site: Tom and Charles (foreman). Aggregate should not be heated above 180ºF. Spoke of failures setting up too quickly, and some staying soft which had to be cut out. Put primer where cut out and everything is able to bond back to itself. Charles talked about possible bridges to get coring samples from. (Rocky River and 49 - 2 bridges) (36th street - was set up and traffic was on in an hour or so.) (Rocky River and Plaza - 2 bridges at bottom of creek.) Also spoke about the effect of humidity on finish. Obtained cube specimens (6), and 3"x6" cylinder specimens.

Figure E-3. Charlotte (Northlake) fresh-field data sheet

Elastomeric Concrete Research Field Trip Data

Fresh-Field Visits

Location	Date			Weather Conditions
	Month	Day	Year	
Wilmington - Martin Luther King and McCra	4	29	2007	Night - About 60ºF

Placement Description	Heated Aggregate?	Product
Failure/Replacement	No	Pro-Crete NH

Failure Removal Procedure:

Angle was lost on edge of elastomeric joint due to spalling. Evazote seal has also come apart from the elastomeric concrete. One lane already completed, left hand lane to be replaced. Joint further up on same bridge will eventually need to be replaced. Failed joint is being sawed out. Jackhammer used to remove unwanted elastomeric concrete. Obtained samples of failed elastomeric concrete. Joint being completely cleaned for the new pour.

Placement Procedure:

Workers cleaned joint of old elastomeric concrete, now cleaning surface with air gun. Will now put in formwork, pour elastomeric and allow to set, eventually returning to replace Evazote seal. Workers decided to remove foam finish pad. Plywood being used as formwork. Stakes added to ensure proper spacing for new foam sealer pad. First batch of non-heat aggregate was heated. This led to that first batch setting up quicker than normal. All batches after this used non-heated aggregate as the product

Other Comments:

(3) - 2"x2"x2" cube samples obtained, (3) - 3"x6" cylinder samples obtained, Previous Evazote seal obtained, as well as removed elastomeric concrete joint.

Figure E-4. Wilmington (MLK) fresh-field data sheet

Elastomeric Concrete Research Field Trip Data

Fresh-Field Visits

Location	Date			Weather Conditions
	Month	Day	Year	
Denver - Railroad Bridge	5	21	2007	Sunny, Clear about 85ºF

Placement Description	Heated Aggregate?	Product
Initial Placement	No	Pro-Crete NH

Failure Removal Procedure:

Placement Procedure:

Sandblasting prior to placement. Primer applied with rubber gloves to blockout and steel armor. Heated trowels used during installation.

Other Comments:

Specimens obtained: cube specimens (6), impact resistance and tensile splitting specimens (6 each), slant shear specimens (3)

Figure E-5. Denver (RR) fresh-field data sheet

Elastomeric Concrete Research Field Trip Data

Fresh-Field Visits

Location	Date			Weather Conditions
	Month	Day	Year	
Denver - New 16 off 150 (Structures 9 &10)	6	6	2007	Sunny, Clear about 80ºF

Placement Description	Heated Aggregate?	Product
Initial Placement	No	Pro-Crete NH

Failure Removal Procedure:

Placement Procedure:

Sandblasting prior to placement. Primer applied with rubber gloves to blockout and steel armor. Heated trowels used during installation.

Other Comments:

Specimens obtained: cube specimens (6), impact resistance and tensile splitting specimens (6 each), slant shear specimens (3)

Figure E-6. Denver (9&10) fresh field data sheet

Elastomeric Concrete Research Field Trip Data

Fresh-Field Visits

Location	Date			Weather Conditions
	Month	Day	Year	
Denver - New 16 off 150 (Structures 11&12)	6	7	2007	Sunny, Clear about 80ºF

Placement Description	Heated Aggregate?	Product
Initial Placement	No	Pro-Crete NH

Failure Removal Procedure:

Placement Procedure:

Sandblasting prior to placement. Primer applied with rubber gloves to blockout and steel armor. Heated trowels used during installation.

Other Comments:

Specimens obtained: cube specimens (6), impact resistance and tensile splitting specimens (6 each), slant shear specimens (3) After speaking with one of the foreman on the project, workers placed a joint containing elastomeric concrete after a heavy rain. Premature bonding issues may result.

Figure E-6. Denver (11&12) fresh-field data sheet

Elastomeric Concrete Research Field Trip Data

Fresh-Field Visits

Location	Date			Weather Conditions
	Month	Day	Year	
Clayton 1	7	24	2007	Sunny, Clear about 75ºF

Placement Description	Heated Aggregate?	Product
Initial Placement	No	E-Crete #57

Failure Removal Procedure:

Placement Procedure:

Sandblasting prior to placement. Primer applied with rubber gloves to blockout and steel armor. Product is not heated. There is some difficulty due to change in elevation from gutterline to gutterline.

Other Comments:

Specimens obtained: cube specimens (6), impact resistance and tensile splitting specimens (6 each), slant shear specimens (3)

Figure E-7. Clayton (1) fresh field data sheet

Elastomeric Concrete Research Field Trip Data

Fresh-Field Visits

Location	Date			Weather Conditions
	Month	Day	Year	
Clayton 2	7	25	2007	Sunny, Clear about 75ºF

Placement Description	Heated Aggregate?	Product
Initial Placement	Yes	Ply-Krete

Failure Removal Procedure:

Placement Procedure:

Sandblasting prior to placement. Primer applied with rubber gloves to blockout and steel armor. Aggregate is heated.

Other Comments:

Specimens obtained: cube specimens (6), impact resistance and tensile splitting specimens (6 each), slant shear specimens (3) Foreman speaks about using mixed binder as primer within blockout, rather than actual primer that is traditionally supplied with elastomeric concrete product packages.

Figure E-8. Clayton (2) fresh field data sheet

Elastomeric Concrete Research Field Trip Data

Fresh-Field Visits

Location	Date			Weather Conditions
	Month	Day	Year	
Clayton 3	7	26	2007	Sunny, Clear about 80ºF

Placement Description	Heated Aggregate?	Product
Initial Placement	Yes	Ply-Krete

Failure Removal Procedure:

Placement Procedure:

Sandblasting prior to placement. Primer applied with rubber gloves to blockout and steel armor.

Other Comments:

Specimens obtained: cube specimens (6), impact resistance and tensile splitting specimens (6 each), slant shear specimens (3) Same foreman as Clayton 2 site.

Figure E-9. Clayton (3) fresh field data sheet

Elastomeric Concrete Research Field Trip Data

Fresh-Field Visits

Location	Date			Weather Conditions
	Month	Day	Year	
Marshall	8	16	2007	Sunny, Clear about 80ºF

Placement Description	Heated Aggregate?	Product
Initial Placement	Yes	Pro-Crete Plus

Failure Removal Procedure:

Placement Procedure:

Sandblasting prior to placement. Primer applied with rubber gloves to blockout.

Other Comments:

Specimens obtained: cube specimens (18), impact resistance and tensile splitting specimens (18 each), slant shear specimens (18). Samples obtained from 3 different joints within bridge. One samples worth of material never fully cured in the lab.

Figure E-10. Marshall (1-3) fresh-field data sheet

Elastomeric Concrete Research Field Trip Data

Fresh-Field Visits

Location	Date			Weather Conditions
	Month	Day	Year	
Greensboro	9	29	2007	Sunny, Clear about 80ºF

Placement Description	Heated Aggregate?	Product
Initial Placement	Yes	Ply-Krete

Failure Removal Procedure:

Placement Procedure:

Sandblasting prior to placement. Primer applied with rubber gloves to blockout. Heated agrgegate finsihed with heated trowels.

Other Comments:

Specimens obtained: cube specimens (6), impact resistance and tensile splitting specimens (6 each), slant shear specimens (6).

Figure E-11. Greensboro fresh field data sheet

APPENDIX F: REVISED MATERIAL SPECIFICATIONS

ELASTOMERIC CONCRETE

Description

Elastomeric concrete is a mixture of a two-part polymer consisting of polyurethane and/or epoxy, and kiln-dried aggregate. Have the manufacturer supply it as a unit. Use the concrete in the blocked out areas on both sides of the bridge deck joints as indicated on the plans.

Materials

Provide materials that comply with the following minimum requirements at 14 days (or at the end of the specified curing time).

ELASTOMERIC CONCRETE PROPERTIES	TEST METHOD	MINIMUM REQUIREMENT
Compressive Strength, psi (MPa)	ASTM D695	2200 (15.2)
5% Deflection Resilience (%)	ASTM D695	95
Splitting Tensile Strength, psi (MPa)	ASTM D3967	625 (4.31)
Bond Strength to Concrete, psi (MPa)	ASTM D882 (D882M)	450 (3.10)
Durometer Hardness	ASTM D2240	50

BINDER PROPERTIES (without aggregate)	TEST METHOD	MINIMUM REQUIREMENT
Tensile Strength, psi (MPa)	ASTM D638	1000 (6.89)
Ultimate Elongation (%)	ASTM D638	150
Tear Resistance, lb/in (kN/m)	ASTM D624	200 (34.9)

In addition to the requirements above, use elastomeric concrete that also resists water, chemical, UV, and ozone exposure and withstands temperature extremes.

Elastomeric concrete materials requiring preheated aggregates are not allowed.

Prequalification

Manufacturers of elastomeric concrete materials shall submit samples (including aggregate, primer, and binder materials) for prequalification to: North Carolina Department of Transportation, Materials and Tests Unit, 1801 Blue Ridge Road, Raleigh, NC 27607.

The submitted binder (a minimum volume of 1 gallon) and corresponding aggregate samples will be evaluated for compliance with the minimum requirements specified herein. Materials satisfying all of these requirements will be prequalified for up to one year. Before the end of this period, or whenever changes are made to components, formulation or installation procedures, new product samples shall be submitted to renew the material's prequalification.

Manufacturer's Responsibility

Furnish a manufacturer's certification verifying that the materials satisfy the above requirements, including a valid prequalification certificate provided by NCDOT.

Require a manufacturer's representative to be present on site during the installation of the elastomeric concrete to ensure compliance with the manufacturer's recommendations, including, but not limited to: weather conditions (ambient temperature, relative humidity, precipitation, wind, etc...), concrete deck surface preparation, binder and aggregate mixing, primer application, elastomeric concrete placement, curing conditions, and minimum curing time before joint exposure to traffic.

Field Sampling

Provide additional production material to allow freshly mixed elastomeric concrete to be sampled for acceptance. A minimum of six 2 inch cube molds and three 3x6 inch cylinders will be taken by the Department per joint or for each day's production. Compression, splitting tensile, and durometer hardness testing will be performed for material acceptance. Materials not meeting the requirements listed above shall be removed and replaced at no cost to the Department.

Basis of Payment

No separate payment will be made for elastomeric concrete. The lump sum contract price bid for "Evazote Joint Seals" will be full compensation for furnishing and placing the Elastomeric Concrete.