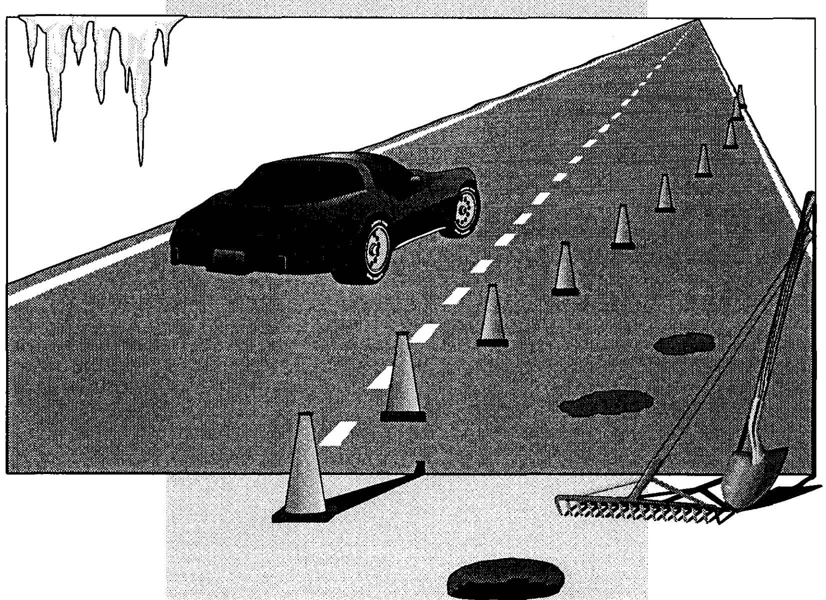
FINAL REPORT

EVALUATION OF COLD MIXES FOR WINTER POTHOLE REPAIR



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Evaluation of Cold Mixes for Winter Pothole Repair

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Abstract

This study was conducted to evaluate the performance of 13 proprietary cold-mix patching materials, 4 of which are currently approved under a Virginia Department of Transportation (VDOT) Special Provision for High Quality Cold Patching Materials. Cold-mix patching materials are regularly submitted to VDOT's Materials Division for approval, and the purpose of this study was to determine which of the submitted materials were of the same caliber as the existing approved materials. The addition of materials of equal quality will promote competition in VDOT's competitive bidding system.

Three test sections were placed to evaluate the materials' performance, and a standardized evaluation form and performance model were developed to rank the materials. The field performance results were compared with the laboratory test results in an effort to develop a laboratory screening test that could be used for other submitted materials. Design and quality control procedures were also identified. These procedures were used to design a material that has performed well. Recommendations for changes in VDOT's cold-mix specifications were also developed.

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(A Cooperative Organization Sponsored Jointly by the
Virginia Department of Transportation and
the University of Virginia)

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ABSTRACT

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INTRODUCTION

The Road Information Program reported that pothole repair costs in 16 eastern and northeastern states increased by 38% in 1994 as a result of the severe winter weather (Virginia Asphalt Association, 1994). Winter weather conditions contribute to accelerated pavement deterioration, which often takes the form of a pothole. A pothole is a localized deterioration of asphalt concrete or portland cement concrete pavement resulting from a loss of material or depression in the pavement surface. Potholes are glaring and often dangerous deficiencies to the traveling public primarily because of the reduction in the ride quality of the pavement. Public discontent is exacerbated when repairs are short lived and the same areas are repaired repeatedly.

Since hot-mix asphalt (HMA) is not available during the winter months when most potholes develop, maintenance crews substitute cold-mix patching materials. An emulsified or cut-back asphalt is mixed with a relatively small (< 9.5 mm) top-size aggregate to produce a material that can be placed in cold, wet weather. Antistripping agents are generally added to reduce moisture susceptibility. VDOT currently has two specifications for cold-mix patching materials: the specification for the Virginia Type P mix, a stockpile material produced with medium cure (MC)-400 cut-back (VDOT, 1991), and a Special Provision for High Quality Cold Patching Materials. The special provision is a list of approved proprietary products developed from a 1991 field study by the Virginia Transportation Research Council (VTRC) (Mahone et al., 1991). Since then, additional products have been submitted to VDOT for approval.

This research aimed at identifying cold-mix materials that would improve patch longevity. Many of these materials are proprietary products with significantly higher material costs than those of conventional cold mixes. However, the material's cost may be insignificant compared to user and placement costs (Wilson & Romine, 1993a; Anderson et al., 1988), especially in the current environment of increased worker safety where the "throw and go" patching techniques of the past are no longer acceptable.

PURPOSE AND SCOPE

The purpose of this study was to evaluate the performance of the proprietary cold-mix patching materials submitted to VDOT to date and develop a performance-based specification for cold-mix patching materials. Three test sections were placed to evaluate their performance. Samples of materials from VDOT's approved proprietary cold-mix patching material list, Virginia Type P cold mix, and HMA were also included. Samples of the mixes (with one exception) were evaluated in the laboratory.

METHODOLOGY

General

Three field test sections were placed to evaluate the performance of the products. Two of the sections were periodically monitored using a standardized evaluation sheet. The third section was placed primarily to evaluate the workability and survivability of the materials in extremely cold weather. Samples collected at the field installations were tested in the laboratory. The results of the laboratory tests were compared with those of the field evaluations.

Materials

The materials tested are listed in Tables 1 and 2.

TABLE 1. APPROVED PROPRIETARY COLD-MIX PATCH PRODUCTS

Company Name	Product Name	Description	Cost/Ton Cold Mix
National Paving and Contracting	Perma Patch	Proprietary cold mix supplied in bags	$258
US Pro-Tec Co.	QPR-2000	Proprietary binder mixed with approved aggregates supplied in bags	$317
Koch Materials Co.	Styrelf Stockpile Patch Mix	Proprietary polymer-modified binder	$30-35
Unique Paving Materials (Sylvax)	Cold-Mix UPM	Proprietary binder mixed with approved aggregate supplied in bags	$217 ($50-65 in bulk)

TABLE 2. CANDIDATE PROPRIETARY COLD-MIX PRODUCTS

Company Name	Product Name	Description	Cost/Ton Cold Mix
American Stone Mix	Sakrete	Proprietary cold mix supplied in bags	$172
Suit-Kote, S.E., Inc.	MacPatch CM-300	Proprietary binder mixed with local approved aggregates	$230
Optimix, Inc.	Optimix Cold Patch	Proprietary binder mixed with local approved aggregates	$50-55
Heilman Pavement Specialties	HEI-WAY	Latex-modified emulsion produced as proprietary cold mix	$40-50
Tough Patch USA	Tough Patch	Proprietary product with 5-year guarantee supplied in buckets	$1,120
Sylcrete Corporation (Flinn Paving Co.)	Sylcrete EV Cold Mix	Proprietary binder mixed with local approved aggregates	$47-53
ReCLAIM, Inc.	RePAVE	Proprietary mix produced from recycled roofing scrap, AC-20, and solvents supplied in bags	$240
Fiberized Products	FiberPave	Standard state mix with polypropylene fibers	$35-45
Seaboard Asphalt Products Co.	Bond-X	Proprietary binder mixed with locally approved aggregates	$32-45

Tests and Measurements

Field Tests

The following field tests were conducted to determine the performance and workability of the products.

Workability

The workability of the materials was closely observed. As each test section was placed, members of VDOT's Yellow Branch and Boyd's Tavern Area Headquarters were questioned on how difficult they felt the products were to place and compact. Specifically, they were asked to rank the workability of each product. Every effort was made to remove the influence of packaging from the ratings. The researchers then categorized the worker's response as good, fair, or poor. For analysis, the categories were assigned a numerical rating from 1 to 3, with 3 being good.

Performance

An inspection form was developed for measuring the performance of each repair. The form rated each repair in the following five categories: bleeding, dishing, debonding (edge disintegration and missing patch), raveling, and pushing and shoving. The categories were chosen and a survey form was developed based on a literature review of the distress modes common to cold-mix patching materials (Smith et al., 1991; Anderson et al., 1988). The patch survey form is shown in Figure 1. Each patch to be evaluated was divided into four quadrants, and each of the five categories was rated on a scale of 1 to 4 based on the criteria presented in the patch survey form for each quadrant. For example, a quadrant with 9.5 mm (3/8 in) of dishing would be given a rating of 3.

The five categories were defined and rated as follows:

1. *Bleeding* is the flushing of the asphalt binder to the surface of the patch. It is caused by a combination of traffic loads, insufficient voids in the mix, or too much binder in the mix. Bleeding is not necessarily a symptom of failure, but the resulting film of binder on the surface of the patch may become slick and cause the patch to have poor skid resistance. The use of open (gap) gradations and lower binder content should keep bleeding to a minimum (Anderson et al., 1988). The ratings were based on visual observation of the percentage of the surface that was flushed in each quadrant.

2. *Dishing* is the further compaction of the patch under traffic loads. It is the result of material instability and inadequate compaction during the placement of the materials (Smith et al., 1991). Compactability is related to workability. Mixes with poor workability are more difficult to compact (Anderson et al., 1988). To determine the amount of dishing, a 1-m metal bar was placed across the patch parallel with the direction of travel. The amount of dishing was measured with a ruler accurate to 1.5 mm in the center of each quadrant. The ratings were determined from the depth measurements.

3. *Debonding* occurs when the patch material loses its adhesion to the pavement at the bottom and/or sides of the pothole. When debonding occurs, the patch material can be

Patch Survey Form 1995

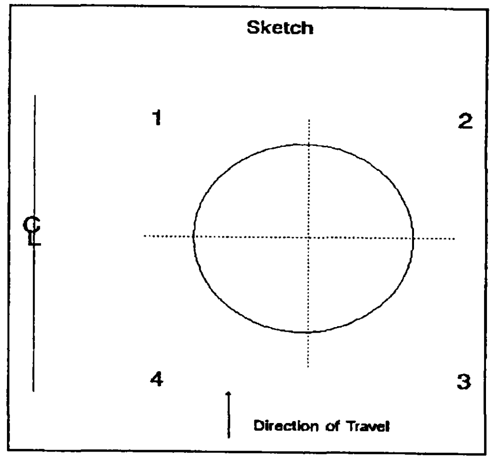
Date: __________ Surveyor: ________

Inspection No. (Circle One)
1d, 3d, 7d, 14d, 28d, 3m, 6m, 9m

Patch No. _____________

Photograph No.(s) _______________

Comments:



Distress Types	Quadrant				Average
	1	2	3	4	
Bleeding					
Dishing					
Edge Disintegration					
Missing Patch					
Raveling					
Shoving/Tracking (Specify)					

Distress Types	Rating			
	1	2	3	4
Bleeding	None	< 30%	> 30% but < 60%	> 60%
Dishing	None	< 6.4 mm	>6.4 mm but < 12.5 mm	> 12.5 mm
Edge Disintegration	None	< 30%	> 30% but < 60%	> 60%
Missing Patch	None	< 30%	> 30% but < 60%	> 60%
Raveling	None	Pock marks on surface due to loss of fines	Larger particles loose, loss limited to surface	Damage not limited to surface
Shoving	None	Localized bulge < 12.5 mm	< 12.5 mm but < 25 mm	Depth of corrugation > 25 mm

FIGURE 1. PATCH SURVEY FORM

pulled out of the hole by traffic, so the patch fails (Smith et al., 1991). Debonding was examined in two categories: edge disintegration and missing patch. Edge disintegration was measured as the percentage of cracking at the edge of the patch for each quadrant. The cracking is caused by differentials in thermal coefficients or loss of volatiles in the mix (Highway Innovative Technology Evaluation Center, 1995). The cracks allow water to enter the repair, leading to early failure. Missing patch was evaluated as a large scale loss of material. In some cases, these appeared to be cohesion failures rather than adhesion failures as all of the remaining particles were fully coated.

4. *Raveling* is the loss of aggregate from the surface of the patch. Raveling failures generally begin as a localized loss of fines. In its early stages, raveling may be the loss of only fine aggregates from the surface, but it may progress to the loss of the larger aggregates. Raveling is caused by stripping, poor cohesion, excessive fine aggregates (passing the 0.075 mm sieve), and poor aggregate interlock of the patch material (Anderson et al., 1988). Raveling was rated based on the size of the particles that were being lost.

5. *Pushing and shoving* is the vertical or horizontal movement of the patch material in the pothole. Pushing and shoving may result in the patch materials being "pushed" or "shoved" out of the pothole. Lack of stability is the primary cause (Anderson et al., 1988). Though pushing and shoving was one of the categories evaluated, the relatively small size of the "manufactured" potholes made the occurrence difficult to detect. Where it was observed, the distress was measured as dishing.

In order to compare the overall performance of each product, a performance rating equation was developed. The equation combines the ratings for bleeding, dishing, edge disintegration, pushing and shoving, raveling, and workability. The percentage of patches remaining in service, defined as the survivability, was used as an overall multiplier. The ratings for each quadrant were averaged to obtain an average rating for each replicate patch. Then, the average rating for each replicate was entered into the performance model. The performance ratings for each replicate were then averaged to determine the overall performance for each material in a given test section. The ratings for workability (1-3) were multiplied by 1.33 to equate them with the other factors. The greatest possible performance rating would be 4.0 for this rating system, and it would be representative of the "perfect" patch (1.0 for survivability, 3.0 for workability, and 4.0s for all other distress type). The performance ratings were divided by 4.0 and multiplied by 100 to convert the ratings to percentages.

$$Performance\ Rating = Sur\,\frac{[(0.171\,W)+(0.177\,R)+(0.156\,E)+(0.144\,B)+(0.180\,D)+(0.204\,PS)]}{4.0}\,x\ 100$$

where W = workability evaluation rating
R = raveling evaluation rating

E = edge disintegration evaluation rating
B = bleeding evaluation rating
D = dishing evaluation rating
PS = pushing and shoving evaluation rating
Sur = survivability.

$$Sur = \frac{Surviving\ Number\ of\ Patches\ of\ the\ Material}{Original\ Number\ of\ Patches\ of\ the\ Material}$$

Initially, the distress types were ranked in order of importance and weighting factors assigned by the researchers. However, it was found that the rankings were fairly sensitive to these factors. To eliminate any bias on the part of the researchers, a survey of all 25 of VDOT's maintenance and materials engineers was conducted. The respondents were asked to rate the importance of each factor to the performance of a cold-mix patching material on a scale of 1 to 5. The results in Table 3 are based on 16 responses. The average response for each factor was normalized such that the sum of all the factors except survivability (which was used as an overall modifier) equaled 1.0.

TABLE 3. WEIGHTING FACTORS

Distress Type	Average Response	Standard Deviation	Weighting Factor
Bleeding	2.38	0.99	0.114
Dishing	3.75	0.83	0.180
Edge disintegration	3.25	0.90	0.156
Pushing and shoving	4.25	0.83	0.204
Raveling	3.69	0.85	0.177
Workability	3.56	0.93	0.171
Survivability	4.81	0.73	NA

Laboratory Tests

Under VDOT's Special Provision for High Quality Patching Materials, the materials were approved through a field test section. Since new materials are constantly being supplied to the Materials Division for approval, and field tests are costly and time-consuming, a laboratory screening procedure was desired. Once approved, there were no provisions for further quality acceptance testing of the product. Further, several of the approved products were proprietary binders that were then mixed with local aggregates. Though each manufacturer purported that compatibility tests were run with each aggregate, the methods were not standardized and the results were not reported to VDOT. Thus the laboratory tests were aimed at producing a design/screening procedure that could be used in lieu of field tests for acceptance of new products as well as for quality acceptance of the products currently used.

An effort was made to identify laboratory tests that could be correlated to the field distress modes. Several test methods and a design procedure were proposed in the literature (Anderson et al., 1988; Wilson & Romine, 1993b; Kandhal & Mellott, 1981). These formed the basis of the laboratory testing. Additionally, efforts were made to develop a harsher test to predict moisture susceptibility and an adhesion test.

Coating Test

The coating test was performed as described in *Materials and Procedures for the Repair of Potholes in Asphalt-Surfaced Pavements* (Wilson & Romine, 1993b) and is now designated AASHTO TP40-94 (American Association of State Highway and Transportation Officials, 1995). The test was used to ensure that a sufficient residual binder content was present to coat the aggregates completely. This was primarily a design test, but uncoated aggregates were observed in the proprietary materials.

Stripping Test

Two forms of stripping tests were performed. In the first, a 100-g sample is placed in a 1-liter jar of distilled water at 60 °C for 16 to 18 hr (Wilson & Romine, 1993b; American Society for Testing and Materials, 1992). Then, the percentage of mix that remains coated is visually estimated. This method has since been designated AASHTO TP41-94 (AASHTO, 1995). In the second test, VTM 13, a 200-g sample is placed in a beaker of boiling water for 10 min (VDOT, 1993). Then, the sample is drained and visually compared to an unconditioned sample. The percentage that remains coated is recorded.

Draindown Test

The draindown test (AASHTO TP42-94) is normally run as part of the design procedure to determine the upper limit for the residual binder content. In this study, it was performed on the proprietary mixes as supplied from the manufacturer. In this test, a 1,000-g sample is placed in an aluminum pie plate in a 60 °C oven for 24 hr. Then, the pan is inverted to remove all of the aggregate particles and the weight of the residual asphalt is determined (Wilson & Romine, 1993b; AASHTO, 1995). The draindown is calculated as a percentage of the sample's initial binder content.

Cohesion Test

AASHTO TP42-94 is recommended primarily for quality acceptance. In this test, a cold-mix sample is compacted with 5 blows of the Marshall hammer. The extruded sample is placed in a 30.5-cm diameter, full-height sieve with 25.4-mm openings. A cover is placed on the sieve, and the sieve is rolled back and forth 20 times on its side. To pass this test, the weight of the material retained after rolling must be greater than 60% of the initial weight (Wilson & Romine, 1993b; AASHTO, 1995).

Asphalt Content and Gradation Tests

Cold-mix samples were tested for asphalt content and gradation according to ASTM D 2172 and ASTM C 117 (ASTM, 1994).

Workability and Storageability Tests

The workabilty of the mixtures was examined using two methods: the Pennsylvania Transportation Institute/Strategic Highway Research Program (PTI/SHRP) workability test (AASHTO TP43-94) and the Pennsylvania Department of Transportation spatula method (Kandhal & Mellott, 1981). For the PTI test, a sample is loosely placed in a 102-mm cubical box with a 10-mm hole centered on one side. A soil penetrometer with a round nose adapter 10 mm in diameter is pressed through the hole into the material. The value from the penetrometer is recorded as the workability reading (Anderson et al., 1988; Wilson & Romine, 1993b).

The workability of the materials was evaluated after they had been stored for 6 months as a measure of their storageability. The materials were stored in sealed bags or buckets (as shipped) outside the VTRC Research Lab. The workability of the materials was tested at -7 and 4 °C by the PennDOT spatula test (Kandhal & Mellott, 1981). A spatula was used to subjectively evaluate the ability of the materials to be broken up.

Adhesion Tests

It is desirable for cold-mix materials to bond to the substrate HMA without the addition of a tack coat. Such materials are termed "self-tacking." Anderson et al. (1988) proposed a shear test for self-tacking, but their results were inconclusive. Therefore, numerous methods were tried to produce a suitable alternative, and one method was used with some success. In this method, a loose cold-mix sample was oven aged for 4 hr at 60 °C. After the sample cooled to room temperature, 800 g was placed in a 150-mm Marshall mold on top of a 75-mm sample of compacted HMA and compacted with 10 blows of a standard Marshall hammer. The compacted composite sample was extruded and inverted. The adhesion/cohesion of the mixture was measured by the time it took for the cold-mix material to debond from the substrate asphalt. The percentages of the failure that were adhesive and cohesive were recorded.

Test Sections

Two test sections were placed to measure the cold-mix performance. An additional section was placed to evaluate the workabilty of the materials in cold weather. The first section was placed in July 1994, the second in February 1995, and the final in March 1995.

Route 29, Campbell County, July 1994

This section was placed in the northbound travel lane of Route 29 near Altavista, Virginia. Forty potholes, 3,800 mm in diameter and 75 mm deep, were made in the right-hand wheel path with a drilling rig (see Figures 2 and 3). A special bit with carbide teeth was used to produce the hole. The "pothole" was cleaned with compressed air prior to be being backfilled with cold mix (see Figure 4). Thirteen materials were included, with three replicates of each. The materials included (in order of placement) were Styrelf Cold Mix, MacPatch CM-300, Sylcrete EV, Cold Mix UPM, HEI-WAY, Optimix Cold Mix, Virginia Type P mix with Bondade, Sakrete Professional, Perma Patch, Tough Patch, QPR-2000, Virginia Type P mix, and HMA (SM-2A). The order of placement was randomly determined for the first set and repeated thereafter. Virginia Type P mix and HMA were used as control mixes. Styrelf, UPM, QPR-2000, and Perma Patch were used as benchmarks for the performance of high-quality cold-mix materials.

FIGURE 2. DRILLING RIG

FIGURE 3. MANMADE POTHOLES IN RIGHT WHEEL TRACK

FIGURE 4. POTHOLE BEING CLEANED WITH COMPRESSED AIR

Artificial potholes were used for a variety of reasons. Sufficient "natural" potholes were unavailable in July. The manufactured potholes allowed a smaller number of replicates to be used that would all be exposed to identical traffic and environmental conditions and reduced effects from variations in the substrate HMA and pothole size.

The materials, with the exception of the HMA control, were supplied in buckets or bags. The potholes were overfilled with cold mix, hand tamped, and rolled with a dump truck's tires (see Figures 5 and 6). The ambient air temperature during placement ranged from 26 to 29 °C.

FIGURE 5. PATCHES BEING HAND TAMPED

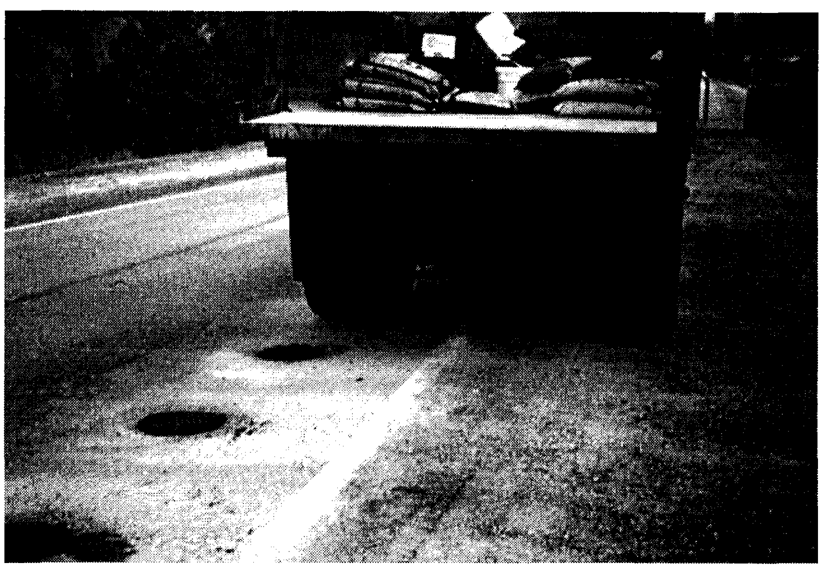


FIGURE 6. PATCHES BEING ROLLED WITH A DUMP TRUCK

Route 29, Campbell County, February 1995

This test section was placed just north of the first, and the potholes were prepared in the same manner. Their depth was reduced to 50 mm, and 1 liter of distilled water was added to the pothole prior to backfilling. Though this section was designed to test performance in cold weather, the air temperature was 17 °C during placement.

Virginia Type P mixes with and without Bondade were not included in this test section due to their poor performance in the previous test section. Tough Patch and HMA were not included because they were unavailable when the section was placed. These four products were replaced by Bond-X, FiberPave, RePAVE, and VTRC HP. Three replicates of each product were placed.

I-64, Albemarle County, March 1995

The final section was placed in March 1995 on a section of concrete pavement on I-64 near Charlottesville that had developed numerous potholes. It was primarily placed to evaluate the workability of the materials in cold weather. The low temperature prior to placement was -8 °C. The ambient air temperature had warmed to -2 °C when the first material was placed. A high temperature of 7 °C was reached during the day. The potholes were tamped prior to reopening to traffic. All of the materials except Fiberpave, HMA, Tough Patch, and Virginia Type P mix were placed. Only the workability and the short-term survivabilty were evaluated.

RESULTS AND DISCUSSION

Field Tests

Workability

The results of the workability surveys are presented in Table 4. Generally, the workability was independent of temperature.

Performance

Evaluations

The July 1994 test section was evaluated at 7 and 14 days and 1, 3, 8, 9, and 12 months after placement. The February 1995 test section was evaluated at 7 days, 2 months, and 5 months after placement. The evaluations were conducted by the same two researchers. All of the materials have survived to date except the Virginia Type P mix. All three of the patches treated with Bondade and filled with Virginia Type P mix failed by the 14-day evaluation. The remaining Virginia Type P repairs initially displayed progressive cohesive failures. However, by the last evaluation, all three repairs had failed to the substrate HMA.

TABLE 4. WORKABILTY RATINGS

Material	July 1994	February 1995	March 1995	Average Rating
Styrelf Cold Mix	Good	Fair	Fair	2.3
MacPatch CM-300	Poor	Poor	Poor	1.0
Sylcrete EV	Good	Fair	Fair	2.3
Cold Mix UPM	Good	Fair	Good	2.7
Hei-way	Good	Good	Good	3.0
Optimix Cold Mix	Poor	Fair	Poor	1.7
Sakrete Professional	Fair	Poor	Poor	1.0
Perma Patch	Fair	Good	Good	2.3
Tough Patch	Fair	NA	NA	2.0
QPR-2000	Fair	Fair	Fair	2.0
Virginia Type P Mix	Good	NA	NA	3.0
HMA	Good	NA	NA	3.0
Bond-X	NA	Good	Good	3.0
Fiberpave	NA	Poor	NA	1.0
RePAVE	NA	Poor	Poor	1.0
VTRC HP	NA	Good	Good	2.5

Note: In some cases, the manufacturer supplied a different formulation between the July 1994 and February 1995 test sections.

The primary forms of distress observed were dishing, raveling, and bleeding. It was felt that the relatively small size of the repair precluded pushing and shoving. In some instances, this distress was observed but recorded as dishing. Edge disintegration was observed in limited cases. It was felt that the smooth, vertical sides of the drilled holes may have suppressed this mode of deterioration.

Ratings

Figure 7 shows a typical relationship between the performance rating of a product and its deterioration. The initial reduction in the performance rating was due to a combination of the

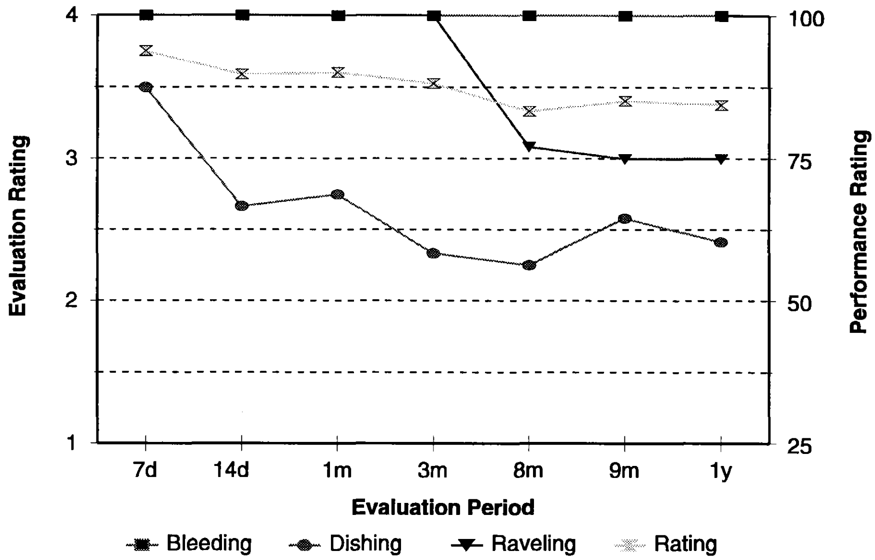


FIGURE 7. STYRELF STOCKPILE PATCH MIX, JULY 1994 TEST SECTION

fair workability and the initial dishing due to densification under traffic loads. The onset of raveling in the form of loss of fines further reduced the performance rating at 8 months. The dishing rating at the end of the evaluation period corresponded to an average settlement of 6 mm. The complete survey results for the July 1994 and February 1995 test sections are presented in the Appendix.

The average performance of the three replicates for the 7-day evaluation of the July 1994 test section is presented in Figure 8. The initial reductions reflect the workability ratings and the

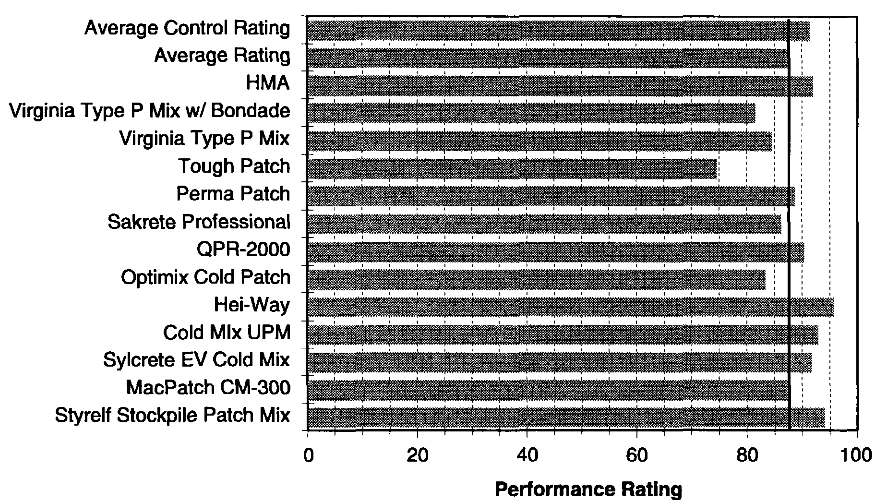


FIGURE 8. PERFORMANCE RATING AFTER 1 WEEK, JULY 1994 TEST SECTION

early densification recorded as dishing. It should be noted that Tough Patch exhibited more than 12.5 mm of dishing during the 7-day evaluation. Due to the severity of the dishing, additional material was added at the request of VDOT officials to the Tough Patch replicates. Further densification was recorded after this addition.

Bondade is designed to work as a tacking agent. The bleeding and cohesive failures observed in all of the patches filled with Virginia Type P mix indicated excessive binder content. It is felt that the combined effects of the tacking agent and the excessive binder content led to early failures of the Virginia Type P mix with Bondade and that no conclusions can be reached on the performance of Bondade with a properly designed mix.

The overall average performance during the year and the performance after 1 year for the July 1994 test section are presented in Figures 9 and 10, respectively. Each performance rating is the average of the three replicate patches for a given material. The overall average is the average of the performance ratings calculated for each evaluation period. Although it would be more accurate to calculate the time weighted average for the area under the performance rating curve, the difference is subtle, so this was not done. The currently approved proprietary materials had an average performance rating of 84.8 at 1 year (labeled as average control rating) and an average of 87.3 over the life span of the patches. The average performance rating for all of the materials excluding the Virginia Type P mixes was 85.9 over the life span of the patches and 83.6 after 1 year. Based on these results, the researchers recommend a minimum performance of 85 at the end of 1 year. This value should be valid for future sections placed under similar climatic conditions and traffic loadings.

Figures 11 and 12 present the average performance ratings after 5 months and the average performance over the 5-month period, respectively, for the February 1995 test section. Though water was introduced into the patch cavity prior to backfilling, none of the materials debonded. MacPatch, Styrelf, Sylcrete, QPR-2000, Sakrete, and Optimix all showed signs of raveling after 2 months. FiberPave and RePAVE performed significantly worse than the other products. The workability of both products was poor. Fiber Pave suffers from higher than average dishing and raveling. The RePAVE material had not cured after 5 months and could still be displaced with light pressure. Both Bond-X and VTRC HP (which was produced with the Bond-X binder) are performing extremely well, but it is too early to make conclusions concerning their long-term performance.

All of the materials placed in the February 1995 test section (with the exception of RePAVE) showed significantly less dishing than those placed in the July 1994 section. This was probably because of the reduced pothole depth.

An analysis of variance was performed in conjunction with Fisher's least significant difference (LSD) on the performance rating for each patch in the July 1994 test section using MINITAB Statistical Software. These procedures compare the rankings of the average performance ratings (at the end of 1 year for each replicate). The analysis showed that all of the

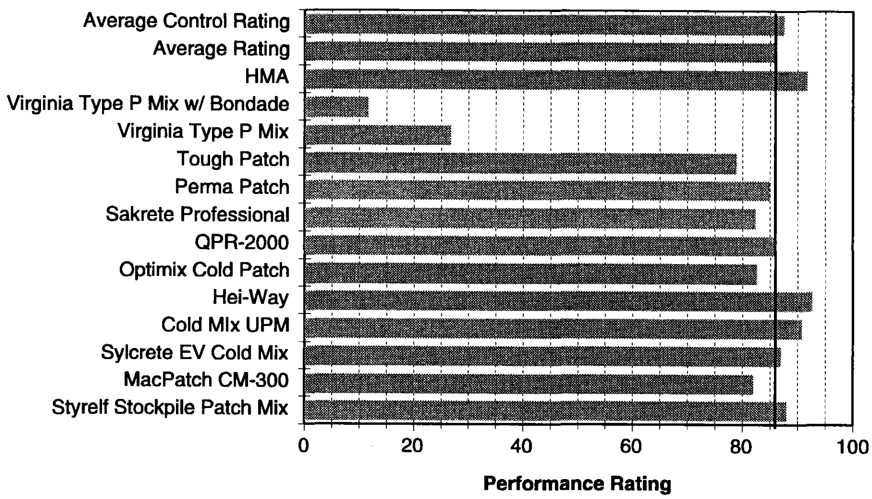


FIGURE 9. PERFORMANCE RATING AVERAGE, JULY 1994 TEST SECTION

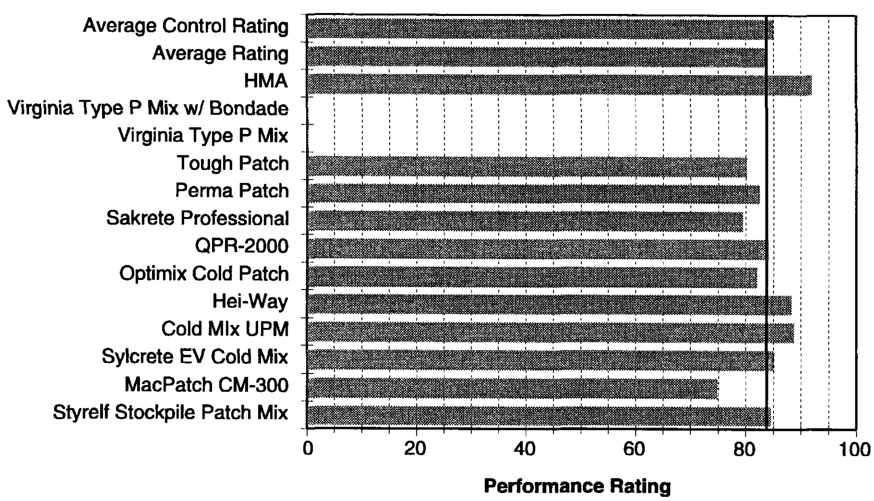


FIGURE 10. PERFORMANCE RATING AFTER 1 YEAR, JULY 1994 TEST SECTION

proprietary products performed significantly better than the Virginia Type P mix (with and without Bondade) at the 95% confidence level. Significant differences existed between some of the proprietary materials. From this analysis, HEI-WAY and Sylcrete were selected as candidate products for the Special Provision for High Quality Cold Patching Materials. The comparisons for HMA, UPM, HEI-WAY, Sylcrete, and Optimix are presented in Table 5. HEI-WAY performed statistically the same as HMA and UPM, which had the highest overall and cold-mix ratings, respectively, after 1 year. Though Sylcrete performed worse than HMA, it performed as well as the two best cold-mix products, HEI-WAY and UPM. The next highest ranked product, Optimix, did not perform as well as HEI-WAY or UPM and, therefore, was not recommended for approval.

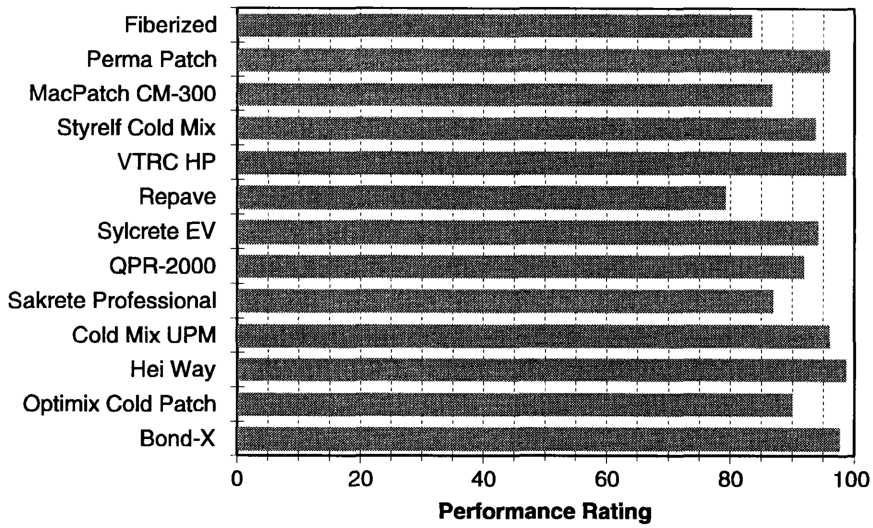


FIGURE 11. PERFORMANCE RATINGS AVERAGE, FEBRUARY 1995 TEST SECTION

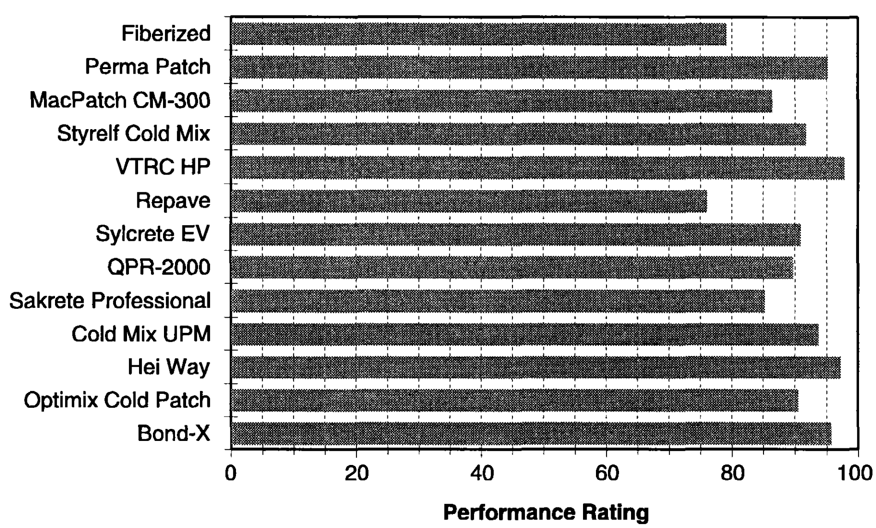


FIGURE 12. PERFORMANCE RATINGS AFTER 5 MONTHS, FEBRUARY 1995 TEST SECTION

TABLE 5. PERFORMANCE COMPARISONS BASED ON FISHER'S LEAST SIGNIFICANT DIFFERENCE

Product	Performed Worse Than	Performed the Same As	Performed Better Than
HMA	None	HEI-WAY and UPM	All others
UPM	None	HEI-WAY, HMA, Sylcrete, and Styrelf	All others
HEI-WAY	None	HMA, Sylcrete, Styrelf, and UPM	All others
Sylcrete	HMA	HEI-WAY, Optimix, QPR-2000, Perma Patch, Styrelf, and UPM	All others
Optimix	HEI-WAY, HMA, and UPM	Perma Patch, QPR-2000, Sakrete, Styrelf, Sylcrete, and Tough Patch	MacPatch and Virginia Type P mix

Bond-X was not included in the July 1994 test section and, therefore, could not be evaluated using Fisher's LSD. However, its performance in the February 1995 test section was between those of HEI-WAY and UPM and, therefore, it is also recommended for approval.

Laboratory Tests

The results of the laboratory tests are summarized in Table 6, and the gradation results are reported in Table 7. The results shown are for the materials provided for the July 1994 test section with the exception of the materials that were used only in the winter sections. There was not a sufficient quantity of Fiber Pave material left for testing.

Coating

All of the materials passed the coating test (> 90% coated).

Stripping

Due to the difficulties in subjectively determining the percentage coated values, it was decided that the values would be reported in 5% ranges. Thus 95%-100% coated was the highest possible rating.

TABLE 6. SUMMARY OF THE RESULTS OF THE LABORATORY ACCEPTANCE TESTS

Mix	Coating Test (% Coated)	Stripping Test (% Coated)	Boil Test (% Coated)	Drainage Test (% Draindown)	Workability 40 °C	Adhesion Test (sec)
Recommended Criteria	**>90%**	**>90%**	**>85%**	**<8**	**<3**	**5-30**
Styrelf Cold Mix	95-100	95-100	70-75	2.2	3.06	39
MacPatch CM-300	95-100	95-100	85-90	5.0	3.38	97
Sylcrete EV	95-100	95-100	95-100	3.8	2.81	26
Cold Mix UPM	95-100	95-100	95-100	5.8	3.06	24
HEI-WAY	95-100	95-100	95-100	4.54	2.88	8
Optimix Cold Mix	95-100	95-100	85-90	1.7	2.81	> 120
QPR-2000	95-100	95-100	85-90	1.4	3.06	7
Sakrete Professional	95-100	95-100	95-100	1.0	2.5	57
Perma Patch	95-100	95-100	85-90	1.0	2.38	20
Tough Patch	95-100	95-100	90-95	1.0	3.31	>120
Virginia Type P	95-100	95-100	70-75	12.0	3.00	19
VTRC HP	95-100	95-100	95-100	6.4	2.69	10
RePAVE	95-100	95-100	90-95	0.3	3.10	NA
Bond-X	95-100	95-100	85-90	1.5	2.67	NA

All of the materials passed the SHRP stripping test. Since VDOT did not have previous experience with the SHRP test indicating a correlation with field performance, VTM 13 (Boil Test) was also performed. VTM 13 did indicate differences in the moisture resistance of the materials. Efforts were made to correlate the results of VTM 13 to the ratings observed in the July 1994 test section. A scatter plot of the percentage stripped (100 - % coated) versus the inverted field raveling ratings (1 = good, no raveling) at 1 year is shown in Figure 13. Virginia Type P mix was not included since the patches had failed prior to the 1-year evaluation. HMA

TABLE 7. COLD MIX GRADATIONS (% PASSING SIEVE)

Sieve (mm)	Styrelf	MacPatch	Sylcrete	UPM	HEI-WAY	Optimix	QPR-2000	Sakrete	Perma Patch	Tough Patch	Virginia Type P	Bond-X	VTRC-HP	RePAVE	Proposed Specs
12.5	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
9.5	96	84	100	100	93	100	96	100	100	100	95	99	100	99	95-100
4.75	44	23	50	95	60	94	35	81	80	99	49	36	94	57	85-95
2.36	25	7	12	30	20	38	10	28	18	90	30	7	25	20	10-40
1.18	17	4	7	7	5	16	6	11	5	76	22	4	6	19	0-10
0.6	12	3	6	3	4	10	5	8	3	63	16	3	4	7	0-10
0.3	8	3	6	3	3	7	5	7	3	49	11	2	3	3	0-10
0.15	5	2	6	2	3	6	4	6	3	30	8	2	3	1	0-10
0.08	3.5	2.0	5.3	2.3	2.7	4.4	3.9	5.4	2.5	16.8	6.0	2.1	2.7	0.3	0-3

was not included since results were unavailable for the boil test. A simple linear regression was performed using percentage stripped as the predictor variable for the observed raveling rating using Quattro Pro. The predictor variable is the independent, or *x,* variable, and percentage stripped is the dependent, or *y*, variable. Quattro Pro calculates both the best-fit linear equation ($y = ax + b$) and the coefficient of determination (R^2) that represents the degree of correlation between the variables or the fraction of variation in *y* explained by the fitted equation. Quattro Pro also calculates the standard error of the *y* estimate (*s*). The $R^2 = 0.20$ indicates a relatively poor correlation, which may be expected considering the small spread of the data.

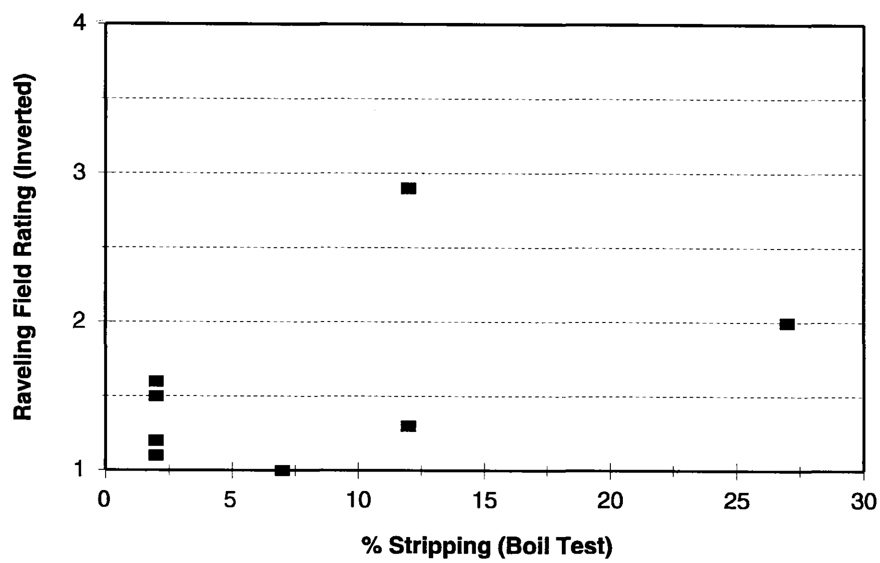


FIGURE 13. STRIPPING VERSUS RAVELING AT 1 YEAR

Draindown

According to the SHRP criteria, 4% is the maximum allowable draindown. Several materials failed to meet this criteria. The manufacturer's reported values for residual binder content were used to calculate draindown because of erratic results from reflux extractions.

The results from the draindown test are somewhat erroneous for two reasons. First, it is difficult to remove all of the aggregate particles from the pie plate after the 24-hr aging period. Second, at low residual binder contents, "apparent" draindown occurs where the aggregate particles touch the pie plate (Anderson, 1988). Two of the materials used in the study, Virginia Type P mix and Bond-X, exhibited draindown in the 5-gallon buckets used for sample storage. Though the Virginia Type P mix failed the draindown criteria (12.0%), Bond-X did quite well (1.5%). Draindown was not observed in the remaining materials with failing test results.

Therefore, the authors feel that the 4% limit may be too stringent and recommend 8% until further data can be analyzed, particularly since two of the best performing materials, UPM and HEI-WAY, had draindown results in the 4%-8% range.

Cohesion

All materials passed this test.

Asphalt Content and Gradation

VTRC had difficulty verifying the manufacturer's reported residual binder contents with reflux solvent extractions.

Kandhal and Mellott (1981) reported improved workability and durability with finer (100% passing 9.5 mm sieve) and predominately one-sized aggregate with a low percentage (< 2.0%) passing (P) the 0.075 mm sieve (P 0.075). In the July 1994 test section, only UPM and Perma Patch came close to meeting this criteria (both had a slightly higher P 0.075 mm). They were ranked by average rating, second and sixth, respectively. VTRC HP also came close to meeting this criterion. These three products were ranked 1, 4, and 5 after 5 months in the February 1995 test section. The material with the best average performance, HEI-WAY, is slightly coarser, but predominately one-sized with a low P 0.075 mm. The field workability of all four of these products was good.

The proposed gradation limits were determined from these results (see Table 7). It was felt that Kandhal's and Mellott's recommendation of < 2.0% P 0.075 mm may have been too stringent, and the limit was increased to 3.0%. Some (95%-100% P 9.5 mm) 9.5 mm aggregate was allowed to promote stability. The aggregate will primarily be retained on the 2.36 mm sieve.

Workability and Storageability

All of the mixes passed the PTI workability test (Penetration No. < 4.0). Six of the materials fell in the marginal range (3 < Penetration No. < 4). A scatter plot of PTI workability penetrometer readings versus inverted (1 = good workability and 3 = poor workability) observed workability ratings is presented in Figure 14. A simple linear regression was performed using the PTI penetrometer readings as the predictor variables for the observed field workability. The R^2 value was 5.4%, and the number of observations *(n)* was 14. The scatter plot seemed to indicate a better correlation. Two points were considered as potential outliers. The Virginia Type P mix showed good workability in the field, but the sample tested in the laboratory suffered from draindown and appeared to have partially cured. Sakrete had the worst values for field

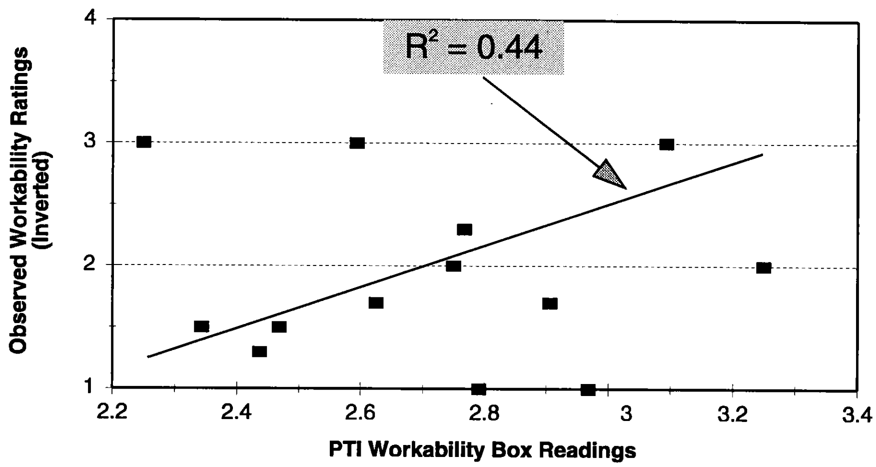


FIGURE 14. PTI WORKABILITY VERSUS FIELD WORKABILITY

workability, but once the material was sufficiently broken up to test it in the workability box, it was fairly noncohesive and crumbled at low temperatures, providing low penetrometer readings. With these points removed, the regression was rerun with an observed R^2 = 44.1%, standard error of the estimate *(s)* = 0.53, and n = 12. This indicates the test may be used to estimate the workability of the material.

Kandhal and Mellott (1981) suggested the use of the spatula test for workability where a sample is cooled to -7 °C and the ability to break up the material with a 200 mm spatula is observed. Once the researchers became experienced with the materials, it was felt that this was a more sensitive test. The penetrometer readings are subject to the rate at which the penetrometer is inserted into the workability box. The test can also be affected by the proximity of large aggregate particles. Controlling the amount of compaction when "loosely" packing the material in the sample box also affects the results. However the PTI workability test still has value since it is not entirely subjective and produces a numerical result. Since several of the materials that fell into the marginal range had poor workability ratings in the field, it is felt that the acceptable criterion should be a penetration number less than 3.0.

The storageability results are presented in Table 8. Only Cold Mix UPM and QPR-2000 demonstrated reduced workability from the values reported in Table 1.

Adhesion

The adhesion test was developed to produce a test that could be run in a field lab that would help ensure the survivability of the patching materials. It was hoped that it could be used for quality control. Unfortunately, with the exception of Virginia Type P mix, the materials that

TABLE 8. WORKABILITY RATINGS AFTER 6-MONTH STORAGE

Material	Workability -7 °C	Workability 4 °C
Styrelf Cold Mix	Poor	Fair
MacPatch CM-300	UW	Fair
Sylcrete EV	Fair/poor	Fair
Cold Mix UPM	Fair/poor	Fair
HEI-WAY	Good/fair	Good/fair
Optimix Cold Mix	Poor	Fair
Sakrete Professional	UW	Poor
Perma Patch	Fair	Good
Tough Patch	NA	NA
QPR-2000	UW	Poor/fair
Bond-X	Good	Good
FiberPave	Poor	Poor
RePAVE	NA	NA
VTRC HP	Fair	Good

performed well in the field tests had lower adhesion values than materials with lower than average performance ratings.

From the data, it appears that an adhesion time of 5 to 30 sec would be optimum. Times less than 5 sec may indicate excessive binder contents. Times in excess of 30 sec may indicate insufficient binder content or too stiff a binder. Though this test may not be indicative of a mix's adhesive properties, it may have value as a measure of mix quality. Further development will be required.

CONCLUSIONS

1. Proprietary, high-quality cold-mix patching materials performed significantly better than the Virginia Type P mix.

2. The evaluation system and performance model developed in this study may be used to rank potential cold mixes. Survivability and stability (pushing and shoving) were identified as the most important properties for a good cold mix.

3. Potholes greater than 50 mm in depth should be filled and compacted in two lifts to reduce dishing.

4. Laboratory tests alone are insufficient to screen potential cold mixes at this time. They do provide a valuable tool for design and quality control that should improve the quality of the material.

5. Solvent extractions may not be accurate for determining residual binder contents for cold mix.

RECOMMENDATIONS

1. HEI-WAY, Sylcrete EV, and Bond-X should be added to VDOT's Special Provision for High Quality Cold Patching Materials.

2. The special provision should be separated into two categories: one for materials supplied as a complete proprietary cold mix, typically in buckets or bags, and one for proprietary binders that are mixed with local aggregates. A design procedure should be adopted for the second group.

3. The gradation set forth below is proposed. The gradation was modified slightly from Kandhal's and Mellott's recommendations to allow some coarser aggregate and additional P 0.075 mm material based on field performance. It is felt that a slightly coarser gradation will promote greater stability in the cold mix.

Sieve Size (mm)	Percentage Passing
9.5	95-100
4.75	75-95
2.36	10-40
0.075	0-3

4. The following design procedure is proposed:

   - Use a proprietary binder from VDOT's Special Provision for High Quality Cold Mix.

- Use the proposed aggregate gradation.
- Determine the residual binder content using the following tests:

Coating Test	> 90% coated
Stripping Test	> 90% coated
VTM 13 (Boil Test)	> 85% coated
Draindown Test	< 8%
Workability Test	< 3.0 at 4 °C

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APPENDIX

Survey Results

Average Performance Ratings, July 1994 Test Section

Product	Mix	7 Day	14 Day	1 Month	3 Month	7 Month	9 Mont	1 year	Average
Styrelf Stockpile Patch Mix	**1**	93.8	89.7	90.1	88.2	83.3	85.2	84.4	87.8
MacPatch CM-300	**2**	87.2	86.4	86.7	81.9	77.0	78.2	74.7	81.7
Sylcrete EV Cold Mix	**3**	91.4	87.8	87.4	87.0	84.8	84.8	84.8	86.9
Cold MIx UPM	**4**	92.7	91.9	93.0	90.0	88.6	89.3	88.6	90.6
Hei-Way	**5**	95.5	94.7	95.1	92.9	89.5	90.3	88.0	92.3
Optimix Cold Patch	**6**	83.1	84.4	83.3	81.2	81.0	81.8	81.8	82.3
QPR-2000	**7**	90.2	86.8	86.5	86.5	82.7	84.6	83.8	85.9
Sakrete Professional	**8**	86.0	85.7	84.5	80.4	79.7	79.3	79.3	82.1
Perma Patch	**9**	88.5	86.6	85.6	83.0	80.8	85.8	82.3	84.7
Tough Patch	**10**	74.4	78.1	79.7	79.9	77.8	80.8	79.9	78.7
Virginia Type-P Mix	**11**	84.3	20.6	20.1	20.1	20.1	22.0	0.0	26.7
Virginia Type-P Mix w/ Bondade	**12**	81.2	0.0	0.0	0.0	0.0	0.0	0.0	11.6
HMA	**HMA**	91.8	91.8	92.2	91.8	89.6	91.8	91.8	91.5
Average Rating		87.7						83.6	85.9
Average Control Rating		91.3						84.8	87.25

Summer 1994

Results of Seven Day Evaluation

Set 1

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	4	4	4	4	4	1	2.3	96.0
2	4	4	4	4	4	4	1	1	88.7
3	4	3	4	4	4	4	1	2.3	91.5
4	4	3.5	4	4	4	4	1	2.7	96.0
5	4	3.5	4	4	4	4	1	3	97.8
6	4	2	4	4	4	4	1	1.7	83.6
7	4	2.5	4	4	4	4	1	2	87.6
8	4	3.5	4	4	4	4	1	1	86.4
9	3	3.5	4	4	4	4	1	2.5	92.2
10	1	1	4	4	4	4	1	2	72.6
11	1	3.5	4	4	2.5	4	1	3	82.8
12	1	2	4	4	2.5	4	1	3	76.0
HMA	1	4	4	4	4	4	1	3	91.8

Set 2

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2.5	4	4	4	4	1	2.3	89.3
2	4	3.75	4	4	4	4	1	1	87.5
3	4	3.5	4	4	4	4	1	2.3	93.8
4	4	2.75	4	4	4	4	1	2.7	92.7
5	4	3.5	4	4	4	4	1	3	97.8
6	4	2.25	4	4	4	4	1	1.7	84.8
7	4	3.75	4	4	4	4	1	2	93.2
8	4	3	4	4	4	4	1	1	84.2
9	2	3	4	4	4	4	1	2.5	87.2
10	1	1	4	4	4	4	1	2	72.6
11	1	3.5	4	4	3	4	1	3	85.0
12	1	3.25	4	4	3.5	3.75	1	3	84.9
HMA	1	4	4	4	4	4	1	3	91.8

Set 3

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	4	4	4	4	4	1	2.3	96.0
2	4	3.25	4	4	4	4	1	1	85.3
3	3.5	2.75	4	4	4	4	1	2.3	89.0
4	4	2	4	4	4	4	1	2.7	89.3
5	4	2	4	4	4	4	1	3	91.0
6	3	2	4	4	4	4	1	1.7	80.9
7	4	3	4	4	4	4	1	2	89.8
8	4	3.75	4	4	4	4	1	1	87.5
9	2.5	2.5	4	4	4	4	1	2.5	86.3
10	3	1	4	4	4	4	1	2	78.1
11	1	2.5	4	4	4	4	1	3	85.0
12	1	2	4	4	4	4	1	3	82.8
HMA	1	4	4	4	4	4	1	3	91.8

Results after 14 Day Evaluation

Set 1

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2.5	4	4	4	4	1	2.3	89.3
2	4	4	4	4	4	4	1	1	88.7
3	4	2	4	4	4	4	1	2.3	87.0
4	4	3.25	4	4	4	4	1	2.7	94.9
5	4	3.25	4	4	4	4	1	3	96.6
6	4	2	4	4	4	4	1	1.7	83.6
7	4	2.5	4	4	4	4	1	2	87.6
8	4	3.25	4	4	4	4	1	1	85.3
9	3.5	3	4	4	4	4	1	2.5	91.3
10	3	1	4	4	4	4	1	2	78.1
11	1.75	2.5	4	3.25	4	4	0.33	3	28.7
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Set 2

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2	4	4	4	4	1	2.3	87.0
2	4	3.5	4	4	4	4	1	1	86.4
3	4	2.5	4	4	4	4	1	2.3	89.3
4	4	2.5	4	4	4	4	1	2.7	91.5
5	4	3.5	4	4	4	3.75	1	3	96.5
6	4	2	4	4	4	4	1	1.7	83.6
7	4	2.5	4	4	4	4	1	2	87.6
8	4	3	4	4	4	4	1	1	84.2
9	2	2	4	4	4	4	1	2.5	82.7
10	3	1	4	4	4	4	1	2	78.1
11				1			0.33	3	5.6
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Set 3

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	3.5	3.75	4	4	4	1	2.3	92.8
2	4	3	4	4	4	4	1	1	84.2
3	4	2	4	4	4	4	1	2.3	87.0
4	4	2	4	4	4	4	1	2.7	89.3
5	4	2	4	4	4	4	1	3	91.0
6	4	2.5	4	4	4	4	1	1.7	85.9
7	4	2	4	4	4	4	1	2	85.3
8	4	3.75	4	4	4	4	1	1	87.5
9	1.5	3	4	4	4	4	1	2.5	85.8
10	3	1	4	4	4	4	1	2	78.1
11	1	2	4	4	4	4	0.33	3	27.3
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Results of 1 Month Evaluation

Set 1

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2.5	4	4	4	4	1	2.3	89.3
2	4	4	4	4	4	4	1	1	88.7
3	4	2	4	4	4	4	1	2.3	87.0
4	4	4	4	4	4	4	1	2.7	98.3
5	4	3.5	4	4	4	4	1	3	97.8
6	4	1.75	4	4	4	4	1	1.7	82.5
7	4	2	4	4	4	4	1	2	85.3
8	4	3.75	4	4	4	4	1	1	87.5
9	3.5	2.75	4	4	4	4	1	2.5	90.2
10	4	1	4	4	4	4	1	2	80.8
11	1	2	4	3.25	4	4	0.33	3	27.3
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Set 2

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2	4	4	4	4	1	2.3	87.0
2	4	4	4	4	4	4	1	1	88.7
3	4	2	4	4	4	4	1	2.3	87.0
4	4	2.5	4	4	4	4	1	2.7	91.5
5	4	3.5	4	4	4	4	1	3	97.8
6	4	2	4	4	4	4	1	1.7	83.6
7	4	2.75	4	4	4	4	1	2	88.7
8	4	2.5	4	4	4	4	1	1	81.9
9	2	2	4	4	4	4	1	2.5	82.7
10	3.5	1	4	4	4	4	1	2	79.5
11				1			0.33	3	5.6
12				1			0	3	0.0
HMA	1.5	4	4	4	4	4	1	3	93.1

Set 3

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	3.75	3.75	4	4	4	1	2.3	93.9
2	3.5	3	4	4	4	4	1	1	82.8
3	4	2.25	4	4	4	4	1	2.3	88.2
4	4	2	4	4	4	4	1	2.7	89.3
5	4	1.75	4	4	4	4	1	3	89.9
6	4	2	4	4	4	4	1	1.7	83.6
7	4	2	4	4	4	4	1	2	85.3
8	4	3	4	4	4	4	1	1	84.2
9	2.5	2	4	4	4	4	1	2.5	84.0
10	3.25	1	4	4	4	4	1	2	78.8
11	1	2	4	4	4	4	0.33	3	27.3
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Results of 3 Month Evaluation

Set 1

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2.75	4	4	4	4	1	2.3	90.4
2	4	3.75	4	4	4	4	1	1	87.5
3	4	2	4	4	4	4	1	2.3	87.0
4	4	2.5	4	4	4	4	1	2.7	91.5
5	4	3.5	4	4	4	4	1	3	97.8
6	4	1.75	4	4	4	4	1	1.7	82.5
7	4	2	4	4	4	4	1	2	85.3
8	4	2.25	4	4	3.75	4	1	1	79.7
9	3	2.25	4	4	4	4	1	2.5	86.5
10	4	1	4	4	4	4	1	2	80.8
11	1	2	4	3.25	4	4	0.33	3	27.3
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Set 2

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2	4	4	4	4	1	2.3	87.0
2	4	2.75	4	4	4	4	1	1	83.0
3	4	2	4	4	4	4	1	2.3	87.0
4	4	2	4	4	4	4	1	2.7	89.3
5	4	2.5	4	4	4	4	1	3	93.3
6	4	1.25	4	4	4	4	1	1.7	80.3
7	4	2.75	4	4	4	4	1	2	88.7
8	4	2.25	4	4	4	4	1	1	80.8
9	1.5	2	4	4	4	4	1	2.5	81.3
10	3.5	1	4	4	4	4	1	2	79.5
11				1			0.33	3	5.6
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Set 3

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2.25	3.75	4	4	4	1	2.3	87.2
2	4	2	4	4	3	4	1	1	75.2
3	4	2	4	4	4	4	1	2.3	87.0
4	4	2	4	4	4	4	1	2.7	89.3
5	4	1.25	4	4	4	4	1	3	87.6
6	3	2	4	4	4	4	1	1.7	80.9
7	4	2	4	4	4	4	1	2	85.3
8	4	2.25	4	4	4	4	1	1	80.8
9	1.5	2	4	4	4	4	1	2.5	81.3
10	3.5	1	4	4	4	4	1	2	79.5
11	1	2	4	4	4	4	0.33	3	27.3
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Results of 7 Month Evaluation

Set 1

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2.5	4	4	3	4	1	2.3	84.8
2	4	3.5	4	4	3	4	1	1	81.9
3	4	2	4	4	3	4	1	2.3	82.5
4	4	2.5	4	4	4	4	1	2.7	91.5
5	4	2.5	4	4	3.75	4	1	3	92.1
6	4	1.25	4	4	4	4	1	1.7	80.3
7	4	2	4	4	3.25	4	1	2	82.0
8	4	2.25	4	4	3.75	4	1	1	79.7
9	3	2.25	4	4	3.75	4	1	2.5	85.4
10	4	1	4	4	4	4	1	2	80.8
11	1	2	4	3.25	4	4	0.33	3	27.3
12				1			0	3	0.0
HMA	1.5	4	4	4	3	4	1	3	88.6

Set 2

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2	4	4	2.75	3.75	1	2.3	80.2
2	4	2.75	4	4	3.25	3.75	1	1	78.4
3	4	2	4	4	4	4	1	2.3	87.0
4	4	2	4	4	4	4	1	2.7	89.3
5	4	3	4	4	3.75	3.75	1	3	93.1
6	4	1.25	4	4	4	4	1	1.7	80.3
7	4	2	4	4	3.25	4	1	2	82.0
8	4	2.25	4	4	4	4	1	1	80.8
9	2.5	2	4	4	2.25	4	1	2.5	76.2
10	3.5	1	3.5	4	4	4	1	2	77.5
11				1			0.33	3	5.6
12				1			0	3	0.0
HMA	1	3.75	4	4	3.75	4	1	3	89.5

Set 3

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2.25	3.75	4	3.5	4	1	2.3	84.9
2	4	2	4	4	2	4	1	1	70.7
3	4	2	4	4	3.5	4	1	2.3	84.8
4	4	2	4	4	3	4	1	2.7	84.8
5	4	1.25	3.75	4	3.25	4	1	3	83.3
6	4	1.75	4	4	4	4	1	1.7	82.5
7	4	2	4	4	3.75	4	1	2	84.2
8	4	2	4	4	3.75	4	1	1	78.5
9	2.5	2	4	4	3.25	4	1	2.5	80.7
10	3	1	3.25	4	4	4	1	2	75.1
11	1	2	4	4	4	4	0.33	3	27.3
12				1			0	3	0.0
HMA	1	4	4	4	3.75	4	1	3	90.6

Results of 9 Month Evaluation

Set 1

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2.75	4	4	3	4	1	2.3	85.9
2	4	3.75	4	4	3	4	1	1	83.0
3	4	2	4	4	4	4	1	2.3	87.0
4	4	2	4	4	4	4	1	2.7	89.3
5	4	2	4	4	3.25	4	1	3	87.6
6	4	1.25	4	4	4	4	1	1.7	80.3
7	4	2	4	4	3.5	4	1	2	83.1
8	4	2.25	4	4	3.5	4	1	1	78.5
9	3.5	2.75	4	4	3.5	4	1	2.5	87.9
10	4	1	4	4	4	4	1	2	80.8
11	4	4	4	3.75	4	4	0.33	3	33.0
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Set 2

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2	4	4	3	4	1	2.3	82.5
2	4	3	4	4	2.75	4	1	1	78.5
3	4	2	4	4	3	4	1	2.3	82.5
4	4	2	4	4	4	4	1	2.7	89.3
5	4	2.75	4	4	3.75	4	1	3	93.3
6	4	1.75	4	4	4	4	1	1.7	82.5
7	4	2	4	4	4	4	1	2	85.3
8	4	2	4	4	4	4	1	1	79.7
9	3.5	2	4	4	4	4	1	2.5	86.8
10	4	1	4	4	4	4	1	2	80.8
11				1			0.33	3	5.6
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Set 3

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	3	4	4	3	4	1	2.3	87.0
2	4	2	4	4	2.5	4	1	1	72.9
3	4	2	4	4	3.5	4	1	2.3	84.8
4	4	2	4	4	4	4	1	2.7	89.3
5	4	1.75	4	4	4	4	1	3	89.9
6	4	1.75	4	4	4	4	1	1.7	82.5
7	4	2	4	4	4	4	1	2	85.3
8	4	2	4	4	4	4	1	1	79.7
9	2	2	4	4	4	4	1	2.5	82.7
10	4	1	4	4	4	4	1	2	80.8
11	1	2	4	4	4	4	0.33	3	27.3
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Results of 1 Year Evaluation

Set 1

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2.5	4	4	3	4	1	2.3	84.8
2	4	3.75	4	4	2.5	4	1	1	80.8
3	4	2	4	4	3.5	4	1	2.3	84.8
4	4	2.25	4	4	4	4	1	2.7	90.4
5	4	2.25	4	4	3	4	1	3	87.6
6	4	1.25	4	4	4	4	1	1.7	80.3
7	4	2	4	4	3.5	4	1	2	83.1
8	4	2	4	4	3.75	4	1	1	78.5
9	3	2.75	4	4	3.5	4	1	2.5	86.5
10	4	1	4	4	4	4	1	2	80.8
11				1			0	3	0.0
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Set 2

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2	4	4	2.25	4	1	2.3	79.2
2	4	3	4	4	2	3.75	1	1	73.9
3	4	2	4	4	3.5	4	1	2.3	84.8
4	4	2	4	4	4	4	1	2.7	89.3
5	4	2.5	4	4	3.75	4	1	3	92.1
6	4	1.75	4	4	4	4	1	1.7	82.5
7	4	2	4	4	3.75	4	1	2	84.2
8	4	2.25	4	4	3.75	4	1	1	79.7
9	1	2	4	4	4	4	1	2.5	79.9
10	4	1	4	4	4	4	1	2	80.8
11				1			0	3	0.0
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Set 3

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2.75	4	4	3.75	4	1	2.3	89.3
2	4	2	4	4	1.75	4	1	1	69.5
3	4	2	4	4	3.5	4	1	2.3	84.8
4	4	1.5	4	4	3.75	4	1	2.7	85.9
5	4	1	4	4	3.5	4	1	3	84.3
6	4	1.75	4	4	4	4	1	1.7	82.5
7	4	2	4	4	3.75	4	1	2	84.2
8	4	2	4	4	4	4	1	1	79.7
9	2	2	4	4	3.5	4	1	2.5	80.4
10	3	1	4	4	4	4	1	2	78.1
11				1			0	3	0.0
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

AVERAGE PERFORMANCE RATINGS

February 1995 Test Section

Product	Mix	7 Day	2 Mont	5 Month	Average
Bond-X	1	99.3	97.8	95.5	97.5
Optimix Cold Patch	2	89.5	89.6	90.4	89.8
Hei Way	3	99.2	98.9	97.0	98.4
Cold Mix UPM	4	97.9	96.0	93.4	95.8
Sakrete Professional	5	87.5	87.9	84.9	86.8
QPR-2000	6	93.9	91.6	89.5	91.6
Sylcrete EV	7	95.6	95.3	90.8	93.9
Repave	8	84.4	76.9	75.9	79.1
VTRC HP	9	98.8	98.9	97.8	98.5
Styrelf Cold Mix	10	96.0	93.0	91.5	93.5
MacPatch CM-300	11	87.9	85.7	86.0	86.5
Perma Patch	12	96.8	96.0	95.0	95.9
Fiberized	13	87.4	83.4	78.9	83.3

Average Performance Ratings, July 1994 Test Section

Product	Mix	7 Day	14 Day	1 Month	3 Month	7 Month	9 Mont	1 year	Average
Styrelf Stockpile Patch Mix	**1**	93.8	89.7	90.1	88.2	83.3	85.2	84.4	87.8
MacPatch CM-300	**2**	87.2	86.4	86.7	81.9	77.0	78.2	74.7	81.7
Sylcrete EV Cold Mix	**3**	91.4	87.8	87.4	87.0	84.8	84.8	84.8	86.9
Cold MIx UPM	**4**	92.7	91.9	93.0	90.0	88.6	89.3	88.6	90.6
Hei-Way	**5**	95.5	94.7	95.1	92.9	89.5	90.3	88.0	92.3
Optimix Cold Patch	**6**	83.1	84.4	83.3	81.2	81.0	81.8	81.8	82.3
QPR-2000	**7**	90.2	86.8	86.5	86.5	82.7	84.6	83.8	85.9
Sakrete Professional	**8**	86.0	85.7	84.5	80.4	79.7	79.3	79.3	82.1
Perma Patch	**9**	88.5	86.6	85.6	83.0	80.8	85.8	82.3	84.7
Tough Patch	**10**	74.4	78.1	79.7	79.9	77.8	80.8	79.9	78.7
Virginia Type-P Mix	**11**	84.3	20.6	20.1	20.1	20.1	22.0	0.0	26.7
Virginia Type-P Mix w/ Bondade	**12**	81.2	0.0	0.0	0.0	0.0	0.0	0.0	11.6
HMA	**HMA**	91.8	91.8	92.2	91.8	89.6	91.8	91.8	91.5
Average Rating		87.7						83.6	85.9
Average Control Rating		91.3						84.8	87.25

Summer 1994

Results of Seven Day Evaluation

Set 1

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	4	4	4	4	4	1	2.3	96.0
2	4	4	4	4	4	4	1	1	88.7
3	4	3	4	4	4	4	1	2.3	91.5
4	4	3.5	4	4	4	4	1	2.7	96.0
5	4	3.5	4	4	4	4	1	3	97.8
6	4	2	4	4	4	4	1	1.7	83.6
7	4	2.5	4	4	4	4	1	2	87.6
8	4	3.5	4	4	4	4	1	1	86.4
9	3	3.5	4	4	4	4	1	2.5	92.2
10	1	1	4	4	4	4	1	2	72.6
11	1	3.5	4	4	2.5	4	1	3	82.8
12	1	2	4	4	2.5	4	1	3	76.0
HMA	1	4	4	4	4	4	1	3	91.8

Set 2

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2.5	4	4	4	4	1	2.3	89.3
2	4	3.75	4	4	4	4	1	1	87.5
3	4	3.5	4	4	4	4	1	2.3	93.8
4	4	2.75	4	4	4	4	1	2.7	92.7
5	4	3.5	4	4	4	4	1	3	97.8
6	4	2.25	4	4	4	4	1	1.7	84.8
7	4	3.75	4	4	4	4	1	2	93.2
8	4	3	4	4	4	4	1	1	84.2
9	2	3	4	4	4	4	1	2.5	87.2
10	1	1	4	4	4	4	1	2	72.6
11	1	3.5	4	4	3	4	1	3	85.0
12	1	3.25	4	4	3.5	3.75	1	3	84.9
HMA	1	4	4	4	4	4	1	3	91.8

Set 3

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	4	4	4	4	4	1	2.3	96.0
2	4	3.25	4	4	4	4	1	1	85.3
3	3.5	2.75	4	4	4	4	1	2.3	89.0
4	4	2	4	4	4	4	1	2.7	89.3
5	4	2	4	4	4	4	1	3	91.0
6	3	2	4	4	4	4	1	1.7	80.9
7	4	3	4	4	4	4	1	2	89.8
8	4	3.75	4	4	4	4	1	1	87.5
9	2.5	2.5	4	4	4	4	1	2.5	86.3
10	3	1	4	4	4	4	1	2	78.1
11	1	2.5	4	4	4	4	1	3	85.0
12	1	2	4	4	4	4	1	3	82.8
HMA	1	4	4	4	4	4	1	3	91.8

Results after 14 Day Evaluation

Set 1

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2.5	4	4	4	4	1	2.3	89.3
2	4	4	4	4	4	4	1	1	88.7
3	4	2	4	4	4	4	1	2.3	87.0
4	4	3.25	4	4	4	4	1	2.7	94.9
5	4	3.25	4	4	4	4	1	3	96.6
6	4	2	4	4	4	4	1	1.7	83.6
7	4	2.5	4	4	4	4	1	2	87.6
8	4	3.25	4	4	4	4	1	1	85.3
9	3.5	3	4	4	4	4	1	2.5	91.3
10	3	1	4	4	4	4	1	2	78.1
11	1.75	2.5	4	3.25	4	4	0.33	3	28.7
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Set 2

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2	4	4	4	4	1	2.3	87.0
2	4	3.5	4	4	4	4	1	1	86.4
3	4	2.5	4	4	4	4	1	2.3	89.3
4	4	2.5	4	4	4	4	1	2.7	91.5
5	4	3.5	4	4	4	3.75	1	3	96.5
6	4	2	4	4	4	4	1	1.7	83.6
7	4	2.5	4	4	4	4	1	2	87.6
8	4	3	4	4	4	4	1	1	84.2
9	2	2	4	4	4	4	1	2.5	82.7
10	3	1	4	4	4	4	1	2	78.1
11				1			0.33	3	5.6
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Set 3

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	3.5	3.75	4	4	4	1	2.3	92.8
2	4	3	4	4	4	4	1	1	84.2
3	4	2	4	4	4	4	1	2.3	87.0
4	4	2	4	4	4	4	1	2.7	89.3
5	4	2	4	4	4	4	1	3	91.0
6	4	2.5	4	4	4	4	1	1.7	85.9
7	4	2	4	4	4	4	1	2	85.3
8	4	3.75	4	4	4	4	1	1	87.5
9	1.5	3	4	4	4	4	1	2.5	85.8
10	3	1	4	4	4	4	1	2	78.1
11	1	2	4	4	4	4	0.33	3	27.3
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Results of 1 Month Evaluation

Set 1

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2.5	4	4	4	4	1	2.3	89.3
2	4	4	4	4	4	4	1	1	88.7
3	4	2	4	4	4	4	1	2.3	87.0
4	4	4	4	4	4	4	1	2.7	98.3
5	4	3.5	4	4	4	4	1	3	97.8
6	4	1.75	4	4	4	4	1	1.7	82.5
7	4	2	4	4	4	4	1	2	85.3
8	4	3.75	4	4	4	4	1	1	87.5
9	3.5	2.75	4	4	4	4	1	2.5	90.2
10	4	1	4	4	4	4	1	2	80.8
11	1	2	4	3.25	4	4	0.33	3	27.3
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Set 2

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2	4	4	4	4	1	2.3	87.0
2	4	4	4	4	4	4	1	1	88.7
3	4	2	4	4	4	4	1	2.3	87.0
4	4	2.5	4	4	4	4	1	2.7	91.5
5	4	3.5	4	4	4	4	1	3	97.8
6	4	2	4	4	4	4	1	1.7	83.6
7	4	2.75	4	4	4	4	1	2	88.7
8	4	2.5	4	4	4	4	1	1	81.9
9	2	2	4	4	4	4	1	2.5	82.7
10	3.5	1	4	4	4	4	1	2	79.5
11				1			0.33	3	5.6
12				1			0	3	0.0
HMA	1.5	4	4	4	4	4	1	3	93.1

Set 3

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	3.75	3.75	4	4	4	1	2.3	93.9
2	3.5	3	4	4	4	4	1	1	82.8
3	4	2.25	4	4	4	4	1	2.3	88.2
4	4	2	4	4	4	4	1	2.7	89.3
5	4	1.75	4	4	4	4	1	3	89.9
6	4	2	4	4	4	4	1	1.7	83.6
7	4	2	4	4	4	4	1	2	85.3
8	4	3	4	4	4	4	1	1	84.2
9	2.5	2	4	4	4	4	1	2.5	84.0
10	3.25	1	4	4	4	4	1	2	78.8
11	1	2	4	4	4	4	0.33	3	27.3
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Results of 3 Month Evaluation

Set 1

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2.75	4	4	4	4	1	2.3	90.4
2	4	3.75	4	4	4	4	1	1	87.5
3	4	2	4	4	4	4	1	2.3	87.0
4	4	2.5	4	4	4	4	1	2.7	91.5
5	4	3.5	4	4	4	4	1	3	97.8
6	4	1.75	4	4	4	4	1	1.7	82.5
7	4	2	4	4	4	4	1	2	85.3
8	4	2.25	4	4	3.75	4	1	1	79.7
9	3	2.25	4	4	4	4	1	2.5	86.5
10	4	1	4	4	4	4	1	2	80.8
11	1	2	4	3.25	4	4	0.33	3	27.3
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Set 2

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2	4	4	4	4	1	2.3	87.0
2	4	2.75	4	4	4	4	1	1	83.0
3	4	2	4	4	4	4	1	2.3	87.0
4	4	2	4	4	4	4	1	2.7	89.3
5	4	2.5	4	4	4	4	1	3	93.3
6	4	1.25	4	4	4	4	1	1.7	80.3
7	4	2.75	4	4	4	4	1	2	88.7
8	4	2.25	4	4	4	4	1	1	80.8
9	1.5	2	4	4	4	4	1	2.5	81.3
10	3.5	1	4	4	4	4	1	2	79.5
11				1			0.33	3	5.6
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Set 3

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2.25	3.75	4	4	4	1	2.3	87.2
2	4	2	4	4	3	4	1	1	75.2
3	4	2	4	4	4	4	1	2.3	87.0
4	4	2	4	4	4	4	1	2.7	89.3
5	4	1.25	4	4	4	4	1	3	87.6
6	3	2	4	4	4	4	1	1.7	80.9
7	4	2	4	4	4	4	1	2	85.3
8	4	2.25	4	4	4	4	1	1	80.8
9	1.5	2	4	4	4	4	1	2.5	81.3
10	3.5	1	4	4	4	4	1	2	79.5
11	1	2	4	4	4	4	0.33	3	27.3
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Results of 7 Month Evaluation

Set 1

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2.5	4	4	3	4	1	2.3	84.8
2	4	3.5	4	4	3	4	1	1	81.9
3	4	2	4	4	3	4	1	2.3	82.5
4	4	2.5	4	4	4	4	1	2.7	91.5
5	4	2.5	4	4	3.75	4	1	3	92.1
6	4	1.25	4	4	4	4	1	1.7	80.3
7	4	2	4	4	3.25	4	1	2	82.0
8	4	2.25	4	4	3.75	4	1	1	79.7
9	3	2.25	4	4	3.75	4	1	2.5	85.4
10	4	1	4	4	4	4	1	2	80.8
11	1	2	4	3.25	4	4	0.33	3	27.3
12				1			0	3	0.0
HMA	1.5	4	4	4	3	4	1	3	88.6

Set 2

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2	4	4	2.75	3.75	1	2.3	80.2
2	4	2.75	4	4	3.25	3.75	1	1	78.4
3	4	2	4	4	4	4	1	2.3	87.0
4	4	2	4	4	4	4	1	2.7	89.3
5	4	3	4	4	3.75	3.75	1	3	93.1
6	4	1.25	4	4	4	4	1	1.7	80.3
7	4	2	4	4	3.25	4	1	2	82.0
8	4	2.25	4	4	4	4	1	1	80.8
9	2.5	2	4	4	2.25	4	1	2.5	76.2
10	3.5	1	3.5	4	4	4	1	2	77.5
11				1			0.33	3	5.6
12				1			0	3	0.0
HMA	1	3.75	4	4	3.75	4	1	3	89.5

Set 3

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2.25	3.75	4	3.5	4	1	2.3	84.9
2	4	2	4	4	2	4	1	1	70.7
3	4	2	4	4	3.5	4	1	2.3	84.8
4	4	2	4	4	3	4	1	2.7	84.8
5	4	1.25	3.75	4	3.25	4	1	3	83.3
6	4	1.75	4	4	4	4	1	1.7	82.5
7	4	2	4	4	3.75	4	1	2	84.2
8	4	2	4	4	3.75	4	1	1	78.5
9	2.5	2	4	4	3.25	4	1	2.5	80.7
10	3	1	3.25	4	4	4	1	2	75.1
11	1	2	4	4	4	4	0.33	3	27.3
12				1			0	3	0.0
HMA	1	4	4	4	3.75	4	1	3	90.6

Results of 9 Month Evaluation

Set 1

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2.75	4	4	3	4	1	2.3	85.9
2	4	3.75	4	4	3	4	1	1	83.0
3	4	2	4	4	4	4	1	2.3	87.0
4	4	2	4	4	4	4	1	2.7	89.3
5	4	2	4	4	3.25	4	1	3	87.6
6	4	1.25	4	4	4	4	1	1.7	80.3
7	4	2	4	4	3.5	4	1	2	83.1
8	4	2.25	4	4	3.5	4	1	1	78.5
9	3.5	2.75	4	4	3.5	4	1	2.5	87.9
10	4	1	4	4	4	4	1	2	80.8
11	4	4	4	3.75	4	4	0.33	3	33.0
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Set 2

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2	4	4	3	4	1	2.3	82.5
2	4	3	4	4	2.75	4	1	1	78.5
3	4	2	4	4	3	4	1	2.3	82.5
4	4	2	4	4	4	4	1	2.7	89.3
5	4	2.75	4	4	3.75	4	1	3	93.3
6	4	1.75	4	4	4	4	1	1.7	82.5
7	4	2	4	4	4	4	1	2	85.3
8	4	2	4	4	4	4	1	1	79.7
9	3.5	2	4	4	4	4	1	2.5	86.8
10	4	1	4	4	4	4	1	2	80.8
11				1			0.33	3	5.6
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Set 3

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	3	4	4	3	4	1	2.3	87.0
2	4	2	4	4	2.5	4	1	1	72.9
3	4	2	4	4	3.5	4	1	2.3	84.8
4	4	2	4	4	4	4	1	2.7	89.3
5	4	1.75	4	4	4	4	1	3	89.9
6	4	1.75	4	4	4	4	1	1.7	82.5
7	4	2	4	4	4	4	1	2	85.3
8	4	2	4	4	4	4	1	1	79.7
9	2	2	4	4	4	4	1	2.5	82.7
10	4	1	4	4	4	4	1	2	80.8
11	1	2	4	4	4	4	0.33	3	27.3
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Results of 1 Year Evaluation

Set 1

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2.5	4	4	3	4	1	2.3	84.8
2	4	3.75	4	4	2.5	4	1	1	80.8
3	4	2	4	4	3.5	4	1	2.3	84.8
4	4	2.25	4	4	4	4	1	2.7	90.4
5	4	2.25	4	4	3	4	1	3	87.6
6	4	1.25	4	4	4	4	1	1.7	80.3
7	4	2	4	4	3.5	4	1	2	83.1
8	4	2	4	4	3.75	4	1	1	78.5
9	3	2.75	4	4	3.5	4	1	2.5	86.5
10	4	1	4	4	4	4	1	2	80.8
11				1			0	3	0.0
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Set 2

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2	4	4	2.25	4	1	2.3	79.2
2	4	3	4	4	2	3.75	1	1	73.9
3	4	2	4	4	3.5	4	1	2.3	84.8
4	4	2	4	4	4	4	1	2.7	89.3
5	4	2.5	4	4	3.75	4	1	3	92.1
6	4	1.75	4	4	4	4	1	1.7	82.5
7	4	2	4	4	3.75	4	1	2	84.2
8	4	2.25	4	4	3.75	4	1	1	79.7
9	1	2	4	4	4	4	1	2.5	79.9
10	4	1	4	4	4	4	1	2	80.8
11				1			0	3	0.0
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

Set 3

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2.75	4	4	3.75	4	1	2.3	89.3
2	4	2	4	4	1.75	4	1	1	69.5
3	4	2	4	4	3.5	4	1	2.3	84.8
4	4	1.5	4	4	3.75	4	1	2.7	85.9
5	4	1	4	4	3.5	4	1	3	84.3
6	4	1.75	4	4	4	4	1	1.7	82.5
7	4	2	4	4	3.75	4	1	2	84.2
8	4	2	4	4	4	4	1	1	79.7
9	2	2	4	4	3.5	4	1	2.5	80.4
10	3	1	4	4	4	4	1	2	78.1
11				1			0	3	0.0
12				1			0	3	0.0
HMA	1	4	4	4	4	4	1	3	91.8

AVERAGE PERFORMANCE RATINGS

February 1995 Test Section

Product	Mix	7 Day	2 Mont	5 Month	Average
Bond-X	**1**	99.3	97.8	95.5	97.5
Optimix Cold Patch	**2**	89.5	89.6	90.4	89.8
Hei Way	**3**	99.2	98.9	97.0	98.4
Cold Mix UPM	**4**	97.9	96.0	93.4	95.8
Sakrete Professional	**5**	87.5	87.9	84.9	86.8
QPR-2000	**6**	93.9	91.6	89.5	91.6
Sylcrete EV	**7**	95.6	95.3	90.8	93.9
Repave	**8**	84.4	76.9	75.9	79.1
VTRC HP	**9**	98.8	98.9	97.8	98.5
Styrelf Cold Mix	**10**	96.0	93.0	91.5	93.5
MacPatch CM-300	**11**	87.9	85.7	86.0	86.5
Perma Patch	**12**	96.8	96.0	95.0	95.9
Fiberized	**13**	87.4	83.4	78.9	83.3

Winter 1995

Results of Seven Day Evaluation

Set 1

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	4	4	4	3.75	4	1	3	98.9
2	4	3	4	4	4	3.5	1	1.7	85.6
3	4	4	4	4	4	4	1	3	100.0
4	4	4	4	4	4	4	1	2.7	98.3
5	4	4	4	4	4	4	1	1	88.7
6	3.5	4	4	4	4	4	1	2	93.0
7	4	4	4	4	4	4	1	2.3	96.0
8	3.25	3.5	3.5	4	4	4	1	1	82.3
9	4	3.5	4	4	4	3.75	1	2.5	93.7
10	4	4	4	4	4	4	1	2.3	96.0
11	4	4	4	4	4	4	1	1	88.7
12	4	4	4	4	4	4	1	2.5	97.2
13	3.5	4	4	4	4	4	1	1	87.3

Set 2

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	3.75	4	4	4	4	1	3	98.9
2	4	4	4	4	3.5	4	1	1.7	90.4
3	4	3.75	4	4	4	3.75	1	3	97.6
4	4	3.75	4	4	4	4	1	2.7	97.2
5	4	3.75	4	4	3.75	4	1	1	86.4
6	4	4	4	4	4	4	1	2	94.3
7	4	4	4	4	4	3.75	1	2.3	94.8
8	4	4	3.75	4	4	4	1	1	87.7
9	4	4	4	4	4	4	1	2.5	97.2
10	4	4	4	4	4	4	1	2.3	96.0
11	4	4	4	4	3.5	4	1	1	86.4
12	4	4	4	4	4	4	1	2.5	97.2
13	4	4	4	4	4	4	1	1	88.7

Set 3

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	4	4	4	4	4	1	3	100.0
2	4	4	4	4	4	4	1	1.7	92.6
3	4	4	4	4	4	4	1	3	100.0
4	4	4	4	4	4	4	1	2.7	98.3
5	4	4	4	4	3.75	4	1	1	87.5
6	4	4	4	4	4	4	1	2	94.3
7	4	4	4	4	4	4	1	2.3	96.0
8	2	4	4	4	4	4	1	1	83.2
9	4	4	4	4	4	4	1	2.5	97.2
10	4	4	4	4	4	4	1	2.3	96.0
11	4	4	4	4	4	4	1	1	88.7
12	4	3.75	4	4	4	4	1	2.5	96.0
13	4	3.75	4	4	3.75	4	1	1	86.4

Results after 2 Month Evaluation

Set 1

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	4	4	4	4	4	1	3	100.0
2	4	3	4	4	4	4	1	1.7	88.1
3	4	3.75	4	4	4	4	1	3	98.9
4	4	4	4	4	4	4	1	2.7	98.3
5	4	4	4	4	4	4	1	1	88.7
6	4	4	4	4	3.75	4	1	2	93.2
7	4	4	4	4	4	4	1	2.3	96.0
8	3	1.75	4	4	4	4	1	1	75.8
9	4	3.5	4	4	4	4	1	2.5	94.9
10	4	4	4	4	3.75	4	1	2.3	94.9
11	4	4	4	4	3.75	4	1	1	87.5
12	4	4	4	4	4	4	1	2.5	97.2
13	4	3.25	4	4	4	4	1	1	85.3

Set 2

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	2.5	4	4	4	4	1	3	93.3
2	4	3.75	4	4	3.25	4	1	1.7	88.1
3	4	3.5	4	4	4	4	1	3	97.8
4	4	3.5	4	4	4	4	1	2.7	96.0
5	4	3.5	4	4	4	4	1	1	86.4
6	4	4	4	4	4	3.5	1	2	91.8
7	4	4	4	4	4	4	1	2.3	96.0
8	3	2.25	4	4	4	4	1	1	78.0
9	4	3.75	4	4	4	4	1	2.5	96.0
10	4	4	4	4	3.75	4	1	2.3	94.9
11	4	3.5	4	4	3.5	4	1	1	84.2
12	4	4	4	4	4	4	1	2.5	97.2
13	4	3	4	4	3.5	4	1	1	81.9

Set 3

Patch	Bleeding	Dishing	Edge Disintegration	Missing Patch	Raveling	Shoving	Surviveability	Workability	Performance Rating
1	4	4	4	4	4	4	1	3	100.0
2	4	4	4	4	4	4	1	1.7	92.6
3	4	4	4	4	4	4	1	3	100.0
4	4	3	4	4	4	4	1	2.7	93.8
5	4	4	4	4	4	4	1	1	88.7
6	4	3.75	4	4	3.25	4	1	2	89.8
7	4	4	4	4	3.5	4	1	2.3	93.8
8	3	2	4	4	4	4	1	1	76.9
9	4	4	4	4	4	4	1	2.5	97.2
10	4	3.25	4	4	3.25	4	1	2.3	89.3
11	4	4	4	4	3.25	4	1	1	85.3
12	4	3.25	4	4	4	4	1	2.5	93.8
13	4	3.5	4	4	3.25	4	1	1	83.0