Flexible Pavement Rehabilitation Using Asphalt-Rubber Combinations: Progress Report

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Several flexible pavement rehabilitation strategies incorporating asphalt-rubber were used experimentally on a project in northeastern California in the fall of 1983. Included were rubberized dense-graded asphalt concrete (AC) overlays containing a binder then being marketed by the Arizona Refining Company, PlusRide dense-graded AC overlays, and four thicknesses of conventional dense-graded AC overlay for comparative evaluations. Some of the rubberized dense-graded AC overlays were placed on a stress-absorbing membrane interlayer. In addition, two sections of double stress absorbing membrane (SAM) and one section of conventional (single) SAM were placed. Distress began to develop in the conventional dense-graded AC within one year in the form of raveling, rutting, and cracking. This distress has become more extensive and more severe during subsequent years. Distress has also developed in the other overlays and surface treatments. To date, however, all the asphalt-rubber combinations are performing equal to or better than equivalent or greater thicknesses of conventional dense-graded asphalt concrete.

The California Department of Transportation (Caltrans) has been using a deflection-based flexible pavement rehabilitation design procedure for more than 30 years. This procedure is used to obtain 10 or more years of additional service life during which little or no pavement maintenance will be required. The rehabilitation strategy most frequently used is to overlay the existing asphalt concrete (AC) pavement with one or more layers of new AC. In May 1982 this procedure was used to develop an overlay design for a portion of Route 395 in northeastern California. To obtain the desired 10-yr service life, a 0.70-ft thick overlay of conventional Caltrans dense-graded AC (DGAC) would have been required. The cost of this overlay would have been significantly more than the funding available for the project. The results of limited Caltrans research and research by others had indicated that asphalt-rubber combinations might provide the desired service life at a lesser cost, due to the possibility of being able to use substantially thinner overlays or even surface treatments. Thus, it was decided to try several of these products in the fall of 1983 in lieu of the thick overlay required in the Caltrans standard procedure.

PROJECT FEATURES

The section of Route 395 involved was originally constructed in three segments. The first of these was built in 1948. This was followed by additional contracts in 1952 and 1954 that resulted in completion of the original pavement. Subsequently, at least two thin overlays had been placed.

The two-lane pavement is located in a somewhat remote portion of northeastern California about 100 miles north of Reno, Nevada. The highway at this location traverses a rocky valley between two mountain masses. The elevation of the highway is about 4,400 feet at the south end of the project and approximately 5,400 feet at the north end of the project. Most of the southernmost 2½ miles is on a low fill, whereas the remainder is on solid or nearly solid basalt. The average annual precipitation varies from 8 inches at the south end, to 12 inches in the middle, and 10 inches at the north end. This precipitation falls throughout the year. In addition, frost occurs throughout the year, with some snowfall during the period from November to March. During the summer, the ambient temperatures often exceed 90°F while winter temperatures occasionally drop to below zero°F. From May to November, the diurnal temperature range averages nearly 40°F. During the remainder of the year, it is generally about 20°F.

The traffic using the roadway varies from about 1,400 vehicles per day (VPD) in the summer to approximately 550 VPD in mid winter. The average annual daily traffic (AADT) is 1,100. This includes about 100 five-axle trucks per day.

The roadway structural section as of mid 1983 consisted of AC having an average thickness of 0.38 foot, supported by an aggregate base (AB) of 0.42-ft average thickness. Underlying the AB was aggregate subbase (ASB) that was 0.97-ft thick (average). There was some variation in these layer thicknesses, as shown on table 1.

In situ pavement deflections were measured using the Dynaflect (see figure 1). The measured values were converted to equivalent Deflectometer values per standard Caltrans procedures. The 80th percentile equivalent values ranged from 0.023 inch to 0.063 inch. The average value was 0.043 inch. The tolerable deflection for the existing pavement was 0.017 inch. The effects of this excessive deflection were obvious in that the pavement throughout the project was cracked extensively. The percent of pavement cracked, as determined using overhead photos of representative portions of each pavement segment, varied from 8 to 100 as indicated in table 1. For ten of the thirteen segments, the percent of pavement cracked was in excess of 50. The cracking included both wide transverse cracks of the type often associated with cold temperatures and extensive alligator cracking of the type associated with traffic loads. There was also substantial rutting noted

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TABLE 1 EXISTING PAVEMENT

Segment No.	ASB Thkn. (ft.)	AB Thkn. (ft.)	AC Thkn. (ft.)	Rutting (in.)	% of Pavmt Area Crkd.
1	0.85	0.50	0.45	0.40	33
2	0.95	0.30	0.55	0.32	76
3	0.93	0.40	0.47	0.40	15
4	1.16	0.26	0.28	0.40	8
5	0.82	0.48	0.30	1.15	83
6	0.82	0.48	0.38	0.40	52
7	1.10	0.37	0.33	1.25	100
8	1.13	0.34	0.33	0.50	74
9	0.96	0.46	0.38	0.40	83
10	1.05	0.52	0.33	0.50	100
11	0.77	0.57	0.36	0.25	57
12	1.08	0.40	0.42	0.50	74
13	1.00	0.40	0.30	0.75	100
Average	0.97	0.42	0.38		

Notes: "AC" = Asphalt Concrete
"AB" = Aggregate Base
"ASB" = Aggregate Subbase

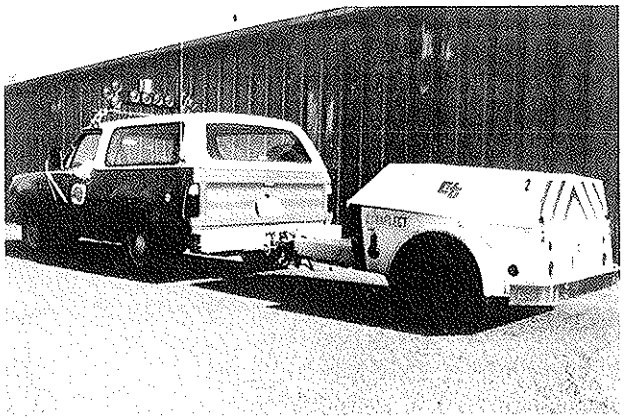


FIGURE 1 Dynaflect—used to measure pavement deflection.

throughout the project. This rutting varied from 0.25 inch to 1.25 inches in depth. The average rut depth was 0.60 inch.

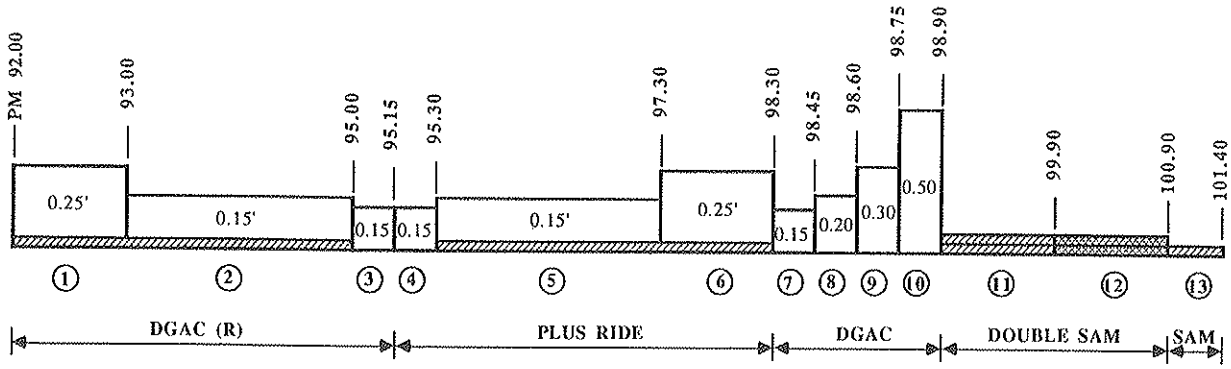
TEST SECTIONS

The objective of this ongoing study is to evaluate several flexible pavement rehabilitation approaches involving the use of asphalt-rubber. The combinations being studied are:

1. Dense graded asphalt concrete (DGAC) containing an asphalt-rubber blend then (1983) being marketed by the Arizona Refining Company, both with and without a stress absorbing membrane interlayer (SAMI),
2. PlusRide DGAC, both with and without a SAMI,
3. Single- and double-stress absorbing membranes (SAMs) containing the binder referred to in 1 above, and,
4. A double stress absorbing membrane (SAM) containing the binder marketed by Sahuaro Petroleum in the early 1980s.

Conventional DGAC was used for four short segments involving different overlay thicknesses to serve as a basis for making determinations regarding the effectiveness of the asphalt-rubber combinations being studied. These products were used for the test sections depicted in figure 2 and table 2.

For the purpose of performance documentation, a representative 200-ft long, one-lane wide test section was selected in the northbound lane for each of the thirteen project segments. A second test section was selected within segments 2 and 5 because each of these segments is two miles long. The condition of the pavement within each of these test sections is being documented annually with overhead and oblique photographs as well as pavement deflection testing (Dynaflect) and pavement skid testing (towed trailer).



LEGEND

(R) = Rubberized
▨ = Ariz. Refining System
▩ = Sahuaro System

NOTES

1. Used type A 3/4" max. medium DGAC and AR 4000 asphalt.
2. Test sections placed in Sept, 1983.
3. Old pavement consists of 0.38' AC/0.41' AB/ 0.96' ASB.

FIGURE 2 Ravendale test section layout.

TABLE 2 PROJECT SEGMENTS

SEGMENT NUMBER	PM TO PM = MILES	DESIGN
1	92.00 - 93.00 = 1.00	0.25' of ARS DGAC over ARS SAMI
2	93.00 - 95.00 = 2.00	0.15' of ARS DGAC over ARS SAMI
3	95.00 - 95.15 = 0.15	0.15' of ARS DGAC
4	95.15 - 95.30 = 0.15	0.15' of PlusRide DGAC
5	95.30 - 97.30 = 2.00	0.15' of PlusRide DGAC over ARS SAMI
6	97.30 - 98.30 = 1.00	0.25' of PlusRide DGAC over ARS SAMI
7	98.30 - 98.45 = 0.15	0.15' of Conventional DGAC Control
8	98.45 - 98.60 = 0.15	0.20' of Conventional DGAC Control
9	98.60 - 98.75 = 0.15	0.30' of Conventional DGAC Control
10	98.75 - 98.90 = 0.15	0.50' of Conventional DGAC Control
11	98.90 - 99.90 = 1.00	ARS Double SAM
12	99.90 - 100.9 = 1.00	Sahuaro Double SAM
13	100.90 - 101.4 = 0.50	ARS Single SAM

PM = Post Mile

Binders

The paving asphalt selected for this project was Grade AR-4000. The vulcanized portion of the ground, reclaimed rubber used for several of the segments was supplied by Genstar and the devulcanized portion was supplied by U.S. Rubber Reclaiming.

The ARS binder (used for segments 1-3, 11, 13, and the SAMIs in segments 1, 2, 5, and 6) consisted of 78 percent AR-4000 grade paving asphalt, 18 percent ground reclaimed rubber, and 4 percent extender oil, all by weight of total binder. The reclaimed rubber consisted of 20 percent devulcanized rubber and 80 percent vulcanized rubber. The rubber and asphalt were combined at a temperature of approximately

350°F using a special mixing/blending unit. The blend to be used for the DGAC in segments 1 to 3 was then recirculated within a holding tank for approximately 45 minutes after which it was pumped into the contractor's asphalt storage tanks at the plant. This 45-min holding time requirement resulted in a discontinuous supply of binder to the plant that caused occasional interruptions in plant production of the DGAC for segments 1 to 3.

The asphalt-rubber binder used for segment 12 conformed to the specifications promulgated by the Sahuaro Petroleum Company. The primary differences between the ARS binder and the Sahuaro binder were that more reclaimed rubber was used (23 percent instead of 18 percent) and a diluent was used instead of an extender oil. The blending times and temperatures also differed somewhat.

The binder for the PlusRide segments (4 to 6) consisted of AR-4000 grade paving asphalt. This asphalt was also used for the conventional DGAC comprising segments 7 to 10.

Aggregate

AC aggregate conforming to the Caltrans' specifications for ¾-in maximum medium Type A DGAC was used for the conventional DGAC (see table 3). Aggregate conforming to Caltrans' specifications for ½-in maximum medium Type A DGAC was specified for the ARS mixes (segments 1 to 3). The gap grading shown in table 3 was specified for the PlusRide. This gap in the aggregate grading was required to accommodate the coarser portion of the reclaimed rubber that was included in the PlusRide mix. The need to provide this gap can and did result in the accumulation of some waste aggregate. The requirement of 8 to 12 percent passing the No. 200 also created a problem in that this resulted in the need to import and add 4.7 percent pozzolan to the mix.

The aggregate used for the SAMIs (segments 1, 2, 5, and 6) and for the single SAM (segment No. 13) conformed to Caltrans' specifications for ⅜ × No. 6 medium screenings (see table 3). The specifications for the screenings used in the double SAMs (segments 11 and 12) are also shown on table 3.

Construction

The project was constructed in August and September of 1983. A Standard 10,000-lb capacity batch plant was used to mix the DGAC in 8,000-lb batches. The design asphalt content (Hveem) for the conventional DGAC was 4.6 percent by dry weight of aggregate. The design binder content (asphalt-rubber blend) for the ARS DGAC, as provided by Arizona Refining Company personnel, was 8.0 percent by dry weight of aggregate. The design asphalt content for the PlusRide provided by All-Seasons personnel was initially 9.65 percent by dry weight of aggregate. In addition, 3.0 percent rubber by total weight of mix was added to PlusRide aggregate and pre-mixed for 20 seconds before the AR-4000 asphalt was added.

The mixes were transported to the street using bottom dumps and placed using a Ko-Cal pickup machine and a Blaw Knox PF-180 paver. A 20-ft ski was used for grade control.

No pre-leveling or milling was done to eliminate the pre-

TABLE 3 AGGREGATE GRADING SPECIFICATIONS (PERCENT PASSING)

Sieve Size	ARS DGAC	PlusRide DGAC	Conv. DGAC	Double SAM 1st Lift	Double SAM 2nd Lift	SAM and SAMI
1"			100			
3/4	100		95-100	100		
5/8		100				
1/2	95-100			90-100		100
3/8	80-85	60-80	65-80	50-80	100	90-100
1/4		30-50				
#4	55-65		46-56	0-15	60-85	5-30
#8	38-48		33-43	0-5	0-25	0-10
#10		19-32				
#16					0-5	0-5
#30	18-28	13-25	14-24		0-3	
#200	3-8	8-12	3-8	0-2	0-2	0-2

construction rutting prior to constructing the overlays. A leveling course was placed prior to placing the SAMs, however. The segments with design thicknesses of 0.15-foot and 0.20-foot were placed in one lift. Segments 1 and 7 (design thickness of 0.25 foot) were placed in lifts of 0.13-ft, then 0.12-ft. The 0.30-ft thick segment (No. 9) was placed in two lifts of 0.15-ft each. Segment 10 (0.50-ft total design thickness) was placed in lifts of 0.20-ft, then 0.15-ft, and 0.15-ft.

A Dynapac CC50A vibratory steel-wheel roller was used for breakdown compaction. This roller was operated at high amplitude and 2,400 VPM in accordance with prior Caltrans qualification testing of this roller for conventional DGAC paving. A Hyster C350 steel-wheel roller was used for finish rolling. No pneumatic rolling was required.

No problems were encountered when placing the ARS DGAC or the conventional DGAC. The PlusRide mix, however, had a consistency resembling bubble gum when placed and was noticeably springy even after compaction. This appeared to contribute to the initial difficulties in obtaining at least the specified 96 percent (minimum) of theoretical maximum density. A reduction in the design binder content (from 9.65 percent to 9.41 percent) and an adjustment in the amount of supplemental fines (pozzolan) being added to the mix resulted in compliance with the density specification but no change in the stickiness or resilience of the mix was noted. The tendency to stick to the rollers was subsequently alleviated somewhat when the breakdown compaction was delayed until the mix temperature had dropped to 285°F or less in lieu of the originally specified 300°F minimum.

The construction of the SAMIs (segments 1, 2, 5, and 6) and the SAMs (segments 11 to 13) involved placement of the ARS and Sahuaro binders using a distributor truck followed by application of the pre-heated pre-coated (0.33 percent asphalt) screenings. These surfaces were then rolled with a minimum of three coverages using pneumatic rollers. For segments 11 and 12, the design binder application rate was 0.50 gal/sy. For the SAMIs and segment 13, the design application rate was 0.60 gal/sy. The design application rates for the screenings were 34 lbs/sy for the first lift of segments 11 and 12, 26 lbs/sy for the second lift of segments 11 and 12, and 35 lbs/sy for the SAMIs and segment 13. Prior to the placement of the SAMs, a levelling course of minimal thickness was placed consisting of ½-in maximum conventional DGAC. This was needed to adjust the cross slope of the pavement and to eliminate the rutting at these locations. The only problem that occurred during the placement of the SAMs and SAMIs was caused by smoke generated by the distributor truck operation. This obscured the spray bar, which resulted in a somewhat streaked appearance, due to undetected intermittent partial or complete plugging of some of the spray-bar nozzles.

Cost Estimate

An estimate of the in-place cost of each of the segments is shown in table 4. This provides an indication of the extent to which the various asphalt-rubber products must out-perform the conventional DGAC to be cost effective.

As-built Properties

The data in Table 5 indicate that conformance to the aggregate gradation specifications was obtained. Table 6 contains data indicating that the as-built thickness of the various segments differed from the design thicknesses to some extent. The permeability data indicates that the PlusRide DGAC was virtually impermeable, whereas the permeability of the ARS DGAC was very low, and the permeability of the conventional DGAC was somewhat greater than the 150 ml/min considered typical of Caltrans mixes. This suggests the need for a SAMI

TABLE 4 ESTIMATED COST OF EACH STRATEGY

SEGMENT NUMBER		COST (Square Yard)
1	0.25' of ARS DGAC over ARS-SAMI	$10.41
2	0.15' of ARS DGAC over ARS-SAMI	6.88
3	0.15' of ARS DGAC	5.37
4	0.15' of PlusRide DGAC	6.32
5	0.15' of PlusRide DGAC over ARS-SAMI	7.83
6	0.25' of PlusRide DGAC over ARS-SAMI	12.00
7	0.15' of Conventional DGAC Control	3.04
8	0.20' of Conventional DGAC Control	4.03
9	0.30' of Conventional DGAC Control	6.02
10	0.50' of Conventional DGAC Control	9.99
11	Double SAM, ARS Binder	2.60
12	Double SAM, Sahuaro Binder	2.62
13	Single SAM, ARS Binder	1.56

TABLE 5 AGGREGATE GRADATION SPECIFICATION COMPLIANCE

PERECENT PASSING									
SIEVE SIZE	ARS (Segment No. 1)		PLUSRIDE (Segment No. 5)		CONVENTIONAL DGAC				
					SEGMENT NUMBER				
	EXTRACTED	SPEC.	EXTRACTED	SPEC.	7	8	9	10	SPEC.
1"								100	100
3/4	100	100			100	100	98	100	95-100
5/8			100	100					
1/2	97	95-100	89		79	86	82	84	
3/8	80	80-85	63	60-80	70	72	69	75	65-80
1/4			47	30-50					
#4	57	55-65	36		48	51	46	53	46-56
#8	44	38-48	25		35	38	35	40	33-43
#10			23	19-32					
#30	25	18-28	17	13-25	21	23	21	23	14-24
#100	10		11		10	11	9	11	
#200	7	3-8	9	8-12	7	8	6	8	3-8

of some sort to provide a more impermeable pavement and thereby protect the underlying pavement from surface water (rainfall) intrusion.

Caltrans experience has revealed that surface abrasion losses greater than 35 grams (per Calif. Test 360, Method B) generally are associated with DGAC exhibiting marginal or unsatisfactory resistance to moisture. The surface abrasion test results in table 6 indicate that the ARS DGAC (with an average value of 17 g) and the PlusRide (average value of 13 g) are substantially more resistant to surface abrasion than is the conventional DGAC used on this job (average loss of 41 g).

The results of the towed-trailer skid testing indicated tnat the PlusRide pavement is adequate and the other surfaces (ARS DGAC, conventional DGAC, and the SAMs) are very good.

In situ pavement deflection measurements were made in May of 1984. Comparison of these values with those measure in May of 1983 provides an indication of the structural section stiffening provided by the various strategies. These values illustrate that substantial reductions in deflection were achieved in most cases. These values are discussed in more detail in the next section of this paper.

LONG-TERM PERFORMANCE

Four months after construction, the first report of pavement distress was received. A field condition survey revealed that a considerable loss of surface fines had occurred, especially in the wheel tracks in the two thinner segments of conventional DGAC (segments 7 and 8—see figure 3). In addition, transverse cracks about 2 feet apart had developed over a distance of approximately 400 feet and longitudinal cracking had developed in the southbound lane outer wheel track, both in segment 8. The other segments containing conventional DGAC (9 and 10) had experienced the loss of a minor amount of surface fines but no cracking.

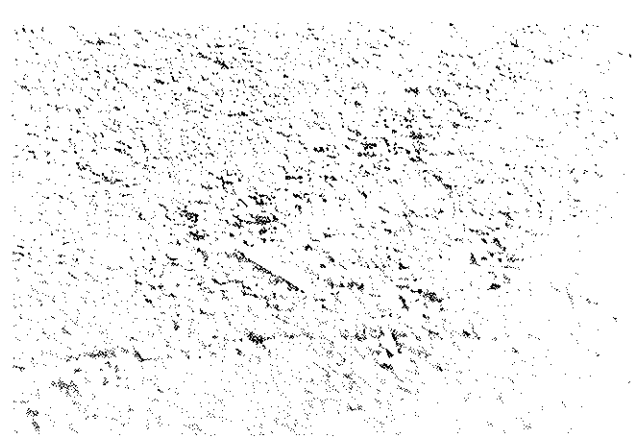


FIGURE 3 Loss of fines in wheel tracks, 0.15 ft DGAC—segment 7 (age 4 months).

TABLE 6 AS-BUILT PROPERTIES

Material	Segment Number	Overlay Thkn[1] (ft) As-Built	Overlay Thkn[1] (ft) Design	% Comp.	Permea-[2] bility (ml/min)	Surface[3] Abrasion (gms loss)	Skid[4] No. (SN_{40})	Deflection[5] (0.001") 5/83	Deflection[5] (0.001") 5/84
ARS	1	0.27	0.28	93.3	36.3	17.1	55	54	26
DGAC	2	0.17	0.18	91.7	22.3	17.6	57	43	25
	3	0.12	0.15	92.8	-	18.7	54	25	16
PlusRide	4	0.19	0.15	97.1	-	9.7	39	55	27
DGAC	5	0.21	0.18	98.4	11.0	14.8	39	30	26
	6	0.28	0.28	96.1	6.8	11.4	44	27	16
Conv.	7	0.20	0.15	91.7	177.0	47.8	66	23	18
DGAC	8	0.18	0.20	91.2	-	48.2	68	60	44
	9	0.32	0.30	91.4	-	32.5	65	63	28
	10	0.52	0.50	92.1	-	35.1	67	46	13
Double	11	0.10	0.04	-	-	-	62	44	42
SAM	12	0.13	0.04	-	-	-	59	51	35
SAM	13	0.14	0.03	-	-	-	57	54	52

Notes: 1. Includes SAMI, segments 1, 2, 5, and 6
2. Per Calif. Test 341
3. Per Calif. Test 360, Method B
4. Per ASTM E274; Meas 10/83
5. 80th percentile deflections per Calif. Test 356 (Dynaflect Method)

The following June (nine months after construction), it was noted that a glaze observed on the PlusRide surface immediately after construction was no longer evident. In addition, the crack pattern in the underlying old AC pavement was beginning to become visible in segment 11 (double SAM using ARS binder). Also, some hairline cracking was observed in the SAM (segment 13). No other additional distress was observed at the time of the June 1984 review.

Because of some warm weather in July of 1984 (11 days with maximum temperatures of 90°F or more), the project was reviewed again on July 26, 1984. Some additional distress had become evident. There was some localized bleeding at some of the transverse construction joints in segment 4 (Plus Ride) and some flushing beginning to develop in the double SAMs (segments 11 and 12). In addition, rutting 0.25-in deep was noted in the thickest of the control sections (segment 10). No other significant rutting was noted.

Subsequent to the July 1984 survey, additional field condition surveys have been completed in the late spring or early summer of 1985, 1986, and 1987. In addition, pavement skid numbers and deflections have been measured each year. The results of these tests are summarized in table 7. Examination of this data reveals some anomalies for which no explanation is apparent. For example, the reason for the significant reduction in deflection between June of 1986 and May of 1987 for segments 1 to 4 is unknown. The remainder of the deflection data is plausible in most cases, in that it indicates that a measurable initial stiffening of the structural sections was achieved via placement of each of the asphalt-rubber and conventional overlays. The percent reduction in deflection was directly related to the thickness of the overlay placed in most cases. The surprisingly large percentage decreases in deflection as a result of the thinnest PlusRide overlay (segment 4) and the Sahuaro double SAM (segment 12) are difficult to explain. Based on inspection of the data, the May 1984 deflection reported for segment 12 may be erroneous. The subsequent deflections indicate that most or all this stiffening effect has dissipated with the exception of segments 1, 6, 9, and 10. These segments comprise the thickest of the rubber-modified DGAC (segments 1 and 6, each of which were 0.25-ft+ thick) and the conventional DGAC (segments 9 and 10, with nominal overlay thicknesses of 0.30 and 0.50

TABLE 7 PAVEMENT STIFFNESS AND SURFACE TEXTURE

Material	Segment	Deflections (80th percentile, 0.001") Date Tested					Skid No. (SN_{40})	
		5/83*	5/84**	6/85	6/86	5/87	10/83	5/87
ARS	1	54	26(52)	35	43	28	55	64
DGAC	2	43	25(42)	37	44	36	57	64
	3	25	16(36)	28	37	29	54	62
Plus	4	55	27(51)	42	56	45	39	60
Ride	5	30	26(13)	34	41	41	39	62
DGAC	6	27	16(41)	21	22	21	44	59
	7	23	18(22)	22	22	26	66	64
Conv.	8	60	44(27)	52	51	59	68	56
DGAC	9	63	28(56)	42	36	32	65	65
	10	46	13(72)	21	20	19	67	62
Double	11	44	42(5)	52	52	59	62	34
SAM	12	51	35(31)	53	54	51	59	26
SAM	13	54	52(4)	55	56	66	57	63

*Prior to construction of the segments in 9/83

**Percent reduction in deflection shown in parenthesis

foot, respectively). These also were the overlays that provided some of the largest initial stiffening as indicated by percent reduction in deflection.

As expected, the deflections measured for the SAMs suggest that the stiffening effect of these surface treatments was minimal. The significance of the pavement deflections, as related to the asphalt-rubber products, is one of the experimental features of this study.

All of the segments are now exhibiting some distress in the form of cracking (longitudinal, transverse, block, and/or alligator—see figures 4 to 13). There is a small amount of rutting present (conventional DGAC - segment 10) and some pot holes (in the PlusRide). The amount of cracking, however, is probably the best indication of the remaining service life for each of the segments. Table 8 contains an estimate of the amount of cracking that has developed. Because of the flushing and bleeding that has developed in segments 11 and 12, much of the cracking therein is sealed, due to the kneading action of traffic during warm weather. The deflections measured in the badly cracked segment 7 and, in some cases, segment 8 (both conventional DGAC) have been comparable to or less than those measured for segments 1 to 6; yet the amount of cracking in segments 1 to 6 is relatively insignificant. This suggests that the tolerable deflection for these asphalt-rubber dense graded AC pavements may be considerably greater than that for comparable thicknesses of conventional DGAC. It should be remembered that the conventional DGAC overlays were substantially under-designed in that 0.70-ft was the design thickness determined for this roadway using the conventional Caltrans design procedure.

FIGURE 4 Typical Cracking—longitudinal, test segment 2, 0.15 ft ARS DGAC on SAMI (age 48 months).

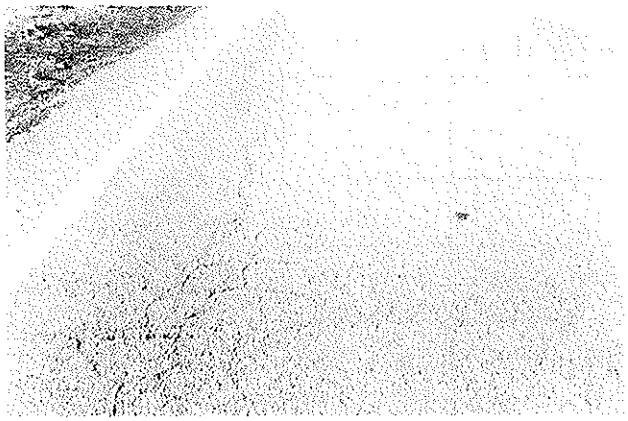


FIGURE 5 Typical cracking—alligator, test segment 3, 0.15 ft ARS DGAC (age 48 months).

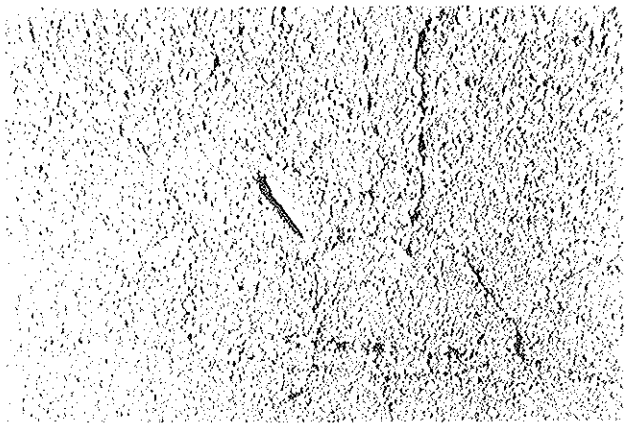


FIGURE 6 Typical cracking—alligator, test segment 3, 0.15 ft ARS DGAC (age 48 months).

FIGURE 7 Typical cracking, test segments 7 and 8, 0.15 and 0.20 ft conventional DGAC (age 48 months).

FIGURE 8 Typical raveling, test segments 7 and 8, 0.15 and 0.20 ft conventional DGAC (age 48 months).

FIGURE 9 Typical cracking—transverse, test segments 9 and 10, 0.30 and 0.50 ft conventional DGAC (age 48 months).

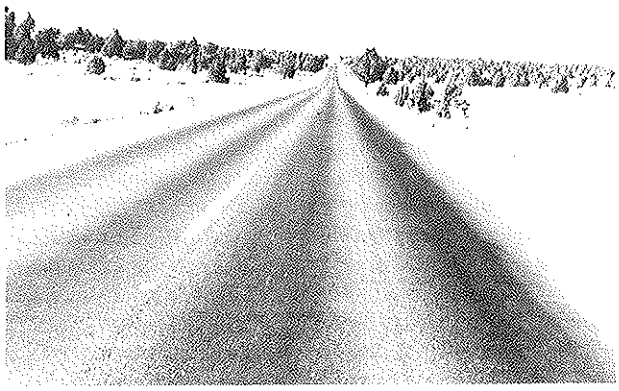


FIGURE 10 Typical wheel track bleeding, test segments 11 and 12, double SAM (age 48 months).

FIGURE 11 Typical wheel track bleeding, test segments 11 and 12, double SAM (age 48 months).

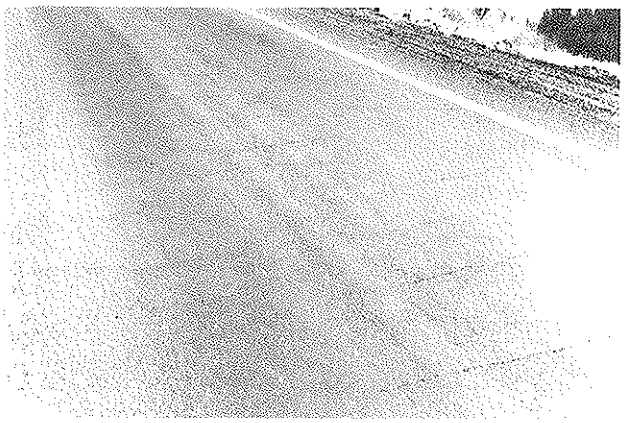


FIGURE 12 Typical cracking—transverse, test segments 11 and 12, double SAM (age 48 months).

FIGURE 13 Typical cracking, test segment no. 13, SAM (age 48 months).

The results of the skid testing (table 7) coincide with the loss of the glaze on the surface of the PlusRide after approximately 6 months of service. Thus, this glaze may have been the reason for the substantially lower skid numbers measured initially for the PlusRide as compared to the other segments. As of May 1987, the PlusRide values were comparable with all the other values measured except those for the Double SAMs. These substantially lower values indicate a marginal pavement and are no doubt associated with the flushing and bleeding that has been observed in segments 11 and 12 since the 1985 survey.

CONCLUSIONS

The findings and observations to date indicate that for the conditions present at the test site location, the initial stiffening effect of the asphalt-rubber overlays studied is equal to or greater than that of equivalent thicknesses of conventional DGAC and that the tolerable deflection of these asphalt-rubber overlays is greater than that of equivalent thicknesses of DGAC. This would suggest that the service life of the asphalt-rubber DAGC overlays under study may be considerably greater than those of equivalent thicknesses of conventional DGAC, at least with some combinations of traffic and climate. In addition, both of the thin conventional DGAC overlays have failed (figures 7 and 8) whereas the asphalt-rubber overlays of comparable thickness (segments 2 to 5—figures 14 to 17) have not yet failed. However, the cost-effectiveness of these more expensive overlays cannot yet be determined, as most of the segments being studied have not yet failed. In addition, although a substantial amount of cracking is visible in the SAM segments (11 to 13), these pavements have not yet required the amount of maintenance effort required in segments 7 and 8. This suggests that even the SAMs may be superior to conventional overlays 0.20-ft thick. Based on a comparison of the single SAM versus double SAMs, there is no apparent advantage provided by the double SAM.

Final conclusions for the conditions present at the test site location will be contingent on the performance of the various segments during the next few years. In addition, some additional similar experiments at locations having both similar and different traffic and/or climatic conditions are needed before overall conclusions regarding these asphalt-rubber combinations can be determined.

ACKNOWLEDGMENTS

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The Principal Investigators for the research project are Bobby G. Page of the Caltrans Office of Transportation Laboratory

TABLE 8 ESTIMATE OF PAVEMENT CRACKING

Material	Segment Number	Estimated Percent Cracked (May 1987)
ARS DGAC	1	<5%
	2	<5%
	3	5-10%
PlusRide DGAC	4	<5%
	5	5-10%
	6	5-10%
Conv. DGAC	7	70-75%*
	8	75-80%*
	9	10-15%
	10	<5%
Double SAM	11	60-65%
	12	65-70%
SAM	13	85-90%

*Failed

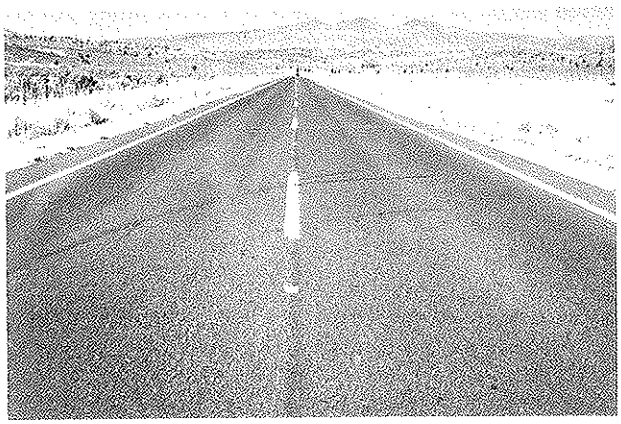

FIGURE 14 Typical "overall" view, ARS DGAC (age 48 months).

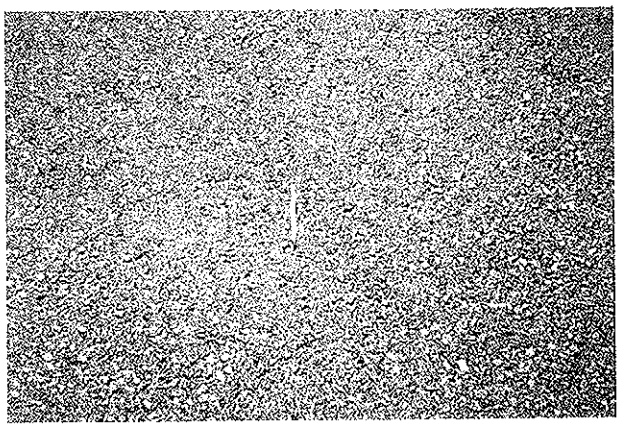

FIGURE 15 Typical texture, ARS DGAC (age 48 months).

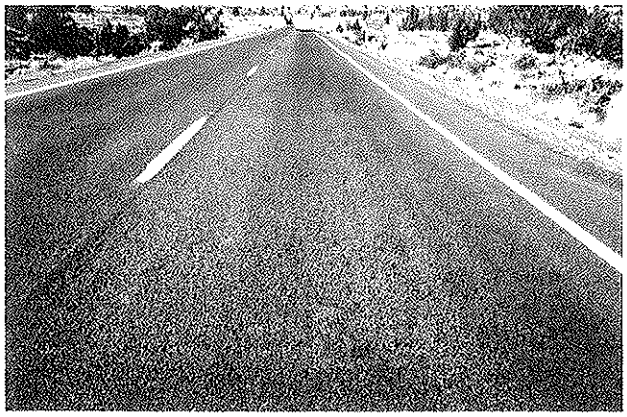

FIGURE 16 Typical "overall" view, PlusRide DGAC (age 48 months).

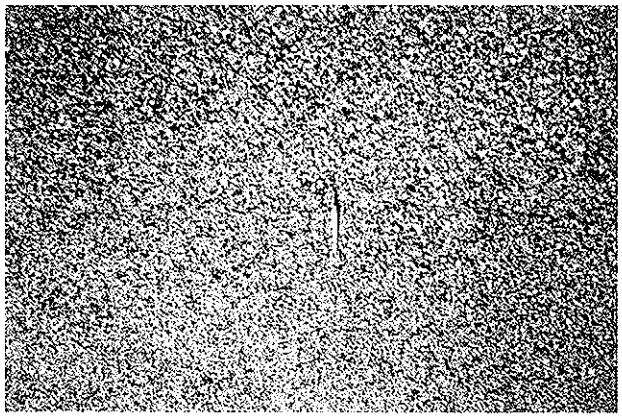

FIGURE 17 Typical texture, PlusRide DGAC (age 48 months).

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