Evaluation of Asphaltic Expansion Joints

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16. Abstract

Asphaltic expansion joints, commonly referred to as Asphaltic Plug Joints (APJs), provide a relatively low cost joint option for bridges with approximately one-inch of movement. However, failure of these joints can expose the underlying structural bridge components to water and salts that can lead to corrosion. In New England, many of these joints have reached or nearing the end of there anticipated service life. The objectives of the research presented herein is to identify reasons of joint failure, identify the useful life span, evaluate the overall costs, identify flaws in installation and maintenance methods, and establish recommendations regarding initial design considerations (skew, expansion, etc.). Field inspections were conducted on 64 in-service APJs in five New England states to determine predominate materials distresses leading to failure. These distresses were determined to be debonding, cracking and rutting. Lab testing was conducted on virgin binder and aggregate as well as cores of in-service APJ material. Each binder was tested to determine its Superpave Performance Grade (PG) and evaluate its resiliency. The aggregates were tested to determine their gradation and amount of fines. The core material was extracted to determine gradation and approximate binder content. This testing information, along with a comprehensive review of existing specifications, was used to develop design guidelines, a design specification, an installation specification, and a repair specification for use in New England.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimetres	mm
ft	feet	0.305	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km
		AREA		
in^2	square inches	645.2	millimetres squared	mm^2
ft^2	square feet	0.093	metres squared	m^2
yd^2	square yards	0.836	metres squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometres squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	mililitres	mL
gal	gallons	3.785	Litres	L
ft^3	cubic feet	0.028	metres cubed	m^3
yd^3	cubic yards	0.765	metres cubed	m^3

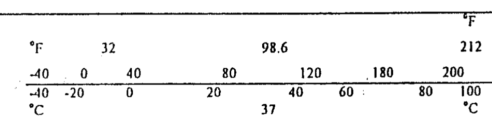
NOTE: Volumes greater than 1000 L shall be shown in m^3

Symbol	When You Know	Multiply By	To Find	Symbol
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
^oF	Fahrenheit temperature	5(F-32)/9	Celcius temperature	^oC

* SI is the symbol for the International System of Measurement

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimetres	0.039	inches	in
m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi
		AREA		
mm^2	millimetres squared	0.0016	square inches	in^2
m^2	metres squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometres squared	0.386	square miles	mi^2
		VOLUME		
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m^3	metres cubed	35.315	cubic feet	ft^3
m^3	metres cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C+32	Fahrenheit temperature	°F



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LIST OF ACRONYMS

AAT = Advanced Asphalt Technologies
APJ(s) = Asphaltic Plug Joint(s)
APT = Accelerated Pavement Tester
BAM = "German Materials Lab"
CT = Connecticut
DOT(s) =Department of Transportations(s)
EMPA = "Swiss Materials Science and Technology Institution"
FHWA = Federal Highway Administration
HCA = Hot Compressed Air
JMF = Job Mix Formula
LTPP = Long Term Pavement Performance
MA = Massachusetts
NH = New Hampshire
PG = Performance Grade
RI = Rhode Island
VT = Vermont

1.0 INTRODUCTION

Asphaltic expansion joints, more commonly referred to as Asphaltic Plug Joints (APJs), have been used in New England since the early 1990's. These joints have many benefits including relatively low cost and less disruption to traffic during installation as compared with other joint types. Conversely APJs do have some decided disadvantages as well including sensitivity to temperature, bridge movement, and heavy traffic loading.

Many of these APJs used in New England are now failing or reaching the end of their projected service life. The performance of these joints has varied substantially, resulting in some New England states adopting them for continued use while others are limiting their use completely.

The research presented here will evaluate the APJs performance in relation to the conditions present in New England. More specifically this project will explore the following objectives:

- Identify the reasons for joint failure
- Identify useful life span
- Identify flaws in installation and maintenance
- Identify and evaluate the key material properties
- Estimate overall costs for installation and maintenance
- Evaluate curb and sidewalk treatments
- Conduct survey of other state DOT's regarding APJs
- Perform field inspections on existing APJs in service

The end result of these objectives will be culminated to develop draft specifications for APJ use in New England.

1.0.1 APJ System Overview

A typical APJ system is composed of several components. A typical cross section of an APJ system is shown in Figure 1 below:

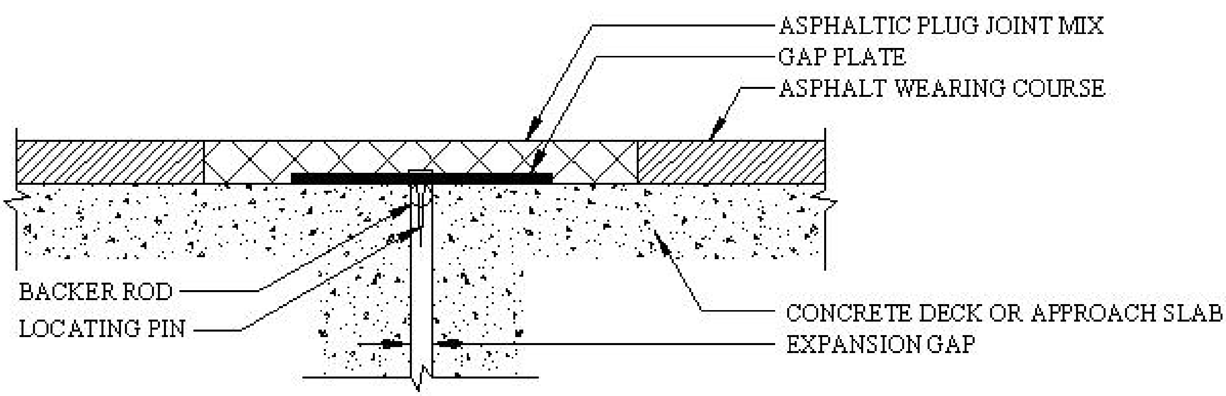


Figure 1: Typical APJ Cross Section

Each component performs a critical function for the overall performance of the joint. The backer rod serves as a dam to prevent liquid binder from flowing into the expansion gap during the tanking process (described later), and is held in place with locating pins that extend through the gap plate. The gap plate prevents the APJ mixture from being "pushed" or compacted into the expansion gap during when loads pass over the joint. Finally the APJ mixture itself is the most integral part of the system. It compensates for the contraction and extension of the bridge during temperature changes. Unlike normal Hot-Mix Asphalt (HMA) which is used for the wearing course (pavement overlay), the APJ mix is composed of a special blend of aggregates combined with a polymer modified binder that enable the material to be more resilient during temperature changes.

2.0 LITERATURE REVIEW

Limited research has been conducted in the United States regarding APJs. A survey conducted by Umass Dartmouth as part of this study showed that 67% of the state DOT officials surveyed do not currently use APJs and 33% do not plan on using APJs in the foreseeable future. Coincidentally, a comprehensive literature review conducted by Umass Dartmouth determined that the majority of APJ research is currently being conducted in Europe. More specifically the Swiss Federal Roads Office (ASTRA) and German Road Authorities have undertaken extensive studies into APJ material testing and behavior. The UK Bridge Association has developed a set of APJ specifications that deal with QC/QA practices. These sources combined with other conventional sources were used to compile the current state of practice for the APJ.

2.1 Failure Modes – Material Distress

APJs have many advantages over other joint systems, such as relatively easy installations, easy to repair, and relatively inexpensive (1). However, the APJs unique composition also has some decided disadvantages, most notably the fact that the material behaves very differently as a function of temperature. Most authors noted that the APJ mixture acts "stiff" or "brittle" at colder temperatures and is "soft" or "pliable" at warm temperatures (2,1). This material phenomenon makes the joint more sensitive to distress and more likely to fail.

APJs are subject to many internal and external phenomena that can cumulatively lead to the failure of the joint. Failure is reached when the APJ system fails to be impervious, thus allowing water and associated contaminants, like salt, to enter and/or pass through the joint into the underlying superstructure. This process is commonly referred to as "leaking" or "leakage". During leaking, water can infiltrate through the joint and cause accelerated corrosion to integral parts of the structure and substructure, thus decreasing the bridges service life and increasing maintenance costs. The entry points for water infiltration into and through the APJ vary.

Defining the causes and modes of water entry into the APJ are integral in defining the required material properties and improvements to the APJ system as a whole. No one distress has been defined as the identifiable cause for joint failure, rather it appears that many different distress working in combination or a severe occurrence of one particular distress leads to failure.

2.1.1 Debonding

Debonding, also commonly referred to as separation, is a material adhesion failure between the APJ and adjacent pavement interface as shown in Figure 2.

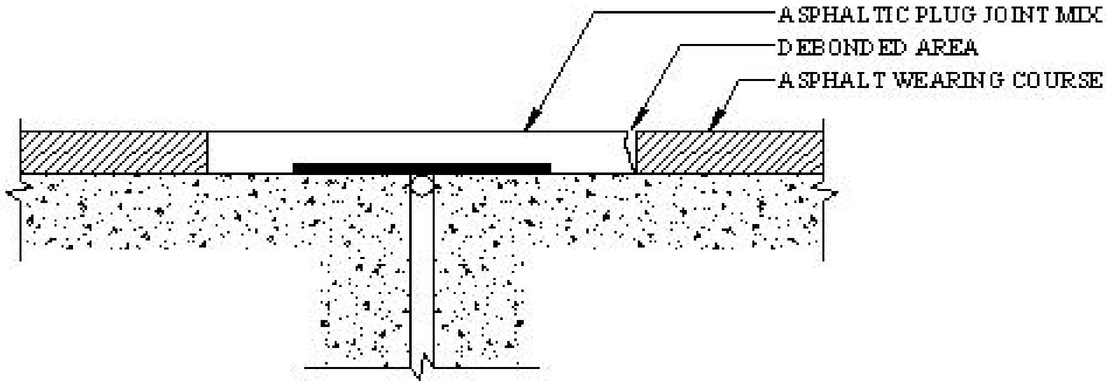


Figure 2: Typical Debonding of APJ

Many theories exist as to the causes of debonding. The work of Partl et al. suggests debonding is caused by water intrusion. Specifically if the pavement directly adjacent to the APJ has a high void content, 6% or higher, it was theorized that water will build up at the APJ/pavement interface because the APJ mixture is impervious. This collection of water would then sit at this interface and, unless it drains out, will freeze in the winter and expand the material at the interface thus causing debonding. The authors suggested that the tanking procedure completed on the vertical faces of the pavements abutting the APJ is not enough to prevent debonding and water intrusion. It was suggested that adding dense pavement adjacent to the APJ on each side as a better means of mitigating the debonding effects (3).

Another theorized cause of debonding was linked to the use of primers on the vertical wearing course pavement faces. The solvents in the primer may not fully evaporate or be absorbed by the wearing course, thus leading to weakened adhesion strengths at the APJ to wearing course interface (3).

There are currently no means to quantify the degree and amount of this material distress, however there has been some experimental tests aimed to better specify APJ in regards to debonding susceptibility. In a 1999 report, The University of Wyoming conducted normal bond (load applied perpendicular to bond plane) test using a modification of ASTM D897 (1). The results of these test showed that the normal bond strength was dependent on temperature. More recently in 2002, work was conducted by Partl et. al. for the EMPA (Swiss Federal Laboratories for Materials Testing and Research) that involved coring the APJ/Pavement interface. The specimens were placed in a special device that pulled each side of the core independently at a rate of 100mm/min (0.3 ft/min), thus testing the adhesion strength between the interfaced materials. From these tests the EMPA recommended that a minimum pull of strength of 1.5 N/mm^2 (218 psi) between the APJ and wearing course should be required (3).

2.1.2 Cracking (Splitting in Tension)

Full depth longitudinal and transverse cracks within the APJ create direct paths for water to enter into the joint and cause leakage. The researched conducted by University of Wyoming suggests that cracking is caused by the material reaching excessive strains and or stress induced by joint motion, material fatigue, and thermal stresses exceeding the materials capabilities at low temperatures (1).

From lab test conducted on APJ material at the University of Wyoming it was determined that the material is very stiff at low temperatures thus leading to cold temperature cracking. Also test were conducted to establish the glass transition temperature of the APJ material. At this temperature the material becomes brittle with little plastic deformation. Below this temperature, thermal induced stresses alone may be enough to cause cracking (1). These phenomena are very important to quantify and understand in the New England states due to length and severity of the winter seasons.

No means exist currently to quantify the extent and severity of cracking within an APJ. However, the FHWA Distress Identification manual does have a means to qualify and quantify cracking distresses in normal pavements. Definition of the severity of the crack is based on the mean width of the crack from which it can be classified as Low, Moderate, or High (4).

2.1.3 Reflective Cracking

Reflective cracking occurs within an APJ differently than initially expected. Since the gap plate covers the expansion gap, the reflective cracking does not occur over this gap rather the crack develops at the edges of gap plate. It is theorized from finite element analysis (FEA) that these edges of the gap plate are an area of localized stress (5). This stress is relieved through the formation of a reflective crack. Also if the gap plate does not lie perfectly flat the plate will "rock" back and forth perhaps also inducing reflective cracking at the edges of the plates.

No means exist currently to quantify the extent and severity of reflective cracking within an APJ. The FHWA Distress Identification manual does offer the same means of quantifying and qualifying the severity of reflective cracking as previously noted for general cracking.

2.1.4 Rutting

Rutting is a surface deformation defined as "…a longitudinal surface depression in the wheelpath. It may have associated transverse displacement" (4). In an APJ rutting occurs during periods of warm weather, mainly during the summer. Because the APJ material is soft and pliable at warmer temperatures it is capable of expanding as the bridge thermally expands, however it also makes it highly susceptible to rutting in the wheelpaths (1). This distress may not directly lead to leakage, but does not allow the APJ to provide a smooth transition between pavement overlays and may propagate more severe distresses, like spalling, that can result in joint failure.

No means exist currently to quantify the extent and severity of rutting within an APJ. The FHWA Distress Identification manual does outline a procedure to quantify rutting by measuring the rut depth at selected intervals. No specific means of categorizing the severity of the distress exists in this manual (4).

Research has been conducted regarding the rutting potential of APJ. In the 1999 report of the University of Wyoming, APJ material was tested utilizing an Accelerated Pavement Tester (APT) known as the Georgia Wheel Loader. Tests were conducted at 46ºC (110ºF) for 8,000 cycles with a maximum allowable rut depth of 7mm (0.3 in). Each sample failed prior to reaching 8,000 cycles with all meeting the maximum rut depth by 4,000 cycles (1).

In the 2002 report, the EMPA conducted rutting tests using a different APT known as the Model Mobile Load Simulator (MMLS). The tests were conducted at a temperature of 35ºC (63ºF), speed of 0.8 m/s (1.8 mph), load of 2.1 kN (0.5 kips), and a tire pressure of 600 kPa (87 psi). All the samples failed prior to the end of the test; with each reaching the 10mm (0.4 inches) maximum allowable rut depth by 56,400 passes (3).

2.1.5 Raveling

Raveling was noted during the APJ field inspections, further explained in Section 4.0, conducted by Umass Dartmouth as part of this research. There were no sources that had mentioned this type of distress, most likely because it may not directly cause joint leakage. However over time it may prevent the joint from providing a smooth transition over the joint, lead to more severe distresses like spalling, and may create an area for cracks to form. This could be a cold or warm weather phenomena.

Raveling is a surface defect defined as "…Wearing away of the pavement surface caused by the dislodging of aggregate particles and loss of asphalt binder. Raveling ranges from loss of fines to loss of some coarse aggregate and ultimately to a very rough and pitted surface with obvious loss of aggregate" (4).

Like the majority of other distresses there are no means to quantify the severity and distress within an APJ. The FHWA Distress Identification manual also does not offer much information, but it does note, "The presence of raveling indicates potential mixture related performance problems" (4).

2.1.6 Shoving/Pushing

Shoving is a surface deformation defined as "…a longitudinal displacement of a localized area of the pavement surface. It is generally caused by braking or accelerating vehicles, and is usually located on hills or curves, or at intersections. It may also have associated vertical displacement" (4).

Again no literature had previously mentioned shoving/pushing as a failure mode for an APJ. However, there were many instances of shoving/pushing in the field inspections conducted for this research. Shoving/pushing will affect the ability of the APJ to provide a smooth transition over the joint and may propagate other distresses that can lead to joint failure. This is predominately a warm weather phenomena.

The FHWA Distress Identification manual offers that the severity of this distress can be defined by it's effect of the ride quality of a pavement and can be quantified by measure the total area in square meters that it effects (4). No specific information in regards to APJ was available.

2.1.7 Segregation

Segregation is a concentration of either coarse or fine materials in one particular area within a paved mat. Asphalt mixes that have this distress do not conform to the gradation and binder requirements required during final production (6). APJs suffer from random segregation induced by poor mixing and installation procedures resulting in a non-uniform distribution of aggregate and binder throughout the APJ. This non-uniform mix will not exhibit the same performance characteristics of a uniformly distributed mix.

This non-uniformity can lead to areas of weakness in the APJ that can lead to any of a number of more severe distresses including: debonding, rutting, and cracking. Each of these can ultimately lead to leaking. Given the unique geometry and material composition of the APJ, conventional methods of determining segregation with a density gauge will not work. Since the APJ material is placed in a relatively thin lift, a visual inspection may be the best method of determining segregation.

2.1.8 Bleeding (Track Out)

Bleeding is a surface defect defined as "…Excess bituminous binder occurring on the pavement surface, usually found in the wheel paths. May range from a surface discolored relative to the remainder of the pavement, to a surface that is losing surface texture because of excess asphalt, to a condition where the aggregate may be obscured by excess asphalt possibly with a shiny, glass-like, reflective surface that may be tacky to the touch." (4) The FHWA Distress Identification manual also notes "The presence of bleeding indicates potential mixture related performance problems" (4).

For the purposes of this quantification and definition for this research, and corresponding field inspections, the bleeding distress was combined with another distress called track out. Track out is loosely known in the industry as the displacement or dragging of the APJ mixture from the joint by traffic. Since this distress has no formal definition, and occurrences of bleeding were noted at most of the track out locations during field inspections, the two distresses were combined together as bleeding.

This distress was noted during the Umass Dartmouth field inspections and at one joint in particular was severe. In this case the binder materials was flowing from the joint being dragged by passing traffic. Occurrences of this distress can once again will prevent a smooth joint transition and may propagate further distresses. It is believed that this type of distress is a warm weather phenomena.

Like the majority of other distresses there are no means to quantify the severity and extent of bleeding or track out within an APJ.

2.1.9 Other

Other distresses noted during the Umass Dartmouth field inspections are described below:

Polished Stone – A surface defect defined as "Surface binder worn away to expose aggregate" (4). Alone will not cause failure of APJ, rather is a material distress that may eventually lead to more severe distresses.

Spalls – Displacement of large portions or chunks of APJ material from the joint. Likely caused by a combination or severe occurrence of any of the previously noted distresses.

2.2 Joint Failure Modes – Other

In the last section, the causes of APJ failure due to material distress were explored. In this section, other considerations that may lead to APJ failure will be presented including APJ geometry, temperature, and installation procedures.

The UK Bridge Association lists the following items to be considered when choosing an APJ for use on bridge (7):

- Traffic Flow
- Speed Limit
- HGV Count (Similar to AADT)
- Normal Incidence of Stationary Traffic
- Working Temperature Range
- Radius of Any Bend
- Maximum Gradient
- Maximum Skew Angle
- Installation Depth
- Installation Width
- Installation Length

Any number of these factors can play a significant role in the performance and life of an APJ.

2.2.1 Movements and Temperature

The primary function of an APJ is to cover the expansion gap of a bridge and remain watertight. Fulfilling this requirement is difficult when taking into account that a bridge will expand and contract depending on the ambient temperature (i.e. bridge expands in the summer and contracts in the winter). Hence the APJ material must be able to expand and contract with the bridge.

In the UK, a typical APJ is required to be functional within a temperature range of -25ºC (-13ºF) to +45ºC (+113ºF) (3). In the United States, New England in particular, the seasonal temperatures can vary greatly from north to south. The National Oceanic and Atmospheric Administration (NOAA) keeps records of the temperature data for each state and region. In New England, the average seasonal temperatures from 1971-2000 were as shown in Table 1 below (8):

State	Fall Season	Winter Season	Spring Season	Summer Season	Average Annual
Connecticut	51.2ºF (10.7ºC)	28.5ºF (-1.9ºC)	47.3ºF (8.5ºC)	69.2ºF (20.7ºC)	49.0ºF (9.4ºC)
Maine	44.2ºF (6.8ºC)	16.8ºF (-8.4ºC)	39.1ºF (3.9ºC)	63.7ºF (17.6ºC)	41.0ºF (5.0ºC)
Massachusetts	50.3ºF (10.3ºC)	27.4ºF (-2.6ºC)	45.7ºF (7.6ºC)	68.0ºF (20ºC)	47.9ºF (8.8ºC)
New Hampshire	46.3ºF (7.9ºC)	21.1ºF (-6.1ºC)	42.4ºF (5.8ºC)	65.5ºF (18.6ºC)	43.8ºF (6.6ºC)
Rhode Island	53.1ºF (11.7ºC)	31.4ºF (-0.3ºC)	47.0 ºF (8.3ºC)	68.8ºF (20.4ºC)	50.1ºF (10.1ºC)
Vermont	45.7ºF (7.6ºC)	19.4ºF (-7.0ºC)	41.5ºF (5.3ºC)	65.1ºF (18.4ºC)	42.9ºF (6.1ºC)

Table 1: Average Seasonal Temperatures from 1971-2000 for the New England States

Although pertinent, the seasonal temperatures only represent a statistical average of the temperature range. The temperature extremes at the bridge joint location are also crucial in understanding the anticipated bridge movement. As part of the Long-Term Pavement Performance (LTPP) project sponsored by the Federal Highway Administration (FHWA), pavement distresses were measured at selected tests sites in the United States and Canada. Included in this research was measurement of the daily maximum and minimum air temperatures at selected sites. These measurements do not necessarily accurately reflect the temperature extremes over the entire state, but do provide an accurate depiction of the varying extremes from state-to-state. For the New England States, the following daily extremes were measured as shown in Table 2 below (9):

State	Data Collection Period	Low Temperature Extreme	High Temperature Extreme
Connecticut	1994-1997	-20.8ºC (-5.4ºF)	34.0ºC (93.2ºF)
Maine	1994-1997	-36.6ºC (-33.9ºF)	36.0ºC (96.8ºF)
Massachusetts	1994-1997	-24.1ºC (-11.4ºF)	35.2ºC (95.4ºF)
New Hampshire	1994-1997	-30.9ºC (-23.6ºF)	36.2ºC (97.2ºF)
Rhode Island	N/A	N/A	N/A
Vermont	1994-2003	-38.5ºC (-37.3ºF)	36.3ºC (97.3ºF)

Table 2: Daily Extreme Temperatures for the New England States

From the data it can be seen that there is significant variation from the northern to the southern New England states. Also, there is a large gap between the seasonal averages stated before and the extremes noted here. For the purposes of the APJ design, the temperature extremes should be evaluated when calculating the anticipated bridge movement.

Bridge joint movement can be either horizontal or vertical. Horizontal movements are considered quasi-static, happening slowly over time and are mainly induced by thermal contraction and expansion (5). The forces induced on the APJ during this type of movement are considered to be far less than the dynamic forces from traffic loading (5). Vertical movements can be caused by dynamic loading and end beam rotation.

No consensus exists between authors on the applicable horizontal and vertical movement capacity of the APJ. In the UK, the APJ is expected to maintain -12.5 mm (-1/2 inch) to +25 mm (+1 inch), or a total movement capacity of 37.5 mm (1-1/2 inches) (3). Other authors state that horizontal movements of 25 mm (1 inch) (10), ± 20 mm (0.8 inches) set at mean (7), and less than 50 mm (2 inches) (1) are the limit. The vertical movement capacity required in the UK is a maximum of 5 mm (0.2 inches) (3). Only one other author mentioned vertical movement and stated that 2 mm (0.08 inches) is the limit. It is clear that there is no agreement on the functional movement limits of an APJ either in respect to horizontal or vertical movements.

2.2.2 Geometric Considerations

There are many geometric considerations and limitations involved with an APJ because of the unique nature of the material. The following should, at a minimum, be considered prior to selecting an APJ for use:

- Installation Depth
- Installation Width
- Installation Length
- Skew Angle

An APJ with limited or excessive thickness can pose a concern for joint failure. Because of the APJs unique material composition, a thin joint might be susceptible to material failure like cracking, debonding, and spalling in cold weather. Conversely, if the APJ is too thick it may be more susceptible to rutting and shoving in hot weather. Again there is no real agreement on what the minimum and maximum joint depths are required. One source recommended a joint depth of a minimum depth of 75 mm (3 inches) and a maximum of 100 mm (4 inches) (10). Another offered a joint depth range from 70 mm (2-3/4 inches) to 160 mm (6-1/4 inches) (3).

The joint width must be sufficient to allow room for thermal expansion and contraction without letting the gap plate hit the abutting wearing course during this process. If the gap plate does end up hitting the wearing course on either side of the joint, the joint may fail and the wearing course may be damaged as well. There appears to be a bit more consistency between authors on the size of the joint width. Joint widths are typically no less than 500 mm (20 inches) (3, 10). One author did note a high-end maximum of 750 mm (29-1/2 inches).

Joint length and skew angle may also be an area of concern when considering using an APJ. However, no authors have specified any limitations on these parameters to date.

2.2.3 Curb Intersections

The expansion gap of a bridge does not terminate at the curb, rather it continues through any curb and/or sidewalk. Similarly the bridge joint waterproofing and expansion gap must continue over its entire length, including the curb area. The EMPA research noted that these curb areas might present more problems than the traffic lane (3). The waterproofing in these areas normally consists of sealant compatible with the surrounding substrate and tooled on the vertical and horizontal faces of the curb. If this sealant separates from the substrate or fails in any manner, the curb areas will leak and may cause damage to the underlying substructure, similar to leakage through the APJ.

Not much information is available on the design of the joint system at the curb. In the UK, the curb expansion gap is required to be equivalent and directly in line with the bridge expansion gap (7). Another author suggest that the APJ from the bridge should be placed the full width of the bridge and the curb placed on top (3).

2.2.4 Materials

Varied criteria and research exist for the acceptance and use of the materials that constitute an APJ system.

Most authors agree that the aggregate used in an APJ system should be Basalt, Gabbro, or Granite (7, 10). Other types of aggregates were also noted including Delerite and Grit Stone (7, 10). The nominal maximum aggregate size (NMAS) of the aggregate is another area for discussion as one author notes that it should be 12.5 mm for depths up to 75 mm (10) whereas another states that the maximum size is 22 mm (3). The gradation of the aggregate is suggested to be gap graded, thus yielding larger voids in mineral aggregate (VMA) allowing for a larger asphalt content (1). Most agree that the aggregate must be double washed and dried prior to delivery to the site and many recommend that it should be placed into pre-weighed bags (7, 11). Perhaps the least evaluated property of the aggregates is related to temperature. One author notes that the heating of the aggregate during install is critical. More specifically, based on testing, if the aggregate temperature is too low there will be an increase in the air voids of the mix. If the temperature is too high, the adhesion between the binder and the aggregate may be affected as well as possible damage to the polymers in the binder (3).

The binder for an APJ has also been discussed among authors, however none really offer any new insight into its mechanistic properties. Some random thoughts regarding binder are that the binder will lose ductility as it ages (1); binder should be rubberized, polymer modified, or blend of bitumen with Styrene Butadiene Rubber (SBR) and each should have different material criteria (7); binder testing needs to be performed on the binder by an independent testing facility (11); binder testing should be performed before and during construction as well as 2 and 5 years post construction; and various certificates of compliance should be supplied for the binder prior to construction.

Little information exists on the requirements for the backer rod used in an APJ system. One author states that the backer rod shall be 150% of joint opening and have a density of 25 to 30 kg/m^3 (10).

The gap plate has been noted as aluminum, mild steel, and weldable structural steel with or without corrosion protection (7, 10). The size and shape of these plates were mainly noted as 6mm (1/4 inch) thick and 200 mm (8 inches) wide with varying lengths (11, 10). The hole locations were noted at every 300 mm (12 inches) on center (11, 10) secured with locating pins comprised of 16d common nails (11). One author also noted the use of flashing above the gap plate as a membrane to prevent water intrusion (7).

Caulking for curbs was rarely noted, however in its only notation it was recommended that the caulking be heat resistant enough to withstand maximum safe heating temperature of the binder.

2.2.5 Installation Methodology

Poor or inconsistent installation practice in many ways can lead to failure of an APJ. Many of these types of joints are installed not by the manufacturer, but rather an independent company that may or may not receive training from the manufacturer regarding the intricacies of the joint system. In a series of field installations, one author noted that the construction procedures were not consistent with the manufacturers specifications or between independent work crews (3). Results have shown that APJ performance can be improved if the installation is completed by well-trained teams (3). Installation issues can also arise from unclear and incomplete installation documents or lack of documents on-site (3). Material inconsistency from different sub lots can also hinder installation and joint performance (3). To address some of these concerns, some general guidelines have been suggested to ensure better installation:

- Require a technically competent manufacturer's representative on site during installation (11).

- Allow only approved operatives to install joints. Approved operatives must be issued a certificate of training and it must be renewed less than every three years (7).

- Require the manufacture to provide evidence of 5,000 linear feet of APJ with at least two years of satisfactory performance in conditions similar to the proposed site conditions (11).
- Install joint at temperatures between 5ºC (41ºF) and 35ºC (95ºF)with no inclement weather forecast for the day (10).

Each APJ system installation consists of several steps that are common to all manufacturers. They are as follows:

- Removal of existing joint or pavement
- Cleaning of joint
- Tanking of joint
- Installation and compaction of APJ mixture
- Application of finish coat (Finish Dressing)

The fist step in the installation process involves removal of existing joint or pavement. This material should be cut with a dry-saw as opposed to a wet saw, since the wet saw may introduce water into the new joint system. The cut should be deep enough to sufficiently remove the existing pavement. The depth of the cut can be established by drilling a pilot hole with a drill to establish existing pavement depths, thus reducing the amount cutting to the existing concrete depth. The existing bituminous pavement is then removed with jackhammer and hand tools. The deck should then be inspected and any significant damages brought to the attention of the supervising engineer (7).

The vertical and horizontal surfaces to receive the joint are cleaned using a hot compressed air (HCA) lance to remove any moisture and debris. The joint must be thoroughly cleaned prior to the next step. The new backer rod is then installed. The base of the joint is then tanked, flooded, with the APJ binder material. The gap plate is centered over the expansion gap and nailed into place with locating pins. The entire joint, including the vertical sides, are then tanked with APJ material again.

Concurrent to the actions noted before, the APJ binder and aggregates are prepared for mixing. This material can be mixed in three different ways (3):

1. Hot non-coated aggregate is placed into the joint and APJ binder is then added.
2. Hot aggregate is pre-coated with APJ binder in a mixer and then spread into joint and then APJ binder is added.
3. Hot non-coated aggregates are dumped into the joint and mixed in-place with APJ binder.

Methods 2 is the most desirable method because it ensures thorough coating of the aggregate, however it is more difficult to spread and will require compacting (3). Method 1 can be lead to problems with coating of the aggregates, especially if the aggregates are dusty (3). Method 3 is less practical as it will require the contractor to work in small batches to keep the mixing temperatures in range (3).

Mixing temperatures and methodologies for measuring it during installation do pose a concern for APJ failure. In a field study of 18 APJ installations, the EMPA noted that many different temperature control devices were used. Those contractors using Method 2 used stirring drums with integrated temperature control and in 3 of the 18 cases these devices were non-functional (3). In some cases the binder was heated above 224ºC (435ºF), causing polymer decomposition of up to 35% (3). This decomposition affects the elasticity, adhesion strength and durability of the APJ that can ultimately lead to failure (3). Also infrared thermometers were used for aggregate temperature readings and digital thermometers for binder temperatures.   It was noted that some of these thermometers varied as high as 20ºC (68ºF) from calibrated thermometers (3).

Ideas vary on the means of filling the joint with the APJ mixture. Beyond the methods noted above, the number of lifts and compaction techniques vary significantly. Some recommend that the mixture be placed in three lifts (1), others surmise that the lifts should be 30 to 40 cm (1 to 1-1/2 inches) until the final desired height is reached (3). Compaction techniques vary from rolling the finished joint with a 2-ton roller (1) to compacting using a vibratory plate compactor (3) to simply stating that the mixture should be consolidated during installation (7).

Application of the finish coat happens after the joint is filled with APJ mixture and compacted, if performed. It normally involves tanking the finished APJ material with binder and distributing a broadcast stone on top.

The work presented by the EMPA did discuss some methods of QC during the install process. Their suggestions were (3):

1. Require a form that includes the following information after the joint install is complete
   - Bridge reference and location
   - Joint location
   - Date of installation
   - Weather during installation
   - Materials used
   - Plate material and size
   - Joint size
   - Use of debonding strip

- Primer used
- Surface dressing

2. Require the supplier to submit the following regarding their joint system:
   - Description or name of joint system
   - Horizontal movement capacity
   - Vertical movement capacity
   - Aggregate test report
   - Binder test report
   - Gap plate test report
   - Caulking test report
   - Flashing test report

The authors stated that a certified lab shall complete the aggregate and binder test.

2.3 Performance Research

There have been a few research projects related to APJ that have been conducted in the last 5 years. Most notably the research by University of Wyoming, EMPA (Switzerland), and BAM (Germany) has been at the forefront of APJ testing.

The University of Wyoming conducted a study for the Wyoming Department of Transportation that was completed in May of 1999. Their research focused on the material properties of the APJ mixture and binder. More specifically, they tested joint material from Pavetech, Koch/LDI (Linear Dynamics), and Watson Bowman Acme. (It should be noted that LaFarge Road Marking now owns the Koch/LDI product and the results of the Wyoming research may or may not necessarily be representative of the material currently being produced by this company. Similarly the materials tested for Pavetech and Watson Bowman Acme may or may not necessarily be representative of the material currently being produced.) The manufacturer placed material into specially designed concrete molds and the corresponding test specimens were taken from these molds. The University of Wyoming then conducted the following test (1):

- Finite Element Analysis
- Thermal Stress Restrained Specimen Test (TRST)
- Resilient Modulus
- Georgia Wheel Loading Rut Tests
- Shear Bond Test
- Normal Bond Strength Test
- Yield Stress
- Modulus of Elasticity

Perhaps the greatest discovery during this research was the glass transition temperature of the binder material. Their research discovered that between a temperature of - 18°C and -40°C the binder material becomes brittle and fails with little plastic deformation (1). The researchers then theorized this temperature was as a non-conservative lower temperature limit that an APJ could be used.

From the material property tests the authors concluded that the material behavior is characterized as elastic perfectly plastic. Adhesion tests led to the conclusion that the adhesion of the APJ material is brittle. Also noted was that the material's modulus of elasticity of the APJ material is consistently lower than the resilient modulus. Finally the authors noted that the rutting requirements of HMA not met by the APJ material (1).

More current research has been undertaken by the EMPA (Switzerland) and the BAM (Germany). Each individual has undertaken new test methodologies relating to the APJ.

The EMPA has been conducting field research into APJ. As part of their research 18 APJs were installed at 7 different locations on the same day under the same climatic conditions (3). The researchers have performed long-term field monitoring using a high frequency torsional dynamic resonance rheometer that evaluates the changes in the viscoelastic properties. Their research has shown that the APJ material placed in the field has stiffened over the years from 1998 to 2000 (3). The penetration resistance of the APJ was also monitored in the field. A flat stamp under a static load of 400N was applied to each APJ. Their results confirmed that APJ compacted with a vibratory machine had higher penetration resistance that those that were not compacted (3).

The researchers at the BAM have developed a test device, called the function test, that tests a section of the APJ system as a whole (APJ material, backer rod, gap plate, etc.). The testing apparatus described is used to perform two tests on the APJ system: Thermal Cycling Test and the Vibration Test.

The Thermal Cycling Test is used to measure the performance of the APJ system under slow, quasi-static, horizontal joint movements. Specifically the joint expansion and contraction is varied between +25mm (+1") and -12.5mm (-1/2") respectively at a rate of 0.2mm/h. Simultaneously the temperature of the APJ system is varied from -20°C (-4°F) during extension of the joint to +50°C (122°F) during contraction of the joint. This test is conducted for 8 hours or until the samples reaches failure. Sample failure is deemed to have occurred when it can no longer be impervious to a NaCl solution that is applied over the joint prior to testing. (12)

The Vibration Test is used to evaluate the performance of the APJ system when subjected to dynamic loading. This test, conducted at -20°C (-4°F), involves subjecting the APJ system dynamic loading in a sinusoidal waveform at a frequency of 1Hz. Exact loading levels are determined from a continuous pulsating bending test. In total there are 130 stress sections with each being subjected to 10,000 cycles of loading. The tests will proceed until all sections have passed the criteria or the joint fails. Failure is determined as described previously for the Thermal Cycling Test. (12)

Finally attempts have been made to mathematically evaluate different joint geometry. A finite element analysis (FEA) was completed on a "typical" APJ under traffic and thermal expansion/contraction loading conditions as well as two radically different APJ shapes. The first shape tested eliminating the vertical debonding sides of the APJ and replacing it with a 45º-angle transition, creating a trapezoidal section shape. The second shape involved converting the plan of the joint into a sinusoidal shape rather than a straight line. The results of the FEA showed that the both shapes were more effective at reducing stresses than a "typical" APJ (2). The implications of this are that changing the shape of the APJ will have a positive effect on stress distributions, however the reality may be that these new shapes are unrealistic to construct.

2.4 Survey

In an effort to better understand the design, repair and usage of the APJ in the United States, a survey was created and distributed to members of the state DOT's in late 2002. Umass

Dartmouth received an overall response of 23% of which only 25% of those respondent's stated that APJs are currently used in their state. Some other significant findings from the survey were:

- Only 8% of the total respondents stated that they plan to use APJs in the future.
- Only 8% of the total respondents stated that they use an APJ **DESIGN** specification.
- No state has or uses any defined criteria for evaluating good vs. poor performing APJs.
- 25% of respondents stated they specify curb details.
- 17% of the total respondents stated that they use an APJ **REPAIR** specification.
- The majority of respondents believe that material distress leads to APJ failure.

A detailed summary of the survey along with a blank copy of the survey and the respondent's responses is located in Appendix A.

2.5 Criteria for Good vs. Poor Performing Joints

No criteria exist for classifying a Good vs. Poor performing joint. This subjective qualification is further complicated by the expectations of the joint performance by the design engineer. One may safely assume that if the joint leaks that it would be classified as poor performing. The extent at which the joint can be consider good depends of the acceptable levels of distress and when they occur during the life of the joint, which to this point have not had formal quantification procedures established.

2.6 Useful Life

No written documentation of the useful life of an APJ was found as part of the research for this project. However, in talking with professionals in the industry, a useful life of 5 years is a realistic expectation.

2.7 Cost

Only one source made mention of cost associated with APJ. In the University of Wyoming report of 1999, their research indicated that the cost range for a new APJ is $60 linear foot to $325 linear foot (1). Umass Dartmouth did ask for cost data from the current manufacturers, but none was received.

3.0 SPECIFICATIONS

Please note that the majority of the information listed in this Section 3.0 Specifications was authored by the respective agency, manufacturer or author noted. Umass Dartmouth has presented or summarized their work here to inform the readers of this report on the current specifications and criteria being used. Umass Dartmouth does not claim any authorship or assume any responsibility for the information contained in this section.

3.1 ASTM & New England DOT Specifications – Materials

The materials required for use in an APJ are universally accepted. Each system requires a backer rod, gap plate, locating pins, binder, and aggregate. The material acceptance requirements for these items vary in each New England state.

Tables 3 through 8 outline the current material requirements of each state and the latest APJ ASTM specification for APJ materials. They were compiled from the following sources:

- ASTM - Annual Book of ASTM Standards 2004 (13)
- Connecticut - *Item #601604A - Asphaltic Plug Expansion Joint System*, June 1997.
- Maine - No Specifications were available for this report.
- Massachusetts – *Section 971 Asphaltic Bridge Joint System*, 2002.
- New Hampshire –Specifications were in a drawing format rather than a text dissemination. No text specifications were forwarded to Umass Dartmouth for this project.
- Rhode Island – Draft Code 823.1750 *Asphaltic Expansion Joint System Materials and Workmanship Warranty,* May 2002. (Please note this is only a draft specification and has not been formally approved as of the publication of this report.)
- Vermont – Certain items from formal specification were received via unpublished personal email with VTrans. A formal specification does exist but was not forwarded to Umass Dartmouth for this project.

A copy of the available specifications, besides the ASTM specification, is located in Appendix B.

3.1.1 Binder

Table 3 summarizes the requirements for the APJ binder. Please note that Maine, New Hampshire and Vermont do not have or did not supply specifications for APJ binder.

		Required Property Values Per Specification			
Test	**ASTM Test ID**	**ASTM D6297-01**	**CT[5]**	**MA**	**RI[7]**
Softening Point	D36	83°C (min.)	82°C (min.)	83°C (min.)	180°F (82°C)(min.)
Tensile Adhesion	D5329	700% (min.)	Per ASTM D3583[1] 800% (min.)	700% (min.)	-
Ductility	D113	@ 25°C (77°F) 400 mm (min.)	@ 25°C 40 cm (min.)	@ 25°C 400 mm (min.)	-
Penetration	D3407[2]	@ 25°C (77°F), 150g, 5s 7.5 mm (max.)	@ 25°C, 150g, 5s 90 dmm (max.)	@ 25°C, 150g, 5 s 7.0 mm (max.)	-
Low Temperature Penetration	D5	@ -18°C (0°F), 200g, 60s 1.0 mm (min.) [4]	Per ASTM D3407[2] @ -18°C, 200g, 60 seconds 10 dmm (min.)	@ -18°C, 200g, 60 seconds 1.0 mm (min.)[6]	-
Flow	D3407[2]	5 h @ 60°C (140°F) 3.0 mm (max.)	5 h @ 60°C 3.0 mm (max.)	5 Hours @ 60°C 3.0 mm (max.)	-
Resiliency	D3407[2]	@ 25°C (77°F) 40% (min.) 70% (max.)	@ 25°C 60% (min.)	@ 25°C 70% (max.)	-
Asphalt Compatibility	D3407[2]	PASS	PASS	PASS	-
Flexibility	D5329	@ -23°C (-10°F) PASS	-	@ -23°C PASS	-
Bond	D3405[3]	3 Cycles @ -7°C (+20°F) , 100% Elongation PASS	-	3 Cycles @ -20°F, 50% Elongation PASS 3 Cycles @ 0°F, 100% Elongation PASS	-
Recommended Installation Temperature	N/A	182°C -199°C (360°F-390°F)	199°C	182°C -199°C	-
Safe Heating Temperature	N/A	199°C - 216°C (390°F - 420°F)	210°C	199°C - 216°C	-

[1]ASTM D3583 withdrawn and replaced by ASTM D3569 & D5329.
[2]ASTM D3407 withdrawn and replaced by ASTM D5329.
[3]ASTM D3405 withdrawn and replaced by ASTM D6690.
[4]ASTM D6297 requires a modification to the D5 test method for the low temperature penetration test. A penetration cone conforming to ASTM D217 is used instead of a standard penetration needle. The total moving weight of the cone and attachments shall be 150.0±0.1 g. Pour the APJ binder into three (3) 177-mL tins. The tin dimensions shall be 69 mm in diameter by 44 mm deep. Condition the specimens and penetration cones at 18°C for at least 4 hours. Make penetration determination on the 120° radii, halfway between the center and outside. Report results as an average of three individual tests.
[5] CT DOT offers a set of alternate criteria for acceptance of APJ binder as follows:

1. Softening Point > 65°C Tested by Ring & Ball Method (ASTM E28)
2. Flow Resistance < 5% (Per ASTM D1191 which has been withdrawn and replaced by ASTM D5329)
3. Cone Penetration < 40 mm @ 25°C, 150g, 5 seconds (ASTM D217)
4. Extension Test - PASS 3 cycles of extension to 50% at a rate of 3.2mm/hr and 5°C (Blocks prepared according to ASTM D1190 which was withdrawn and replaced by ASTM D6690)

[6] Methodology similar to footnote 4.
[7] RI DOT requires that APJ binder conform to ASTM D 3405, which was withdrawn and replaced by ASTM D6690.

Table 3: ASTM & New England DOT Specifications - Binder Requirements

3.1.2 Backer Rod

Table 4 summarizes the requirements for the backer rod. Please note that Maine, New Hampshire and Vermont do not have or did not supply specifications for backer rod.

		Required Property Values Per Specification			
Item	**ASTM Test ID**	**ASTM D 6297-01**	**CT**	**MA**	**RI**
Type	n/a	Closed Cell Foam	Cylindrical Closed Cell Expanded Polyethylene Foam	Closed Cell Foam	Expanded Closed Cell Polyethylene Foam
Size	n/a	-	Diameter 150% the width of joint opening	In accordance with Manufacturers recommendations. Shall meet requirements of ASTM D 1752	Diameter 150% the width of joint opening
Density	D1622	-	32 kg/m^3 (2.0 $lbs./ft^3$) (min.)	-	2.0 $lbs./ft^3$ (min.)
Tensile Strength	D1623	-	172 kPa (25 psi) (min.)	-	25 psi (min.)
Water Absorption	C509	-	1.0% of mass (max.)	-	1% of weight (max.)
Compression, 50%	D545	-	-	91.70 kPa[1]	-
Extrusion	D545	-	-	2.54 mm[1]	-
Recovery	D545	-	-	99.21%[1]	-
Water Absorption, Volume	D545	-	-	0.246%[1]	-
Other	n/a	Non-gassing and capable of withstanding the elevated installation temperature (199°C) of binder & meet all requirements of ASTM D5249	Capable of withstanding the temperature of hot binder material.	Compatible with polymeric binder and the elevated temperatures of the polymeric binder application.	-

[1]Values using a 12 mm specimen.

Table 4: ASTM & New England DOT Specifications - Backer Rod Requirements

3.1.3 Aggregate

Table 5 summarizes the requirements for the aggregate. Please note that Maine, New Hampshire and Vermont do not have or did not supply specifications for the aggregate.

	Required Property Values Per Specification			
Item	**ASTM D 6297-01**	**CT**	**MA**	**RI**
Type	-	Granite, Basalt or Gabbro	Granite, Basalt or Gabbro	Basalt, Gabbro or Granite groups
Aggregate Delivery Condition	Crushed, Washed, and Dried. Pre-weighed and pre-packaged.	Crushed. Double-Washed and Dried	Crushed, Processed, Double-Washed and dried at the source. Delivered to the site in prepackaged waterproof containers.	Stones shall be crushed, double-washed, dried and delivered to the site pre-weighed in labeled packs
Aggregate Material Requirements	Specific size and gradation to be agreed upon by purchaser and APJ manufacturer.	Shall be supplied in 19 mm, 12.5 mm and 9.5 mm nominal sizes as recommended by the manufacturer.	Shall be made available in 19mm, 12 mm and 10 mm sizes and meet the gradation requirements specified by manufacturer for the joint system.	When performing AASHTO T11, material passing the #200 sieve shall not be more than 0.3% by weight of the stone
Broadcast Stone	-	-	-	Basalt sized to pass the #8 sieve and be retained on the #16

Table 5: ASTM & New England DOT Specifications - Aggregate Requirements

3.1.4 Gap Plate

Table 6 summarizes the requirements for the gap plate. Please note that Maine, New Hampshire and Vermont do not have or did not supply specifications for the gap plate.

	Required Property Values Per Specification				
Item	**ASTM D 6297-01**	**CT**	**MA**	**RI**	**VT**[1]
Type	Mild Steel or Aluminum	Grade 250 Steel	Grade 250 Steel	Steel Grade 36	Steel
Conformance Requirements	ASTM A36/ A36M-Mild steel ASTM B209 - Aluminum	ASTM A709M	AASHTO M270	AASHTO M270	-
Galvanized	-	-	AASHTO M111	AASHTO M232	
Thickness	6 mm (min.)	6.5mm (min.)	6 mm (min)	1/4” (6.4 mm)	6 mm
Width	200 mm	-	200 mm (min.)	-	200 mm
Length	1.2 m (min.)	-	-	3’ to 4’	
Hole Location	When specified 300 mm O.C.	300 mm center-to-center along centerline of plate	300 mm on center	1’ Center-to-Center along the centerline of the plate	

[1]Steel Plate may be omitted where the approach slab is covered with a stone base or bituminous pavement and vertical movement of the plated might occur.

Table 6: ASTM & New England DOT Specifications - Gap Plate Requirements

3.1.5 Locating Pins

Table 7 summarizes the requirements for the locating pins. Please note that Maine, New Hampshire and Vermont do not have or did not supply specifications for the locating pins.

	Required Property Values Per Specification			
Item	**ASTM D 6297-01**	**CT**	**MA**	**RI**
Type	16d common nails or larger	16d common nails or larger	16d common nails or larger	16d common nails or larger
Coating	Galvanized	Hot-Dipped Galvanized per ASTM A153	Hot-Dipped Galvanized	Hot-Dipped Galvanized per ASTM A153

Table 7: ASTM & New England DOT Specifications - Locating Pins Requirements

3.1.6 Curb

Table 8 summarizes the requirements for the curb sealant and backer rod. Please note that only Connecticut supplied any specifications.

<table>
<tr><td></td><th colspan="5">Required Property Values Per Specification</th></tr>
<tr><th>Item</th><th>ASTM D 6297-01</th><th colspan="2">CT</th><th>MA</th><th>RI</th></tr>
<tr><td>Sealant</td><td>-</td><td colspan="2">Dow Corning 888 or Approved Equal</td><td>-</td><td>-</td></tr>
<tr><td rowspan="4">Backer Rod</td><td rowspan="4">-</td><td colspan="2">Cylindrical closed-cell polyethylene foam with a diameter 25 mm greater than the joint opening.</td><td rowspan="4">-</td><td rowspan="4">-</td></tr>
<tr><td>Density (ASTM D1622)</td><td>32 kg/m^3 (min.)</td></tr>
<tr><td>Tensile Strength (ASTM D1623)</td><td>172 kPa (min.)</td></tr>
<tr><td>Water Absorption (ASTM C509)</td><td>1.0% of mass (max.)</td></tr>
</table>

Table 8: ASTM & New England DOT Specifications - Curb Requirements

3.2 New England DOT Specifications – Installation

3.2.1 ASTM & New England DOT Installation Specifications: General
Please note that Maine does not have a general specification for APJs.

	General Joint Conditions					
Item	**ASTM D6297-01**	**CT**	**MA**	**NH**	**RI**	**VT**
Joint Movement Limitations	±25 mm	-	50 mm from max. expansion to max. contraction	2”	-	-
Maximum Joint Opening	-	-	-	-	-	-
Joint Installation Depth	50 mm	-	-	2” (min.)	-	-
Joint Installation Width	500 mm	-	-	20”	20”	-
Acceptable Vertical Displacements	-	-	-	-	-	-
Acceptable Skew Angles	-	-	-	Under 25°	-	-
Acceptable Gradient	-	-	-	-	-	-
Installation Weather Conditions	-	-	Ambient air temperature shall be 5°C and rising.	Joint cannot be installed if wet conditions exist.	-	Ambient air temperature is at least 10°C and rising. The road surface is sufficiently dry.
Other	-	Vehicular traffic may pass over the joint 2 hours after compaction of joint material.	-	-	Joint shall not be opened to traffic until surface cools to 120°F or 30 minutes after broadcast stone placement is complete.	Joint shall be protected from traffic until the material as cooled to 52°C (125°F)

Table 9: ASTM & New England DOT Specifications - General Conditions

3.2.2 ASTM & New England DOT Installation Specifications: Removal of Existing Bridge Joint System/Pavement & New Joint Preparation

ASTM D6297-01
No criteria listed in the ASTM D6297-01specification.

ConnDOT (Connecticut Department of Transportation)
Saw cut and remove the bituminous concrete overlay and membrane waterproofing to the required dimensions of the joint. Existing concrete headers, defective joint sealant, and reinforcement within the required dimensions of the joint shall also be removed. All concrete joint surfaces shall then be cleaned by the use of a hot compressed air lance until a clean, dry surface is produced. The cut asphalt surfaces shall be cleaned in a similar manner taking care to remove all water and cutting dust.

MassHighway (Massachusetts Highway Department)
The contractor shall produce uniform and parallel surfaces in the forming of and placement of the blockout area within the reinforced concrete slabs as detailed on the plans. The formed blockout area shall be protected by the contractor to prevent any edge damage by any site equipment throughout the on-going construction process. The contractor shall produce the required gap width within the full depth of the joint as dimensioned on the plans. If the existing curbstones bridge the existing sidewalk and safety curb joint gaps, they shall be modified by saw cutting a smooth face which shall be aligned and placed to maintain the uniform joint gap. Immediately prior to placing any binder, the blocked out section and joint gap shall be inspected full depth and any debris shall be removed. Immediately thereafter the blockout, sidewalk and safety curb gap, and road surface 150 mm either side of the blockout shall be thoroughly cleaned and dried using a hot compressed air (HCA) lance capable of producing flame-retarded air stream at a temperature of at least 1100°C. The lance's blast orifice shall be capable of producing one MPa of pressure.

NH DOT (New Hampshire Department of Transportation)
No criteria listed in the NH DOT specification.

RIDOT (Rhode Island Department of Transportation)
Saws shall be set to cut the full depth of the bituminous concrete and any membrane present. Bituminous concrete pavement shall be removed from those areas where asphaltic joint material is to be placed by the use of saws and pneumatic hand tools. Variations in the thickness of the bituminous concrete across the road should be considered to ensure, where possible, that the deck is not damaged. The entire joint must be thoroughly cleaned and dried using a Hot Compressed Air Lance immediately prior to tanking. All loose debris shall be removed from the gap. Care must be taken to ensure that the sawcut surfaces have been thoroughly cleaned of any dust or wet paste from the cutting operation.

VTrans (Vermont Agency of Transportation)
The joint shall be located centrally over the deck expansion gap or fixed joint and marked out to the manufacturer's recommended width. The joint shall be excavated as shown on the plans, by use of saws and pneumatic hammer or a hammer and chisel. The joint shall be blast cleaned of

debris and asphalt. The joint area shall be thoroughly dried using a hot compressed air prior to applying binder material. Spalled and defective concrete shall be repaired with an approved material as agreed upon by the resident engineer.

3.2.3 <u>ASTM & New England DOT Installation Specifications:</u> Installation of Backer Rod

ASTM D6297-01
"The closed cell, foam expansion joint filler shall be placed into the expansion gap at a depth of not greater than the width of the gap. Where the gap is greater than 25 mm, the minimum depth shall be 25 mm."

ConnDOT (Connecticut Department of Transportation)
The backer rod shall be installed in the joint opening at a minimum depth of 25 mm through the roadway curbs.

MassHighway (Massachusetts Highway Department)
The backer rod shall be installed in the sidewalk and safety curb gap to the proper depth to ensure a correct width/depth ratio as specified by the manufacturer. The backer rod shall be set in accordance with the plans. There will be no splicing of backer rods at the curb lines.

NH DOT (New Hampshire Department of Transportation)
No criteria listed in the NH DOT specification.

RIDOT (Rhode Island Department of Transportation)
The joint gap shall be caulked with a backer rod as shown on the plans. It shall be placed in such a manner as to allow for appropriate placement of the required binder material.

VTrans (Vermont Agency of Transportation)
Properly sized heat resistant backer rod shall be placed in the movement gap allowing 25 mm± (1 inch ±) of binder above the rod.

3.2.4. <u>ASTM & New England DOT Installation Specifications:</u> Curb Joint Treatments

ASTM D6297-01
No criteria listed in the ASTM D6297-01specification.

ConnDOT (Connecticut Department of Transportation)
The parapet joints shall be thoroughly cleaned of all scale, loose concrete, dirt, dust, or other foreign matter by abrasive blast cleaning. Residual dust shall then be removed by blasting with oil free compressed air. Projections of concrete into the joint space shall also be removed. Closed cell elastomer shall be placed in the joint as shown on the plans and as directed by the Engineer. The joint shall be clean and dry before the silicone joint seal is applied. The silicone joint sealant shall be applied as outlined in accordance to with the manufacturer's printed instructions and as directed by the manufacturer's representative, and with the equipment prescribed by the manufacturer.

MassHighway (Massachusetts Highway Department)
For sidewalk, curb, and median joint gaps a non-sag polyurethane joint sealer compatible with the asphaltic binder shall be used.

NH DOT (New Hampshire Department of Transportation)
No criteria listed in the NH DOT specification.

RIDOT (Rhode Island Department of Transportation)
No criteria listed in the RIDOT specification.

VTrans (Vermont Agency of Transportation)
No criteria listed in the VTrans specification.

3.2.5 <u>ASTM & New England DOT Installation Specifications:</u> Priming of Surfaces

ASTM D6297-01
No criteria listed in the ASTM D6297-01specification.

ConnDOT (Connecticut Department of Transportation)
No criteria listed in the ConnDOT specification.

MassHighway (Massachusetts Highway Department)
No criteria listed in the MassHighway specification.

NH DOT (New Hampshire Department of Transportation)
No criteria listed in the NH DOT specification.

RIDOT (Rhode Island Department of Transportation)
No criteria listed in the RIDOT specification.

VTrans (Vermont Agency of Transportation)
No criteria listed in the VTrans specification.

3.2.6 <u>ASTM & New England DOT Installation Specifications:</u> Heating of Binder

ASTM D6297-01
"The AB (asphalt binder) shall be heated to a temperature as specified by the manufacturer. The melter must be supplied with a continuous agitation system and calibrated thermometers."

ConnDOT (Connecticut Department of Transportation)
Binder material shall be heated to a temperature greater than 176°C, but not to exceed the manufacturer's recommended safe heating temperature. The heating kettle shall have a continuous agitation system, temperature controls, calibrated thermometers and be double steel jacketed with an oil layer in between, to prevent scorching of the binder.

MassHighway (Massachusetts Highway Department)
The binder shall be melted and heated to the application temperature in a double jacketed, hot oil, heat transfer kettle, or as recommended by the manufacturer. The kettle shall be equipped with a continuous agitation system and temperature controls that can accurately maintain the material temperatures.

NH DOT (New Hampshire Department of Transportation)
No criteria listed in the NH DOT specification.

RIDOT (Rhode Island Department of Transportation)
The binder shall be hated and maintained at the manufacturer's recommended placement temperature in excess of 350°F (177°C). At no time shall the manufacturer's recommended safe heating temperature be exceeded.

VTrans (Vermont Agency of Transportation)
The binder material shall be heated an placed as recommended by the manufacturer.

3.2.7 <u>ASTM & New England DOT Installation Specifications:</u> Tanking of Joint

ASTM D6297-01
"The joint opening shall then be filled with AB until it runs into the corresponding blockout to ensure a water-tight joint below the bridging plate."

ConnDOT (Connecticut Department of Transportation)
During application, the binder material temperature shall be maintained at a minimum of 176°C. The binder shall be poured into the expansion joint opening until it runs over the edges.

MassHighway (Massachusetts Highway Department)
The binder shall be poured into the joint gap. The binder shall overfill the roadway joint gap to allow the binder to be spread onto the adjacent concrete deck in order to form a bond breaker between the deck and the bridge plate.

NH DOT (New Hampshire Department of Transportation)
No criteria listed in the NH DOT specification.

RIDOT (Rhode Island Department of Transportation)
Immediately after cleaning/caulking, the bottom of the blockout area shall be coated with a layer of hot binder. If a delay greater than one (1) hour occurs between cleaning and tanking, the joint shall be re-cleaned using a Hot compressed Air Lance.

VTrans (Vermont Agency of Transportation)
No criteria listed in the VTrans specification.

3.2.8 <u>ASTM & New England DOT Installation Specifications:</u> Placement of Gap Plate

ASTM D6297-01
Bridging plate shall be centered over the entire length of the expansion joint gap when specified.

ConnDOT (Connecticut Department of Transportation)
A backing plate shall be placed from curb to curb on the roadway portion of the expansion joint. The plate shall be centered over the joint opening. The plate section shall be butted up to each section and not overlapped. Locating pins shall be placed in the pre-drilled holes and hammered in to secure plates. Binder material shall be applied over the plate and in the blockout to seal this area.

MassHighway (Massachusetts Highway Department)
The bridge plate shall be centered and placed over the entire length of the roadway joint gap. The plate shall be secured by placing locating pins through the pre-drilled holes into the joint gap backer rod. The bridge plate sections shall not overlap. The horizontal and vertical surfaces of the joint blockout joint shall be coated immediately with hot binder before pouring hot binder over the floor area of the joint. The coating shall be continuous and adhere to the surfaces.

NH DOT (New Hampshire Department of Transportation)
No criteria listed in the NH DOT specification.

RIDOT (Rhode Island Department of Transportation)
The gap plate shall be bridged with three to four feet long steel backing plates. Steel plates shall be located with pins along the centerline. The plates shall be butted to each other and shall not be overlapped. Immediately coat the walls of the blockout area and the bridging plates with binder, making sure that the plate is entirely encapsulated by the binder.

VTrans (Vermont Agency of Transportation)
Place steel plates over the center of the movement gap. Secure plates from moving by inserting locating pins through the pre-stamped holes into the backer rod and cover with hot binder.

3.2.9 <u>ASTM & New England DOT Installation Specifications:</u> Preparation of Aggregate & APJ Mixture

ASTM D6297-01
“ The specified aggregate shall be heated shall be heated to the manufacturer’s prescribed temperature in a manufacturer’s recommended mixer. The temperature of the specified aggregate shall be controlled by a digital temperature sensor.” “ The AB (asphalt binder) shall be blended with the heated aggregate at a ratio of aggregate to AB as specified by the manufacturer. The blend tolerance shall be ±5% by weight. The minimum aggregate content shall be 68% by weight.” “Alternately, the AB and specified aggregate can be pre-measured and pre-packaged, heated on site in a manufacturer’s recommended mixing unit.” “The specified aggregate shall be coated completely with binder prior to placement in the blockout.”

ConnDOT (Connecticut Department of Transportation)
The aggregate shall be heated in a rotating drum mixer to a minimum of 176°C. The temperature shall be monitored with a calibrated digital temperature sensor. Binder material shall be added to the mixer to precoat the aggregate.

MassHighway (Massachusetts Highway Department)
The aggregate shall be heated to a temperature of 150°C to 200°C in a suitable rotating drum blending unit with a heat source attached or by a secure HCA lance to remove moisture. Temperature of the aggregate shall be controlled by a hand held digital temperature sensor or other means as approved by the engineer. The heated aggregate and polymeric binder shall be combined in the blending unit with sufficient binder to thoroughly coat each aggregate individually while avoiding an excess of binder. In no instance shall the amount of binder added to the blending unit be less than 15% by weight. The binder used for coating is not included in the above percentage.

NH DOT (New Hampshire Department of Transportation)
No criteria listed in the NH DOT specification.

RIDOT (Rhode Island Department of Transportation)
The aggregate must be dried, cleaned and heated in a drum mixer by hot compressed air. The stone shall be heated to a temperature between 375°F (190°C) and the maximum safe binder temperature, as specified by the manufacturer. The temperature should be monitored with a calibrated infrared thermometer. Under no circumstances shall the binder be mixed with the aggregate if its temperature is above the maximum. All tangible signs of dust must be removed prior to mixing of binder with the aggregate.

VTrans (Vermont Agency of Transportation)
The binder material and aggregate shall be heated and mixed as recommended by the manufacturer.

3.2.10 ASTM & New England DOT Installation Specifications: Placement of APJ mixture

ASTM D6297-01
"The blended heated AB and heated specified aggregate shall be placed in accordance with the manufacturer's recommended installation procedures." "The blended heated AB and heated coated specified aggregate shall be compacted longitudinally and transverse to the joint using a roller or plate compactor, which delivers a minimum centrifugal force of 15 kN."

ConnDOT (Connecticut Department of Transportation)
The coated aggregate shall be placed into the blockout in layers as recommended by the joint manufacturer. The blockouts shall be overfilled with coated aggregate as required to compensate for compaction. Equipment for compaction shall be as recommended by the joint manufacturer.

MassHighway (Massachusetts Highway Department)
The coated aggregate shall be placed in the blockout in layers and raked level as recommended by the joint material manufacturer. The final layer shall be raked level and compacted flush with the adjacent deck surface. This layer shall be compacted to the point of refusal with a 1-1/2 to 2-1/2 megagram roller to ensure the proper density an interlocking of the aggregate in the layer. Immediately following compaction, the surface of the joint and surrounding road shall be dried and cleaned using the HCA lance. Sufficient binder shall immediately be spread over the joint and the adjacent road surface to fill the voids and seal the surface stone.

NH DOT (New Hampshire Department of Transportation)
No criteria listed in the NH DOT specification.

RIDOT (Rhode Island Department of Transportation)
Binder material shall be added to the mixer just sufficient enough to thoroughly coat the aggregate. The coated aggregate shall be placed into the blockout in layers as recommended by the joint material manufacturer. The blockouts shall be overfilled with coated aggregate as required to compensate for compaction. Equipment for compaction shall be capable of sufficient compaction force as recommended by the joint manufacturer. Additional binder material shall be screeded over the compacted joint to fill any surface voids. (For the surface layer,) accurately measured quantities of hot aggregate shall be mixed with the binder in a rotating drum mixer. The binder should be at the approved temperature to ensure complete coating of all the stone. The mix shall be transferred to the joint and leveled to be slightly higher than the adjacent road surface. Compaction shall begin immediately after placement of the material in the blockout, using equipment as specified by the joint system manufacturer and the joint surface made flush with the existing road surface. Prior to final screeding, the surface of the joint and surrounding road shall, if necessary, be dried and cleaned with a Hot compressed Air Lance. Immediately thereafter a single screed of binder shall be applied to fill all surface voids.

VTrans (Vermont Agency of Transportation)
The installation of material, compaction, and top coating shall be as recommended by the manufacturer.

3.2.11 <u>ASTM & New England DOT Installation Specifications:</u> Finish Dressing

ASTM D6297-01
"Where an antiskid/antitracking surface is required, the surface of the APJ shall be heated prior to broadcasting the antiskid material in accordance with the manufacturers written instructions."

ConnDOT (Connecticut Department of Transportation)
Additional binder material shall be screeded over the compacted joint to fill any surface voids.

MassHighway (Massachusetts Highway Department)
The finished joint shall then be dusted with a fine, dry aggregate to prevent tackiness.

NH DOT (New Hampshire Department of Transportation)
No criteria listed in the NH DOT specification.

RIDOT (Rhode Island Department of Transportation)
The interface between the joint and the pavement shall be sealed with a 2 inch wide band of binder, centered over the interface, for the entire length of the joint on both the leading edge and trailing edges, relative to traffic. The surface adjacent to the interface shall be heated with a Hot Compressed Air Lance to promote adhesion of the binder. Immediately after the application, while the binder is still hot, basalt stone shall be broadcast onto the band. It shall cover 75% of the surface of the band.

VTrans (Vermont Agency of Transportation)
Immediately after topcoating, an anti-skid material shall be cast over the joint to reduce this risk of tracking.

3.2.12 <u>ASTM & New England DOT Installation Specifications:</u> Quality Control/Quality Assurance Procedures

ASTM D6297-01
This specification lists criteria for sampling of material for testing. "A minimum of 1.4 kg of the thermoplastic polymeric modified asphalt shall constitute one sample for testing purposes. A minimum of 23 kg of the specified aggregate shall constitute one sample for size and gradation analysis. A minimum of 300 mm of the closed cell, foam expansion joint filler constitutes one sample for testing purposes."

ConnDOT (Connecticut Department of Transportation)
Certification reports are required for the backer rod and binder material. A materials certificate is required for gap plates, locating pins, joint sealant and aggregates.

A competent technical representative of the manufacturer shall be present during installation of the expansion joint to give such aid and instruction in the installation of the joint as is required to obtain satisfactory results.
The contractor shall arrange for, and have present at the time of the first joint sealing operation is to be performed, a manufacturer's representative knowledgeable in the methods of installation of the sealant. The contractor shall also arrange to have the representative present at such other times as the engineer may request.

MassHighway (Massachusetts Highway Department)
A qualified employee of the manufacturer or an installer certified by the manufacturer and approved by the department shall be at the job site prior to the beginning of the joint construction process to instruct the work crews in the proper joint construction procedures and shall remain on the job site for the duration of the joint installation.

The contractor shall have sufficient mixers and personnel at the site to assure continuous and timely joint installation.

The manufacturer shall document and submit the successful performance of their material in a similar Asphaltic Bridge Joint System.

The installer shall have previously demonstrated the ability to have successfully produced a joint of similar nature and shall provide documentation of a working joint to the Department.
The contractor shall furnish Certified Test reports, Materials Certificates and Certificates of compliance for the asphaltic polymeric binder, the aggregate, and the joint sealer. The backer rod and locating pins require Certificates of Compliance.

NH DOT (New Hampshire Department of Transportation)
No criteria listed in the NH DOT specification.

RIDOT (Rhode Island Department of Transportation)
The contractor shall submit to the engineer, for approval at least thirty (30) days prior to the start of work, the following: a) The name of the manufacturer and b) The manufacturer's warranty certificate.

The contractor shall provide an affidavit from the joint manufacturer certifying that the aggregate is single size, and a certificate of compliance from the binder manufacturer certifying that the binder conforms to the specification.

At the direction of the engineer, the contractor shall arrange for, and have present at the time the first joint-sealing operation is performed, a manufacturer's representative knowledgeable in the methods of installation of the joint system. The contractor shall also arrange to have the representative present at such other times as the engineer may request.

For quality assurance purposes, RIDOT has the following warranty requirements written in their draft specification as shown in Table 10.

Distress	Limit for Each APJ	Corrective Action
Debonding	5% total for the joint, with no debond greater than two (2) feet	Saw cut and remove affected area; Replace with new asphaltic expansion system
Transverse Cracking	5% total for the joint, with no crack greater than two (2) feet	Saw cut and remove affected area; Replace with new asphaltic expansion system
Longitudinal Cracking	3 times joint longitudinal dimension	Seal
Perviousness (Leakage)	Visible seepage of water	Seal
Rutting	Maximum depth of 1/2"	Saw cut and remove affected area; Replace with new asphaltic expansion system

Table 10: ASTM & New England DOT Specifications - RIDOT QC/QA Corrective Actions

VTrans (Vermont Agency of Transportation)
No criteria listed in the VTrans specification.

3.3 Approved Manufacturers

In New England, some states require that approved manufacturers supply the APJ materials noted previously. Please note that Massachusetts and Rhode Island have not included this as part of their specification. Maine does not allow the installation of APJs. Table 11 summarizes the approved manufacturers for the New England states. This information was compiled from the same specifications used to determine the required material properties in Section 3.1

Manufacturer	System Name	CT	NH	VT
A.H. Harris & Sons, Inc	Polyjoint	✓		Under Review
LaFarge Road Marking[1]	Koch BJS	✓	✓	✓
LaFarge Road Marking[1]	Thorma-Joint	✓	✓	✓
Silicone Specialties Inc.	SSI APJ			✓
Pavetech International, Inc.	Matrix 502		✓	Under Review
Watson Bowman Acme Corp.	Wabo® Expandex		✓	✓
Wyoming Equipment Sales	A.P.J		✓	✓

[1]These items were formerly owned and distributed by Linear Dynamics.

Table 11: ASTM & New England DOT Specifications - Approved Manufacturers and Systems

A history of these joint systems, prepared by Lafarge Road Marking, including change of ownership information is located in Appendix C. It should be noted that A.H. Harris and Silicone Specialties Inc. have either suspended or ceased projection of their respective APJ systems. Also the Koch BJS system manufactured by Lafarge Road Marking is no longer being distributed for use in the New England states.

The manufacturers material properties and installation notes presented in Section 3.3 and 3.4 were compiled from the following sources:

A.H. Harris & Sons, Inc. - Sales Brochure. *Harris Polyjoint.* No date of issue.

Lafarge Road Markings - Sales Brochure. *Specification for the Installation of the Thorma Joint® Asphaltic Plug Expansion Joint System By Lafarge Road Marking*. No date of issue.

Pavetech International Inc. - Sales Brochure. *Matrix 502*. No date of issue.

Watson Bowman Acme - Sales Brochure. *Wabo® Expandex Asphaltic Plug Joint System.* 2001

Wyoming Equipment Sales - Sales Brochure. *A.P.J. Asphalt Plug Joint System – Specification & Installation*. No date of issue.

A copy of these sources is located in Appendix D. No product data was available for the SSI and Koch BJS systems.

3.4 Manufacturers Specifications – Materials

3.4.1 Binder

		Material Property Value				
		A.H. Harris & Sons, Inc	**LaFarge Road Marking**	**Pavetech International, Inc.**	**Watson Bowman Acme Corp.**	**Wyoming Equipment Sales**
Test	**ASTM Test ID**	**Polyjoint**	**Thorma-Joint**	**Matrix 502**	**Wabo® Expandex[3]**	**A.P.J.**
Softening Point	D36	200°F (93°C) (min.)	180°F (82°C)	180°F (82°C) (min.)	-	200°F (94°C) (min.)
Tensile Adhesion	D3583[2]	750% (min.)	750% (min.)	700% (min.)	-	-
Ductility	D113	@ 77°F (25°C) 40 cm (min.)	@ 77°F (25°C) 40 cm (min.)	@ 77°F (25°C) 40 cm (min.)	40 (min.)	-
Penetration	D3407[1]	@ 77°F (25°C) 150g, 5 sec. 90 dmm (max.)	@ 77°F (25°C) 150g, 5 sec. 90 dmm (max.)	@ 77°F (25°C) 150g, 5 sec. 90 dmm (max.)	Cone Penetration @77°F (25°C) 75 (max.)	@ 77°F (25°C) 90 dmm (max.)
Low Temperature Penetration	D3407[1]	@ 0°F (-18°C) 200g, 60 sec. 10 dmm (min.)	@ 0°F (-18°C) 200g, 60 sec. 10 dmm (min.)	@ 0°F (-18°C) 200g, 60 sec. 10 dmm (min.)	-	-
Flow	D3407[1]	5 h @140°F (60°C) 3.0 mm (max.)	5 h @140°F (60°C) 3.0 mm (max.)	5 h @140°F (60°C) 3.0 mm (max.)	@140°F (60°C) 2 mm (max.)	@140°F (60°C) 3 mm (max.)
Resiliency	D3407[1]	@ 77°F (25°C) 40% (min.)	@ 77°F (25°C) 40% (min.)	@ 77°F (25°C) 60% (min.)	60% (min.)	-
Asphalt Compatibility	D3407[1]	PASS	PASS	PASS	COMPLETE	-
Flexibility	D5329	-	-	-	-	-
Bond	D3407[1]	-	-	-	3 Cycles @ 0°F (-18°C) 100% extension PASS	-
Recommended Installation Temperature	N/A	390°F (199°C)	390°F (199°C)	370°F -390°F (188°C--199°C)	-	370°F - 390°F (188°C-- 199°C)
Safe Heating Temperature	N/A	410°F (216°C)	410°F (216°C)	390°F (199°C)	-	400°F (205°C)
Specific Gravity	-	-	-	1.10 ± .05	-	-

[1]ASTM D3407 withdrawn and replaced by ASTM D5329.
[2] ASTM D3583 withdrawn and replaced by ASTM D3569 & D5329.
[2] Watson Bowman Acme modified elastomeric binder meets or exceed the requirements of ASTM 3405 and ASTM 1190 and have the properties listed. Note that ASTM D3405 was withdrawn and replaced by ASTM D6690 and ASTM D1190 was withdrawn and replaced by ASTM D6690.

Table 12: Manufacturers Data - Binder Requirements

3.4.2 Backer Rod

		Material Property Value				
		A.H. Harris & Sons, Inc	**LaFarge Road Marking**	**Pavetech International, Inc.**	**Watson Bowman Acme Corp.**	**Wyoming Equipment Sales**
Test	**ASTM Test ID**	**Polyjoint**	**Thorma-Joint**	**Matrix 502**	**Wabo® Expandex**	**A.P.J.**
Type	n/a	Extruded from a cross linked, closed cell polyolefin	Closed cell foam expansion joint filler	Closed cell foam expansion joint filler	Cylindrical Closed Cell Foam	Cross-linked, closed cell, polyethylene expansion joint filler
Size	n/a	-	-	-	25% greater than the joint opening	1.5 times the joint opening
Density	D1622	-	Per ASTM D545 2 lbs./ft^3 (min.)	-	-	2 lbs./ft^3 (nominal)
Tensile Strength	D1623	-	Per ASTM D545 30 psi (min.)	-	-	31.4 psi
Compression	D1621	-	-	-	-	4.7 psi @ 25%
Water Absorption	C509	-	Per ASTM D545 0.03 g/cc by weight (min.)	-	-	0.02% by volume
Compression	D545	-	5 psi @ 25% (min.)	-	-	-
Extrusion	D545	-	-	-	-	-
Recovery	D545	-	-	-	-	-
Water Absorption, Volume	D545	-	-	-	-	-
Other	n/a	Heat resistant backer rod specifically developed to withstand the high temperatures inherent to hot-applied rubber asphalt sealers and polymeric sealants.	Capable of withstanding the elevated temperature of the polymeric binder.	Capable of withstanding the elevated temperature of the Matrix 502 binder.	Capable of withstanding the temperature of the hot modified elastomeric binder, as supplied or recommended by the manufacturer.	Capable of withstanding the elevated temperature of the binder (@ 410°F no melting of rod)

Table 13: Manufacturers Data - Backer Rod Requirements

3.4.3 Aggregate

	Material Property Value				
	A.H. Harris & Sons, Inc	LaFarge Road Marking	Pavetech International, Inc.	Watson Bowman Acme Corp.	Wyoming Equipment Sales
Item	**Polyjoint**	**Thorma-Joint**	**Matrix 502**	**Wabo® Expandex**	**A.P.J.**
Type	Fractured, angular trap rock in ¾" minus gradation	Granite, Basalt, Gabbro, Porphyry, or Gritstones (See Gradation in Section 3.3.4)	(See Gradation in Section 3.3.4)	Size B & C Granite (See Gradations in Section 3.3.4)	Basalt, Gabbro, or Granite (See Gradation in Section 3.3.4)
Aggregate Delivery Condition	Double-washed, kiln dried and prepackaged	Crushed and double washed	-	-	Crushed, double washed, dried and packaged in 50lbs bags.
Aggregate Material Requirements	-	-	-	-	-
Broadcast Stone	Back Beauty	Black Beauty Sand, Medium Grade	Finely graded, double washed and dried black granite	Black Beauty	Non-silica grit

Table 14: Manufacturers Data - Aggregate Requirements

3.4.4 Aggregate Gradations

	Percent Passing				
Sieve Size (in)	**LaFarge Road Marking**	**Pavetech International, Inc.**	**Watson Bowman Acme Corp. Wabo® Expandex**		**Wyoming Equipment Sales**
	Thorma-Joint	**Matrix 502**	**Size B Granite**	**Size C Granite**	**A.P.J.**
1"	-	99 - 100%	100%	100%	-
7/8"	95 - 100%	-	-	-	95 - 100%
3/4"	-	65 - 85%	-	-	-
5/8"	30 - 50%	-	-	-	30 - 50%
1/2"	10 - 30%	40 - 60%	90 - 100%	90 - 100%	10 - 30%
3/8"	0 - 7%	20 - 35%	-	-	0 - 15%
1/4"	-	0 - 10%	0 - 15%	0 - 15%	-

Table 15: Manufacturers Data - Aggregate Gradation Requirements

3.4.5 Gap Plate

	Material Property Value				
	A.H. Harris & Sons, Inc	LaFarge Road Marking	Pavetech International, Inc.	Watson Bowman Acme Corp.	Wyoming Equipment Sales
Item	**Polyjoint**	**Thorma-Joint**	**Matrix 502**	**Wabo® Expandex**	**A.P.J.**
Type	Grade 36 Steel	Mild Steel	18 Gauge aluminum plate or alternatively a mild steel plate	Steel	Natural Mild Steel
Conformance Requirements	ASTM A709	-	-	ASTM A36	-
Galvanized	Available galvanized	-	-	-	-
Thickness	1/4"	1/4"	-	1/4" (8 mm)	1/8”, 1/4" or thickness specified by the Engineer
Width	8”	8”	6” (150 mm) Width can be increased if gap is > 2” (50 mm)	8” (203 mm)	8”
Length	-	4’ to 5’	4’ and 5’	6’	48”
Hole Location	24” C.C.	1’ intervals along longitudinal centerline	-	12” (305 mm) along longitudinal centerline	12” intervals on longitudinal centerline

Table 16: Manufacturers Data - Gap Plate Requirements

3.4.6 Locating Pins

	Material Property Value				
	A.H. Harris & Sons, Inc	LaFarge Road Marking	Pavetech International, Inc.	Watson Bowman Acme Corp.	Wyoming Equipment Sales
Item	**Polyjoint**	**Thorma-Joint**	**Matrix 502**	**Wabo® Expandex**	**A.P.J.**
Type	#16 Nails	-	-	16d common nail	16d common nail
Coating	Galvanized	-	-	-	Galvanized

Table 17: Manufacturers Data - Locating Pin Requirements

3.5 Manufacturers Specifications – Installation

3.5.1 Manufacturer Installation Specifications: General

	General Joint Conditions				
	A.H. Harris & Sons, Inc	**LaFarge Road Marking**	**Pavetech International, Inc.**	**Watson Bowman Acme Corp.**	**Wyoming Equipment Sales**
Item	**Polyjoint**	**Thorma-Joint**	**Matrix 502**	**Wabo® Expandex**	**A.P.J.**
Joint Movement Capacity	-	1” Expansion 1” Contraction	About 1” (25 mm)	± 3/4" @ time of installation	Maximum horizontal movement 2” measured from max. expansion to max. contraction
Maximum Joint Opening	-	-	-	3” @ time of installation	-
Joint Installation Depth	-	2” (min.)	2” (min.)	2” (min.)	2” (min.) 8” (max.)
Joint Installation Width	Not less than 12”	20”	20” (500 mm)	20” (500 mm) (min.) 24” (610 mm) (max.)	Standard 20” May vary between 16” and 32”
Acceptable Vertical Displacements	-	-	-	Dynamic Intermittent displacements less than 1/4"	1/2"
Acceptable Skew Angles	-	-	-	Less than 45°	Less than 30°
Acceptable Gradient	-	-	-	-	Less than 4%
Installation Weather Conditions	-	-	-	Deck Temperature of 40°F (5°C) and rising	No wet conditions and no frost planes in the surrounding structure or wearing surfaces.
Other	-	-	Ready for traffic 30 - 60 minutes after completion depending on joint depth and ambient temperature.	Minimum cooling time is 1 hour.	Depending on temperature and joint depth, the joint could be ready for traffic in one-half hour.

Table 18: Manufacturers Data - General Conditions

3.5.2 Manufacturer Installation Specifications: Removal of Existing Bridge Joint System/Pavement & New Joint Preparation

A.H. Harris - Polyjoint

Remove existing bridge joint system from bridge deck and saw-cut joint cavity a minimum of 2" depth from top of asphalt wearing course, and 1-1/2" depth for latex modified overlay bridge deck. Remove debris from cut-out section and clean the surface areas and joint cavity allowing no dust or moisture to be present. Sandblast vertical and horizontal surfaces of the joint. Clean out all residual sand and debris. Joint must be dry. The horizontal plane of the joint box-out shall be smooth.

Lafarge Road Marking - Thorma-Joint

The new joint system shall be located centrally over the deck expansion gap or fixed joint and marked out to the recommended with of 20". The joint shall be excavated by the use of saws and pneumatic hand tools. Where possible, saws shall be set to cut the full required depth of the wearing surface and any membrane present. Variations in depth of the wearing course across the road should be considered to ensure, where possible, that the deck is not damaged. All debris from the excavated channel shall be removed to allow the full volume of the new joint to be installed. The entire channel must be thoroughly cleaned and dried. Small debris will be removed by using compressed air. The Hot Compressed Air Lance (capable of delivering flame retarded air stream with a temperature of 3,000°F (1648°C), at a speed of 3,000 ft/s) will then be applied to throughout the length of the channel. Installation in concrete overlays requires sandblasting of the concrete vertical walls and adjacent deck area prior to the use of the Hot Compressed Air Lance application. Spalled and defective concrete should be repaired with an approved material as agreed upon by the Project Engineer.

Pavetech International - Matrix 502

Matrix 502 shall be centered over ±1" (25 mm) over the existing expansion joint gap to the recommended width of 20" (500 mm). Saw cut the pavement transversely at the determined width (normally 10" (250 mm) each side of the expansion gap centerline) parallel to the joint gap and remove all material between the saw cuts, including the waterproofing, riser bars, any old expansion joint material and loose concrete from the bridge deck. This will form the bridge joint block out. The block out must be cut to a minimum depth of 2" (50 mm) in order to obtain a representative installation of the Matrix 502. In some cases this may require scarifying of the concrete bridge deck with a small scabbler. Care should be taken to yield a level joint table consistent with existing site conditions. The joint block out shall be further prepared by cleaning and drying all horizontal and vertical surfaces and at least 6" (150 mm) of the road surfacing adjacent to the vertical saw cuts. The use of a hot compressed air (HCA) lance or a hand held torch is recommended. If there is an interruption due to weather or other causes, the cleaning and drying operation is to be repeated immediately before priming and tanking operation.

Watson Bowman Acme - Wabo®Expandex

The block out shall be constructed to the dimensions on the drawings. The block out base shall be of sound material with no vertical misalignment and parallel with the plane of the roadway. Should repairs be required to the block out an agency approved repair material shall be used. Before installation of the Wabo®Expandex material, all block out surfaces shall be dry, then abrasive-blasted to remove contaminants and loose aggregate. Block out should then be heated and cleaned using a hot compressed air lance capable of producing 3000°F (1648°C) and a directional velocity of 90,000 cps (3000 fps) to ensure the removal of any residue from the abrasive-blast operation. Care should be taken to ensure that the abrasive blast and compressed air cleaning does not contaminate the block out. Installation should not be done unless the deck temperature is a minimum of 40°F (5°C) and rising.

Wyoming Equipment Sales - A.P.J.
The A.P.J. shall be centered over the existing expansion gap to the recommended width of 20". The engineer and W.E.S. if required, shall determine variations in the width. The A.P.J. shall be marked out by locating the center of the joint opening then marking the joint width as specified, Using a self-propelled dry saw, cut the wearing course and membrane to the joint table. (Where additional depth is required, the saw cut maybe continued into the deck, with the engineer's approval). The joint shall be excavated using pneumatic hammers with spades or a planer. Care should also be taken not to damage the vertical edge of the block out. Care should also be taken to produce a smooth joint table to ensure that the bridging plate sits flat on the surface. Defective concrete on the joint table should be removed and repaired with rapid set repair mortar according to the manufacturer's specifications. The mortar shall be completely set and dry before continuing with the installations. All debris in the block out area and six (6) inches either side of the joint shall be cleaned and dried with a hot compressed air lance (HCA). Although rarely specified, we [Wyoming Equipment Sales] recommend that wire brushing and abrasive sand blasting to be considered, prior to the HCA procedure. (The grit shall be of a non-silica type).

3.5.3 <u>Manufacturer Installation Specifications:</u> Installation of Backer Rod

A.H. Harris - Polyjoint
Place backer rod into the joint cavity. Backer rod must be placed to a minimum depth of 1-1/2".

Lafarge Road Marking - Thorma-Joint
The gap should be caulked with backer rod, allowing for approximately 1" of binder in the gap on top of the rod. If the previous caulking is intact and will hold the binder, it may be used to take the place of the backer rod. A small amount of hot binder should be placed onto the caulking to ensure the gap is adequately plugged.

Pavetech International - Matrix 502
Backer rod capable of withstanding the elevated temperature of the binder shall be placed into the expansion joint gap 1/8" (3 mm) or wider. Place the backer rod at a minimum depth of 1/2" (12 mm).

Watson Bowman Acme - Wabo®Expandex
Once the joint opening and block out have been properly prepared, the backer rod is placed in the joint opening to a depth of approximately 1" (25 mm). A closed-cell, high temperature, expanded polyethylene foam rod is recommended. The size of the backer rod should be 25% greater than the joint opening being sealed.

Wyoming Equipment Sales - A.P.J.
Hot Rod, or equivalent backer rod, shall be placed into the joint opening to a depth of one-inch (1") below the joint table. The backer rod should be a minimum of 1.5 times the joint opening and forced into the gap. If there are compressible materials already in place that can withstand the elevated temperature of the binder, they may remain in place with the engineer's approval.

3.5.4. <u>Manufacturer Installation Specifications:</u> Curb Joint Treatments

A.H. Harris - Polyjoint
Specification does not address curb joint treatments.

Lafarge Road Marking - Thorma-Joint
Specification does not address curb joint treatments.

Pavetech International - Matrix 502
Specification does not address curb joint treatments.

Watson Bowman Acme - Wabo®Expandex
Specification does not address curb joint treatments.

Wyoming Equipment Sales - A.P.J.
The vertical curb joint shall be sealed according to specifications. Dow Corning 888 with a soft type backer rod, or Dow Corning 1-2-3 silicone system is recommended.

3.5.5 <u>Manufacturer Installation Specifications:</u> Priming of Surfaces

A.H. Harris - Polyjoint
Prime the vertical surfaces with the Harris Polyjoint primer CCS1H using a stiff bristle brush or roller. Allow primer to become tacky prior to tanking of joint.

Lafarge Road Marking - Thorma-Joint
The Thorma-Joint system does not use a primer.

Pavetech International - Matrix 502
Prior to the tanking procedure, all horizontal and vertical surfaces of the prepared joint block out shall be brush coated or sprayed with Matrix primer. This will assist adhesion of the Matrix 502 joint within the block out.

Watson Bowman Acme - Wabo®Expandex
The Wabo®Expandex system does not use a primer.

Wyoming Equipment Sales - A.P.J.
The A.P.J. system does not use a primer.

3.5.6 <u>Manufacturer Installation Specifications:</u> Heating of Binder

A.H. Harris - Polyjoint
Heat Harris Polyjoint binder/sealer in an approved melter/applicator (double jacketed with heat transfer fluid and continuous mechanical agitation) in excess of 375°F but not to exceed 400°F.

Lafarge Road Marking - Thorma-Joint
The binder shall be heated to the recommended pouring temperature, 370°F - 385°F (188°C - 196°C). At no time shall the recommended safe heating temperature of 400°F (204°C) be exceeded. The melter unit shall be equipped with agitation and an automatic temperature control which can accurately maintain the material temperature from 100°F - 650°F (38°C - 343°C). A thermometer to monitor the material temperature must be provided. The burner system shall have a safety pilot capable of shutting of the gas supply in the event of a flame out.

Pavetech International - Matrix 502
The Matrix 502 binder shall be heated to a minimum of 380 °F (193°C), preferably in a double-jacketed oil melter. The melter must be equipped with a continuous agitation system, temperature controls and calibrated thermometers to maintain the binder at the manufacturer's recommended temperature. Additionally, a system for accurately determining the weight of the binder dispensed from the melter shall be available on site. The binder application temperature shall be between 380°F and 400°F (193°C and 204°C).

Watson Bowman Acme - Wabo®Expandex
Melt the elastomeric binder in a double-jacketed kettle and heat to a minimum of 380°F (193°C) but do not exceed 400°F (204°C).

Wyoming Equipment Sales - A.P.J.
Heat the bridge joint binder to the manufacturer's specified pouring temperature in a double jacketed, thermostatically controlled melter, with constant material agitation. Do not exceed the safe heating temperature of the material.

3.5.7 <u>Manufacturer Installation Specifications:</u> Tanking of Joint

A.H. Harris - Polyjoint
Fill Joint cavity with Harris Polyjoint binder/sealer. Puddle binder/sealer along the base of the cut-out section and the vertical sides.

Lafarge Road Marking - Thorma-Joint
Immediately after cleaning and caulking, the entire channel shall be coated with a thin layer of hot binder. If significant delay occurs, the channel shall be inspected to determine if re-cleaning is necessary.

Pavetech International - Matrix 502
Pour the binder into the expansion gap, overfilling the joint gap to allow the binder to be spread onto the joint table. The binder will form a bond breaker between the joint table and the aluminum (or mild steel) bridging sections.

Watson Bowman Acme - Wabo®Expandex
Pour the heated binder over the backer rod in the joint opening to seal the gap. This binder shall be poured level with the base of the block out. Apply the heated binder over the entire block out (base and sidewalls) to form a monolithic membrane approximately 1/16” (1.5 mm) to 1/8” (3 mm) thick.

Wyoming Equipment Sales - A.P.J.
Coat the entire block out area with binder, while at the same time, filling the joint gap opening.

3.5.8 Manufacturer Installation Specifications: Placement of Gap Plate

A.H. Harris - Polyjoint
Place bridging plate centered over the joint cavity previously filled. Place #16 galvanized nails into each hole of bridging plate. Puddle the binder/sealer over the bridging plate.

Lafarge Road Marking - Thorma-Joint
The gap shall be bridged with the steel plates centered over the gap by placing locating pins in the centerline of the plate. There must be at least 2” between the edge of the steel plate and the wall of the channel. Once the locating pins are in place, the top of the plate shall be coated with a thin layer of hot binder.

Pavetech International - Matrix 502
The aluminum bridging sections are then centered over the entire joint length and bedded into the Matrix 502 binder. All prepared, exposed surfaces (vertical and horizontal) of the joint block out including the aluminum bridging sections shall be sealed with the Matrix 502 binder. Pour Matrix 502 binder into the joint block out and screed to coat all exposed surfaces. The binder shall achieve a minimum of thickness of 1/32” (1mm) throughout. The binder application temperature shall be between 380°F and 400°F (193°C and 204°C).

Watson Bowman Acme - Wabo®Expandex
The steel traffic wearing plates are centered over the joint opening end-to-end along the joint with no overlapping. Centering pins (16D common nail is recommended) are installed in the pre-driller holes and inserted directly into the modified elastomeric binder plug. These pins are designed to hold the plates in place. The heated binder shall be poured over the closure plate to encapsulate it.

Wyoming Equipment Sales - A.P.J.
Immediately place the bridging plate centered over the joint opening, the plates shall be butted to each other and shall not be overlapped. Secure the plates from moving by inserting the locating pins through the pre-stamped holes into the backer rod. (A slight twisting motion of the nail when inserting will help penetrate the backer rod). Immediately coat the bridging plate with binder, making sure that is entirely encapsulated by the binder.

3.5.9 <u>Manufacturer Installation Specifications:</u> Preparation of Aggregate & APJ Mixture

A.H. Harris - Polyjoint

Heat specification aggregate in a rotating drum mixer (275°F-375°F), then blend with binder/sealer until the aggregate is 100% coated. Temperature shall be monitored with an electronic heat sensing device. Temperature of mixed aggregate and Polyjoint binder shall be a minimum of 275°F prior to placement of mix in joint opening. Mixer drum shall be kept clean of all foreign material not synonymous with the Harris Polyjoint system.

Lafarge Road Marking - Thorma-Joint

The aggregate must be heated in a vented or un-vented rotating drum mixer by the use of a hot compressed air lance (HCA Lance), or a pressure injection torch (PAT Torch). Once the aggregate has been heated to a temperature of 370°F - 380°F (188°C - 193°C), it is then coated with a small quantity of binder. One gallon of binder per 100lb. of stone should be sufficient to coat the stone.

Pavetech International - Matrix 502

The pre-blended SBG aggregate shall be heated to 275°F - 325°F (135° - 163°C) in a rotating drum mixer to remove dust and all moisture. The temperature of the aggregate shall be monitored by using a hand held, calibrated, digital temperature sensor. Add Matrix 502 binder to the heated SBG aggregates in the mixer in a ratio approximately 1 gallon (8.5 lbs.) of binder per 50 lbs. Of SBG aggregate. Minor variation in the amount of Matrix 502 binder added to the heated SBG aggregate is allowed. The heated SBG aggregate must be completely coated prior to placement.

Watson Bowman Acme - Wabo®Expandex

Pre-measured granite aggregate, one 40 lb (18 kg) bag B and one pre-measured granite aggregate 40lb (18 kg) bag C is placed in a rotating drum mixer and heated to a minimum of 250°F (121°C) not exceeding 375°F (190°C). A correct volume, 2.5 gallons (9.5 Liters), of heated Wabo®Expandex binder, 380°F (193°C) not exceeding 400°F (204°C), is added to this heated granite aggregate. This blend of elastomeric binder and granite aggregate is mixed for approximately 3 minutes or until all granite aggregate is coated and there are no “dry pockets” of aggregate. A hot air lance may be used to maintain the mix temperature on cooler days. Do not let the mix temperature exceed 400°F (204°C) if applying heat. Never apply direct flame to the liquid binder. The mixture is ready for placement in the block out.

Wyoming Equipment Sales - A.P.J.

Place the aggregate in the mixers and heat to the recommended pouring temperature of the binder with HCA lances. The mixers shall be of type recommended by the manufacturer. A hand-held digital temperature sensor shall be used to monitor the aggregate temperature. Do not overheat the aggregate. [After gap plate installation] The seal of the bridge joint is now complete and a stable and flexible wearing surface or matrix must be installed. In order to achieve stability, the maximum amount of aggregate must be placed in the block out. To achieve the required flexibility, all the voids in the matrix must be filled with binder. This also ensures the water tightness of the matrix. Making sure that the aggregate is at temperature, pour the binder into the mixer to pre-coat the aggregate and mix thoroughly (normally, one-half gallon, per fifty (50) pounds of aggregate). Do not add excessive amounts of binder.

3.5.10 Manufacturer Installation Specifications: Placement of APJ Mixture

A.H. Harris - Polyjoint

Fill cut-out section with coated aggregate in one lift slightly above grade of pavement. Compact Harris Polyjoint system with 2-ton static roller. Apply seal coat of liquid binder to top surface of Harris Polyjoint.

Lafarge Road Marking- Thorma-Joint

Layers of hot pre-coated aggregate not more than 2.5 inches thick shall be placed in the channel and immediately covered (with binder) to the level of the coated aggregate. This will ensure that the 3:1 weight ratio of aggregate to binder has been achieved. Layers shall be raked to ensure the aggregate is completely coated and that all the air pockets are eliminated. This process shall cease approximately three-quarters of an inch (3/4”) from the top of the channel. The surface layer shall be applied as the other layers except that the pre-coated aggregate is not flooded with binder. The pre-coated aggregate shall be transferred to the joint and leveled slightly higher than the adjacent road surface. On a standard 2” deep joint, the topcoat should be one quarter inch (1/4”) higher than the road surface. Deeper joints will require higher levels before tamping. Compaction should take place after the joint has cooled to approximately 225°F (107°C). The joint surface shall be made approximately level with the existing road surface by using the vibratory plate or roller. After compaction, lines of 4” tape are placed one inch beyond the joint width on each side of the joint to ensure evenness of appearance. The joint and at least one inch of road surface shall be top-coated with the hot binder until the surface is smooth and absent of voids.

Pavetech International - Matrix 502

To obtain best results, Matrix 502 must be installed in layers. The depth of the joint block out determines the number of layers (MINIMUMN 3 layers) of coated SBG aggregate that comprise a complete joint. The final top layer of coated SBG shall be approximately 1/2" thick. All other intermediate layers of the coated SBG shall be no more than 1-1/2" thick, and will generally be not less than 3/4" thick. Each layer of SBG should be achieved by placing the hot mixture into the joint block out and raking level to the desired thickness. Use hot steel rakes to spread and level the coated SBG aggregate. Apply additional Matrix 502 binder to each layer of coated SBG aggregate to lightly fill in voids as necessary. (The correct appearance of a completed layer will show aggregate raised above the binder level). When installing the top 1/2" layer, place the coated SBG approximately 1/4" above the existing surface to allow for compaction. Compaction is achieved using a minimum 1-1/2 ton roller perpendicular to and transversely with the joint. Alternately, a vibratory plate compactor may be used to compact the layered SBG aggregate.

Watson Bowman Acme - Wabo®Expandex

Pour the Wabo®Expandex into the block out to the road surface and level with rakes. Once the block out is filled, the Wabo®Expandex is to be compacted perpendicular to the joint. A minimum two-ton, water cooled drum roller is acceptable for this work. Care shall be taken to ensure that the compaction process does not transfer material to the roller. Water can be used to prevent this should material transfer occur. The application of water should be kept to a minimum. Do not allow the material mixture to cool prior to beginning the compaction operation. This step should be ongoing during the installation process. Complete final compaction process by rolling the joint longitudinally.

Wyoming Equipment Sales - A.P.J.
Immediately dump the hot pre-coated aggregate into the joint block out and rake into place in a layer not to exceed one and one-half inches. Using the rake, pack the aggregate tightly together assuring that the maximum amount of aggregate is contained in the layer. Immediately pour hot binder over the layer and slightly agitate with the rake to ensure that all voids are filled with binder. [Continue layering and flood coat of binder] until the block out is full. The final layer shall not exceed one inch in depth. Do not fill the voids in the final layer at this point. If the depth of the joints exceed four inches (4"), it is recommended that it be vibrated with a vibrating plate compactor near the midway of the joint depth. This must be accomplished prior to flooding the layer with binder. Use the minimum amount of water required to ensure that the binder does not stick to the plate. This water must be dried up with a propane torch prior to application of the binder. This layer should not exceed one inch (1") in depth. Using a vibrating plate compactor, as recommended by the manufacturer, interlock the aggregate by running the plate perpendicular to the joint, a minimum of three (3) times. This will ensure the proper density and stability of the matrix. The minimum amount of water should be used on the plate to ensure that the binder does not stick. This water shall be dried up with a propane torch from the surface of the joint and surrounding areas. Care shall be taken not to oxidize the binder with excess heat.

3.5.11 Manufacturer Installation Specifications: Finish Dressing

A.H. Harris - Polyjoint
Dust the Harris Polyjoint surface with black beauty immediately after seal coat is applied.

Lafarge Road Marking - Thorma-Joint
Immediately after top-coating, an anti-skid material is spread evenly over the joint to eliminate material tracking (Black Beauty Sand, Medium Grade).

Pavetech International - Matrix 502
The completed joint surface must be carefully heated with a heat lance or hand held torch to a tack consistency. A thin membrane of hot Matrix 502 binder shall then be applied followed immediately by broadcasting Matrix D type aggregate at the rate of approximately 3 lbs. Per lineal foot over the entire joint length. Partially imbed the D type aggregate by compacting.

Watson Bowman Acme - Wabo®Expandex
After compacting, the Wabo®Expandex is ready for final treatment. The top surface shall be heated with a hot air lance until the surface becomes tacky. Duct tape should be placed 1" (25 mm) away from the joint edges and parallel to the joint. Pour heated elastomeric binder over the top surface to form a membrane. Broadcast Black beauty to eliminate possible tackiness. (Do not use silica sand). The installed Wabo®Expandex joint will be ready to accept traffic once the joint has cooled to the touch. Minimum cooling time is 1 hour.

Wyoming Equipment Sales - A.P.J.
Place masking approximately one inch (1”) from the edge of the joint on the existing wearing surface of the bridge. Immediately pour hot binder over the joint surface. Using a squeegee, fill the voids in the final surface. This may require more than one application in order to fill the voids to refusal. The final appearance of the joint will show signs of the tops of the aggregate. Overfilling can cause damage to the top surface of the matrix. Immediately broadcast a fine aggregate as recommended by the joint manufacturer over the joint surface. Depending on ambient temperature and joint depth, the joint could be ready for traffic in one-half (1/2) hour.

3.5.12 <u>Manufacturer Installation Specifications:</u> Quality Control/Quality Assurance Procedures

A.H. Harris - Polyjoint
Specification does not list any QC/QA procedures.

Lafarge Road Marking - Thorma-Joint
The Thorma-Joint system is to be installed only by factory trained and certified installation professionals.

Upon request, certification of materials will be provided. The project engineer may require the contractor to provide samples during the course of the work for laboratory tests of any or all of the properties specified.

Pavetech International - Matrix 502
The manufacturer recommends that an installation be closely supervised and performed by trained personnel.

Watson Bowman Acme - Wabo®Expandex
The contractor shall submit product information and necessary details after the award of the contract. At the discretion of the Engineer, the manufacturer may be required to furnish a representative sample of material to be supplied in accordance with project specifications.

Wyoming Equipment Sales - A.P.J.
A qualified W.E.S. employee, or an W.E.S. trained and approved contractor, shall be at the site prior to the beginning of the joint process, to instruct the work crews in the proper joint installation procedures. This individual shall remain on the job site for the duration of the installation.

4.0 FIELD INSPECTIONS

Existing in-service APJs were field inspected by Umass Dartmouth personnel during various seasonal temperatures. Each APJ was visually inspected for overall condition, problems, and mechanisms of failure, if applicable. This data was collected in order to identify the typical failure modes in each New England state, the conditions associated with failure, and explore if any relationship between material performance/joint design and joint quality/performance exists.

A total of 64 APJs on 29 different bridges were evaluated for this research throughout the five New England States (Maine was excluded because they have no in-service APJs). The breakdown of inspection locations for each state was as follows:

Bridge No.	Location	City or Town	Number of Joints
03163	Route 160 over I-91 Southbound	Rocky Hill	4
03164	Route 160 over I-91 Northbound	Rocky Hill	4
03507	Route 9 Northbound over Private Road	Berlin	5
03913	Route 71 over Route 72	New Britain	1
03313	I-84 TR over I-84, Route 72, 372 and B&M RR	New Britain	10
3399A	I-84 West On Ramp Sisson Ave.	N/A	1

Table 19: CT APJ Field Inspection Locations and Number of Joints

Bridge No.	Location	City or Town	Number of Joints
W30025	I-195 West over Sanford Road	Westport	2
W30025	I-195 East over Sanford Road	Westport	2
N06013	Route 140 North over Braley Road	New Bedford	2
N06013	Route 140 South over Braley Road	New Bedford	2
M09009	Route 28 over I-195	Wareham	2
W06053	North Street over I-195	Mattapoisett	2

Table 20: MA APJ Field Inspection Locations and Number of Joints

Bridge No.	Location	City or Town	Number of Joints
102/120	Old Route 16 over Branch River	Milton	1
123/173	NH Route 27 over NH Route 101	Hampton	2
127/110	Bridge Street over Cocheco River	Rochester	1
088/126	US Route 4 over Suncook River Overflow	Epsom	1
109/037	NH Route 101 Eastbound over NH Route 125	Epping	1
109/038	NH Route 101 Westbound over NH Route 125	Epping	1

Table 21: NH APJ Field Inspection Locations and Number of Joints

Bridge No.	Location	City or Town	Number of Joints
661	I-95 over Thurbers Ave.	Providence	3
310	Route 107 over Clear River	Burrillville	1
164	School Street over Blackstone River	Lincoln/Cumberland	2

Table 22: RI APJ Field Inspection Locations and Number of Joints

Bridge No.	Location	City or Town	Number of Joints
1N	I-93 over VT 18	Waterford	1
1S	I-93 over VT 18	Waterford	1
3N	I-93 over TH NO 12	Waterford	1
3S	I-93 over TH NO 12	Waterford	1
5N	I-93 over TH NO 7	Waterford	2
5S	I-93 over TH NO 7	Waterford	2
144	US 5/ Passumpsic River	Lyndon	4
1	VT 144/ Passumpsic River	Lyndon	2

Table 23: VT APJ Field Inspection Locations and Number of Joints

Each of these joints noted in Tables 19 through 23 was visually inspected for the following distress conditions

- Bleeding (Track out)
- Curb/Sidewalk Issues
- Cracking
- Debonding
- Leaking or Leakage
- Polished Stone
- Raveling
- Reflective Cracking
- Rutting
- Segregation
- Shoving & Pushing
- Spalls

Please note that inspection for leakage was sporadic due to limited access to the underside of the joints in many locations. From these inspections, the following percentages of occurrence were calculated:

Inspection Parameter	Percentage of Occurrence for ALL New England States Inspected (64 Total APJs)
Bleeding (Track out)	6.3%
Curb/Sidewalk Issues	9.4%
Cracking	39.1%
Debonding	60.9%
Leaking	9.4%
Polished Stone	1.6%
Raveling	37.5%
Reflective Cracking	0%
Rutting	31.3%
Segregation	14.1%
Shoving & Pushing	15.6%
Spalls	3%

Table 24: Field Inspection Parameter Occurrences for ALL New England States

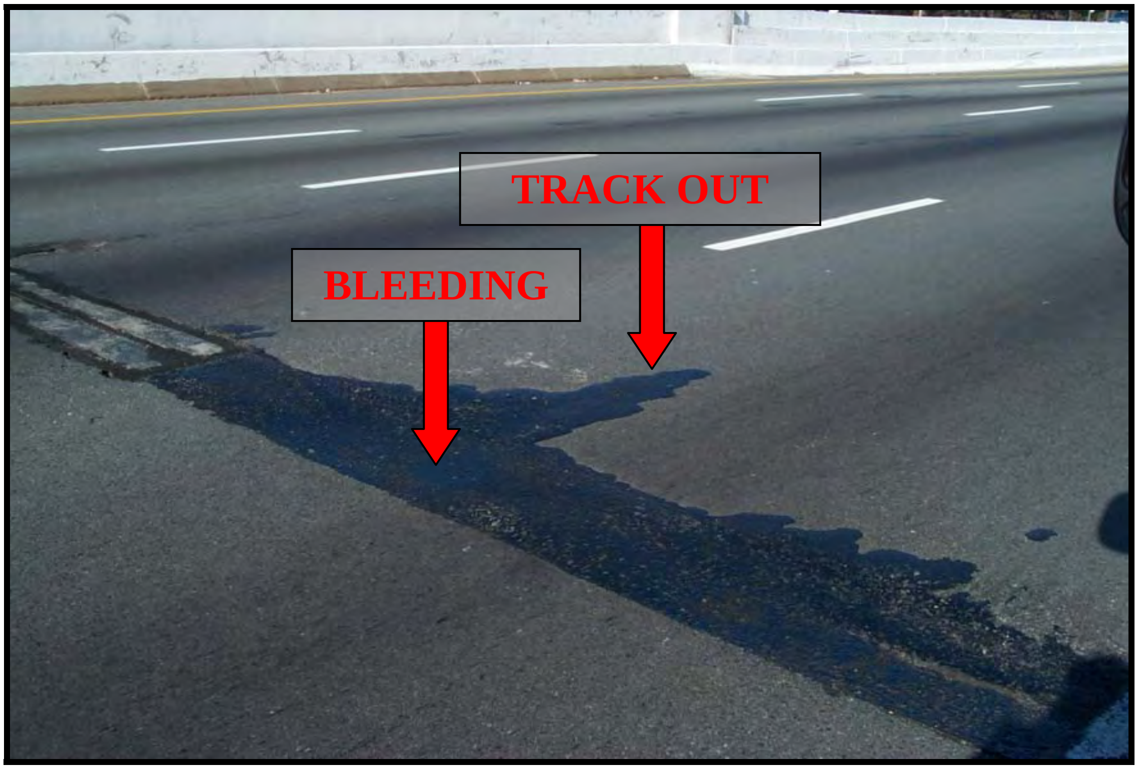
As can be deduced from the table above, the major APJ distresses in New England are debonding, raveling, rutting, and cracking. The breakdown of all distress per state is as follows:

	Percentage of Occurrence per State Inspected				
Inspection Parameter	**CT (25 Joints)**	**MA (12 Joints)**	**NH (7 Joints)**	**RI (6 Joints)**	**VT (14 Joints)**
Bleeding (Track out)	4%	0%	0%	50%	0%
Curb/Sidewalk Issues	4%	25%	29%	0%	0%
Cracking	24%	25%	57%	33%	71%
Debonding	48%	75%	86%	50%	64%
Leaking	N/A*	25%*	43%*	N/A*	N/A*
Polished Stone	0%	0%	0%	17%	0%
Raveling/Track Out	20%	33%	86%	50%	43%
Reflective Cracking	0%	0%	0%	0%	0%
Rutting	28%	33%	43%	67%	14%
Segregation	32%	0%	0%	17%	0%
Shoving & Pushing	16%	8%	43%	33%	0%
Spall	0%	8%	0%	0%	7%

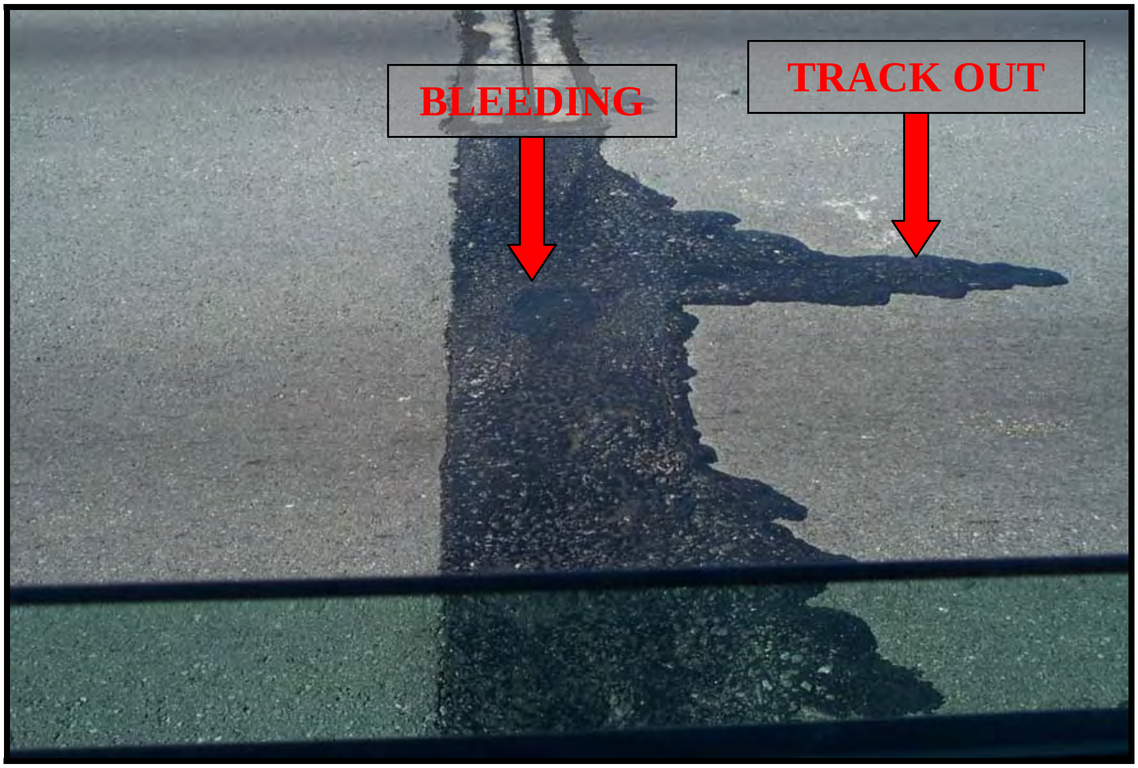
**Not all bridges were inspected from underneath for leakage due to accessibility issues.*

Table 25: Field Inspection Parameter Occurrences for EACH New England State

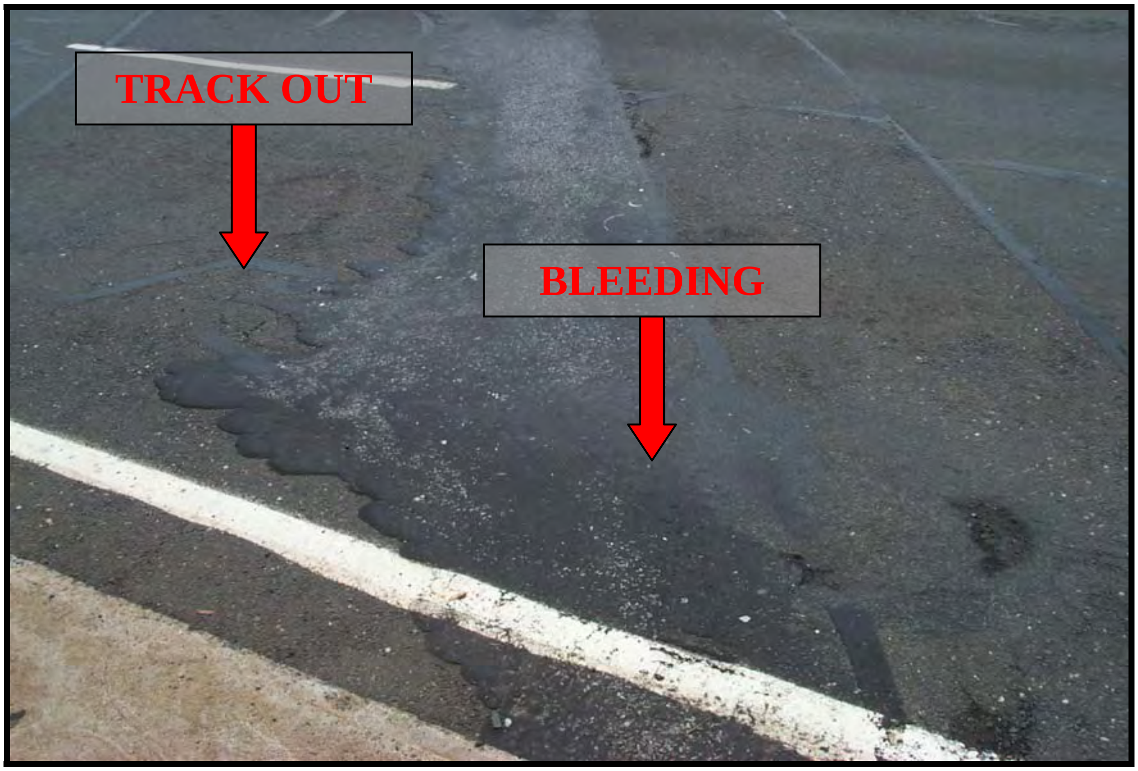
A copy of the field inspection summary for each individual joint is located in Appendix E. Correspondingly during the field investigations, digital photos were taken of the main distress on each joint. The following photos summarize some of the extreme occurrences of each distress. Please note that there were no available pictures of polished stone or reflective cracking.



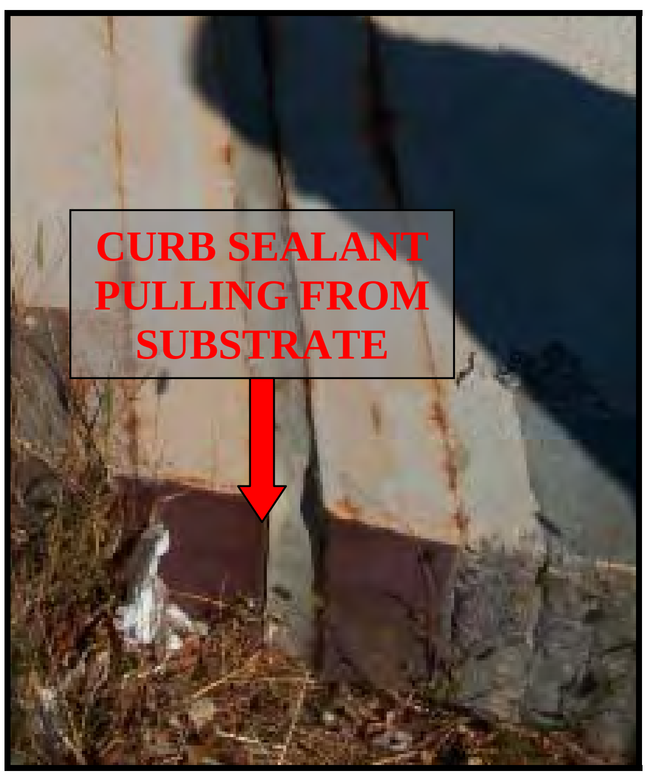
Picture #1: Bleeding/Track out on bridge #661 I-95 over Thurbers Ave. Providence, RI



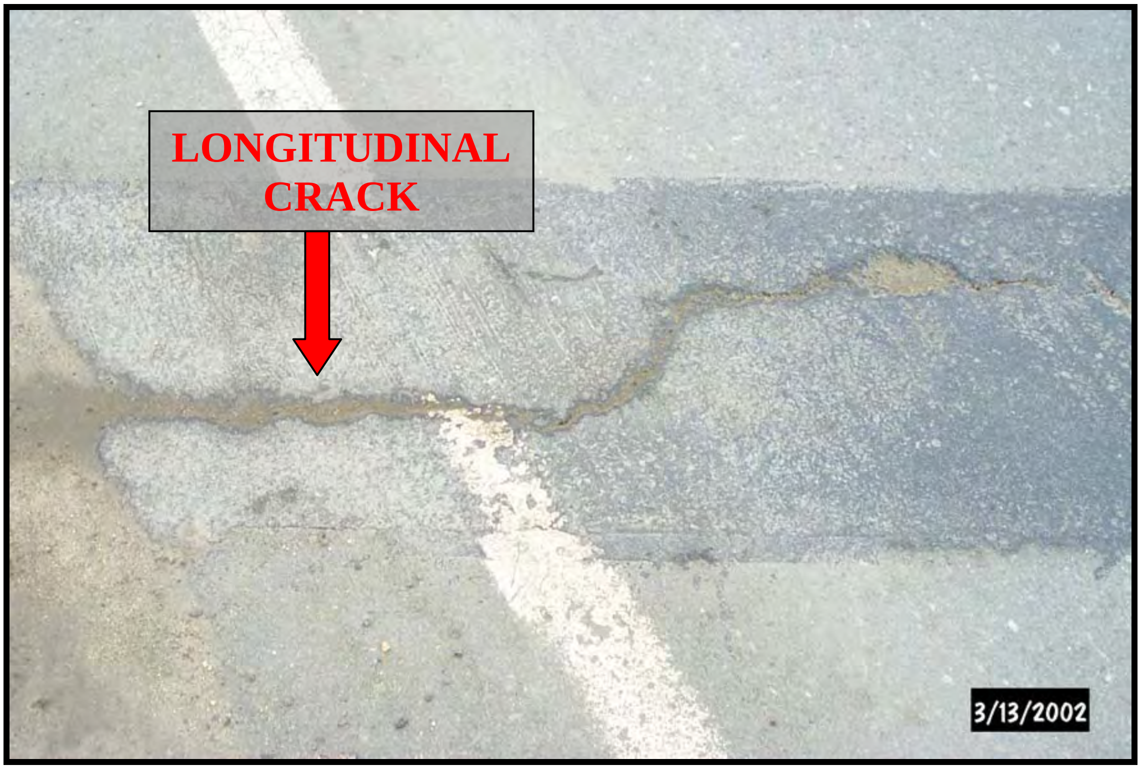
Picture #2: Bleeding/ Track out on bridge #661 I-95 over Thurbers Ave. Providence, RI



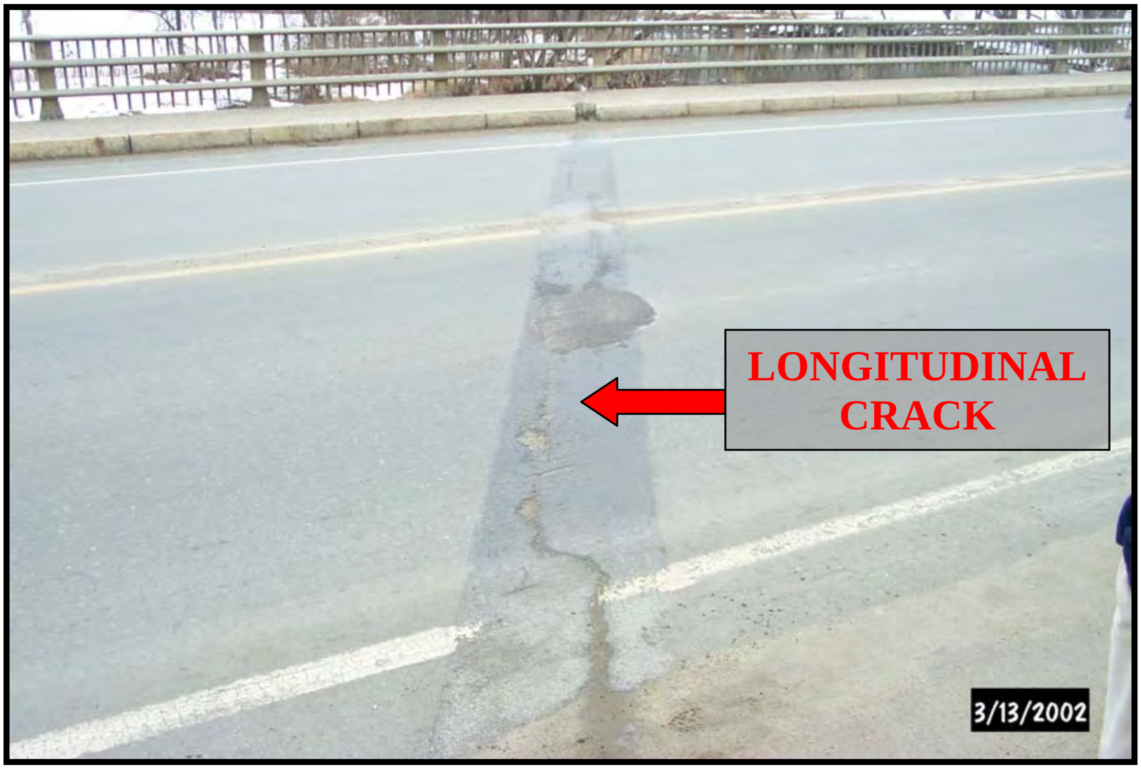
Picture #3: Bleeding/ Track out bridge #03913 Route 71 over Route 72 New Britain, CT



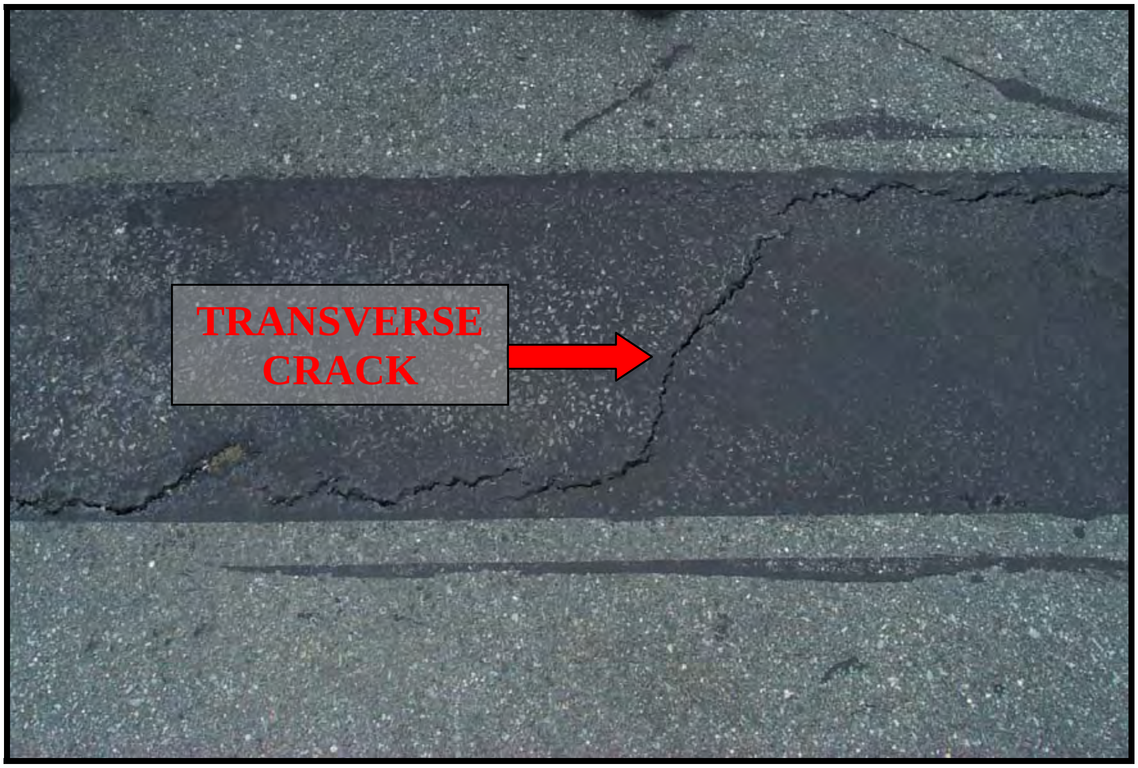
Picture #4: Curb Sealant Issues on bridge #W06053 North Street Over I-195, Wareham, MA



Picture #5: Cracking on bridge#144 US 5/Passumpsic River Joint 2 Lyndon, VT

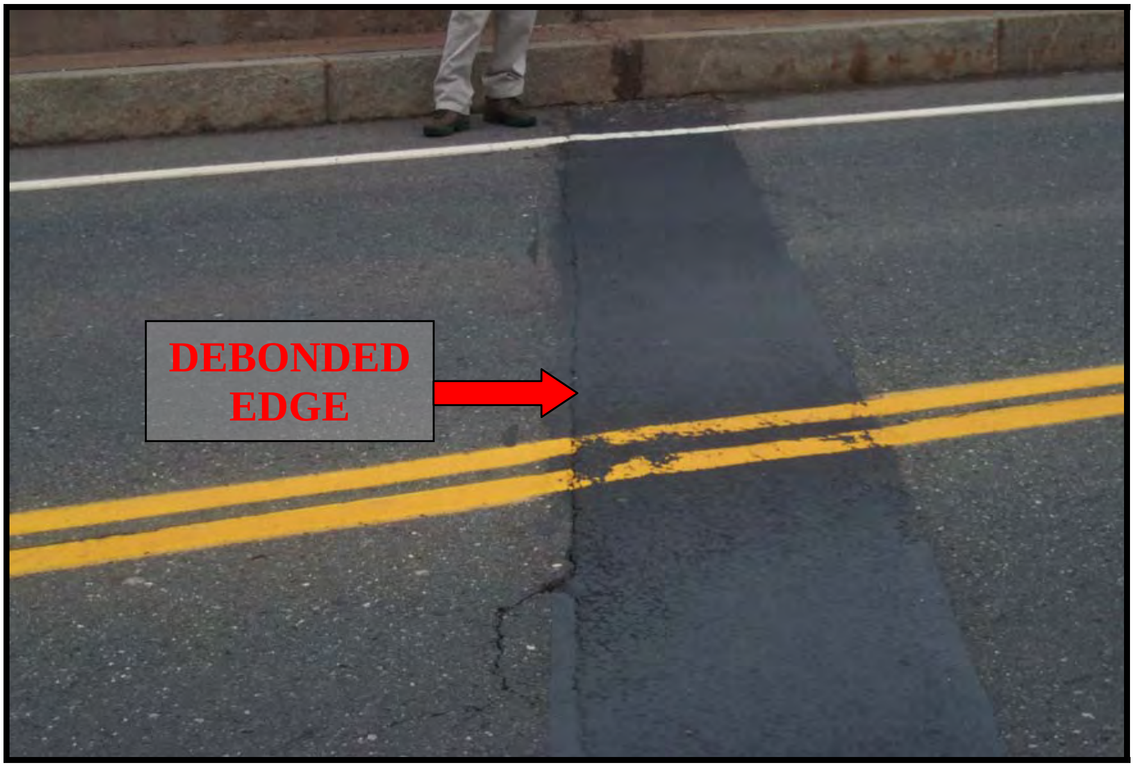


Picture #6: Cracking on bridge#144 US 5/Passumpsic River Joint 2 Lyndon, VT



Picture #7: Cracking on bridge #1N I-93 over VT 18 North Waterford, VT

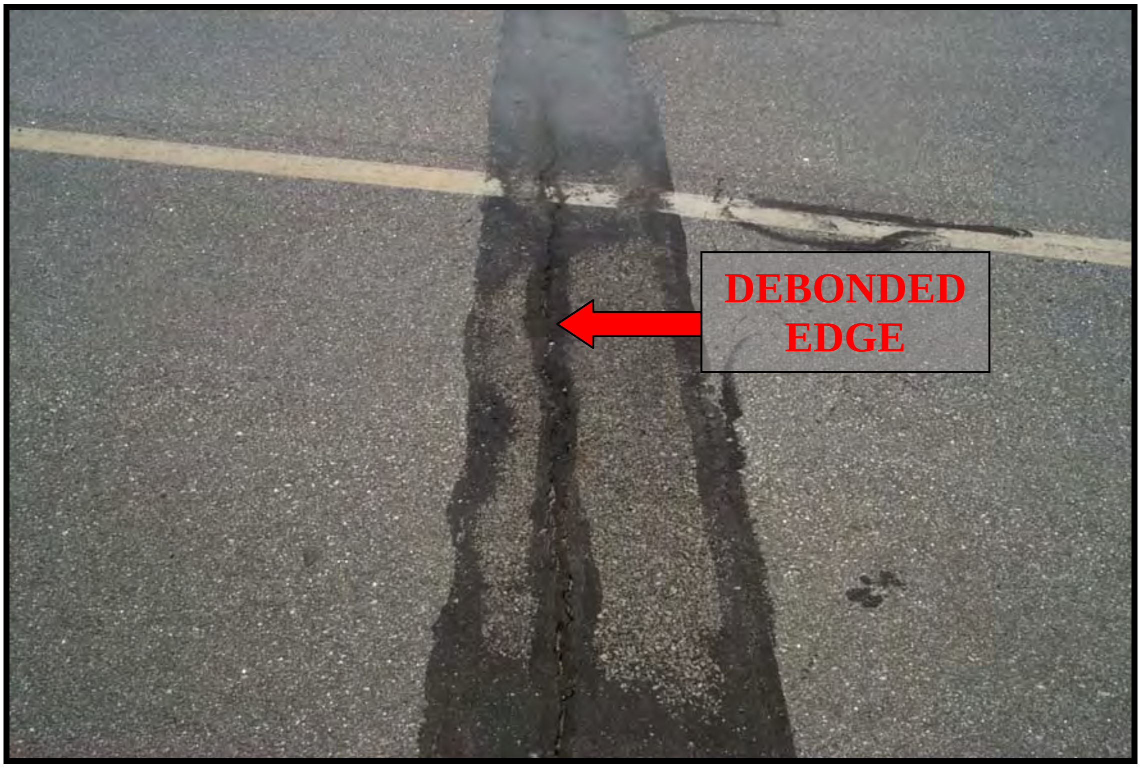
Picture #8: Cracking on bridge #088/126 US Route 4 over Suncook River Overflow Epsom, NH



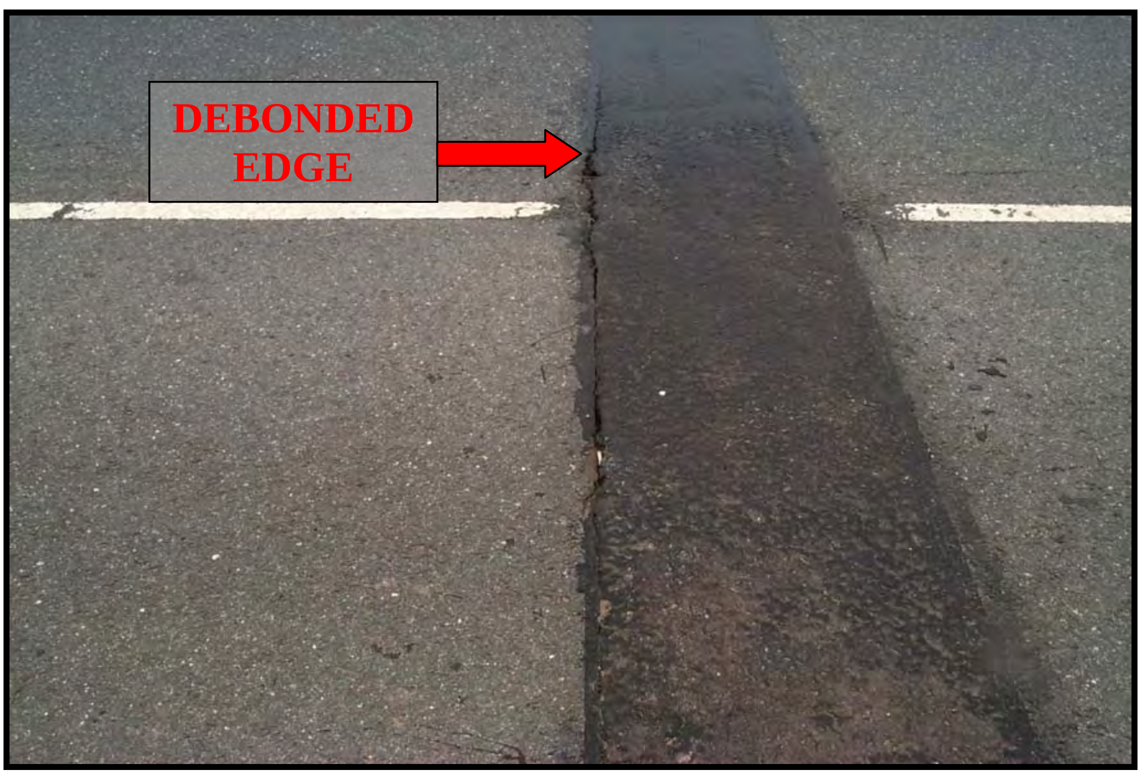
Picture #9: Debonding on bridge #03163 RTE. 160 over I-91 Rocky Hill, CT

Picture #10: Debonding on bridge # M09009 Route 28 over I-195 Mattapoisett, MA

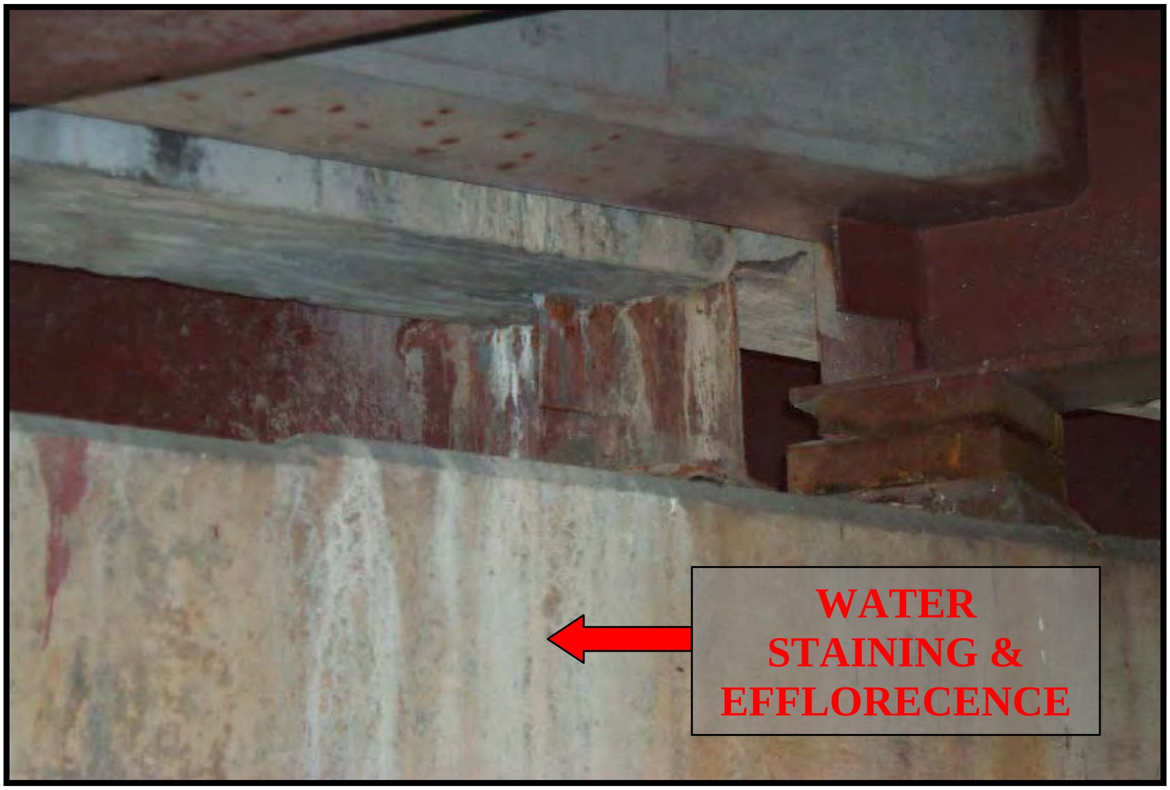
Picture #11: Debonding on bridge # W06053 North Street over I-195 Wareham, MA



Picture #12: Debonding on bridge #123/173 NH Route 27 over NH route 101 Hampton, NH



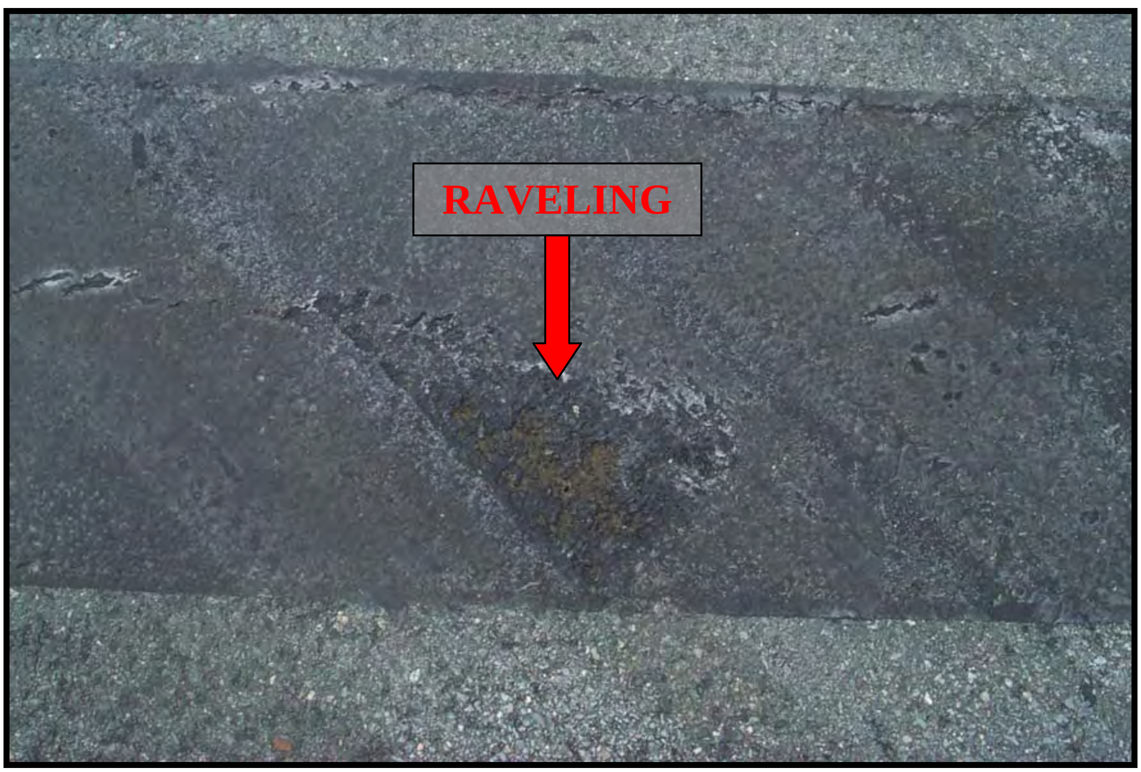
Picture #13: Debonding on bridge #03313 I-84 TR over 815 New Britain, CT



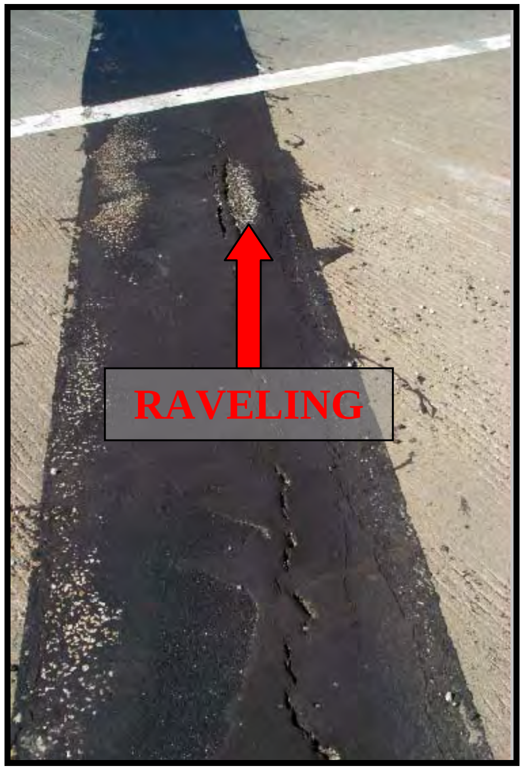
Picture #14: Water staining on bridge#N06013 Route 140 over Braley Road New Bedford, MA

Picture #15: Water staining on bridge#102/120 Old Route 16 over Branch River Milton, NH

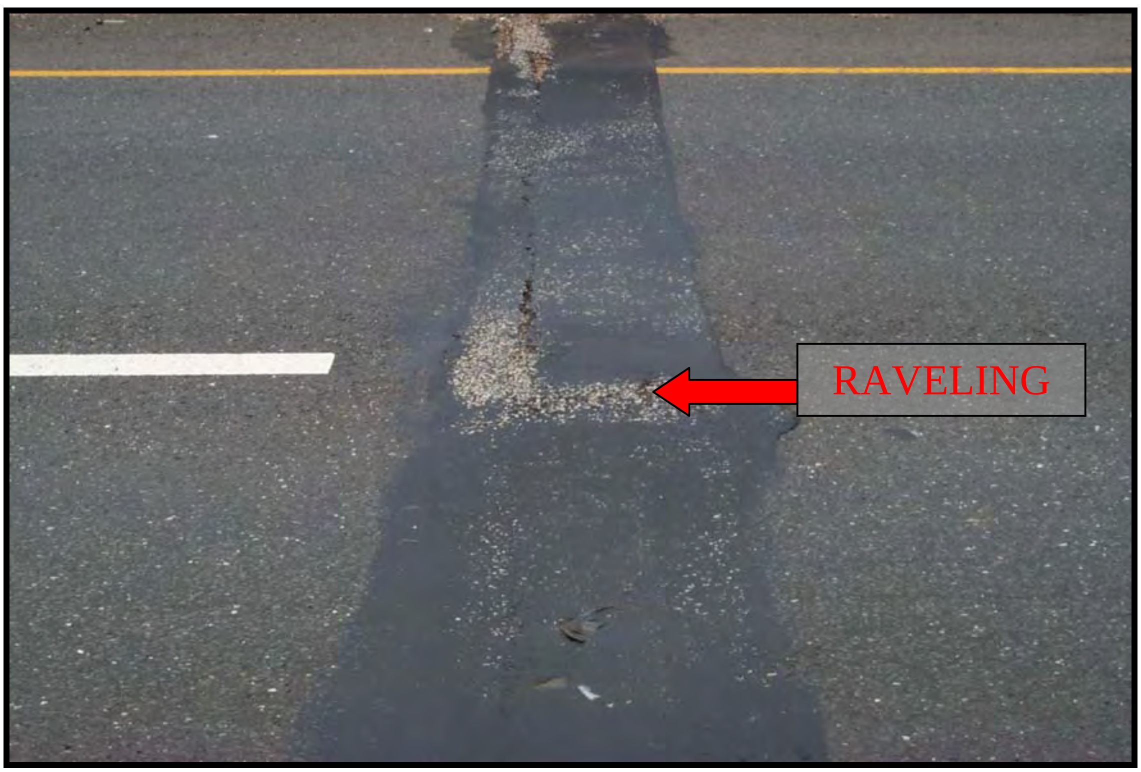
Picture #16: Girder corrosion on bridge #102/120 Old Route 16 over Branch River Milton, NH



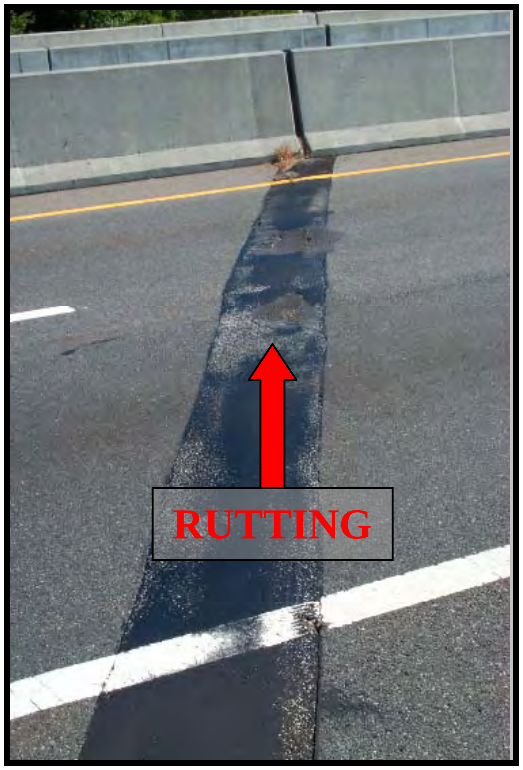
Picture #17: Raveling on bridge #5N I-93 over TH NO 7 North Joint #2 Waterford, VT



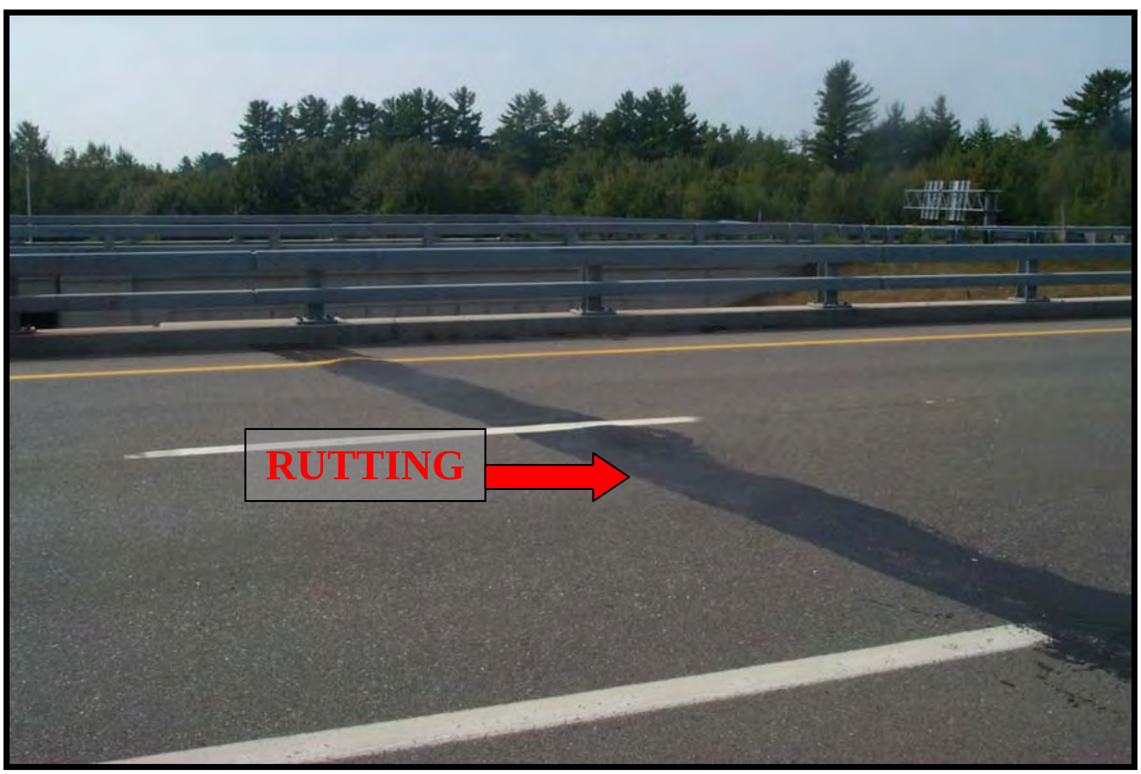
Picture #18: Raveling on bridge #W30025 I-195 West over Sanford Road Westport, MA



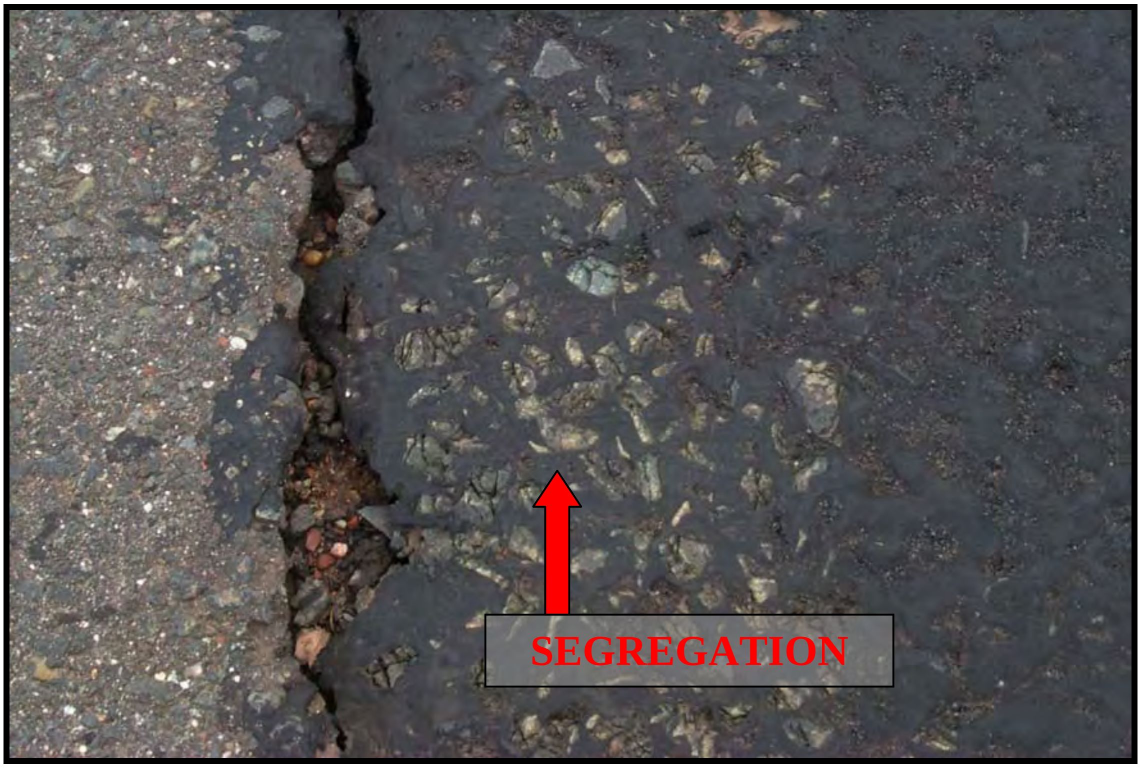
Picture #19: Raveling on bridge #03507 Route 9 over Private Road Berlin, CT



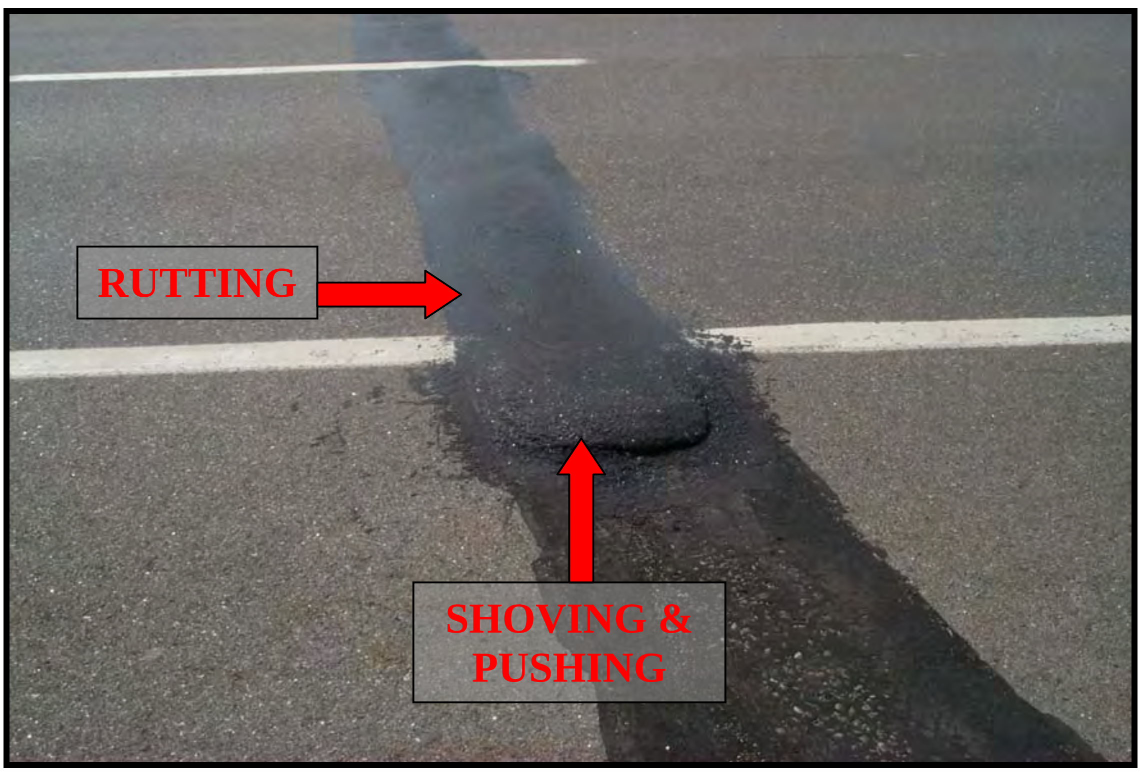
Picture #20: Rutting on bridge#N06013 Route 140 over Braley Road New Bedford, MA



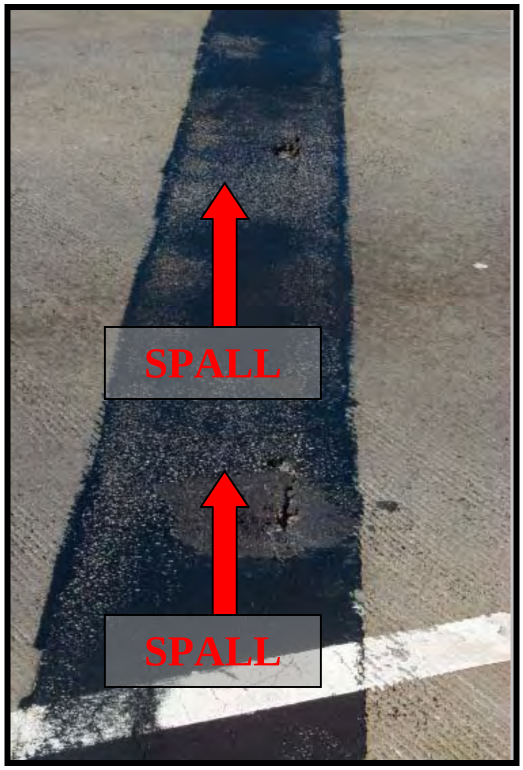
Picture #21: Rutting on bridge #109/038 NH Route 101 over NH Route 125 Epping, NH



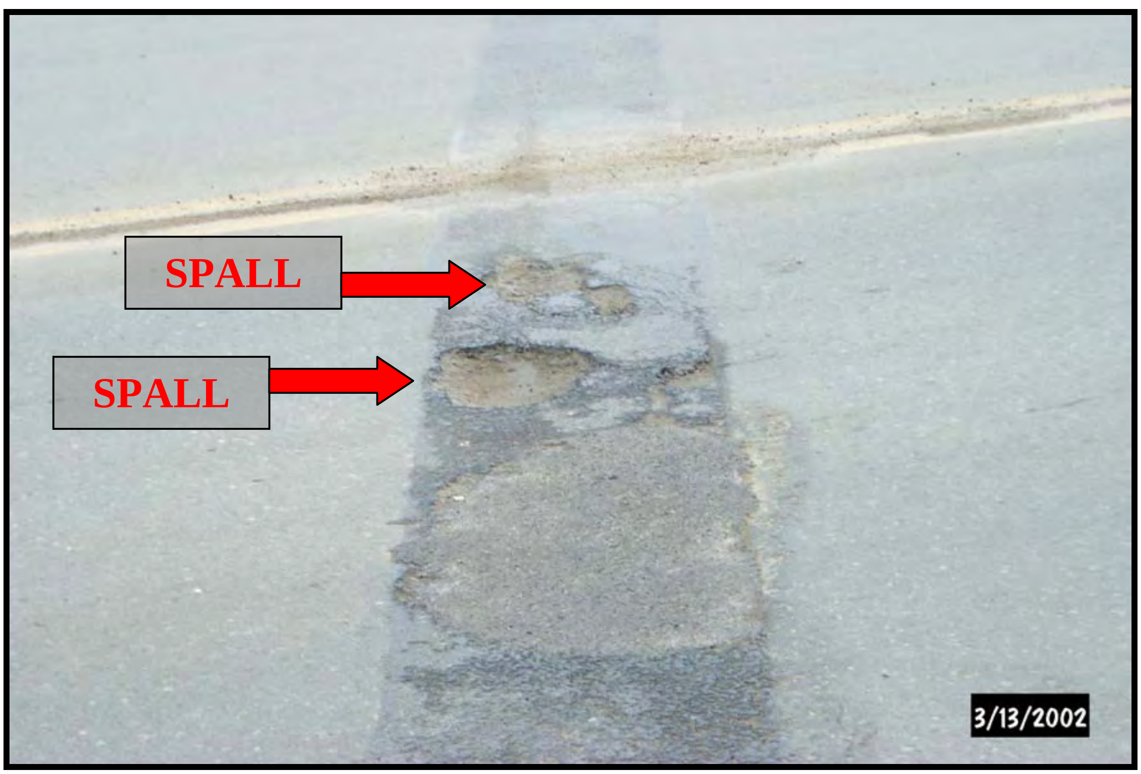
Picture #22: Segregation on bridge #03313 I-84 TR Over 815 New Britain, CT



Picture #23: Shoving & Pushing on bridge#109/038 NH Route 101 over NH Route 125 Epping, NH



Picture #24: Spalled joint on bridge #W30025 I-195 West over Sanford Road Westport, MA



Picture #25: Spalled joint on bridge#144 US5/Passumpsic River Joint 3 Lyndon, VT

Picture #26: Snowplow damage on bridge #123/173 NH Route 27 over NH Route 101 Hampton, NH

From these field inspections it was concluded that the major material distresses leading to failure of the joint (leakage) would be debonding and cracking due to the high percentage of their occurrence in New England. Similarly rutting is of concern, not necessarily because of leakage, but rather because of poor ride quality over the joint.

5.0 BRIDGE DATA

In an effort to correlate particular distresses conditions to geometric phenomena, Umass Dartmouth requested bridge plans for each of the bridges that were field inspected. The parameters that were researched: bridge length, bridge width, span sizes, skew angle, joint width, joint depth, and special curb/sidewalk details. The results of this work can be seen in Appendix F.

In addition Umass Dartmouth requested any information on the manufacturer of the existing bridge joint, installation date, name of installation company, and the ADT/percent trucks on the bridge. Again, the results of this work can be seen in Appendix F.

From this information an attempt was made to correlate the distress to a specific geometric parameter or type of joint. However due to incomplete information on many bridges, no correlation could be attempted. Making any correlation with the available data would result in a generalization and would have no scientific merit at this time.

6.0 WITNESSED INSTALLATIONS

As part of this research Umass Dartmouth was able witness demolition of existing APJs and installation of the new systems in CT and VT. These installations were done by a different manufacturer in each state, and on a varied number of joints. In VT only one joint was replaced while in CT four joints were replaced. During the demolition and installation processes witnessed, Umass Dartmouth noted the following occurrences at one or both of the sites:

1. None of the construction procedures addressed issues existing at the curbs. In many cases the curb sealant was severely deteriorated and would require replacement to keep the joint watertight.
2. In all cases the backer rod in the bridge deck was not replaced; instead the existing backer rod was left in place and the new system installed.
3. In one case the state DOT official was not on-site to verify the conditions of the deck until after the new joint system was already being placed.
4. In one case the installer did not appear, in the opinion of the authors, to know how to properly operate the equipment. Also, this installer did not check the temperature of the material being placed into the joint.
5. In all cases the existing APJ material removed from the joint was not in sufficient condition to cut cores for further lab testing by Umass Dartmouth. Type and manufacturer at these installation locations of the existing APJ was also not known.

7.0 LABORATORY TESTING

In order to properly identify the relevant material properties of the APJ, virgin materials were requested from each approved APJ manufacturer used in the New England states. Initially this process was fruitless. Due to the proprietary nature of all materials used in an APJ, most manufacturers were very reluctant to supply materials. However after almost 8 months of persistence from Umass Dartmouth and the NETC committee, the materials outlined in Section 7.0.1 were obtained. Pictures of these materials in their as received condition can be seen in Appendix G.

In addition to the virgin material, Umass Dartmouth requested from each New England state core material from existing joints for material and performance testing. This was requested in lieu of preparing lab specimens or making a “scaled” joint mold that material could be placed in. The lab specimen option was negated because no representative compaction parameters could be established for all APJ manufacturers (i.e. Roller compaction, Superpave gyratory compaction, number of gyrations, compaction temperature, etc.). The second option of creating a mold that APJ material could be placed into by the manufacturer was originally negated because there was insufficient time to create a mold and have the manufacturers place their material. As this option was thought of in depth, a series of geometric considerations for the mold size made this option very difficult to be completely unbiased. First and foremost the mold would not be strong enough, even if cast out of concrete, to support joint rolling with a one-ton compactor as was the case of Watson Bowman Acme (verbally disseminated to Umass Dartmouth). Secondly, it was the opinion of Umass Dartmouth that creating a mold of a fixed size and depth may be favorable for one manufacturer and not for another (i.e. one manufacturer works better at shorter depths and one at longer depths). For these reasons and the anticipated costs involved, the attempts to create APJ material samples were suspended. After discussion with the technical committee it was decided that drilling core material from existing joints would be the most logical means of material testing for this report.

Umass Dartmouth was able to obtain limited amount of core material from NH and CT. New Hampshire supplied 10 cores from three different bridges, all of which were included in the field inspection portion of this research. Connecticut provided APJ demolition material from an unspecified bridge. The material was found to be unsuitable for core cutting, and due to its unknown origin and type, was not tested for inclusion in this report. CT also supplied a limited amount of field produced APJ loose mix from a Lafarge Road Marking job. However the amount was too small to complete any significant testing. Pictures of the NH and CT materials can be seen in Appendix G.

7.0.1 Virgin Material Testing

In an effort to better understand the material specification criteria for the components of the APJ mixture, Umass Dartmouth contacted each approved APJ manufacturer listed in Table 11 for virgin samples of aggregate and binder for their systems. From these conversations, Umass Dartmouth was able to obtain the following:

Manufacturer	**Material Obtained**
Lafarge Road Marking	60lb Box – Binder B/N 0753102101 Part No. 89998801
Watson Bowman Acme	40lb Bag – Expandex Aggregate "B" Lot N/7247 40lb Bag – Expandex Aggregate "C" Lot N/7248 30lb Box – Expandex Modified Elastomeric Binder Lot P1726
Wyoming Equipment Sales	50lb Bag – A.P.A. Basalt Stone 30lb Box – Binder WES APB Lot 523

Table 26: Virgin Material Obtained for Testing

A gradation analysis of the aggregates received from the manufacturers was performed at Umass Dartmouth in accordance with AASHTO T11-97(2000) entitled "*Materials Finer than 75-μm (No. 200 sieve) in Mineral Aggregates by Washing*" and AASHTO T27-99 entitled "*Sieve Analysis of Fine and Coarse Aggregates*". The results of the analysis as well as the corresponding limits stated by each manufacturer are presented in Table 27 and 28.

	Watson Bowman Acme Expandex Size B	**Watson Bowman Acme Expandex Size C**	**Wyoming Equipment Sales - A.P.A. Basalt Stone**
% Material Finer than No. 200 Sieve	0.08%	0.1%	0.45%

Table 27: AASHTO T-11 Results for Virgin APJ Aggregate

		Percent Passing		
Sieve Size (mm)	Sieve Size (in)	Watson Bowman Acme Expandex Size B	Watson Bowman Acme Expandex Size C	Wyoming Equipment Sales - A.P.A. Basalt Stone
25	1	100	100	100
19	0.75	100	96.6	96.1
12.5	0.5	100	24.9	23.4
9.5	0.375	92.0	4.2	4.3
(No. 4) 4.75	0.187	7.5	0.4	1.1
(No. 8) 2.36	0.0937	0.4	0.4	0.8
(No. 16) 1.18	0.0469	0.3	0.3	0.8
(No. 30) 0.600	0.0234	0.3	0.3	0.8
(No. 50) 0.300	0.0117	0.3	0.3	0.8
(No. 100) 0.150	0.0059	0.3	0.3	0.7
(No. 200) 0.075	0.0029	0.3	0.3	0.7

Table 28: AASHTO T-27 Results for Virgin APJ Aggregate

	Percent Passing					
Sieve Size (in)	UMD Gradation Analysis Watson Bowman Size B	Manufacturer Stated Gradation Watson Bowman Size B	UMD Gradation Analysis Watson Bowman Size C	Manufacturer Stated Gradation Watson Bowman Size C	UMD Gradation Analysis WES APA Basalt Stone	Manufacturer Stated Gradation Wyoming Equipment Sales - A.P.A. Basalt Stone
1”	100%	100%	100%	100%	100%	-
7/8”*	-	-	-	-	-	95 - 100%
3/4”	100%	-	96.6%	-	96.1%	-
5/8”*	-	-	-	-	-	30 - 50%
1/2"	100%	90 - 100%	24.9%	90 - 100%	23.4%	10 - 30%
3/8”	92%	-	4.2%	-	4.3%	0 - 15%
1/4"*	-	0 - 15%	-	0 - 15%	-	-

Please note that Umass Dartmouth does not have the 1/4”, 5/8”, or 7/8” sieve sizes.

Table 29: APJ Aggregate Gradation Analysis vs. Manufacturer’s Data

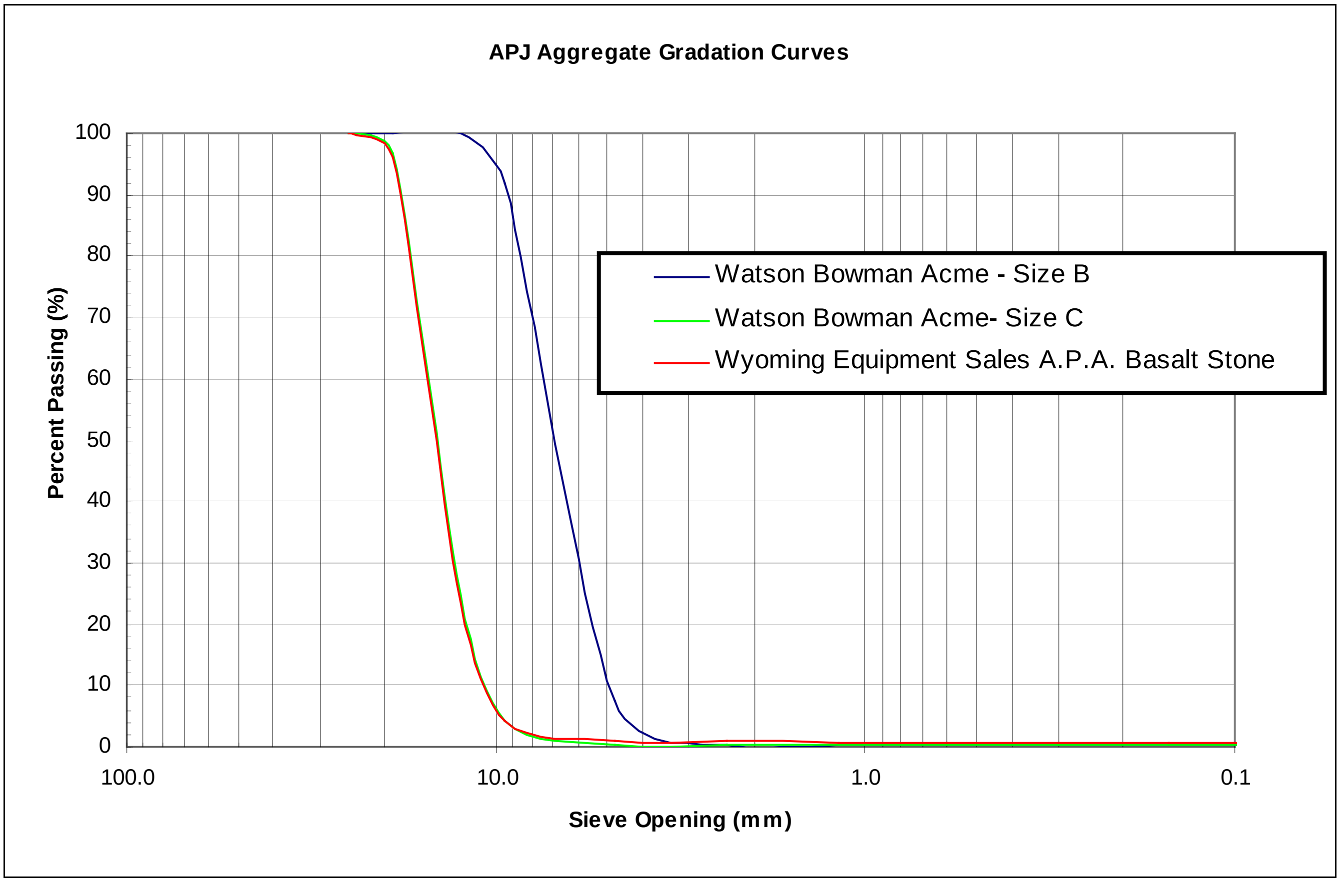


Figure 3: APJ Aggregate Gradation Curves

It can be seen from this data that all aggregate material has met the manufacturers written criteria except for the Watson Bowman Size C aggregate. This aggregate is far out of tolerance for the 1/2" sieve size. It is Umass Dartmouth assumption that the since the gradation limits for the Watson Bowman Acme Size B & C aggregate are exactly the same, that the Size C gradation was simply misrepresented in the manufacturers data because of a clerical error. Efforts to contact Watson Bowman Acme on this issue have been unsuccessful.

In addition to the aggregate testing, the virgin binder material that was received was also tested. Due to the time constraints and specialized equipment involved, these binders could not be tested for every parameter in Table 3. It was decided that each of the binders would be tested to determine the performance grade (PG), if possible. This means of classifying binders came as a result of work conducted under the Strategic Highway Research Program (SHRP) and is the designation given to any Superpave asphalt binder being produced currently. In addition to this Superpave classification test, it was decided to run the Resilience test in accordance to ASTM D5329 as well. In speaking with APJ industry professionals, many believed that resiliency of the binder plays a major role in the functional characteristics of the APJ system.

These two tests were not conducted at Umass Dartmouth as originally anticipated. Due to the unique nature of these binder materials, it was necessary to send the samples to a lab better equipped to handle such a specialized product. The testing was conducted by Advanced Asphalt Technologies (AAT), which is an AASHTO accredited laboratory located in Sterling Virginia.

Umass Dartmouth cut smaller chunks of binder from each box with a reciprocating saw and mailed them to AAT. The results of their tests are presented in Table 30.

Manufacturer	**Binder Information**	**Resiliency @25°C per ASTM D5329**	**Performance Grade**
Lafarge Road Marking	Binder B/N 0753102101 Part No. 89998801	68%	PG88-22
Watson Bowman Acme	Expandex Modified Elastomeric Binder Lot P1726	62%	Could not be Determined
Wyoming Equipment Sales	Binder WES APB Lot 523	18%	PG94-22

Table 30: Virgin APJ Binder Test Results

First, the binders tested for resilience met their printed requirements. Lafarge Road Marking required 40% minimum, Watson Bowman Acme required 60% minimum, and Wyoming Equipment Sales had no required value. If this value were compared against ASTM and current available New England State specifications, only the Lafarge Road Markings and the Watson Bowman Acme binder would suitably meet each requirement. ASTM requires resilience between 40-70%; CT requires 60% minimum, and MA requires 70% maximum. The Wyoming Equipment Sales product would meet the resilience requirement for MA only.

Next, AAT subjected each binder sample to a series of tests in accordance with AASHTO R29 entitled, *"Grading or Verifying the Performance Grade of an Asphalt Binder"*. The results of these tests were compared with AASHTO M320 entitled, *"Performance-Graded Asphalt Binder"* to determine each binder's Performance Grade (PG). The PG tests were developed to determine the binder's optimum temperature performance range thus leading to better performing pavement. Each binder is given the following designation: PG XX-YY. The XX portion represents the average 7-day maximum pavement design temperature, whereas the YY portion represents he minimum pavement design temperature. In southern New England a PG64-28 is considered the standard value for a neat (unmodified) binder. This binder is suitable for pavements with an average 7-day maximum pavement temperature of 64ºC and a minimum of -28ºC.

No specific requirement has been published for the PG of APJ binders. The assumption regarding these binders is that they are highly modified as opposed to conventional neat binders This modification involves the addition of polymers and associated materials necessary to increase the PG of the binder. The most significant work available regarding the PG of modified asphalts results from NCHRP 9-10 entitled, *"Superpave Protocols for Modified Asphalt Binders"* conducted by the University of Wisconsin.

Umass Dartmouth consulted the Principle Investigator (PI) of NCHRP 9-10 project when the PG testing for the APJ materials was completed to get a better understanding of the results. From the two binders that could be graded, the average 7-day maximum pavement design temperature was 88ºC (PG88-22) for the Lafarge Road Marking binder and 94ºC (PG94-22) for the Wyoming Equipment Sales binder. In talking with PI of NCHRP 9-10, it was his and Umass

Dartmouth's opinion that these numbers appeared valid and almost necessary to keep the APJ mixture from tracking out of the joint in warmer weather, especially since these systems are composed of a single aggregate. On the minimum temperature side, both of the binders were -22ºC (PGXX-22). It was Umass Dartmouth and the NCHRP 9-10 PI's opinion that since normally a neat binder of PGXX-28 is used in New England, that these binders were not adequate for the New England temperature conditions. It is suggested that the binders be adjusted so they grade at PGXX-28 or higher. The current PGXX-22 binders are more prone to thermal cracking and fatigue. It appears that future adjustments will need to be made in the APJ binder in order to meet this minimum temperature requirement.

7.0.2 Core Material Testing

As noted previously, Umass Dartmouth received APJ cores from NH. These cores came in varying sizes (4" or 6") from three different bridges in this study. Specifically, the following cores were received:

- Four (4) cores from Bridge No. 123/173 located in Hampton, NH
- Three (3) cores from Bridge No. 102/120 located in Milton, NH
- Three (3) cores from Bridge No. 109/038 located in Epping, NH

The cores from each bridge were taken at different locations along the length of the joint with some being taken in the shoulder while others in the travel lanes.

When Umass Dartmouth received the cores, it should be noted that there were areas within the individual cores where it appeared dry (i.e. clean aggregate with no binder coating). Pictures of some of these cores can be found in Appendix G.

Originally it was intended to use these cores for performance testing, however due to the limited quantity and poor quality of the cores, it was decided to use them for extraction tests. The extraction test was used to determine the binder content of each core (per AASHTO T164 Method A) and the approximate gradation (per AASHTO T30). From this data it was hoped that in-place gradations could be verified and that an approximate binder content for an APJ could be determined. Again the extraction tests were completed by AAT due to the unique nature of the binder. The results are summarized in Table 31 through 33. The raw data results from AAT are available in Appendix H.

	NH Bridge No. 123/173				
Sieve Size	**Core #1**	**Core #2**	**Core #3**	**Core #4**	**Average**
1"	100	100	100	100	**100**
3/4"	100	100	100	100	**100**
1/2"	99.6	99.6	100	100	**99.8**
3/8"	90.5	89.2	89.5	92	**90.3**
No. 4	46.2	44.7	48.1	47.8	**46.7**
No. 8	14.8	12.2	15.3	13.4	**13.9**
No. 16	10.1	7.9	10	8.2	**9.1**
No. 30	8.2	6.5	8.1	6.8	**7.4**
No. 50	6.6	5.7	6.9	6.2	**6.4**
No. 100	5.9	5.2	6.3	5.8	**5.8**
No. 200	5.4	4.8	5.8	5.5	**5.4**
% Asphalt	18.93	17.15	19.29	17.92	**18.3**

Table 31: NH Bridge No. 123/173 Core Extraction Data

	NH Bridge No. 102/120			
Sieve Size	**Core #1**	**Core #2**	**Core #3**	**Average**
1"	100	100	100	**100**
3/4"	100	100	100	**100**
1/2"	98.3	99	98.3	**98.5**
3/8"	76.1	76	81.7	**77.9**
No. 4	26.1	33.8	44.4	**34.8**
No. 8	18.1	21.5	31.6	**23.7**
No. 16	14.9	16.3	23.6	**18.3**
No. 30	13.1	13.2	19.3	**15.2**
No. 50	12.3	12	17.1	**13.8**
No. 100	11.7	11.2	15	**12.6**
No. 200	11.1	10.6	13	**11.6**
% Asphalt	41.24	38.12	47.21	**42.2**

Table 32: NH Bridge No. 102/120 Core Extraction Data

	NH Bridge No. 109/038			
Sieve Size	**Core #1**	**Core #2**	**Core #3**	**Average**
1"	100	100	100	**100**
3/4"	99.3	98.7	94.4	**97.5**
1/2"	83.8	82.9	60.5	**75.7**
3/8"	71.5	70.7	47.2	**63.1**
No. 4	26.4	31.4	13.8	**23.9**
No. 8	14.9	16.8	10.7	**14.1**
No. 16	12.5	13.5	9.7	**11.9**
No. 30	11.1	11.8	9.1	**10.7**
No. 50	10.1	10.7	8.7	**9.8**
No. 100	9.5	9.9	8.3	**9.2**
No. 200	8.9	9.1	7.7	**8.6**
% Asphalt	19.87	19.14	17.1	**18.7**

Table 33: NH Bridge No. 109/038 Core Extraction Data

From these results it can be seen that there was minimal variance between core gradations for any particular one bridge, indicating that segregation issues were not present at these locations. The percent binder for each of these locations seems consistent as well. The next step was to compare the gradations to the manufacturers intended gradation as outlined in Table 15.

Bridge No. 123/173 was a Watson Bowman APJ system installed in 1997. The Watson Bowman Acme system is a two stone system. The gradation requirement of the aggregate should have a similar average extraction gradation. The comparison is shown in Table 34. Please note that the extraction method was done chemically so little variance in the gradation is expected, as opposed to an ignition oven where some of the fines may be consumed as the asphalt is burned off.

	Percent Passing	
Sieve Size (in)	**Extraction Analysis**	**Watson Bowman Acme Expandex**
1”	100%	100%
7/8”*	-	-
3/4”	100%	-
5/8”*	-	-
1/2"	99.8%	90 - 100%
3/8”	90.3%	-
1/4"*	-	0 - 15%
No. 4	46.7%	-

**** Please note that Umass Dartmouth does not have the 1/4”, 5/8”, or 7/8” sieve sizes.***

Table 34: NH Bridge 123/173 Extraction Gradation Analysis vs. Manufacturer’s Data

As one can tell, the cores taken from NH Bridge 123/173 had significantly more material passing the 1/4" sieve than was published by Watson Bowman Acme. This may have occurred for several different reasons. First, since the joint was placed in 1997, Watson Bowman Acme could have changed their aggregate gradation for this system since them. Secondly, a mix up could have occurred in bookkeeping and the joint that is on that particular bridge may not be a Watson Bowman Acme joint. For the sake of argument, if Watson Bowman Acme manufactured the joint, this suggests that the aggregate may be broken or crushed by repeated traffic loading. In any event, a material compliance submission and check must be completed to ensure the material being placed is indeed the material specified.

Bridge No. 102/120 was a experimental plug joint installed by the NH Bridge Maintenance group in 1998. This joint was installed using Crafco RS-201 crack sealer and a NH specified aggregate gradation (This gradation was not available to Umass Dartmouth). Since this joint was experimental, there are no standards to compare it to.

Bridge No. 109/038 had a system that of unknown origin and installation date and therefore could not be compared with any manufacturers specification.

In regards to the binder content, the values between Bridge No. 123/173 and 109/038 seem to be consistent, indicating that a “conventional” APJ will have a binder content around 18.5%. The cores from Bridge 102/120 are significantly higher at 42.2% on average, but one must bear in mind that this was an experimental joint with likely little or no emphasis placed on percent binder relative to aggregate. Thus the assumption made here, that a conventional APJ has a binder content around 18.5%, is a lofty one and should be verified in the future with cores from a bridge with known manufacturer and system.

Finally please also note that AAT found a significant amount of crumb rubber particles in the extracted cores samples. These rubber particles are most likely remnants of the binder modification procedure. Modifying the performance grade of a binder, in a general sense, involves the addition of polymers and waste rubbers to raise the PG level. As in the case of these extractions, the crumb rubber particles indicate that the binders used for these joints systems were highly modified.

7.0.3 Performance Testing

As part of the performance research presented here, Umass Dartmouth was to develop and evaluate testing methodologies for the APJ mixture. Originally this included lab testing the material for indirect tensile strength and field-testing by a simple penetration test.

The field simple penetration test was to be conducted immediately after construction by taking three readings of a modified cone penetrometer. This test would then be conducted with the same joint being cooled to a specific temperature with dry ice. Finally the test would be conducted immediately after re-heating the joint with an infrared heater to the pre-cooling temperature. After numerous discussions with experts, the field test was omitted due to concerns that the rapid heating and freezing cycle proposed would stress the material beyond its capability. Thus another lab test was added as part of this research, which was the rutting susceptibility of the APJ mixture using an accelerated pavement tester (APT) known as the Asphalt Pavement Analyzer (APA).

Unfortunately due to the small quantity and poor quality of the core material received, the performance-testing portion of this research had to be omitted. Lab indirect tensile strength tests would have required at least two specimens from each manufacturer. The APA test that replaced the simple penetration test would have required at least three cores per manufacturer. All these cores would have need to have been of excellent quality and approximately equal thickness.

8.0 CURB INTERSECTION DETAILS

No firm literature was available on the proper means to seal a curb joint location at an APJ. In addition, the survey conducted by Umass Dartmouth concluded that only 25% of the respondents specify any particular curb details.

As was the case in the New England states, most specifications simply state that the sealant be installed according to the manufacturers instructions. Some state that the curb sealant should be a Dow 888 (See Appendix D for data sheet) or approved equal. Therefore the recommendations presented here are based on field inspections and rule of thumb engineering.

During the field investigations conducted by Umass Dartmouth, many different curb details were noted in the New England states. Umass Dartmouth has classified them into the following categories: no curb, standard curb (with or without sidewalk), parapet, sliding plate, and custom curb detail. Examples of each can be seen in the pictures below.

Picture #27: Parapet Detail on Bridge#03313 I-84 TR over 815 New Britain, CT

Picture #28: Parapet Detail on Bridge#W30025 I-195 West over Sanford Road Westport, MA

Picture #29: Standard Curb Detail on Bridge #W06053 North Street over I-195 Wareham, MA

Picture #30: Sliding Plate Detail on Bridge#123/173 NH Route 27 over NH Route 101 Hampton, NH

Picture #31: Custom Curb Detail on Bridge#102/120 Old Route 16 over Branch River Milton, NH

Picture #32: No Curb on Bridge #164 School Street over Blackstone River Lincoln Cumberland, RI

Each of these details, at the time of inspection, appeared to be working within the limits of the sealant. Numerous instances of sealant deterioration and corresponding pealing or pulling from substrate were noted but no evidence of joint leaking from these areas was noted. In addition most of the structural elements of the curb appeared intact and functional, with the minor exception of surface rusting on steel plates as shown on the standard curb detail picture noted above.

The deterioration of the curb sealant seems linked to harsh weathering conditions, especially exposure to sunlight, which can dry out the sealant and cause it to become brittle over time. Excessive bridge movements can compound this deterioration when the sealant becomes brittle, thus leading to the pulling action from the substrate. There is no real means to mitigate this sealant deterioration, although many sealants have been designed to resist the harmful effects of sunlight. Unfortunately most of these sealants are residential grade and may not be applicable to the harsh condition of a bridge joint.

Umass Dartmouth would recommended that the state DOT's introduce a maintenance program to reseal these joints on a periodic basis. An item should be added to the bridge inspection report to quantify and qualify the condition of the curb areas including sealant issues to keep up with proper maintenance. In lieu of this, the DOT's may consider trying to incorporate drainage into the curb intersection design to remove water that will enter the joint when/if the sealant deteriorates.

9.0 DEVELOPMENT OF DESIGN GUIDELINES

The design guidelines developed by Umass Dartmouth as a part of this research were incorporated into three individual documents. The first document was a checklist created for engineers or joint designers to determine if an APJ was suitable for their specific application. The second was a summarized material compliance specification for the individual components constituting an APJ. The last document created was an installation specification that addressed all the necessary steps in constructing a quality APJ. It was intended that these three documents would be used in conjunction with each other to take an engineer from preliminary design phase through construction. The final copies of these documents are located in Appendix I through K.

Before further elaborating on the these specifications, the following terms need to be more clearly defined:

Manufacturer - Company that produces and sells the APJ system (i.e. Watson Bowman Acme.)
Contractor - Company or person that installs the APJ system on behalf of the manufacturer and has been trained to do so by the manufacturer.
Installer - Same definition as Contractor.
Designer or Design Engineer - State DOT or highway department official that is the person responsible for deciding whether or not to use an APJ.
Field Engineer - State DOT or highway department official that is on-site during the installation process and responsible for ensuring the joint is placed according to specification.

9.0.1 Asphaltic Plug Joint Suitability Checklist Development

The APJ design checklist was developed by reviewing the manufacturers product data, state DOT specifications, and talking with professionals in the industry. In comparing all this data, it was noted that some values are common "standards". Namely these "standards" were the maximum allowable joint movement at ±1", joint width at 20", and minimum joint depth of 2".

The first addition to this checklist was the elaboration on the minimum depth of the APJ value. Because of cross slopes and unique curb details, the depth of the APJ may change depending on where it is measured along the joint (i.e. the joint depth is not constant). Therefore a stipulation was added that the 2" requirement should be measured at the point of minimum thickness. If 2" is not attained, then an APJ is not suitable. Some states consider 3" to 4" as the optimum depth for an APJ. Finally restrictions needed to be put on maximum depth of installation. Based on manufacturers data, Umass Dartmouth decided that 6" should be the maximum allowable depth. This value should be verified by examining in place joints performance with these depths.

The second addition to the checklist was a disclaimer that using APJ where vertical displacements occur is not advised. From the literature review and talking with industry professionals, the APJ is not capable of taking vertical movement or end beam rotations. Thus the APJ is more suitable for shorter span applications where vertical displacements are minimized. The exact span size will need to be determined by future testing procedures outside the scope of this project.

Third, the skew angles limitations were elaborated on. The state DOT specifications summarize that the skew angle should be less than 25°, whereas the manufacturers data suggest that an APJ can function up to 45°. Thus the checklists was scripted such that all skew angles under 25° are acceptable, skew angles applications between 25° and 45° should be verified by existing functional joints of that particular joint system with those angles, and skews greater than 45° are not allowed.

Fourth, no DOT specifications addressed proper gradient at the APJ locations.   The manufacturers data suggested that gradients exceeding 4% were not suitable for APJ. Thus, the gradient was specified at a maximum of 4%.

Fifth, an item was added to address scenarios known to cause rutting and material displacement of an APJ. These scenarios include APJ near intersections where heavy trucks might stop on top of the joint and push it out in hot weather and locations at the bottom of negative grades where heavy trucks will break frequently.

Finally items were added to address the installation conditions and temperature during installation, as well as the anticipated amount of time the road will need to be closed after the joint is finished.

The factors listed above should be considered critical when deciding whether or not an APJ s suitable for a particular application. The engineer must meet all of the criteria on the checklist prior to considering specifying an APJ for their application.

9.0.2 Asphaltic Plug Joint Material Specification Development

When reviewing materials to develop a material specification, Umass Dartmouth noted that the state DOT's and the manufacturers varied greatly on many different aspects. Umass Dartmouth used not only these specifications but also ASTM specifications and lab testing for this research to help develop a comprehensive material specification.

First Umass Dartmouth added a item requiring that the contractor submit representative materials of their systems for outside testing by the DOT lab or a third party lab. The basis for this, as with most pavement related work, is the majority of any state related bituminous works require independent verification of the relevant material properties.   From the material testing conducted by Umass Dartmouth for this project it can be seen that not all the material met the manufacturers data, thus further solidifying the case for additional check testing.

Second the limits for the batch sizes and testing sample sizes required of the manufacturer for the binder, aggregate and backer rod were stated as outlined in ASTM D6297-01. The manufacturer should be testing their materials at these batch intervals.

Third the binder requirements were consolidated and update to eliminate the use of any withdrawn or suspended ASTM specifications.   ASTM D3407 was replaced with ASTM D5329 and ASTM D3405 was replaced by D6690. Umass Dartmouth compared the withdrawn specifications with the new specifications, and no significant changes could be found. Please note that ASTM D6297 still refers to the withdrawn specification D3407 and D3405. It is Umass Dartmouth's opinion that these should be changed to the new specifications and no basis for referencing the withdrawn specifications could be found. The required property values stated in specification table for the binder material are as stated in ASTM D6297-01.

Also added to the binder specification was a requirement for the Performance Grade of the binder. From the lab testing conducted for this report, it was found that the minimum temperature of the PG grade was not sufficient. Normally neat binders used in New England are specified at a grade of PG64-28. However, lab testing showed that these APJ binders are only PGXX-22. Thus a line item was added that the APJ should be graded and they should be at least a PGXX-28. No high temperature could be specified as the lab values were above the 64ºC normally specified. In general, the binder used in an APJ should be much higher than a PG64-XX.

The aggregate material requirements currently issued by the state DOT's and the manufacturers seem to be in agreement on stone type (Granite, Basalt, and Gabbro). No specific blend gradation could be stated since this information is proprietary to each individual manufacturer. Some use a two stone system, other use a single stone system and each gives a broad gradation limit that the aggregate must fall within. At this time the best specification that can be written is that the aggregate must be wet washed (AASHTO T11) and sieved (AASHTO T27) by the DOT or third party lab in order to verify that it meets the gradation limits printed by the manufacturer. Additionally, Umass Dartmouth added a requirement from the RI draft specification that stated the limit on material passing the No. 200 sieve should be less than 0.3% by weight. It is Umass Dartmouth's opinion that aggregates with fines in excess of this limit are not "double-washed".

The backer rod material requirements were updated to conform to Type 2 requirements outlined in ASTM D5249-95(2000) entitled *"Standard Specification for Backer Material for Use with Cold- and Hot-Applied Joint Sealants in Portland-Cement Concrete and Asphalt Joints"*. This specification appears to be more applicable to the intended application of the backer rod. Previous outlined specifications like ASTM D1623, D1621 and C509 are only applicable to rigid cellular plastics and elastomeric cellular gaskets.

Notable changes to the backer rod specification were the deletion of the tensile strength requirement and extrusion requirement, both of which are not required by ASTM D5249. One addition was made as well; ASTM D5249 outlines a procedure to quantify the heat resistance capabilities of the backer rod. The required property values were either summarized as the most conservative values stated among the DOT specification and manufacturers data or stated values required by the ASTM specification.

The gap plate requirements were updated to reflect ASTM D6297-01. This specification includes requirements for not only a steel plate but an aluminum plate as well. It is Umass Dartmouth's opinion that the aluminum plates are better suited for applications where a rigid steel plate is unsuitable. For instance at abutments where the approach or trailing side has a significantly weaker base than the concrete deck, a steel plate may settle on the weaker side causing the plate to "rock" or rotate in place over time thus displacing the APJ material. Additionally aluminum plates may be beneficial in scenarios where the bottom of the block out cannot be leveled since aluminum can be more easily molded. Umass Dartmouth suggests additional testing or experimental trials before widespread implementation of aluminum gap plates.

The required property values for the gap plate were either summarized as the most conservative values stated among the DOT specification and manufacturers data or stated values required by the ASTM specification.

The locating pin requirements were almost universally the same between DOT specifications and manufacturers data. The only discrepancy was in the declaration of hot dipped galvanized per ASTM A153. This statement was added for completeness.

The curb sealant data was very sparse. From the available information, it was surmised that the sealant should be a non-sag silicone joint sealer like a Dow Corning 888. Additionally Umass Dartmouth added that the sealant must be compatible with asphaltic materials since it will in be in direct contact with the APJ in certain areas. Also added was a statement that the sealant should be capable of withstanding the safe heating temperature of the APJ binder since in certain scenarios the curb sealant may not be replaced at the time of new joint installation, thus leaving it susceptible to the heat of the binder material. Ideally, the curb sealant in new installations would be placed after the newly installed joint has cooled completely. These requirements may also prove valuable in creating new curb details.

The curb backer rod requirements should be the same as for the bridge joint backer rod as stated in the material compliance specification. In addition the backer rod should be compatible with the binder material, as well as the non-sag curb sealant.

9.0.3 Asphaltic Plug Joint Installation Specification Development

Converse to the material specification development, less information was available on the proper methodology for installing an APJ. The specification presented as part of this research was compiled from the state DOT specifications, manufacturers data, ASTM specifications, and field observations of APJ installations.

As an overall general requirement of the installation specification, Umass Dartmouth included a narrative requiring a manufacturers trained representative for both the APJ and curb sealant to be present throughout the installation process. This item was noted several times in state DOT specifications. An additional general requirement regarding the installation temperature was also added. A conservative temperature value of 10°C (50°F) and rising was made the threshold limit for commencement of construction as stated in the manufacturers data.

The procedure for removing the existing joint material was in principle the same for the DOT and manufacturers. Umass Dartmouth added an item stating that the existing material should be dry cut instead of wet cut. Wet cutting will introduce water into the block out area, and this water may not be dried out entirely by the HCA lance. Water inside the block out could cause poor adhesion of the APJ material. Thus a line was added to the specification to clarify that only dry cutting should be allowed. Additionally from the witnessed field installations, Umass Dartmouth noted that in each case the bridge gap backer rod was not removed and replaced. Since the existing backer rod is of unknown origin and makeup, it was Umass Dartmouth's opinion that this material should be replaced during every joint installation for two reasons. First, the backer rod may not have enough heat resistance capabilities, thus allowing the hot binder to leak through the bridge rendering the joint pervious. Secondly the backer rod may not be of sufficient strength to secure the gap plate in it's proper location thus leading to shifting plates and material distress. Therefore the specification was written to suggest that the backer rod always be replaced, unless the design or field engineer specifies otherwise.

Similarly from the witnessed installations, Umass Dartmouth noted that no curb repairs were attempted during APJ installations. Many of these curb locations were in serious disrepair, and it is Umass Dartmouth's opinion that they should have been replaced. In order to address this situation, an item regarding removal of existing curb joint was added to the specification. This item simply states that the curb sealant and backer rod shall be removed at the same time as the APJ.

The methodology to prepare the joint block out for the new joint system was almost universal. Most DOT and manufacturers data agreed that the joint should be cleaned with a Hot Compressed Air (HCA) lance and small debris should be removed with clean compressed air. One manufacturer recommended sandblasting, but it is Umass Dartmouth's opinion that this methodology will create more debris in the block out (i.e. waste sand) that could lead to contamination of the joint. Realistically it would be virtually impossible to thoroughly clean the joint block out after sandblasting has occurred. Two exceptions to the use of sandblasting were made. Case one would be when the abutting pavement is concrete rather than asphalt. To clean the vertical asphalt faces of the block out a HCA lance is suitable, however for concrete vertical faces an HCA will likely not clean suitably. Second, sandblasting may be required to clean the curb area that will receive the curb joint sealant. A HCA lance will not be able to get to these areas and hand tools will likely not be enough to clean thoroughly.

Backer rod installation depths varied between the DOT's to the manufacturers. However, the ASTM D6297-01 specification outlined an acceptable procedure of placing the backer rod at a depth not greater than the gap width unless the gap width is larger than 1" (25 mm) then the backer road shall be place at 1" (25 mm). Umass Dartmouth added an item similar to the MA specification regarding eliminating backer rod splices at curb intersections. Avoiding these areas will better maintain the watertight requirement of the joint in the event water enters the joint. Umass Dartmouth also added an item regarding the installation of backer rod at the curb joint. No previous information was available on this item, so the specification was written in a rule of thumb approach.

One manufacturer suggests using a primer on the vertical and horizontal surfaces of the block out. As was uncovered in the literature review, primer is thought to have an adverse effect on the vertical bonding capability between the new APJ and existing overlay thus leading to debonding. Therefore the specification was written to eliminate the use of primers in the joint block out.

The APJ binder heating requirements were summarized from the available manufacturer and DOT data. Most agree, in general, on the specified installation and safe heating ranges of the binder. The numbers presented in the Umass Dartmouth specification represent a conservative value for each. The DOT's and manufacturers also agreed upon the heating chamber type. The system needs to be a double-jacketed oil melter equipped with continuous agitation to prevent localized overheating of the binder. The system should also be equipped with temperature controls and thermometer(s). Umass Dartmouth added an additional statement regarding not using infrared thermometers to read binder temperatures because of the existing research uncovered in the literature review that suggest these thermometers inaccurately measure binder temperatures.

There were not any substantial aggregate heating requirements presented by the DOT's or manufacturers. Umass Dartmouth expanded on these by adding that the aggregate should not be heated past the binder installation heating temperature, as the binder may become overheated when mixed with the aggregate. An additional item was added requiring the aggregate temperature to monitored with a calibrated handheld infrared thermometer.

The process for tanking the joint was universally agreed upon. Similarly the procedure for placing the gap plate was universally agreed upon. Umass Dartmouth did elaborate on this item by addressing the initial layout of the plates to minimize the amount of custom cut plates along the joint.

The preparation of the APJ mixture differed slightly from one source to another. Umass Dartmouth added an item addressing the application rate of binder to aggregate by stating per ATSM D6297-01 that the mixture shall be 68% aggregate by weight. Also Umass Dartmouth suggests that the aggregate and binder be mixed in a third vessel (besides the binder melter or aggregate rotating drum). This will help control the application rate of binder to aggregate (as opposed to dumping one into another) and allow continuous production of mix (as opposed to cleaning out melter or rotating drum and then restarting the reheating of binder or aggregate process).

Information on the placement of the APJ mixture was the same in principle between the DOT and manufacturers. It was suggested that the mix be placed in lifts and covered in binder up to the top layer, but the lift thickness were not in agreement. Umass Dartmouth suggests that 1-1/2" be taken as the maximum and 3/4" as the minimum lift thickness based on the approximate maximum aggregate size.

The placement of the top layer of mixture is also the same in methodology as previously noted, except that this layer is compacted. No firm agreement was made on the method or type of compactor. ASTM D6297-01 recommends that the compactor be able to deliver a minimum centrifugal force of 15kN. Umass Dartmouth added this item to the specification along with the allowable type of compactors as plate or roller compactors capable of meeting the ASTM compaction requirement.

The finish dressing of the joint is widely accepted as application of binder to the top layer and broadcast of anti-tack aggregate onto the hot binder. No significant changes were made to this section of the specification.

Umass Dartmouth added a section regarding construction joints during stage construction. In most scenarios the entire joint length is not replaced at one time, rather only a portion is completed while traffic is re-routed around the construction. Then traffic is re-routed onto the completed section while the remaining portion of the joint is completed. This process may or may not be completed on the same day. In any event, the area of the joint between these two stages should be properly spliced with a construction joint. Umass Dartmouth suggests that careful consideration is taken in regards to the type and location of this joint, and at no time should a vertical joint be used. The vertical joint may present itself as a weak area along the joint susceptible to material distress or water intrusion.

No information was available on the installation of the curb sealant beyond recommending that a manufacturer trained person complete the work. Umass Dartmouth added this item along with suggesting some in joint drainage if possible.

Finally Umass Dartmouth added a brief Quality Control/Quality Assurance section that addressed required material submissions, documentation of contractor training, submission of equipment lists, and calibration certificates. It was felt that all these items were necessary to ensure proper completion of joint installation.

10.0 DEVELOPMENT OF REPAIR GUIDELINES

A draft copy of the Umass Dartmouth developed APJ repair specification is located in Appendix L. This specification was developed as rule-of-thumb rather than based on any particular testing or experience. Additionally no literature currently exists regarding the corrective actions for particular distresses within an APJ system. Moreover and more importantly, no data exists on methods to properly quantifying the distresses within an APJ.

Without this information, a narrow and defined specification could not be developed. Rather a more generalized version had to be created in reference to the distresses outlined in the literature review of this report. The following distresses were addressed:

Bleeding
Cracking/Reflective Cracking
Curb Leakage
Debonding
Leakage
Polished Stone
Raveling
Rutting
Segregation
Shoving/Pushing
Spalls

The corrective actions were generalized to joint resealing, addition of more APJ mixture, and joint replacement. Please note that cutting of sections of joint and replacing with new APJ material was not considered a viable option because of the following reasons:

1. It was Umass Dartmouth’s opinion that this was a very temporary fix and the longevity of the repair could not be quantified.

2. No data exist on how to build a proper construction joint between old and new sections of this material. A vertical construction joint may add additional areas of weakness and possible water intrusion areas.

3. If the existing joint was unidentifiable, Umass Dartmouth was unsure if there would be compatibility issues between the two different types of APJ systems used within the same joint.

11.0 CONCLUSIONS

Limited research has been conducted on APJs used in the United States. The majority of the research has been conducted overseas in Europe. From a comprehensive literature review conducted for this research and talking with industry professionals, the useful life span of an APJ is 5 years with the overall cost fluctuating depending on the method of cost measurement.

APJ failure can be loosely defined as the joint's inability to remain impervious thus leading to corrosion of the integral bridge components below. This phenomenon is commonly referred to as APJ leaking or leakage. The literature review revealed that many different material distresses are common to the APJ mixture, many of which can lead to leaking. These include: debonding, cracking, reflective cracking, rutting, raveling, shoving/pushing, segregation, bleeding/track out, spalls and polished stone. The other factors to consider in regards to failure were: individual material properties, bridge movements, operating temperatures, curb details and installation methodology.

A series of field investigations were performed by Umass Dartmouth to identify the APJ material distresses present in the New England states. These inspections were conducted on in-service bridges in Connecticut, Massachusetts, New Hampshire, Rhode Island and Vermont. The results of these inspections concluded that debonding, cracking, raveling, and rutting were the highest occurring distress for New England APJs.

A survey was prepared by Umass Dartmouth and sent to various DOTs in the United States to determine the current state of practice with regards to APJs. From this work it was determined that only 25% of those DOTs surveyed use APJs, and of those only 8% plan on using them in the future. Only 8% follow any specification or guideline in regards to designing an APJ. The majority of those surveyed believe material distress and installation in unsuitable locations lead to APJ failure. More shockingly, those surveyed do not use any guidelines to define good vs. poor performing joints or to define the severity of the material distress of the APJ.

A comprehensive review of the current specifications (DOT and APJ manufacturer) currently being used in New England was also presented as part of this research. Although all contained sections on material compliance and installation, it was noted that there were major variances in the degree and accuracy between these documents. Many DOT specifications required that numerous items be of the type specified by the manufacturer or installed per the their recommendations. This presented an interesting scenario since each manufacturer's specification was different. Also the DOT and manufacturers specifications were not in agreement on the general conditions of the joint (skew limits, gradient, etc.). Thus as part of this research Umass Dartmouth developed an APJ suitability checklist to determine if an APJ is applicable given certain general requirements; a design specification incorporating conservative values of the current ASTM, New England DOT and manufacturers specifications; an installation specification incorporating methodologies from ASTM, New England DOT and manufacturers specifications; and a general repair guideline catered to the material distresses noted during the field inspection in New England.

A limited amount of laboratory testing was conducted for this research due to difficulties in obtaining materials. Virgin aggregates were wet washed and then correspondingly used to determine their gradation. The gradations were compared to the manufactures printed data, and the majority fell within the applicable gradation ranges specified. Virgin binder was tested for Resiliency per AASHTO D5329. Not all of these binders were within the printed limits published by ASTM, but were within limits published by the state DOTs. Finally, the Superpave performance grade of these binders was determined in accordance to AASHTO R29. Of the three binders tested, only two were able to be determined with values of PG94-22 and PG88-22.

Additionally core material testing was conducted to verify in place gradations and approximate binder content. The analysis showed average core binder contents ranged from 18.3% to 42.2%. In place gradations were consistent between cores taken on the same joint, however these gradations did not necessarily meet the manufacturers printed data. This suggests that some crushing of the aggregate may occur over time due to repeated traffic loading.

Curb details were examined during field inspection, as they are another potential cause for leakage. Umass Dartmouth classified them into the following categories: no curb, standard curb (with or without sidewalk), parapet, sliding plate, and custom curb detail. Each of these details seemed to be structurally sound, with only distress being curb sealant deterioration. Thus a comprehensive maintenance program on the sealant was defined as the best means to avoid leakage in these areas.

12.0 RECOMMENDATIONS

In order to enhance the future performance the APJ in New England, Umass Dartmouth has the following recommendations:

Develop a guideline, similar to the Distress Identification Manual for Pavements published by the FHWA, to quantify the major APJ distresses. Quantification of these distresses needs to be made by geometric means (width, length, depth) so that they may be placed into categories such as low, moderate, and severe. With this information, a more definitive service life can be determined as well as allowing for development of more specific repair guidelines and intervals.

Review specifications on an annual basis and revise if necessary. As noted during this research, many of the specifications used withdrawn and replaced ASTM specifications that may not accurately depict the current state of practice for that particular test. The Umass Dartmouth developed suitability checklist, design guideline, material specification, and repair specification should be used as a guide to update the current DOT specifications.

Records of bridge inspections, geometry, and joint replacements should be stored in a database like GIS or equivalent. As was attempted in this research, a correlation of distresses to a particular joint system or geometric parameter could not be made due to incomplete data. With complete data, trends might unfold that suggest the applicable limits of skew angle, traffic loading, and span lengths for an APJ.

Conduct more material testing. The lab testing presented in this research outlines only a fraction of the testing that could be done with more resources. First, the function test device developed by the BAM in Germany should developed and used to test APJ systems in New England. This device is currently the only one that tests a scaled APJ system. Modifications to the device could be made to vary the skew angles, mixture depths, temperatures, mixture gradations, binder contents, and binder types to evaluate the joint response. Secondly the debonding test conducted by the EMPA should be investigated for use in New England. From the Umass Dartmouth field inspections, the distress with the greatest occurrence in New England was debonding. This test would give valuable insight on mitigating debonding occurrence in New England. Finally, in lieu of the other tests outlined, a protocol should be developed to properly test asphalt mixes (including APJ) that are placed in relatively thin lifts. Currently, no specification exists for mixes that are placed in such small lifts (≈±2”).

Binder material should be tested for its performance grade. As conducted during this research, the performance grade of the binders was determined. The low temperature minimum was found to be insufficient at PGXX-22. Normally a neat PGXX-28 binder is used in the New England region, thus all APJ binders should meet or exceed this requirement. Binders below PGXX-22 are very susceptible to thermal cracking and fatigue. Conversely the high maximum temperatures were far above the normal PG64-XX. No practical ceiling limit could be applied from this research, however future research should evaluate binders in order to determine this range.

The process for binder modification needs to be evaluated. Most binder modifications are completed by adding polymers and rubbers to an existing neat binder. Each of these polymers is different and may vary between APJ manufacturers. Thus, the dose of polymer and applicable heating ranges for the modified binder will be different between manufacturers. As noted in this research overheating of the binder can be extremely detrimental to the APJ mixture, thus this item must be investigated more in depth.

The APJ mixtures need to be defined by a Job Mix Formula (JMF). Currently there are only gradation limits for the aggregate used in an APJ. A JMF needs to be developed and evaluated for each APJ system, including testing for the optimum binder content for the mix.

Require material compliance submissions. Currently it the assumption that most DOTs do not have the proper equipment to test the binder material used in an APJ. This item, along with all the other components of the APJ system, need to be verified by the DOT or an independent lab and compared with the manufacturers printed data. During the research presented here, there were scenarios where the materials did not meet the criteria printed on the manufacturer’s data sheet.

Improve construction supervision. It was noted during witnessed APJ installation for this research that a DOT representative was not on site during the critical phases of the joint replacement like cleaning of the joint and placement of APJ mixture. A DOT representative must be on site to inspect condition of substrates after demolition, monitor material temperatures, and witness installation procedure to ensure completion according to specifications. Without this supervision, many shortcuts can be taken by the installer that can lead to premature joint failure.

Require manufacturer factory-certified installers. Most APJ manufacturers are beginning to comply with this item right now. Unfortunately in the past there were instances where a certified installer was someone who purchased the materials from the manufacturer, not necessarily someone who received any formal training. Because of the APJ unique purpose, the entire installation needs to be completed by factory-trained professionals who understand the intricacies of the system.

Explore the use of Ultraviolet (UV) resistant sealants at curb intersections. Sealant deterioration was the one curb distress noted that could lead to joint failure. UV resistant sealants could greatly reduce the occurrence of deterioration and increase the amount of time between maintenance.

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12. BAM Berlin, Germany. (Bundesanstalt für Materialforschung und-prüfung) Federal Institute for Materials Research and Testing. *Technical Test Specifications for Asphalt Carriageway Crossings* (TP-BEL-FÜ) ENGLISH Translation January 1999. *Additional Technical Contract Conditions and Directives for the Construction of Asphalt Carriageway Crossings in Coatings on Concrete Bridges and other Concrete Engineering Constructions* (ZTV-BEL- FÜ) ENGLISH Translation January 1999. *Technical Supply conditions for Materials for the Manufacture of Asphalt Carriageway Crossings* (TL-BEL- FÜ) ENGLISH Translation January 1999.

13. ASTM International *Annual Book of ASTM Standards 2004*. Section 4, Volume 04.03. Published in 2004.

Appendix A
Survey & Results

UNIVERSITY OF MASSACHUSETTS DARTMOUTH

To: (This is a BLANK copy)

Asphaltic Plug Joint Survey

1. Are Asphaltic Plug Joints (APJ's) currently used in your state?

2. Does your state follow any specifications or guidelines in regard to **design** and use of an APJ system? If so, could you please list.

3. Does the specifications include a criteria for defining a good vs. poor performing APJ?

4. Does your state specify details at curbs (sealants, backer rod, etc.)?

5. Does your state follow any specifications or guidelines in regard to **repair** of an APJ system? If so, could you please list.

6. Who are the approved manufacturers and installers of APJ in your state?

7. What are the predominant pavement distresses that lead to APJ failure in your state?

8. Are there any guidelines that you use to define the severity and extent of each distress?

9. Are APJ's used as replacements of older expansion joint systems or are they only allowed for new construction?

Asphaltic Plug Joint Survey Comments

1. **Are Asphaltic Plug Joints (APJ's) currently used in your state?**
   - We do not use Asphaltic Plug Joints.
   - Georgia DOT Specification section 449 - Bridge Deck Joint Seals does not include APJ.
   - Never heard of Asphaltic Plug Joints.
   - Started using in 1991.
   - Alabama DOT has no experience with Asphaltic Plug Joints.
   - Started using more than 10 years ago.
   - Been used since 1992.
   - No plans to use APJ's in foreseeable future.
   - Had test joints that failed. No plans to use in future.
   - Field trials only.
   - APJ's not his field of expertise.
   - Currently use hot pour concrete pavement joints in new pavement and old resealing. We are reviewing the need for joint reseal in the future.

2. **Does your state follow any specifications or guidelines in regard to design and use of an APJ system? If so, could you please list.**
   - Based on span size (for movement range) and skew. Span is limited to 100 feet and skews less than 30 degrees.
   - We use an approved product list.
   - APJ's not his field of expertise
   - Use AASHTO Design Guide

3. **Does the specifications include a criteria for defining a good vs. poor performing APJ?**
   - We are instituting a performance warranty, so we do not define good vs. bad in the specification. Problem systems have been rescinded.
   - APJ's not his field of expertise.

4. **Does your state specify details at curbs (sealants, backer rod, etc.)?**
   - APJ's not his field of expertise.

5. **Does your state follow any specifications or guidelines in regard to repair of an APJ system? If so, could you please list.**
   - We specify distresses and required repair method. For debonding, transverse cracking and rutting-remove and replace affected area. For longitudinal cracking and perviousness - seal.
   - Utilize same process as for initial installation. Not all the time. Sometimes crack sealers are used.
   - APJ's not his field of expertise.
   - Have joint resealing scheduled every 10 years.

6. **Who are the approved manufacturers and installers of APJ in your state?**

- Approved Manufacturers: Deery American Corp.; LaFarge Road Marking Inc.; Watson Bowman Acme Corp.; A.H. Harris and Sons, Inc.
- A.P.J. by Silicone Specialties Inc.; BJS by Lafarge Road markings; Polyjoint by A.H. Harris and Sons; Throma-joint by Lafarge Road markings; Wabo Expandex by Watson Bowman Acme.
- Trial Joint was Matrix 502 by Pavetech.
- APJ's not his field of expertise
- Attached a list of approved joint sealers. Not APJ manufacturers.

Asphaltic Plug Joint Survey Comments (Cont'd)

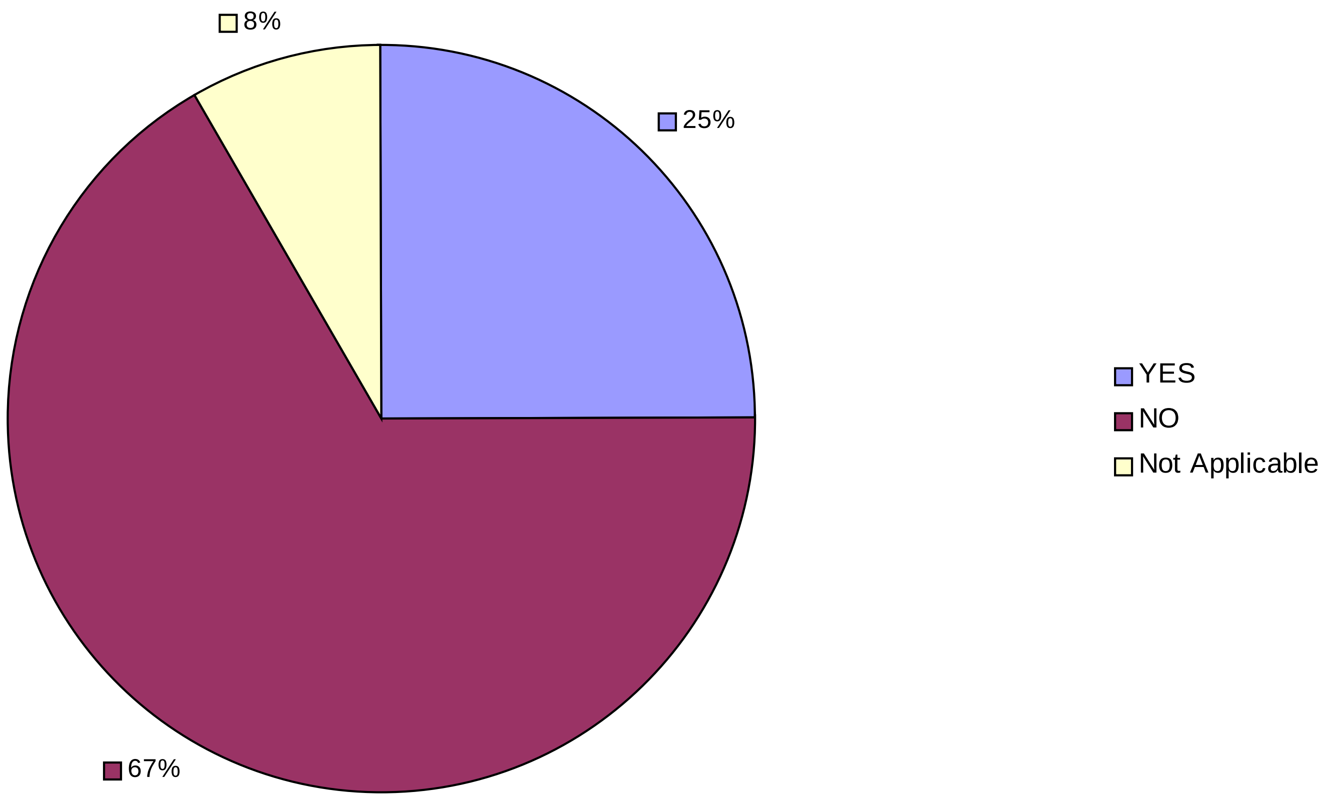
7. **What are the predominant pavement distresses that lead to APJ failure in your state?**
   - Failures seem confined to either material problems or installation issues. The factors listed do not seem to have much impact.
   - Many - Mostly use in areas where not warranted and application problems.
   - In test joints, material could not take bridge movement. Separation between asphalt and concrete lead to leakage.
   - Pavement expansion/contraction. Corrosion between sliding steel plates causing them to bond together and restrict sliding movements.
   - APJ's not his field of expertise.
   - Adhesion and cohesion.

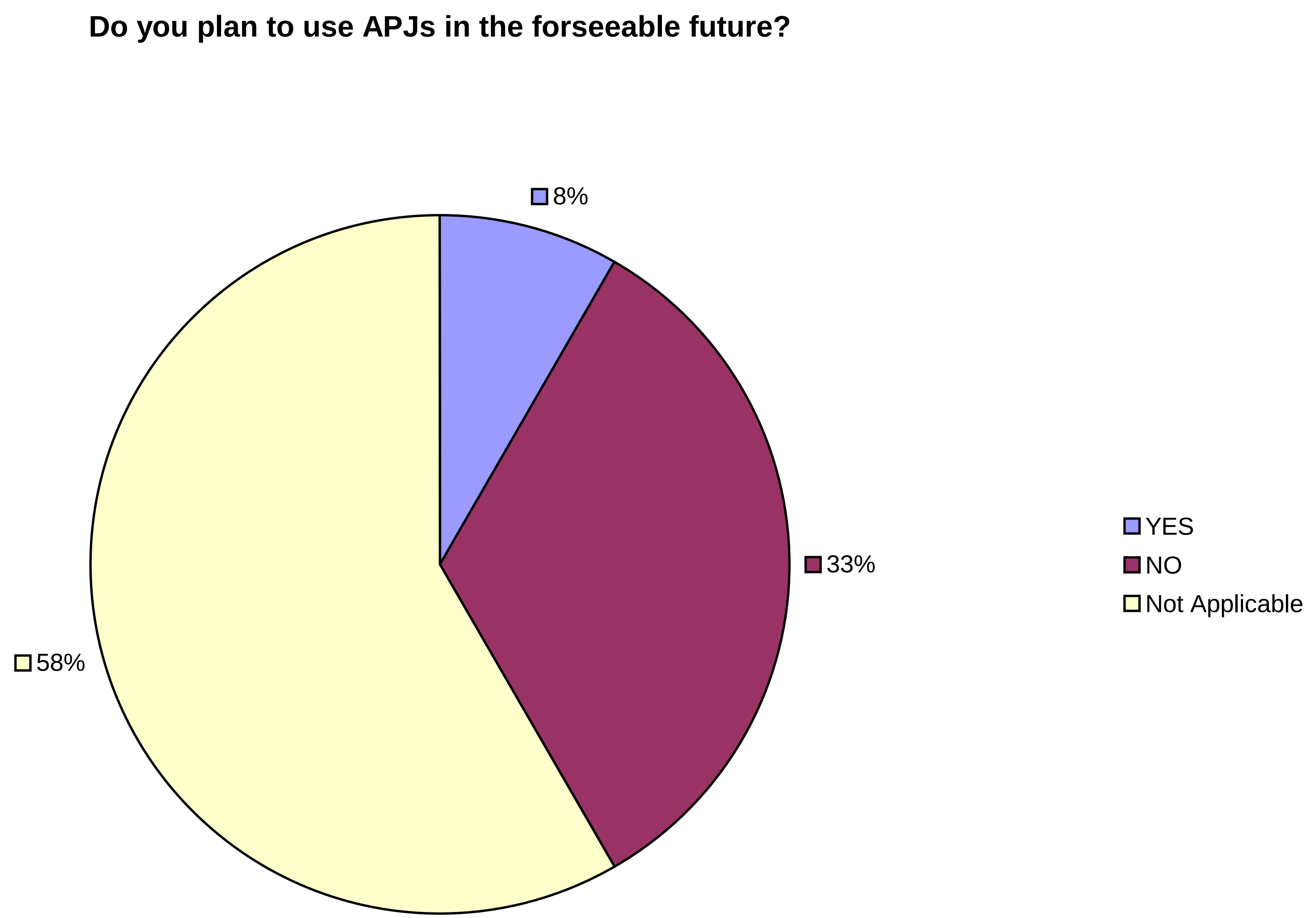
8. **Are there any guidelines that you use to define the severity and extent of each distress?**
   - Nothing specific. Most problems seem to be rutting (including raveling) and the joint is repaired when the impact on traffic warrants it.
   - APJ's not his field of expertise.

9. **Are APJs used as replacements of older expansion joint systems or are they only allowed for new construction?**

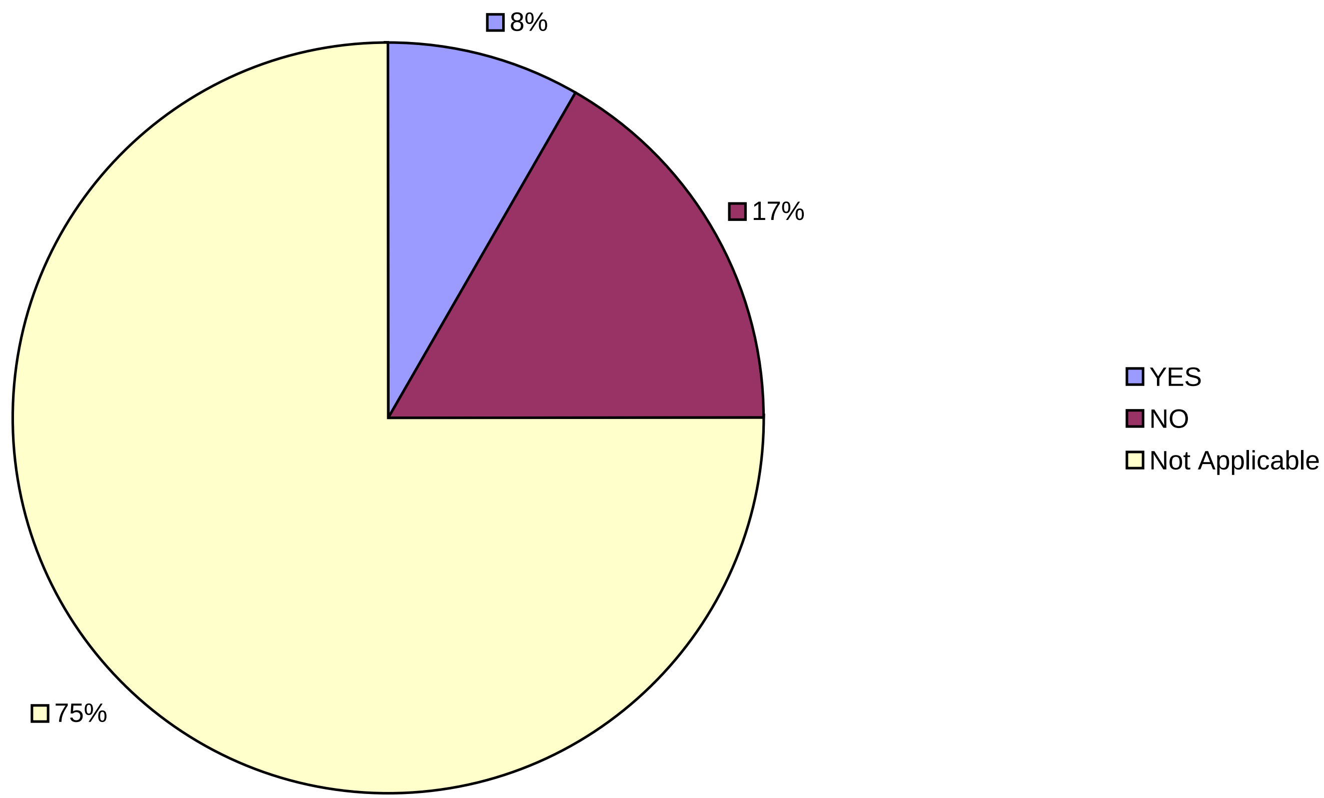
- APJ' are used for both rehabilitation and new construction. Failed joints are generally not replaced in service with APJ's.
- Both
- If used, could be for both cases.
- APJ's not his field of expertise.
- Hot pour is allowed in joint resealing too.

Do you currently use asphaltic plug joints (APJs) in your state?

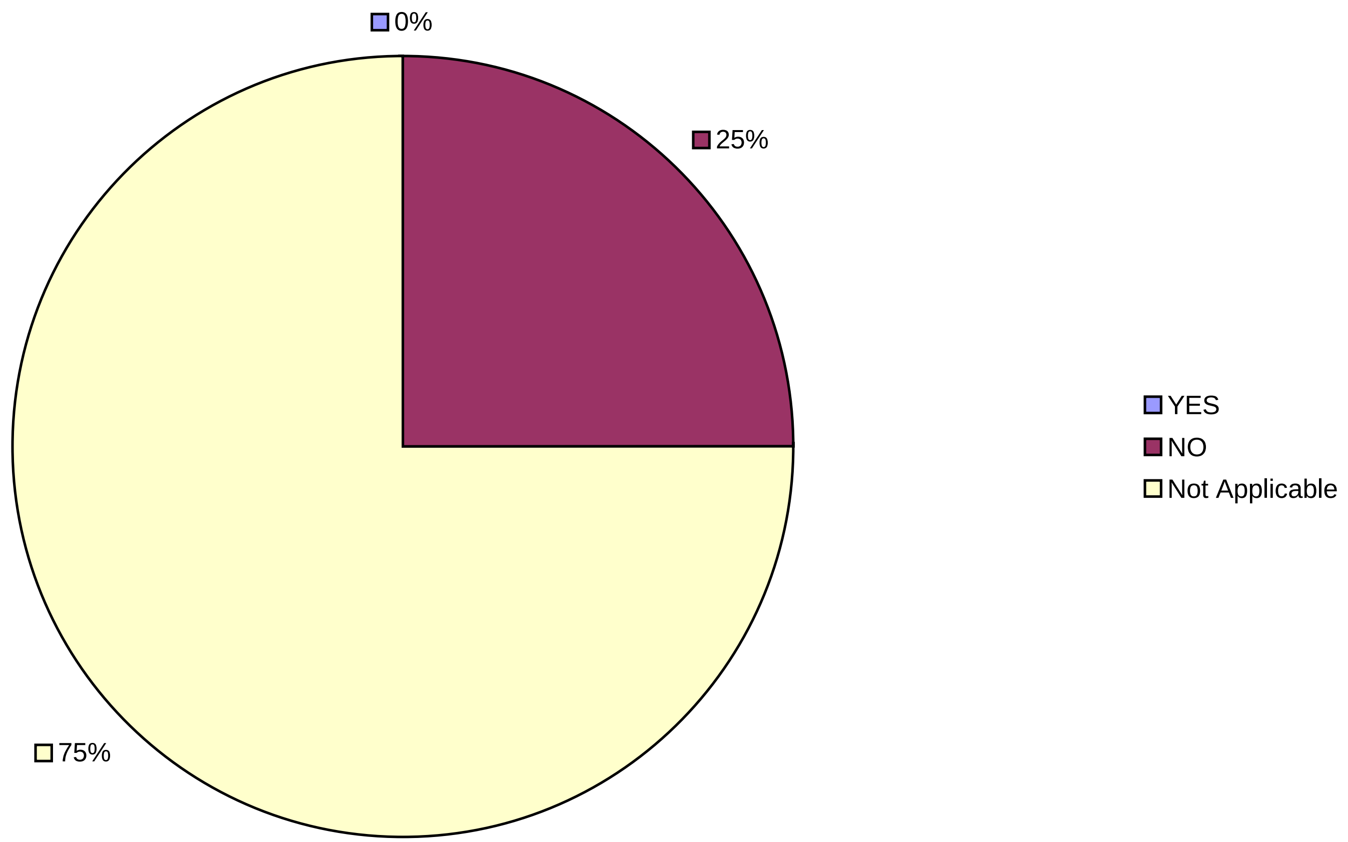



Do you plan to use APJs in the forseeable future?
8%
33%
58%
YES
NO
Not Applicable

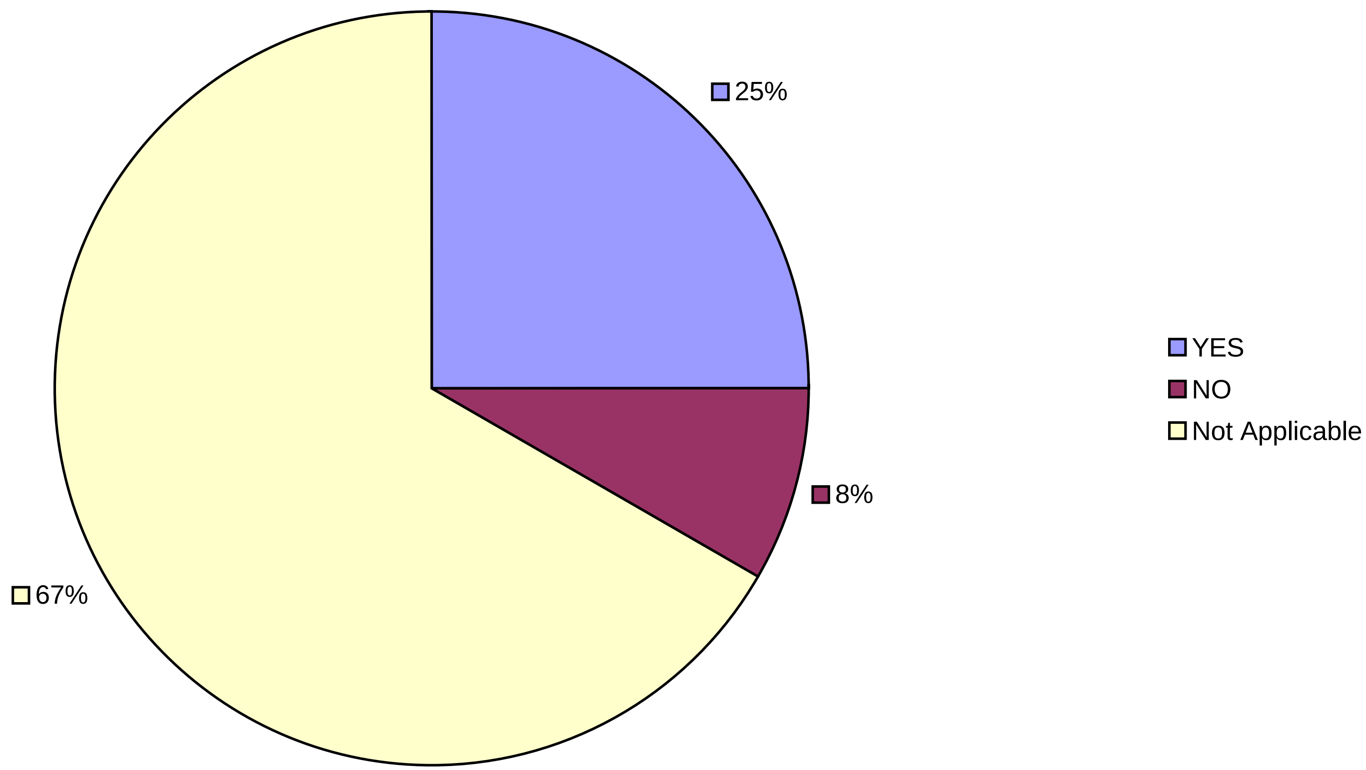
Does your state follow any specifications or guidelines, such as ASTM or AASHTO, in regards to the DESIGN and use of an APJ system?



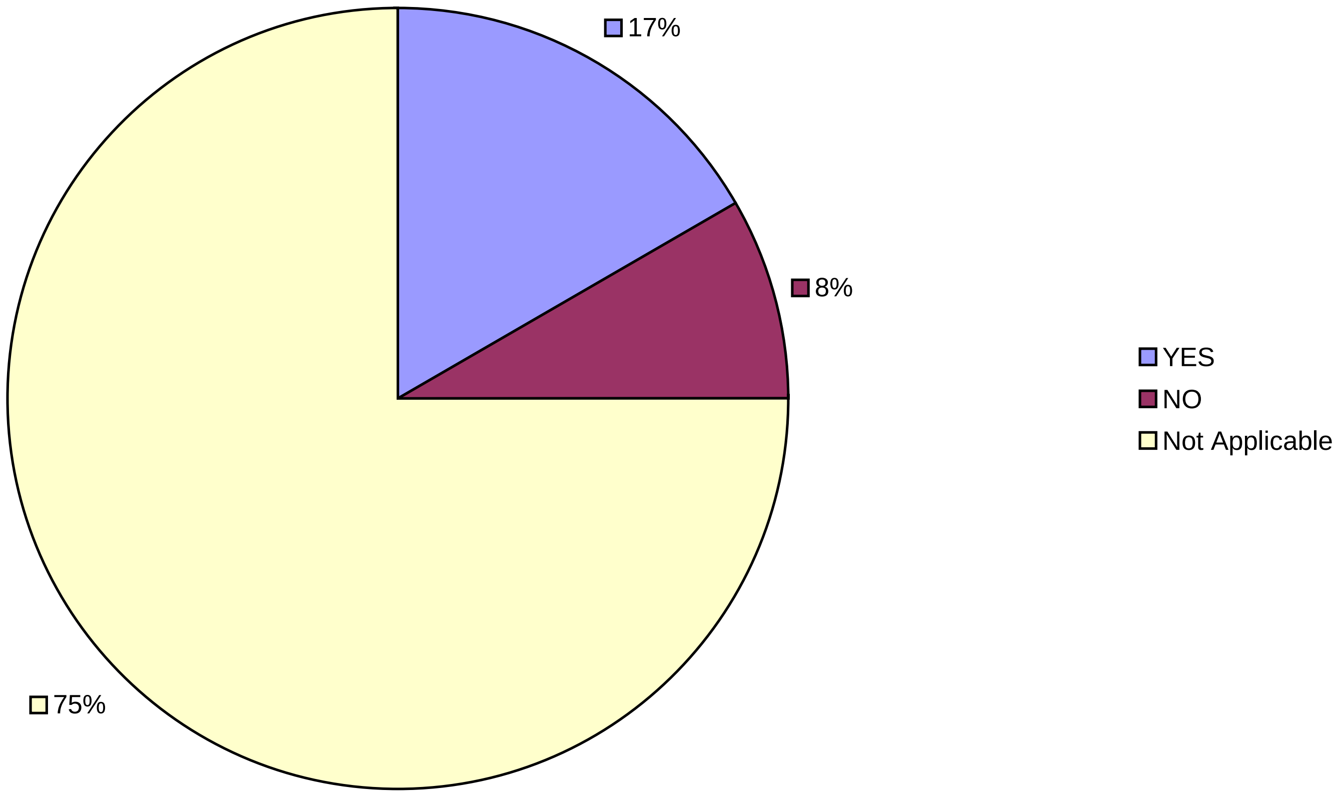
Does the specification in your state include criteria for defining a good vs. poor performing APJ?



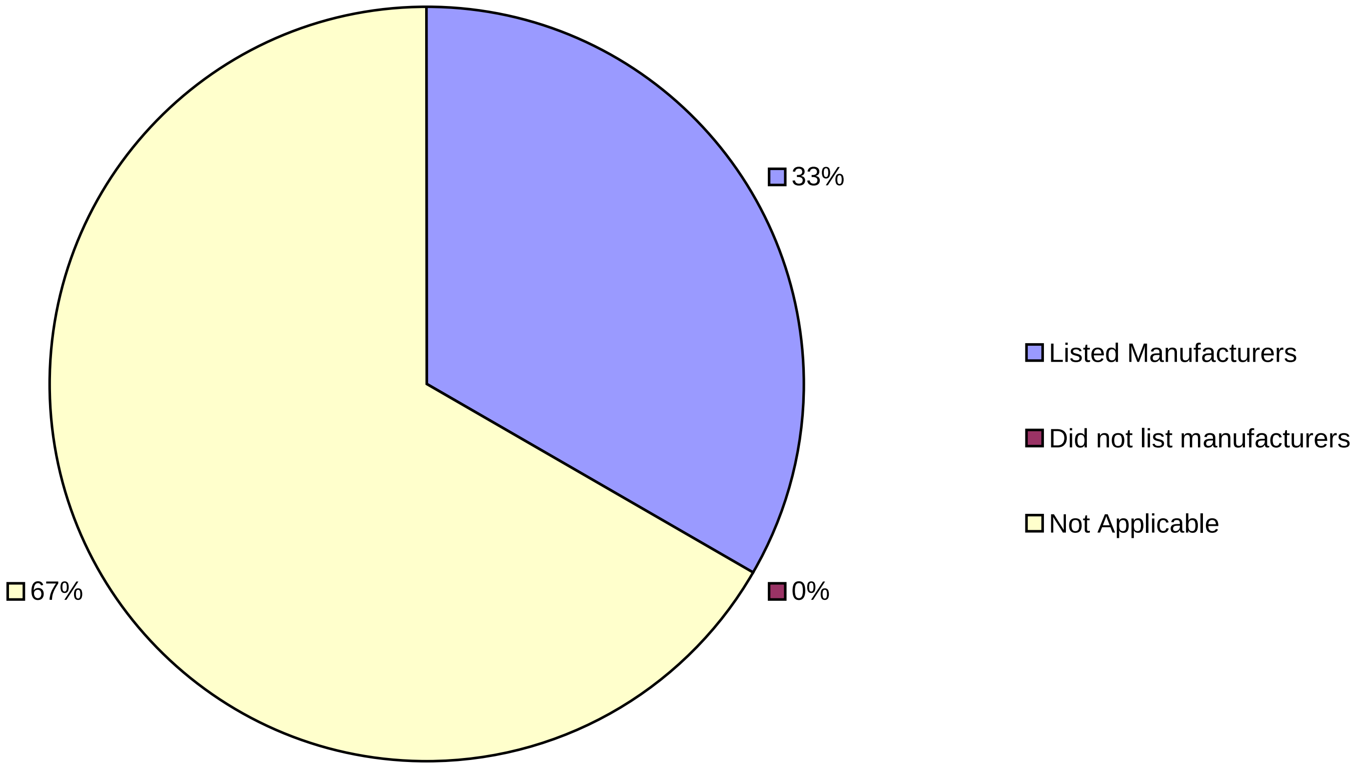
Does your state specify details at curbs (sealants, backer rod, etc.)?



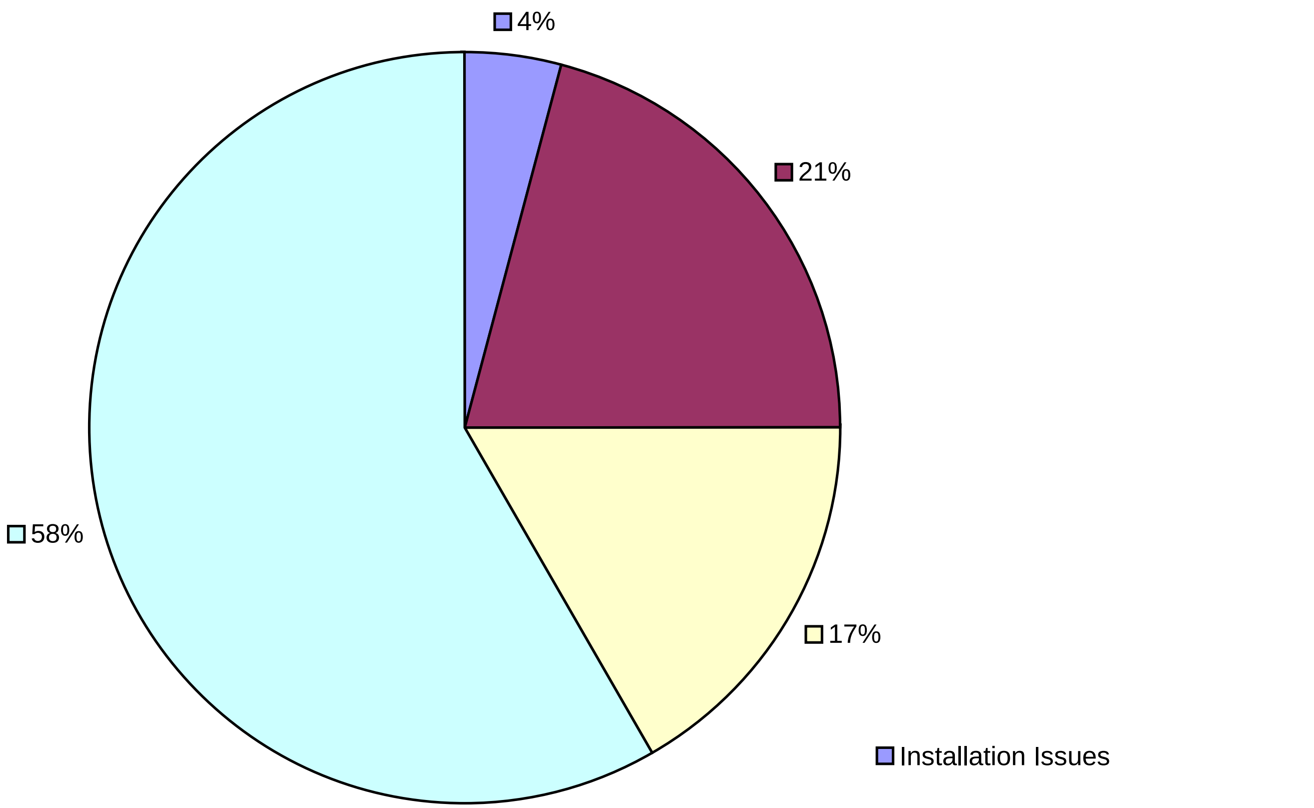
Does your state follow any specifications or guidelines in regard to the REPAIR of an APJ sytem?



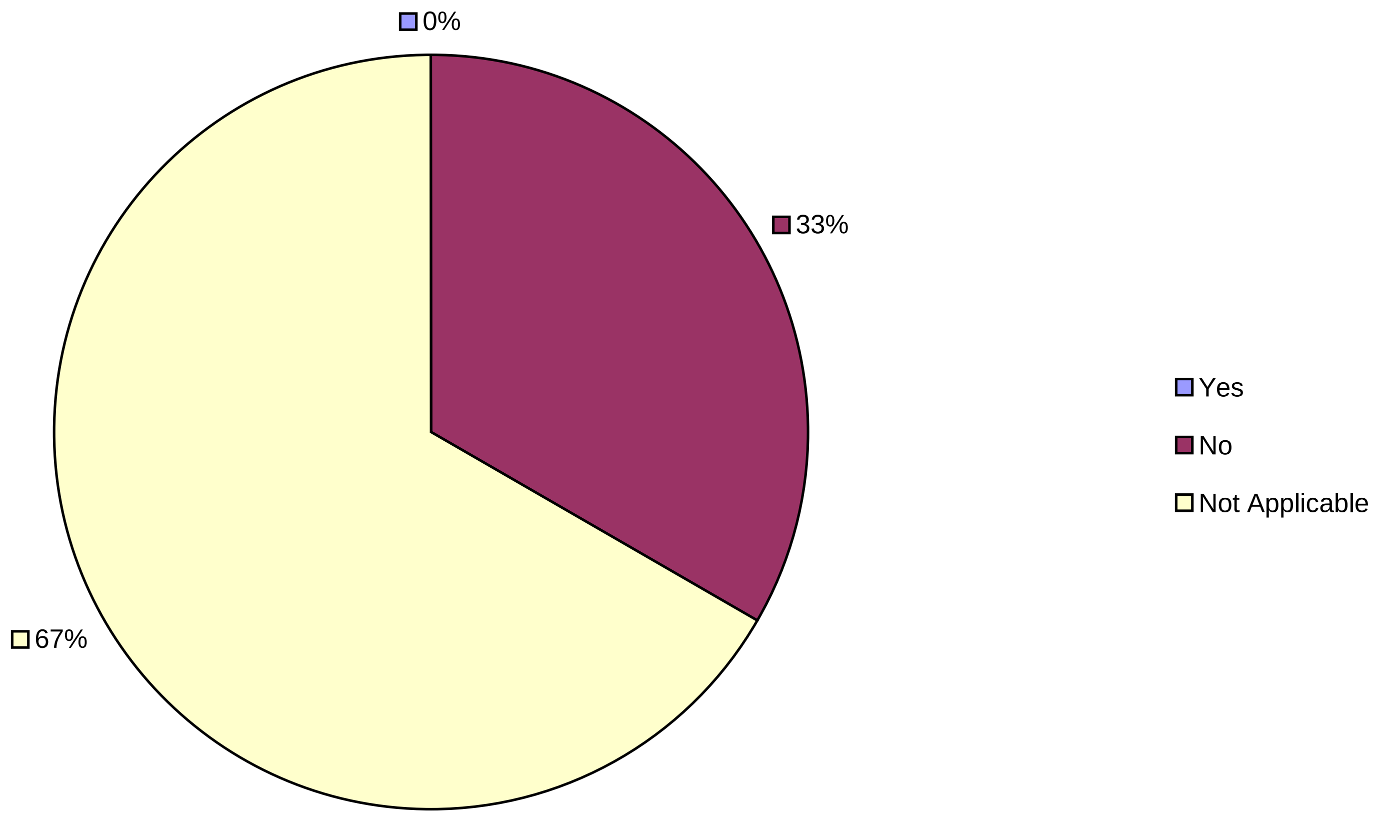
Please list the approved manufacturers, suppliers, and installers of the APJ's in your state.



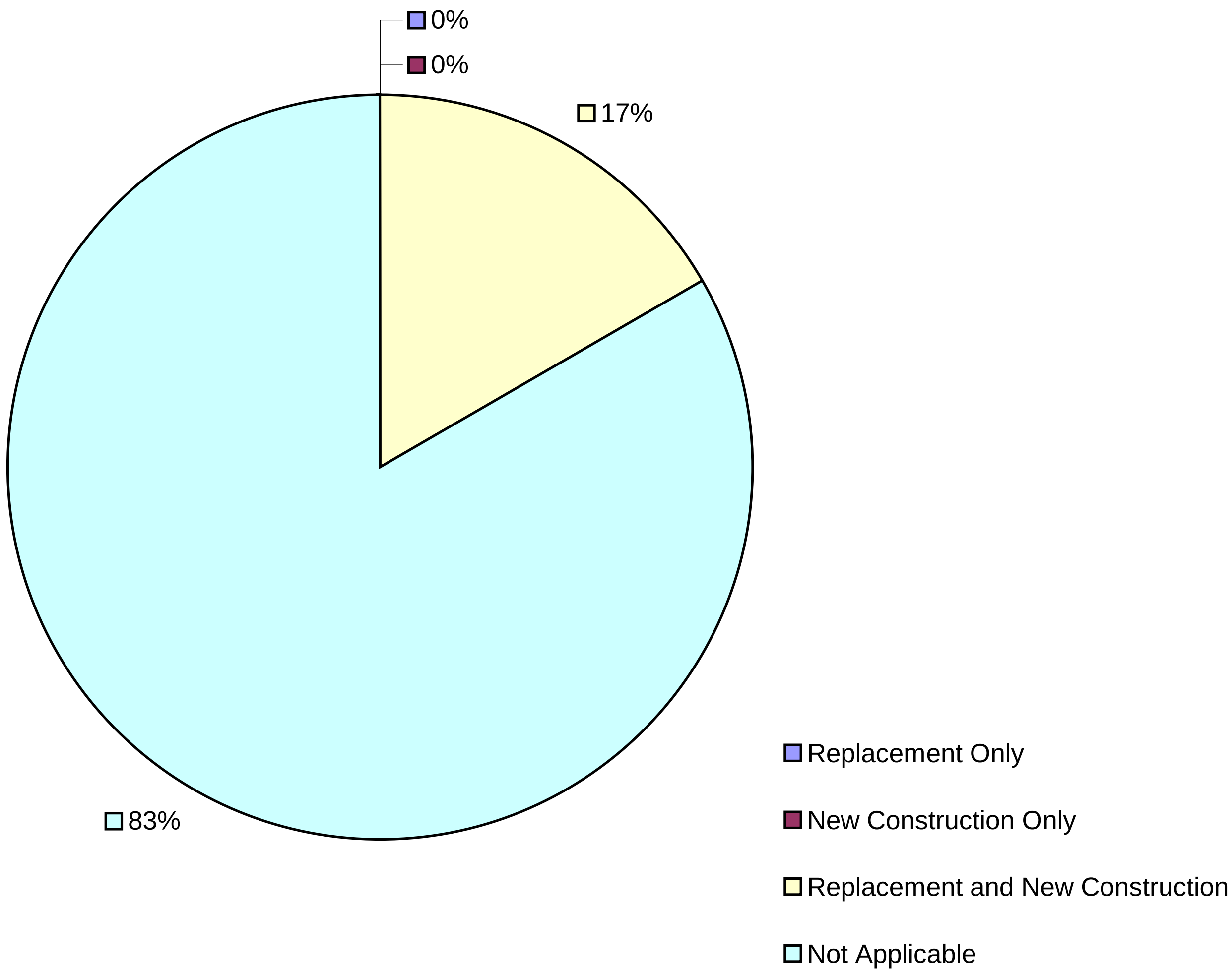
What are the predominant pavement distresses or environmental conditions that lead to APJ failure in your state?



Are there any guidelines that you use to define the severity and extent of each distress?



Are APJ's used as replacements for older expansion joint systems or are they only allowed for new construction?



Appendix B
State DOT Specifications

ITEM #601604A - ASPHALTIC PLUG EXPANSION JOINT SYSTEM

Description: Work under this item shall consist of furnishing and installing an asphaltic plug expansion joint, including cleaning and resealing the portion of bridge joint in the parapet, as shown on the plans, as directed by the Engineer and in accordance with these specifications.

Materials: The asphaltic plug expansion joint system shall be comprised of the following:

1. Backer Rod: The backer rod material shall be a closed cell expanded polyethylene foam, cylindrical, 150% the diameter of the joint opening, and capable of withstanding the temperature of the hot binder material.

   Properties: Density, ASTM D1622 .... 32 kg/m^3 (min.)
   Tensile Strength, ASTM D1623 .... 172 kPa (min.)
   Water Absorption, ASTM C509 .... 1.0% of mass (max.)

2. Backing Plate: The backing plate shall be ASTM A709M Grade 250 Steel and have a minimum nominal thickness of 6.5 mm. Holes for the locating pins shall be approximately 300 mm center to center along the centerline of the plate.

3. Locating Pins - 16d common nails or larger and hot-dipped galvanized in accordance with ASTM A153.

4. Binder - Shall be a hot applied polymer modified asphalt, complying with the following:

   a. Softening Point - greater than 65 °C (tested by the Ring & Ball method - ASTM E28).

   b. Flow Resistance - less than 5% (tested in accordance with ASTM D1191).

   c. Cone Penetration - less than 40mm (when tested at 25° C, 150g, 5 seconds - ASTM D217).

   d. Extension Test - to pass 3 cycles of extension to 50% at a rate of 3.2 mm/hr and 5° C (blocks prepared to ASTM D1190).

OR

Softening Point, (ASTM D36) .... 82 °C (min.)
Tensile Adhesion, (ASTM D3583) .... 800% (min.)
Ductility @ 25 °C, (ASTM D113) .... 40 cm (min.)
Penetration, (ASTM D3407) 25 °C, 150g, 5sec .. .. 90 dmm (max.)
-18 °C, 200g, 60sec. .... 10 dmm (min.)
Flow 5h @ 60 °C, (ASTM D3407) .... 3.0 mm (max.)
Resiliency @ 25 °C, (ASTM D3407) .. .. 60% (min.)
Asphalt Compatibility, (ASTM D3407) .... Pass

Recommended Pouring Temperature .... 199 °C
Safe Heating Temperature .... 210 °C

5. Aggregate - Shall be crushed, double-washed and dried granite, basalt or gabbro. It shall be supplied in 19 mm, 12.5 mm, and 9.5 mm nominal sizes as recommended by the joint manufacturer.

Materials for the asphaltic plug expansion joint shall be supplied by one of the following companies, and all materials must be approved by the Engineer before use:

Thorma-Joint, manufactured by:	Linear Dynamics, Inc. 400 Lannidex Plaza Parsippany, NJ 07054
Koch BJS, manufactured by:	Koch Materials Company PO Box 510 Stroud, OK 74079
Polyjoint, manufactured by:	A.H. Harris 321 Ellis Street New Britain, CT. 06050

Certification: A Certified Test Report shall be required for the closed cell foam backer rod and the binder material in accordance with Article 1.06.07, certifying the conformance of these materials to the testing requirements stated herein.

A Materials Certificate shall be required for the backing plates, locating pins, and aggregate in accordance with Article 1.06.07, certifying the conformance of these materials to the requirements stated herein.

The materials for the sealing of the joints in the parapets shall be comprised of the following:

1. The joint sealant shall be Dow Corning 888 or approved equal.

   Other single component, non-sagging silicone joint sealants expressly manufactured for use with concrete will be considered for this item provided they are submitted in advance for approval to the Engineer. Other joint sealants will be considered for use only if a complete product description is submitted, as well as documentation describing at least five installations of the product. These documented installations must demonstrate that the product has performed successfully for at least five years under traffic conditions. The joint sealant shall be gray in color.

2. The closed cell polyethylene foam backer rod shall be cylindrical, with a diameter 25 mm wider than the joint opening, and shall conform to the following:

   Density, (ASTM D1622) .... 32 kg/m^3 (min.)

Tensile strength, (ASTM D1623) .... 172 kPa (min.)
Water absorption, (ASTM C509) .... 1.0% of mass (max.)

Certification: A Certified Test Report shall be required for the closed cell foam backer rod in accordance with Article 1.06.07, certifying the conformance of this material to the testing requirements stated herein.

A Materials Certificate shall be required for the joint sealant in accordance with Article 1.06.07, certifying the conformance of this material to the requirements stated herein.

Construction Methods: A competent technical representative of the manufacturer shall be present during installation of the expansion joint to give such aid and instruction in the installation of the joint as is required to obtain satisfactory results.

Saw cut and remove the bituminous concrete overlay and membrane waterproofing to the required dimensions of the joint. Existing concrete headers, defective joint sealant, and reinforcement within the required dimensions of the joint shall also be removed. All concrete joint surfaces shall then be cleaned by the use of a hot compressed air lance until a clean, dry surface is produced. The cut asphalt surfaces shall be cleaned in a similar manner taking care to remove all water and cutting dust.

The backer rod shall be installed in the joint opening at a minimum depth of 25 mm through the roadway and curbs. At curbs, the backer rod shall be placed as indicated on the plans.

Binder material shall be heated to a temperature greater than 176 °C, but not to exceed the manufacturer's recommended safe heating temperature. The heating kettle shall have a continuous agitation system, temperature controls, calibrated thermometers and be double steel jacketed with an oil layer in between, to prevent scorching of the binder. During application, the binder material temperature shall be maintained at a minimum of 176 °C. The binder shall be poured into the expansion joint opening until it runs over the edges.

A backing plate shall be placed from curb to curb on the roadway portion of the expansion joint. The plate shall be centered over the joint opening. The plate section shall be butted up to each section and not overlapped. Locating pins shall be placed in the pre-drilled holes and hammered in to secure the plates.

Binder material shall be applied over the plate and in the blockout to seal this area.

The aggregate shall be heated in a rotating drum mixer to a minimum of 176° C. The temperature shall be monitored with a calibrated digital temperature sensor. Binder material shall be added to the mixer to precoat the aggregate.

The coated aggregate shall be placed into the blockout in layers as recommended by the joint material manufacturer. The blockouts shall be overfilled with coated aggregate as required to compensate for compaction. Equipment for compaction shall be as recommended by the joint manufacturer. Additional binder material shall be screeded over the compacted joint to fill any surface voids.

Vehicular traffic may pass over the installed joint 2 hours after compaction of the joint material.

The parapet joints shall be thoroughly cleaned of all scale, loose concrete, dirt, dust or other foreign matter by abrasive blast cleaning. Residual dust shall then be removed by blasting with oil free compressed air. Projections of concrete into the joint space shall also be removed. Closed cell elastomer shall be placed in the joint as shown on the plans and as directed by the Engineer. The joint shall be clean and dry before the silicone joint sealant is applied.

The silicone joint sealant shall applied as outlined in the accordance with the manufacturer's printed instructions and as directed by the manufacturer's representative, and with the equipment prescribed by the manufacturer.

The Contractor shall arrange for, and have present at the time the first joint-sealing operation is to be performed, a manufacturer's representative knowledgeable in the methods of installation of the sealant. The Contractor shall also arrange to have the representative present at such other times as the Engineer may request.

Method of Measurement: This work will be measured for payment by the number of meters of joint measured from gutterline to gutterline (final condition) on a horizontal line along the centerline of the joint.

Basis of Payment: This work will be paid for at the contract unit price per meter for "Asphaltic Plug Expansion Joint System", complete in place, which price shall include all materials, equipment, tools and labor incidental thereto.

MASSACHUSETTS SPECIFICATION

SECTION 971
ASPHALTIC BRIDGE JOINT SYSTEM

SECTION 971 ASPHALTIC BRIDGE JOINT SYSTEM

(page II.289) Add the following new Section:

DESCRIPTION

971.20 General.

The work shall include the furnishing and installation of a polymeric binder and aggregate system composed of specially blended, polymer modified asphalt and selected aggregate, placed into a prepared joint blockout as shown on the plans. The system shall provide a flexible waterproof bridge joint capable of accommodating a total movement of up to 50 millimeters from maximum expansion to maximum contraction, and maintain a continuous load bearing surface.

Incidental to this system shall be the placement of the non-sag joint sealer and backing rod through the safety curb and sidewalk deck joint as shown on the plans.

MATERIALS

971.40 General.

Materials shall meet the requirements specified in the following Subsections of Division III, Materials:

Polyurethane Joint Sealer, Non-Sag	M9.14.4
Asphaltic Binder for Asphaltic Bridge Joint System	M9.17.0
Aggregate for Asphaltic Bridge Joint System	M9.17.1
Backer Rod	M9.17.2
Bridge Plate for Asphaltic Bridge Joint System	M9.17.3

CONSTRUCTION METHODS

971.60 General.

A qualified employee of the manufacturer or an installer certified by the manufacturer and approved by the Department shall be at the job site prior to the beginning of the joint construction process to instruct the work crews in proper joint construction procedures and shall remain on the job site for the duration of the joint installation.

The minimum ambient air temperature during installation shall be 5°C and rising.

The Contractor shall produce uniform and parallel surfaces in the forming and placement of the blockout area within the reinforced concrete deck slabs as detailed on the plans. The formed blockout area shall be protected by the Contractor to prevent any edge damage by any site equipment throughout the on-going construction process.

The Contractor shall produce the required gap width within the full depth of the joint as dimensioned on the plans. If the existing curb stones bridge the existing sidewalk and safety curb joint gaps, they shall be modified by saw cutting a smooth face which shall be aligned and placed to maintain the uniform joint gap.

Immediately prior to placing any binder, the blocked out section and the joint gap shall be inspected full depth and any debris shall be removed. Immediately thereafter the blockout, sidewalk and safety curb gap, and road surface 150 millimeter either side of the blockout shall be thoroughly cleaned and dried using a hot compressed air (H.C.A.) lance capable of producing flame-retarded air stream at a temperature of at least 1100 degrees Celsius. The lance's blast orifice shall be capable of producing 1 megaPascal of pressure.

The backer rod shall be installed in the sidewalk and safety curb gap to the proper depth to ensure a correct width/depth ratio as specified by the manufacturer. The backer rod shall be set in accordance with the plans. There will be no splicing of the backer rod at the curb lines.

The binder shall be melted and heated to the application temperature in a double jacketed, hot oil, heat transfer kettle, or as recommended by the manufacturer. The kettle shall be equipped with a continuous agitation system and temperature controls that can accurately maintain the material temperatures.

The binder shall be poured into the joint gap. The binder shall overfill the roadway joint gap to allow the binder to be spread onto the adjacent concrete deck in order to form a bond breaker between the deck and the bridge plate.

For sidewalk, curb, and median joint gaps a non-sag polyurethane joint sealer compatible with the asphaltic binder shall be used.

The bridge plate shall be centered and placed over the entire length of the roadway joint gap. The plate shall be secured by placing locating pins through the pre-drilled holes into the joint gap backer rod. The bridge plate sections shall not overlap.

The horizontal and vertical surfaces of the joint blockout joint shall be coated immediately with hot binder before pouring hot binder over the floor area of the joint. The coating shall be continuous and adhere to the surfaces.

The aggregate shall be heated to a temperature of 150°C to 200°C in a suitable rotating drum blending unit with a heat source attached or by a secure H.C.A. lance to remove moisture. Temperature of the aggregate shall be controlled by a hand held calibrated digital temperature sensor or other means as approved by the Engineer.

The heated aggregate and polymeric binder shall be combined in the blending unit with sufficient binder to thoroughly coat each aggregate individually while avoiding an excess of binder. In no instance shall the amount of the binder added to the blending unit be less than 15% by weight. The binder used for coating is not included in the above percentage.

The coated aggregate shall be placed in the blockout in layers and raked level as recommended by the joint material manufacturer.

The final layer shall be raked level and compacted flush with adjacent deck surface. This layer shall be compacted to the point of refusal with a 1½ to 2½ megagram roller to ensure the proper density and interlocking of the aggregate in the layer.

Immediately following the compaction, the surface of the joint and surrounding road shall be dried and cleaned using the H.C.A. lance.

Sufficient binder shall immediately be spread over the joint and adjacent road surface to fill surface voids and seal the surface stone. The finished joint shall then be dusted with a fine, dry aggregate to prevent tackiness.

QUALITY CONTROL

971.70 General.

The Contractor shall have sufficient mixers and personnel at the site to assure continuous and timely installation of the joint.

The Manufacturer shall document and submit the successful performance of their material in a similar Asphaltic Bridge Joint System.

The Installer shall have previously demonstrated the ability to have successfully produced a joint of similar nature and shall provide documentation of a working joint to the Department.

The Contractor shall furnish Certified Test reports, Materials Certificates and Certificates of Compliance for the asphaltic polymeric binder, the aggregate, and the joint sealer. The backer rod and locating pins require Certificates of Compliance.

COMPENSATION

971.80 Method of Measurement.

Item 971. Asphaltic Bridge Joint System will be paid for at the contract unit bid price per meter, as measured between curb lines complete in place.

Item 971.1 Asphaltic Bridge Joint System will be paid for at the contract unit bid price per cubic meter. The volume measurement shall consist of the product of (1) the distance between the curbs along the length of the joint times (2) the width of the asphaltic plug joint noted on the plans times (3) the average depth of the installation across the centerline of the joint.

The joint treatment at the safety curb, sidewalk and median shall be considered incidental to the work to be done under these items.

971.81 Basis of Payment.

Payment shall be considered full compensation for installation of the Asphaltic Bridge Joint System including all labor, material, equipment, manufacturer's representative and all items incidental to the satisfactory completion of the work.

Removal of existing joints and materials will be paid for under separate Item.

971.82 Payment Items.

971.	Asphaltic Bridge Joint System	Meter
971.1	Asphaltic Bridge Joint System	Cubic Meter

SECTION 975
METAL BRIDGE RAILINGS

(page II.289) Revise the title of this Section as follows:

SECTION 975
METAL BRIDGE RAILINGS AND PROTECTIVE SCREENS

SUBSECTION 975.20 General.

(page II.289) Replace this Subsection with the following:

Work under this item shall consist of furnishing and erecting metal bridge railing and protective screens in accordance with the plans and specifications.

SUBSECTION 975.40 General.

(page II.289) Delete Bridge Railing, Galvanized, M8.13.1 and Rubber-Cotton Duck, M9.16.1, and add the following:

Paint and Protective Coatings	M7
Anodized Coatings	M7.20.0
Powder Coatings	M7.25.0
Bridge Railing, Steel, Type S3-TL4	M8.13.1
Molded Fabric Bearing Pad	M9.16.2
Aluminum Handrail and Protective Screen Type I and Type II	M8.13.3

(page II.290) In the first paragraph change "Department Inspector" to "Department".

SUBSECTION 975.60 Shop Drawings.

(page II.290) Replace the last sentence with the following:

No material for the metal bridge railings or protective screens shall be fabricated before the approval of the detail or shop drawings by the Engineer.

SUBSECTION M9.16.2 Moulded Fabric Bearing Pad.
(page III.97) Change the word Moulded to Molded in the Subsection title.

SUBSECTION M9.17.0 Asphaltic Binder for Asphaltic Bridge Joint System.
SUBSECTION M9.17.1 Aggregate for Asphaltic Bridge Joint System.
SUBSECTION M9.17.2 Backer Rod.
SUBSECTION M9.17.3 Bridge Plate for Asphaltic Bridge Joint System.
(page III.97) Add the following new Subsections.

M9.17.0 Asphaltic Binder for Asphaltic Bridge Joint System.

The thermoplastic polymeric modified asphalt binder shall conform to the following physical properties based on the designated ASTM testing methods:

TEST	ASTM TEST METHOD	REQUIRED PROPERTIES
Softening Point	D 36	83°C minimum
Tensile Adhesion	D 5329	700% minimum
Ductility, @ 25°C	D 113	400 mm minimum
Penetration @ 25°C, 150g, 5 seconds	D 3407	7.0 mm maximum
Flow, 5 hours @ 60°C	D 3407	3.0 mm maximim
Resiliency, @ 25°C	D 3407	70% maximum
Asphalt Compatibility	D 3407	Pass
Low Temperature Penetration @ -18°C, 200g, 60 sec.	D 5 *	1.0 mm minimum
Flexibility, @ -23°C	D 5329	Pass
Recommend Installation Range		182°C - 199°C
Safe Heating Temperature Range		199°C - 216°C
Bond 3 Cycles @ -20°F , 50% Elongation	D 3405	Pass
Bond 3 Cycles @ 0°F, 100% Elongation	D 3405	Pass

* Use Method D 5 **with cone**, however replace the standard penetration needle with a penetration cone conforming to the requirements given in Test Method D 217, except the interior construction may be modified as desired. The total moving weight of the cone and attachments shall be 150.0 g +/- 0.10.

M9.17.1 Aggregate for Asphaltic Bridge Joint System.

The aggregate shall be granite, basalt or gabbro. The aggregate shall be selected, crushed, processed, double-washed and dried at the source. It shall be delivered to job site in prepackaged waterproof containers. The supplier shall certify the above requirements are met.

The aggregate shall be made available in 19 mm, 12 mm and 10 mm sizes and shall meet gradation requirements specified by the manufacturer for the joint system.

M9.17.2 Backer Rod.

The backer rod shall be closed cell foam expansion joint filler, compatible with polymeric binder and the elevated temperatures of the polymeric binder application. The size of the backer rod shall be in accordance with the manufacturer's recommendations for gaps widths.

The backer rod shall meet ASTM D 1752 and have the following typical physical properties using a 12 mm specimen and the test method ASTM D 545:

Compression, 50% ....91.70 kPa
Extrusion ....2.54 mm
Recovery ....99.21 %
Water Absorption, Volume ....0.246 %

M9.17.3 Bridge Plate for Asphaltic Bridge Joint System.

The bridge plate shall be AASHTO M270 Grade 250 steel, minimum 200 mm wide by 6 mm thick and shall be galvanized in accordance with AASHTO M111. Holes for the locating pins shall be 300 mm on center. Locating pins shall be 16d common nails or larger, hot dipped galvanized.

SUBSECTION M9.30.0 Reflective Sheeting.

(page III.97) Add the following to the end of this Subsection:

Reflective sheeting for drums shall meet or exceed the requirements set forth in the following table:

REFLECTIVE SHEETING FOR REFLECTORIZED DRUMS Minimum Coefficient of Retroreflection, R_A (Candelas per lux per square meter) From an Observation Angle of 0.2°		
	Entrance Angle = -4°	Entrance Angle = 30°
Fluorescent Orange	180	100
White	550	300

SUBSECTION M9.30.4 Acrylic Plastic 82.5 Millimeter Diameter Center-Mount Reflector (Type A).

(page III.97) Replace this Subsection with the following:

M9.30.4 Acrylic Plastic 82.5 Millimeter Diameter Center-Mount Reflectors.

Acrylic plastic 82.5 millimeter diameter center-mount reflectors shall be a material previously approved by the Department for the purpose intended and listed on the Qualified Products List maintained by MassHighway Research and Materials Section.

SUBSECTION M9.30.9 Reflectorized Plastic Drum.

(page III.98) Replace this Subsection with the following:

M9.30.9 Reflectorized Drum.

Reflectorized drums shall conform to the applicable sections of the MUTCD and be constructed of an approved ultraviolet resistant, low density, impact resistant linear polyethylene plastic (or approved equal) with a minimum thickness of 2.4 millimeters. The drums shall stand approximately 1 meter in height and have a minimum diameter of 450 millimeters. Reflective sheeting for drums shall meet the requirements of M9.30.0.

Newly developed products providing equivalent target value and stability may be used in place of the drums specified above if approved by the Engineer.

SUBSECTION M9.50.0 Geotextile Fabrics.

(page III.98) Replace existing Subsection with the following:

Geotextile fabric used for subsurface drainage, separation, stabilization, permanent erosion control, temporary silt fences, or paving fabric shall conform to requirements of AASHTO M 288 for the intended application.

********** END OF DOCUMENT *********

RI DRAFT

ASPHALTIC EXPANSION JOINT SYSTEM
MATERIALS AND WORKMANSHIP WARRANTY
CODE 823.1750

a. Description. The materials and workmanship pavement warranty shall consist of the warranty bond and the terms of this special provision, including the appendix. This special provision establishes the common terms and definitions applied to all projects requiring a warranty (the warranted work). The appendix contains information unique to the asphaltic expansion joint system. The Materials and Workmanship Warranty warrants the Department against defects in materials and workmanship.

b. Definitions.

1. Materials & Workmanship Warranty - The Contractor is responsible for correcting defects in the asphaltic expansion joint system caused by elements within the Contractor's control (i.e., the materials supplied and the workmanship) during the warranty period. Since the Department is responsible for the bridge design, the Contractor assumes no responsibility for defects that are design related. If a defect is attributable to both, the materials and/or workmanship, and the design, responsibility for correcting the defect shall be shared by the Department and the Contractor; the Contractor is responsible for the percentage of fault attributable to the workmanship and/or materials, and the Department is responsible for the percentage of fault attributable to the design.

2. Acceptance Date of Construction - The date when the warranted work is complete and confirmed in writing on the initial acceptance document, by the Department, to be in compliance with the contract specifications and is open to traffic. This is the date of initial acceptance and constitutes the start date for the warranty period. There may be more than one acceptance date of construction for a project.

3. Warranty Bond - A bond issued by a surety which guarantees that the warranty requirements will be met.

4. Conflict Resolution Team (CRT) - The five-person team responsible for resolving disputes between the Department and the Contractor regarding any claim of non-compliance with the warranty requirements.

5. Warranty Work- Corrective action taken to bring the warranted work into contract compliance.

c. Initial Acceptance. The Department and the Contractor shall jointly review all completed warranted work, or a portion thereof, as determined by the Department. If the work does not meet contract requirements, the Contractor shall make all necessary corrections, at their expense, prior to initial acceptance. Initial acceptance will occur as soon as the Department confirms in writing, on the initial acceptance form that contract requirements have been met for the warranted work. The date on which initial acceptance occurs is termed the Acceptance Date of Construction.

Initial acceptance will be documented and executed jointly by the Department and the Contractor on a form furnished by the Department. A copy of the form will be sent to the Contractor's warranty bond surety agent by the Department. Neither the initial acceptance nor any prior inspection, acceptance or approval by the Department diminishes the Contractor's responsibility under this warranty.

The Department may accept the work and begin the warranty period, excluding any area needing corrective work, to accommodate seasonal limitations or staged construction.

Acceptance of material, in penalty, under the Department's quality assurance program will not relieve the Contractor from meeting the material and workmanship warranty requirements for the accepted material.

d. Warranty Bond. The Contractor shall furnish a single term warranty bond, in an amount stipulated in the appendix, prior to contract award. The effective starting date of the warranty bond shall be the Acceptance Date of Construction. The warranty bond will be released at the end of the warranty period or after all warranty work has been satisfactorily completed, whichever is latest.

e. Rights and Responsibilities of the Department. The Department:

1. Reserves the right to approve the schedule proposed by the Contractor to perform warranty work.

2. Reserves the right to approve all materials and specifications used in warranty work.

3. Reserves the right to determine if warranty work performed by the Contractor meets the contract specifications.

4. Reserves the right to perform or have performed, routine maintenance during the warranty period, which routing maintenance will not diminish the Contractor's responsibility under the warranty.

5. Reserves the right, if the Contractor is unable, to make immediate emergency repairs to the asphaltic expansion joint system to prevent an unsafe road condition as determined by the Department. The Department will attempt to notify the Contractor that action is required to address an unsafe condition. However, should the Contractor be unable to comply with this requirement, to the Department's satisfaction and within the time frame required by the Department, the Department will perform, or will have performed any emergency repairs deemed necessary. Any such emergency repairs undertaken will not relieve the Contractor from meeting the warranty requirements of this Special Provision. Any costs associated with the emergency repairs will be paid by the Contractor if it is determined the cause was from defective materials and/or workmanship.

6. Is responsible for monitoring asphaltic expansion joint system throughout the warranty period and will provide the Contractor all written reports of the system's condition related to the warranty requirements. The Contractor shall not be relieved of any responsibility based upon a claim that the Department failed to adequately monitor the asphaltic expansion joint system to report its findings to the Contractor.

7. Is responsible for notifying the Contractor, in writing, of any corrective action required to meet the warranty requirements.

f. Rights and Responsibilities of the Contractor. The Contractor:

1. Shall warrant to the Department that the warranted work will be free of defects in materials and workmanship for a period of five (5) years after completion of joint installation. The warranty bond shall be described on a form furnished by the Department. The completed form shall be submitted to the Department prior to award of contract.

2. Is responsible for performing all warranty work including, but not limited to, maintaining traffic and restoring all associated bridge and pavement features, at the Contractor's expense.

3. Is responsible for performing all temporary or emergency repairs, resulting from being in non-compliance with the warranty requirements, using Department approved materials and methods.

4. Shall notify the Department and submit a written course of action for performing the needed warranty work a minimum of ten calender days prior to commencement of warranty work, except in the case of emergency repairs as detailed in this special provision. The submittal must propose a schedule for performing the warranty work and the materials and methods to be used.

5. Shall follow a Department approved maintaining traffic plan when performing warranty work. All warranty work shall be performed under permit issued by the Department.

6. Is required to supply to the Department original documentation that all insurance required by the contract is in effect during the period(s) that warranty work is being performed, as required by subsection 107.13 of the standard specifications.

7. Shall furnish to the Department, in addition to the regular performance and lien bond for the contract, supplemental performance and lien bonds covering any warranty work being performed. These supplemental bonds shall be furnished prior to beginning any warranty work, using Department approved forms. These supplemental bonds shall be in the amount required by the Department to cover the costs of warranty work.

8. Shall complete all warranty work prior to conclusion of the warranty period, or as otherwise agreed to by the Department.

9. Shall be liable during the warranty period in the same manner as Contractors currently are liable for their construction related activities with the Department pursuant to the standard specifications. This liability shall arise and continue only during the period when the Contractor

is performing warranty work. This liability is in addition to the Contractor performing and/or paying for any required warranty work, and shall include liability for injuries and/or damages and any expenses resulting therefrom which are not attributable to normal wear and tear of traffic and weather, but are due to non-compliant materials, faulty workmanship, and to the operations of the Contractor.

g. Quality Control.

1. The Contractor shall provide an affidavit from the joint manufacturer certifying that the aggregate is single size, and a certificate of compliance from the binder manufacturer certifying that the binder conforms to these Specifications.

2. At the direction of the Engineer, the Contractor shall arrange for, and have present at the time the first joint-sealing operation is to be performed, a manufacturer's representative knowledgeable in the methods of installation of the joint system. The Contractor shall also arrange to have the representative present at such other times as the Engineer may request.

h. Evaluation Method. The Department will conduct evaluations of each asphaltic expansion joint system installed under this contract.

i. Warranty Requirements. Warranty work will be required when the threshold limit for a condition parameter is exceeded as a result of a defect in material and/or workmanship.

Specific threshold limits and segment limits are covered in the appendix.

To determine whether the failure to meet the warranty criteria is a result of defects in materials and/or workmanship, a joint field investigation by the Department and the Contractor will be conducted. The Department and Contractor may elect to have a forensic investigation conducted. The decision to undertake a forensic investigation, the scope of it, and the selection of the party to conduct it will be agreed to by the Department and the Contractor. If agreement cannot be reached a Conflict Resolution Team (CRT) may be convened in accordance with this special provision. The CRT will then decide the need for a forensic investigation, its scope and the party to conduct the investigation. All costs related to the forensic investigation will be shared proportionately between the Contractor and the Department based on the determined cause of the condition.

During the warranty period, the Contractor will not be held responsible for distresses that are caused by factors unrelated to materials and workmanship. These include, but are not limited to: chemical and fuel spills, vehicle fires, snow plowing, and quality assurance testing such as coring. Other factors considered to be beyond the control of the Contractor which may contribute to distress will be considered by the Engineer on a case by case basis upon receipt of a written request from the Contractor.

j. Conflict Resolution Team. The sole responsibility of the Conflict Resolution Team (CRT) is to provide a decision on disputes between the Department and the Contractor regarding application or fulfillment of the warranty requirements. The CRT will consist of five members:

- Two members selected, and compensated by the Department.
- Two members selected and compensated by the Contractor.
- One member mutually selected by the Department and the Contractor. Compensation for the third party member will be equally shared by the Department and the Contractor.

If a dispute arises on the application or fulfillment of the terms of this warranty, either party may serve written notice that appointment of a CRT is required.

At least three members of the CRT must vote in favor of a motion to make a decision. The CRT may decide to conduct a forensic investigation, will determine the scope of work and select the party to conduct the investigation. All costs related to the forensic investigation will be shared proportionately between the Contractor and the Department based on the determined cause of the condition.

k. Emergency Repairs. If the Department determines that emergency repairs are necessary for public safety, the Department or its agent may take repair action.

Prior to emergency repairs, the Department will document the basis for the emergency action. In addition, the Department will preserve evidence of the defective condition.

l. Non-extension of Contract. This Special Provision shall not be construed as extending or otherwise affecting the claim process and statute of limitation applicable to this Contract.

m. Measurement and Payment. All costs, including engineering and maintaining traffic costs, associated with meeting the requirements of this special provision are considered to be included in the Contract unit price for the warranted work item regardless of when such costs are incurred throughout the warranty period. These costs include but are not limited to, all materials, labor and equipment necessary to complete required warranty work.

APPENDIX
MATERIALS AND WORKMANSHIP WARRANTY
FOR
ASPHALTIC EXPANSION JOINT SYSTEM

A1. **APPLICATION.** This appendix is applicable for performance warranties on asphaltic expansion joint systems. The work consists of the placement of a 20-inch nominal width, or as specified on the plans, of a special asphalt material with elastic properties over concrete deck joints in the space usually occupied by the bituminous wearing surface. This deck joint system is a commercial product and must be installed in strict accordance with the manufacturer's recommendations. Manufacturers of this joint system are included in the RIDOT's List of Approved Materials and Suppliers.

A2. **LIMITS OF WARRANTED WORK.** The warranted work includes all asphaltic expansion joint systems within the project limits unless otherwise indicated on the proposal.

A3. **WARRANTED PERIOD**. The length of the warranty will be five years from the acceptance date of warranted work.

A4. **AMOUNT OF WARRANTED BOND.** The Contractor will supply a warranty bond equal to 100% of the warranted work for asphaltic expansion joint systems.

A5. **MATERIALS**:

a. Backer Rod. The backer rod material shall be an expanded closed cell polyethylene foam capable of withstanding the temperature of the hot binder material, shall have a diameter 150 percent the width of the joint opening and shall have the following properties:

Density -	2.0 lbs./cu.ft. min.	ASTM D1622
Tensile Strength -	25 psi min.	ASTM D1623
Water Absorption -	1-percent of weight max.	ASTM C509

b. Asphaltic Joint System. The materials for the joint system, both aggregate and binder, shall be provided by one of the manufacturers included in the RIDOT's List of Approved Materials and Suppliers.

1. Binder. The binder shall be a hot applied polymer modified bituminous material conforming to all specifications as detailed in ASTM D3405, and manufactured under strict quality control procedures as approved by the Engineer and meet the following specifications:

Softening Point, (ASTM D36).......................................180°F min.

2. Aggregate. The aggregate shall be of the Basalt, Gabbro or Granite groups, meeting the manufacturer's size and gradation requirements. All stones shall be crushed, double-washed, dried and delivered to the site pre-weighed in labeled packs. When tested in accordance with AASHTO T-11, the material passing the #200 sieve will be no more than 0.3% by weight of the stone. The broadcast stone for the surface of the joint system will be basalt and shall be sized as to pass the #8 sieve and be retained on the #16.

c. Steel Backing Plate. The backing plate shall conform to requirements of AASHTO M270, Grade 36, Steel, minimum 1/4" thick and shall be galvanized in accordance with AASHTO M232. Holes for locating pins shall be approximately 1-foot center to center along the centerline of the plate, unless indicated otherwise on the Plans.

d. Locating Pins. Locating pins shall be 16d common nails or larger and shall be hot-dipped galvanized in accordance with ASTM A153.

A6. CONSTRUCTION METHODS:

a. Removal of Bituminous Pavement. Saws shall be set to cut the full depth of the bituminous concrete and any membrane present. Bituminous concrete pavement shall be removed from those areas where asphaltic joint material is to be placed by the use of saws and pneumatic hand tools. Variations in the thickness of the bituminous concrete across the road should be considered to insure, where possible, that the deck is not damaged.

b. Joint Preparation.

1. Cleaning. The entire joint must be thoroughly cleaned and dried using a Hot Compressed Air Lance immediately prior to tanking. All loose debris shall be removed from the gap. Care must be taken to ensure that the sawcut surfaces have been thoroughly cleaned of any dust or wet paste from the cutting operation.

2. Caulking. The joint gap shall be caulked with a backer rod as shown on the Plans. It shall be placed in such a manner as to allow for the appropriate placement of the required binder material.

3. Tanking. Immediately after cleaning/caulking, the bottom of the blockout area shall be coated with a layer of hot binder that has been heated in accordance with the manufacturer's recommendations. If a delay greater than one (1) hour occurs between cleaning and tanking, the joint shall be re-cleaned using a Hot Compressed Air Lance as described above.

4. Plating. The gap shall be bridged with three to four feet long steel backing plates. Steel plates shall be located with pins along the centerline. The plates shall be butted to each other and shall not be overlapped. Immediately coat the walls of the blockout area and the bridging plates with binder, making sure that the plate is entirely encapsulated by the binder.

c. Asphaltic Joint Material Preparation.

1. **Aggregate.** The aggregate must be dried, cleaned and heated in a drum mixer by hot compressed air. The stone shall be heated to a temperature between 375°F (190°C) and the maximum safe binder temperature, as specified by the manufacturer. The temperature shall be monitored with a calibrated infrared thermometer. Under no circumstances shall the binder be mixed with the aggregate if its temperature is above the maximum. All tangible signs of dust must be removed prior to mixing of the binder with the aggregate.

2. **Binder.** The binder shall be heated to and maintained at the manufacturer's recommended placement temperature in excess of 350°F (177°C). At no time shall the manufacturer's recommended safe heating temperature be exceeded.

d. Material Installation. The method used shall be according to the manufacturer's recommended procedure. Variations from the manufacturer's procedure or from this specification must be approved by the Engineer prior to commencement of work.

1. Placement of the aggregate/binder mix into the blockout area: Binder material shall be added to the mixer just sufficient to thoroughly coat the aggregate. The coated aggregate shall be placed into the blockout in layers as recommended by the joint material manufacturer. The blockouts shall be overfilled with coated aggregate as required to compensate for compaction. Equipment for compaction shall be capable of sufficient compaction force as recommended by the joint manufacturer. Additional binder material shall be screeded over the compacted joint to fill any surface voids.

2. Surface Layer. Accurately measured quantities of hot aggregate shall be mixed with the binder in a rotating drum mixer. The binder should be at the approved temperature to insure complete coating of all the stone. This mix shall be transferred to the joint and leveled to be slightly higher than the adjacent road surface.

3. Compaction. Compaction shall begin immediately after the placement of the material in the blockout, using equipment as specified by the joint system manufacturer and the joint surface made flush with the existing road surface.

4. Screeding. Prior to the final screeding, the surface of the joint and surrounding road shall, if necessary, be dried and cleaned with a Hot Compressed Air Lance. Immediately thereafter a single screed of hot binder shall be applied to fill all surface voids.

5. Joint sealing. The interface between the joint and the pavement shall be sealed with a 2-inch wide band of the binder, centered on the interface, for the entire length of the joint on both the leading and trailing edges, relative to traffic. The surface adjacent to the interface shall be heated with a Hot Compressed Air Lance to promote adhesion of the binder. Immediately after the application, while the binder is still hot, basalt stone shall be broadcast onto the band. It shall cover 75% of the surface of the band.

6. Opening to Traffic: The joint shall not be opened to traffic before the surface reaches a temperature of 120°F or 30 minutes has elapsed from placing the basalt stone.

e. Equipment. The following equipment is required for the proper installation of asphaltic bridge deck joints.

1. A manually propelled, high speed water cooled saw with diamond tipped blades capable of cutting to the full depth required in one pass.

2. A pneumatic compressor of 185 CFM capacity to power drills and breakers of various sizes with suitable size bits.

3. Two Hot Compressed Air Lances (HCA Lances), each capable of delivering a flame retarded air stream with a temperature of 3,000°F (1,648°C), at a speed of 3,000 feet per second. The use of a torch rather than a Hot Air Lance to heat the block out surfaces is not allowed.

4. A 200-gallon air-jacketed, trailer-mounted melter with two flame baffled L.P. ribbon type burners rated a minimum output of 175,000 BTU which shall apply indirect heat to the melting chamber. The unit shall have automatic temperature controls which can accurately maintain the material temperatures between 100°F and 650°F (38°C and 343°C). A temperature gauge, calibrated to ± 10°F of actual, must be provided and mounted such that the temperature is clearly visible to the operator and the Engineer.

The burner system shall have a safety pilot capable of shutting off the base supply in the event of a flame-out.

The melter shall be equipped with a horizontally mounted double-paddle, full sweep reversible agitation system which runs the length of the melting chamber and is driven hydraulically with a dedicated engine and compressor. Material delivery shall be by an angled 3-inch discharge port.

5. Storage tanks capable of holding a minimum of 600 pounds propane, 600 pounds oxygen, 200 pounds acetylene.

6. A dedicated drum mixer, with compressed hot air apparatus sufficient to heat the aggregate and aggregate/binder mix in the drum to the specified temperature range.

7. Acetylene cutting torches.

8. An arc welder powered by a suitable generator.

9. 500-gallon capacity water tank fitted with suitable spigots.

10. A hand-held infrared thermometer, calibrated to ± 10°F.

11. A vibratory plate compactor.

12. A powered roller sufficient to span the width of the joint system in a single pass.

13. In the event of equipment failure during installation, backup equipment must be available, or in the case of a major breakdown, replacement equipment should be on site within 48 hours.

f. Submittals.

1. The Contractor shall submit to the Engineer, for approval at least thirty (30) days prior to start of work, the following: a) The name of Manufacturer and: b) The Manufacturer's Warranty Certificate.

A7. **<u>METHOD OF MEASUREMENT:</u>** "Asphaltic Expansion Joint System" will be measured by the number of linear feet of such joints actually installed in accordance with the Plans and/or as directed by the Engineer.

A8. **<u>BASIS OF PAYMENT:</u>** The accepted quantities of "Asphaltic Expansion Joint System" will be paid for at their respective contract unit prices per linear foot as listed in the Proposal. The prices so-stated constitute full and complete compensation for all labor , materials, and equipment, and for all other incidentals required to finish the work, complete and accepted by the Engineer.

A9. <u>WARRANTY PARAMETERS.</u> Condition parameters are used to measure the performance of the asphaltic expansion joint system during the warranty period. Each condition parameter has a threshold limit that defines when corrective action (warranty work) is required.

<u>Definitions.</u>

Debonding. Physical separation of the asphaltic expansion joint from the adjacent vertical face of the pavement or the bridge deck.

Transverse crack. Any open crack that extends more in the transverse (perpendicular to traffic flow) than in the longitudinal direction.

Longitudinal crack. Any open crack that extends more in the longitudinal (parallel to traffic flow) than in the transverse direction.

Perviousness. Absence of watertightness.

Rutting. Depression, displacement, or dislodgment of the asphaltic expansion joint surface.

A10. <u>WARRANTY REQUIREMENTS.</u> The table lists the allowable threshold limit for each condition parameter for each asphaltic expansion joint. If any of the warranty requirements are not met as a result of a defect in materials and/or workmanship, corrective action (warranty work) is required.

<u>WARRANTY REQUIREMENTS</u>

Condition Parameter	Threshold Limit for each Asphaltic Expansion Joint
Debonding (either edge)	5% total for the joint, with no debond greater than two (2) feet.
Transverse cracking	5% total for the joint, with no crack greater than two (2) feet.
Longitudinal cracking	3 times joint longitudinal dimension
Perviousness	Visible seepage of water
Rutting	Maximum depth ½"

A11. <u>CORRECTIVE ACTIONS.</u> The following corrective actions are recommended to outline typical acceptable treatments for the various condition parameters. The Department will accept the listed corrective action if the action addresses the cause of the condition parameter. The Contractor may use an alternative action subject to the Department's approval.

<u>CORRECTIVE ACTIONS</u>

Condition Parameter	Recommended Action
Debonding	Sawcut and remove the affected area; Replace with new asphaltic expansion joint.
Transverse cracking	Sawcut and remove the affected area; Replace with new asphaltic expansion joint.
Longitudinal cracking	Seal
Perviousness	Seal
Rutting	Sawcut and remove the affected area; Replace with new asphaltic expansion joint.

RHODE ISLAND DEPARTMENT OF TRANSPORTATION
INITIAL ACCEPTANCE FOR WARRANTY

CONTRACT ID:	
CONTRACT SECTION:	**JOB NUMBER:**
SURETY NAME:	
SURETY ADDRESS:	
CONTRACTOR NAME:	
CONTRACTOR ADDRESS:	

IDENTIFY EACH JOB NUMBER, LOCATION AND WORK SEPARATELY

JOB NUMBER	*ROUTE NUMBER*	*CONTROL SECTION*	*WORK TYPE*	*DATE ACCEPTED*	*PROJECT ENGINEER*

INITIAL ACCEPTANCE OF WARRANTY WORK APPROVAL
CONTRACTOR'S SIGNATURE:
ENGINEER'S SIGNATURE:
ACCEPTANCE DATE:

RHODE ISLAND DEPARTMENT OF TRANSPORTATION
WARRANTY BOND

Bond Number ____________________

KNOWN ALL MEN BY THESE PRESENTS:
That we, ____ (hereinafter called the "Principal"), and ____, a corporation duly organized under the laws of the State of ____________________ and duly licensed to transact business in the State of Rhode Island (hereinafter called "Surety"), are held and firmly bound unto the Rhode Island Department of Transportation (hereinafter called the "Obligee"), in the sum of __________________ Dollars ($), for the payment of which sum well and truly to be made, we, the said Principal and the said Surety, bind ourselves, our heirs, executors, administrators, successors and assigns, jointly and severally, firmly by these presents.

WHEREAS, the said Principal has heretofore entered into a contract with the Rhode Island Department of Transportation dated __________________ under Rhode Island Contract No.________ ________________ and;

WHEREAS, the said Principal is required to guarantee the________________________ installed under said contract, against defects in materials or workmanship which may develop during the period(s) of ____________________ years beginning the date(s) of the Acceptance Date of Construction by the Obligee.

In no event shall losses paid under this bond aggregate more than the amount of the bond.

NOW, THEREFORE, THE CONDITION OF THIS OBLIGATION IS SUCH, that if said Principal shall faithfully carry out and perform the said guarantee, and shall, on due notice, repair and make good at its own expense any and all defects in materials or workmanship in the said work which may develop during the period specified above or shall pay over, make good and reimburse to the said Obligee all loss and damage which said Obligee may sustain by reason of failure or default of said Principal so to do, then this obligation shall be null and void; otherwise it shall remain in full force and effect.

PROVIDED HOWEVER, that in the event of any default on the part of said Principal, a written statement of the particular facts showing such default and the date thereof shall be delivered to the Surety by registered mail, promptly in any event within ten (10) days after the Obligee or his representative shall learn of such default and that no claim, suit or action by reason of any default of the Principal shall be brought hereunder after the expiration of thirty (30) days from the end of the warranty period as herein set forth.

Signed this____________ day of__________________,_________ .

Contractor______________________________

By ______________________________

Surety ______________________________

By ______________________________

Attorney-In-Fact

Appendix C
Asphaltic Plug Joint History

Asphaltic Plug Joint History

Thorma-Joint®

- Originally developed in the UK by Prismo in the late 1970's. It was the first asphaltic plug joint on the market.
- First United States installations began in the early 1980's. Product was originally installed by Prismo's own crews ensure a proper and quality installation.
- Prismo became Linear Dynamics, Inc (LDI) in 1988.
- LDI was purchased by Lafarge in 1998 and became known as Lafarge Road Marking in 2002.
- Product is currently sold as Lafarge Road Marking's Thorma-Joint and is installed by Lafarge's own crews as well as a series of certified installers.

BJS®

- Originally developed by Koch Pavement Solutions.
- Product gained wide use throughout the U.S. but was eventually sold to Linear Dynamics in 1996.
- BJS is still used on a regular basis in the Northwest U.S.

Matrix 502®

- Originally developed by Pavetech International.
- Like LDI, Pavetech tried to use their own installation crews wherever possible to ensure a quality end product.
- D.S. Brown eventually purchased Pavetech International and began marketing the Matrix system under its own name.
- When the asphaltic plug joint market became too crowded, D.S. Brown divested the Matrix 502 system and Pavetech once again became a stand-alone business.

Wabo Expandex®

- Originally developed by Watson Bowman Acme.

A.P.J.

- Originally developed by SSI.
- Sold to Wyoming Equipment. They currently market the product under their own name. SSI is no longer affiliated with the product.

Appendix D
Manufacturers Data

A.H. Harris & Sons, Inc.

HARRIS

CONSTRUCTION SPECIALTIES

Since 1916

Both

Both

DESCRIPTION

Harris Polyjoint System Elastomer Strip Overlay Expansion Joint

Materials:

A. **Backer Rod - Sealtight Cera-Rod, manufactured by W.R. Meadows, Inc.** Sealtight Cera Rod is a heat resistant backer rod specifically developed to withstand the high temperatures inherent to hot-applied rubber asphalt sealers and polymeric sealants. It is a round, flexible continuous length, white material extruded from a crosslinked, closed cell polyolefin. Cera Rod is non staining and is virtually non absorbent.

B. **Bridging Plate** - ASTM A 709, Grade 36 steel 1/4" x 8" with 1/4" dia. holes 24" c.c. Also available galvanized.

C. **Primer** - Harris Polyjoint Primer CSSIH.

D. **Binder and Sealant** - Harris Polyjoint (see below)

E. **Aggregate** - fractured, angular trap rock in 3/4" minus graduation, double washed, kiln dried and prepackaged.

Harris Polyjoint Asphalt Binder-Sealer is a polymeric modified asphaltic mixture packaged in plastic 5 gallon pails with 40 pounds of binder. Harris Polyjoint Asphalt Binder-Sealer adheres to the following specifications:

Test	Test Method	Requirements
Softening Point	ASTM D-36	200° F (93° C) Min
Tensile Adhesion	ASTM D-3583	750% Min.
Ductility @ 77° F (25° C)	ASTM D-113	40 cm Min.
Penetration	ASTM D-3407	
77° F (25° C) 150 g. 5 sec.		90 dmm Max.
0° F (-18° C) 200 g 60 sec		10 dmm Min.
Flow 5 hr @ 140° F (60° C)	ASTM D-3407	3.0 mm Max.
Resiliency @ 77° F (25° C)	ASTM D-3407	40% Min.
Asphalt Compatibility	ASTM D-3407	Pass
Recommended Pouring Temperature		390° F (199° C)
Safe Heating Temperature		410° F (216° C)

HARRIS Harris Polyjoint

APPLICATION

A. The concrete substrate temperature shall be 40°F and rising prior to installation of the Harris Polyjoint System.
B. The Harris Polyjoint System applications must be centered over the existing expansion joint to a width no less than 12". Remove existing bridge joint system from bridge deck and saw-cut joint cavity a minimum of 2" depth from top of asphalt wearing course, and 1-1/2" depth for latex modified overlay bridge deck.
C. Remove all debris from the cut-out section and clean the surface areas and joint cavity allowing no dust or moisture to be present.
D. Sandblast vertical and horizontal surfaces of joint.
E. Clean out all residual sand and debris. Joint must be dry. The horizontal plane of the joint box-out shall be smooth.
F. Place backer rod into the joint cavity. Backer rod must be placed to a minimum depth of 1-1/2".
G. Heat Harris Polyjoint binder/sealer in an approved melter/applicator (double jacketed with heat transfer fluid and continuous mechanical agitation) in excess of 375°F but not to exceed 400°F.
H. Prime the vertical surfaces of the joint with the Harris Polyjoint primer CCS1H using stiff bristle brush or roller (Allow primer to become tacky prior to step I.)
I. Fill joint cavity with Harris Polyjoint binder/sealer.
J. Puddle the binder/sealer along the base of the cut-out section and the vertical sides. Place bridging plate centered over the joint cavity previously filled. Place **#16 GALVANIZED NAILS** into each hole of bridging plate. Puddle the binder/sealer over the bridging plate.
K. Heat specification aggregate in a rotating drum mixer(275°-375°F),then blend with binder/sealer until the aggregate is 100% coated. Temperature shall be monitored with an electronic heat sensing device. Temperature of mixed aggregate and polyjoint binder shall be a minimum of 275°F prior to placement of mix in joint opening. Mixer drum shall be kept clean of all foreign material not synonymous with the Harris Polyjoint System.
L. Fill cut-out section with coated aggregate in one lift slightly above grade of pavement. Compact Harris Polyjoint system with a 2 ton static roller.
M. Apply seal coat of liquid binder to top surface of Harris Polyjoint.
N. Dust the Harris Polyjoint surface with black beauty immediately after seal coat is applied.
O. Harris Polyjoint shall achieve a nonporous matrix upon completion of each joint.

LAFARGE ROAD MARKING

SPECIFICATION FOR THE INSTALLATION OF THE THORMA JOINT® ASPHALTIC PLUG EXPANSION JOINT SYSTEM BY LAFARGE ROAD MARKING

SCOPE

This work shall consist of supplying and installing a binder and aggregate system composed of specially blended polymer modified asphalt and specific aggregate placed in layers into a prepared expansion joint block-out. When properly installed, the **THORMA JOINT** system by LRM will provide a flexible waterproof bridge joint, which will allow for a joint movement of 1" in expansion and 1" in compression.

MATERIAL

Binder Material

The bridge joint binder shall be a polymer modified asphalt, as manufactured by Lafarge Road Marking, and shall meet the following requirements when tested according to ASTM test methods:

	TEST METHOD	TYPICAL VALUES
Softening Point	ASTM D-36	180° F (82° C)
Tensile Adhesion	ASTM D-3583	750% Min.
Ductility @ 77°F (25°C)	ASTM D-113	40 cm. Min
Penetration	ASTM D-3407	
	77°F (25°C) 150g, 5 sec.	90 dmm Max.
	0° F (-18°C) 200g, 60 sec.	10 dmm Min.
Flow 5h @ 140° F(60°C)	ASTM D-3407	3.0 MM Max.
Resilience @ 77° F (25°C)	ASTM D-3407	40% Min
Asphalt Compatibility	ASTM D-3407	Pass
Recommended Pouring Temperature		390° F (199° C)
Safe Heating Temperature		410° F (216° C)

Aggregate

The stone type shall consist of Granite, Basalt, Gabbro, Porphyry or Gritstones. The specified aggregate shall be crushed, double washed, and shall meet the following requirements:

GRADATION

Sieve Size	¾" Percent Passing
7/8	95-100
5/8	30-50
½	10-30
3/8	0-7
¼	-
#8	-

Backer Rod

The backer rod shall be a closed cell, foam expansion joint filler, capable of withstanding the elevated temperature of the polymeric binder. The backer rod shall have the following typical physical properties using a 2" specimen and test method ASTM D-545:

Density:	2.0Lbs/Cu.Ft, min
Tensile Strength:	30 psi, min.
Compression:	5 psi @ 25%, min
Water Absorption:	0.03 g/cc by weight, min
Temperature @ 410°F (210°C)	No Melting

Bridging Plate

The bridging plate shall be a mild steel plate, ¼" thick by 8" wide, cut in 4' to 5' lengths. Spike holes shall be drilled on a longitudinal centerline at 1' intervals.

INSTALLATION CREWS

The **THORMA JOINT** system is to be installed only by factory trained and certified installation professionals.

EQUIPMENT

The equipment will consist of:

1. Small self-propelled dry cut saw
2. Pneumatic compressor of 185 CFM capacity.
3. One Hot-Compressed Air Lance (HCA Lance), capable of delivering flame retarded air stream with a temperature of 3,000° F (1648° C), at a speed of 3,000 feet per second.
4. Rotating vented or un-vented drum type mixers each with a Hot-Compressed Air Lance (HCA Lance), or a pressure – air injection torch (PAT torch).
5. Melter unit equipped with agitation and an automatic temperature control which can accurately maintain the material temperature from 100°F - 650°F (38°C - 343°C). A thermometer to monitor the material temperature must be provided. The burner system shall have a safety pilot capable of shutting off the gas supply in the event of a flame-out.
6. 100 lb. Bottles of propane or smaller
7. Vibratory roller or plate capable of compacting up to 1" in one pass.
8. Hand held calibrated digital temperature sensor.
9. Chop-saw with carbide blade, if needed.
10. Sandblasting equipment, required only for installation in a concrete overlay.
11. Safety clothing and equipment as required by OSHA.

INSTALLATION

The following procedures are to be followed to ensure a successful installation:

Note: Thorma-Joint must be installed at a minimum depth of two inches (2") in order to perform correctly.

Marking out: **THORMA JOINT** system shall be located centrally over the deck expansion gap or fixed joint and marked out to the recommended width of 20".

Excavation: The joint shall be excavated by the use of saws and pneumatic hand tools. Where possible, saws shall be set to cut the full required depth of the wearing surface and any membrane present. Variations in the depth of the wearing surface across the road should be considered to insure, where possible, that the deck is not damaged. All debris from the excavation channel shall be removed to allow the full volume of new joint to be installed.

Cleaning: The entire channel must be thoroughly cleaned and dried. Small debris will be removed by using compressed air. The Hot Compressed Air Lance will then be applied throughout the length of the channel. Installation in concrete overlays requires sandblasting of the concrete vertical walls and adjacent deck area prior to the use of the HCA Lance application.

Repairs: Spalled and defective concrete should be repaired with an approved material as agreed upon by the Project Engineer.

Caulking: The gap shall be caulked with the backer rod, allowing for approximately 1" of binder in the gap on top of the rod. If the previous caulking is intact and will hold the binder, it may be used to take the place of the backer rod. A small amount of hot binder should be placed onto the caulking to insure that the gap is adequately plugged.

Tanking: Immediately after cleaning and caulking, the entire channel shall be coated with a thin layer of hot binder. If significant delay occurs, the channel shall be inspected to determine if re-cleaning is necessary.

Plating: The gap shall be bridged with the steel plates centered over the gap by placing locating pins in the centerline of the plate. There must be at least 2" between the edge of the steel plate and the wall of the channel. Once the locating pins are in place, the top of the plate shall be coated with a thin layer of hot binder.

MATERIAL PREPARATION:

Aggregate: The aggregate must be heated in a vented or un-vented rotating drum mixer by the use of a hot compressed air lance (HCA Lance), or a pressure air injection torch (PAT torch). Once the aggregate has been heated to a temperature of 370° - 380° F (188° - 193° C), it is then coated with a small quantity of binder. One gallon of binder per 100 lbs. of stone should be sufficient to coat the stone.

Binder: The binder shall be heated to the recommended pouring temperature, 370° - 385° F (188° - 196° C). At no time shall the recommended safe heating temperature of 400° F (204° C) be exceeded.

Material Installation: Layers of hot pre-coated aggregate not more than 2.5" thick shall be placed in the channel and immediately covered to the level of the coated aggregate. This will ensure that the 3:1 weight ratio of aggregate to binder has been achieved. Layers shall be raked to insure the aggregate is completely coated and that all air pockets are eliminated. This process shall cease approximately three-quarters of an inch (3/4") from the top of the channel.

Surface Layer: The surface layer shall be applied as other layers except that the pre-coated aggregate is not flooded with binder. The pre-coated aggregate shall be transferred to the joint and leveled slightly higher than the adjacent road surface. On a standard 2" deep joint, the topcoat should be one quarter inch (1/4") higher than the road surface. Deeper joints will require higher levels before tamping.

Compaction: Compaction should take place after the joint has cooled to approximately 225° F (107° C). The joint surface shall be made approximately level with the existing road surface by using the vibratory plate or roller.

Top Coating: After compaction, lines of 4" tape are placed one inch beyond the joint width on each side of the joint to insure evenness of appearance. The joint and at least one inch of the road surface shall be top-coated with the hot binder until the surface is smooth and absent of voids.
Note: If it is impossible to topcoat the joint during the same working day/night, it is allowable that the topcoat step be completed on the next working day/night. However, the surface must be cleaned, dried, and heated with the HCA Lance.

Surface Dressing: Immediately after top-coating, an anti-skid material is spread evenly over the joint to eliminate material tracking (Black Beauty Sand, Medium Grade).

Final Preparation: Prior to departure the crew will insure that the entire work area is clean of debris.

Temporary Joint: In the event of a work stoppage while constructing a joint, the following procedure can be used for low ADT roadways (<20,000). Fill the cavity with cold uncoated aggregate to the level of the road surface and top the aggregate with binder to form a temporary riding surface. Roadways with an ADT greater than 20,000 will require materials similar to a cold patch asphalt. Be sure whatever is used is approved by the state agency.

QUALITY CONTROL

Upon request, certifications of the materials will be provided.

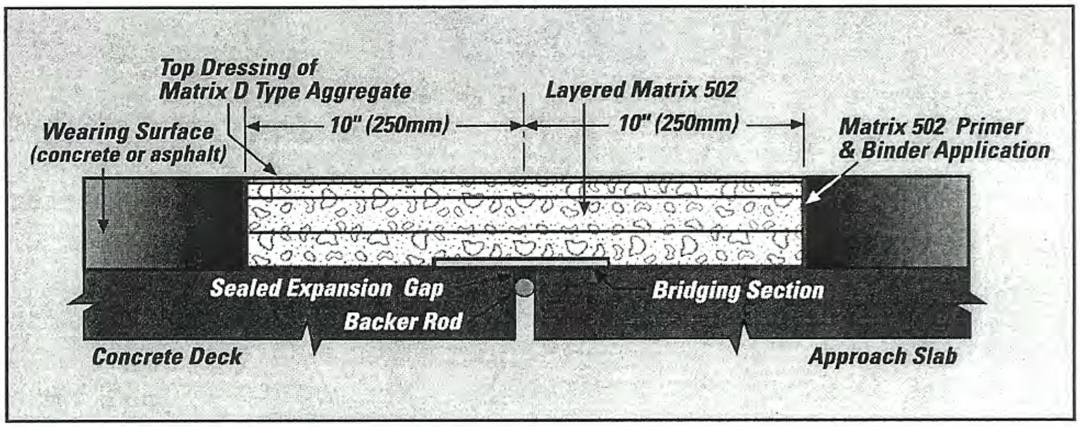
The Project Engineer may require the contractor to provide samples during the course of the work for laboratory test of any or all of the properties specified.

Quality of every **THORMA JOINT** system will reflect the quality put forth by Lafarge Road Marking and shall receive the highest priority in contractual obligation.

Evidence of Compliance

Lafarge Road Marking is prepared to provide with its bid evidence of successful installations of this system over the past several years.

Matrix 502 *is an asphaltic plug joint that differentiates itself from other asphaltic plug products in several ways. Matrix SBG Aggregate, a specially selected pre-blended, nonuniform igneous aggregate is used in its layering process. The result is a tighter matrix of aggregate and binder capable of exceptional wear life performance. Wear life and skid resistance of Matrix 502 are further enhanced by its Matrix D Type Aggregate used to top dress the joint. Improved adhesion of the product is achieved by the use of Matrix Primer applied to all horizontal and vertical surfaces. The use of 18 gauge aluminum bridging sections in Matrix 502 significantly reduces the potential for reflective cracking.*



Typical Concrete Slab Bridge Span

Materials

Matrix 502 Binder
A specially formulated thermoplastic polymer-modified asphalt binder certified by Pavetech to meet several ASTM Standards.

Matrix SBG Aggregate
A specially selected igneous aggregate, double washed, dried and packaged according to a pre-blended, nonuniform mixture meeting a specific gradation requirement.

Matrix D Type Aggregate
Finely graded, double washed and dried black granite used for top dressing a completed Matrix 502 joint.

Bridging Section
3003 - H14 18 gauge aluminum plate, 6" (150mm) wide, cut in 4 and 5 foot lengths is standard. When the gap width exceeds 2" (50mm), the width of aluminum plate may be increased. Alternatively, mild steel plate may be specified.

Backer Rod
A closed cell, foam expansion joint filler capable of withstanding the elevated temperature of the Matrix 502 Binder.

Pavetech has engineered an all-in-one, state-of-the-art version of Matrix 502.

MATRIX ONE

- **Eliminates component ratio variation.**
- **Matrix One Binder and Aggregate are pre-measured and packaged by the unit.**
- **No on-site mixing of separate components.**
- **Heated and blended in a Pavetech HB-200 mixing unit.**
- **Same features and benefits as the original Matrix 502.**

Matrix One. Performance. Solutions.

Summarized Installation Guidelines

■ After all resurfacing operations are completed, the overlay is to be transversely saw cut full depth, minimum 2" (50mm), and 20" (500mm) wide centered over the joint opening.

■ Break out and remove all material, including waterproofing, between the saw cuts.

■ Clean and dry the excavated joint area using a hot compressed air lance.

■ Prime all vertical and horizontal surfaces with Matrix Primer.

■ Place backer rod into expansion joint opening and overfill with hot Matrix 502 Binder.

■ Center and butt joint aluminum bridging sections over the expansion gap and bed into the hot binder.

■ Coat all vertical and horizontal surfaces, including the aluminum plate, with Matrix 502 Binder.

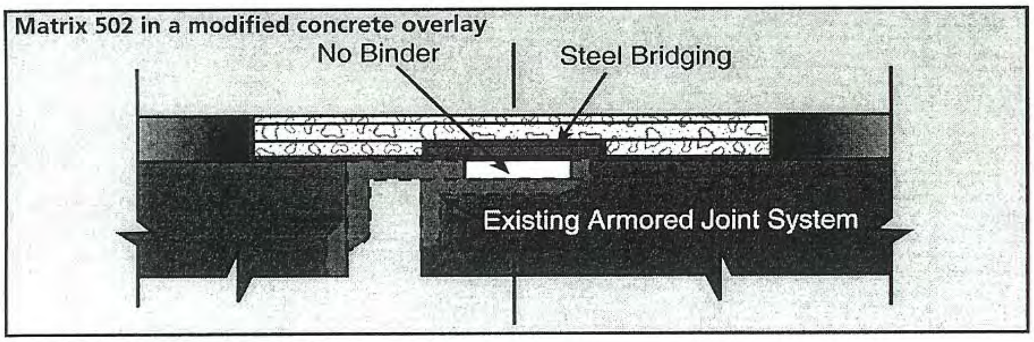
■ Heat the Matrix SBG Aggregate to a temperature of 275°F. to 325°F. (135°C. to 163°C.) in a suitable rotating drum mixer. Heat Matrix 502 Binder to a minimum of 380°F. (193°C.) in a double jacketed oil melter.

■ Mix the Matrix 502 Binder and SBG Aggregate in accordance with the Matrix 502 specification.

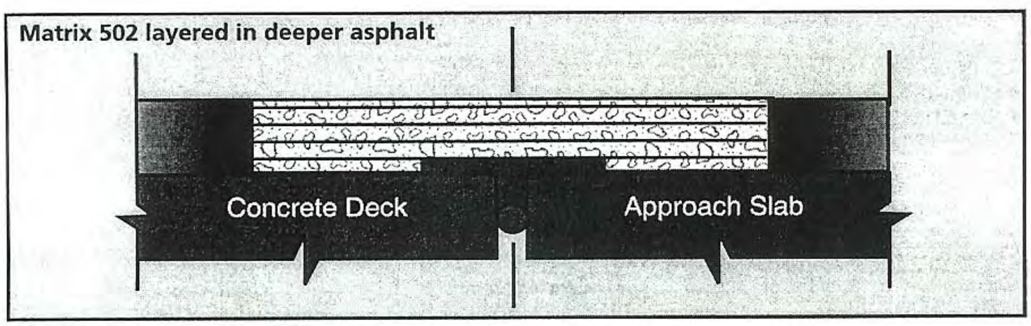
■ Place the 502 mixture as detailed in the Matrix 502 application procedure.

■ Compact the Matrix 502 joint level to the adjacent wearing course.

■ Heat the Matrix 502 surface, apply a thin membrane of binder and broadcast Matrix D Type Aggregate to complete the installation.



Typical Steel Beam Bridge



Typical Prestressed Box Beam Bridge

Site Suitability

Typical Structures - Concrete Slab, Concrete Beam, Prestressed Concrete, Steel Beam } Simple Span, Multi-Span

Typical Joint - Expansion and Fixed End Joints on abutments and piers.

Movement Capacity - Expansion Joints with thermal movement of about 1" (25mm).

Surfacing - Matrix 502 may be placed within any of a variety of Modified Concrete Overlays and Asphaltic Concrete wearing courses where access is available for the necessary excavation.

Depth Requirement - Matrix 502 must be placed to a minimum depth of 2" (50mm). Minor scarification of the bridge deck may be necessary in some instances.

Other Applications

Matrix 502 is an easily adaptable product. Due to its flexible, yet resilient nature, Matrix 502 can be used in the following circumstances:

■ a PRESSURE RELIEF JOINT on approach slabs

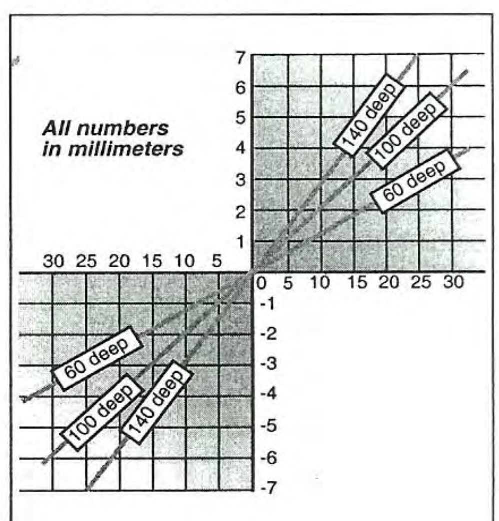
■ a MATRIX MINI-JOINT to solve reflective cracking problems

■ a LONGITUDINAL JOINT between two decks to accommodate small live load deflections

Plot of Theoretical Displacement

Graph Description

The graph plots the theoretical displacement of various thicknesses of Matrix 502 over a range of thermal movement.



Procedure for the Installation of

MATRIX 502

Asphaltic Plug Bridge Joint System

Introduction

Proper installation of Matrix 502 will yield a smooth riding, watertight expansion join capable of absorbing about 1 inch (25mm) of thermal movement. Strict adherence to procedures is required to validate the warranty and to obtain a proper Matrix 502 installation. The manufacturer recommends that an installation be closely supervised and performed by trained personnel.

Installation Procedures

Matrix 502 shall be centered (+/- 1"/25mm) over the existing expansion joint gap to the recommended width of 20" (500mm). Variation in the width of the joint may be necessary to accommodate site conditions as determined by the manufacturer and/or engineer.

Saw cut the pavement transversely at the determined width (normally 10"/250mm each side of the expansion gap C/L) parallel to the joint gap and remove all material between the saw cuts, including the waterproofing, riser bars, any old expansion joint material and loose concrete from the bridge deck. This will form the bridge joint block out. The block out must be cut to a minimum depth of 2" (50mm) in order to obtain a representative installation of Matrix 502. In some cases, this may require scarifying of the concrete bridge deck with a small scabbler. Care should be taken to yield a level joint table consistent with existing site conditions.

The joint block out shall be further prepared by cleaning and drying all horizontal and vertical surfaces and at least 6" (150mm) of the road surfacing adjacent to the vertical saw cuts. The use of a hot compressed air (HCA) lance or a hand held torch is recommended. If there is an interruption due to weather or other causes, the cleaning and drying operation is to be repeated immediately before the priming and tanking operation.

If required by the contract, install pressure relief drainage at this phase of the Matrix 502 installation. (See Specification—Pressure Relief Drainage)

The Matrix 502 Binder shall be heated to a minimum of 380°F (193°C), preferably in a double jacketed oil melter. The melter must be equipped with a continuous agitation system, temperature controls and calibrated thermometers to maintain the binder at the manufacturer's recommended temperature. Additionally, a system for accurately determining the weight of binder dispensed from the melter shall be available on site.

Prior to the tanking procedure, all horizontal and vertical surfaces of the prepared joint block out shall be brush coated or sprayed with Matrix Primer. This will assist adhesion of the Matrix 502 joint within the block out.

Backer rod capable of withstanding the elevated temperature of the Binder shall be placed into expansion joint gaps 1/8" (3mm) or wider. Place the backer rod at a minimum depth of 1/2" (12mm). Pour the binder into the expansion gap, overfilling the joint gap to allow the binder to be spread onto the joint table. The binder will form a bond breaker between the joint table and the aluminum (or mild steel) bridging sections. The aluminum bridging sections are then centered over the existing expansion gap and butt jointed over the entire joint length and bedded into the Matrix 502 Binder.

All prepared, exposed surfaces (vertical and horizontal) of the joint block out including the aluminum bridging sections shall be sealed with the Matrix 502 Binder. Pour Matrix 502 Binder into the joint block out and screed to coat all exposed surfaces. The binder shall achieve a minimum thickness of 1/32" (1mm) throughout. The binder application temperature shall be between 380°F and 400°F (193°C and 204°C).

The pre-blended SBG Aggregate shall be heated to 275°F – 325°F (135°C – 163°C) in a rotating drum mixer to remove dust and all moisture. The temperature of the aggregate shall be monitored by using a hand held, calibrated, digital temperature sensor. Add Matrix 502 Binder to the heated SBG Aggregate in the mixer in a ratio of approximately 1 gallon (8.5 lbs.) of binder per 50 lbs. of SBG Aggregate. Minor variation in the amount of Matrix 502 Binder added to the heated SBG Aggregate is allowed. The heated SBG Aggregate must be completely coated prior to placement.

PAVETECH® International

Installation Procedures continued...

To obtain best results, Matrix 502 must be installed in layers. The depth of the joint block out determines the number of layers (MINIMUM 3 layers) of coated SBG Aggregate that comprise a completed joint. The final top layer of coated SBG shall be approximately 1/2" thick. All other intermediate layers of coated SBG shall be no more than 1 1/2" thick, and will generally be not less than 3/4" thick. Each layer of coated SBG should be achieved by placing the hot mixture into the joint block out and raking level to the desired thickness. Use hot steel rakes to spread and level the coated SBG Aggregate.

Apply additional Matrix 502 Binder to each layer of coated SBG Aggregate to lightly fill in voids as necessary. (The correct appearance of a completed layer will show aggregate raised above the binder level.) When installing the top 1/2" layer, place the coated SBG approximately 1/4" above the existing surface to allow for compaction. Compaction is achieved using a minimum 1 1/2 ton roller perpendicular to and transversely with the joint. Alternatively, a vibratory plate compactor may be used to compact the layered SBG Aggregate. After compaction is completed, Matrix 502 should be level with the adjacent surface. Matrix 502 forms an interlocking matrix of SBG Aggregate layers enhancing performance.

The completed joint surface must be carefully heated with a heat lance or hand held torch to a tack consistency. A thin membrane of hot Matrix 502 Binder shall then be applied followed immediately by broadcasting Matrix D Type Aggregate at the rate of approximately 3 lbs. per lineal foot over the entire joint length. Partially imbed the D Type Aggregate by compacting. A Matrix 502 expansion joint will be ready for traffic 30–60 minutes after completion, depending on joint depth and ambient temperature. Clean the job site of packaging and other debris and open to traffic.

Suggested Equipment for Matrix 502 Installation

	Quantity
• Material melter, preferably double jacketed oil, 100/200 gallons	1
• Motor driven, rotating drum mixers, 3 CF	3 to 4
• 125/175 CFM air compressor	1
• Hot compressed air lance or hand held torch	1 to 2
• 50 ft. air hose	1 to 2
• Concrete saw with diamond asphalt cutting blade	1
• Asphalt breaker with chisel attachments	2
• Motorized steel drum roller/compactor, minimum 1 1/2 tons	1
• Vibratory plate compactor instead of drum roller	1
• 100 lb. LPG cylinders with hoses & fittings	3 to 4
• Steel cutting torch	1
• High pressure air blow pipe	1
• Steel rakes	3 to 4
• Flat end steel scraper	2 to 3
• Straight edge utility shovel	2
• Heavy-duty push broom	2
• Steel bucket, 3 gallon	2 to 3
• Hand tools	
• 3 lb. hammer	2
• 50' chalk line	1
• 50' tape measure	2
• Wire brushes	2
• 2" masking tape rolls	3
• Box cutter utility knife with replacement blades	3
• Heavy-duty work gloves	6
• Heavy-duty flash lights	4
• Equipped tool box	1
• First-aid kit	1

Safety Guidelines

- Do not exceed maximum safe heating temperature of materials.
- Do not allow water to come into contact with Matrix 502 Binder.
- Wear suitable protective clothing such as long pants, long sleeved shirts, heavy-duty gloves, and steel toed footwear.
- Face shields are recommended if windy conditions are prevalent or if there is a danger of hot binder splashing.
- If hot material comes into contact with skin, do not remove. Immerse the affected area in cold water immediately and obtain medical treatment without delay.
- Wear ear plugs during period of high noise levels.

MATRIX 502

MATRIX 502 Binder - Table of ASTM Values

Test	Test Method	Typical Values
Softening Point	ASTM D 36	180°F. (82°C.) Min.
Tensile Adhesion	ASTM D 3583	700% Min.
Ductility @ 77°F. (25°C.)	ASTM D 113	40 cm Min.
Penetration	ASTM D 3407	
	77°F. (25°C.) 150g., 5 sec.	90 dmm Max.
	0°F. (-18°C.) 200g,60 sec.	10 dmm Min.
Flow 5 h @ 140°F .(60°C.)	ASTM D 3407	3.0 mm Max.
Resiliency @ 77°F. (25°C.)	ASTM D 3407	60% Min.
Asphalt Compatibility	ASTM D 3407	Pass
Recommended Pouring Temperature		370°F. - 390°F. (188°C.- 199°C.)
Safe Heating Temperature		390°F. (199°C.)
Specific Gravity		1.10 ± .05

MATRIX SBG Aggregate - Gradation Table

Sieve Size	Aggregate % Passing
1"	99 - 100
3/4"	65 - 85
1/2"	40 - 60
3/8"	20 - 35
1/4"	0 - 10

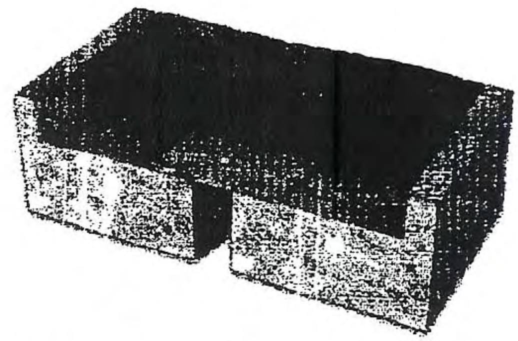
PAVETECH International, Inc.

13066 Montgomery Road • Cincinnati, Ohio 45249

Wabo®Expandex

Asphaltic Plug Joint System

Watson Bowman Acme®



DESCRIPTION:

Wabo®Expandex is a flexible asphaltic plug joint system designed to accommodate minimum structure movement while providing a smooth transition between the approach pavement and the bridge deck. Wabo®Expandex is used typically at abutments or with asphalt overlays due to its unique asphalt compatibility. The system combines the use of a traffic bearing plate with special aggregate reinforced modified elastomeric material.

FEATURES/BENEFITS:

- **Simplicity**
  Wabo®Expandex is relatively a low-cost joint system, simple in design while allowing a smooth transition. The one-piece monolithic design eliminates the need for troublesome anchors and moving parts
- **Versatility**
  The special blended elastomeric material has the ability to flow and fill in any spalls or inconsistencies in the blockout providing a flexible, yet smooth riding, and waterproof joint system
- **Ease of Installation**
  Wabo®Expandex is a single pour application system requiring minimum down time of the structure. During resurfacing operations, the system can be cold milled and installed to the new level of pavement.

RECOMMENDED FOR:

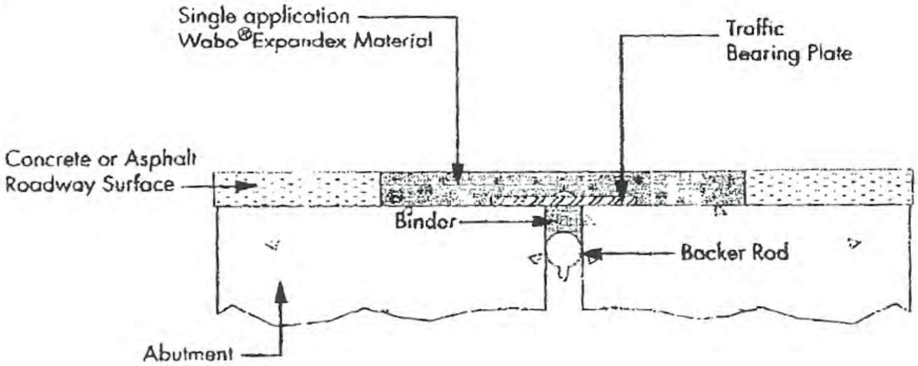
- Sealing joints on secondary highway bridge structures
- Joints whose movements will not exceed +/- 3/4" at time of installation
- Repair and maintenance of existing joints
- Overlay projects

degussa.

Construction Chemicals Americas

Watson Bowman Acme®

TYPICAL APPLICATION:



PHYSICAL PROPERTIES:

- Modified elastomeric binder shall meet or exceed the requirements of ASTM-3405 and ASTM-1190 and have the following properties:

PROPERTIES OF ELASTOMERIC BINDER:

[illegible]	[illegible]	[illegible]
Cone Penetration @ 77 F (25 C)	D 3407	75 max
Resilence	D 3407	60% Min.
Bond @ 0 F (-18 C) 100% Extension	D 3407	Pass 3 Cycles
Flow @ 140 F (60 C)	D 3407	2mm max
Asphalt Compatability	D 3407	Complete
Ductility	D 113	40 min.

- **Specialty aggregate**
  The granite aggregate shall be B size and C size. Percentage of aggregate passing through listed sieve size:

PERCENTAGE OF AGGREGATE PASSING THROUGH SIEVE SIZE:

[illegible]	[illegible]	[illegible]
B Size Granite	1" 1/2" 1/4"	100% 90 to 100% 0 to 15%
C Size Granite	1" 1/2" 1/4"	100% 90 to 100% 0 to 15%

PACKAGING/COVERAGE:

Packaging

- Wabo®Expandex elastomeric binder is supplied in standard 30lb. blocks.
- Each type of Wabo®Expandex specialty aggregate is supplied in 40 lb. bags
- Traffic bearing plates are supplied in standard 6'-0 lengths

Coverage

- Wabo®Expandex packaged units will yield approximately 2 1/2 feet, based on a standard 2" x 20" blockout. Yield will depend on placement, waste and experience.

SURFACE PREPARATION:

- The blockout should be of sound material with no vertical misalignment and parallel with the plane of the roadway. All surfaces shall be dry, then abrasive-blasted to remove contaminants and loose aggregate.

LIMITATIONS/STORAGE:

Watson Bowman Acme does NOT recommend the use of the Wabo®Expandex joint system under the following conditions:

Limitations

- On joints where movements exceed +/- 3/4" at time of installation
- Maximum joint opening at time of installation does not exceed 3 inches
- Do not install at joint locations where dynamic intermittent vertical displacements of over 1/4" occur.
- Blockout widths are a minimum of 20 inches wide, but do not exceed 24 inches.
- Minimum depth requirement of 2 inches
- Do not install at joint locations with skews greater then 45 degrees.

Storage

- Store specialty aggregate for the Wabo®Expandex in a dry place
- Store Wabo®Expandex material in an area that will not damage materials

Watson Bowman Acme®

INSTALLATION SUMMARY:

- Properly sized blockouts are sandblasted, then cleaned using a compressed hot air lance.
- Place backer rod in gap and pour heated binder material over blockout interfaces and surfaces.
- Position and center traffic bearing plates over joint gap and encapsulate with heated binder.
- Place pre-measured granite aggregate into a rotating drum mixer and heat to a minimum of 121°C (250°F). Wabo®Expandex binder is added to the heated granite aggregate.
- Pour aggregate and binder mixture in blockout level with deck surface. Compact Wabo®Expandex perpendicular to the joint.
- Seal top surface of joint with heated binder.

ADDITIONAL REQUIREMENTS/EQUIPMENT:

- Oil jacketed, double boiler Asphalt melter with agitation
- Rotating mixers
- Hot air lance
- Minimum two ton roller

RELATED DOCUMENTS:

Wabo®Expandex:

- Specification
- Installation Procedure
- MSDS

SPECIFICATION

Wabo®Expandex Joint System
Asphaltic Plug Joint System
for Bridge & Highway Applications

A. General

The work shall consist of furnishing and installing a bridge asphaltic plug joint system in accordance with the details shown on the plans and the requirements of the specifications.

B. Product

Provide an asphlatic plug joint system that is capable of accommodating movements of +/- ¾" at time of installation. The bridge deck joint system shall consist of a traffic bearing plate utilized with a modified elastomeric binder and aggregate. The asphaltic plug material shall be field mixed and consist of a one component elastomer binder and pregraded aggregate mix.

C. Component and Materials

The Contractor shall furnish a manufacturer's certification that the materials proposed have been pre-tested and will meet the requirements as set forth in the specification.

1. Traffic Bearing Plate

The traffic bearing plate shall be steel conforming to ASTM A36. It shall have 7/32" (5.5mm) holes to receive a 16D common nail for anchorage to the backer rod along the longitudinal centerline at 12" (305mm) intervals. The standard 6 foot plate shall be a minium thickness of ¼" (6mm) and 8" (203mm) in width

2. Backer Rod

A closed cell foam cylindrical backer rod, capable of withstanding the temperature of the hot modified elastomeric binder, as supplied or recommended by the manufacturer.

Wabo®Expandex Joint System
Asphaltic Plug Joint System
for Bridge & Highway Applications

3. Modified Elastomeric Binder

The elastomeric binder shall meet or exceed the requirements of ASTM 3405 and ASTM 1190 and have the following physical properties

PHYSICAL PROPERTIES	TEST METHOD	REQUIREMENT
Cone penetration @ 77°F (25°C)	ASTM D3407	75 max
Resilience	ASTM D3407	60% min
Bond @ 0°F (-18°C) 100% extension	ASTM D3407	Pass 3 cycles
Flow @ 140°F (60°C)	ASTM D3407	2mm max
Asphalt compatibility	ASTM D3407	complete
Ductility	ASTM D113	40 min

4. Granite Aggregate

The granite aggregate shall be B size and C size. It shall be supplied at the jobsite washed, dried and appropriately bagged. The following specifications for percentage of aggregate passing through listed sieve sizes:

GRANITE SIZE	SIEVE SIZE	REQUIREMENT
B Size Granite	1 inch	100%
	½ inch	90 to 100%
	¼ inch	0 to 15%
C Size Granite	1 inch	100%
	½ inch	90 to 100%
	¼ inch	0 to 15%

D. Construction Requirements

The Contractor shall submit product information and necessary details after the award of the contract. At the discretion of the Engineer, the manufacturer may be required to furnish a representative sample of material to be supplied in accordance with the project specifications

Where indicated and noted on the contract plans, install asphaltic plug in a neat and workmanlike manner. All surfaces to receive the asphaltic plug joint shall be free from dirt, water and any other loose foreign debris which may be detrimental to effective joint sealing.

SPECIFICATION

Wabo®Expandex Joint System
Asphaltic Plug Joint System
for Bridge & Highway Applications

The binder and granite aggregate shall be in the following portions to yield one unit:

Modified elastomeric binder..............................2-1/2 to 3 gallons
B size aggregate (40 lbs) ....1 bag
C size aggregate (40 lbs)...................... ....1 bag

The standard mix will yield 30 inches of joint when installed in a standard 20" wide by 2" deep blockout.

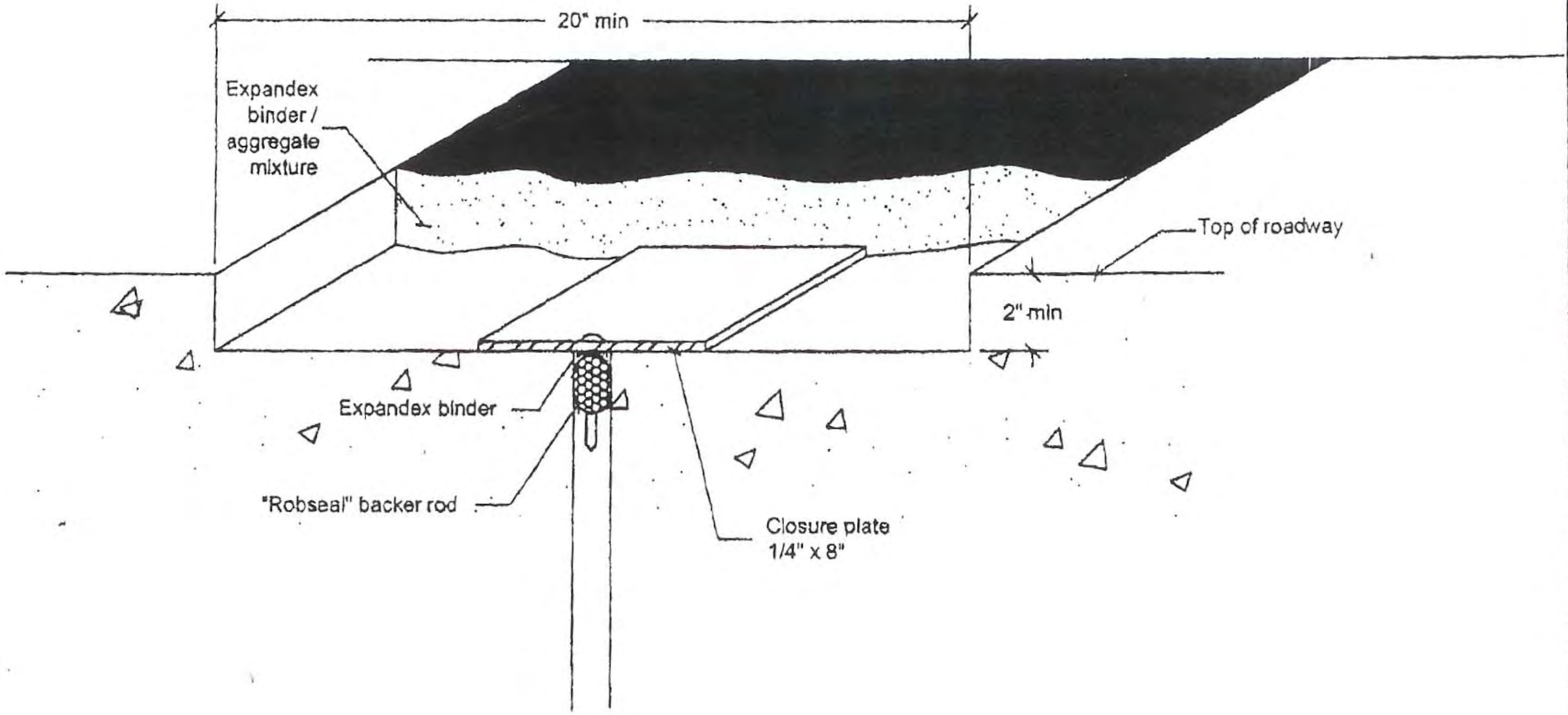
The asphaltic plug joint system shall be installed in strict accordance with the manufacturers written instructions along with the advice of their qualified representative.

E. Payment

The accepted quantity of asphaltic plug joint system will be paid for at the contract unit price per lineal foot. Measurement of the asphaltic plug joint system will be taken horizontally and vertically along the centerline of the joint system between the outer limits indicated on the contract plans. Payment will be made under:

PAY ITEM	PAY UNIT
Asphaltic Plug Joint System	Lineal Foot

Payment will be full compensation for all work necessary to complete the items including furnishing and installing the asphaltic plug joint system, and any miscellaneous patching required.



Design Features

- Low cost joint system
- Provides a flexable and smooth riding
- Compatable with asphalt overlays

Wabo®Expandex

Wabo® Expandex

Asphaltic Plug Joint

Watson Bowman Acme Corp.
95 Pineview Drive, Amherst, NY 14228
Phone: 716-691-7566 / Fax: 716-691-9239
Webpage: www.wbacorp.com

DETAILED BY: RMC		DATE: 10/18/00	
CHECKED BY: WBA		CURRENT ISSUE: 10/12/00	
SCALE: NTS		SALES	
SHEET SIZE: A	SHEET NO: 1	DRAWING NO: C - 20522	

INSTALLATION PROCEDURE

Watson Bowman Acme

Wabo®Expandex
Asphaltic Plug Joint System
for Bridge & Highway Applications

A. General

The work shall consist of furnishing and installing a Wabo®Expandex joint system in accordance with the details shown on the plans and the requirements of the specifications. Placement of the Wabo®Expandex joint system shall consist of proper surface preparations, material and application of materials. The Wabo®Expandex joint system is shipped by length and volume of joint. The steel traffic wearing plates are cut and shipped 8"(203 mm) wide by 72"(1828 mm) lengths. The elastomeric binder and granite aggregate are calculated on a volume basis and shipped by weight. One kit of Wabo®Expandex is comprised of 30 lb. (13.6 kg) elastomeric binder, 40 lb. (18 kg) bag of B granite aggregate and 40 lb. (18 kg) bag of C granite aggregate.

B. Joint Preparation

The blockout shall be constructed to the dimensions on the drawings. The blockout base shall be of sound material with no vertical misalignment and parallel with the plane of the roadway. Should repairs be required to the blockout an agency approved repair material shall be used.

Minimum blockout width is to be 20" (500 mm) but not exceeding 24" (610 mm).
Minimum blockout depth is to be 2" (50 mm).

Before installation of the Wabo®Expandex material, all blockout surfaces shall be dry, then abrasive-blasted to remove contaminants and loose aggregate. Blockout should then be heated and cleaned using a hot compressed air lance capable of producing 3000°F (1648°C) and a directional velocity of 90,000 cps (3000 fps) to insure the removal of any residue from the abrasive-blast operation. Care should be taken to insure that the abrasive blast and compressed air cleaning does not contaminate the blockout.

Note: Installation of the Wabo®Expandex should not be done unless the deck temperature is a minimum of 40°F (5°C) and rising.

C. Backer Rod Placement

Once the joint opening and blockout have been properly prepared, the backer rod is placed in the joint opening to a depth of approximately 1" (25mm). A closed-cell, high temperature, expanded polyethylene foam rod is recommended. The size of the backer rod should be 25% greater than the joint opening to be sealed.

Wabo®Expandex
Asphaltic Plug Joint System
for Bridge & Highway Applications

D. Modified Elastomeric Binder Placement

Melt the elastomeric binder in a double jacketed kettle and heat to a minimum of 380°F (193°C) but Do Not exceed 400°F (204°C). Pour the heated binder over the backer rod in the joint opening to seal the gap. This binder shall be poured level with the base of the blockout. Apply the heated binder over the entire blockout (base and sidewalls) to form a monolithic membrane approximately 1/16" (1.5 mm) to 1/8" (3 mm) thick.

E. Traffic Wearing Plate Placement

The steel traffic wearing plates are centered over the joint opening end-to-end along the joint with no overlapping. Centering pins (16D common nail is recommended) are installed in the pre-drilled holes and inserted directly into the modified elastomeric binder plug. These pins are designed to hold the plates in place. The heated binder shall be poured over the closure plate to encapsulate it.

F. Binder and Granite Aggregate Placement

Pre-measured granite aggregate, one 40 lb (18 kg) bag B and one pre-measured granite aggregate 40 lb. (18 kg) bag C is placed in a rotating drum mixer and heated to a minimum of 250°F (121°C) not exceeding 375°F (190°C). A correct volume, 2.5 gallons (9.5 Liters), of heated Wabo®Expandex binder, 380°F (193°C) not exceeding 400°F (204°C), is added to this heated granite aggregate.

This blend of elastomeric binder and granite aggregate is mixed for approximately 3 minutes or until all granite aggregate is coated and there are no "dry pockets" of aggregate. A hot air lance may be used to maintain the mix temperature on cooler days. Do not let the mix temperature exceed 400°F (204°C) if applying heat. Never apply direct flame to the liquid binder. The mixture is ready for placement in the blockout. Pour the Wabo®Expandex into the blockout to the road surface and level with rakes.

Once the blockout is filled, the Wabo®Expandex is to be compacted perpendicular to the joint. A minimum two-ton, water cooled drum roller is acceptable for this work. Care shall be taken to insure that the compaction process does not transfer material to the roller. Water can be used to prevent this should material transfer occur. The application of water should be kept to a minimum. Do not allow the material mixture to cool prior to beginning the compacting operation. This step should be ongoing during the installation process. Complete final compaction process by rolling the joint longitudinally.

Wabo®Expandex
Asphaltic Plug Joint System
for Bridge & Highway Applications

G. Final Treatment

After compacting, the Wabo®Expandex is ready for final treatment. The top surface shall be heated with a hot air lance until the surface becomes tacky. Duct tape should be placed 1" (25 mm) away from the joint edges and parallel to the joint. Pour heated elastomeric binder over the top surface to form a membrane.

Broadcast Black Beauty to eliminate possible tackiness. (Do not use silica sand) The installed Wabo®Expandex joint will be ready to accept traffic once the joint has cooled to the touch. Minimum cooling time 1 hour.

EQUIPMENT SALES

A.P.J.

Asphalt Plug Joint System – Specification & Installation

SCOPE:
This work shall consist of supplying and installing specially blended polymer modified asphalt and specific aggregate, placed into a prepared expansion joint blockout, in accordance with the engineer's plans and specifications.

MATERIALS:
The bridge joint binder (APB) shall be a thermoplastic modified asphalt with the following requirements:

TEST	Test Method	Typical Values
Softening Point	ASTM D36	200 °F. Min.
Penetration	ASTM D3407	90d mm at 77°F. Max.
Flow	ASTM D3407	3 mm Max at 140° F.
Recommended Pour Temp	---------------	370° F – 390° F
Safe Heating Temp	---------------	400° F.

The aggregate (APA), normally basalt, gabbro, or granite, shall be crushed, double-washed, dried and packaged in 50 lb. bags. The following is typical graduation:

Sieve Size	% Passing
7/8"	95 to 100
5/8"	30 to 50
½"	10 to 30
3/8"	0 to 15

The Backer rod shall be a cross-linked, closed cell, polyethylene, expansion joint filler, capable of withstanding the elevated temperature of the binder and shall have the following properties.

Property	Test Method	Value
Density	ASTM D1622	2lbs./cf. (nominal)
Tensile Strength	ASTM D1623	31.4 psi.
Compression	ASTM D1621	4.7 psi. at 25%
Water Absorption	ASTM C0509	0.02% by volume
Temperature	No melting of Rod	410° F.

The bridging plate shall be natural mild steel, 8" x 48" L, it can be 1/8, ¼, or other thickness, as specified by the Engineer. Spike holes will be placed on a longitudinal centerline at 12" intervals.

The locating pin shall be galvanized 16D common nail. The broad cast sand shall be a non-silica grit.

CONSTRUCTION PROCEDURES:

A qualified W.E.S employee, or an W.E.S. trained and approved contractor, shall be at the site prior to the beginning of the joint process, to instruct the work crews in the proper joint installation procedures. This individual shall remain on the job site for the duration of the installation.

The A.P.J. shall be centered over the existing expansion joint gap to the recommended width of 20". The engineer and W.E.S. if required, shall determine variations in the width.

A. INSTALLION

1. The A.P.J. shall be marked out by location the center of the joint opening then marking the joint width as specified. Using a self-propelled dry saw, cut through the wearing course and membrane to the joint table. (Where additional depth is required, the saw cut may be continued into the deck, with the engineer's approval).

2. The joint shall be excavated using pneumatic hammers with spades or a planer. Care should be taken not to damage the vertical edge of the block out. Care should also be taken to produce a smooth joint table to ensure that the bridging plate sits flat on the surface.

3. Defective concrete on the joint table should be removed and repaired with rapid set repair mortar according to the manufacturer's specifications. The mortar shall be completely set and dry before continuing with the installations.

4. All debris in the block out area and six (6) inches either side of the joint shall be cleaned and dried with a hot compressed air lance (HCA). Although rarely specified, we recommend that wire brushing and abrasive sand blasting to be considered, prior to the HCA procedure. (The grit shall be of a non-silica type.)

5. Hot Rod, or equivalent backer rod, shall be placed into the joint opening to a depth of one-inch (1)" below the joint table. The backer rod should be a minimum of 1.5 times the joint opening and forced into the gap. If there are compressible materials already in place that can withstand the elevated temperature of the binder, they may remain in place with the engineer's approval.

6. The vertical curb joint shall be sealed according to specifications. Dow Corning 888 with a soft type backer rod, or Dow Corning 1-2-3 silicone system is recommended.

7. Heat the bridge joint binder to the manufacturer's specified pouring temperature in a double jacketed, thermostatically controlled melter, with constant material agitation. Do not exceed the safe heating temperature of the material.

8. Organize and set up the materials, equipment and tools used for the installation of the system. This will help to ensure a continuos process once it has begun.

9. Place the aggregate in the mixers and heat to the recommended pouring temperature of the binder with HCA lances. The mixers shall be of the type recommended by the manufacturer. A hand-held digital temperature sensor shall be used to monitor the aggregate temperature.
   Do not overheat the aggregate.

10. Coat the entire blockout area with binder, while at the same time, filling the joint gap opening.

11. Immediately place the bridging plate centered over the joint opening, the plates shall be butted to each other and shall not be overlapped. Secure the plates from moving by inserting the locating pins through the pre-stamped holes into the backer rod. (A slight twisting motion of the nail when inserting will help penetrate the backer rod).

12. Immediately coat the bridging plate with binder, making sure that it is entirely encapsulated by the binder.

13. The seal of the bridge joint is now complete and a stable and flexible wearing surface or matrix must be installed. In order to achieve stability, the maximum amount of aggregate must be placed in the blockout. To achieve the required flexibility, all the voids in the matrix must be filled with binder. This also ensures the water tightness of the matrix. Making sure that the aggregate is at temperature, pour the binder into the mixer to pre-coat the aggregate and mix thoroughly (normally, One-half gallon, per fifty (50) pounds of aggregate). Do not add excessive amounts of binder.

14. Immediately dump the hot pre-coated aggregate into the joint blockout and rake into place in a layer not to exceed one and one-half inches . Using the rake, pack the aggregate tightly together assuring the that maximum amount of aggregate is contained in the layer.

15. Immediately pour hot binder over the layer and slightly agitate with the rake to ensure that the voids are filled with binder.

16. Continue steps 13, 14, and 15, above until the blockout is full. The final layer shall not exceed one inch in depth. Do not fill the voids in the final layer at this point. If the depth of the joints exceed four inches (4"), it is recommended that it be vibrated with a vibrating plate compactor near the midway of the joint depth. This must be accomplished prior to flooding the layer with binder. Use the minimum amount of water required to ensure that the binder does not stick to the plate. This water must be dried up using a propane torch prior to the application of the binder. This layer should not exceed one inch (1") in depth.

17. Using a vibrating plate compactor, as recommend by the manufacturer, interlock the aggregate by running the plate perpendicular to the joint, a minimum of three (3) times. This will ensure the proper density and stability of the matrix. The minimum amount of water should be used on the plate to ensure that the binder does not stick. This water shall be dried up with a propane torch from the surface of the joint and surrounding areas. Care shall be taken not to oxidize the binder with excess heat.

18. Place masking approximately one inch(1) from the edge of the joint on the existing wearing surface of the bridge.

19. Immediately pour hot binder over the joint surface: using a squeegee, fill the voids in the final surface. This may require more than one application in order to fill the voids to refusal. The final appearance of the joint will show signs of the tops of the aggregate. Overfilling can cause damage to the top surface of the matrix.

20. Immediately broadcast a fine aggregate as recommended by the joint manufacturer over the joint surface.

21. Depending on the ambient temperature and joint depth, the joint could be ready for traffic in one half (1/2) hour.

ASPHALTIC PLUG EXPANSION JOINT

LIMITATIONS

1. Maximum horizontal movement: 2" measured from maximum expansion to maximum contraction.
2. Maximum vertical movement: +/1/2.
3. Minimum depth: 2",must be full depth of overlay.
4. Maximum depth: 8" depth's greater the 4" to be vibrated at the approximate midpoint of the depth (Greater depth's subject to WYOMING EQUIPMENT SALES approval).
5. Installation width: Standard 20", required bonding area to be 6" between edge of bridging plate and the vertical edge of the joint. The joint width may vary between 16" and 32" (subject to WYOMING EQUIPMENT SALES approval).
6. Maximum gradient: 4%.
7. Maximum skew angle: 30 degrees (for skews> than 30 degrees, please consult Wyoming Equipment Sales).
8. Joint table conditions: Bridging plate must not rock, no vertical misalignment between spans or any projections.
9. Weather conditions: no wet conditions and no frost planes in the surrounding structure or wearing surfaces.

WARRANTY INFORMATION--- PLEASE READ CAREFULLY

Unless W.E.S provides you with a specific written warranty of fitness for a particular use, W.E.S. sole Warranty is that the APB and APA will meet current sales specifications. W.E.S. specifically disclaims Any other express or implied warranty, including the warranties of merchantability and of fitness for Use. Your exclusive remedy and W.E.S. sole liability for breach of warranty is limited to refund of the Purchase price or replacement of any product shown to be other than as warranted, and W.E.S. expressly Disclaims any liability for incidental or consequential damages.

NOTE: W.E.S. RESERVES THE RIGHT TO CHANGE THES SPECIFICATIONS WITHOUT NOTICE.

- For further information or technical assistance contact Wyoming Equipment Sales at (570) 693-2810.*

Product Information

Silicone Sealants

DOW CORNING

Dow Corning® 888 Silicone Joint Sealant

FEATURES

- Easy to use
- All-temperature gunnability
- Unprimed adhesion
- Seals irregular surfaces
- High movement capability
- Low modulus
- Fully elastic
- Resilient
- Good weatherability
- Fast cure – typically tack-free surface in one hour or less
- Long-life reliability

COMPOSITION

- One-part, cold-applied silicone that cures to a durable, flexible, low-modulus silicone rubber joint seal

Low-modulus silicone sealant for new and remedial joint sealing applications in Portland cement concrete

APPLICATIONS

- Sealing transverse contraction and expansion joints, longitudinal, center line and shoulder joints in Portland cement concrete (PCC)

TYPICAL PROPERTIES

Specification Writers: Please contact your local Dow Corning sales office or your Global Dow Corning Connection before writing specifications on this product.

Test	Unit	Result
As Supplied		
Color		Gray
Flow, Sag or Slump		Nil
Extrusion Rate	grams per minute	90-250
Specific Gravity		1.450-1.515
Skin-Over Time, at 25°C (77°F)	minutes	10
Tack-Free Time, at 25°C (77°F)	minutes	60
Cure Time, at 25°C (77°F)	days	7-14
Full Adhesion	days	14-21
As Cured – after 7 days at 25°C (77°F) and 50 percent RH		
Elongation, minimum	percent	1200
Modulus, at 150 percent elongation, maximum	psi (kPa)	45 (310)
Durometer Hardness, Shore A	points	15-25
Joint Movement Capability, +100/-50 percent, 10 cycles		No failure
Adhesion to Concrete, minimum elongation	percent	+500

DESCRIPTION

Dow Corning® 888 Silicone Joint Sealant can be used as the original sealant in new concrete construction or as a remedial or repair sealant in old construction. In new construction, it provides the extra insurance needed if all the "shrink" or contraction cracks do not occur during the initial "weakening" step. Thus, two or three concrete lengths act in unison, stressing a sealant two or three times the design dimensions or movement.

Because of its low-modulus characteristics and good extension/compression recovery (+100/-50 percent of original joint width), *Dow Corning* 888 Silicone Joint Sealant gives outstanding performance in highway, airport and bridge joints in which high movement occurs.

Highway concrete contraction/expansion joints are generally sealed to prevent erosion of pavement sub-base and/or corrosion of metal tie bars embedded in the concrete. Such corrosion results from water and deicing chemicals entering the joints at the pavement surface.

Sealing of highway joints also prevents spalling and breakage of concrete along the slab edge, which occurs when noncompressibles (dirt, stones and/or ice) are forced into or form in the joint.

For use in repair or remedial applications where other joint sealing materials have failed because of excessive movement or poor weatherability, *Dow Corning* 888 Silicone Joint Sealant can be used to seal irregularly shaped and/or spalled joints. Thus, the joints do not need reforming before sealing. These joints should be dry and free of all old sealing compounds.

Benefits

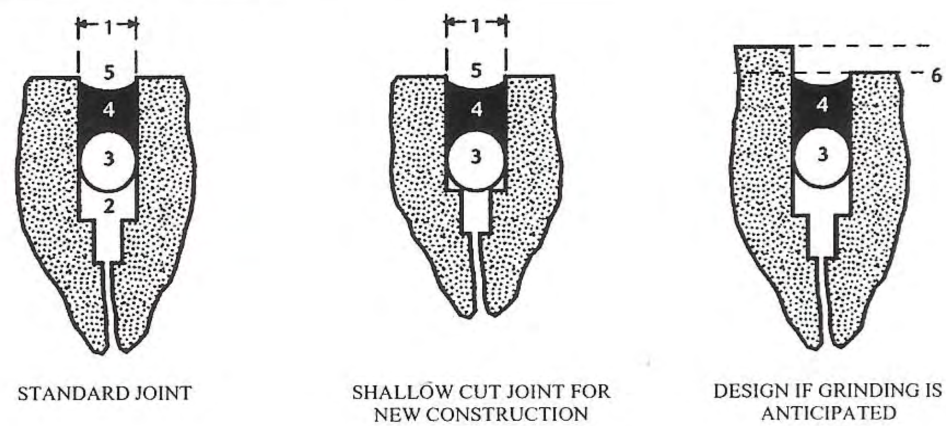
- Easy to use – one-component, cold-applied, ready-to-use as supplied; no mixing required; dispensed directly from bulk container into joint by hand or with an air-powered pump.
- All-temperature gunnability – consistency is relatively unchanged over normal installation temperature range.
- Unprimed adhesion – primer is not required for bonding to PCC. For optimum adhesion, the surface must be clean, dry and frost-free.
- Seals irregular surfaces – can be used to seal joints where spalls have occurred, provided adequate contact is made between sealant and substrate.
- High movement capability – the sealant will perform in a continuous joint movement of +100/-50 percent. In new construction, it will take the 25 percent movement of each of two or three slab lengths working in unison before all the "shrink" or contraction cracks occur.
- Low modulus – the sealant stretches 100 percent in the joint with very little force. This places very little strain on the bond line or joint wall, which maximizes the probability of a successful seal with continuous joint movement. Joint movement caused by temperature, traffic and faulting requires a sealant that does not strongly resist stress and/or shear.
- Fully elastic – the sealant can be stretched to 100 percent or compressed to 50 percent of the joint bond width and held there. When released, it will recover 95 percent or greater of the original dimension. The extension and/or compression can be repeated many times and the sealant will resume its original shape without splits or cracks. Thus, when properly installed in a highway contraction joint, it does not "pump" out of the joint during compression. Nor does it split, crack or lose adhesion during extension.
- Resilient – once cured, the sealant prevents stones and other noncompressibles from entering the joint by "squeezing" them out as soon as the force pushing these noncompressibles into the sealant is removed.
- Good weatherability – its 100 percent silicone rubber is virtually unaffected by sunlight, rain, snow, ozone or temperature extremes.
- Fast cure – typically, the sealant will have a tack-free surface in one hour or less. With this fast cure and recessed joint design, the road can be opened soon after sealing in most applications.
- Long-life reliability – under normal conditions, cured sealant stays rubbery from -45 to 149°C (-49 to 300°F) without tearing, cracking or becoming brittle.

Applicable Standards

Meets and/or exceeds ASTM D 5893-96 "Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements," Type NS (Non-Sag). In addition, the Federal Aviation Administration has published the "FAA Engineering Brief 36 – Silicone Joint Sealants." This publication approves the use of these materials in airfield situations.

Meets and exceeds both Federal Specifications TT-S-001543A Class A (one-part silicone sealants) and TT-S-00230C Class A (one-component sealants) that were written for construction sealants requiring extremely high movement capability. Also meets Canadian Specification 19GP9 Type I and approximately 41 Department of Transportation (DOT)

Figure 1: Good Joint Design



1. Joint width wide enough to accommodate movement. (For additional information on joint width, see papers by Spells and Klosowski, "Silicone Sealants for Use in Concrete Construction," Vol. 1, No. 1, *American Concrete Institute*, SP-70, 1981; J.B. Cook, "Construction Sealants and Adhesives," Wiley-Interscience, 1970; and J.M. Klosowski, "Sealants in Construction," Marcel Dekker, 1989.)
2. Joint sawed deep enough to allow backer rod/sealant placement and space for pumping of old sealant compounds. NOTE: This applies to standard joints only; void space beneath backer rod in new construction is not needed.
3. Proper backer rod placement to prevent three-sided adhesion.
4. Sealant installed to proper depth and width.
5. Sealant tooled 1/4 to 1/2 inch (6 to 13 mm) below pavement surface.
6. Depth of lowest slab determines the amount of recess required if grinding is anticipated; once grinding is complete, the sealant will have proper recess below the pavement surface.

Table I: Recommended Backer Rod Installation (Shallow Cut)[1]

Measured in Inches						
Joint Width	1/4"	3/8"	1/2"	3/4"	1"	2"
Recessed Below Surface	3/8"	3/8"	3/8"	3/8"	3/8-1/2"	3/8-1/2"
Sealant Thickness	1/4"	1/4"	1/4"	3/8"	1/2"	1/2"
Backer Rod Diameter	3/8"	1/2"	5/8"	7/8"	$1^1/_4$"	$2^1/_2$"
Total Joint Depth	$1\text{-}1^1/_8$"	$1^1/_8\text{-}1^1/_4$"	$1^1/_4\text{-}1^3/_8$"	$1^5/_8\text{-}1^3/_4$"	$2^1/_4\text{-}2^3/_8$"	$2^1/_2\text{-}2^5/_8$"
Measured in Millimeters						
Joint Width	6 mm	9 mm	13 mm	19 mm	25 mm	51 mm
Recessed Below Surface	9 mm	9 mm	9 mm	9 mm	9-13 mm	9-13 mm
Sealant Thickness	6 mm	6 mm	6 mm	9 mm	13 mm	13 mm
Backer Rod Diameter	9 mm	13 mm	16 mm	22 mm	32 mm	64 mm
Total Joint Depth	25-29 mm	29-32 mm	32-35 mm	41-44 mm	57-60 mm	64-67 mm

[1]On road surfaces where grinding is planned at a later date, the sealant and backer rod should be installed so that sealant is approximately 3/8 inch (9 mm) below the road surface after grinding is complete. An additional small amount should be added to allow for surface imperfections on the bottom and to provide room for old sealant to pump up from below during rehabilitation work in the summer months.

specifications that require a low-modulus sealant with high movement capability.

HOW TO USE

Please refer to the *Pocket Installation Guide* for additional information on applications, preparation and installation information.

Low-modulus *Dow Corning* 888 Silicone Joint Sealant easily withstands extreme joint movement when properly applied. The sealant will withstand 100 percent extension and 50 percent compression of the original joint width. However, the recommended joint movement design is for ±25 percent (50 percent total) and not at the sealant limits. This difference ensures a successful seal when job site joint widths are different than designed widths. Therefore, the joint design dimensions should be less than the ultimate sealant capability.

A thin bead of silicone sealant will accommodate more movement than a thick bead. *Dow Corning* 888 Silicone Joint Sealant should be no thicker than 1/2 inch (13 mm) and no thinner than 1/4 inch (6 mm). Within these limits, the sealant width-to-depth ratio should be 2:1.

In all cases, the sealant must be recessed below the pavement surface at least 3/8 inch (9 mm) with 1/2 inch (13 mm) recess being acceptable in wider joints (see Table I). Consideration should also be given to other possible road-working operations, such as diamond-grinding of the surface. Activities of this type would require the sealant bead to be recessed even deeper.

Dow Corning 888 Silicone Joint Sealant is a nonsag sealant. This allows its use in vertical curb joints as well as horizontal joints.

Being a non-leveling sealant, *Dow Corning* 888 Silicone Joint Sealant must be "tooled" to ensure good contact and adhesion as well as to control sealant depth and provide a recessed surface. Several devices can be used for tooling. Among the simplest and easiest to obtain is the expanded closed-cell polyethylene foam backer rod, which must be larger than the joint width.

In new construction where the joint is a new cut, a shallow cut is recommended where the backer rod is placed on the "shelf" or bottom of the joint (see Figure 1). Recommended depths are shown in Table I. This design provides a firm support for sealant tooling, making the sealant easier to install, and further ensures good sealant/concrete contact. A shallow cut design also saves saw blades and time.

In repair work where previous sealing materials have been of a joint filling type rather than a joint sealing type, or where the joint is not broadened by sawing, a standard joint design is recommended in which the backer rod is slightly above the shelf. Extra space (1/4 to 1/2 inch [6 to 13 mm]) between the bottom of the backer rod and shelf should be provided to allow for possible "pumping" of old joint filling material from the bottom of the joint. It is recommended that care be given to selection of proper oversized backer, so that a firm tooling support is obtained (generally 1/4 inch [6 mm] larger than the joint works quite well).

Dow Corning 888 Silicone Joint Sealant is part of a system that must include the proper backer rod and proper installation procedures. The backer rod must be expanded closed-cell polyethylene foam. Where irregularly shaped joints exist, backer rod that is open-cell with an impervious skin is recommended to ensure a tight fit. Several other back-up materials (paper, fibrous ropes and open cell foam) are available, but have proven to be unacceptable. There are several manufacturers of closed-cell polyethylene foam and any may be used.

Please refer to the *Pocket Installation Guide* for more information on applications, preparation and installation information.

HANDLING PRECAUTIONS

PRODUCT SAFETY INFORMATION REQUIRED FOR SAFE USE IS NOT INCLUDED IN THIS DOCUMENT. BEFORE HANDLING, READ PRODUCT AND MATERIAL SAFETY DATA SHEETS AND CONTAINER LABELS FOR SAFE USE, PHYSICAL AND HEALTH HAZARD INFORMATION. THE MATERIAL SAFETY DATA SHEET IS AVAILABLE ON THE DOW CORNING WEBSITE AT WWW.DOWCORNING.COM, OR FROM YOUR DOW CORNING REPRESENTATIVE, OR DISTRIBUTOR, OR BY CALLING YOUR GLOBAL DOW CORNING CONNECTION.

USABLE LIFE AND STORAGE

When stored in original, unopened containers between 0°C (32°F) and 32°C (90°F), *Dow Corning* 888 Silicone Joint Sealant has a shelf life of 12 months from date of manufacture. Keep containers tightly closed. Refer to product packaging for "Use By Date."

PACKAGING

Dow Corning 888 Silicone Joint Sealant is supplied in 29-fl oz (857-mL) disposable cartridges, 4.5-gal (17-L) bulk pails, and 50-gal (189-L) bulk drums.

LIMITATIONS

Dow Corning 888 Silicone Joint Sealant is not recommended for conditions where continuous water/moisture exposure is expected. It should not be applied in totally confined spaces where the sealant is not exposed to atmospheric moisture. The sealant should never be applied to wet or damp concrete or installed during inclement weather. New concrete should be allowed to cure and dry for at least 7 days of good drying weather. For each day of rain that occurs during that period, an additional day should be added to the 7-day drying time. For "Fastrack" or high early concrete mixes, please contact your Dow Corning Technical Service Representative.

The sealant bead should be recessed below the pavement surface to prevent abrasion from traffic and snow removal equipment.

The adhesion to substrates other than PCC should be checked before performing full-scale sealing. Contact your Dow Corning Technical Service Representative.

This product is neither tested nor represented as suitable for medical or pharmaceutical uses.

HEALTH AND ENVIRONMENTAL INFORMATION

To support customers in their product safety needs, Dow Corning has an extensive Product Stewardship organization and a team of Product Safety and Regulatory Compliance (PS&RC) specialists available in each area.

For further information, please see our website, www.dowcorning.com, or consult your local Dow Corning representative.

LIMITED WARRANTY INFORMATION – PLEASE READ CAREFULLY

The information contained herein is offered in good faith and is believed to be accurate. However, because conditions and methods of use of our products are beyond our control, this information should not be used in substitution for customer's tests to ensure that Dow Corning's products are safe, effective, and fully satisfactory for the intended end use. Suggestions of use shall not be taken as inducements to infringe any patent.

Dow Corning's sole warranty is that the product will meet the Dow Corning sales specifications in effect at the time of shipment.

Your exclusive remedy for breach of such warranty is limited to refund of purchase price or replacement of any product shown to be other than as warranted.

DOW CORNING SPECIFICALLY DISCLAIMS ANY OTHER EXPRESS OR IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY.

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Appendix E
Inspection Results

	BRIDGE #	LOCATION	JOINT	BLEEDING	CURB SEALANT DETERIORATION	CRACKING	DEBONDING	LEAKING	POLISHED STONE	RAVELING	REFELCTIVE CRACKING	RUTTING	SEGREGATION	SHOVING & PUSHING	SPALLS	COMMENTS
				DISTRESSES												
RHODE ISLAND	661	I-95 OVER THURBERS AVENUE	1	✓			✓			✓		✓	✓			
			2	✓						✓		✓				Shiny surface, fat spots
			3	✓						✓		✓				
	310	ROUTE 107 OVER CLEAR RIVER	1						✓							Very good condition, polished aggregates
	164	SCHOOL STREET OVER BLACKSTONE RIVER	1			✓	✓					✓		✓		
			2			✓	✓							✓		

	BRIDGE #	LOCATION	JOINT	BLEEDING	CURB SEALANT DETERIORATION	CRACKING	DEBONDING	LEAKING	POLISHED STONE	RAVELING	REFELCTIVE CRACKING	RUTTING	SEGREGATION	SHOVING & PUSHING	SPALLS	COMMENTS
				DISTRESSES												
MASSACHUSETTS	W30025	I-195 WEST OVER SANFORD ROAD	1				✓			✓					✓	
			2		✓		✓									
	W30025	I-195 EASTOVER SANFORD ROAD	1				✓			✓		✓				
			2				✓			✓		✓				
	N06013	ROUTE 140 NORTH OVER BRALEY ROAD	1		✓	✓										Repairs to local locations within joint
			2		✓	✓										
	N06013	ROUTE 140 SOUTHOVER BRALEY ROAD	1				✓					✓				Heaving in shoulder. Spall in roadway.
			2			✓		✓		✓						Compression of material in shoulder. Previous repairs.
	M09009	ROUTE 28 OVER I-195	1				✓					✓		✓		Rutting severe in left hand turn lane.
			2				✓									
	W06053	NORTH STREET OVER I-195	1				✓	✓								Debond in severe along entire joint length.
			2		✓		✓	✓								Debond in severe along entire joint length.

	BRIDGE #	LOCATION	JOINT	BLEEDING	CURB SEALANT DETERIORATION	CRACKING	DEBONDING	LEAKING	POLISHED STONE	RAVELING	REFELCTIVE CRACKING	RUTTING	SEGREGATION	SHOVING & PUSHING	SPALLS	COMMENTS
				DISTRESSES												
CONNETICUT	03163	RTE.160 OVER I-91 SB	1				✓						✓			Segregation one lane only
			2										✓			Segregation both lanes
			3				✓					✓				Some pop outs (isolated)
			4										✓			Segregation, some pop outs (spreadout)
	03164	RTE.160 OVER I-91 NB	1		✓		✓									Failure at curb, some pop outs
			2										✓			Segregation, some pop outs
			3				✓						✓			Segregation
			4									✓				
	03507	RTE.9 NB OVER PRIVATE ROAD	1			✓				✓		✓		✓		Some pop outs, fractured aggregates (sand stone?),
			2			✓				✓		✓		✓		Some bridge movement
			3													Movement less than joint 2
			4			✓				✓		✓		✓		Some bridge movement
			5			✓				✓		✓		✓		Missed Joint?
	03913	RTE. 71 OVER RTE. 72	1	✓			✓									Material flowing out
	03313	I-84 TR 815 OVER I-84,RTE. 72,372,AND B&M RR	1			✓	✓									Some pop outs, missed joint while installing?
			2			✓	✓									Aggegrates crushed/fractured
			3				✓						✓			Some pop outs, segregation
			4				✓						✓			Segregation
			5													
			6				✓									Aggregate breaking up, some snow plow damage
			7				✓						✓			Segregation
			8													
			9													
			10													Minor snow plow damage, pop outs, exposed
	3399A	I-84 W ONRAMP SISSON AVE.					✓			✓		✓				Aggregates broken & stripped of asphalt,

	BRIDGE #	LOCATION	JOINT	BLEEDING	CURB SEALANT DETERIORATION	CRACKING	DEBONDING	LEAKING	POLISHED STONE	RAVELING	REFELCTIVE CRACKING	RUTTING	SEGREGATION	SHOVING & PUSHING	SPALLS	COMMENTS
				DISTRESSES												
NEW HAMPSHIRE	102/120	OLD ROUTE 16 OVER BRANCH RIVER	1		✓		✓	✓								
	123/173	NH ROUTE 27 OVER NH ROUTE 101	1 SOUTH			✓	✓	✓		✓						
			2 NORTH			✓	✓			✓		✓		✓		Snow Plow Damage
	127/110	BRIDGE STREET OVER COCHECO RIVER	1			✓	✓			✓						
	088/126	US ROUTE 4 OVER SUNCOOK RIVER OVERFLOW	1			✓	✓			✓						
	109/037	NH ROUTE 101 EASTBOUND OVER NH ROUTE 125	1		✓		✓			✓		✓		✓		
	109/038	NH ROUTE 101 WESTBOUND OVER NH ROUTE 125	1					✓		✓		✓		✓		

	BRIDGE #	LOCATION	JOINT	BLEEDING	CURB SEALANT DETERIORATION	CRACKING	DEBONDING	LEAKING	POLISHED STONE	RAVELING	REFELCTIVE CRACKING	RUTTING	SEGREGATION	SHOVING & PUSHING	SPALLS	COMMENTS
				DISTRESSES												
VERMONT	1 N	I-93 OVER VT 18	1			✓	✓			✓						
	1 S	I-93 OVER VT 18	1			✓	✓			✓						
	3 N	I-93 OVER TH NO 12	1			✓	✓									
	3 S	I-93 OVER TH NO 12	1			✓	✓									
	5 N	I-93 OVER TH NO 7	1			✓						✓				
			2			✓	✓			✓		✓				Loose particles
	5 S	I-93 OVER TH NO 7	1			✓	✓			✓						
			2				✓									
	144	US 5/PASSUMPSIC RIVER	1													
			2			✓				✓						Patching
			3			✓									✓	Patching
			4							✓						Hump at shoulder
	1	VT 114/PASSUMPSIC RIVER	1N				✓									
			1S			✓	✓									

Appendix F
Bridge Data

RHODE ISLAND	BRIDGE #	LOCATION	BRIDGE TYPE	BRIDGE LENGTH	BRIDGE WIDTH	SPAN(S)	SKEW ANGLE	JOINT WIDTH	JOINT DEPTH	CURB/SIDEWALK	DESIGNED FOR APJ	COMMENTS
	661	I-95 OVER THURBERS AVENUE	STEEL BEAM									
	310	ROUTE 107 OVER CLEAR RIVER	PRESTRESSED CONCRETE BOX GIRDER		32' + Sidewalk	51'	48.5°	20"	N/A		YES (1994)	
	164	SCHOOL STREET OVER BLACKSTONE RIVER	STEEL BEAM			97' 97'	0°				N/A	

MASSACHUSETTS	BRIDGE #	LOCATION	BRIDGE TYPE	BRIDGE LENGTH	BRIDGE WIDTH	SPAN(S)	SKEW ANGLE	JOINT WIDTH	JOINT DEPTH	CURB/SIDEWALK	DESIGNED FOR APJ	COMMENTS
	W30025	I-195 WEST OVER SANFORD ROAD		125'	56.2'	56'	16°				NO	
	W30025	I-195 EASTOVER SANFORD ROAD		125'	56.2'	56'	16°				NO	
	N06013	ROUTE 140 NORTH OVER BRALEY ROAD		139'	49'	62'	28°				NO	
	N06013	ROUTE 140 SOUTHOVER BRALEY ROAD		138'	42.7'	61'	28°				NO	
	M09009	ROUTE 28 OVER I-195		217'	37.3'	106'	5°				NO - NEOPRENE COMPRESSION SEAL	
	W06053	NORTH STREET OVER I-195		225'	97.7'	110.3'	17°				NO - NEOPRENE COMPRESSION SEAL	

CONNECTICUT	BRIDGE #	LOCATION	BRIDGE TYPE	BRIDGE LENGTH	BRIDGE WIDTH	SPAN(S)	SKEW ANGLE	JOINT WIDTH	JOINT DEPTH	CURB/SIDEWALK	DESIGNED FOR APJ	COMMENTS
	03163	ROUTE 160 OVER I-91 SOUTHBOUND	WELDED PLATE GIRDER	193		3 SPANS MAX SPAN OF 109	0°					
	03164	ROUTE 160 OVER I-91 NORTHBOUND	WELDED PLATE GIRDER	261		3 SPANS MAX SPAN OF 105	0°					
	03507	ROUTE 9 NORTHBOUND OVER PRIVATE ROAD		500		4 SPANS MAX SPAN OF 127	0°					
	03913	ROUTE 71 OVER ROUTE 72		343		2 SPANS MAX SPAN OF 170	24°					
	03313	I-84 TR 815 OVER I-84,ROUTE 72,372,AND B&M RR		928		9 SPANS MAX SPAN OF 111	0°					

NEW HAMPSHIRE	BRIDGE #	LOCATION	BRIDGE TYPE	BRIDGE LENGTH	BRIDGE WIDTH	SPAN(S)	SKEW ANGLE	JOINT WIDTH	JOINT DEPTH	CURB/SIDEWALK	DESIGNED FOR APJ	COMMENTS
	102/120	OLD ROUTE 16 OVER BRANCH RIVER	I-BEAM	126'	49.8'	63'-63'	0°	N/A	N/A		NO - NEOPRENE COMPRESSION SEAL (1965)	
	212/128	RTE. 125/RR	N/A	N/A	N/A	46'-54'-46'	N/A	N/A	N/A			
	123/173	NH ROUTE 27 OVER NH ROUTE 101	WELDED PLATE GIRDER	234'	63.5'	117'-117'	21°	20"	N/A		YES (1995)	
	127/110	BRIDGE STREET OVER COCHECO RIVER	WELDED PLATE GIRDER	85'	N/A	85'	0°	N/A	N/A		N/A	
	088/126	US ROUTE 4 OVER SUNCOOK RIVER OVERFLOW	PRE-STRESSED CONCRETE GIRDER	97'	57'	97'	0°	20"	1.5"		YES (1995)	
	109/037	NH ROUTE 101 EASTBOUND OVER NH ROUTE 125	WELDED PLATE GIRDER	104'	N/A	104'	10°	20"	N/A		YES (1996)	
	109/038	NH ROUTE 101 WESTBOUND OVER NH ROUTE 125	WELDED PLATE GIRDER	104'	N/A	104'	10°	20"	N/A		YES (1993)	

VERMONT	BRIDGE #	LOCATION	BRIDGE TYPE	BRIDGE LENGTH	BRIDGE WIDTH	SPAN(S)	SKEW ANGLE	JOINT WIDTH	JOINT DEPTH	CURB/SIDEWALK	DESIGNED FOR APJ	COMMENTS
	1 N	I-93 OVER VT 18	STEEL RIGID FRAME	205	40.8	35'-122'-45'	39°					
	1 S	I-93 OVER VT 18	STEEL RIGID FRAME	171	40.8'	22'-112'-33'	39°					
	3 N	I-93 OVER TH NO 12	WELDED PLATE GIRDER	113	40.8'	113'	10°					
	3 S	I-93 OVER TH NO 12	WELDED PLATE GIRDER	113	40.8'	113'	13°					
	5 N	I-93 OVER TH NO 7	WELDED PLATE GIRDER	109	40.8'	109'	48°					
	5 S	I-93 OVER TH NO 7	WELDED PLATE GIRDER	109	40.8'	109'	46°					
	144	US 5/PASSUMPSIC RIVER	STEEL BEAM	147	52.5'	N/A	30°					
	1	VT 114/PASSUMPSIC RIVER	CONTINOUS CURVED GIRDER	178	36.7'	54'-65'	45°					

RHODE ISLAND	BRIDGE #	LOCATION	CITY OR TOWN	ADT/ % TRUCKS	JOINT SYSTEM	JOINT MANUFACTURER	JOINT INSTALLER	JOINT INSTALLED	COMMENTS
	661	I-95 OVER THURBERS AVENUE	PROVIDENCE	74,100/13%	N/A	DS BROWN	SEALCOAT	1998	Condition-some rutting and shoving
	310	ROUTE 107 OVER CLEAR RIVER	BURRILLVILLE	10,200 / 4%	Wabo Expandex	WATSON BOWMAN	SEALCOAT	1996	Condition-good
	164	SCHOOL STREET OVER BLACKSTONE RIVER	LINCOLN/ CUMBERLAND	1200 / 1%	N/A	N/A	SEALCOAT	1995	Condition-rutted/cracked

MASSACHUSETTS	BRIDGE #	LOCATION	CITY OR TOWN	ADT/ % TRUCKS	JOINT SYSTEM	JOINT MANUFACTURER	JOINT INSTALLER	JOINT INSTALLED	COMMENTS
	W30025	I-195 WEST OVER SANFORD ROAD	WESTPORT	N/A	N/A	LINEAR DYNAMICS	LAL CONSTRUCTION CO. INC.	N/A	
	W30025	I-195 EASTOVER SANFORD ROAD	WESTPORT	N/A	N/A	LINEAR DYNAMICS	LAL CONSTRUCTION CO. INC.	N/A	
	N06013	ROUTE 140 NORTH OVER BRALEY ROAD	NEW BEDFORD	N/A	N/A	D.S. BROWN	D.S. BROWN	N/A	
	N06013	ROUTE 140 SOUTHOVER BRALEY ROAD	NEW BEDFORD	N/A	N/A	D.S. BROWN	D.S. BROWN	N/A	
	M09009	ROUTE 28 OVER I-195	WAREHAM	N/A	N/A	LINEAR DYNAMICS	LAL CONSTRUCTION CO. INC.	N/A	
	W06053	NORTH STREET OVER I-195	MATTAPOISETT	N/A	N/A	LINEAR DYNAMICS	LAL CONSTRUCTION CO. INC.	N/A	

CONNECTICUT	BRIDGE #	LOCATION	CITY OR TOWN	ADT/ % TRUCKS	JOINT SYSTEM	JOINT MANUFACTURER	JOINT INSTALLER	JOINT INSTALLED	COMMENTS
	03163	ROUTE 160 OVER I-91 SOUTHBOUND	ROCKY HILL	7,100 / 3%	N/A	LINEAR DYNAMICS	LINEAR DYNAMICS	SUMMER 2001	All joints are in excellent condition
	03164	ROUTE 160 OVER I-91 NORTHBOUND	ROCKY HILL	7,100 / 3%	N/A	LINEAR DYNAMICS	LINEAR DYNAMICS	SUMMER 2001	All joints are in excellent condition
	03507	ROUTE 9 NORTHBOUND OVER PRIVATE ROAD	BERLIN	27,250 / 5%	Polyjoint	A.H. HARRIS	LINEAR DYNAMICS	SUMMER 1998	Poor align.,adh. failures,segregation,cracking
	03913	ROUTE 71 OVER ROUTE 72	NEW BRITAIN	15,800 / 5%	Koch BJS	LINEAR DYNAMICS	LINEAR DYNAMICS	SUMMER 1990	Bridge is sched. for joint replacement summ.2002.Rutting in wheel path.
	03313	I-84 TR 815 OVER I-84,ROUTE 72,372,AND B&M RR	NEW BRITAIN	14,600 / 9%	Polyjoint	A.H. HARRIS	LINEAR DYNAMICS	SUMMER 2001	Adh. failures,splitting, reflective cracking,moisture. Most joints are in good condition.

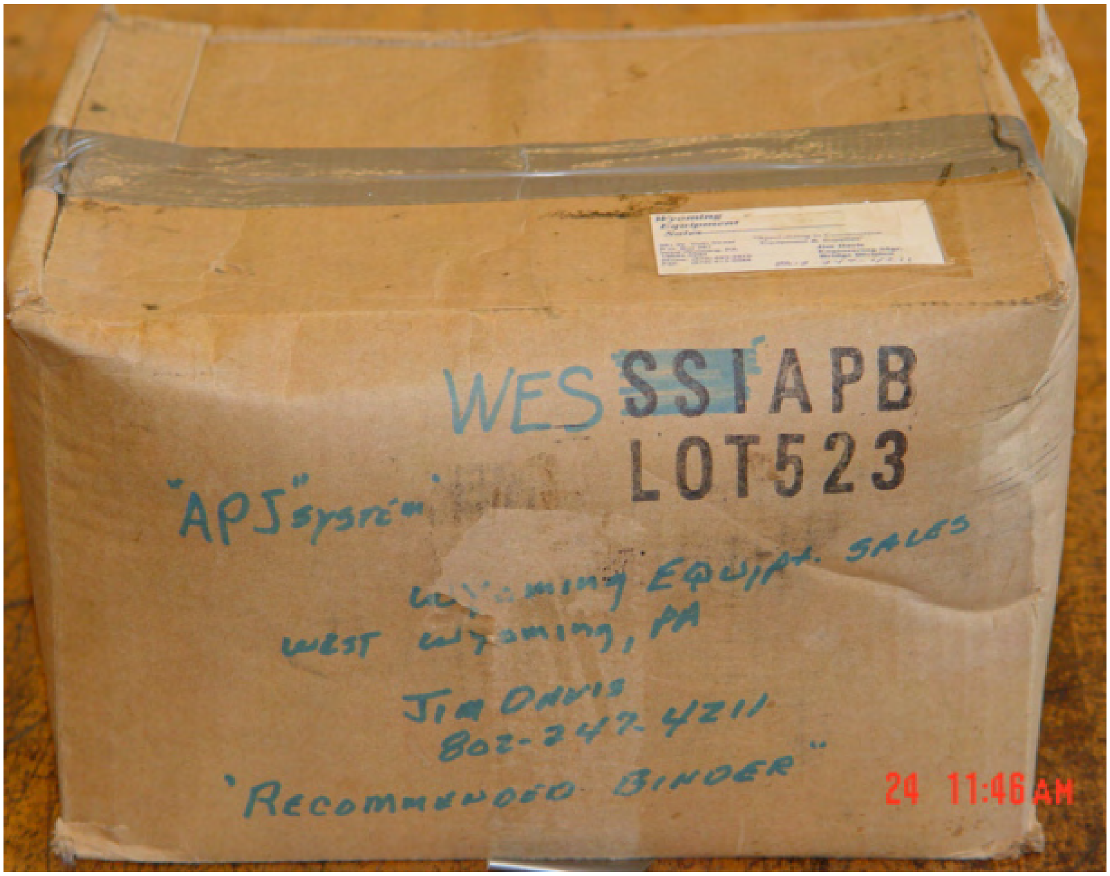
NEW HAMPSHIRE	BRIDGE #	LOCATION	CITY OR TOWN	ADT/ % TRUCKS	JOINT SYSTEM	JOINT MANUFACTURER	JOINT INSTALLER	DATE JOINT INSTALLED	COMMENTS
	102/120	OLD ROUTE 16 OVER BRANCH RIVER	MILTON	2,000 (1989)/10%	RS-201	CRAFCO	NH BRIDGE MAINTENANCE	SEPT.- 1998	
	212/128	RTE. 125/RR	MILTON	N/A	N/A	DS BROWN	N/A	MAY-1998	
	123/173	NH ROUTE 27 OVER NH ROUTE 101	HAMPTON	8,850 (1993)/2%	N/A	WATSON BOWMAN	A.S. ROSSI CORPORATION	1997	
	127/110	BRIDGE STREET OVER COCHECO RIVER	ROCHESTER	N/A	N/A	WATSON BOWMAN	N/A	SEPT.-1994	
	088/126	US ROUTE 4 OVER SUNCOOK RIVER OVERFLOW	EPSOM	15,680 (1992)/2%	N/A	N/A	N/A	SEPT.-1996	
	109/037	NH ROUTE 101 EASTBOUND OVER NH ROUTE 125	EPPING	N/A	N/A	N/A	N/A	1996	
	109/038	NH ROUTE 101 WESTBOUND OVER NH ROUTE 125	EPPING	N/A	N/A	N/A	N/A	N/A	

VERMONT	BRIDGE #	LOCATION	CITY OR TOWN	ADT/ % TRUCKS	JOINT SYSTEM	JOINT MANUFACTURER	JOINT INSTALLER	JOINT INSTALLED	COMMENTS
	1 N	I-93 OVER VT 18	WATERFORD	3,700 (1998)	BJS	LINEAR DYNAMICS,INC.	NICOM	AUG.-1999	
	1 S	I-93 OVER VT 18	WATERFORD	3,700 (1998)	BJS	LINEAR DYNAMICS,INC.	NICOM	SEPT.-1999	
	3 N	I-93 OVER TH NO 12	WATERFORD	3,700 (1998)	BJS	LINEAR DYNAMICS,INC.	NICOM	AUG.-1999	
	3 S	I-93 OVER TH NO 12	WATERFORD	3,700 (1998)	BJS	LINEAR DYNAMICS,INC.	NICOM	SEPT.-1999	
	5 N	I-93 OVER TH NO 7	WATERFORD	3,700 (1998)	BJS	LINEAR DYNAMICS,INC.	NICOM	AUG.-1999	
	5 S	I-93 OVER TH NO 7	WATERFORD	3,700 (1998)	BJS	LINEAR DYNAMICS,INC.	NICOM	SEPT.-1999	
	144	US 5/PASSUMPSIC RIVER	LYNDON	3,500 (1998)	BJS	LINEAR DYNAMICS,INC.	NICOM	SEPT.-1999	
	1	VT 114/PASSUMPSIC RIVER	LYNDON	3,900 (1998)	BJS	LINEAR DYNAMICS,INC.	NICOM	NOV.-1997	

Appendix G
Material Pictures

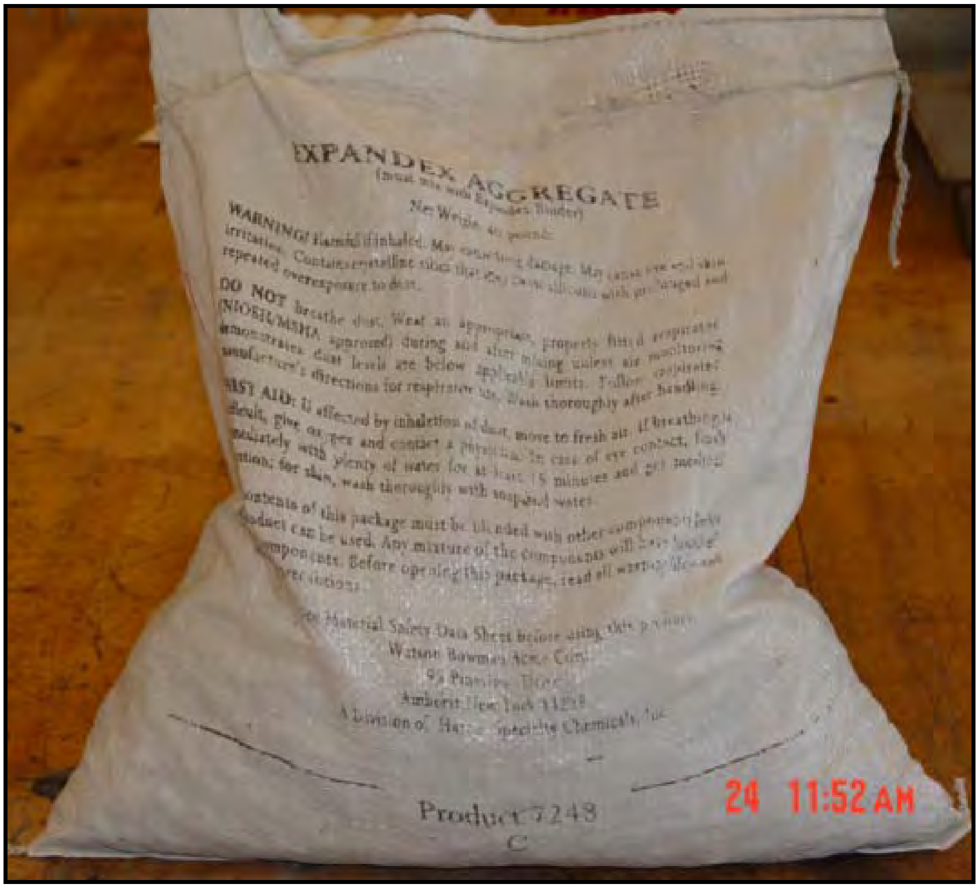
Lafarge Road Markings Virgin Binder: 60lb Box B/N 0753102101 Part No. 89998801

Watson Bowman Acme Virgin Binder: 30lb Box Expandex Modified Elastomeric Lot P1726



Wyoming Equipment Sales Virgin Binder: 30lb Box WES (SSI) APB Lot 523

Watson Bowman Acme Virgin Aggregate: 40lb Bag Expandex "B" Lot N/7247



Watson Bowman Acme Virgin Aggregate: 40lb Bag Expandex “C” Lot N/7248

Wyoming Equipment Sales Virgin Aggregate: 50lb Bag A.P.A. Basalt Stone

<u>NH Bridge 102-120 Cores Milton, NH (Not All Cores Shown)</u>

<u>NH Bridge 109-038 Cores Epping, NH (Not All Cores Shown)</u>

NH Bridge 123-173 Cores Hampton, NH (Not All Cores Shown)

CT APJ Demolition Material (Source and Manufacturer Unknown)

CT Supplied Field Produced Mix (Lafarge Road Markings Product)

Appendix H
Binder and Core Extraction Test Data

ADVANCED ASPHALT TECHNOLOGIES

LABORATORY AND TECHNICAL SERVICES

TEST REPORT

Test Report No.: 07060002
Report Date: 6/21/04 [X] **Original** [ ] **Amended**

Client:	**Project No.:** WO# 706
Prof. Walaa Mogawer, P. E. Civil and Environmental Engineering Department UMass Dartmouth North Dartmouth, MA 02747	**Description:** Sealant Binder and Joint Sealant Core Evaluation
Report Distribution: Dr. Walaa Mogawer	
Sample No.: See Below	**Date Received:** 6/8/04
Sample Description: Three blocks of sealant for PG grade and 10 joint-sealant cores for extraction and gradation.	
Technical Responsibility	**Technical Contact**
Name Don Jack	**Name:** Kevin Knechtel, P.E.
Title: Chief Technician	**Title:** Laboratory Manager
Signature: Donald P. Jack	**Signature:** Kevin J. Knechtel
Date: 6/21/04	**Date:** 6/21/04
Comments: - This a true record of test results obtained by Advanced Asphalt Technologies, LLC in accordance with the test methods and procedures stipulated by AASHTO/ASTM.	

PG Grade and Mixture Analysis of Joint Sealer Binder and Roadway Specimens

ADVANCED ASPHALT TECHNOLOGIES
LABORATORY AND TECHNICAL SERVICES

TEST REPORT

Test Report No.: 07060002
Report Date: 6/21/04

[X] **Original** [ ] **Amended**

Test Results

Test	Method	Test Results PG Grading			AASHTO M320
		AC1296 Lafarge	AC1297 Watson Bowman ACME	AC1298 Wyoming Equipment Sales	
		Original Binder			
Resilience, at 25°C	ASTM D5329	**68%**	**62%**	**18%**	Max., 3.0
Viscosity (Pa·s), at 135°C	ASTM D4402	***3.4**	***30.7**	***6.5**	Max., 3.0
Dynamic Shear, G*/sinδ (kPa), at 88°C 94°C 100°C	AASHTO T315	**1.38** **1.21** **0.88**	**9.57** **7.68** **5.51**	**1.98** **1.35** **0.95**	Min., 1.00
		Rolling Thin Film Oven Residue			
Dynamic Shear, G*/sinδ (kPa), at 88°C 94°C 100°C	AASHTO T315	**2.22** **1.78**	**13.1** **9.68** **6.78**	**3.31** **2.21** **1.54**	Min., 2.20
		Pressure Aging Vessel Residue (100°C)			
Dynamic Shear, G*sinδ (kPa), at 7°C 4°C 1°C	AASHTO T315	**3426** **4641** **6246**	**246** **352** **518**	**2132** **2864** **3829**	Max., 5000
Creep Stiffness and Slope, at -12°C S(MPa) / m-value -18°C S(MPa) / m-value -30°C S(MPa) / m-value	AASHTO T313	**60 / 0.365** **147 / 0.247**	** ** **36 / 0.440**	**65 / 0.383** **93 / 0.285**	Max., 300 / Min., 0.300
Grade	**AASHTO M320**	**PG88-22**	**PG Grade could not be determined**	**PG94-22**	

Note: *All sealants exceed the Viscosity requirement of 3.0Pa-s maximum.
**Binder/Sealant AC1297 could not be properly molded into Beams for Bending Beam Rheometer at –12 & -18C. This Sample exceeds testing range of standard PG Binder equipment.

108 POWERS COURT, SUITE 100
STERLING, VA 20166-9321

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ADVANCED ASPHALT TECHNOLOGIES
LABORATORY AND TECHNICAL SERVICES

TEST REPORT

Test Report No.: 07060002 *Page 3 of 3*
Report Date: 6/21/04 [X] **Original** [ ] **Amended**

Test	***Method***	***Results***									
		NH Bridge No. 123/173				**NH Bridge No. 102/120**			**NH Bridge No. 109/038**		
		FS1072.1 7' 0" from Curb	FS1072.2 3' 2" from Curb	FS1072.3 7' 7" from Curb	FS1072.4 15' 0" from Curb	FS1073.1 6' 2" from Curb	FS1073.2 12' 6" from Curb	FS1073.3 3' 2" from Curb	FS1074.1 5' 8" from Curb	FS1074.2 3' 4" from Curb	FS1074.3 7' 9" from Curb
% Asphalt Cement	AASHTO T164 Method A	18.93	17.15	19.29	17.92	41.24	38.12	47.21	19.87	19.14	17.10
Gradation, % Passing	AASHTO T30 ***Sieve Size***	*	*	*	*	**	**	**	*	*	*
	2"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	1 ½	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	¾	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.3	98.7	94.4
	½	99.6	99.6	100.0	100.0	98.3	99.0	98.3	83.8	82.9	60.5
	3/8	90.5	89.2	89.5	92.0	76.1	76.0	81.7	71.5	70.7	47.2
	No. 4	46.2	44.7	48.1	47.8	26.1	33.8	44.4	26.4	31.4	13.8
	No. 8	14.8	12.2	15.3	13.4	18.1	21.5	31.6	14.9	16.8	10.7
	No. 16	10.1	7.9	10.0	8.2	14.9	16.3	23.6	12.5	13.5	9.7
	No. 30	8.2	6.5	8.1	6.8	13.1	13.2	19.3	11.1	11.8	9.1
	No. 50	6.6	5.7	6.9	6.2	12.3	12.0	17.1	10.1	10.7	8.7
	No. 100	5.9	5.2	6.3	5.8	11.7	11.2	15.	9.5	9.9	8.3
	No. 200	5.4	4.8	5.8	5.5	11.1	10.6	13.0	8.9	9.1	7.7

Note: * Crumb-rubber particles found in all extracted aggregate samples.
** Significant amount of crumb-rubber particles found in all extracted aggregate samples.

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Appendix I
Asphaltic Plug Joint Suitability Checklist

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Asphaltic Plug Joint Suitability Checklist

Umass Dartmouth created this checklist as part of the research work conducted in NETC 99-2 "Evaluation of Asphaltic Expansion Joints" project. It is intended that this document will allow design engineers to accurately determine if an APJ is suitable for their application. This is only a guideline and the capabilities of a particular system should be verified with the manufacturer prior to specifying.

___ Maximum allowable anticipated joint movement is ±1" (±25mm) or 2" (50mm) total. (Note: If using Watson Bowman Acme product allowable movement is ±3/4" (±19mm) or 1-1/2" total.)

___ Minimum joint installation depth is 2" (500mm). This value should be measured from the top of the deck to the top of the pavement overlay at the point of minimum thickness along the joint. An installation depth of 3" to 4" is considered optimum is some states. Joint installation depths of 6" or more should be verified by the manufacturer prior to specifying.

___ Standard joint width is 20". Joint widths greater than 20" should be verified with manufacturer before specifying.

___ APJ are not suitable in locations where there are anticipated vertical displacements at the joint locations.

___ Skew angles up to 25° are acceptable. Skew angles between 25° and 45° are acceptable upon verification of previous field trails where the manufacturer joint system has functioned properly. Skew angles over 45° are not acceptable.

___ Maximum acceptable gradient at the joint location is 4%.

___ Joint should not be installed near intersections or other areas where trucks might brake on top of the joint including along large negative grades.

___ Joint should only be installed in ambient conditions where the temperature is 4.4°C (40°F) and rising. The adjacent road surfaces should be dry prior to installation of the joint.

___ Completed joints may be opened to traffic after a minimum of 1-1/2 hours after completion of the joint system. This time value may increase in warmer weather, as the joint will take longer to cool.

Appendix J
Asphaltic Plug Joint Material Specification

Asphaltic Plug Joint Design Material Specification

Umass Dartmouth, as part of the NETC 99-2 research project entitled *"Evaluation of Asphaltic Expansion Joints"*, has developed the following material specification for asphaltic expansion joints. Many of the items listed here are summarized from ASTM D6297-01 entitled *"Standard Specifications for Asphaltic Plug Joints for Bridges"*. The latest revision of this ASTM specification should be consulted before using this document

This specification addresses the material conformance and acceptance requirements for the constituents of an Asphaltic Plug Joint (APJ) system. Namely this document refers to the binder, aggregate, backer rod, locating pins, and steel plate used in a typical APJ system. This specification does not address all safety issues involved with its use. It is the duty of the user to make sure that he/she is in compliance with all health and safety regulations prior to using this specification.

Manufacturer Required Testing

The binder used for the APJ system shall be tested for all the requirements outlined later in this document. The manufacturer shall test, at a minimum, 1.4kg (3lbs) of binder per every batch. ASTM has defined a one batch as a maximum of 19, 100 kg (21 tons) of binder material.

The aggregate used in the APJ system shall be tested for the requirements noted later herein at a rate of 23kg (51 lbs) per batch size of 20,000kg (22 tons).

Finally the backer rod sample size shall be 300mm (12") per batch size of 305m (1000ft) per ASTM specification and tested for the properties noted later.

Material Submissions

In addition to the manufacturers required testing, the contractor/supplier will be required to submit representative APJ materials for use on the specific project in question one month prior to commencement of work. At this time the data results sheets for the manufacturers test will also be supplied. The design engineer and/or a third party testing lab will, at their discretion, test these materials as outlined in this specification and compare the results for conformance to the manufacturer's data as well as well as any ASTM or AASHTO specifications. On the first day of work, the field or design engineer will be given adequate quantities of material samples to compare with the pre-construction samples. Also the lot, batch or otherwise identifying sample origination number for all materials used for that specific location will be supplied on the first day of work.

At the discretion of the design engineer, the project may be suspended if the proper sample materials submissions and data are not submitted and/or the materials test results show the material does not meet the requirements presented here. Also, the project may be suspended if the materials used during construction are not of the same type as the sample material submission. The project may resume after the materials have been properly evaluated by the engineer/engineer's authorized testing lab or the originally submitted and approved materials are used

Binder Requirements

The requirements for the APJ binder samples are summarized below. Please note some variances between these test procedures and those outlined in the ASTM specification. The test procedure identification numbers were update to omit the use of withdrawn specifications.

Test	**ASTM Test Procedure**	**Test Condition**	**Required Property Value**
Softening Point	D36	N/A	83°C (min.)
Tensile Adhesion	D5329	N/A	700% (min.)
Ductility	D113	@ 25°C (77°F)	400 mm (min.)
Penetration (Non-Immersed)	D5329	@ 25°C (77°F), 150g, 5s	7.5 mm (max.)
Low Temperature Penetration[1]	D5	@ -18°C (0°F), 200g, 60s	1.0 mm (min.)
Flow	D5329	5 h @ 60°C (140°F)	3.0 mm (max.)
Resiliency	D5329	@ 25°C (77°F)	40% (min.) 70% (max.)
Asphalt Compatibility	D5329	N/A	PASS
Flexibility	D5329	@ -23°C (-10°F)	PASS
Bond (Non-Immersed)	D6690	3 Cycles @ -7°C (+20°F) 100% Elongation	PASS
Recommended Installation Temperature	N/A	N/A	182°C -199°C (360°F-390°F)
Safe Heating Temperature	N/A	N/A	199°C - 216°C (390°F - 420°F)

[1]ASTM D6297 requires a modification to the D5 test method for the low temperature penetration test. A penetration cone conforming to ASTM D217 is used instead of a standard penetration needle. The total moving weight of the cone and attachments shall be 150.0±0.1 g. Pour the APJ binder into three (3) 177-mL tins. The tin dimensions shall be 69 mm in diameter by 44 mm deep. Condition the specimens and penetration cones at 18°C for at least 4 hours. Make penetration determination on the 120° radii, halfway between the center and outside. Report results as an average of three results.

In addition, it is highly recommended that each prospective APJ binder be graded in accordance with AASHTO R29 entitled, *"Grading or Verifying the Performance Grade of Asphalt Binder"* and AASHTO M320 entitled, *"Performance-Graded Binder"*. Binders should have a maximum temperature performance grade well above PG64-XX and a minimum temperature performance grade of PG XX-28.

Aggregate Requirements

Aggregate used in the APJ should be Granite, Basalt, or Gabbro. This aggregate should be crushed, double-washed, and dried. These aggregates should be placed by mass into waterproof packaging prior to delivery to the jobsite.

The APJ aggregates blend gradations are proprietary to the manufacturer; hence no specific gradation requirements can be stated. However, each aggregate test sample should be wet washed in accordance with AASHTO T11 and then sieved per AASHTO T27. The values obtained from these tests should be compared with the manufacturers printed data for conformance. Additionally, the material passing the No. 200 sieve after the wet wash should be no more than 0.3% by total weight of the aggregate.

The broadcast stone for anti-tack surface dressing should be Black Beauty or other aggregate acceptable to the design engineer.

Backer Rod Requirements

The backer rod shall be cylindrical closed cell foam (polyethylene) capable of withstanding the safe heating temperature of the binder, 199°C - 216°C (390°F - 420°F). The backer rod diameter shall be 25% to 35% larger than the joint opening. In addition the backer rod shall conform to all requirements for Type 2 backer rod as outlined in ASTM D5249-95 (2000). This specification outlines the following individual requirements:

Test	**ASTM Test Procedure**	**Required Property Value**
Density	D545	32kg/m^3 (2.0 lbs./ft^3) min.
Water Absorption	D545	0.03 g/cc by weight (min.)
Compression, 50%	D545	91.7 kPa (13.3 psi)
Recovery	D545	99.21%
Heat Resistance	D5249	Less than 10% Shrinkage

Gap Plate Requirements

The gap plate shall be mild steel conforming to ASTM A36/A36M or aluminum conforming to ASTM B209. These plates shall conform to the following requirements:

Parameter	Required Property Value
Galvanized	Per AASHTO M111 or M232
Thickness	1/4" (6.5 mm) min.
Width	8” (200 mm) min.
Length	4’ (1.2 m) min.
Locating Pins Pre-drilled Locations	1’ (300 mm) Center-to-Center Along Centerline of Plate

Locating Pins Requirements
Locating pins shall be 16d common nails or larger. These nails shall be hot dipped galvanized per ASTM A153.

Curb Sealant
Curb sealant shall be a non-sag silicone joint sealer (like Dow Corning 888 or approved equal). Sealant must be compatible with asphaltic materials and capable of withstanding the safe heating temperature of the binder in applications where the curb joint is not removed. In applications where a new curb joint will be installed, the bridge joint should be allowed to completely cool before attempting installation of the curb sealant. In addition the backer rod should be compatible with the binder material, as well as the non-sag curb sealant.

Curb Backer Rod
The backer rod for use at the curbs shall meet the requirements stated for the expansion joint backer rod previously outlined in this specification.

Appendix K
Asphaltic Plug Joint Installation Specification

Asphaltic Plug Joint Design Installation Specification

Umass Dartmouth, as part of the NETC 99-2 research project entitled *"Evaluation of Asphaltic Expansion Joints"*, has developed the following installation specification for asphaltic expansion joints. This specification does not address all safety issues involved with its use. It is the duty of the user to make sure that he/she is in compliance with all health and safety regulations prior to using this specification.

General

Any contract documents that contradicts the contents of the specification will supersede this specification.

It is strongly recommend that a representative of the APJ manufacturer and the curb joint sealant manufacturer (where applicable) shall be on-site during the applicable construction processes. These representatives should be on-site to insure that the installation goes according to specification and that any field changes are promptly brought to the field or design engineer's attention.

Construction should not commence during inclement weather or when the ambient temperature dictates. The temperature should be at least 4.4°C (40°F) and rising at the time of installation.

Removal of Existing Joint System or Pavement Overlay

Pilot holes should be drilled along the existing joint or pavement overlay to establish the appropriate cutting depth with minimal impact to the concrete deck. The approximate centerline of the bridge expansion gap should be located and a pair of parallel lines offset 10" (for a 20" wide finished joint) on either side with a chalk line. The exact joint dimensions shall be as described on the contract drawings. The material should be **DRY** saw cut along the two offset chalk lines at the depth established from the pilot holes (Note: **WET** saw cutting is not allowed). This saw cut should not significantly pierce the underlying concrete deck.

The existing material, including waterproofing, down to the concrete deck should then be removed with hand and pneumatic tools. The bridge deck should then be inspected and any defects noted should be brought to the attention of the field or design engineer **PRIOR** to commencement of new joint installation. The degree and methodologies for repair of defective areas will be as decided by the design or field engineer and contractor. Additionally all joint geometry shall be checked against the contract drawings to ensure proper clearances for new joint system.

Finally the existing backer rod shall be removed from the bridge expansion gap. Although not recommended, the existing backer rod may be left in lieu of new backer rod at the discretion of the field or design engineer only.

Removal of Existing Curb Joint

Where specified, continuous vertical curb joints shall be prepared immediately after the bridge joint demolition. Existing sealant and backer rod shall be removed with care taken to avoid damage to the concrete substrates.

Preparation for New Joint

After removal of existing joint system, the trough or block out must be cleaned and prepared to accept the new joint system. The horizontal and vertical surface of the joint block out should be cleaned and dried using a Hot Compressed Air Lance (HCA) capable of producing flame retarded air stream at a temperature of at least 1100°C. The lance's blast orifice shall be capable of producing 1 MPa of pressure (145 psi). In addition the 6" (150 mm) of abutting pavement overlay on both sides of the block out shall be cleaned with the HCA. Any remaining small debris shall be removed with clean compressed air.

The block out sides and base (A.K.A. a table) shall be inspected again for defects and any noted shall be brought to the attention of the field or design engineer. The base shall be **LEVEL** between both sides of the bridge expansion gap. If the base is not approximately level, the field or design engineer shall be consulted prior to any additional construction. The sides of the block out shall be vertical and clean with no loose material after inspection.

Due to contamination possibilities, sandblasting is not recommended as an alternate to using a HCA for asphalt pavement overlays as outlined previously outlined. At the discretion of the engineer and contractor, sandblasting may be used or required for concrete pavement overlays that abut the block out.

Concurrent to the block out cleaning, the curb joint location shall be cleaned of any scale, dirt or debris. Areas where the sealant will be applied need to be thoroughly cleaned of any foreign matter including rust from any steel plates. Sandblasting may be required to clean these areas properly. This process should be completed before cleaning and preparing the bridge joint block out.

Installation of Backer Rod

The new backer rod shall be placed in the bridge expansion gap at a depth no greater than the width of the gap opening. In the vent that the gap is greater than 1" (25 mm), the backer rod shall be placed 1" (25 mm) into the gap. Backer rod shall be placed such that no splice occurs at curb intersections or areas where large geometric changes occur in the deck. Bridge deck backer rod should be placed in a manner to continue into and under the curb areas if possible.

Curb backer rod shall be placed after the bridge joint backer rod. Placement into the curb gap shall be dictated by the standards set by the curb sealant manufacturer or contract documents. In lieu of these standards, at a minimum, the backer rod shall be placed at a uniform depth as necessary to allow for placement and tooling of sealant. Additionally it shall be placed to mimic the existing geometry of the curb or parapet.

Priming of Surfaces
Priming of any surfaces surrounding the block out is not recommended. Priming may be required in curb sealant areas. Care should be taken to avoid introducing these primers into the block out areas that will receive the APJ system.

Heating of Binder
The binder shall be heated to the recommended installation temperature range, generally 370°F - 385°F (188°C - 196°C). The binder should **NEVER** be heated past the safe heating temperature, generally 400°F (204°C). Binder that is overheated shall be discarded and not used for installation. It is the responsibility of the contractor to properly dispose of any overheated binder.

To better ensure that binder will not be overheated, it should be heated in a double jacketed oil melter equipped with a continuous agitation system. Additionally, the melter unit should have built in temperature controls and thermometers that can accurately maintain the binder temperature in the installation temperature range. The thermometers shall be calibrated prior to use and the contractor may be required proof of calibration to the engineer prior to commencement of work. At **NO** time may binder temperatures be checked by the use of infrared handheld thermometers.

Heating of Aggregate
Aggregate should be heated in a rotating drum mixer separate from the binder material. Heating can be done utilizing a HCA or another approved method. The temperature of the aggregate shall not exceed the installation temperature range of the binder 370°F - 385°F (188°C - 196°C) and be monitored with a calibrated handheld infrared digital thermometer. If the aggregate is heated past the acceptable range, the aggregate will be allowed to cool before the introduction of binder. Additionally the aggregate must be heated and mixed until the majority of the dust in the aggregate is dispersed.

Tanking of Joint
Immediately after cleaning the block out, it shall be tanked with the heated APJ binder. The binder shall be in the installation temperature range when placed into the block out. All vertical sides and base (or trough) shall be coated with binder. Additionally, the gap between the top of the expansion joint backer rod and base should be filled with binder as well. Additional tooling may be required to have and even consistent amount of binder on the base and vertical sides.

Placement of Gap Plate
Prior to tanking the joint, the steel or aluminum gap plates should be laid out along the joint length. Plates should firmly abut each other with no overlap in plates or gap space between. Plates shall be laid out in order to maximize the number of full plates and minimize the amount of custom cutting. Any cutting operation shall be performed away from the cleaned joint block out.

Once tanking has occurred, the plates shall be immediately placed centrally over bridge expansion gap into the hot binder. The plates should then be fixed with the locating pins hammered through the pre-drilled holes in the plates into the backer rod below. Once the plates are secure, the entire plate and base of the block out shall again be coated with hot binder.

Preparation of APJ Mixture

The heated aggregate and binder shall be mixed together to ensure a minimum of 68% aggregate by weight. It is recommended that the aggregate and binder be mixed until thoroughly coated in a third vessel as opposed to the aggregate heating drum or binder melter. Heating in this manner will help ensure control over the rate of binder to aggregate and facilitate constant production of mix with little to no downtime between batches.

Placement of APJ Mixture

APJ mixture shall be placed into the block out in lifts. It is recommended that a minimum of three lifts be attempted. Lifts should be no more than 1-1/2" thick and not less than 3/4" thick. Intermediate lifts of equal thickness will continue up to 3/4" to 1/2" below the top of the block out. These lifts shall be first placed and then raked. Hot binder is then applied to the top of each intermediate layer to eliminate the void space.

The top layer commences where the intermediate layers terminate. APJ mixture should be placed in the block out until it overflows 1/4" to 1/2", or enough to compact the joint level with the pavement overlay. This layer is then compacted transversely and longitudinally with a plate or roller compactor capable of delivering a minimum centrifugal force of 15kN. The joint should **NOT** be allowed to cool prior to compaction. As joint depth increases, intermediate compaction may be required.

After compaction, 1" to 2" of the pavement overlay on each side of the joint should be cleaned and dried with the HCA. Care should be taken to avoid heating of the top layer of APJ mixture.

The top layer of APJ mixture and recently cleaned pavement overlay areas are then screed immediately with hot binder to fill **ALL** surface voids. Tape should be placed down on the pavement overlay to create a professional finish.

Finish Dressing of Joint

Immediately after binder application to top layer and adjacent pavement overlay, a broadcast stone should then be applied to the joint surface.

Construction Joints

If construction joints are necessary between APJ mixture placements along one joint (i.e. stage construction), every effort must be made to ensure this is not a vertical joint located in a travel lane or other area which may cause weakness in the final bridge joint. Thus, careful consideration should be taken when deciding the type of this joint and location.

Installation of Curb Sealant

Curb sealant shall be installed at the curb locations after installation of the new APJ system since not all existing sealant may be capable of withstanding the binder installation temperature. A professional trained by the manufacturer shall install the sealant. Additional means of in joint drainage may be considered at the time sealing to alleviate any water intrusion.

Quality Control/ Quality Assurance Procedures

Manufacturer and contractor shall supply all materials and certification forms necessary to verify material compliance for all components of the new joint system.

Manufacturer shall provide written documentation stating that a majority of the members of the contractor (installer) team have been properly trained in APJ installation by their organization.

Contractor shall provide field or design engineer a list of equipment intended for use during the joint construction process.

Contractor shall have copies of all calibration certificates for thermometers on-site should the engineer request them.

Appendix L
Asphaltic Plug Joint Repair Specification

Asphaltic Plug Joint Repair Specification

Umass Dartmouth, as part of the NETC 99-2 research project entitled *"Evaluation of Asphaltic Expansion Joints"*, has developed the following repair specification for asphaltic expansion joints.

Since no firm repair guidelines have ever been written for an APJ, the following matrix of corrective actions and limits is based on rule-of-thumb rather than testing or past experience. Please note that no corrective action involves cutting sections of the joint out and replacing areas within the joint. It is the opinion of the authors that this type of correction could be performed as a temporary fix only.

Distress	Corrective Action
Bleeding	1. Minor bleeding should be monitored. 2. Major bleeding should be corrected by replacing the joint.
Cracking/Reflective Cracking	1. Minor cracking can be corrected by sealing temporarily with binder material. 2. Severe cracking should be corrected by replacing the joint.
Curb Leakage	Existing curb sealant and backer rod should be removed and substrates re-cleaned. New backer rod sealant should be installed by a trained professional.
Debonding	1. Minor debonding (i.e. small width of opening, small length) can be corrected by sealing temporarily with binder material. 2. Severe debonding (i.e. large width opening and long length) can be corrected by replacing the joint in its entirety.
Leakage	Leakage onto any critical bridge components should be corrected by replacing the entire joint.
Polished Stone	Polished stone should be monitored and corrected by sealing with binder material when necessary.
Raveling	Raveling should be monitored and corrected by sealing with binder material when necessary.
Rutting	1. Minor rutting not significantly affecting ride quality should be monitored until a severe condition exists. 2. Severe rutting should be corrected by replacing the joint.
Segregation	1. Segregated areas at the time of installation should be immediately removed and replaced. 2. Segregated areas discovered post-installation should be monitored and have the joint replaced if necessary.
Shoving/Pushing	1. Minor shoving/pushing not significantly affecting ride quality should be monitored until a severe condition exists. 2. Severe shoving/pushing should be corrected by replacing the joint.
Spalls	Spalls may be corrected by filling with APJ material.