

Correlation of Laboratory Tests to Field Performance for Chip Seals

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The Nevada Department of Transportation constructed 44 chip-seal test sections between Yerington and Wabuska, Nevada. One of the purposes of these test sections was to correlate laboratory and field testing with pavement performance. The laboratory testing consisted of the Vialit-time series and the Vialit-temperature series. Field testing included only the Vialit-time series. Pavement performance was based on pavement evaluations and percent reflective cracking. The pavement evaluations recorded overall condition, aggregate retention, aggregate embedment, and bleeding. After a comparison of the field and laboratory testing with pavement performance three conclusions were drawn: (a) the field Vialit-time series testing did not correspond to laboratory Vialit-time series testing because of the variation in curing temperature of the field samples; (b) the laboratory Vialit-temperature series can detect the effects of aggregate gradation on different binders; and (c) aggregate retention of the sample cured at 0°F is a good indicator of overall chip-seal performance. Ratings of 8.0 or greater are likely for overall condition and aggregate retention if the percent aggregate retention for the laboratory sample cured at 0°F is greater than 60 percent.

The three main factors that determine the success of a chip seal are weather conditions during construction, construction practices, and selection of materials. Weather conditions, although they cannot be controlled, can in many cases be anticipated. Chip sealing in cool weather might affect the selection of binder or require much tighter control of the construction sequence.

Construction practices can alter the performance of almost any binder. Careful attention must be paid to the uniformity of the binder application, the time between the binder and aggregate applications, and the sequencing and timing of the rollers.

However, even if construction practices are perfect, some binder-aggregate systems still will not perform adequately. Many choices of materials are available from conventional emulsions and viscosity grade binders to a myriad of modified binders. Each of these materials has desirable properties, such as low application temperatures (emulsions), quick setting time (emulsions, viscosity grades), and increased resistance to thermal cracking (modified binders). Variables associated with selecting aggregates include gradation (uniformly sized stone versus graded), prewet, or precoated.

The purpose of the joint research of the Nevada Department of Transportation (NDOT) and the University of Nevada, Reno (UNR) conducted in July 1989 was to attempt to

develop laboratory test methods for chip seals to determine the performance of different binder-aggregate systems.

RESEARCH PROGRAM

The research program had one main objective: to correlate laboratory testing with field test results and performance of chip seals. Laboratory testing included Vialit testing versus both time and temperature. The field testing included taking Vialit field samples during construction. Pavement performance was based on pavement evaluations conducted 3 months and 11 months after construction and percent reflective cracking.

Forty-four experimental chip-seal test sections were placed on US-95 (Alternate) near Yerington, Nevada, between July 17 and July 21, 1989. Nine product suppliers provided the following: one unmodified emulsion, two unmodified viscosity grade asphalt cements, and six modified viscosity grade asphalt cements. The binder and aggregate quantities were designed to vary (two levels). Two aggregate gradations were used with each of the binder quantities. The same source of aggregate was used for both gradations.

Vialit sample plates that were placed on the pavement and subjected to the actual construction sequence of spraying, aggregate application, and rolling were used to monitor the material that each binder was capable of retaining at various test times.

MATERIALS

The physical properties of the binders were obtained from the producers, and the aggregate properties reported below were determined by the UNR laboratory.

Binders

The field test sections consisted of two control and seven experimental binders from various companies. The control binders were LMCRS-2H (emulsion) and ASTM D3381 Table 3 AR 2000 (viscosity grade). Other binders used were the following:

- ASTM D3381 Table 2 AC10,
- EVA-modified AC10,
- Kraton-modified AR 1000,
- AC20R,
- AR1000 modified with crumb rubber,

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- AC10R, and
- AR 4000 modified with a styrene-based polymer.

The physical properties of these binders, as supplied by the producers, are presented in Table 1.

Aggregates

Two gradations of aggregates were used during the course of this project: the standard NDOT 705.03.05 and the Texas Item 302 No. 4 (3,4). The gradations are presented in Table 2. Most of the aggregates used were precoated with 0.5 percent AR 4000 and stockpiled for at least a week before construction.

There was one major source for all the aggregates used in the construction of these test sections with one exception—the uncoated Texas gradation used in only four of the LMCRS-2H control sections. Inadvertently, all of the Texas gradation aggregate prepared was precoated. Therefore, the uncoated Texas gradation aggregate from the previous year's chip-seal test sections was used. The physical properties of the aggregates can be found in Table 2.

CONSTRUCTION OF TEST SECTIONS

Test sections were constructed according to the data presented in Table 3. A total of 11 test sections was constructed in this field experiment. To provide easier notation, each section was assigned a number that also designated the order of construction. For example, the first binder applied was assigned the number one, the second applied was given the number two, and so on. Sections 10 and 11 were duplicates of sections 1 and 2 (i.e., they were control sections).

Each test section was separated into four subsections: A, B, C, and D. (Figure 1). The viscosity grade asphalt cement subsections labeled A and B were constructed with the Nevada gradation precoated aggregate. The C and D subsections were constructed with the Texas gradation precoated aggregate. The A and B emulsion subsections were constructed with uncoated Nevada gradation aggregate; uncoated Texas gradation aggregate was used for test sections C and D. Aggregate spread rates varied among sections and subsections from 13 to 30 lb/yd².

TABLE 2 AGGREGATE PROPERTIES

Test	Specification		Project Aggregate	
	Nevada	Texas	Nevada	Texas (Pre)
Bulk Specific Gravity	NA	NA	-----	2.785
Bulk Specific Gravity, SSD	NA	NA	2.689	2.825
Apparent Specific Gravity	NA	NA	-----	2.902
Adsorption Capacity, %	NA	NA	1.180	1.443
Theoretical Maximum	NA	NA	NA	2.748
Sieve Analysis (% Passing)				
5/8"	100	100	99.7	94.5
1/2"	100	98-100	77.4	61.0
3/8"	50-80	65-85	32.6	43.5
#4	0-15	0-5	3.6	0.8
#8	0-5	---	---	---
#10	---	0-1	1.7	0.6
#16	---	---	---	---
#30	---	---	---	---
#50	---	---	---	---
#100	0-2	---	---	---
#200	---	---	---	---
Board Test (lb/yd ²)	NA	NA	15	18
Unit Weight Rodded	NA	NA	50.0	47.6
Shoveled	NA	NA	45.5	45.0
Average Least Dimension	NA	NA	0.31	0.32

NOTE: Information provided by UNR, except aggregate gradation of Texas precoat, which was provided by Exxon.

TABLE 3 SUMMARY OF BINDER AND AGGREGATE QUANTITIES FOR SUBSECTIONS

Product	Subsection	Binder Quantity (gal/yd ²)	Aggregate Quantity (lb/yd ²)
AR 2000 (2)	A	0.36	21
	C	0.46	25
AC20R (3)	A	0.35	22
	C	0.43	28
AR 1000 w/crumb rubber (4)	A	0.60	30
	C	0.69	30
AC10 (5)	A	0.38	24
	C	0.39	22
EVA Modified AC10 (6)	A	0.36	18
	C	0.36	23
Kraton Modified AR 1000 (7)	B	0.36	20
	C	0.36	21
Liquid Styrene Modified AR 4000 (8)	B	0.33	20
	C	0.34	23
AC10R (9)	A	0.40	20
	B	0.36	20
AR 2000 (10)	A	0.36	20
	C	0.36	20

A binder quantity selected as optimum by the producer was used for all subsections labeled A and C. Subsections labeled B and D were constructed with an increased binder quantity, relative to each binder's original design quantity.

FIELD TESTING AND PERFORMANCE

The field performance was based on Vialit samples from actual construction, pavement evaluations 3 months and 11 months after construction, and percent reflective cracking.

TABLE 1 ASPHALT CEMENT PROPERTIES

Test	AC10	EVA Modified	Kraton Modified AR 1000	AC20R	AR 1000 Modified w/Crumb Rubber	AC10R	Liquid Styrene Modified AR 4000
Viscosity							
140°F, P	---	---	---	---	---	1000	---
275, cSt	250	418.8	550	325	---	---	---
Penetration							
77°F, 100g							
5 sec	80	62	110	---	---	83	---
Ductility							
77°F, cm	75	---	---	---	---	---	---
39.2°F, cm	---	9	145	25	---	26	---
45°F	---	32	---	---	---	---	---

NOTE: Results supplied by producers.

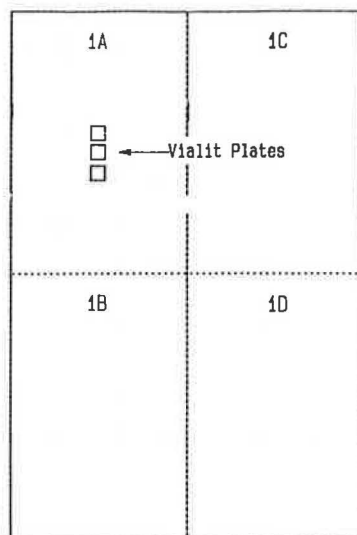


FIGURE 1 Typical test section.

Field Vialit Test

The Vialit test, described in detail in previous work, was used to evaluate aggregate retention. A brief synopsis of the test is as follows: a chip seal is simulated on a 7- × 7-in. steel plate and is allowed to cure for various time intervals (typically 10 min, 30 min, 2 hr, 5 hr, and 24 hr). The plate is then weighed, inverted for 10 sec, weighed, and inverted while a steel ball is dropped three times on the back of it. The plate is weighed again, and the material retained is calculated.

The Vialit plates were placed on the pavement 6 ft from and parallel to the center line (Figure 1). These plates proved to be heavy enough to allow construction to proceed as usual with one exception: rollers were slowed to half their normal speed to prevent the metal plates from flipping up and damaging the samples. After the last roller and before the brooms had passed, the plates were picked up and tested (Figure 2). Figure 3 shows the testing apparatus.

Samples were then tested after the appropriate time interval. The test times were limited to 10 min, 30 min, and 2 hr for viscosity grade binders because of the large quantity of



FIGURE 2 Removal of Vialit plates for testing.

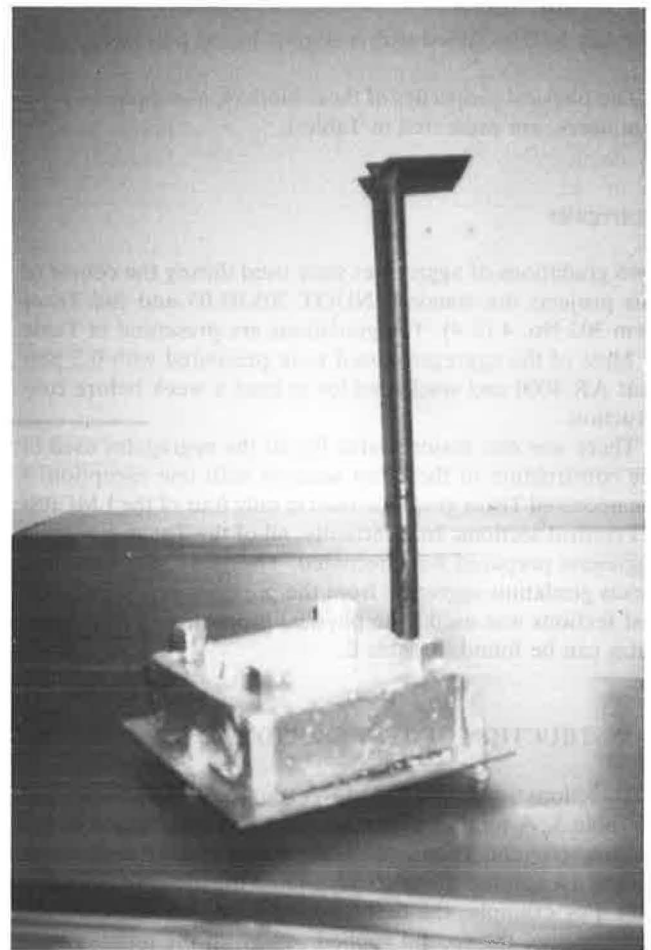


FIGURE 3 Vialit test apparatus.

test sections being placed and the limited mobile storage for test plates. The 2-hr limit was chosen on the basis of previous research by UNR that indicated results for viscosity grade did not change after this time interval.

Field Evaluations

Field evaluations were conducted 3 months after construction (October 1989) and 11 months after construction (May 1990). The evaluations were made at the same location both times. The evaluators were Jon Epps (UNR), Ken Davis (NDOT), and representatives from each of the participating suppliers.

To save time, evaluations were recorded in only two of the four subsections per binder. One subsection was located where the Texas gradation was used and the other was located where the Nevada gradation was used. The subsections evaluated were chosen as the most representative subsections for each binder and gradation. Evaluation sites were located near the field testing sites.

Overall condition, aggregate retention, and bleeding were rated on a scale of 1 to 10, 10 being best. Aggregate embedment was assessed by the percentage of embedment of an average-sized aggregate.

Percent Reflective Cracking

The percent reflective cracking was calculated as the number of feet of cracking 1 year after construction divided by the number of feet of cracking before chip-seal construction. These quantities were determined from preconstruction and postconstruction crack maps.

Preconstruction crack maps covered 24- × 100-ft sections (i.e., both the northbound and southbound lanes) and were recorded every 1,200 ft for the length of the project. Three to four crack maps are located in each binder section. Moderate to severe cracking was recorded at the south end of the project, whereas slight to moderate cracking was noted at the north end. None of the cracks at the north end were sealed just before construction; cracks at the south end of the project were sealed several months before construction. Postconstruction crack maps were recorded in the same locations and cover the same distance as the preconstruction crack maps. The postconstruction maps were recorded by UNR personnel June 25 to 28, 1990.

LABORATORY TESTING

The purpose of the laboratory testing was to establish a criterion for accepting or rejecting binders to be used for future chip seals. The testing consisted of the laboratory Vialit (both over time and various temperatures).

Actual binder and aggregate quantities used to construct each test section were determined, and these quantities were used to prepare the laboratory Vialit plates for each test section. The binder quantity was found by averaging the tank stabbing, and the aggregate spread rate was calculated from the average of the pan tests for each subsection. The laboratory Vialit-time series is the same test used in the field (described above). Plates 7 × 7 in. were prepared in the laboratory and then tested at 10-min, 30-min, and 2-hr intervals for the hot binders (Figures 4–8).

Because hot binders behave relatively the same over time, a more severe test was needed to differentiate between binders. This test was the temperature series Vialit. Five samples for each section were prepared as before and cured for 24 hr



FIGURE 5 Aggregate application box over sample plate after application of binder.



FIGURE 6 Preparing to drop aggregate on binder.



FIGURE 4 Preparation of sample plate (application of binder).



FIGURE 7 Metal plate being pulled out so that chips fall evenly onto binder surface.

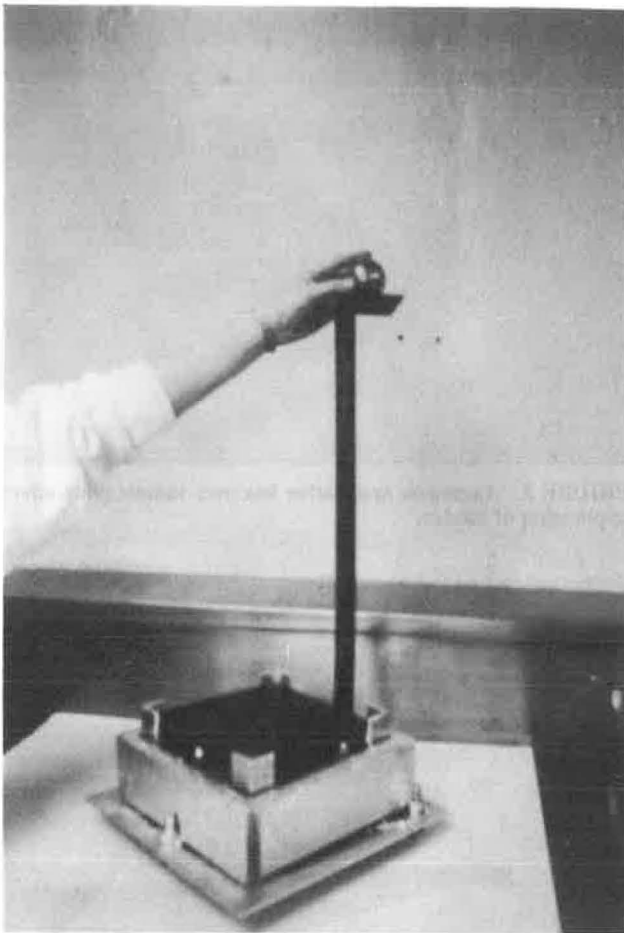


FIGURE 8 Preparation of cured specimen testing.

at 77°F. The first sample was then conditioned to 0°F, the second to 32°F, the third to 50°F, the fourth to 77°F, and the fifth to 104°F; each sample was tested after 24 hr.

ANALYSIS OF TEST RESULTS

The LMCRS-2H sections were not analyzed in this report because of the limited use of the binder in this project and because of the difference in properties from the hot-paving binders.

In the data analysis some binders exhibited definite differences between subsections in laboratory and field results. These subsections are discussed individually. Other binders did not show differences in subsections; therefore the average of the two subsections was analyzed.

Field Vialit-Time Series

Field testing information was not available for the AR 2000 section (2) and the AC20R section (3A). All of the binder sections had aggregate retention between 60 and 100 percent except one. AR 2000 (10) had aggregate retention between 25 and 100. The AR 1000 modified with crumb rubber (4)

section, the styrene-based polymer modified AR 4000 (8) section, and the AC10R (9) section showed some decrease in aggregate retention with time. This was caused by the change in curing temperature during the day. For example, a field sample may have been completed at 10:00 when the temperature was 85°F and tested 2 hr later when the temperature was 100°F. Therefore, the aggregate retention for the 2-hr test would probably be less than the aggregate retention after 10 min. Figures 9 and 10 show typical aggregate retention versus time.

Pavement Evaluation 3 Months After Construction

The overall condition of the sections ranged from 6.0 to 9.4, and aggregate retention ranged from 6.0 to 9.7. Little bleeding was detected in any of the sections; ratings varied from 8.4 to 10. Aggregate embedment fluctuated between 25 and 66 percent in the wheelpaths and from 20 to 52 percent between the wheelpaths. Results are presented in Table 4.

Pavement Evaluation 11 Months After Construction

Section 4, an AR 1000 modified with crumb rubber, had the best overall condition with ratings of 9.2 and 9.3. Other sections had moderate to good overall condition with ratings from 7.0 to 8.7. Two of the binders showed significant drop in overall condition. They were the AC 10R (9C) and the AR 2000 (10A and 10C) with ratings of 5.4, 3.9, and 3.8, respectively.

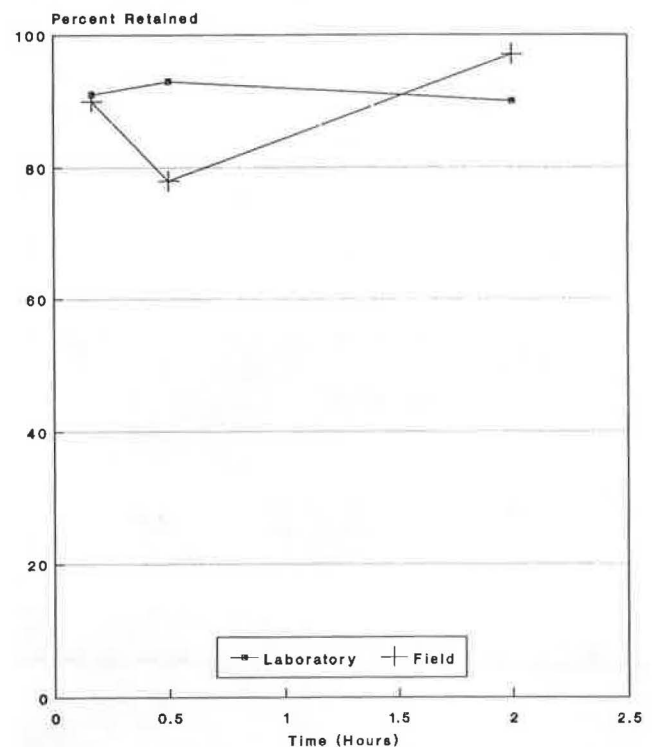


FIGURE 9 Percent retention of laboratory and field testing (styrene-based modified AR 4000, Section 8B).

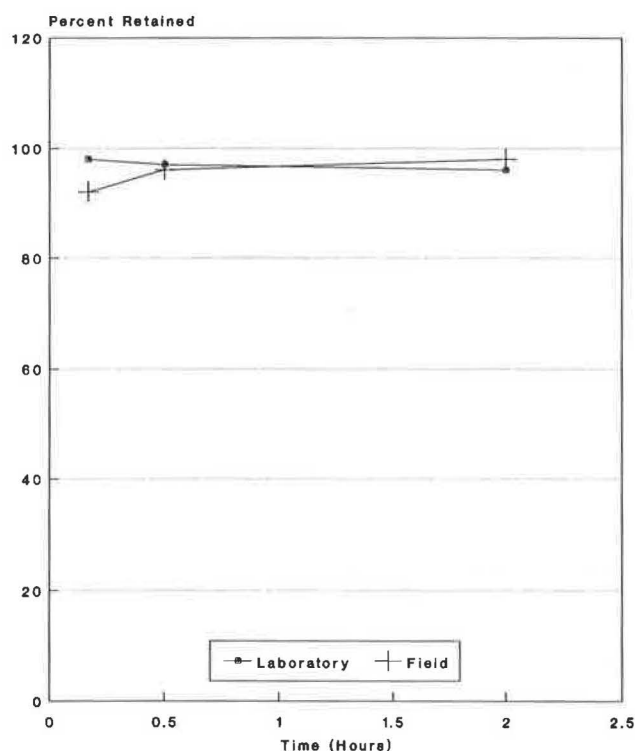


FIGURE 10 Percent retention of laboratory and field testing (styrene-based modified AR 4000, Section 8C).

TABLE 4 SUMMARY OF PAVEMENT EVALUATION 3 MONTHS AFTER CONSTRUCTION

Overall Condition	Aggregate Retention	Bleeding	Aggregate Embedment	Section	Product
9.4	9.4	10	36	7B	Kraton modified AR 1000
9.4	9.2	9.9	37	6A	EVA modified AC10
9.3	9.7	9.8	60	4	AR 1000 modified w/crumb rubber
9.2	9.0	9.9	32	7C	Kraton modified AR 1000
9.0	9.1	9.9	30	9B	AC10R
8.8	9.4	9.5	42	2	AR 2000
8.7	8.2	9.9	28	6C	EVA modified AC10
8.6	9.1	9.7	25	3A	AC20R
8.6	8.3	9.9	42	5A	AC10
8.0	7.7	9.7	33	5C	AC10
7.7	7.2	9.9	25	9C	AC10R
7.3	6.6	9.9	30	10	AR 2000
7.0	6.6	9.9	34	8B	Liquid styrene modified AR 4000
6.0	6.0	9.9	25	8C	Liquid styrene modified AR 4000

Aggregate retention followed the same ranking in performance as discussed in the overall condition ratings. These values ranged from 6.3 to 3.1 in the wheelpath and from 5.3 to 2.9 between the wheelpaths.

Aggregate embedment in the wheelpaths was 67 percent for Section 4, whereas sections 1–3 had moderate aggregate embedment in the wheelpaths with ratings ranging from 43 to 51 percent. Sections 5–11 had values between 23 and 41 percent. Between the wheelpaths aggregate embedment was slightly less than the values above.

Bleeding for all sections ranged from 8.3 to 9.6 between the wheelpaths and from 8.6 to 9.5 at the center line. The results are presented in Table 5.

Comparison of Pavement Evaluations

All of the binder sections looked fairly good after 3 months, but after the winter weather there were definite changes in 2 of the binders. The styrene-based polymer modified AR 4000 (8C) declined in overall condition from 6.0 to 2.4. Its aggregate retention also dropped from a 6.0 to a 2.9. The bleeding and aggregate embedment had little change. The average aggregate embedment was about 24 percent for this section. AR 2000 sections 10A and 10C also decreased in overall condition from 7.5 to 3.9 and from 7.0 to 3.8, respectively. Aggregate retention dropped from 7.8 to 4.8 in Section 10A and from 6.6 to 4.4 in Section 10C.

AR 2000 sections 2A and 2C, however, did not show significant drops in either the overall condition or the aggregate retention. Sections 2A and 2C had greater embedment depth, 38 and 51 percent, than sections 10A and 10C, which had 32 and 29 percent. The greater embedment probably increased the performance for both the overall condition and aggregate retention in sections 2A and 2C.

No significant changes occurred in the other sections between the 3- and 11-month evaluations for overall condition, aggregate retention, bleeding, or aggregate embedment. The relationship between the 3- and 11-month pavement evaluations is shown in Figure 11.

Percent Reflective Cracking

In each section the pre- and postconstruction crack maps closest to the evaluation site were used to determine the percent reflective cracking. These crack maps were located less than 400 ft from the evaluation site.

The least amount of cracking was found in Section 4 (AR 1000 modified with crumb rubber), which had 0 percent. Sections 5A and 5C (AC10) had slightly more cracking with values of 10 and 13 percent. Next were sections 2 and 3A (the AR 2000 section and the AC20R section) having 13 and 19 percent reflective cracking. Values of 19 and 51 percent were recorded in the Kraton-modified AR 1000 section (7C) and the Kraton-modified AR 1000 (7B). Moderate reflective cracking was found in the AC10R section (9C) and the EVA-modified sections (6A and 6C), which had corresponding percentages of 58, 75, and 83. The AC10R section (9B) had 90 percent reflective cracking, and the AR 2000 section (10) had 99 percent. Excessive reflective cracking was recorded in sections 8C and 8B (AR 4000 modified with a styrene-based polymer) with 100 and 113 percent reflective cracking (Table 6).

Laboratory Vialit-Time Series

Most of the binders had similar results over time with usually greater than 85 percent retention. The AR 2000 section (10) had slightly lower retention for subsection C after 10 min, but

TABLE 5 SUMMARY OF PAVEMENT EVALUATION 11 MONTHS AFTER CONSTRUCTION

Overall Condition	Aggregate Retention	Bleeding	Aggregate Embedment	Section	Product
9.3	9.3	9.4	67	4	AR 1000 modified w/crumb rubber
8.7	9.9	9.6	36	7B	Kraton modified AR 1000
8.6	8.9	8.9	44	3A	AC20R
8.1	8.1	9.5	41	7C	Kraton modified AR 1000
8.1	8.4	9.1	39	5A	AC10
8.1	8.2	9.3	33	9B	AC10R
7.9	8.5	9.4	39	6A	EVA modified AC10
7.7	7.6	9.0	43	2	AR 2000
7.3	8.1	9.3	36	8B	Liquid styrene modified AR 4000
7.3	8.0	9.1	37	5C	AC10
7.1	7.5	9.5	27	6C	EVA modified AC10
5.4	5.8	9.3	29	9C	AC10R
3.9	4.4	9.0	29	10	AR 2000
2.4	3.1	8.6	23	8C	Liquid styrene modified AR 4000

all other tests were above 85 percent retention. Figures 9 and 10 show typical aggregate retention versus time.

The AR 2000 section (2) had aggregate retention greater than 95 percent for the 10-min, 30-min, and 2-hr tests. However, the AR 2000 section (10) had lower percent aggregate retention. These values ranged from 75 to 98 percent after 10 min, 98 percent after 30 min, and 90 to 95 percent after 2 hr. Asphalt and aggregate spread rates for these sections were similar. The AR 2000 section (2) had binder spread rates of

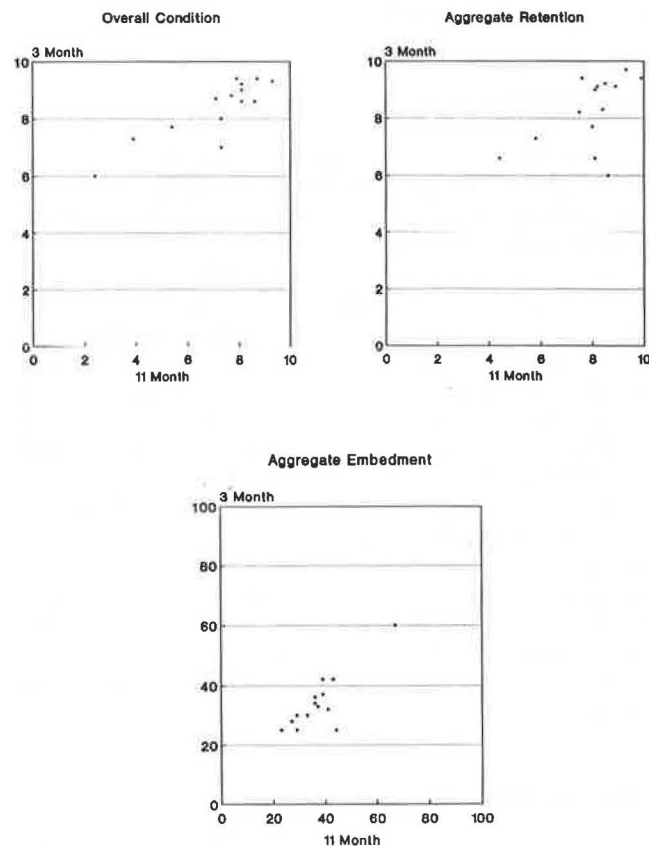


FIGURE 11 Comparison of 3-month and 11-month overall condition, aggregate retention, and aggregate embedment.

TABLE 6 PERCENT REFLECTIVE CRACKING IN EACH SECTION

% Reflective Cracking	Section	Product
0	4	AR 1000 modified with crumb rubber
10	5A	AC10
13	5C	AC10
13	2	AR 2000
19	3A	AC20R
19	7C	Kraton modified AR 1000
51	7B	Kraton modified AR 1000
58	9B	AC10R
75	6A	EVA modified AC10
83	6C	EVA modified AC10
90	9A	AC10R
99	10	AR 2000
100	8C	Liquid styrene modified AR 4000
113	8B	Liquid styrene modified AR 4000

0.36, 0.37, and 0.46 gal/yd² and aggregate spread rates of 21, 25, and 21 lb/yd². Both subsections of the AR 2000 (10A and 10C) had binder spread rates of 0.36 gal/yd² and aggregate spread rates of 20 lb/yd².

Laboratory Vialit-Temperature Series

The AR 1000 modified with crumb rubber section (4) and the EVA-modified AC10 (6A) had the best aggregate retention at 0°F with values of 98 and 92 percent, respectively. Aggregate retention percentages for the AC10 section (5A), the Kraton-modified AR 1000 section (7B), and the AC10R section (9B) were 88, 87, and 82. In the AC20R section (3A) aggregate retention dropped to 75 percent, and in the Kraton-modified AR 1000 (7C) aggregate retention was 67 percent. Aggregate retention for the AC10 section (5C) was fairly good at 60 percent, whereas the EVA-modified AC10 section (6C) was lower at 43 percent. The AR 2000 section (10), the styrene-based AR 4000 section (8B), and the AC10R section had aggregate retentions of 36, 34, and 33 percent, respectively. The least aggregate was retained in the AR 2000 section (2), which had 8 percent aggregate retention, and the styrene-based AR 4000 section (8C), which had 5 percent retention. The best and worst cases are shown in Figures 12 and 13.

Aggregate retention seems to be affected by the different gradations. The subsections constructed with the Nevada gradation (A and B subsections) have greater aggregate retention than the subsections of the same binder constructed with the Texas gradation (C and D subsections). Because the Texas gradation is more of a one-sized gradation than the Nevada gradation, more embedment depth is needed with the Texas gradation for adequate aggregate retention (Table 7).

CORRELATION BETWEEN LABORATORY AND FIELD TESTING

Laboratory Versus Field Vialit-Time Series

Field testing results are not available for the AR 2000 section (2) and the AC20R section (3). Some sections had less than

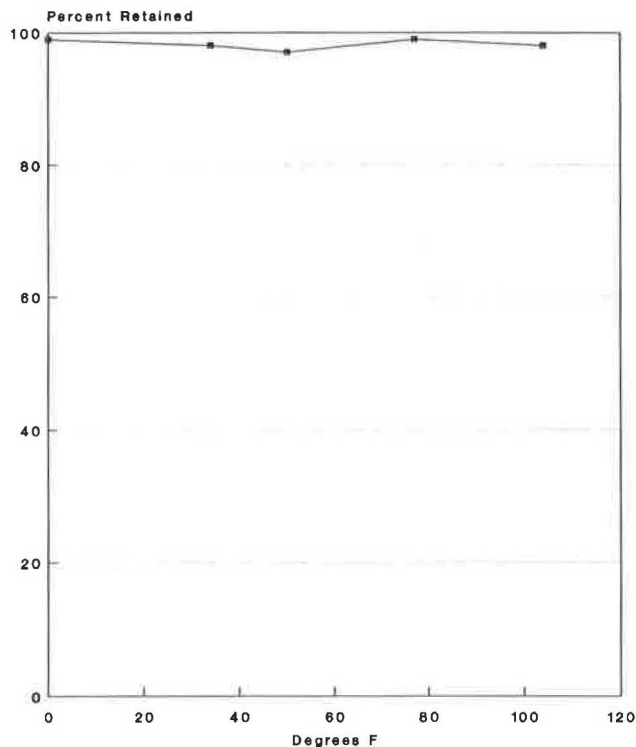


FIGURE 12 Percent retention of laboratory Vialit-temperature series (AR 1000 modified with crumb rubber, Section 4).

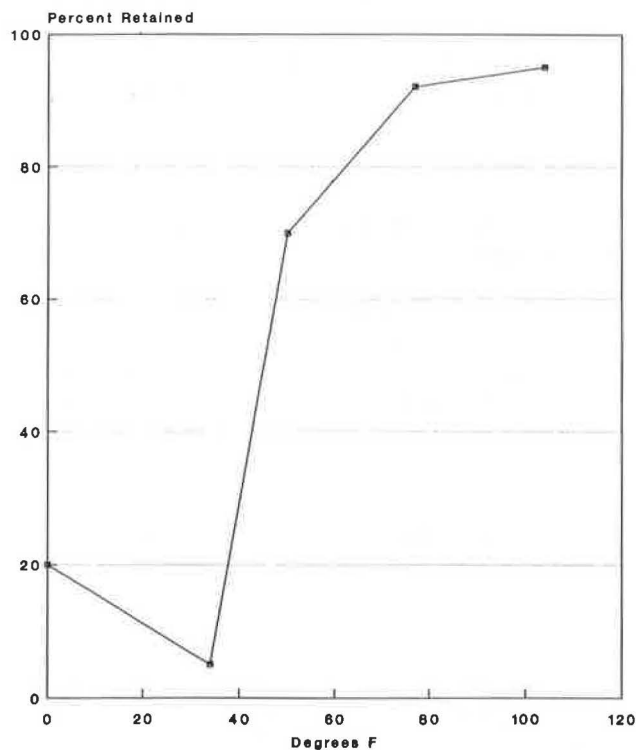


FIGURE 13 Percent retention of laboratory Vialit-temperature series (styrene-based modified AR 4000, Section 8C).

TABLE 7 LABORATORY VIALIT-PERCENT AGGREGATE RETENTION AT 0°F FOR EACH SECTION

% Aggregate Retention at 0°F	Section	Product
98	4	AR 1000 modified with crumb rubber
92	6A	EVA modified AC10
88	5A	AC10
87	7B	Kraton modified AR 1000
82	9B	AC10R
75	3A	AC20R
67	7C	Kraton modified AR 1000
60	5C	AC10
43	6C	EVA modified AC10
36	10	AR 2000
34	8B	Liquid styrene based AR 4000
33	9C	AC10R
8	2	AR 2000
5	8C	Liquid styrene based AR 4000

TABLE 8 COMPARISON OF OVERALL CONDITION AND PERCENT AGGREGATE RETENTION AT 0°F FOR EACH SECTION

Overall Condition	% Retention at 0°F	Section	Product
9.3	98	4	AR 1000 modified with crumb rubber
8.7	87	7B	Kraton modified AR 1000
8.6	75	3A	AC20R
8.1	88	5A	AC10
8.1	67	7C	Kraton modified AR 1000
8.1	82	9B	AC10R
7.9	92	6A	EVA modified AC10
7.7	8	2	AR 2000
7.3	34	8B	Liquid styrene modified AR 4000
7.3	60	5C	AC10
7.1	43	6C	EVA modified AC10
5.4	33	9C	AC10R
3.9	36	10	AR 2000
2.4	5	8C	Liquid styrene modified AR 4000

10 percent difference in aggregate retention between laboratory and field testing, with the higher values from the laboratory testing. These sections were the Kraton-modified AR 1000 section (7B and 7C), the styrene-based modified AR 4000 section (8C), the AC10R section (9C), and the AR 2000 section (10). The other binders had between 10 and 35 percent difference in aggregate retention between laboratory and field testing. These were the AR 1000 modified with crumb rubber section (4), the AC10 section (5), the EVA-modified AC10 section (6), the styrene-based modified AR 4000 section (8B), and the AC10R section (9B).

Some sections, such as the styrene-based modified AR 4000 section (8B), had little difference in aggregate retention between laboratory and field for the 10-min test. At 30 min there was a large difference in aggregate retention between laboratory and field. At 2 hr there was little difference in aggregate retention between laboratory and field testing (Figures 9 and 10). This was because of the large fluctuation of curing temperatures in the field. A sample made at 11:00 when the ambient temperature was 90°F and tested 30 min later after being stored in an automobile at 100°F will have less aggregate retention than a sample tested after 10 min.

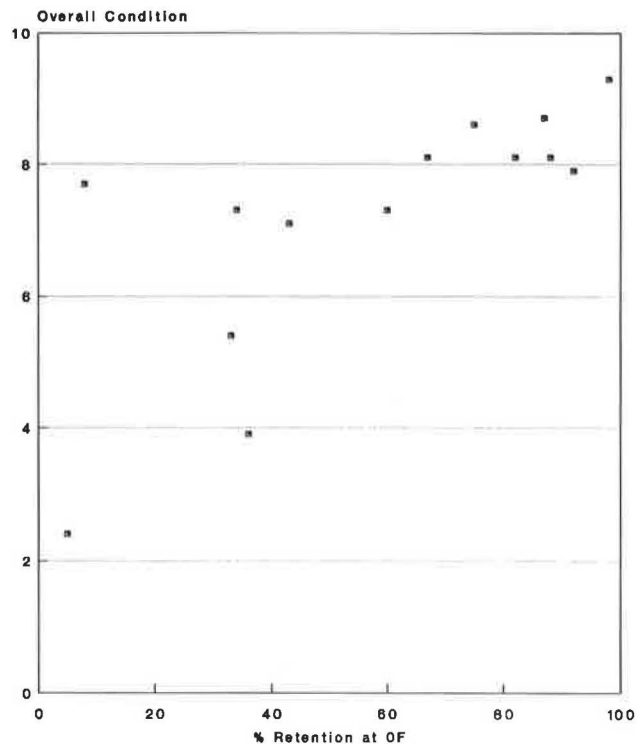


FIGURE 14 Correlation between percent retention at 0°F and overall condition.

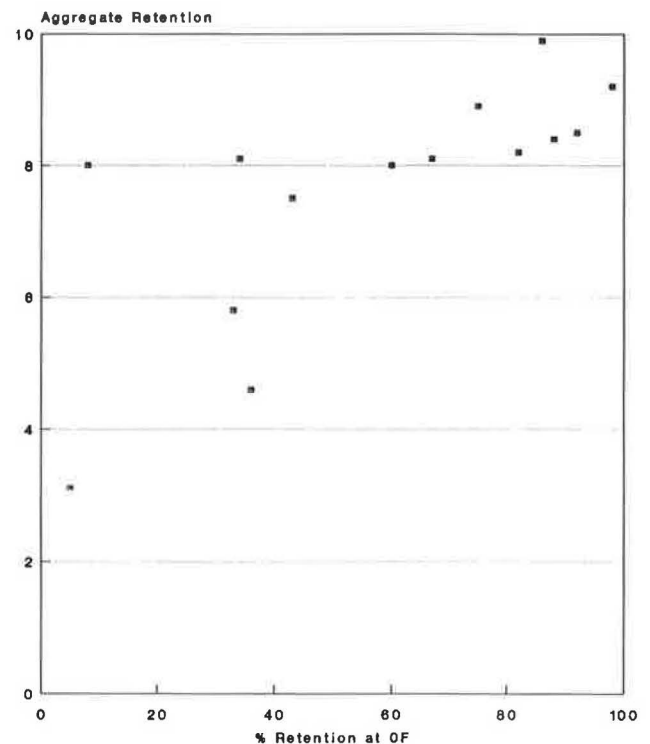


FIGURE 15 Correlation between percent retention at 0°F and aggregate retention.

TABLE 9 COMPARISON OF AGGREGATE RETENTION AT 11 MONTHS FROM PAVEMENT EVALUATIONS AND PERCENT AGGREGATE RETENTION AT 0°F FROM VIALIT TEST

Aggregate Retention at 11 months	% Retention at 0°F	Section	Product
9.9	86	7B	Kraton modified AR 1000
9.2	98	4	AR 1000 modified with crumb rubber
8.9	75	3A	AC20R
8.5	92	6A	EVA modified AC10
8.4	88	5A	AC10
8.2	82	9A	AC10R
8.1	67	7C	Kraton modified AR 1000
8.0	8	2	AR 2000
8.0	60	5C	AC10
7.5	43	6C	EVA modified AC10
8.1	34	8B	Liquid styrene modified AR 4000
5.8	33	9C	AC10R
4.6	36	10	AR 2000
3.1	5	8C	Liquid Styrene modified AR 4000

Laboratory Vialit-Temperature Series Versus Overall Condition

Aggregate gradation influenced the overall condition rating in some binders. Sections constructed with the Nevada gradation had better overall condition ratings than those constructed with the Texas gradation. The Texas gradation is more of a one-sized aggregate than the Nevada gradation. It

is believed that greater embedment depths (thus greater binder quantities) are needed to prevent aggregate loss in the Texas gradation sections.

There is a correlation between the percent retention at 0°F and the overall condition. To achieve an overall condition rating of 8.0 or better the aggregate retention at 0°F from the laboratory Vialit test should be greater than 60 percent (Table 8 and Figure 14).

Laboratory Vialit-Temperature Series Versus Aggregate Retention

Table 9 and Figure 15 show the relationship between aggregate retention and percent retention at 0°F for the upper values of aggregate retention. For aggregate retention values of 8.0 or better, aggregate retention at 0°F determined from the laboratory Vialit should be greater than 60 percent.

Laboratory Vialit-Temperature Series Versus Percent Reflective Cracking

The AR 2000 section (2) and the AR 2000 section (10) had the same performance in the laboratory but different performance in the field. Aggregate embedment depth for the AR 2000 section (2) was about 47 percent, whereas the AR 2000 section (10) was about 30 percent. This is probably the reason that the AR 2000 section (2) had considerably less reflective cracking than the AR 2000 section (10) (Table 10).