NDOT Research Report

Report No. 114-08-803

Evaluation of Asphalt Bridge Deck Joint Systems

December 2009

Nevada Department of Transportation
1263 South Stewart Street
Carson City, NV 89712

Disclaimer

Evaluation of Asphalt Bridge Deck Joint Systems

A Research Report for Grant No. P114-08-803 submitted to

Nevada Department of Transportation
Research Division
Attn: Mr. Ken Chambers
1263 S. Stewart Street
Carson City, NV 89712

By

Nader Ghafoori, Ph.D., P.E.
Professor and Principal Investigator

University of Nevada, Las Vegas
Department of Civil and Environmental Engineering
4505 Maryland Parkway
Mail Stop 4015
Las Vegas, NV 89154-4015
Tel: (702) 895-2531
Fax: (702) 895-3936
nader.ghafoori@unlv.edu

December 2009

ABSTRACT

Asphaltic Plug Joint is an expansion joint that is used for new and rehabilitated bridges. It provides a smooth and watertight surface free of debris; and offers simple, easy and staged construction. Asphaltic plug joint can be repaired segmentally and it is cheaper than most other expansion joint types.

The durability and performance of asphaltic plug joints depend greatly on the temperature variations. In high temperatures APJs are susceptible to rutting, heaving, and delamination. In low temperatures, asphaltic plug joint area may develop spalling, pot holes, debonding and exposure of metal plate.

Recently, over 25% of NDOT District III bridges have experimented failure of their newly constructed asphaltic plug joints. This premature failure has been observed to be predominantly in bridges having high movement decks (over 2 inches). While designed for 5 to 8 years of service, those deck joints need significant maintenance within six months of service.

In an attempt to address the problems encountered with the NDOT bridge deck asphaltic plug joints, this investigation intended to:

1 assess the condition and the extent of the problems associated with the asphaltic plug joints placed in the three NDOT districts;

2 compile available published and unpublished information, and to conduct a national survey to all departments of transportation; and

3 analyze the compiled relevant information and data, and to offer recommendations regarding quantifiable design parameters which can be used for proper construction of asphaltic plug joints.

Properly selected materials, sound designs, viable construction methods, and maintenance strategies can lead to attaining improved bridge deck systems that can meet a set of performance criteria, as well as result in cost saving. The information presented in this report should assist NDOT in dealing with premature failure of asphaltic plug joints.

SECTION		**PAGE**

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Introduction

The bridges are structures in permanent motion. The factors affecting the movement are traffic and seismic loads, wind, different type of impacts on the superstructure and expansion and contraction due to temperature variations. All these factors induce stresses into the bridge deck and through bearings to piers and abutments. The joints are designed to accommodate these movements.

Over the lifetime of a bridge the deck joints can be a source of many problems. During its service, without a proper design, installation and maintenance, the joints can deteriorate by leaking water and deicing chemicals towards the structural elements beneath the deck, by losing their bond with the pavement and causing material distresses in the traffic lanes. The overall performance of the bridge can be drastically reduced and the repairing costs could be high. Therefore, to ensure the performance of the bridge superstructure the joints should provide a smooth ride, a waterproof surface, durable and stable at temperature cyclic variations.

1.2 Classification

The general classification for accommodating a big range of movements can be summarized below.

- Small movements with maximum 45 mm (1.8 in)
- Medium movements between 45 mm – 130 mm (1.8 in – 5 in)

- Large movements with minimum 130 mm (5 in)

For each type of movement there were designed and developed different types of deck joints. Some of the joints can span between small, medium and large movements. Following is a description of each type of joint and its advantages and disadvantages.

In the category of small movement joints the most used ones are the sliding plate joints, poured seals, compression seals, butt joints and asphalt plug joints (APJ).

· Sliding Plate Joints

The sliding plate joints consist of a sliding steel plate, a steel angle and an anchorage (typical) and an anchor bolt (also typical). The top steel plate slides (hence the name) on the two steel angle plates underneath, placed at each side of the joint. The anchor bolt and the anchorage prevent the plates from geometric deformation, being embedded into the concrete slab (Malla et al, 2003). It does not prevent water or deicing chemicals to enter into the joint but it does prevent debris to pass through the opening. Because they are not waterproof, the plates corrode and bond to each other, losing the ability to accommodate the movements they were designed to.

Their advantages consist in their simplicity, reasonable cost and satisfactorily performance. The installation of troughs underneath the joint, to carry away the water, was proven beneficial and prolonged their life service. They can also be used to accommodate medium movements of up to 100 mm (4 in).

The main disadvantage is the water intrusion that leads to corrosion and structural damage. If they are installed improperly or are not perfectly aligned they can warp or bend and under heavy traffic it can become a traffic hazard. Also, the plates have to be adjusted periodically because they loosen up and the noise level it might be disturbing.

- Poured Seals

The poured seal joints consist of a backer rod (which is a polyethylene foam) pushed into the bottom of the joint to prevent any debris from entering, a polymer concrete header placed on each side of the opening and a poured in place silicone sealant. Most of the sealants used have a high performance level in terms of elasticity, temperature range and resistance to ozone and UV rays. Their advantage is their ability to have a good performance response to the temperature variations. They are easy to use in new and rehabilitation projects. They have a relatively short maintenance time frame, they should be replaced every eight years or so making them good candidates for rehabilitated bridge projects. They can accommodate movements of up to 75 mm (3 in) and can be used in joints where the surfaces are not perfectly plane or vertical. Disadvantages include sensitivity to field condition installation; the placing should be made at the midpoint of the historical ambient temperature range. If the deck edge is damaged then the joint is damaged leading to debonding with the underneath layers and thus permitting the water to leak into the opening.

- Compression Seals

Compression seals consist of an elastomeric seal made of polychloroprene or neoprene and a filling of polyurethane with 75% solids to minimize the intrusion of water and debris. It can also be used with steel armoring to reinforce the walls of the joint. They are designed to function in a compressive state to ensure the waterproofing and to stay in place by using the friction forces developed between the seal and the joint walls. They can accommodate movements of up to 100 mm (4 in). The advantages are their cost effectiveness, easy replacement and water proofing. One of the disadvantage is that they can be damaged by snowplow, and the accumulation of debris upon the top of the joint may deteriorate it and allow water to penetrate into the layers underneath the joint. If the joint is used with steel armoring then it should be repainted periodically or coated with epoxy to prevent corrosion.

- Butt Joints

Butt joints are used when only a small rotation or movement need to be accommodated of maximum 25 mm (1 in)., because it does not provide at all a transition between the bridge deck and abutments. The joint can have armoring or not. If armoring is provided its purpose it to protect the deck edges and it is embedded into the concrete deck through bolts and bars (Purvis et al, 1989). Due to the fact that it is an open joint, which water and debris can pass through, it is very prone to deterioration. The armoring can be corroded and dislocated creating a traffic hazard, and when is completely missing the pavement experiments ravelling and spalling.

- Asphalt Plug Joint (APJ)

The APJ is used for movements of maximum 50 mm (2 in). It consists of a polymer modified asphalt (PMA) with open-graded aggregates poured into a saw-cut “box” typically of 20 in wide and 2 in deep. Before placing the PMA a backer rod is installed at the bottom of the joint and the space is filled with closed cell polyethylene foam for waterproofing. A steel plate of typically 8 in. wide is centered over the joint to prevent the binder to flow into the opening. The binders used for the joint are usually bitumen-modified with plasticizers to obtain the desired flexibility. Their advantages are numerous. They provide a smooth and watertight surface free of debris. They are simple, easy and quick to install and can be easily repaired or cold milled when a road is resurfaced. On the other hand the disadvantages are not insignificant. It is recommended to be used for skewed decks of maximum 30^o, otherwise they can be damaged by snowplow. The joints installation, maintenance and material behavior is strictly influenced by temperature. They are soft when it's warm and brittle when it's cold. Their service temperature doesn't always meet the actual climate condition.

When the temperatures are high, the joint area develops rutting, heaving and delamination. When the temperatures are low, the joint area develops spalling, pot holes, leading to debonding at the joint plug - pavement interface and to exposure of metal plate and consequently to its corrosion.

In the category of medium movement joints the most commonly used are finger joints and strip seals.

- Finger Joint

Finger joints are accommodating movements greater than 75 mm (3 in) but no bigger than 125 mm (5 in). The joint consists of a steel plate installed in cantilever configuration. Because they are metallic they need to be stiff in order to avoid vibrations under traffic loads. They also need to withstand rotations and vertical deflections. For a minimum impact from the blade of the snowplow the fingers can be slightly tapered downward towards the center of the joint (Malla et al, 2003). Usually they are constructed with a trough underneath made of neoprene to carry away the debris, deicing chemicals and water. An optimum slope should be 1% to ensure the proper drainage and debris removal. Some of the advantages are that they tend to have fewer problems than other joints, and they permit horizontal and vertical movements. Their main disadvantage is that being designed as an open joint it allows for water and debris to pass through. They have to be properly maintained and the drainage troughs cleaned periodically. Because of the traffic sometimes they can have broken fingers that have to be replaced. They also can have an increased noise level and the riding surface is not perfectly smooth.

- Strip Seals

Strip seal can accommodate movements of maximum 100 mm (4 in). They consist of a "V" shaped elastomeric strip seal that locks into steel edges at each side of the joint. The metallic edges are embedded into the concrete through an anchorage system. The movements are permitted by the folding (at the slab contraction) and unfolding (at the slab expansion) of the "V" shaped membrane.

They have the advantage of a long service life if installed properly. On the other hand the seals are difficult to replace and are easily damaged by snowplow especially if the skew angle is greater than 20^{o}. They also tend to accumulate debris that later induce damage to the joint by losing its waterproofing quality.

In the category of large movement joints the most common ones are bolt-down panel joint, the modular elastomeric seal, the inflatable neoprene seal and the reinforced elastomeric joint.

- Bolt-down Panel Joint

Bolt-down panel joint consists of a monolithic elastomeric panel placed into a block out, centered on the joint, reinforced with steel plates and connected to the deck through bolts. The advantage is that it can accommodate movements of up to 330 mm (13 in) and can be constructed in various widths. The disadvantages are related to the displacement of the anchorage elements (bolts and nuts) due to the traffic loads, thus conducting to potential traffic hazard. Also, due to the loosening of the bolts the water and debris can penetrate underneath the joint leading to possible structural problems.

- Modular Elastomeric Joint

The modular elastomeric joint consists of modular assembly of transverse neoprene seals, edge and separation beams, bearing on support bars spanning the joint opening. The configuration comprise neoprene strip seals mechanically held in place by steel edge and separation beams. Each separation beam is supported by independent multiple support bars, which are welded to the separation beams. The multiple support bars are suspended over the joint opening by sliding elastomeric bearings. Modular elastomeric joint are more complex and expensive to install therefore their maintenance costs are high. Usually they are used for large spans and large movements of up to 600 mm (24 in). Sometimes with special designs they can accommodate movements of up to 1200 mm (48 in). They have a satisfactory life service performance and they are watertight.

- Inflatable Neoprene Seal

Inflatable neoprene seal is known by the trade name of Jeene Structural Sealing Joint System being manufactured by Hydrozo/Jeene, Inc, the only supplier. It consist of a preformed open cell neoprene strip of the same size as the midrange joint opening bonded to the edges of the joint with an epoxy adhesive. After placing, the seal is inflated in order to compress the neoprene and achieve waterproofing. During the curing time of the adhesive the inflation is maintained allowing to deflate after approximately 24 hours. Its advantage is that is a very easy to put in place joint type with minor traffic interruptions. The disadvantage consists mainly in loss of adhesion and therefore water intrusion.

- Reinforced Elastomeric Joints

These type of joints are generally available as two types: the sheet seal and the plank seal. The sheet seals can accommodate movements of up to 100 mm (4 in), whereas the plank seal can accommodate movements of up to 225 mm (9 in). The sheet seal consists of a steel neoprene pad with overlapping ends. The pad is connected with the deck by cast in place studs. After a flexible epoxy is coated on the flap of the pad the second pad is laid down to create a field splice.

The plank seal is similar in construction and installation procedure to the sheet seal with the difference of having a tongue and groove ends.

If not installed properly the joint edge can spall thus making the joint prone to water infiltration. The bolts must be retorqued after several days following installation to account for the creep developed in the elastomer, all the bolts must be re-tightened annually and/or replaced if damaged (Purvis et al, 1989). They can be easily deteriorated by snow plow. Their performance is not cost effective, they are sensitive to installation and maintenance which is hard and expensive to do.

CHAPTER 2

LITERATURE REVIEW

2.1 Background on Asphalt Plug Joints (APJ)

Asphaltic plug joint (APJ), and as an expansion joint, is easy to install, relatively inexpensive, and suitable for new and rehabilitated bridges. The asphalt plug joints connect the abutment with the bridge deck making a smooth transition onto the bridge surface. It allows the bridge deck to expand or contract, at the same time keeping the joint free of debris and water as can be seen in Figure 1. Their benefits include a relatively low cost and less disruption to traffic during installation in comparison with other joint types but they also have their disadvantages, mainly the sensitivity to temperature, bridge movement, and heavy traffic loading.

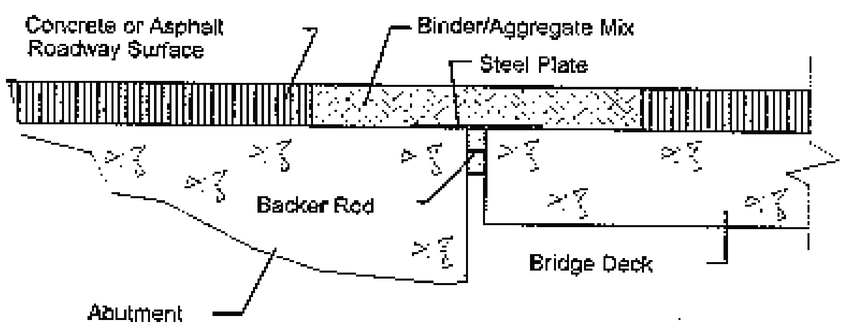


Figure 1

Abutment and bridge deck connection

Any material distress in the joint area can compromise the designed function of the joint and can lead to costly maintenance repairs or replacements. A modified binder aggregate mix is placed in a blockout and is bonded to the substrate on three sides as can be seen in Figure 2. Displacements occur where the gap plate slides on the bottom of the blockout leading to high strain deformations.

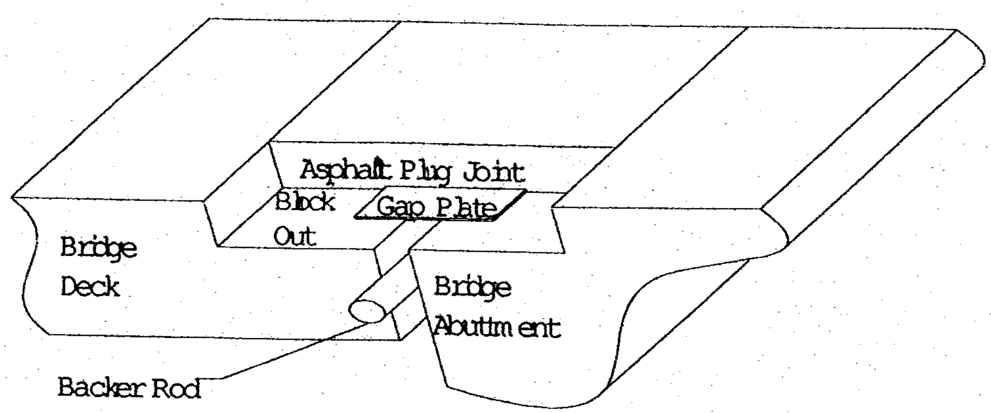


Figure 2

Typical APJ Section

In United States, Bramel at al. (1999) at the University of Wyoming, have done extensive research regarding the APJ material tests in the laboratory and in-situ and they developed design guidelines based on field observations, material tests, and analytical evaluations. A short review of their work will be presented in the coming sections.

Mogawer et al. (2004) did an evaluation of APJ that were started being used in the northeastern states in the beginning of 1990. Fifteen years later the authors published their results in respect with identifying the reasons for joint failure, the life span, material properties and failures in installation and maintenance.

As opposed to US, extensive research has been conducted in Europe and Australia. Australia developed a bridge design code AS-5100 for bearings and expansion joints (Velo et al, 1996). United Kingdom adopted standards to be used in installation of APJ joints dealing with QC/QA practices. All the principal manufacturers and installers, even though they have their own materials and techniques, adhered to these principles. The standard for APJ produced by the Bridge Joint Association was incorporated in the Design Manual for Roads and Bridges in UK. Some of their requirements include a limit of the longitudinal and vertical movement of 5-40 mm (0.2-1.6 in) and max 3 mm (0.12 in) respectively. Also, it is specified that the design will be done in such a way that joints will function correctly without the need for excessive maintenance during their working lives. Accent is put on following the manufacturer’s instructions regarding the joint installation and waterproofing the interface between the expansion joint and the bridge deck.

In Switzerland, the first bridges with APJ were built in the 1980's. Following their behavior the Swiss Federal Roads Authority (ASTRA) together with industry representatives and laboratory testing experts developed guidelines regarding the design, construction, maintenance and material testing after five years of gathering data and observing the behavior of eighteen APJs. Each test site was monitored and periodically inspected. The behavior of APJ was recorded and laboratory and field experiments were conducted. Some of the APJ installations failed due to the poor quality of the binder material. Also, installation instructions and equipment used were insufficient and the working crew not properly trained. These findings led to the introduction of the ASTRA guidelines in 1996. Since then the authors reported that the situation improved considerably for the APJ systems and emphasized that the quality control during material production and construction are crucial for a durable functioning of asphaltic plug joints. The developing and adoption of ASTRA guidelines was done in close coordination with the activities of a corresponding task group in Germany. The new guideline contained material requirements, test procedures, instructions on quality management and construction.

Asphaltic plug joints are used all over US for new and rehabilitated bridges. Usually the contractors follow the manufacturers' recommendations and specifications. Each APJ component has a special design function that affects the overall performance of the joint. The backer rod prevents the binder to flow into the gap and the gap plate prevents the APJ mixture to be pushed into the expansion gap during traffic loads. The mixture has to be very resilient and resist at the contraction and extension of the bridge during temperature changes.

In the literature it is noted that the aggregate used in an APJ system should be graded, washed and drained crushed rock from the basalt, gabbro, granite, delerite and grit stone groups. The gradation of the aggregate is suggested to be gap graded, having larger voids in mineral aggregate that allow larger asphalt content like 20%-40% by volume (Mogawer et al, 2004). The British APJ standard recommends that if the joint filling is mixed on site, the aggregate shall be delivered to the point of installation in pre-weighed sealed bags. The aggregate should be heated to avoid the increasing of the air voids in the mix but not too much as to exceed the installation temperature of the binder of 370°F - 385°F (188°C - 196°C), because at high temperature the adhesion between the binder and the aggregate might be compromised.

APJ systems, typically between 500 mm (20 in) wide and 70-160 mm (2.8-6.4 in) thick, are required to work within a temperature range from -25°C to +45°C and to sustain gap closings and openings from -12.5mm to 25mm (0.5-1 in). The APJ should accommodate vertical gap movements up to a maximum of 5 mm (0.2 in). The gap of the joint is covered by a sliding steel plate, which prevents the APJ material to be squeezed into the gap by traffic loads. Its width is typically 1060 mm (42.4 in). In most cases, the aggregates have 22 mm maximum aggregate size (Partl et al, 2006).

Different authors suggested that the binder should be rubberized, polymer modified or shall comprise of a blend of bitumen with Styrene Butadiene Rubber (SBR). Binder will also have different properties and shall be hot applied. The tests on binder have to be performed by an independent testing facility and the testing should be performed before and during construction and as well as 2 and 5 years post construction (Bramel et al, 1999).

The blockout is typically between 500 mm (20 in) and 610 mm (24 in) wide and no thinner than 50 mm (2 in) spans between concrete and/or asphalt sections. The backer rod has to be heat resistant and must be placed to a minimum depth of 1-1/2”.

The gap plate can be made of aluminum, mild steel, and structural steel with or without corrosion protection. Usually the aluminum plates, which are more easily molded, are more suitable where the bottom of the block out cannot be leveled, or where the approach or trailing side has a weaker base than the concrete deck and a steel plate might displace the APJ material. The most recommended one is the stainless steel plate with a minimum thickness of 3/16 of an inch and typically 8 in. wide centered over the joint to prevent the binder to flow into the opening.

The size and shape of these plates can be from 6 mm (1/4 inch) thick and 200 mm (8 inches) wide with varying lengths. They are laid into the APJ binder and secured into the backer rod with galvanized 16d nails. The gap plate role is to keep the binder/aggregate mix from extruding into the gap separating the abutment and bridge deck. In UK, the APJ standard specifies that at the in-situ joint the flashing should be used as a flexible membrane for waterproofing. In addition, the caulking is used as a compressible material to fill the expansion joint gap in order to prevent the binder leaking away from the joint during the filling of the joint. It has to be heat resistant to withstand maximum safe heating temperature of the binder.

The drainage must allow water at sub-surface level to be removed from the asphalt/waterproofing interface. The bridge deck requires discharge points at specified locations to allow the water to drain from the bridge deck into a designed drainage system.

2.2 Encountered Problems

Drainage

Failure may occur 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 suprastructure.

The deck design shall incorporate drainage independent of the joint. The drainage is present to allow water which gathers at sub-surface level to be removed from the asphalt/waterproofing interface.

The drainage, which includes collection points or channels transverse to the length of the deck, requires discharge points at specified locations to allow the water to drain from the bridge deck into a suitable system.

During service life, water from the neighboring adjacent pavements with high air void content may build up at the APJ-side and destroy the adhesion between APJ and the pavement in summer time. During winter, this water may freeze and ice-induced debonding may occur.

Movement

Service movement of the joint matrix shall be +/- 20 mm when set at mean whereas some joint types will accommodate greater movements. Maximum allowable anticipated joint movement is stated to be +/- 25mm (1in) or 50mm (2in) (Bramel et al, 1999). Due to thermally induced movements, the joint either expands or contracts. These movements force the gap plate to move relative to the block-out bottom and create debonding below and adjacent to the plate. In order to accommodate movement the joint filling must remain flexible.

Rutting

Rutting on APJ is a problem that will be present all the time. It can be alleviated if the joint will be placed to locations where the traffic is moving relatively fast. The joints should not be installed on intersections where the stationary or slow moving traffic induces a load that forces the material to flow out of the wheel. Another problem generating rutting is the skew angle. Rutting will increase due to skew angle and a reasonable limit to it is 30° (Bramel et al, 1999; Mogawer et al, 2004).

2.3 Failure Modes

Critical failure modes occur when the expansion joint leaks or ride quality over the joint is poor. Leakage in the expansion joints may be due to tension cracks through the joint, debonding, or material spalling out of the blockout. Poor ride quality can occur due to rutting, material piling up due to compression, material flowing out of the blockout in the traffic lanes, and the track-out of the plug joint material by passing traffic (Mogawer et al, 2004).

An ideal APJ material may have a modulus much lower than the pavement material and a nearly constant modulus of elasticity for the operating temperature range. Good range for an asphalt pavement is 1,300 to 4,500 Mpa at room temperature (Bramel et al, 1999). Some of the tests conducted are Normal Bond Test, Shear Bond Test, Modulus Resilience Test, Georgia Loaded Wheel Test, and Thermal Stress Restrained Specimen Test. Most authors noted that the APJ mixture acts “stiff” or “brittle” at colder temperatures and is “soft” or “pliable” at warm temperatures.

2.4 Material Tests

Material tests such as tensile strength, shear bonding strength, normal bonding strength, modulus of elasticity, and modulus of resilience are used to evaluate the failure modes. The temperature plays a crucial role in the performance of APJ therefore the tests were evaluated as functions of temperature to develop the ability of the material to resist to the service demands.

Normal Bond Test

The normal bond test evaluates the bonding capacity of the APJ binder applied to the bridge concrete deck. Usually this occurs at the interfaces between the abutment and the joint perpendicular to the traffic direction. The load is applied perpendicular to the bond plate.

Previously, a test was done in direct tension on previously sawed samples of 50x50x250 mm (2x2x10 in) that was 125 mm (5in) of APJ and 125 mm (5in) of concrete. The tests were conducted at a loading rate of 5mm/min (0.2in/min) with data being recorded using acquisition system (Bramel et al, 1999).

Because the material demonstrates a brittle behavior, only the ultimate strengths are reported. At the interface between the aggregate and the binder, any failure will be a combination of normal bond, shear bond, and APJ binder failure. The normal bond ultimate stress is lower than the material yield stress. Bond failure in the field leads to water infiltration in the joint.

Shear Bond Test

The shear bond test evaluates the bonding capacity of the APJ binder applied to the bridge concrete deck and abutment block-out. This occurs in the APJ joint on the block-out bottom interface parallel to the traffic direction. The load is applied parallel to the bond plane. A test was a thick adherent test where a previously sawed sample of 50x50x250 mm (2x2x10 in) with approximately a 19 mm (0.76 in) shear zone between a concrete and APJ segment was evaluated in pure shear. The tests were conducted at a loading rate of 5mm/min with the data being recorded using data acquisition system (Bramel et al, 1999). The authors observed that at temperatures above -18 °C (0°F) the shear stress was higher than the yield stress allowing the APJ material to deform whereas at temperatures close to and below -18 °C (0°F) the shear stress was lower than the APJ material stress forcing the energy developed from the bridge motion to shear the joint from its support.

Modulus of Resilience Test

The modulus of resilience test (M_R) is a standard test for asphalt materials that measures the modulus of the elastic or visco-elastic rebound by using a dynamic compressive loading of 1, 2, or 3 Hz with a haversine loading waveform of one-tenth cycle duration that produces a rapid loading rate. The resilience modulus is an indirect tensile test where a 150 mm (6 in) diameter by 75 mm (3 in) thick core is placed in compression and the tensile deformations are measured diametrically normal to the compressive load. Modulus of resilience is defined as the slope of the unloading cycle, with two points for computing the long-term modulus of resilience; this being the point at which unloading begins and where the next cycle starts (Bramel et al, 1999).

This test represents the loading due to traffic where a wheel load will be traveling down the pavement and is on the joint for only a short time. However, the test is not a good simulation of the loading condition on the bridge joint, which is not as rapid. For traffic loading, investigation of stress in elastically supported expansion joints under wheel impact loading provides a detailed description of the relationship between a modular expansion joint and truck during the short time of impact. The loading displacement at which one of the failure criteria was met can be considered the maximum allowable motion for the modeled joint geometry and material characteristics at the joint temperature (Bramel et el, 1999).

Georgia Loaded Wheel Test (GLWT)

The Georgia Loaded Wheel Test (GLW) is an asphalt pavement accelerated test to evaluate the rutting. It comprise of a 150 mm diameter by 75 mm thick core placed in a machine that exposes it to a set number of cycles from a standard "wheel". The resulting rut depth is measured. The test is run at an elevated temperature of 46°C (110° F) with a 45-kg steel wheel running on top of a pneumatic hose inflated to 690 kPa (100 psi) for finite increments up to 8000 total cycles. For asphalt pavement acceptable rutting performance has been correlated with a total rutting depth of less than 7 mm (0.3 in) at 8000 cycles of the GLW. This test is only useful as a comparative test for APJ since they are softer than asphalt pavements and will exhibit rutting. (Bramel et al, 1999).

Thermal Stress Restrained Specimen Test (TSRST)

The TSRST test is a low temperature test to evaluate the ability of an asphalt pavement to resist the internal stresses developed through cooling. The test apparatus actively maintains the original length of the specimen and measures the force induced by the thermal contraction as the temperature drops. At a certain temperature, the internal stress will equal the materials resistance and a brittle failure will occur. The TRSRT results indicate that will be a temperature joint failure with zero movement. Also, indicates the glass transition temperature (Tg) which is an important property of the highly modified APJ binder (Bramel et al, 1999). The glass transition temperature (Tg) is the temperature where the APJ binder material becomes brittle with little or no plastic deformation and it fails due to changes in its mechanical behavior. It is situated in between -18°C (0°F) and -40°C (-40°F). Above glass transition temperature the APJ binder behaves like a ductile solid or highly viscous liquid. Below glass transition temperature, the material behaves as a brittle solid and any small joint movement will create a fracture that will propagate through the joint and ultimately will lead to failure.

Relaxation

Relaxation and glass transition temperature Tg are important time-dependent material properties that can be obtained by using the standard TSRST asphalt test slightly altered. Relaxation is a reduction in load/stress while a constant strain in maintained over time. The relaxation is determined by inducing a small displacement, holding it constant, and measuring the load decrease with time. If the material relaxes as rapidly than the temperature change demands, no stress is induced.

With the decreasing temperature the material ability to flow decrease as well. This will happen until an abrupt ductility transition occurs or the material viscosity is practically zero becoming brittle. Any small movement or additional decreasing in temperature will cause a fracture that will propagate through the joint and will result in material failure. Relaxation tests showed that the load relaxed rapidly to an intermediate level, at which point the decay rate was significantly lower. Conceptually a relaxation time less than 15 minutes implies that the joint will relax faster than the thermal inertia allows the bridge to deform, therefore APJ should only be installed where traffic moves at high speeds with a thickness of less than 50 mm (2 in) (Bramel et al, 1999).

Thermal Cycling Test

The Thermal Cycling Test and the Vibration Test were developed by the researchers at the BAM (Germany) to test an APJ function as a whole. The thermal cycling test measures the APJ performance under slow, horizontal joint movements between +25mm (+1”) and -12.5mm (-1/2”) at a rate of 0.2mm/h. The temperature is also varied from -20°C (-4°F) during extension of the joint to +50°C (122°F) during contraction of the joint. The test is conducted until the failure of the specimen, which is considered when it becomes impervious to a NaCl solution (Mogawer et al, 2004).

Vibration Test

The thermal cycling test measures the APJ performance at -20°C (-4°F), under dynamic loading using a sinusoidal waveform at a frequency of 1Hz. A continuous pulsating bending test dictates the loading levels. The failure occurs when the joint fails.

Full Scale Tests

To assess the material properties in-situ strength tests are used to validate the real life APJ behavior. An investigation conducted by Bramel et al, 1999 used special molds allowing one-meter joint segment to be placed in one operation. The molds were sent to three US suppliers for placing with their material: Pavetech, Koch/LDI, and Watson Bowman Acme. The molds were filled using the same construction methods as regular bridge joints. The Pavetech joint showed no signs of a bond failure. Watson Bowman Acme has a material failure with also no sign of bond failure. Koch/LDI joint material was the stiffest of the three samples and exhibited the lowest normal adhesion strength therefore it had a bond failure.

All samples showed signs of fatigue cracking in zones of high stress concentrations, typically at the edge of the gap plate or the top corner of the APJ and the base material. Usually the autogenous healing, traffic flow and seasonal joint compression at elevated temperatures can extend the joint service life but it has to be maintained, inspected and replaced periodically.

2.5 Failure Associated with Design

Repair of deck joints is one of the most common and costly maintenance tasks. Design loads, fatigue, movements, gap width, joints sealants, drainage and installation are essential to be proper constructed so to minimize the cost of their maintenance. Components of movement including temperature, creep, shrinkage, prestress, and any additional construction or settlement movements likely to occur during the life of the bridge should be considered (Purvis et al, 2003). Joints details should be described and shown on the work plan. Drains should be placed uphill of the joint in the sidewalk or curb to prevent as much water as possible from reaching the joint.

The use of aluminum components is not recommended, as they are easily damaged. Still the British Standard recommends the plate to be of aluminum or mild steel with or without corrosion protection of a thickness and width appropriate to the expansion joint gap.

Steel devices must be protected with a coating such as paint or galvanization. Joints should be designated for movements that are likely to occur. Deck joints with little or no tolerance for unanticipated foundation movements should not be used. Joints sensitive to skews should not be used in bridges with large skews. Sliding plate joints should not be used where vertical movements and rotations are probable.

Only joints that have been subjected to successful load tests should be used on highway bridges. Bridging-type joints should only be used if they can survive the application of substantial vehicular overloads. Wide elastomeric joints should not be used in snowplow environments. Substantial joint edge armor and armor anchorage should be used on all joints.

Flexible continuous joint sealants and fillers, and pourable sealants may be used on short span bridges with movement range less than 20 mm. Movement range is limited to + or – 25% of installation width. The advantage of this type of deck joint is the seal because it is repairable without replacement of the full length of seal.

Minimum geometric considerations should be taken into account when selecting an APJ for use. These limitations are imposed due to the special nature of the material. At a minimum the installation depth, width, length and skew angle have to be clearly specified and carefully selected.

In the literature, there are different recommendations for the minimum joint depth, width or length. The values also differ in function of manufacturers and experience. One source recommended a joint depth of a minimum depth of 75 mm (3 inches) and a maximum of 100 mm (4 inches) while another stated a joint depth range from 70 mm (2-3/4 inches) to 160 mm (6-1/4 inches).

There is a minimum dimension for the APJ that is a wedge extending upward at 60° from the edge of the gap plate and debond. The fixed side of the plate must be secured with fasteners or APJ binder to force the joint motion into the preferred side (Bramel et al, 1999).

In hot weather when the APJ becomes too soft some amount of plug joint material might be dislocated by road-tire interactions, such as horizontal breaking forces or vertical bumping loads. In the case of pavements with high air void content or after rainfall lasting for days immediately before the APJ construction, it is impossible to achieve a dry interface between the pavement and APJ. Wet pavements can produce poor interface bond between the pavement and APJ therefore, at these locations the debonding will occur (Partl et al, 2006).

In cold weather a thin joint might be susceptible to material failure like cracking, debonding, and spalling. In hot weather if the joint is too thick it might be susceptible to rutting, bleeding and shoving.

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 hits the wearing course on either side of the joint, the joint may fail and the wearing course may be damaged. Joint widths are typically no less than 500 mm (20 inches) (Mogawer et al, 2004). Joint length and skew angle have to be carefully treated when using an APJ. A skew angle larger than 30 degrees becomes prone to snowplow deterioration.

The joint waterproofing must continue over its entire length just as the expansion gap of a bridge continues through any curb and sidewalk bridge. Researchers from EMPA observed that the curb area might present more problems than the traffic lane. The waterproofing consists of sealant compatible with the substrate and tooled on the vertical and horizontal faces of the curb. If this sealant separates from the substrate the curb areas will leak and may cause damage to the underlying substructure, similar to leakage through the APJ (Partl et al, 2006).

In the British standard for APJ, the curb expansion gap is required to be equivalent and directly in line with the bridge expansion gap. The curbs have to be undercut to the specified joint width as to provide a minimum clearance of 50 mm (2 in) between the underside of the curb and the deck. The gap between curbs has to be properly sealed.

The main function of an APJ is to cover the expansion gap of a bridge and remain waterproof. Depending on the temperature the bridge with contract and expand, therefore the APJ material must be able to "follow" the bridge. In UK, a typical APJ is required to be functional within a temperature range of -25ºC (-13ºF) to +45ºC (+113ºF) (Part et al, 2006). In US, the seasonal temperatures vary greatly from north to south and within each state and they go over the limits adopted for Europe.

The bridge joint moves horizontally and vertical. Horizontal movements are considered quasi-static, happening slowly over time and are mainly induced by thermal contraction and expansion and the forces induced on the APJ during this type of movement are considered to be far less than the dynamic forces from traffic loading (Mogawer et al, 2004). Dynamic loading and end beam rotation can cause vertical movements.

A research conducted by Chang et al, 2001, recommended using APJ in locations with less truck traffic and small bridge movement. An ADT of roughly 20,000 was found to provide a good behavior of asphaltic plug joints in terms of traffic loads.

2.6 Failure Associated with Material

At high temperatures the joint area develops rutting, heaving and delamination. At low temperatures, the joint area develops spalling, pot holes, debonding at the joint plug - pavement interface and exposure of metal plate that leads to rusting. Typical distresses can be seen in Figure 3. A more detailed description of each material distress it will be given in the following pages.

The advantages of APJ regarding their easy installation, repairing and relatively low cost and eclipsed by disadvantages, the biggest one being that the material behaves different function of temperature, like becoming brittle at colder temperatures and soft at warm temperatures. This material phenomenon makes the joint more sensitive to distress and more likely to fail. Many internal and external factors can lead to the failure of APJ.

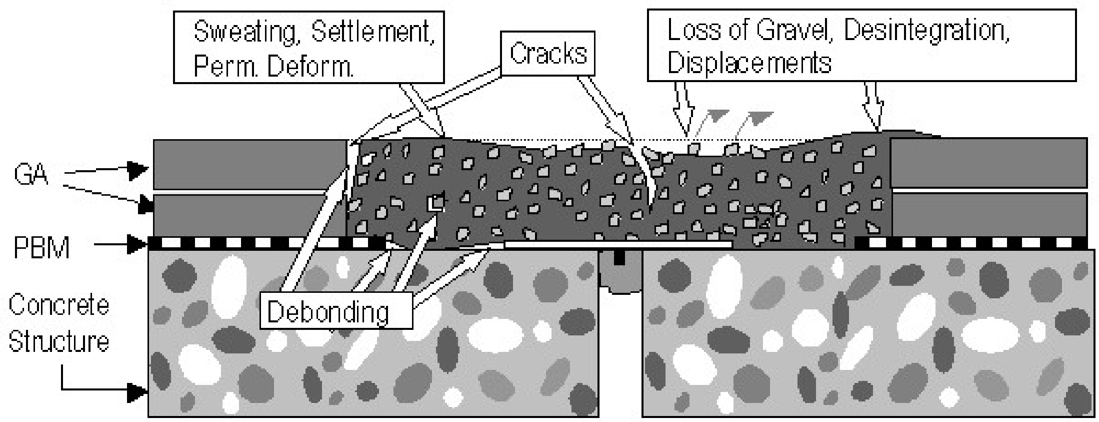


Figure 3 Typical distresses

Failure begins when the APJ system becomes pervious, thus allowing water and deicing chemicals to enter and/or pass through the joint into the underlying superstructure. During leaking, water can infiltrate through the joint, causing accelerated corrosion to integral parts of the structure and substructure, thus decreasing the bridges service life, and increasing maintenance costs (Mogawer et al, 2004). It appears that a number of different effects and material distresses combined are the actual reason for the failure of the APJ system. Some of the distresses are described below.

- Debonding or separation is a material failure between the APJ and adjacent pavement interface (Figures 4a and 4b). This is due to the glass transition temperature at which they become brittle, lose ductility, and crack, causing leaks and debonding.

Different theories try to explain the debonding cause and process. It was considered that the water would collect at the APJ-pavement interface due to the impervious nature of the APJ mixture if the pavement near the joint has a 6% air void content or higher. Unless the water drains out it will freeze in the winter, pushing the material at the interface and thus causing debonding. Other discussions are related to the fact that the solvents used on the vertical wearing course pavement faces might not fully evaporate thus weakening the adhesion at the APJ-pavement interface. One solution to prevent the debonding is the suggestion of adding a denser pavement on each side of the APJ.

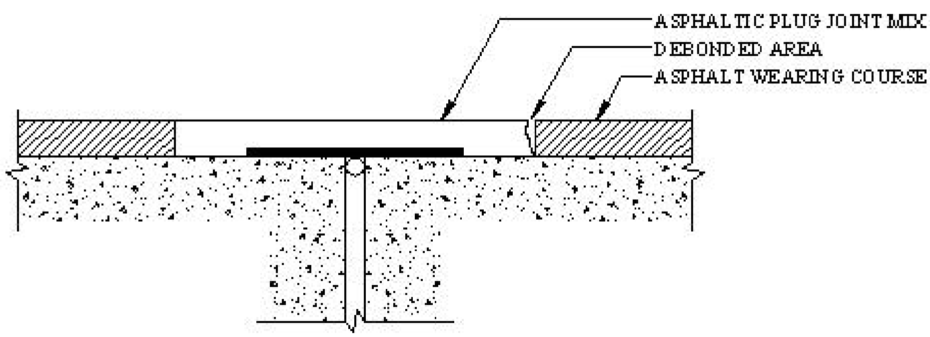


Figure 4a Debonding

- Cracking or splitting in tension is a material failure due to excessive stresses or strains induced by joint motion, material fatigue, and thermal stresses exceeding the materials capabilities at low temperatures. If they are not treated, the transverse and longitudinal cracks are avenues for water to enter into the joint and causing leaking. The researchers at the University of Wyoming determined from the laboratory tests that the material is very stiff at low temperatures thus leading to cold temperature cracking. At the glass transition temperature Tg the material becomes brittle thus thermal stresses exceeding the material capacity (Bramel et al, 1999).

Figure 4b Debonding

- Reflective cracking does not occur over the expansion gap because of the plate above, but rather at the edges of the plate where it develops cracks (Figure 5). From the finite element analysis, it is considered that these edges of the gap plate are an area of localized stress, which is relieved through the formation of a reflective crack. Another reason for reflective crack occurrence is the continuous back and forth motion because the plate is not perfectly flat.
- Rutting is characterized by permanent deformation of the pavement (Figure 6). It generally develops during the hot seasons, as channelized depressions in the wheel paths. For the APJ the rutting occurs usually in the summer when the material is soft and pliable. Even though the distress is not directly linked to leaking, it can propagate more severe distresses like spalling that can result in joint failure. Another problem is the rideability issue that prevents a smooth

transition and the steering that can accelerate the rutting. In addition, it will increase due to the APJ skew angle.

Figure 5 Reflective cracking

Figure 6 Rutting

- Raveling is a progressive separation of aggregate particles in a pavement from the surface downward or from the edges inward (Figure 7). Usually, the fine aggregate wears away first and then leaves little "pock marks" on the pavement surface. As the erosion continues, larger and larger particles are broken free and the pavement soon has the rough and jagged appearance typical of surface erosion. It also has the same unpleasant rideability effect as rutting and in time can lead to more severe distresses that can cause the joint to fail. It is in equal measure a cold or warm weather issue.

Figure 7 Raveling

- Shoving/pushing as can be seen in Figure 8, is a form of plastic movement (like an abrupt wave) across the pavement surface. It usually occurs in warm weather where the asphalt abuts a rigid object (plate) and is caused by traffic action (starting and stopping) combined with poor mix design, excessive moisture in the subgrade or lack of aeration of liquid asphalt emulsions. The issue of skew angle is also a matter of pushing the material out of the joint due to traffic loading. 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.

Figure 8 Shoving/Pushing

- Segregation shown in Figure 9, is the non-uniform distribution of coarse and fine aggregate components within the asphalt mixture. If it is a coarse segregation, the gradation is shifted and there are not enough fine aggregates. The mix has a low asphalt content low density; high air voids, rough surface texture, and accelerated rutting and fatigue failure. If the mix is a fine segregation, the gradation is shifted and there are not enough coarse aggregates. It is characterized by high asphalt content; low density, smooth surface texture, accelerated rutting, and better fatigue performance characterize fine segregation. The non-uniform mix can lead to weakness areas that can later develop into severe distresses like debonding, rutting, and cracking. Usually the best method to detect the segregation is the visual inspection.

Figure 9 Segregation

- The bleeding is characterized as a film of asphalt binder on the pavement surface. It usually creates a shiny, glass-like reflecting surface that can become sticky (Figure 10). When is wet it exhibits loss of skidding. Bleeding usually occurs when asphalt binder fills the aggregate voids during hot weather and then expands onto the pavement surface. In time, it will accumulate on the pavement surface. It is due to excessive asphalt binder in the mix and to low air void content so there is no room for the mix to expand during warm weather. It prevents a smooth joint transition and may lead to further distresses.

Figure 10 Bleeding

- Polished aggregates (Figure 11) are portions of aggregates extending above the asphalt binder. Usually the areas are very small or there are no rough or angular aggregate particles. It decreases the skid resistance and it is due to repeated traffic loading. The process is faster if the aggregates are susceptible to abrasion or subjected to excessive studded tire wear. All by itself, it will not cause failure of APJ but it might lead to more severe distresses.

Figure 11 Polished aggregates

- Spalling as can be seen in Figure 12, occurs when portions of APJ material are displaced from one or both sides of the joint. It might be caused by a combination of the previous material distresses.

  If the APJ becomes separated from the blockout the condition is called delamination. This might be due to the sliding motions of the plate. Aside from material spalling, cracks can propagate to the joint interface.
- Pot holes (Figure 13) are due to fatigue cracking, localized disintegration or freeze-thaw cycles. This bowl shaped hole in the pavement surface can have various sizes and if it is in the proximity of the joint it leads to plate exposure and water infiltration causing joint failure.

Figure 12 Spalling

Figure 13 Pot hole

- Plate exposure / rusting (Figure 14) is associated with joint debonding and presence of pot holes in the joint area. In contact with water and environmental conditions the plate starts to corrode and leads to joint failure.

Figure 14 Plate exposure / rusting

2.7 Failure Associated with Installation

A bad installation practice was proved in many cases to lead to APJ failures. Normally the contractor should follow the manufacturers guidelines of the manufacturer himself must install the joints. This is not always the case. Sometimes, due to various reasons, mostly economical, a third party is installing the APJ which may or may not have the qualification to do this or lacks the training from the manufacturer.

In addition, different reasons can lead to a bad installation, such as unclear documents wording or material inconsistencies that will compromise the APJ performance.

Literature is mentioning that the APJ overall performance can be improved with a complete and thorough installation done by professional teams and with considerable care to the written documents (Mogawer et al., 2004). General guidelines are provided to address the issues of correct installation. Most of them are common sense and are the same for all the manufacturers.

In Europe ASTRA guidelines specify that the correct installation record is an imperative condition for the final acceptance of the work. The installation record has to be made public after each installation stage and delivered to the site manager (Partl et al, 2006).

To mitigate problems that might appear during the installation process several guidelines have been suggested to address this issue. These are as follows:

- A technically competent manufacturer's representative should be present on site during installation
- Only certified people should install the joint.
- Manufacturer must 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
- The joint installation should not be made on inclement weather. The temperatures should be between 5ºC (41ºF) and 35ºC (95ºF).

All the manufacturers are following more or less the same procedural steps when installing the joints. The removal of existing joint is done by dry saw cutting to an enough depth as to safely remove the existing pavement by using jackhammer and hand tools. Usually the depth of the cut can be established by drilling a pilot hole with a drill to establish existing pavement depths. Care must be taken as to not cut too deep into the existing concrete deck. The empty gap created for the future joint should be cleaned and dried with hot compressed air. The surface must be clean of any debris, tanked and flooded with the APJ binder material. The new backer rod is installed and the gap plate shall span the expansion gap and should be fitted in such a manner that the plate will be on a sound concrete support and nailed into place with locating pins. Another tanking of the whole area must be done, including the vertical walls (Bramel et al, 1999).

In the literature, different mixing procedures of aggregates and binder are found. Three are mentioned with the observation that the first of the methods is the most practical and widely used.

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

Although the second method endures the completely aggregate coating with binder, the material cannot be easily spreaded and compacted. The third method is the less practical, causing the contractor to work in small batches to keep the temperature constant. Because is hard to keep uniformity it might result in cavities and over time in blistering. The thermometers used to measure the aggregate and binder reading must be previously calibrated.

The ASTRA guidelines suggest that a typical installation procedure consists of pouring the binder in layers of 3 to 4 cm at a temperature of 180 °C with an equal layer of hot stones added immediately. After the layer is cooled to about 80°C another layer will be added until a height of 16 cm is reached (Partl et al, 2006).

The compaction can be done with a 2-ton roller or with a vibratory plate compactor. The heated mix is placed in three lifts that each sandwich a filler coat of binder. The final coat is a coat of dry aggregate to help reduce binder track out and acts as an adhesive for the fine aggregate thus sealing the joint.

One important issue is the quality control during the installation process. Researchers from Swiss Federal Laboratories for Materials Testing and Research (EMPA) suggested that with the installation process a certain procedure must be followed. Thus, the installer must provide a form after the installation is complete with information pertaining to: bridge reference number and location, joint size and location on the deck, date of installation, and weather during installation, materials used, plate material and size, type of primer used, surface dressing, and use of debonding strip.

In addition the manufacturer must provide information regarding to description or name of the joint system with all the technical data, horizontal and vertical movement range/capacity, aggregate and binder test reports, gap plate, caulking and flashing test reports.

2.8 Failure Associated with Maintenance

Many of the maintenance problems on bridges result from failed joints. Therefore, a proper maintenance done at the right time extends the service life of the bridge and reduces the total life-cycle costs.

Preventive maintenance involves using maintenance-friendly products and designs, which may initially cost more but in time are durable, accessible, repairable and replaceable. Preventive maintenance activities include washing decks, keeping drain open, removing debris and fixing small problems before they result in system failure. The most important thing is that they have to be performed at regular intervals.

If the surfacing adjacent to a failed joint deteriorates, both the joint and the deteriorated surfacing should be replaced to improve ride quality and overall durability. The seal should be repaired if any part is leaking. Debris and gravel should be removed from the surface to prevent damage of the seal.

The joint system should be bonded to sound concrete; the seal has to match the ambient temperature. The joint should be installed after placing the overlay and has to be protected against unusual movement.

The splices in premolded expansion seals have to be avoided. The skewed joints are prone to snowplow damage therefore they have to be protected. A failed joint should be entirely replaced since completely sealing the interface between existing and new joints is very difficult. Areas in the approach slab and deck that exhibit excessive vehicle wear should be repaired immediately to reduce impact loads on the joint.

Consideration should be given to the maintainability of the joints (particularly for movements over 4 in), availability and replaceability of parts, and provisions for access to reach the parts. 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.

2.9 APJ Manufacturers

All the manufacturers in US or Europe have their own installation guidelines, which more or less follow the same principles. Following are some of the manufactures that provide the industry and DOTs with materials and installation guidelines for bridge expansion joints. A list with technical information for each manufacturer can be found in the attached Appendixes A-1 through A-7.

- LaFarge Road Marking – Thorma Joint / Prismo
- Chem-Joint 70
- Watson Bowman Acme Corp. – Wabo Expandex
- Pavetech International Inc. – Matrix 502
- A.H. Harris & Sons – Polyjoint
- Wyoming Equipment Sales – A.P.J.
- Permanite Asphalt – RAB Plug Joint

<u>ThormaJoint</u> - is a combination of an elastomer modified binder (BJ200) and a carefully selected aggregate (BJ stone). The joint is constructed in-situ and is a hot process. All the specifications and technical data are available from the Manufacturer. The joint width can vary from 300-750 mm (12-30 in) with a maximum horizontal movement of ±5 - ±25 mm (0.2-1 in).

<u>Chem-Joint 70</u> - Chem-Crete High Performance APJ Type Bridge Joint System is a hot process in-situ constructed expansion joint system capable of accommodating movements up to 70 mm (2.8 in). Is a combination of a polymer modified binder and

selected aggregates. The binder is a compound blend of bitumens, polymers, fillers and stabilizers.

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. It is recommended for joint openings with movements up to +/- 0.75” at time of installation.

Matrix 502 - is an asphaltic plug joint that has a very good wear life performance. It uses special materials and is employed at expansion joints with thermal movement of about 25 mm (1 in).

Harris Polyjoint – is a polymer modified asphalt mixture. It is described as an elastomer strip overlay expansion joint.

Asphalt Plug Joint System - is a thermoplastic modified asphalt with certain requirements provided by the manufacturer and a maximum horizontal movement of 50 mm (2 in).

RAB plug jointing material is a flexible hot mix bitumen rubber material used in the construction of APJ. The material is installed in accordance with the requirements for the installation of APJ.

CHAPTER 3

NDOT INVENTORY OF ASPHALTIC PLUG JOINTS

3.1 NDOT Districts – Use of APJ

NDOT is organized in three districts for administrative purposes. District 1 includes southern Nevada with headquarters in Las Vegas and a major maintenance station in Tonopah. District 2 covers northwest Nevada with headquarters in Sparks, and District 3 covers northeast Nevada with headquarters in Elko and major maintenance stations in Winnemucca and Ely.

A number of bridges were rehabilitated in the past years (1998 – 2007) using APJ. Out of the total number of 70 of bridges with APJs, two were in District 1, one of which was pedestrian; 33 in District 2; and 35 in District 3. The joints were inspected in a two months span and a detailed technical data sheet was filled for each inspected bridge. A blank sample copy is given in Table 1. Technical files, technical drawings and information, photos of the joint distresses and field observations were documented into separate folders for each District. An indexing calculation was put together following the general rating guidelines employed by NDOT – Bridge Inspection Reporting System. The same procedure was applied to all analyzed bridge joints. An index of 1 was assigned to correspond to the worst existing condition regarding certain distresses and 10 to describe the best existing distress condition. To establish a correlation between the field observations and the joint condition index it was necessary to express the index numbers in percentage. It was assumed that all distresses (i.e., joint separation, potholes, spalling and exposure of plate) had the same numerical impact in the evaluation of the joint. Each distress was evaluated from the worst to best condition on equal scales (1 to 10). The final result was obtained as an average of all joint indices.

Table 1: Technical Data Sheet

District No.
Bridge ID:
- Type of Bridge
- ADT:
- Average Total Span:
- Average Exterior Span:
- Average Interior Span:
- **Movement allowed by NDOT = 1 in**
- Calculated Thermal Expansion for Exterior Span
- Calculated Thermal Expansion for Interior Span

$\Delta L = \alpha \Delta T L$
$\alpha =$ in/in/^{0}F
$\Delta T = {}^0$F

- **Boundary Condition**
- APJ located on the span with both ends free
- APJ located on the span with one end free

Original Contract No.
Modified Contract No.
Original Joint Type
Rehabilitated Joint Type and Geometry
Joint Orientation (angle)
Rehabilitated Joint ID
- Date, Time and Placement Temperature
- Depth and Width of Joint
- Type and Thickness of Plate
- Material Information

Types of Failure
- Material
- Geometry of the Joint (Design)
- Material Distress
- Installation
- Maintenance

Condition Index
- At edge or interior

1 worst - 10 best

Joint Debonding (1-10)
Pot Holes (no. and extend), spalling, rutting, shoving, breaking (1-10)
Exposure of plate, rusting of plate and failure of plate (1-10)

0-2 (<20%) => Critical, in need of immediate replacement
2-4 (20%-40%) => Poor
4-7 (40%-70%) => Fair, some failure but still serviceable
>7 (>70%) => Good, intact
For a more detailed conditioning index please refer to the NDOT general condition rating guidelines

Note:

Due to different climatic conditions between the northern and southern Nevada, and different materials used in the construction of the bridge deck (concrete or steel), different ranges of temperature (ΔT) and specific material thermal expansion coefficient (α) were considered. Their values were as follows:

- Northern Nevada è $\Delta T = 125^{o}F$ for steel bridges
  (Districts 2 and 3) $\Delta T = 80^{o}F$ for concrete bridges
- Southern Nevada è $\Delta T = 80^{o}F$ for steel bridges
  (District 1-Clark County) $\Delta T = 70^{o}F$ for concrete bridges
- $\alpha = 6 \times 10^{-6}$ in/in/^{o}F (for concrete) and $\alpha = 6.5 \times 10^{-6}$ in/in/^{o}F (for steel)

During field observations the following type of distresses were noted: joint debonding, potholes (their number and extent), spalling, rutting, shoving, breaking, and exposure and condition of plate. Samples of APJs in "good", "fair" and "poor" conditions are presented in the sections to follow.

Table 2: District 1 - Centralized Data

No.	Bridge	APJ		Plate			Thermal expansion (av.)		Condition index	Typical failure
		Width (in)	Depth (in)	Width (in)	Thickness (in)	Type	Ext. span (in)	Int. span (in)		
1	B-781	24	2	8	1/8	Steel, hot dipped galvanized	0.46	0.45	10.00	N/A
2	P-1450	10	2	8	1/8	Steel, hot dipped galvanized	0.83	N/A	6.67	Breaking

Table 3: District 2 - Centralized Data

No.	Bridge	APJ		Plate			Thermal expansion (av.)		Condition index	Typical failure
		Width (in)	Depth (in)	Width (in)	Thickness (in)	Type	Ext. span (in)	Int. span (in)		
1	I-699	22	3.4	N/A	N/A	N/A	0.16	0.20	6.67	Cracking, joint debonding Spalling, shoving
2	I-852	20	2	N/A	N/A	N/A	0.13	0.19	4.00	Joint debonding, pot holes Plate exposure, breaking

Table 3: District 2 - Centralized Data (continued)

No.	Bridge	APJ Width (in)	APJ Depth (in)	Plate Width (in)	Plate Thickness (in)	Plate Type	Thermal expansion (av.) Ext. span (in)	Thermal expansion (av.) Int. span (in)	Condition index	Typical failure
3	I-816	36	3 1/2	8	1/8	Steel, hot dipped galvanized	0.21	0.27	7.67	Breaking, spalling
4	I-740	20	5 1/4	8	1/8	Steel, hot dipped galvanized	0.23	0.30	9.33	Spalling
5	G-843	36	5	18	3/16	Steel, hot dipped galvanized	0.34	0.35	4.67	Joint debonding, pot holes Plate exposure, tracking
6	H-1162	20	2.5	N/A	N/A	N/A	0.24	0.39	10.00	N/A
7	I-717	20	5	8	1/8	Steel, hot dipped galvanized	0.32	0.33	10.00	N/A
8	B-716	20	7	8	1/8	Steel, hot dipped galvanized	0.74	0.76	6.00	Breaking, spalling Joint debonding
9	G-772	23	2 1/2	8	1/8	Steel, hot dipped galvanized	0.83	0.92	5.33	Joint debonding, pot holes Plate exposure, breaking
10	G-765	24	2	N/A	N/A	N/A	0.60	0.62	9.00	Joint debonding
11	B-764	24	2	N/A	N/A	N/A	0.66	0.70	9.00	Joint debonding
12	I-773	23	2 1/2	8	1/8	Steel, hot dipped galvanized	0.52	0.49	5.67	Joint debonding, pot holes Plate exposure, breaking
13	I-1289	20	3	8	1/8	Steel, hot dipped galvanized	0.81	N/A	9.00	Tracking, shoving
14	I-1301	20	2 1/2	N/A	N/A	N/A	1.04	N/A	9.33	Breaking
15	H-1090	20	2	N/A	N/A	N/A	0.12	0.17	5.67	Joint debonding, pot holes Breaking, spalling
16	I-1089	20	2	N/A	N/A	N/A	0.12	0.40	6.33	Breaking, spalling Joint debonding
17	I-1000	20	2	N/A	N/A	N/A	0.23	0.45	7.00	Spalling, tracking Joint debonding
18	I-1001	20	2	N/A	N/A	N/A	0.23	0.45	7.33	Spalling, shoving
19	I-1087	20	2	N/A	N/A	N/A	0.21	0.44	4.00	Joint debonding, pot holes Plate exposure, spalling
20	I-1088	20	2	N/A	N/A	N/A	0.23	0.45	6.00	Joint debonding, spalling shoving
21	I-1171	20	2	N/A	N/A	N/A	0.23	0.47	6.67	Pot holes, tracking Shoving, spalling
22	I-1172	20	2	N/A	N/A	N/A	0.20	0.37	6.00	Joint debonding, shoving Breaking, spalling

Table 3: District 2 - Centralized Data (continued)

No.	Bridge	APJ Width (in)	APJ Depth (in)	Plate Width (in)	Plate Thickness (in)	Plate Type	Thermal expansion (av.) Ext. span (in)	Thermal expansion (av.) Int. span (in)	Condition index	Typical failure
23	I-1173	20	2	N/A	N/A	N/A	N/A	N/A	5.67	Pot holes, spalling
24	B-1234	20	2	N/A	N/A	N/A	N/A	N/A	5.00	Breaking, pot holes, spalling
25	I-1252	24	2	N/A	N/A	N/A	1.11	N/A	3.33	Joint debonding, pot holes Plate exposure, spalling
26	I-1248	24	2	N/A	N/A	N/A	0.82	N/A	2.67	Joint debonding, pot holes Plate exposure, spalling
27	H-1830	20	3	8	1/8	Steel, hot dipped galvanized	0.58	N/A	6.67	Tracking, shoving, spalling
28	H-1799	20	3	8	1/8	Steel, hot dipped galvanized	0.71	N/A	6.00	Breaking, joint debonding
29	I-1261	24	5	8	1/8	Steel, hot dipped galvanized	0.67	N/A	8.33	Spalling
30	B-1300	36	2.5	8	1/8	Steel, hot dipped galvanized	0.43	0.43	9.67	N/A
31	H-1130	24	3	8	1/8	Steel, hot dipped galvanized	N/A	N/A	9.00	Tracking, spalling
32	B-608	20	3.5	8	1/8	Steel, hot dipped galvanized	0.16	0.73	9.00	N/A
33	B-1557	20	2	8	1/8	Steel, hot dipped galvanized	0.31	0.41	4.00	Joint debonding, pot holes Breaking, spalling

Table 4: District 3 - Centralized Data

No.	Bridge	APJ Width (in)	APJ Depth (in)	Plate Width (in)	Plate Thickness (in)	Plate Type	Thermal expansion (av.) Ext. span (in)	Thermal expansion (av.) Int. span (in)	Condition index	Typical failure
1	H-869	20	2 1/2	8	1/4	Steel, hot dipped galvanized	0.24	0.54	4.00	Breaking, Spalling, Tracking Joint debonding
2	I-871	20	2 1/2	8	1/4	Steel, hot dipped galvanized	0.90	N/A	6.00	Breaking, shoving, pot holes
3	G-872	20	2	8	1/4	Steel, hot dipped galvanized	0.42	0.70	3.67	Breaking, joint debonding pot holes, spalling
4	I-891	25 1/2	2 3/4	8	1/8	Steel, hot dipped galvanized	0.71	N/A	7.67	Breaking, tracking, rutting
5	I-892	25 1/2	2 3/4	8	1/8	Steel, hot dipped galvanized	0.63	N/A	7.00	Tracking, shoving, rutting

Table 4: District 3 - Centralized Data (continued)

No.	Bridge	APJ Width (in)	APJ Depth (in)	Plate Width (in)	Plate Thickness (in)	Plate Type	Thermal expansion (av.) Ext. span (in)	Thermal expansion (av.) Int. span (in)	Condition index	Typical failure
6	B-894	25 1/2	2 3/4	8	1/8	Steel, hot dipped galvanized	0.48	N/A	8.00	Joint debonding, tracking
7	B-895	25 1/2	2 3/4	8	1/8	Steel, hot dipped galvanized	0.48	N/A	8.00	Joint debonding, tracking
8	I-896	25 1/2	2 3/4	8	1/8	Steel, hot dipped galvanized	0.79	N/A	8.33	Joint debonding
9	H-1205	25 1/2	2 3/4	8	1/8	Steel, hot dipped galvanized	0.73	N/A	8.67	Joint debonding, tracking
10	I-879	24	4 1/4	8	1/8	Steel, hot dipped galvanized	0.83	N/A	7.67	Breaking, joint debonding Tracking, shoving
11	I-882	26	4 1/4	8	1/8	Steel, hot dipped galvanized	0.92	N/A	8.67	Breaking, joint debonding
12	I-889	25 1/2	2 3/4	8	1/8	Steel, hot dipped galvanized	0.21	0.35	8.33	Breaking
13	I-890	25 1/2	2 3/4	8	1/8	Steel, hot dipped galvanized	0.16	0.20	8.33	Tracking, shoving, spalling
14	I-859	20 - 24	4 3/4	8	1/8	Steel, hot dipped galvanized	0.17	0.24	8.33	Tracking, spalling
15	I-860	20 - 24	4 3/4	8	1/8	Steel, hot dipped galvanized	0.17	0.24	9.33	Breaking
16	I-915	20	2 1/4 - 4	8	1/8	Steel, hot dipped galvanized	0.16	0.53	6.67	Joint debonding, breaking
17	I-827	24	3 1/4 - 4	8	1/8	Steel, hot dipped galvanized	0.16	0.20	7.33	Tracking, spalling
18	I-831	24	3 1/4 - 4	8	1/8	Steel, hot dipped galvanized	0.16	0.20	7.67	Tracking, spalling, Joint debonding, breaking
19	I-907	24	3 1/4 - 4	8	1/8	Steel, hot dipped galvanized	0.16	0.20	8.33	Joint debonding, spalling
20	I-908	24	3 1/4 - 4	8	1/8	Steel, hot dipped galvanized	0.25	0.36	5.67	Breaking, joint debonding
21	H-909	24	3 1/4 - 4	8	1/8	Steel, hot dipped galvanized	0.16	0.20	8.67	Tracking, spalling
22	B-911	24	3 1/4 - 4	8	1/8	Steel, hot dipped galvanized	0.16	0.20	7.00	Joint debonding, pot holes, Tracking, shoving
23	H-912	24	3 1/4 - 4	8	1/8	Steel, hot dipped galvanized	0.16	0.20	7.00	Joint debonding, pot holes, Tracking, shoving

Table 4: District 3 - Centralized Data (continued)

No.	Bridge	APJ Width (in)	APJ Depth (in)	Plate Width (in)	Plate Thickness (in)	Plate Type	Thermal expansion (av.) Ext. span (in)	Thermal expansion (av.) Int. span (in)	Condition index	Typical failure
24	H-914	24	3 1/4 - 4	8	1/8	Steel, hot dipped galvanized	0.16	0.20	7.33	Joint debonding, pot holes, Tracking, shoving
25	I-832	24.4	4.2	8	1/8	Steel, hot dipped galvanized	0.16	0.20	8.67	Traking, spalling
26	I-835	24.4	4.2	8	1/8	Steel, hot dipped galvanized	0.20	1/4	8.33	Joint debonding, spalling
27	I-836	24.4	4.2	8	1/8	Steel, hot dipped galvanized	0.17	1/5	7.67	Joint debonding, tracking spalling
28	H-1256	20.4	2	8	1/8	Steel, hot dipped galvanized	0.36	0.47	7.67	Breaking, joint debonding spalling
29	I-900	24	5	8	1/8	Steel, hot dipped galvanized	7/9	N/A	8.67	Rutting, tracking
30	I-901	20.4	3	8	1/8	Steel, hot dipped galvanized	0.85	N/A	8.33	Joint debonding
31	H-903	24	5	8	1/8	Steel, hot dipped galvanized	0.72	N/A	8.00	Spalling, tracking, rutting
32	H-905	24	5	8	1/8	Steel, hot dipped galvanized	0.76	N/A	7.33	Joint debonding, tracking pot holes, rutting
33	I-906	24	5	8	1/8	Steel, hot dipped galvanized	0.76	N/A	7.67	Spalling, tracking, rutting
34	H-918	20.4	2	8	1/8	Steel, hot dipped galvanized	0.19	0.35	8.00	Spalling, tracking
35	H-1485	24	5	8	1/8	Steel, hot dipped galvanized	0.73	N/A	8.00	Tracking, joint debonding

3.2 Discussion of Findings

A summary of the findings is shown in Table 5. Most of the distressed joints had the typical APJ distresses, i.e., debonding, spalling, potholes, rutting. A good number of asphaltic plug joints were found in good condition, whereas the remainders were in need of repair or in need of major rehabilitation/replacement. As it can be seen from Tables 2 through 5, the following observations can be made:

- District 1: 1 bridge was in good condition and 1 (the pedestrian) was in fair, but serviceable condition.
- District 2: 14 bridges were in good condition (42%), 17 were in fair condition (52%) and 2 were in poor condition with severe distresses (6%).
- District 3: 31 bridges were in good condition (88%), 3 were in fair condition (9%) and 1 was in poor condition (3%).

Most of the failures appeared to be caused by material distresses, poor installation, and inadequate maintenance. The design factor seemed to be the least leading cause of APJ failure for the NDOT bridges. It should be noted that the District 2, as compared with the District 3, had more unfavorable ratings. Additionally, the APJs of the District 2 were younger in age than those belonging to the District 3. The difference in the ratings of the two districts can be attributed to a number of factors including but not limited to; material failure, installations, skew angle and joint movement.

Table 5 also documents the condition index, distribution of different distresses, and ADT values for bridges of the three NDOT districts. It can be observed that the main distress for the Districts 2 and 3 was due to joint debonding followed by pothole, tracking, spalling, cracking, plate exposure, and shoving. Only two bridges were evaluated for District 1, out of which one was pedestrian. It should be also noted that the climate condition and average temperature differ considerably for the District 1 in comparison with the Districts 2 and 3. No information regarding installation temperature was found.

An APJ database is a useful tool in monitoring behavior and performance of asphaltic plug joints and in assisting to identify appropriate methodologies for maintenance or rehabilitation / replacement.

Table 5: Condition Index and Distribution of Distresses per NDOT Districts

		District		
		1	2	3
		No. of bridges / *(%)*		
Condition Index	Critical	0	0	0
	Poor	0	2 *(6)*	1 *(3)*
	Fair	1 *(50)*	17 *(52)*	3 *(9)*
	Good	1 *(50)*	14 *(42)*	31 *(88)*
Type of Distress (%)	Joint debonding	55	33	26
	Pot holes	0	12	18
	Spalling	10	10	15
	Shoving	0	8	9
	Breaking/cracking	5	7	10
	Tracking	30	23	12
	Plate exposure	0	7	10
ADT	Mean	35350 (one pedestrian bridge)	44813	8070 (assumed for all bridges)
	Standard deviation		46979	
	Max		150000	
	Min		220	

3.3 Samples of "good", "fair" and "poor" APJ conditions

Figures 15 through 18 depict different bridges with APJs in "good" conditions.

Figure 15 Bridge B-764 Eastbound Joint 2

Figure 16 Bridge B-764 Westbound Joint 6

Figure 17 Bridge G-765 Eastbound Joint 6

Figure 18 Bridge H-918 East End

Figures 19 and 20 depict different bridges with APJ in “fair” conditions.

Figure 19 Bridge I-892, Right (shoving, tracking)

Figure 20 Bridge I-871 W East Abutment 2 (shoving)

Figures 21 through 24 depict different bridges with APJ in “poor” conditions.

Figure 21 Bridge G-872 East Abutment (cracking, joint debonding)

Figure 22 Bridge G-872 West Abutment (potholes, cracking)

Figure 23 Bridge H-869E Pier 7 (breaking, joint debonding)

Figure 24 Bridge H-869W Pier 7 (joint debonding, pot holes, spalling)

CHAPTER 4

NATIONAL SURVEY

4.1 States Survey

In the previous chapter, a detailed description of the NDOT APJ bridges was presented. The objective of this chapter is to present the results of a national survey sent to the US Departments of Transportation (DOTs) about their experiences and recommendations regarding the use of asphaltic plug joints.

The main purpose of the survey was to gather information from all the DOTs regarding the use of APJ for new or rehabilitated bridges. Some of the questions required a simple response, whereas other questions required detailed data including a list of the manufacturers used. A copy of the questionnaire is presented below.

Asphaltic Plug Joint Survey

1. *Does your state typically use Asphaltic Plug Joints (APJ's)? If no, why not?*
1. *If yes, what is the typical depth and width of the APJ? Are you following any standards, guidelines, or are you using manufactures specifications, or have you developed your own state specifications?*
2. *If yes, what is the type of plate used (galvanized, stainless steel, other) and what are the typical dimensions of the plate (min. depth and max. width)?*
3. *What other materials are you using for APJ (type of binder, backer rod type, etc)?*
4. *What is the maximum joint movement that is allowed by your agency?*

5. *Did you observed any relationship (influence/interaction) between APJ, plate, binder and distresses developed in pavement?*
6. *Did you observed any correlation between a bad installation and using non conforming materials?*
7. *What is the installation procedure used? Do you follow any standards/guidelines or, are you using manufactures specifications or have you developed your own state specifications?*
8. *Are you using an approved product list for APJ? If yes, please specify.*
9. *How often you maintain the APJ? Do you follow any specific standards/guidelines?*
10. *Are you using APJ for rehabilitation of existing bridges, new bridges or both? In bituminous overlays only or in concrete decks also?*
11. *How does the season variation affect the APJ? List all the factors that contribute to a deteriorate APJ. (skew angle, braking or turning movements, tire chains or studded tires)*
12. *What are the typical problems that you ran into by using APJ?*
13. *What is your experience using APJ (how long have you used APJ)?*
14. *If you have used APJ for a number of years for various projects did you developed a data base?*
15. *If APJ failed what factors can you attributed to that? (failure due to design, installation, maintenance, material distress, etc). Please elaborate.*
16. *If you have any other observations and/or recommendations regarding the use of APJ please specify.*

Nineteen US DOTs (38%) responded. Out of these responses, the following findings can be summarized:

- 26% of the respondents stated that the APJ had a good behavior. They use both state and manufacturer specifications.
- 32% of the respondents reported that their experiences with APJ was not positive; i.e., APJ did not perform well. Some state DOTs even stopped using the APJ.
- 42% of the respondents stated that they do not use APJ.

The survey responses are tabulated in Tables 6 and 7 together with the technical data, manufacturer, APJ width/depth, type of plate, type of backer rod, and typical problems encountered.

Table 6: Response to the National Questionnaire Survey

	States that responded	How many use APJ	What is the response of those who use APJ
1	Alaska	Yes	Not typically - Only two installations that didn't perform well. They stopped using APJ.
2	Arkansas	No	
3	Arizona	No	
4	California	Yes	Good behavior. Use state and manufacturer specs.
5	Colorado	Yes	Good behavior. Use state and manufacturer specs.
6	Florida	Yes	Not typically - Use manufacturer specs. Some of the APJ didn't perform well
7	Idaho	Yes	Good behavior. Use manufacturer specs.
8	Illinois	Declined to respond	
9	Maryland	No	
10	Michigan	Yes	Not typically - Trial installations that didn't perform well. They stopped using APJ.
11	Minnesota	Yes	Occasionally used only for rehabilitation
12	Missouri	No	
13	New Mexico	Yes	Not typically used due to poor performance. Start using Deery Flexable System following its Specs and it's working well until now.
14	Oregon	Yes	Good behavior if install properly
15	South Carolina	Yes	Good behavior. Use state and manufacturer specs. Use only for rehabilitation.
16	Tennessee	No	
17	Utah	No	
18	Washington	Yes	Not typically used due to poor performance. They stopped using APJ.
19	West Virginia	No	

Table 7: Response to the National Questionnaire Survey (continued)

	States	APJ		Max. APJ movem.	Backer Rod	Plate			Manufacturer	Typical problems encountered
		Width	Depth			Width	Thickness	Type		
1	Alaska	N/A		N/A	N/A	N/A			N/A	Movements > 2-in, Freeze/thaw cycles, Unfamiliarity with repair methods, installed on vertical crest curves, failure of base asphalt material
2	California	12"-16"	2"-4"	2"	closed cell foam	8"	1/4"	Steel A36/A36M	N/A	Heaving of material in the shoulder where traffic does not compact it. Cracking of material if placed less than 2" thick.
3	Colorado	20"	3"	1/2"	N/A	5"-15"	1/4" - 5/8"	Steel A36	Varies	De-bonding at the edges, Cracks within the APJ, Delamination, Bonding failure, poor installation, excessive horizontal movements
4	Florida	N/A		N/A	N/A	N/A			Koch Joint[1]	Heat / sunshine
5	Idaho	20"	2"	1" - 2"	closed cell foam	8"	1/4"	Steel Alumin	Matrix 502[2], Wabo[3] BJS[4], Deery Flex.[5]	N/A
6	Michigan	N/A		N/A	N/A	N/A			Pavetech[6] ThormaJoint[7]	Surface wear, Rutting, Material separation, poor design
7	Minnesota	20"	2"	1"	closed cell foam	8"	1/4"	mild steel	N/A	Delamination, cracking, rutting, sharp skewes
8	New Mexico	N/A		1 1/2"	closed cell foam	N/A	Galv steel		Deery Flexable[5]	None with Deery Flexable, previous problems due to design, maintenance, material distress, freeze-thaw cycles
9	Oregon	N/A	2"	1 3/4"	closed cell foam	8"	1/4"	Galv Steel	N/A	Incorrect mix design, improper binder use, workmanship Specify APJ incorrectly, skew angles, studded tires, breaking, chains

Table 7: Response to the National Questionnaire Survey (continued)

	States	APJ		Max. APJ	Backer	Plate			Manufacturer	Typical problems encountered
		Width	Depth	movem.	Rod	Width	Thickness	Type		
10	South Carolina	N/A		2"	closed cell foam	N/A	Steel	A36	Matrix 502[2], Wabo[3] ThormaJoint[7]	N/A
11	Washington	9"	2"	1"	N/A	8"	1/4"	Galv Steel	N/A	Hot weather, traffic impact, displaced material in wheel path Non conforming materials

Note:

1 Manufacturer: Koch Materials Company; Product: Koch Bridge Joint System
2 Manufacturer: The DS Brown Company; Product: Matrix 502™ Asphaltic Expansion Joint System
3 Manufacturer: Watson Bowman ACME Corporation; Product: WABO Expandex Joint System
4 Manufacturer: Nortwest Joints Inc; Product: BJS (Bridge Joint System) by Linear Dynamics Inc.
5 Manufacturer: Deery American Corp.; Product: Deery Flexable Joint System
6 Manufacturer: Pavetech International; Product: Pavetech Joint Systems
7 Manufacturer: Linear Dynamics; Product: Thorma Joint System

CHAPTER 5

Summary, Conclusions, and Recommendations

Asphalt Plug Joint (APJ), which serves as an expansion joint, is a flexible asphalt segment that spans between the bridge deck and abutment. As an expansion joint, it is required to allow bridge movement caused by expansion and contraction, to provide a smooth transition between the approach pavement and the bridge deck, to remain watertight and durable, and to keep debris entering the gap between the bridge deck and the abutment. This type of expansion joint is a load bearing surface that is made with a combination of polymer modified asphaltic binder and properly graded aggregates. There are multiple advantages in using asphaltic plug joints. APJ construction is quick and simple to install in stages, easily repaired and maintained, and relatively inexpensive. It possesses waterproof properties and heals under traffic load and warm temperature. Asphaltic plug joint is not as prone to snow plow damage and it can be cold milled when the road is resurfaced. Noise reduction can also be attributed to asphaltic plug joints.

However, the use of APJ, as an expansion joint, has some disadvantages as well. Notably, among them are: soft and pliable in hot temperatures promoting shoving and tracking, brittle/stiff in cold temperatures, very little accommodation for differential vertical placements, rutting with heavy volume traffic and heaving in low volume traffic, and vulnerability to material distresses, such as delamination, spalling, raveling, debonding, aggregate polishing, and segregation and bleeding.

While APJ is recognized as an effective expansion joint, it is not maintenance free and, thus, periodic replacement is required. Past experience has shown that asphaltic plug joints can be low maintenance for about five years with an expected life of 8 to 10 years if properly designed and installed.

The available inventory of the three NDOT districts revealed that 66% of the asphaltic plug joints were in good conditions, whereas 39 and 5% were in fair and poor conditions, respectively. Most of the joint failures were caused by combination of material distresses, poor installation, and inadequate maintenance.

The results of the US DOT questionnaire were quite revealing. Forty two percent (42%) of the respondents indicated that they do not use asphaltic plug joints. Thirty two percent (32%) of the respondents reported that their experiences with the use of APJ were not satisfactory and this type of expansion joint did not perform within their expectations. The reminder 26% of the respondents stated that their APJs performed well using both state and manufacturer's specifications.

The response received from each participating DOT showed multiple distresses within the APJ conditions. Seventy three (73%) of the joint distresses was due to material failures, 55% of joint failure was attributed to improper design, 45% of the joint distresses had to do with poor installation, and 36% of the joint failures stemmed from inadequate maintenance.

Based on the available information in the literature and responses to the survey regarding design, construction and maintenance of asphaltic plug joints, the following guidelines are offered. It should be noted that verification of quantifiable design parameters and material specifications through experimental research programs is the natural extension of these recommendations.

1 In general, selection of the joint type is based on bridge movement, ADT, and joint location. Asphaltic plug joints are not recommended for airport and pedestrian bridges, and for bridges with slow moving or stationary traffic. It should not be installed where there is turning or breaking movements or in the areas with high thermal shocks. APJs should be used where traffic is straight or when skew angle is less than 30^o.

2 Joint movement should be limited to 3/4 inch or less.

3 Vertical movement should be limited to 1/4 inch or less.

4 Joint gap should be limited to 2 inches.

5 Joint width should be minimum of 16 inches and maximum of 24 inches.

6 While joint depth is a function of overlay depth, it should not be less than 3 inches on average with no location with less than 2 inches.

7 Plate should be stainless steel with a minimum thickness of 3/16 inch.

8 Plate width should be at least 3 ± 0.5 inches plus joint gap. Use of 8 inches plate is common.

9 Backer rod should be heat treated or highly resistant to heat for asphaltic materials.

10 Spikes, a device used to keep the center of plate in line with the center of joint, should be placed 1 to 1.5 feet apart.

11 Construction should be made during nominal temperatures.

12 Quality aggregates and binder should be used. Specifications regarding aggregate type and gradation, asphalt type, binder to aggregate ratio, mixing time, deck condition at the time of placement, placing and deck temperature,

compaction effort (type and weight of steel roller, and number of passes), and cooling period should be established.

13 Performance-based contract should be considered by NDOT (i.e. contractor should guarantee a minimum of 8-10 years of service life before replacement or major rehabilitation).

14 A manufacturer's representative should be present at the site during construction and maintenance.

15 Contractor should be paid by cubic feet as opposed to linear feet.

16 A specification regarding removal of asphaltic plug joint should be developed (i.e., angle of hammer and hammer tip force).

17 Contractors and inspectors should be made fully aware of NDOT materials, design, installation and removal of asphaltic plug joint.

Future studies should aim at developing in-house specifications that include design, materials selection, mixing, placing, compacting, finishing and removal. A guideline regarding repair of asphaltic plug joint should also be developed. Design parameters and material specifications should be verified through experimental programs.

REFERENCES

1. Bramel, B.K., Puckett, J.A., Ksaibati, K., and Dolan, C.W. *Asphalt Plug Joints: Characterization and Specifications*. Report FHWA-WY-99/03F. Wyoming Department of Transportation, University of Wyoming, May 1999.

2. Bridge Joint Association Standard for Asphaltic Plug Joints in UK, Document Ref: BJA/S2/APJ, 2003

3. Chang, L., Lee, Y., "Evaluation and Policy for Bridge Deck Expansion Joints; Final Report." *Joint Transportation Research Program*, *FHWA/IN/JTR*, Purdue Libraries, 2001

4. Chem-Joint 70, High Performance Asphaltic Plug Type Bridge Joint System

5. EMPA Press Release, Asphaltic Plug Joints in road Surfaces – *Greater Longevity Through Updated Guidelines?* (2005)

6. French, James W., McKeel, Wallace T., Technical Assistance Report An Evaluation of Bridge Deck Joint Sealing systems in Virginia (2003)

7. Installation Procedure – Wabo Expandex, Asphaltic Plug Joint System for Bridge and Highway Application, Watson Bowman Acme (2001)

8. Malla, Ramesh B., Shaw, Montgomery T., Shrestha, Matu R., Boob, Smita, Sealing of Small Movement Bridge Expansion Joints, Prepared for the New England Transportation Consortium, NETCR-58, Project No. 02-6, 2006

9. Malla, Ramesh B., Shaw, Montgomery, Shrestha, Matu Raja, Sealing of Small Movement Bridge Expansion Joints (Project No. NETC 02-6), 2003

10. Mogawer, Walaa S., Austerman, Alexander J., Evaluation of Asphaltic Expansion Joints, Prepared for the New England Transportation Consortium, 2004

11. Partl, M., N., Hean, S., Poulikakos L., Asphaltic Plug Joint Characterization and Performance Evaluation EMPA Swiss Federal Laboratories for Materials Testing and Research, Switzerland, 2006

12. PavePrep & PavePrep SA, Reflective Crack Control, Stress Relief Interlayer, Water Proofing Membrane

13. Prismo ThormaJoint – the proven bridge expansion joint

14. Purvis, R., "Bridge Deck Joint Performance." *NCHRP Synthesis 319*, Transportation Research Board, Washington, D. C., 2003

15. USL Britflex "NJ" Expansion Joints

16. Velo, Oscar, Draft Australian Bridge Design Code AS-5100 Section 4 – Bearings and Expansion Joints. Trends in rehabilitation of deck joints and design developments of modular joints, 1996

17. Wabo Expandex Asphaltic Plug joint system for Bridge and Highway Applications Installation Procedure, Watson Bowman Acme, 2001

18. Wabo Expandex Asphaltic Plug joint system for Bridge and Highway Applications Technical Data Watson Bowman Acme, 2001

APPENDIX A-1

APJ Manufacturers

Thorma Joint Technical Data

PRODUCT INFORMATION

Thormajoint - The proven bridge expansion joint

The first choice for bridge engineers seeking effectiveness, economy and reliability.

Description

Thormajoint is a combination of an elastomer modified binder BJ200, and a carefully selected aggregate, BJ Stone. The joint is constructed in-situ and is a hot process.

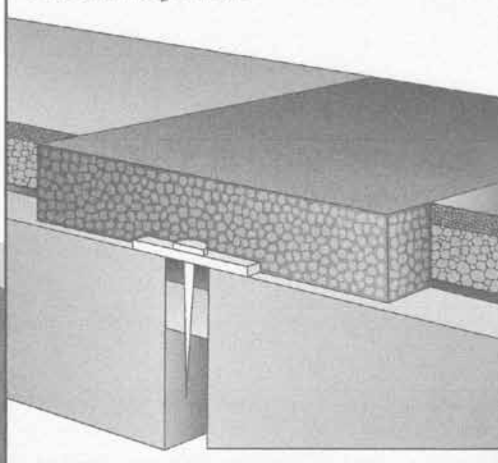
BJ200 is a special blend of bitumen, polymers, fillers and a surface active agent, formulated to combine good fluidity at process temperatures with low temperature flexibility and ambient temperature slump control. It is delivered to site in bags in its solid state, where it is heated in a special pre-heater to its normal application temperature in accordance with the manufacturer's recommendations.

BJ200 is available in a range of grades and is selected according to the climate in which the joint is to be installed. This ensures that it remains flexible even in very cold conditions but does not become too soft in very warm conditions.

BJ Stone is a single-size aggregate preferably from the Basalt, Gritstone, Gabbro or Granite groups. For the standard joint the aggregate size is 20mm to British Standard BS63. In special cases other sizes may be specified, e.g. a 14mm size in shallow joints. The use of single-size aggregate enables a high binder content to be reached and ensures a constant ratio of stone to BJ200, important to give the optimum combination of flexibility and load bearing capacity.

The stone is cleaned, sized and bagged for despatch to site. Immediately prior to use it is further cleaned by being rotated in a perforated drum mixer whilst being heated by hot compressed air to a working temperature range of 150°C – 190°C.

THORMAJOINT



All joints extend the full depth of the asphalt road surfacing and waterproof membrane down to the deck concrete. In certain instances the engineer may decide that a rebate may be created in the concrete, to increase the depth of the joint to the required dimension (table 1).

In gaps up to 30mm wide, an aluminium flashing strip spans the gap to prevent stone entering the gap during joint construction or under the punching action of subsequent traffic. For gaps over 30mm wide, a steel plate is used which also serves to distribute wheel loads across the gap (table 2).

The joint develops a very strong bond to the concrete and to the vertical faces of the adjacent asphalt.

Installation Guidelines

- Remove the asphalt surfacing to the desired width by saw cutting and jack hammering. The asphalt should be completely removed to expose the deck. A clean join to the asphalt is essential. Any waterproofing membrane should be removed.
- Clean out the recess and the expansion gap and prepare with a Prismo hot compressed air lance, as this warms the surrounding surfaces.
- Caulk the expansion gap using Thormafoam.
- Tank the recess with hot BJ200 binder to seal the joint and improve adhesion of the joint to the asphalt.
- Install the aluminum strip or steel plate over the gap.
- Pour stone heated to 150°C – 190°C into the joint to a maximum depth of 40 mm, but not less than 20mm. The layer should then be flooded with binder heated to the correct temperature. This process should be repeated until the joint is within 25mm ±5mm of the surface.
- Apply the Thormajoint pre-mix layer.
- Compact using a compactor or vibrating roller.
- Seal the surface using BJ200.

Prismo

The Prismo

Thormajoint will perform well under most conditions of temperature and traffic flow. However,certain site conditions may detract from its performance and the following guidelines are intended to assist the engineer:

1. The normal maximum recommended gradient is 4% and the Prismo Technical Department should be consulted in respect of steeper gradients.
2. Guidance should also be obtained from the Prismo Technical Department regarding locations where there is likely to be a build up of stationary traffic, such as junctions and traffic lights and where heavy goods vehicles will be skewing on the joint.
3. The standard Thormajoint width is 500mm but may be increased under favourable conditions to a maximum of 750mm. Please consult the Prismo Technical Department for joints in excess of 750mm.
4. Skew angles must be taken into consideration since they increase the effective width or running length of the joint. (A 30° skew produces an effective 15% increase of width, while a 45° skew produces a 41% increase.) Skew should not exceed 45° and in this case maximum joint widths must be limited to 550mm. Longitudinal joints may only be considered when they are not in line with the main wheel track.
5. Movement capability is reduced as depth decreases (see table).

MovementTable:

Joint Width (mm)	Joint Depth (mm)	MaximumHorizontal Movement(mm)
750	100+ 75-100 50-75	±25mm ±25mm ±12mm
500	100+ 75-100 50-75	±25mm ±25mm ±12mm
300	100+ 50-100	±5mm ±5mm

Table 1.

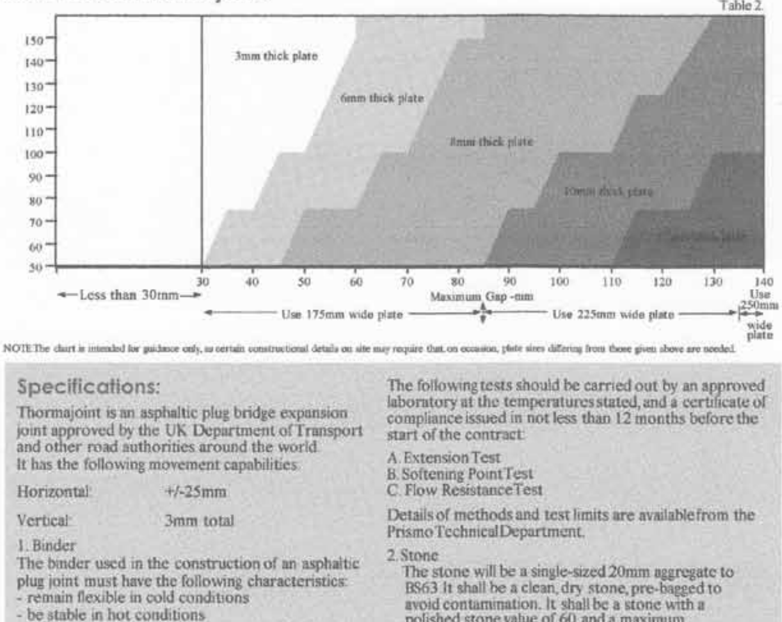
6. Traffic loading will often lead to rapid vertical movements at joints. The total maximum vertical movement capability for Thormajoint is 3mm.
7. Installation of Thormajoint at extremes of temperature should be avoided. If this is not possible, due allowance should be made for the gap position in relation to the expected movement of the joint.
8. The in-joint drainage system may be specified to remove small amounts of water from the joint/surfacing interface. In-joint drainage is not designed to act as drainage for the whole deck. Where a large build-up of water is expected behind the joint, it is recommended that separate deck drainage is used.
9. The various limiting factors are cumulative and care must be taken to avoid situations which lead to an accumulated level of stress. Further guidance may be obtained from the Prismo Technical Department.
10. Due consideration should be given at the design stage to the installation of Thormajoint around ducts in service bays. Pipeways should be capable of withstanding installation temperatures of 190°C. A number of ducts located close together will restrict the capability of the crew to install the joint in the footway.
11. Cure Time: Minimum one hour per 50mm of surfacing. The time may vary according to ambient temperature. Contact the Prismo Technical Department if further guidance is required.

Details of Plates

1. For gaps of maximum 30mm, caulk with Thormafoam and plug with B/200, protected by aluminium flashing strip.
2. For gaps over 30mm, caulking and plugging details as above. For plate size refer to table below.
3. Steel plates should be a maximum of 1 metre in length to aid bedding onto the base of the excavation. In some circumstances it may be necessary to cut the aluminium strip into lengths to reduce the effects of expansion due to heating during installation.

Steel Plates in Thormajoints:

Table 2.



NOTE The chart is intended for guidance only, as certain constructional details on site may require that on occasion, plate sizes differing from those given above are needed.

Specifications:

Thormajoint is an asphaltic plug bridge expansion joint approved by the UK Department of Transport and other road authorities around the world. It has the following movement capabilities:

Horizontal: +/-25mm

Vertical: 3mm total

1. Binder

The binder used in the construction of an asphaltic plug joint must have the following characteristics:
- remain flexible in cold conditions
- be stable in hot conditions
- be flow resistant

The following tests should be carried out by an approved laboratory at the temperatures stated, and a certificate of compliance issued in not less than 12 months before the start of the contract:

A. Extension Test
B. Softening Point Test
C. Flow Resistance Test

Details of methods and test limits are available from the Prismo Technical Department.

2. Stone

The stone will be a single-sized 20mm aggregate to BS63 It shall be a clean, dry stone, pre-bagged to avoid contamination. It shall be a stone with a polished stone value of 60, and a maximum flakiness index of 25.

Prismo UK Contracting:**01302 818300** Prismo Product Services:**+44 (0)1257 225100**
Prismo International: **+44 (0)1257 225100** e-mail:**prismo@jarvis-uk.com** www.prismo.co.uk

APPENDIX A-2

APJ Manufacturers

Chem-Joint 70 Technical Data

Chem-Joint 70

High Performance Asphaltic plug Type Bridge Joint System

PRODUCT DESCRIPTION

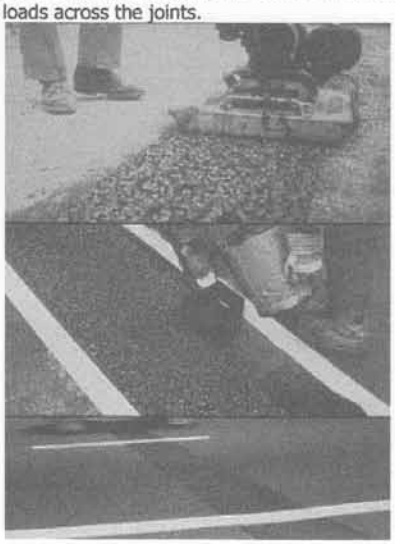
CHEM-JOINT 70 is a combination of polymer modified binder and selected aggregates. The binder is a compound blend of bitumens, polymers, fillers and stabilizers, which is specifically formulated to give good fluidity, low and high temperature stability, and slump control.

CHEM-JOINT 70 is delivered in factory batched 'zip' pails or 4 ply silicone bags ready to be heated by approved pre-heaters.

In standard joints, 20mm graded granite is utilized. For shallower joints other sizes may be specified (please refer to the Technical Services Department). Utilizing single size aggregate allows high binder to aggregate content thereby ensuring optimum combination of flexibility and load bearing capacity.

CHEM-JOINT 70 is available in a range of formulations to suit variations of climates including continental and tropical, thereby ensuring flexibility of the joint in cold temperatures and structural integrity in very warm conditions. **CHEMJOINT 70** is designed to extend the full depth of the road down to the structural concrete deck and will develop a tenacious bond to concrete as well as the adjacent asphalt arises.

For joints up to 50mm wide, an aluminum or steel strip is placed over the joint to prevent aggregate entering the joint. For joints over 50mm, the steel plate assists in the distribution of wheel loads across the joints.



USES

CHEM-JOINT 70 is a hot process in-situ constructed expansion joint system capable of accommodating movments up to 70mm (± 35mm). It forms an integral part of the wearing course.

PRODUCT FEATURES

- Flexible and completely waterproof.
- Ability to accommodate longitudinal, rotational, and transverse movements.
- Easy and quick repairs following accidental damage should this occur.
- Able to withstand extremes of temperature from –30°C to +60°C.
- Low surface noise and excellent ride quality.
- Quick installation, thereby minimizing disruption to traffic flows.
- Can be used across the full depth of the bridge deck.
- Accepts Anti-skid finishes.
- Very low maintenance

SPECIFICATION COMPLIANCE

CHEM-JOINT 70 has been tested to the latest ASTM, British Standards, and TL Min specifications.

PACKAGING

CHEM-JOINT 70 is supplied in 30 kg 'zip' pails or 25 kg bags. Ready to use aggregate is available in 50 kg bags.

TECHNICAL DATA

Chem-Joint 70 Binder Selection Table

Grade	Service Range, °C (°F)
Chem-Joint 70 STD	-5 to 30 (23 to 86)
Chem-Joint 70 C	-30 to 35 (-22 to 95)
Chem-Joint 70 H	0 to 60 (32 to 140)

Movement Accommodation Table

Joint Width, mm (in)	Joint Thickness, mm (in)	Maximum Movement (%)
750 (30)	100+ (4+)	± 25
	75 to 100 (3 to 4)	± 25
	50 to 75 (2 to 3)	± 12
500 (20)	100+ (4+)	± 25
	75 to 100 (3 to 4)	± 25
	50 to 75 (2 to 3)	± 12
300 12	100+ (4+)	± 5
	50 to 100 (2 to 4)	± 5

APPLICATION DATA

Preparation:

The sealing recess prior to application of **CHEM-JOINT 70** must be thoroughly prepared by template former for new works or in the case of remedial works; asphalt surfacing is removed to recommended width by saw cutting and jack hammering. The asphalt must be removed completely to expose the deck. All traces of waterproofing membrane must be removed. Failure to do so will form a bond break.

Where previously mechanical joints have been used, all fixing bolts must be trimmed flush with deck.

The recess and the expansion joint is cleaned and prepared using a hot compressed air lance thereby ensuring that the surface is free from contaminants and it is warm ready to receive the **CHEM-JOINT 70** binder.

Installation:

Ensure that the expansion joint is sealed with good quality cross-linked polyethylene foam. The recess is tanked with hot **CHEM-JOINT 70** binder that has been heated in an approved pre-heater to its application temperature in accordance with the company's instructions.
Aluminium strip or steel plate is placed over the expansion joint. Aggregates is pre-heated to 150°C - 190°C and placed into the joint to a maximum depth of 40mm but not less than 20mm.
The layer is then floated with the correctly heated binder and the process is repeated until the joint is within 25 mm of the surface.
For final 25mm layer apply pre-mix layer and compact using a compactor or vibrating roller. Seal surface using **CHEM-JOINT 70** binder.

STORAGE

Store **CHEM-JOINT 70** binder in cool dry storage facilities. Do not expose to direct sunlight or heat.

SAFETY PRECAUTIONS

Keep Out of the Reach of Children

Adequate precautions and care must be taken duing usage and storage. Avoid direct contact with eyes and skin. Keep away from children and animals. Any direct contact with skin, eyes, etc. should be washed thoroughly with clean water. Use proper safety wear, goggles, and masks, etc.

TECHNICAL ASSISTANCE

Please contact International Chem-Crete Corporation for Technical Personnel.

WARRANTY

LIMITED WARRANTY: International Chem-Crete Inc. warrants that, at the time and place we make shipment, our materials will be of good quality and will conform to our published specifications in force on the date of acceptance of the order.

DISCLAIMER: The information contained herein is included for illustrative purposes only and, t the best of our knowledge, is accurate and reliable. International chem-crete Inc. is not under any circumstances liable to connection with the use of information. As International Chem-Crete Inc. has no control over the use to which others may put its products, it is recommended that the products be tested to determine the suitability for specific applications and/or our information is valid in a particular circumstances. Responsibility remains with the architect or engineer, contractor and owner of the design, application and proper installation of each product. Specifier and user shall determine the suitability of the product for specific application and assume all responsibility in connection therewith. AA/0606.

Manufactured By:

International Chem-Crete Inc. , 800 Security Row, Richardson , TX 75081, U.S.A
Tel: (972) 671-6477, Fax: (972) 238-0307
contactus@chem-crete.com www.chem-crete.com

APPENDIX A-3

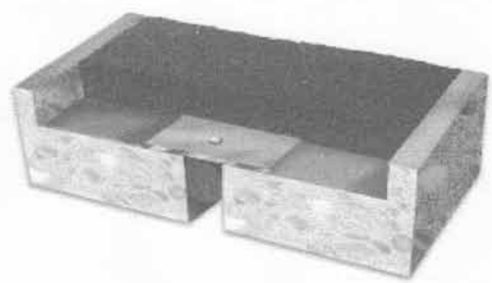
APJ Manufacturers

Wabo Expandex Technical Data

Wabo®Expandex

Asphaltic Plug Joint System

Features	Benefits
• Simplicity	Low cost expansion joint system with smooth top finish. Hot applied binder and aggregate eliminates need for mechanical anchors.
• Versatility	Can accommodate inconsistencies in the expansion joint opening.
• Ease of Installation	Single pour application, yields minimum traffic downtime.



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.

RECOMMENDED FOR:

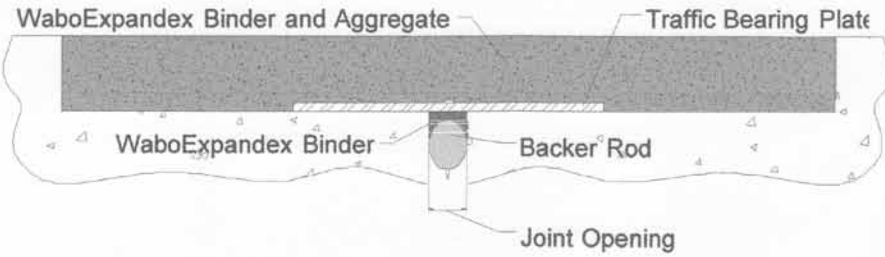
- Sealing joints on secondary highway bridge structures.
- Expansion joint openings with movements up to +/- 0.75" at time of installation
- Repair and maintenance of existing joints.
- Asphalt Overlay projects.

PACKAGING/COVERAGE:

- Wabo®Expandex elastomeric binder is supplied in standard 30 lb blocks (1 block per unit).
- Specialty aggregate is supplied in 40 lb bags, 2 bags per unit.
- Traffic bearing plate is supplied in standard 6'-0" lengths.
- Coverage:
  - 1 unit of Wabo®Expandex will yield 1,200 in^3 (19,664 cm^3).
  - One unit will provide enough material for 2.5 LF of joint length, based on a standard blockout of 2"d x 20"w

BASF
The Chemical Company

TECHNICAL DATA:



Physical Properties:
Elastomeric Binder
Modified elastomeric binder shall meet or exceed the requirements of ASTM-3405 and ASTM-1190.

PHYSICAL PROPERTY	ASTM TEST METHOD	REQUIREMENTS
Binder Only		
Cone Penetration @77°F (25°C)	D 3407	75 max.
Resilience	D 3407	60% min.
Bond @0°F (-18°C) 100% Ext.	D 3407	Pass 3 Cycles
Flow @ 140°F (60°C)	D 3407	2mm max.
Asphalt Compatability	D 3407	Complete
Ductility	D 113	40 min.
Aggregate Sieve Size		
B Size Granite	1.00"	100%
	0.50"	90% to 100%
	0.25"	0 to 15%
C Size Granite	1.50"	100%
	1.00"	90% to 100%
	0.50"	0 to 15%

APPLICATION

Installation Summary:

- 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.
- Measure the blockout to insure the dimensions are correct. The blockout width must be at least 20" and not exceed 24" and a depth of at least 2". All surfaces must be dry, abrasive blast the blockout to remove all latencies and contaminants which may cause bonding problems. Clean the blockout of dust and debris with hot air lance.
- Place backer rod into the joint opening and pour the properly heated binder material filling the joint opening and spreading the binder evenly by coating all interfaces and surfaces of the blockout.
- Position and center the traffic bearing plates over joint gap. Insert the proper nails into the pre-drilled holes of the plate and pour the properly heated binder evenly over the bearing plates completely encapsulating the plates.
- Place pre-measured granite aggregate into a rotating drum mixer and heat to a minimum of 350°F (176°C).
- Pour recommended amount of heated binder (check for min. temperature of 380°F (193°C) into pre-calibrated container and add it to the heated aggregate. Mix binder and aggregate for approximately 3 minutes or until all aggregate is fully coated.
- Pour aggregate and binder mixture in blockout leveling the mix with the deck surface. See installation procedure for compaction instructions.
- Seal top surface of joint with heated binder.

Options/Equipment:

- Oil jacketed, double boiler asphalt melter with built in agitator.
- Rotating mixers.
- Hot air lance.
- Two-ton roller.

For Best Results:

- Install when concrete substrate is clean, sound, dry, and cured (14 day minimum).
- Do not install if the joint's anticipated movement will exceed +/- ¾" or if the joint opening is greater than 3" at the time of installation.
- Do not install at joint locations with skews greater than 45 degrees.
- Do not install at joint locations where dynamic intermittent vertical displacements exceed ¼".
- Protect the work area with appropriate plastic sheeting.
- Do not allow any of the components to freeze prior to installation. Store all components out of direct sunlight in a clean, dry location between 50°F (10°C) and 90°F (32°C).
- Shelf life of chemical components is 1 year.
- Periodically inspect the applied material and repair localized areas as needed. Consult a Watson Bowman Acme representative for additional information.
- Make certain the most current version of the product data sheet is being used. Please consult the website (www.wbacorp.com) or contact a customer service representative.
- Proper application is the responsibility of the user. Field visits by Watson Bowman Acme personnel are for the purpose of making technical recommendations only and not for supervising or providing quality control on the jobsite.

Related Documents:

- Material Safety Data Sheets
- Wabo®Expandex Specification
- Wabo®Expandex Sales Drawings
- Wabo®Expandex Installation Procedure

APPENDIX A-4

APJ Manufacturers

Matrix 502 Technical Data

D.S. BROWN
300 East Cherry Street. • North Baltimore OH 45872
1-800-848-1730 • (419) 257-3561 • FAX (419) 257-2200
www.dsbrown.com

PRODUCT DATA SHEET

MATRIX 502 ASPHALTIC PLUG BRIDGE JOINT SYSTEM

DECEMBER 2005

READ BEFORE USING THIS PRODUCT

GENERAL: The Matrix 502 Asphaltic Plug Bridge Joint System is a hot applied field molded and constructed expansion joint system that is primarily composed of a uniquely formulated polymer modified asphalt binder that is mixed with specially selected and processed aggregate. The Matrix 502 Joint provides a watertight, smooth riding joint that can accommodate up to a maximum of ± 3/4" (19 mm) of annual joint movement and can be used for expansion joint gaps up to 3" (75 mm) wide. The joint is installed in cutouts in the deck surfacing ranging from 2 to 6 inches deep (5 to 15 cm) and 20 to 24 inches (51 to 61cm) wide. The Matrix 502 Joint can be used for both expansion and fixed end joints at abutments or piers in many bridge types including concrete slab, concrete beam, prestressed concrete and steel beam, either simple or mulitspan, in both new construction and rehabilitation projects. The joint is placed in the deck-surfacing layer of either asphalt concrete or portland cement concrete to a minimum depth of 2" (5 cm). Completed joints are black in color. The Matrix 502 Joint can also be used as a pressure relief joint on bridge approach slabs. Compared to conventional anchored bridge joint systems, Matrix 502 Joints are low cost, quick and easy to install and easy to maintain. The Matrix 502 Asphaltic Bridge Joint System meets requirements of ASTM D6297, Standard Specification for Asphaltic Plug Joints for Bridges.

COMPONENTS: The Matrix 502 Asphaltic Plug Bridge Joint System is primarily composed of Matrix 502 binder and two grades of Matrix 502 aggregate. Additional components include primer, backer rod, bridging plates and locating pins. Details and specifications for these components follow.

MATRIX 502 BINDER, Part No. 34528

A specially formulated hot applied polymer modified asphalt binder that is mixed with aggregate forming a bonded, flexible, extensible, compressible and traffic resistant joint system. Matrix 502 Binder meets the polymeric modified asphalt requirements of ASTM D6297 when sampled and heated in accordance with ASTM D5167.

Test	ASTM D6297 limits
Softening Point (ASTM D36)	182°F (83°C) min.
Tensile Adhesion (ASTM D5329)	700% min.
Ductility, 77°F (25°C) (ASTM D113)	400 mm min.
Cone Penetration, 77°F (25°C) (ASTM D3407, D5329)	7.5 mm max.
Low Temperature Cone Penetration 0°F (-18°C) 200g, 60s (ASTM D6297, sec 9.1)	1.0 mm min.
Flow 140°F (60°C), 5 hr. (ASTM D3407, D5329)	3.0 mm max.
Resilience, 77°F (25°C) (ASTM D3407, D5329)	40-70%
Asphalt Compatibility (ASTM D3407, D5329)	Pass
Recommended Installation Temp. Range	360-390°F (182-199°C)
Safe Heating Temp. Range	390-421°F (199-216°C)
Bond, +20°F (-7°C), 100% extension (ASTM D3405, D5329)	Pass 3 cycles
Flexibility at -10°F (-23°C) (ASTM D5329)	Pass

Additional specific properties of Matrix 502 Binder are as follows.

Test	Requirements
Bond, 0°F (-18°C), 50% Extension (ASTM D5329)	Pass 5 cycles
Brookfield Viscosity, 400°F (204°C) (ASTM D4402)	4000 cp max.
Installation Temperature	380°F (193°C)
Safe Heating Temperature	410°F (210°C)
Unit Weight at 60°F (15°C)	9.3 lbs/gal (1.12 kg/l)

Packaging consists of individual boxes of product that are palletized into shipping units. Boxes contain a non-adherent film that permits easy removal of the sealant. Each pallet contains 72 boxes that are stacked in six layers of 12 boxes per layer. The weight of product in each box does not exceed 40 lbs. (18 kg) and pallet weights do not exceed 2,880 lbs. (1310 kg). Pallets of product are weighed and product is sold by the net weight of product. Product boxes are manufactured from double wall kraft board producing a minimum bursting test certification of 350 psi (241 N/cm²) and using water resistant adhesives. Boxes use tape closure and do not contain any staples. Boxes are labeled with the product name, part number, lot number, specification conformance, application temperatures and safety instructions. Palletized units are protected from the weather using a three-mil thick plastic bag, weather and moisture resistant cap sheet and a minimum of two layers of six-month u.v. protected stretch wrap. Pallets are labeled with the product part number, lot number and net weight.

MATRIX 502 AGGREGATE SBG, Part No. 33032 and AGGREGATE D, Part No. 33030

Specially selected igneous aggregates that are screened to specific gradations, double washed, dried and packaged in 50 lb (22.7 kg) bags. SBG aggregate is mixed with the Matrix 502 Binder to produce the mastic to fill the joint cutout. D aggregate is a finer grade, used as surface dressing for the completed joint. Gradation requirements are as follows.

SBG AGGREGATE		D AGGREGATE	
Screen Size	**% Passing**	**Screen Size**	**% Passing**
1"	95-100%	3/16"	100%
3/4"	90-100%	NO 6	90-100%
1/2"	50-70%	NO 8	25-40%
3/8"	25-40%	NO 10	0-10%
1/4"	0-15%		

BRIDGING PLATES, Part Nos. 33050, 33051, 33052, 33053

Bridging plates are used to span the expansion joint opening, to function as a bond breaker and to support traffic loads. Four different plates are available for different specifications. All bridging plates are 8" (20.3 cm) wide and 60" (1.52 m) long, and have 3/16" (4.8 mm) diameter holes at the centerline of the plate at 1' (30.5 cm) intervals for centering over the joint. Plate details are as follows.

Part Number	Material	Thickness	Specification	Typical Uses
33050	Aluminum	18 gauge	ASTM B209/3003-H14	Light traffic, narrow joints, corrosion resistance
33051	Steel	1/8" (3.2mm)	ASTM A36 (36m)	Standard
33052	Steel	1/4" (6.4mm)	ASTM A36 (36m)	Heavy traffic, wide joints
33053	Galvanized Steel	1/4" (6.4mm)	ASTM A36 (36m), ASTM A123	Heavy traffic, wide joints, corrosion resistance

LOCATING PINS

16D galvanized common nails are placed through the holes in the bridging plates and down into the expansion joints opening to center the plate over the opening.

CRAFCO ASPHALT PRIMER, Part No. 33140

A specially formulated solvent-based asphalt primer used to treat all bonding surfaces to improve adhesion. Supplied in 5 gal (17.9 l) pails. Primer exceeds requirements of ASTM D41, Type II.

BACKER ROD, Part No. 34609

A closed cell heat resistant backer rod used to provide back up in the expansion joint opening. Backer rod is 2" (5 cm) diameter and supplied in 6' (1.8 m) lengths. Meets requirements of ASTM D5249, "Standard Specification for Backer Material for Use with Cold and Hot Applied Joint Sealants in Portland Cement Concrete and Asphalt Joints, Type 1". If required, other diameters can be supplied.

TYPICAL INSTALLATION Figure 1 shows a typical installation of the Matrix 502 Asphaltic Plug Bridge Joint System. Locations of each of the components are shown.

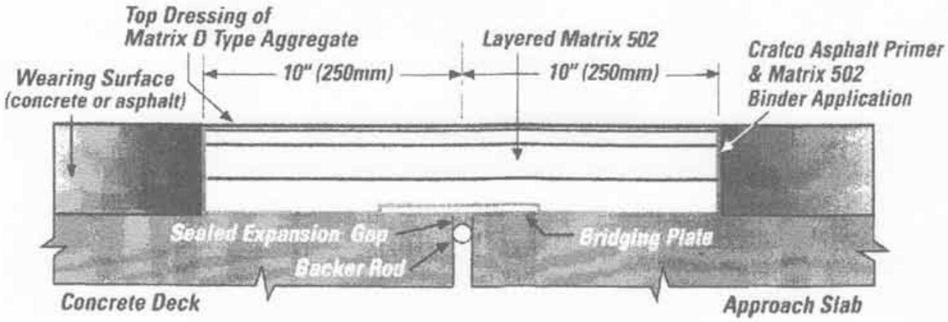


Figure 1. Typical Matrix 502 Asphaltic Plug Bridge Joint System

OVERVIEW OF INSTALLATION PROCEDURES

Following is an overview of installation procedures for the Matrix 502 Joint. For complete detailed installation procedures, refer to the "Installation Procedures for Matrix 502 Asphaltic Plug Bridge Joint System".

1. Transversely saw cut the surfacing layer full depth to the deck surfacing on each side of the joint. Width between cuts is 20 to 24 inches (51 to 61 cm) and centered over the joint gap. Minimum saw cut depth is 2" (50 mm).
2. Break out and remove all material between the saw cuts, including any waterproofing if present, to the concrete deck surface.
3. Clean the cutout area and thoroughly dry with a hot air lance.
4. Prime all vertical and horizontal surfaces with Crafco Asphalt Primer and allow to cure.
5. Place backer rod into the expansion gap to the appropriate depth.
6. Fill the expansion gap with heated Matrix 502 Binder and overfill onto the deck surface.
7. Place bridging plates into the hot Matrix 502 and center over the expansion gap using centering pins. Butt the plates at ends.
8. Coat all vertical and horizontal surfaces, including the bridging plate with hot Matrix 502 Binder.
9. Heat the Matrix SBG aggregate to 275-375°F (135-163°C) in an appropriate rotating drum mixer. Heat Matrix 502 Binder to 380-410°F (193-210°C) in a double-jacketed melter.
10. Add the appropriate quantity of Matrix 502 Binder to the hot aggregate and mix in the mixer to thoroughly coat the aggregate.
11. Place the hot aggregate-binder mixture in the joint cutout in layers between 3/4" and 1 1/2" (19-38 mm) thick. Rake the mixture to level in the cutout.
12. Flood the bonded mixture surface with Matrix 502 Binder to fill voids before placing the next layer.
13. For the last layer, slightly overfill the joint cutout by approximately 1/4" to 1/2" (6 – 12 mm) and compact to surface level.
14. Carefully heat the top surface of the compacted mixture with a heat lance and spread a thin layer of Matrix 502 Binder over the mixture surface.
15. Immediately apply a layer of D aggregate onto the hot binder and compact the aggregate into the surface.
16. Allow the joint to cool, sweep any loose aggregate, clean up the job site and open to traffic.

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

APPENDIX A-5

APJ Manufacturers

Polyjoint Technical Data

A.H. Harris & Sons, Inc.

HARRIS

CONSTRUCTION SPECIALTIES

Since 1916

HARRIS Harris Polyjoint

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)

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.

APPENDIX A-6

APJ Manufacturers

Wyoming Equipment Sales - A.P.J. Technical Data

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 Amy 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 *

APPENDIX A-7

APJ Manufacturers

RAB Plug Joint Technical Data

RAB PLUG JOINT

Product Data Sheet

ISSUE STATUS: 1 MARCH 2007

RAB plug jointing material is a flexible hot mix bitumen rubber material used in the manufacture of Asphaltic Plug Joints (APJ's)

Features and Benefits

- Completely impervious to water
- Excellent bonding properties
- Extremely flexible, even at low temperature

Description

RAB plug joint is a blend of bitumen, polymers, rubber compounds and fine filler blended with graded coarse aggregates in the manufacture and installation of asphaltic plug joints.

Product Details

Colour	-	Black
Product Packaging / Format	Block	10Kg
Storage	Pallet	Cool / Dry
Shelf Life	Unlimited*	
Optimum Laying Temperature	-	150 - 170°C
Maximum Safe Temperature	-	180°C

* If stored as recommended

Typical Physical Properties	Requirement	Typical Result	Test Method
Specific Gravity	N/A	1.21	-
Softening Point (Ring and Ball)	> 85°C	93°C	BS 2000:Part 58
Resilience	> 40%	45%	BS 2499:Part 3
Flow Resistance (5hrs@ 60°C)	< 1mm	No movement	BS 2499:Part 3
Movement Accommodation (0°C)	N/A	200%	-
Movement Accommodation (-20°C)	N/A	22%	-
Tensile Adhesion (Concrete)	> 0.5N/mm²	0.62N/mm²	BD47/99:Section 4.2
Tensile Adhesion (Asphalt)	N/A	0.70N/mm²	BD47/99:Section 4.2

IKO Plc – Permanite Asphalt

IKO Plc Head Office – Appley Lane North, Appley Bridge, Wigan, Lancashire, WN6 9AB **Tel** – 0800 028 5573
Fax – 0800 013 5574 **E-Mail** – marketing@ruberoid.co.uk
Permanite Sales – Coney Green, Clay Cross, Chesterfield, Derbyshire **Tel** – 0800 389 9271

Product Data Sheet

Site Installation

- All prepared surfaces must be free form dust, latence and moisture.
- Clean surfaces with dry compressed air.
- When applicable, application surface should be primed with fast drying primer and allowed to dry, typically one hour in normal ambient temperatures.
- RAB plug joint is melted in mechanically agitated cauldron or similar to a recommended installation temperature of between 150 and 170ºC. At no stage must the temperature exceed 180ºC as material performance properties will be affected.
- Bring to working temperature, do not overheat. Avoid prolonged heating (in excess of 6hrs).
- The material is installed in accordance with the requirements for the installation of Asphaltic Plug Joints.
- It is recommended that the product be used once heated and that no attempt is made to re-use the material once it has cooled.

Specification Clauses

Not applicable

Health and Safety

A detailed Health and Safety data sheet is available from Permanite Asphalt on request. Tel: +44(0)1629 580680 (Reference PADSDS 04)

Technical Design and Support

Technical advice can be obtained from Permanite Asphalt Technical Services Department on +44(0)800 783 3210

Other Products

Permanite Asphalt manufacture a wide range of asphalt roofing, flooring, paving, tanking, road repair / reinstatement, bridgedeck and flood defence products.

Full product literature is available on request.

IKO Plc – Permanite Asphalt
IKO Plc Head Office – Appley Lane North, Appley Bridge, Wigan, Lancashire, WN6 9AB **Tel** – 0800 028 5573
Fax – 0800 013 5574 **E-Mail** – marketing@ruberoid.co.uk
Permanite Sales – Coney Green, Clay Cross, Chesterfield, Derbyshire **Tel** – 0800 389 9271

Nevada Department of Transportation
Rudy Malfabon, P.E. Director
Ken Chambers, Research Division Chief
(775) 888-7220
kchambers@dot.nv.gov
1263 South Stewart Street
Carson City, Nevada 89712