PAVEMENT OVERLAY BOND WITH PREFORMED BRIDGE MEMBRANES

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Prepared By:
Ronald I. Frascoia
Research and Development Supervisor

Reviewed By:

Robert F. Cauley

Robert F. Cauley, P.E.
Materials and Research Engineer

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Introduction

Premature failures of bituminous overlay and membrane waterproofing systems are typically caused by the lack of adequate bond between the pavement and the membrane surface. The failures occur mainly on steep grades, banked decks or where the traffic is braking for turning movements or stopping requirements.

There are a number of factors which can effect bond development and when failures occur it is often due to a combination of inappropriate materials, poor conditions or faulty procedures.

Some of the more important factors directly relating to the bonding properties of the membrane products include the type of surface material, the amount of surface tack, the potential for partial elastomer migration up through a surface reinforcement into the mix and the tensile strength of the membrane surface.

Environmental conditions which can effect bond development include the presence of water, excessive dirt/dust and cold ambient temperatures.

Paving materials and construction procedures which can effect bond include mix coarseness/fineness, overlay thickness, mat temperature at the time of compaction,tenderness of the mat and resulting creep of the material during initial compaction, the compaction effort applied and the rolling technique followed.

Manufacturers and user agencies routinely test new membrane materials for pavement compatibility and bond in the laboratory. However, such tests using a compression load or compaction using a Marshall hammer and confining mold cannot duplicate the action of the field compaction roller. An example can be seen in Vermont Report U88-15 which describes field failures of the Royston 10-AR membrane while laboratory tests revealed excellent bond with the product over a wide range of mix temperatures.

Reports of pavement failures on Maine bridge decks waterproofed with W.R. Grace's Highway and Bridge Membrane early in the 1992 construction season led Vermont to prohibit use of the product. Since the Highway and Bridge Membrane was considered by Grace to be the same as their Bituthene 5000, a product approved and used in Vermont for 20 years, plans were developed to evaluate the substitute product in the field to determine compatibility and bond with Vermont's bituminous mixes.

For comparison purposes, approved membrane systems and other products being considered for use were included in the field test. The products evaluated were as follows:

W.R. Grace's Bituthene 5000* and Highway and Bridge Membrane**
Protectowrap's M-400A* and M-140A(R)*
Royston's 10A* and 10AN**
Northern Elastomeric's C-6000** and C-7000**

* approved
** experimental

FIELD TEST LOCATION, CONDITIONS, MATERIALS, AND PROCEDURES:

The field test was conducted on the Waterbury-Duxbury-Moretown BRF 013(10) project on Routes 2 and 100 on the south end of Waterbury Village. The specific test location was on a 175' long side street known as River Road, which begins at the northeast corner of the new bridge and follows the Winooski River's east bank up stream.

The test area had been paved one day earlier, on 10/5/92, with a Vermont Type III, bituminous pavement. Two 5' +/- long strips of each product were placed in random order, approximately 2' off a granite curb and guard rail. Sample placement was preceded by the installation of a 12" x 20' piece of plastic sheeting intended to prevent the center portion of the membrane samples from bonding to the underlying pavement, thus facilitating their removal following saw-cutting of the surface overlay.

Ambient temperature ranged from 43 degrees F. to 47 degrees F. with sunshine during placement of the membrane products and the bituminous overlay.

Paving of the bituminous overlay began at 10:30 am and was completed at 10:40 am. Mix temperatures in the truck were measured at 290 degrees F. to 320 degrees F. Mix temperatures in place were recorded at 280 degrees F. to 290 degrees F. A thermocouple placed on membrane sample #3 revealed a maximum top mat temperature on the membrane surface of 265 degrees F. Mix at the thermocouple location was rolled within 1 minute, while the temperature was 240 degrees F. The roller's 4th pass over the thermocouple occurred 9 minutes after the mix was placed and the temperature had dropped to 185 degrees F.

Mix compaction was obtained with a 12 ton, steel wheeled, dual drive, Hoister Compactor. The pavement mat appeared very stable and did not appear to creep when rerolled in the opposite direction.

Field lab tests on the Type III mix were in compliance with the specifications. Values on the 75 blow marshall design mix included 6.1% asphalt content, 2,292 lb. stability and air voids of 4.4%. The aggregate gradation consisted of 100% passing the 1" sieve, 98% passing the 1/2" sieve and 66% passing the #4 sieve.

The retrieval of the 168" x 16" pavement and membrane specimens began when the pavement temperature dropped to 73 degrees F. in the sun, approximately 2 hours after paving was complete. All samples were retrieved without difficulty as the diamond sawing operation proceeded.

The samples were kept on a flat surface until peel/adhesion tests were conducted three days later.

LABORATORY TEST PROCEDURE:

The samples were stored and tested at a laboratory room temperature of 73 degrees F. +/- 2 degrees.

A utility knife was used to cut through the membrane to procure 3" wide by 8" long strips. Four replicates were cut on each sample. One end of each membrane sample was peeled back from the pavement approximately 1". Masking tape was then placed on the 1" tab to prevent slippage of the membrane from the jaws of a duckbill vise grip clamp. "C"-clamps were used to secure the pavement specimen to the steel platform of an Instron test machine. The membrane samples were pulled at a rate of 2"/minute. A stripchart recorder documented the force exerted on each membrane sample as it was peeled at 90 degrees from the bituminous concrete pavement. Testing was carried out in random order.

The average total force required to peel the membrane from the substrate was divided by 3 to calculate the peel adhesion value in pounds per inch-width.

TEST RESULTS

The test results can be seen in Table 1 on page 5.

DISCUSSION AND COMMENTS:

Two of the three "standard performed membranes", Bituthene 5000 and Royston 10-A developed minimum peel adhesion values averaging 1.5 pounds or greater. Since both products have a good record of field performance with regard to pavement/membrane stability, it may be assumed that peel adhesion values of 1.5 pounds or greater are sufficient to resist failure under normal traffic conditions. The presence of a significant amount of bituminous particles on the surface of many of the membrane samples suggests that pavement cohesion may often be the factor which limits the peel/adhesion value more than pavement membrane bond.

Both Protectowrap products displayed excellent pavement/membrane bond. The failures occurred with internal separation of the membrane but the type of failure is not considered a high risk due to the magnitude of the values.

The W.R. Grace Highway and Bridge membrane revealed its' sensitivity to pavement overlay conditions with low but possibly adequate bond values on one sample and no bond on the other. The only significant variable was the mix temperature at the time of initial compaction. The sample rolled within 1 minute of overlay developed no measurable bond while the sample compacted approximately 5 minutes after being overlayed developed an average value of 1.3 pounds. Those results are contrary to the popular belief that higher mix temperatures enhance pavement/membrane bond.

The Royston 10-A product also disclosed significant differences in the bond values of the 2 samples although both averaged 1.5 pounds or greater. One of the two Royston 10AN experimental samples met the 1.5 pound level with the second under 1 pound.

It should be noted that the field test involved the use of a Type III bituminous mix containing 1/2" minus aggregate rather than the 3/8" minus Type IV mix normally specified. The finer Type III mix is used to lessen the risk of membrane puncture but it also could be expected to develop less physical bond to the membrane than the coarser Type II mix used in this field study.

CONCLUSIONS

The following conclusions were reached in this study:

Membrane systems which develop pavement to membrane peel adhesion values of 1.5 pounds or greater should be able to resist pavement slippage/shoving failures under reasonable geometric and traffic conditions.

The cohesive strength of the pavement at the membrane interface may often be the factor which limits the peel/adhesion values more than the pavement to membrane bond.

There is a high risk of pavement/membrane bond failure with W.R. Grace's Highway and Bridge Membrane.

RECOMMENDATIONS

Additional field testing similar to that described in this report should be under taken using Vermont Standard Type III bituminous mix on the approved membranes and other new products under evaluation.

The W.R. Grace Highway and Bridge Membrane could be approved for use if the treatment included the application of a suitable tack coat over the surface of the membrane to insure bond of the bituminous overlay.

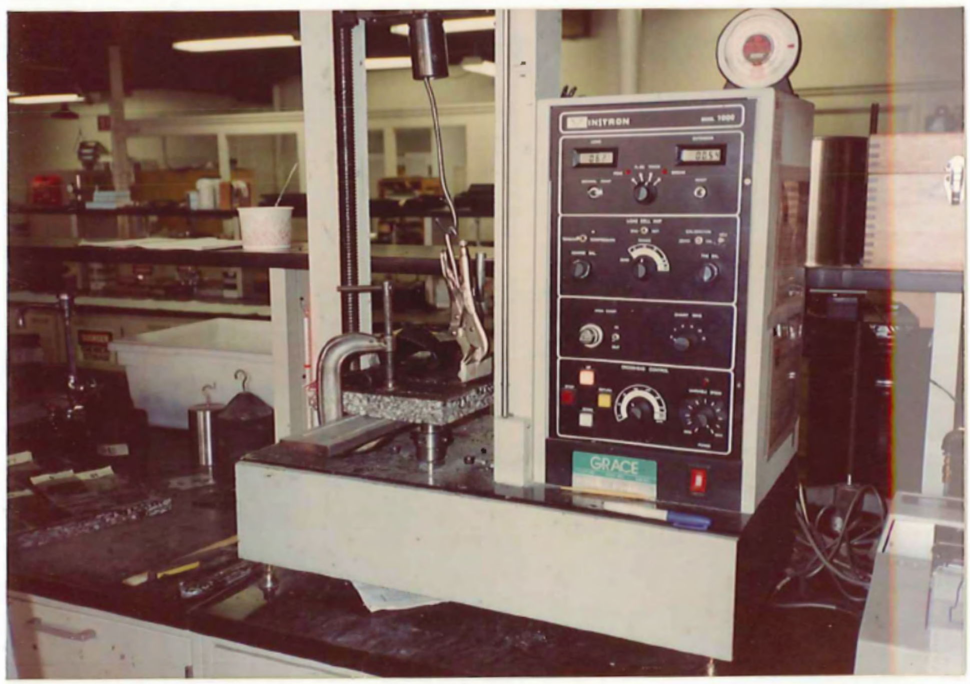
TABLE 1

PAVEMENT BOND TO BRIDGE MEMBRANES
Summary of Product Values

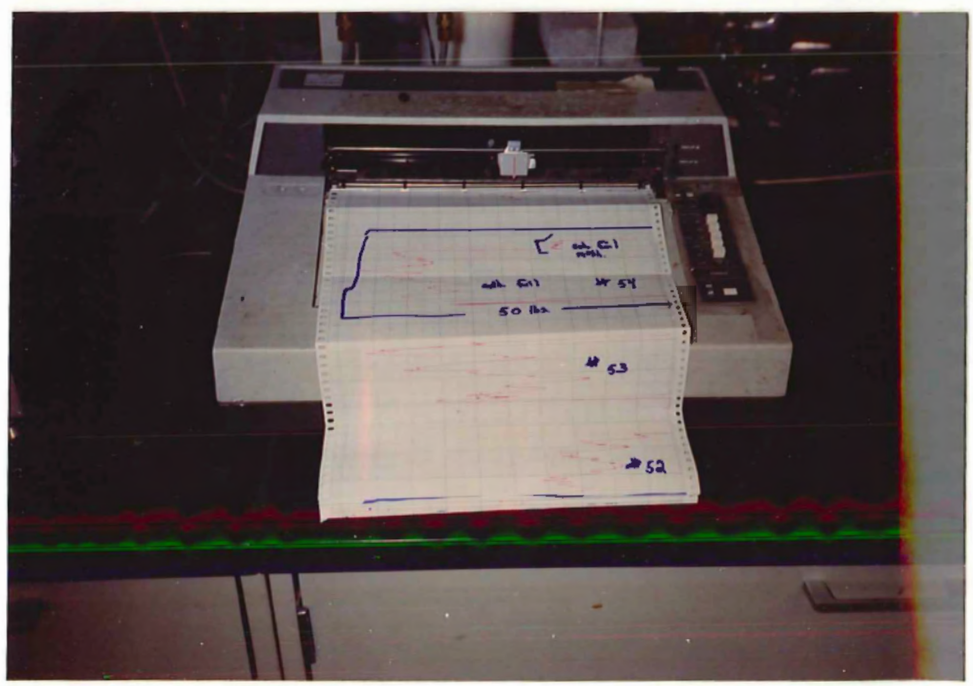
PRODUCT	Lb/in Adhesion				AVG.	MIX TEMP AT INITIAL COMPACTION
Buthene 5000	1.7	1.6	1.8	1.7	1.7	235 deg. F
" "	2.6	1.7	1.4	1.6	1.8	235 deg. F
Grace Hwy & BR	0.1	0.0	0.1	0.0	0.1	240 deg. F*
" "	1.1	1.2	1.0	1.0	1.3	210 deg. F*
Royston 10 A	3.3	3.7	2.6	3.7	3.4	240 deg. F
" "	1.5	1.1	1.4	1.9	1.5	237 deg. F
Royston 10 AN	0.7	0.9	0.8	1.0	0.9	235 deg. F
" "	2.0	1.2	1.0	1.8	1.5	235 deg. F
P-Wrap M400 A	9.7	12.6	13.3	15.3	12.7	240 deg. F
" "	9.2	13.5	12.8	13.5	12.2	230 deg. F
P-Wrap M140 A(R)	6.5	12.6	14.0	12.7	11.5	240 deg. F
" "	10.0	12.0	8.6	12.5	10.8	230 deg. F
NEI C - 6000	2.4	2.5	2.2	2.6	2.4	238 deg. F
" "	1.3	2.7	3.0	2.9	2.5	210 deg. F
NEI C - 7000	2.7	2.4	3.3	3.0	2.9	240 deg. F
" "	2.9	2.7	2.6	2.5	2.7	210 deg. F

* Temperature values recorded with thermocouples located on the membrane surface. Values on other samples are estimated based upon the delay between mix placement and initial compaction.

Preparing Vermont pavement/membrane samples for testing



Pulling a 3" wide membrane strip with the INSTRON test machine



Forces exerted on the samples were registered on the strip chart recorder