a) Overview
PERFORMANCE OF ASPHALT RUBBER AS THIN OVERLAYS

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ABSTRACT: This paper addresses the Caltrans' experience with thin asphalt rubber overlays from field test sections, accelerated pavement tests and laboratory performance tests. Field and laboratory studies have evaluated the performance of asphalt rubber as thin overlays in terms of fatigue, reflective cracking, permanent deformation and moisture sensitivity. The findings have shown that thin asphalt rubber overlays, when properly designed and constructed, can provide superior performance as compared to conventional dense graded overlays. Mechanistic analysis is necessary so that the structural contribution of asphalt rubber mixes can be adequately quantified. Proper overlay thickness design must be based on fatigue testing accompanied by mechanistic analysis.

KEY WORDS: asphalt rubber, thin overlays, overlay design, fatigue, permanent deformation, thermal cracking, moisture sensitivity
Introduction

The use of crumb rubber modifier (CRM) in asphalt concrete overlays has increased in recent years. The California Department of Transportation (Caltrans) has ranked CRM research on top of the priority list in the Caltrans Accelerated Pavement Testing (CAL/APT) Program’s strategic plan.

Asphalt rubber binders have been successfully used for joint and crack sealers, in chip seals, in stress-absorbing membrane interlayers (SAMIs), and in hot paving mixes as thin overlays. Generally, the field performance of CRM mixes have been positive but short comings due to poor performance have been reported which may be attributed in part to poor mix design practices, lack of performance based physical property tests and poor construction practices. In addition, the properties of CRM mixes have been found to vary with the rubber type and gradation, rubber concentration, asphalt type and concentration, diluent type and concentration, diluent cure time and reaction temperature and time [EPP 94].

CRM is incorporated with asphalt paving mixes by one of two production processes, the wet and the dry processes. In the wet process, the CRM is blended and partially reacted with the asphalt cement prior to mixing with the aggregates in a hot-mix plant. Typically, asphalt cement and the CRM are reacted at high temperatures and diluents, aromatic oils, and polymers may be added. An asphalt cement that has been modified with CRM is called asphalt rubber (AR). Two common mixes that use this process are asphalt rubber hot mix - gap graded and - dense graded which are referred to as ARHM-GG and ARHM-DG, respectively. Figure 1 shows typical dense and gap gradations in California.

In the dry process, the CRM is added to the aggregate in a hot-mix central plant operation before adding the asphalt cement. The final mix in this process is often referred to as rubber modified asphalt concrete (RUMAC). The CRM may need a pre-treatment with a catalyst to achieve the optimum particle swell [EPP 94]. In this system, the rubber content should not exceed 3.0 percent by total weight of mix for surface courses [EPP 94]. Since the CRM, the asphalt cement, and the aggregate are added at the same time, it is impossible to determine the binder properties directly.

The wet process has been the most widely used process in California for which structural and reflective cracking equivalencies have been developed. The term asphalt rubber or rubberized asphalt concrete is commonly used interchangeably to refer to both processes of the CRM mix technology.

This paper provides an up-to-date assessment of the performance of asphalt rubber mixes as thin overlays for which some research and experience have been accumulated in California. The assessment is based on field performance and accelerated pavement testing as well as laboratory testing consisting of fatigue cracking, reflective cracking, permanent deformation, thermal cracking and moisture sensitivity.
Field Performance of Caltrans Asphalt Rubber Thin Overlay Projects

In the past, Caltrans depended heavily on long term field test sections to evaluate and validate design procedures. Since the late seventies, Caltrans started experimenting with the use of reclaimed tire rubber in asphalt concrete by constructing field test sections at various sites across the state [SHA 99].

The Ravendale Project

A project that was a turning point in the use of asphalt rubber mixes in California was located near the town of Ravendale on Route 395 in the northeastern part of the state. The project consisted of several test sections of various asphalt-rubber and conventional dense graded asphalt concrete (DGAC) thicknesses with and without stress absorbing membrane interlayers (SAMIs) [DOT 88]. The asphalt rubber mixes used were ARCO-ARM-R-SHIELD (abbreviated as ARS) and PlusRide. These test sections were constructed in 1983. The annual precipitation in that area is between 200 and 255 mm. The air temperature exceeds 32 Celsius in the summer and drops below freezing in the winter.

Test sections were constructed using several rehabilitation strategies as shown in Table 1. These strategies consisted of the following types:

- ARS sections using a 12.5 mm maximum dense gradation with and without SAMIs.
- PlusRide sections using 19 mm maximum gap gradation with and without SAMIs.
- Conventional DGAC sections with 19 mm maximum dense gradation.

The ARS wet process, known as the Arizona refining process, was developed in 1975. With this process, the asphalt rubber blend was composed of 18 percent rubber, of which 40 percent was devulcanized and 60 percent was ground ambient vulcanized, and 78 percent AR-4000 grade asphalt with 4.0 percent Witco extender oil. All of these percentages were by total weight of binder. The ARS granular rubber gradation had 98.0 percent passing the 0.60 mm sieve and 8.0 percent passing the 0.15 mm sieve size. Diluents were not added. The asphalt and the rubber were combined together at a 175 Celsius tank prior to mixing with the aggregate.

The PlusRide was a dry process in which dry ground tire rubber was added as part of the aggregate component. The rubber was not blended with the asphalt cement. The permeability per California Test 341 was between 22.3 and 36.3 ml/min for the ARS, between 6.8 and 11.0 ml/min for the PlusRide and 177.0 ml/min for the conventional DGAC.

Test Section Design and Performance

The required conventional DGAC overlay thicknesses for the project were determined from non-destructive pavement deflection testing. These thicknesses were based on either structural requirements or reflective cracking requirements. After determining the required thickness, the overlays were placed at various thicknesses. Table 1 shows each segment, design basis, design strategy, thickness provided, the ratio of the provided thickness over the required thickness and the number of ESALs to failure. Segments that lasted 10 years experienced over 510,000 ESALs which was the intended design life. The data was evaluated in terms of deflections, pre-overlay distress and post-overlay distress. Caltrans engineers concluded that overlays with asphalt rubber modifiers could perform equal to
conventional DGAC overlays at reduced thicknesses which would otherwise be required for conventional DGAC.

Laboratory Performance

In 1995, field cores were obtained from the center of the lanes that contained the ARS and the DGAC test segments. The measured air void contents were 6.0 percent for the ARS and 11.0 percent for the DGAC segments. The cores were then subjected to reflective cracking testing using the newly developed Caltrans reflective cracking (CRC) device which utilizes both the vertical and the horizontal actuators of the Superpave shear tester (SST) to simulate load associated crack movement; crack opening-closing (Mode I) and vertical shear movement (Mode II). The reflective cracking testing was conducted at 20 Celsius under controlled-displacement mode of loading. The results showed that the ARS rubber mixes would perform better than the DGAC mixes in terms of reflective cracking resistance (Figure 2). These results agree with the field performance data. However, emphasis must be placed on the effect of in-place density on fatigue performance, which can be significant.

Newberry Springs SPS-5 Project

Results from Caltrans field sections and laboratory performance tests in Newberry Springs SPS-5 Project have revealed that asphalt rubber overlays could produce adequate resistance to permanent deformation when properly constructed and designed. Laboratory tests consisting of RSST-CH and the LCPC wheel-tracking device were conducted on field cores from the aforementioned SPS-5 project on Interstate 40. These tests were conducted at a temperature of 60 Celsius which corresponds to the 7-day maximum pavement temperature at 50 mm pavement depth. The shear stress used was 70 kPa with 0.1 seconds loading and 0.6 seconds rest periods. The data were compared at 4.5 percent permanent shear strain which corresponds to 13 mm rut depth according to the following Equation developed in the SHRP project:

\[ \text{Rut Depth (mm)} = 279 \times \gamma_p \]

where, \( \gamma_p \) = the permanent shear strain.

The results show that the DGAC mix has more resistance to permanent deformation than the ARHM-GG mix but this does not mean that the ARHM-GG is prone to rutting (Figures 3 and 4). Field reviews of the two test sections showed that both DGAC and ARHM-GG mixes had comparable performance. The measured rut depth in both sections was less than 2 mm after 5 years of traffic with 40 percent trucks under high desert temperature.

I-5 Warranty Project

In 1993, Caltrans constructed for the first time a unique PCC pavement rehabilitation project where the contractor warranted for 5 years an overlay consisting of 45 mm ARHM-GG on 45 mm DGAC leveling course incorporating a Performance Based Asphalt (PBA-6) over a “cracked and seated” PCC pavement [HAR 95]. This project is located north of Redding, California on Interstate 5 in Shasta County. The asphalt rubber binder consisted of AR-4000 blended with 17.0 percent ground tire rubber and 2.0 percent...
natural rubber. The project consisted of both northbound (NB) and southbound (SB) sections which were constructed by two contractors that used two different aggregate sources.

The mix design methods were based on mix performance using the RSST-CH, traffic, site-specific temperature, and reliability for NB and were based on the air void method for SB. The optimum binder contents for NB were found to be 5.2 percent and 6.5 percent, for DGAC-PBA6 and ARHM-GG, by dry weight of aggregate. The optimum binder content based on the air void method was compared to that obtained with the performance based mix design. It was found that the recommended binder content for the ARHM-GG using the performance based method was much lower than the binder content determined through the air void method which was 8.5 percent. For NB, a compromise between the 8.5 percent and the 6.5 percent binder contents was made before construction which resulted in using a binder content of 7.5 percent. For SB, the binder content was 8.7 percent which was based solely on the air void method. Field reviews of this project to date showed good performance on both directions with only minor raveling.

Other Projects

1995 Hildebrand and Van Kirk Field Review

During 1995, Hildebrand and Van Kirk of Caltrans conducted field reviews of 88 asphalt rubber projects throughout the state of California, the majority of which were ARHM-GG and ARHM-DG overlays [HIL 95]. The reviews revealed that thin asphalt rubber overlays would give good performance when properly designed and constructed. The poor performance found in some projects was related to factors such as mix design and construction problems.

Hildebrand and Van Kirk compared overlay projects constructed using Type I asphalt rubber binder with those constructed with Type II asphalt rubber binder. (Type II binder contains a high natural rubber additive and an extender oil which are not used in Type I binder). They found that asphalt rubber overlays with Type II binder had performed better in reflective cracking resistance than those with Type I binder and they believed that the use of a diluent in Type I and an extender oil in Type II would improve field performance. They mentioned that the rate of cracking and raveling in the asphalt rubber project was significantly less than those with the conventional DGAC projects.

1999 Asphalt Rubber Field Review by Caltrans and Industry

In 1999, another field review of asphalt rubber projects was conducted throughout the state of California with a joint effort between Caltrans and the asphalt industry. The team reviewed a total of 113 projects with the criteria described below:

- Good: exhibited little to no distress and are expected to achieve their design life.
- Fair: exhibited moderate distress, but are expected to achieve their design life.
- Poor: exhibited moderate to severe distress and are not expected to achieve their design life.

Among the 113 projects, 101 projects were rated good, 6 were rated fair, and 6 were rated poor. The 6 projects that were rated fair and the 6 projects that were rated poor are
being investigated in detail by Caltrans to determine the reason for their early distress. However, 90% of the projects reviewed resulted in a good rating.

**Caltrans Structural Design For Flexible Pavement Overlays**

Caltrans structural design procedure for overlays is based on non-destructive deflection testing of existing pavements. The maximum deflection below the load is used to determine the thickness requirements of an overlay for a design life of 10 years. This procedure uses the maximum deflection criteria to obtain the required thickness per Caltrans Test 356. The required overlay thickness is selected to account for structural or reflective cracking requirements. The structural requirements are based on deflections that are higher than certain tolerable criteria. When the pavement experiences severe cracking but the deflections are below the tolerable limits, the reflective cracking requirements prevail. In general, reflective cracking is designed for by providing a conventional DGAC overlay thickness equivalent to 50 percent of the thickness of the existing wearing course.

**Caltrans Structural Design Guidelines for ARHM-GG Thin Overlays**

The performance from the Ravendale sections and from other asphalt rubber sections resulted in the development of a design guide for flexible pavement overlay rehabilitation using ARHM-GG [CAL 92-3]. This guide has recently been used for overlaying “cracked and seated” Portland cement concrete (PCC) pavements. The guide recommends reduced thicknesses for ARHM-GG overlays up to 50 percent of the required conventional DGAC design thicknesses. Caltrans has been using these guidelines since 1992 in all rehabilitation projects involving ARHM-GG overlays.

The thickness requirements per Caltrans design procedure are shown in Tables 2 and 3. The procedure begins first by determining the thickness requirements for a conventional DGAC based on deflections and structural section stiffening requirements. Secondly, the conventional DGAC thickness required to retard reflection cracking is determined. Thirdly, Tables 2 and 3 are used to determine the required thicknesses for ARHM-GG. If the ride score is greater than the allowable minimum and there is no structural need, then two 30 mm thick lifts of ARHM-GG are placed or a depth of 30 mm is cold planed before placing the ARHM-GG as determined by the procedure.

**Basis Behind Caltrans Structural Design Guidelines for ARHM-GG**

Caltrans structural design guidelines have been based largely on the results from the Ravendale project. The performance from field pavement sections in California have supported the conclusions drawn from the Ravendale project.

**Assumptions Used During the Development of Caltrans Structural Design Guidelines for ARHM-GG**

The following assumptions were made during the development of the guidelines:

- The most promising form of asphalt rubber is ARHM-GG.
- ARHM-GG is recyclable.
- Cracking in the overlays is caused by a combination of traffic loads and movement of the underlying pavement.
• Even thinner layers (higher equivalencies) of ARHM-GG may be appropriate but, to limit risk, higher equivalencies should be considered experimental.
• ARHM-GG may be little or no better than DGAC in preventing cold weather induced transverse cracking.
• The degree of stiffening provided by a specific thickness of ARHM-GG is less than the amount of stiffening provided by the same thickness of DGAC. Thus, after the overlay the ratio of tolerable deflection to the actual deflection for ARHM-GG may become less favorable when the ARHM-GG thickness is greater than 60 mm.
• ARHM-GG can withstand considerable higher deflection than the same thickness of DGAC without cracking.
• The mild climate structural equivalency of a SAMI is less than or equal to 15 mm of ARHM-GG (i.e. less than or equal to 30 mm of DGAC; assuming that the SAMI reduces that portion of the total overlay stress caused by reflection of underlying cracks/joints).
• The reflection crack retardation equivalency of ARHM-GG is considerably greater than that of DGAC.
• The reflection crack retardation equivalency of a SAMI is 30 mm of ARHM-GG which is approximately 60 mm of DGAC.
• There may be stability problems if ARHM-GG is placed in thicker than 60 mm even if multiple lifts are used.

Additional Research On Asphalt Rubber Mixes in California

Fatigue

CAL/APT Pilot Project in South Africa

To gain additional validation for the reduced thickness design of ARHM-GG, Caltrans undertook a cooperative effort by initiating an accelerated pavement testing (APT) project which utilized the South African Heavy Vehicle Simulator (HVS) with the Republic of South Africa to perform accelerated pavement testing and research. As part of the experiment, a 75 mm thick DGAC overlay section and three thinner ARHM-GG overlay sections consisting of 50 mm, 38 mm and 25 mm thicknesses were placed on an existing distressed flexible pavement in South Africa which has a climate similar to that found in California. The overlays were constructed using materials and mix design procedures conforming to Caltrans specifications [RUS 93].

The HVS test results indicated that a reduction of at least 50 percent in layer thickness to obtain similar fatigue performance over flexible pavements can be justified when conventional DGAC is replaced with ARHM-GG. These test results served to tentatively validate Caltrans' design guide for ARHM-GG overlays over flexible pavements. This study recommended checking the subgrade rutting criteria when reducing the required thickness based on fatigue performance.

Flexural Bending Beam Fatigue

Flexural fatigue tests conducted in Alaska have supported Caltrans structural thickness adjustments for ARHM-GG overlays. Controlled-strain laboratory flexural beam fatigue tests and multi-layer elastic analysis were conducted at the University of Alaska by Raad et al [RAA 93]. Their analysis indicated that a reduction in the thickness would become more significant with increasing foundation support (higher base and subgrade moduli).
Raad et al developed thickness equivalencies between DGAC and ARHM-GG based on the remaining fatigue life of pavement sections with similar initial fatigue life. By assuming base and subgrade moduli of 550 kPa and 140 kPa, respectively, they demonstrated that DGAC layer thicknesses of 150 mm and 255 mm would be equivalent to ARHM-GG layer thicknesses of 50 mm and 125 mm, respectively. They rationalized that the equivalent ARHM-GG would be significantly smaller in the case of overlays as a result of increased support of the existing pavement structure. In addition to the Alaskan study, controlled-strain flexural fatigue tests were conducted at the University of California for Caltrans as part of the CAL/APT South African pilot project [HAR 94]. The findings indicated that ARHM-GG would provide considerably longer fatigue life when compared with the same thickness of DGAC.

Repetitive Direct Tension Test
Fatigue tests were conducted on beams taken from two SHRP SPS-5 sections using the Caltrans repetitive direct tension test with a test temperature of 20 Celsius and a frequency of 10 Hz under controlled-strain mode of loading. The SPS-5 sections are located on Interstate 40 near Newberry Springs which is in a desert environment with a 7-day maximum pavement temperature of 60 Celsius 50 mm below the pavement surface. These sections were constructed in 1992. One section consisted of a rehabilitation strategy composed of an ARHM-GG layer at a reduced thickness over a new conventional DGAC layer, and another section consisted of a rehabilitation strategy composed of 3 layers of conventional DGAC. Two asphalt sources, Valley and Coastal, were used on this project. The fatigue results revealed that the asphalt rubber mix containing the Valley asphalt source performed better in fatigue than the conventional mixes containing either Valley or Coastal binders (Figure 5) [SHA 97]. In this figure, S2L1 stands for an ARHM-GG (top lift), S2L2 stand for DGAC with Valley asphalt (second lift). These two mixes are from a section designated as Section 2. S4L1 and S4L2 are DGAC mixes with Coastal asphalt placed at the top and second lifts of Section 4, respectively. S4L3 is a DGAC with Valley asphalt placed as the third lift in Section 4. The Valley asphalt produced DGAC mixes with higher stiffness values than the Coastal asphalt and it resulted in mixes having less fatigue resistance than mixes with Coastal asphalt in the controlled-strain repetitive direct tension test. Even with these properties, the asphalt rubber mix containing Valley asphalt outperformed the DGAC mixes containing both asphalt sources in the fatigue test. In addition, Figure 5 shows two distinct fatigue curves for the coastal mixes possibly indicating the effect of aging on the top lift as compared to the second lift. Field reviews after 5 years of traffic showed comparable fatigue performance in both the DGAC and the asphalt rubber sections.

Reflective Cracking
Three laboratory mixes (ARHM-GG, ARHM-DG and DGAC) with air voids of 7.0 percent were subjected to the reflective cracking test at a temperature of 20 Celsius to assess their reflective cracking resistance (Figure 6) [SOU 96]. The results showed that in terms of reflective cracking resistance ARHM-GG ranked first, ARHM-DG ranked second, and DGAC ranked third. The reflective cracking tests simulated crack movement in two modes (Mode I and Mode II) in PCC pavements [SHA 96] [SOU 96]. These results show that asphalt rubber mixes could provide better reflective cracking resistance than conventional DGAC when used as overlays on top of PCC pavements. The results from these tests could
possibly be applied to alternative strategies using ARHM-GG (with and without SAMI) on cracked and seated PCC pavements. These alternatives would provide additional resistance to reflective cracking and would allow placement of thinner layers.

It should be indicated here that field experience with asphalt rubber overlays over PCC pavements has been limited. In 1993, Caltrans constructed for the first time a unique PCC pavement rehabilitation project where the contractor warranted for 5 years an overlay consisting of 45 mm ARHM-GG on 45 mm DGAC leveling course (incorporating a Performance Based Asphalt (PBA-6) over a cracked and seated PCC pavement [HAR 95]. This project is located north of Redding, California on Interstate 5 in Shasta County. The asphalt rubber binder consisted of AR-4000 blended with 17.0 percent ground tire rubber and 2.0 percent natural rubber. The project consisted of both northbound (NB) and southbound (SB) sections which were constructed by two contractors that used two different aggregate sources. The binder contents used were 7.7 percent and 8.7 percent for the NB and SB sections, respectively. Reviews of this project so far have indicated good performance in both directions with some minor surface abrasion.

Permanent Deformation

Results from Caltrans field sections and laboratory performance tests have revealed that asphalt rubber mixes could produce adequate resistance to permanent deformation when properly constructed and designed. Recent work has supported field observations regarding the resistance to permanent deformation. Examples of such projects are the Newberry Springs SPS-5 project, I-5 warranty project, and CAL/APT pilot project. The following are brief descriptions of CAL/APT project. The other two projects were discussed earlier in the paper.

CAL/APT Pilot Project

During the CAL/APT pilot project, the permanent deformation resistance was assessed by conducting companion laboratory tests utilizing the repetitive simple shear test at constant height (RSST-CH) [HAR 94]. These tests were conducted at a temperature of 19 Celsius. This medium temperature is not typically used to assess rutting resistance. It was selected, however, to simulate the temperature of the controlled environment of the HVS test sections in South Africa. The shear stress used was 70 kPa with 0.1 seconds loading and 0.6 seconds rest periods. The data were compared at 4.5 percent permanent shear strain which corresponds to 13 mm rut depth according to the following relationship developed as part of the SHRP A-003A project:

\[
\text{Rut Depth (mm)} = 279 \times \gamma_p
\]

where, \(\gamma_p\) = the permanent shear strain.

The tests indicated that at high air voids (10.0 percent), ARHM-GG would have higher permanent shear than conventional DGAC, and at low air voids (5.0 percent), ARHM-GG would have less permanent shear than DGAC. It is worth emphasizing that permanent deformation testing should be conducted at elevated temperatures where mixes have less resistance to permanent deformation.
Thermal Cracking

Recent research conducted at the University of California by Epps showed that asphalt rubber mixes would have superior thermal cracking performance as compared with conventional DGAC [EPP 97]. The tests conducted included thermal strength using the thermal stress restrained specimen test (TSRTS) and thermal fatigue using the flexural fatigue tests at low frequencies. She concluded that asphalt rubber modification would improve the resistance to both types of thermal cracking. In addition to this work, Raad et al conducted a thermal cracking study using the TSRTS and concluded that thermal cracking would generally be enhanced by using crumb tire modifiers. Raad et al emphasized that the magnitude of improvement would depend on the rubber modification process. It should be emphasized that the above conclusions are dependent on the grade of asphalt used in the DGAC mixes studied.

Moisture Sensitivity

The moisture sensitivity resistance of asphalt rubber mixes has been documented by several research efforts. For example, Maupin used AASHTO T 283 test method to compare asphalt rubber mixes with conventional DGAC mixes [MAU 92]. He showed that asphalt rubber mixes could be more resistant to moisture damage than DGAC mixes containing the same aggregate. Epps indicated that substantial strength loss was shown to occur after moisture conditioning in both the wet and dry processes [EPP 94]. Recent studies in California indicated that there could be moisture sensitivity problems with asphalt rubber mixes. Therefore, it is essential that moisture sensitivity evaluations of these mixes be conducted during the mix design process. In cases where the potential for moisture sensitivity is detected, a treatment with an anti-stripping additive or the use of a different mix may be necessary [SHA 94]. Below are brief descriptions of two moisture sensitivity studies in California:

Moisture Sensitivity Evaluation Using AASHTO T 283

Caltrans conducted testing using the AASHTO T 283 test method on asphalt rubber and conventional DGAC mixes [SHA 94]. The results showed that lower tensile strength ratios (TSRs) for asphalt rubber mixes (ARHM-GG and ARHM-DG) could occur as compared with conventional DGAC mixes containing the same aggregate type (Figure 7). Field performance indicated that moisture damage occurred early in the service life of some asphalt rubber pavement projects.

Environmental Conditioning System (ECS, AASHTO TP34-93)

On the warranted pavement, moisture sensitivity testing using the Environmental Conditioning System (ECS) was conducted on the DGAC-PBA6 and the ARHM-GG with binder contents of 4.5 percent and 5.0 percent for DGAC-PBA6 and 7.0 percent and 8 percent for ARHM-GG. These two mixes were tested at air voids that approximated in-place field air voids of around 8.0 percent and 11.0 percent, respectively. The tests revealed low resistance to water damage in the DGAC-PBA6 mix but not in the ARHM-GG mix (Table 4). An anti-stripping additive was added to selected mixes to increase the resistance to moisture damage.
Discussion

Thin asphalt rubber overlays as demonstrated in this paper can have superior fatigue performance as compared with DGAC mixes. Additionally, thin asphalt rubber overlays when properly designed and constructed can provide adequate resistance to permanent deformation. The lack of a performance based mix design may have contributed to some premature rutting failures.

Since the development of the structural and reflective cracking equivalencies was based mainly on the long term performance of pavement test sections, an approach based on engineering properties is under consideration. A new approach based on laboratory performance testing accompanied with mechanistic analysis can improve the structural design guidelines. This approach may result in modifications to the guidelines.

Conclusions and Recommendations

• Generally, the fatigue performance of thin ARHM-GG overlays has been demonstrated to be superior to conventional DGAC overlays with unmodified binders.
• Thin asphalt rubber overlays can have adequate permanent deformation resistance if properly designed and constructed. A proper design must be based on laboratory performance tests with limiting criteria validated through field performance.
• Thermal cracking properties can improve when asphalt rubber binder is used. This conclusion is dependent on the grade of asphalt used in the DGAC.
• Moisture sensitivity can be a problem for ARHM-GG mixes and must be evaluated during the mix design process. Anti-stripping additives may be necessary to minimize moisture damage.
• Structural and reflective thickness equivalencies for thin asphalt rubber overlays must be based on laboratory fatigue and reflective cracking tests as well as mechanistic analysis.

References


Table 1. Ravendale Project Test Sections Results

<table>
<thead>
<tr>
<th>Segment</th>
<th>Design Basis</th>
<th>Design Strategy</th>
<th>Thickness Provided</th>
<th>Thickness Ratio (Provided/Required)</th>
<th>ESALs to Failure</th>
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<tr>
<td>1</td>
<td>Structural</td>
<td>ARS/SAMI</td>
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<td>Structural</td>
<td>ARS/SAMI</td>
<td>45 mm</td>
<td>0.30</td>
<td>510,000</td>
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<tr>
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<td>Reflective</td>
<td>ARS</td>
<td>45 mm</td>
<td>0.60</td>
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<td>Structural</td>
<td>PlusRide</td>
<td>45 mm</td>
<td>0.33</td>
<td>450,000</td>
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<tr>
<td>5</td>
<td>Structural</td>
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<td>1.00</td>
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Table 2. California Structural Equivalencies (mm)

<table>
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<tr>
<th>DGAC</th>
<th>ARHM-GG1</th>
<th>ARHM-GG/ SAMI</th>
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<td>45</td>
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<td>180</td>
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</table>

Notes:
1. The maximum allowable non-experimental equivalency for ARHM-GG is 2:1.
2. The minimum allowable ARHM-GG lift thickness is 30 mm.
3. Place 45 mm of new DGAC first.
4. Place 60 mm of new DGAC first.
Table 3. California Reflective Crack Retardation Equivalencies (mm)

<table>
<thead>
<tr>
<th></th>
<th>DGAC</th>
<th>ARHM-GG</th>
<th>ARHM-GG/SAMI</th>
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<tr>
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<tr>
<td>105²</td>
<td></td>
<td>45¹</td>
<td>30¹</td>
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</tbody>
</table>

Notes:
1. The minimum allowable ARHM-GG lift thickness is 30 mm.
2. A DGAC thickness of 106 mm is the maximum thickness recommended by Caltrans for reflection cracking.
3. Use 45 mm if the crack width is less than 3 mm and 60 mm if the crack width is equal to or greater than 3 mm.
4. Use 45 mm if the crack width is equal to or greater than 3 mm. If less than 3 mm, use another strategy.

Table 4. ECS Moisture Sensitivity Results for the I-5 Warranty Project

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<th>Mix</th>
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b) 1995 Review
EXECUTIVE SUMMARY

During 1995, a field review was conducted on asphalt-rubber hot mix (ARHM) and asphalt-rubber chip seal (ARCS) projects in California. This review included a total of 88 projects that included city and county, as well as Caltrans, facilities. To date, Caltrans has constructed over 100 projects (these do not include chip seals). Cities and counties have constructed over 400 projects statewide. However, an abnormally high percentage of the Caltrans projects have exhibited various problems. These projects utilized either Type I or Type II asphalt-rubber (AR) binder. Type II AR binder utilizes a high natural rubber (HNR) additive and an extender oil. These materials are not used in Type I AR binder. The difference appears to have an effect on performance. It also appears that certain base asphalts (or crude sources) may perform differently in AR binder.

Three ARCS projects were reviewed where lightweight aggregates were utilized. When used in chip seals, the aggregate reduces the potential for vehicle damage to almost zero. All three projects have performed well to date. Two of these projects are under heavy traffic.

In January 1995, members of the AR industry and Caltrans formed a Task Force to review the ARHM specification. An interim specification was recently completed which incorporated some of the recommendations of the Task Force. This interim specification will be incorporated in all 1996 ARHM projects.

In addition to the field reviews, information is also provided on air emission monitoring and worker complaints during ARHM construction. Some ARHM projects encountered air emission problems during construction. Workers on some projects also complained of illness while working on the job. The complaints were limited almost exclusively to Type I AR binder projects. There were no reported complaints on ARHM projects in 1995. Since 1993, air monitoring, sampling and testing has been conducted on 12 ARHM projects, and it has been found that no violations of Cal-OSHA permissible exposure limits have occurred for the contaminants measured.

Based on the above evaluations, it was concluded that:

1. ARHM and ARCS projects with Type II asphalt-rubber binder have performed better in California overall than projects utilizing Type I asphalt-rubber binder.

2. Type II asphalt-rubber binder appears to resist reflective cracking better than Type I asphalt-rubber binder.
3. Many ARHM projects that develop early distress in the form of cracking or raveling have still provided adequate service life with minor maintenance.

4. When distress in the form of cracking or raveling develops on ARHM projects, it generally propagates at a much slower rate than it does on conventional AC projects.

5. It appears that the base asphalt (crude source) used in asphalt-rubber binder may have an effect on binder performance.
Memorandum

To: MR. ROY BUSHEY, Chief
Office of Materials Engineering and Testing Services

From: DEPARTMENT OF TRANSPORTATION
ENGINEERING SERVICE CENTER
Office of Materials Engineering and Testing Services

Subject: Asphalt-Rubber Project Performance Evaluation

INTRODUCTION

During the months of February through June 1995, Gary Hildebrand and Jack Van Kirk of the Pavement Consulting Services Branch (PCS) made a field review of 88 rubberized asphalt concrete (RAC) and asphalt rubber chip seal (ARCS) projects in California. This review included some city and county facilities, as well as Caltrans projects. The Caltrans review included 56 RAC hot mix projects and 10 ARCS projects placed since 1980. The city and country projects included 12 RAC hot mix projects, 4 ARCS projects and 6 asphalt-rubber cape seal projects. The majority of the RAC projects were asphalt rubber hot mix (ARHM) gap-graded (GG) and dense graded (DG) projects. The RAC projects review primarily focused on projects utilizing asphalt-rubber binder. A matrix showing the breakdown of the projects reviewed is shown in Table 1. A trip report documenting the total projects reviewed is attached as Appendix A.

Caltrans began using RAC in 1978, and to date 111 projects have been constructed (these do not include chip seals). Of these projects, 74 placed since 1992 utilized asphalt-rubber (AR) binder. Since that time, some projects have exhibited various problems. These problems have included opacity complaints at the hot plant, opacity complaints and reported illness at the street during mix placement, and early distress on some projects in the form of raveling, cracking, bleeding or rutting. To help address these problems and to assess the condition of the existing ARHM projects, it was decided to conduct a performance evaluation of the Caltrans ARHM projects. However, in order to get a better overall view of projects in California, some city and country projects were included during the review. The ARHM project performance evaluation is only part of the overall evaluation of the use of AR binder by Caltrans. AR binder from many of the projects has been sampled and stored (at TransLab) for further testing. Unfortunately, this testing could not be completed before this report was prepared. There was also air sampling and monitoring during the actual construction of some of these projects. This will be touched upon briefly later in the report. It was also decided that some of the projects, upon which early distress developed, will be investigated to determine probable cause.

DISCUSSION

Type I AR vs. Type II AR Binder

The evaluation of each ARHM and ARCS project was based on visual condition and age of the project. If a project was relatively new and exhibited major premature distress, it was considered poor performance. However, if a project was relatively old (close to or beyond the expected 10 year service life) and it exhibited major distress (even if the distress occurred early
in the life of the project), it was considered good performance if no extensive maintenance was
required over the life of the project. As mentioned earlier, there were a total of 88 projects
reviewed. However, some of these projects had more than one type of mix or had more than one
type of binder. Most of these projects were split up and counted as two or three projects.
Therefore, the total number of projects reviewed using this format was increased to 97. This
number will be used in the following discussion.

Of the 97 projects, 54 utilized Type I AR binder and 43 utilized Type II AR binder (one Type
II AR binder project also used some Type I AR binder). Of the 54 Type I AR binder projects, 24
(44%) performed poorly. However, of these 24 projects there has been 10 projects to date which
the poor performance could be attributed to non-rubber related causes (such as poor compaction,
high binder content or subsurface water problems). This leaves 14 Type I AR binder projects
(25%) with poor performance which cannot be explained to date (no investigation has been
made). Only five Type II AR binder projects (12%) have performed poorly to date.

It should also be pointed out that ten of the total 97 projects were Caltrans thin (0.06 ft
thickness) maintenance blankets using ARHM-GG and ARHM-OG mixes. It has been
concluded that ARHM-GG placed at 0.06 ft thickness is probably thin. These mixes can be
placed in thin lifts if proper design and construction practices are followed. However, these
blankets can cool quickly and may not obtain adequate compaction. This mix can also drag at
high spots during placement, which leads to raveling. These maintenance blankets should be
placed at a minimum thickness of 0.08 ft. Of the ten thin maintenance blanket projects, eight
used Type I AR binder and two used Type II AR binder. Five of these performed poorly and
used Type I AR binder.

It was concluded from this project performance evaluation that projects with Type II AR
binder have performed much better than projects with Type I AR binder. This has also been
supported by other project reviews. Over the past five years, Caltrans has reviewed many other
projects including city and county projects. Many Caltrans ARCS projects have also been
reviewed. That review along with comments is included in Appendix B. The reviews further
support the conclusions and recommendations in this evaluation report.

It is especially important to discuss the ARCS projects, since all Type I AR binder used in
chip seals prior to about 1992 did not contain a high natural rubber additive (HNR). It has been
found through project reviews, and also supported by Caltrans District Maintenance personnel,
that Type II ARCS projects performed much better. It was found that Type II AR binder projects
retained chips better and resisted reflective cracking much more effectively. During and after
1992, Type I AR binder suppliers for ARCSs began using a HNR additive and the performance
has been more similar to Type II AR binder projects. This improved performance has also been
supported by Caltrans District Maintenance personnel. A total of 27 ARCS projects were
reviewed by Gary Hildebrand. Of those, 19 used Type I AR binder and eight used Type II AR
binder. Of the 19 Type I AR binder projects, nine used HNR. Only three of the ten projects with
no HNR performed well. All nine of the Type I AR binder projects that used HNR performed
well. Also, all eight of the Type II AR binder projects (that used HNR and extender oil)
performed well. This data indicates that the HNR significantly improves the performance of
ARCSs. In previous reviews of city and county ARHM and ARCS projects, it has also been
found that Type II AR binder projects have performed better than Type I AR binder projects. These previous reviews have included over 50 projects.

During the recent project performance evaluation, a significant difference was also found when comparing Type I AR (without HNR) and Type II AR binder used on ARCSs. When a rock is pried loose from a Type II AR binder chip seal, the binder will stretch out, sometimes up to 1-1/2 inches, before the rock breaks away from the binder. Also, the binder appears shiny and sticky. On a Type I AR binder chip seal (without HNR), the rock breaks away almost immediately and appears dull with no stickiness. The use of the HNR and the extender oil is believed to be the reason for improved performance when using Type II AR binder. It is also believed that the use of HNR and extender oil in Type II AR binder should also improve the performance of ARHMs. This belief is supported by the better performance of Type II AR binder projects observed in these field reviews.

It should also be pointed out that on the first 20 Caltrans ARHM projects, 10 were Type I AR binder and 10 were Type II AR binder. Ninety percent of the Type II AR binder projects performed well as opposed to only 60% of the Type I AR binder projects. Eleven of these 20 projects are included in the most recent project performance evaluations (4 Type I AR binder and 7 Type II AR binder).

**ARHM Project Reviews in Arizona**

During the week of September 18-22, 1995, two of Caltrans staff made a trip to Arizona to review AR binder projects. The trip was made possible by the Rubber Pavements Association (RPA). This trip provided the opportunity to review AR binder projects in Arizona and helped to provide more information on the performance of Type I AR binder. A total of 41 projects were reviewed. Nineteen were ARHM-OG, 14 were ARHM-GG, and 8 were ARCSs with 2 using lightweight aggregates. Overall, the Type I AR binder projects performed very well.

The best performance was observed on ARHM-OG projects. ARHM-OG projects were reviewed in high elevation snow country (over 7,000 ft) and in hot desert regions. This performance review proved that ARHM-OG can perform well in cold regions with heavy truck traffic even when the projects are snow plowed. This was quite surprising. In addition, these cold regions had chain controls and temperatures below freezing during the winter months.

Arizona uses a lot of AC 10 asphalt in their AR binder in both hot and cold regions, with the remaining projects using AC 20 (similar to AR 4000). A majority of these projects used Sunbelt and Edgington asphalts. Arizona normally uses cement or lime as an anti-stripping agent in their mixes. They also use a finer rubber gradation and finer aggregate gradation than Caltrans.

Typically AC 10 asphalt is used with 17% CRM with no HNR or extender oils in their AR binder. However, some of the AR binders used in ARCSs do utilize an HNR additive.

Although complete information was not provided on all projects, generally the ARHM-OG was placed on areas that were milled off and leveled prior to placing the OG surface course. There were a few sites that were placed over areas that were not milled. These sites were also
performing well. Two of these sites were over older PCC pavements and one was placed over an older AC pavement.

Several of the ARHM-GG projects looked good while some did not. Distress exhibited was either bleeding, rutting or premature reflective cracking. However, this was not typical of the ARHM-GG projects statewide. According to the RPA, most of the Arizona ARHM-GG projects are performing well and most of the ARCSs are performing very well to date. A couple of these chip seals placed in 1981 and 1985 were still performing well.

Two chip seal projects utilized lightweight aggregate. Both were placed during 1988 and have performed very well. Both projects are heavily traveled expressway type arterial streets.

During the Arizona tour, RPA made arrangements to visit the Crafco facilities. Crafco basically produces and markets AR and polymer modified crack sealants and crack sealant equipment. They also have a laboratory and conduct a lot of testing on these crack sealants. Over the years, Jim Chahovitz of Crafco has conducted a lot of testing on AR binders. During the visit, Mr. Chahovitz discussed a couple of important points. First, he recommended that the spindles on hand-held viscometers be heated in the binders being tested for at least 2 to 3 minutes prior to taking readings. He said that if the spindle is not properly heated first that it could result in erroneous high viscosity readings. Second, he recommended using ASTM 2196 as opposed to ASTM 3236 for testing AR binder viscosity in the laboratory. He said ASTM 3236 worked better on higher viscosity materials such as crack sealants. He also said his experience has shown that ASTM 2196 is more accurate for AR binders. Jim probably has as much experience with AR binder testing as anyone else in the United States.

**Lightweight Aggregate for ARCSs**

During the recent field evaluations in California, three lightweight aggregate ARCS projects were reviewed. Lightweight aggregate is an expanded clay/shale product that is one half the unit weight of conventional aggregate. When used in chip seals, the aggregate reduces the potential for vehicle windshield damage to almost zero. The only concern is how well it will perform under traffic. So far all three projects have performed very well. One of the projects is under light traffic. The other two are under extremely heavy traffic. These three projects that include La Puente Landfill Road prove that this material can provide a good service life as an ARCS. It should also work well in a stress absorbing membrane interlayer (SAMI).

As mentioned earlier, the lightweight aggregate ARCSs reviewed in Arizona also showed excellent performance. It is, therefore, recommended that Caltrans begin to utilize the lightweight aggregates in chip seals and SAMIs in areas where conventional aggregates cannot be used.

**Asphalt Rubber Binder Base Asphalt**

One area that has not been sufficiently researched is the specific properties of the base asphalts (or crude source) used in AR binder. Certain asphalts, depending on their chemical make-up or the way they are refined or blended, may produce a better performing AR binder. In the most recent Caltrans review, 70% of the asphalts used on Type I AR binder projects came
from only three sources (Huntway, Shell or WITCO). Eighty-three percent of the poor performing Type I AR binder projects used one of these three binders. Seventy percent of the asphalts used in the Type II AR binder projects came from only two sources (Paramount and Edgington). All of the poor performing Type II AR binder projects used Paramount asphalt; however, there were only five poor performing projects. Four Type I AR binder projects used either Paramount or Edgington asphalt, and all but one performed well. Huntway, Shell or WITCHO asphalt was not used on any of the Type II AR binder projects. These figures are interesting, but it does not prove that the asphalt played a significant role in performance. However, it indicates that the base asphalt may play a major role and it is recommended that the specific properties of these base asphalts be evaluated to determine what effect they may have on AR binder performance.

Another area that should be evaluated is the effect of extender oil or diluent used in conjunction with certain base asphalts. Our field reviews indicated that the use of these additives improve the performance of AR binders. Diluent has been used in Type I asphalt-rubber binder in the past. However, because of more recent air quality requirements, the use of diluent is currently almost nonexistent. Extender oil has always been used in Type II binder and has been used very little in Type I binder.

**Early Distress on AR Binder Projects**

During the ARHM project reviews, a very important observation was made on ARHM projects after distress first developed. Once distress develops in the form of cracking or raveling on an ARHM project, whether it is premature or normal (late in the design life), it appears to progress at a very slow rate, which is significantly slower than that found in conventional AC mixes. This can especially be seen when the distress is premature. There were a number of projects reviewed where premature distress developed early in the project life, yet had progressed so slowly that most of these projects appear to still provide an adequate service life with very little maintenance. Two example projects are located in the Lake Tahoe Maintenance Region of District 3. The first project placed in 1985, is located on Rt. 89 at South Lake Tahoe (03-ED-89, PM 8.6/10.0 EA 03-279204). It developed cracking and some raveling during the first year. After some minor maintenance the second year, the project has performed extremely well for more than 10 years. The second project placed in 1980, is located on Rt. 50 near Strawberry (03-ED-50, PM 52.5/66.5, EA 03-248304). It also developed early cracking and some raveling after the first few years. However, with some maintenance over the years (patching, blankets, etc.), one-third of the ARHM mix on the project which is still exposed, is performing today as a wearing surface after 15 years. Both projects are in high elevation snow country and have had to withstand severe climatic conditions, snow plowing, and heavy tire chain wear. It was learned from both the area Maintenance Superintendent and Supervisor during these reviews that they have spent less time, money, and resources on these two particular locations than any other areas in their region. There are other projects that can be cited with similar results. This type of performance is not normally found with conventional AC mixes.

Some of the projects that have been placed in the last few years which have developed early distress are currently being investigated. It is planned to investigate other projects with early distress within the next year. Reports will be available upon request. However, the number of projects to be investigated will depend on staffing and workload.
Air Emissions Problems on ARHM Projects

In 1993, there were a number of projects where workers complained of illness while working on the job. These problems are documented in a July 6, 1995 memo to File by Robert N. Doty titled “Asphalt-Rubber Health Issues: Background” and is attached as Appendix C. It has been concluded that there is a direct relationship between mix temperature, smoke and complaints. In January 1994, ARHM specifications were changed to lower mix temperatures (from 350°F to 325°F measured in the paving hopper) and there were no reported complaints in 1995. In addition, the earlier complaints have been limited almost exclusively to Type I AR binder projects with one minor complaint on a Type II AR binder project.

Since 1993, air monitoring, sampling and testing has been conducted on over 12 ARHM projects, and it has been found that No violations of Cal-OSHA permissible exposure limits (PELs) have occurred for the contaminants measured. Mr. Doty’s memo states:

“In summary, this information reveals that manufacturing tires involves the use of sulfur, magnesium oxide, carbon black, oils, styrene butadiene, and other ingredients. Some of these pigments, antioxidants, accelerators, and/or other additives are carcinogens. The extent to which these materials are modified during the tire manufacturing process is not known. In addition, the amount, if any, of carcinogenic and/or toxic material that is released during the mixing, placing, and recycling of asphalt concrete containing crumb rubber modifier has not been determined conclusively. However, the limited data that is available indicates that it is unlikely that any health and/or environmental regulations are being violated when Caltrans specifications are being adhered to.

“A review of the Industrial Hygienist’s reports and October 12, 1993 recommendations to Caltrans by the State Medical Officer resulted in the medical opinion that asphalt-rubber is safe if the Industrial Hygienist’s recommendations are followed.”

ARHM Specifications

On December 19, 1994, a meeting was held at TransLab with the Rubber Pavements Association (RPA) and personnel from the Caltrans Office of Safety and Health and the Office of Materials Engineering and Testing Services (METS). The meeting was chaired by Jim Roberts, Director of the Engineering Service Center. This meeting was held to discuss problems and concerns regarding the use of ARHM by Caltrans. A permanent Standing Committee was formed between Caltrans, RPA and members of the asphalt-rubber industry.

Mr. Roberts appointed Roy Bushey, Chief of METS to head the Standing Committee. At a second meeting in January 1995, a Task Force was set up to rewrite the ARHM specifications. The Task Force has worked on the new specifications which should be completed sometime in 1996. These specifications will then be incorporated into all future Caltrans projects. Some of the changes in the specifications include much tighter control on the production of the binder and ARHM mix; specific requirements on the crumb rubber, asphalt, and equipment used to produce the asphalt rubber; changes in the rubber gradation; and changes in the aggregate gradations for the ARHM-GG mix. Interim specifications that include some of these requirements have been
completed for both ARHM and ARCS. These specifications will be implemented this construction season.

The new specifications mentioned above are recipe type specifications for the production of the asphalt-rubber binder. The long-term approach to specifying asphalt-rubber binder could be an end-result specification. A tentative end result test method is being researched for testing the asphalt-rubber binder. However, there is further work necessary to validate the test method.

CONCLUSIONS

1. ARHM and ARCS projects with Type II asphalt-rubber binder have performed better in California overall than projects utilizing Type I asphalt-rubber binder.

2. Type II asphalt-rubber binder appears to resist reflective cracking better than Type I asphalt-rubber binder.

3. Many ARHM projects that develop early distress in the form of cracking or raveling have still provided an adequate service life with minor maintenance.

4. When distress in the form of cracking or raveling develops on ARHM projects, it propagates at a much slower rate than it does on conventional AC projects.

5. It appears that the base asphalt (crude source) used in asphalt-rubber binder may have an effect on binder performance.

6. The use of diluent in Type I asphalt-rubber binder and extender oil in Type II asphalt-rubber binder appears to have a positive effect on binder performance.

7. Most air emissions problems appear to be associated with high ARHM mix temperatures.

8. There has been compaction and dragging problems encountered on some 0.06 ft. thick ARM-GG maintenance blankets. A 0.06 ft. thickness may be too thin to place ARHM-GG without problems.

9. Lightweight aggregate has performed well when used in ARCSs, even under heavy truck traffic.

10. ARHM-OG has performed extremely well as a wearing surface, even in the snow country.

RECOMMENDATIONS

1. Caltrans should utilize only Type II asphalt-rubber binder on all future ARHM and ARCS projects.

2. Type II asphalt-rubber binder specifications should be rewritten to include better quality control during production and tighter controls on the materials that are used to produce it.
3. Further analysis should be conducted on the information provided for the various ARHM projects reviewed in this study.

4. Base asphalts (crude sources) should be evaluated to determine what effect their specific properties may have on asphalt-rubber binder properties and performance.

5. Air emissions testing should be conducted on additional asphalt-rubber projects to further investigate health/safety issues.

6. The minimum thickness for ARHM-GG maintenance blankets should be 0.08 ft.

7. Caltrans should begin using ARHM-OG as a wearing surface on selected projects throughout California.

8. Caltrans should begin using lightweight aggregates in ARCSs and SAMIs on selected projects as an alternative when conventional aggregates cannot be used.

**SUMMARY**

Based on the ARHM and ARCS projects reviews, it is quite evident that these materials can perform well and provide or exceed the desired service life when properly designed and constructed. Caltrans research (CAL/APT Research Program) has also tentatively validated the field performance for the reduced thickness design philosophy for ARHM overlays on pavement rehabilitation projects. Additional evaluations will be performed.

Some ARHM projects have not performed well. The reason for this poor performance could be attributed to non-rubber related factors. Some of these projects should be investigated to determine the reason for poor performance. Once the backlog of AR binder testing is completed, these data may provide some answers.

It is our opinion that ARHM and ARCSs can be mixed and placed safely and provide good performance if proper design and construction practices are followed. Based on field performance, it is also our opinion that by changing to only Type II AR binder, the potential for successful projects should significantly increase. Lastly, the new ARHM and ARCS specifications should also significantly increase the potential for successful projects.

If you have any questions concerning this report, please call Gary or Jack at 227-7022 or 227-7300, respectively.

_____________________________ ______________________________
GARY HILDEBRAND JACK VAN KIRK, Chief
Maintenance Manager Flexible Pavement Section
Pavement Consulting Services Branch Pavement Consulting Services Branch

Attachments
# TABLE I

## ASPHALT-RUBBER PROJECT MATRIX

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Chris Cummings, the District 2 District Materials Engineer (DME) called Jack Van Kirk (JVK) during the first week of February, 1995 and reported severe raveling was occurring on several asphalt rubber hot mix (ARHM) projects recently placed in the District. He asked that we review the projects experiencing pavement distress.

JVK agreed to go on the review and it was scheduled for the week of February 8, 1995. JVK and Gary Hildebrand (GH) from the Pavement Consulting Service Branch (PCSB) met with District representatives Chris Cummings (DME) and Don Turner (District Maintenance Engineering) on February 8, 1995.

We first visited the District Laboratory then reviewed the projects exhibiting the distress mentioned above. We also reviewed 14 other asphalt rubber (AR) projects throughout the District over the next few days. In addition, on February 14, 1995, JVK and GH reviewed a project in D-10 on Solano I-80.

This became the first of a statewide review of a major portion of the AR projects throughout the state. These included asphalt rubber hot mix (ARHM), asphalt rubber chip seals (ARCS), asphalt rubber cape seals (ARCS covered with a slurry seal) and asphalt rubber stress absorbing membrane interlayer (SAMI) projects.

Trip # 1

02-SHA-5 PM 0.0/3.8 EA 02-288904 Type 1 ARHM-GG (Cottonwood) Pict’s 24/19 Roll 1 AADT’s Veh. 40,500 Truck 22.2%

JVK, GH, Don Turner, and Chris Cummings reviewed this project during the afternoon of February 8, 1995.

The rehabilitation project was placed during August and September 1993 with Jaxon Baker as the Prime Contractor and J.P. Shea as the asphalt concrete (AC) supplier. It was Type-1 ARHM-GG with the AR binder blended by International Surfacing Inc. (ISI). The AR binder consisted of AR-4000 (Shell Martinez) blended with 17% ground tire rubber (Atlos) and 2% high natural rubber (Atlos) with 0% extender oil. The actual binder content was 8.0%.

Distress began to appear within the first few months after it was placed. This project had minor to severe surface abrasion with raveling in some of the areas both northbound (NB) and southbound (SB). The NB lanes also had some areas of popouts and exhibited evidence of sub-
surface moisture problems indicated by the pumping of mud to the surface of the traveled way. There had been some digouts done in the NB lanes. This project is not performing well to date. However, the poor performance is attributed to sub-surface moisture problems.

02-SHA/SIS-5 PM 60.5/67.0, 0.0/2.6 EA 02-301304 Type 1 ARHM-DG (Castella) Placed Sept./Oct. 1994 Pict’s 6/5 Roll 1 and Pict’s 18/17 and 10/7 Roll 2 AADT’s Veh. 165,000 Truck 32.7%

JVK, GH, Don Turner, and Chris Cummings reviewed the NB lanes on this project on February 8, 1995. The SB lanes were reviewed on February 9, 1995.

This rehabilitation project was placed during September and October 1994 with Jaxon Baker as the Prime contractor and Fawndale Rock as the AC supplier. It was Type 1 ARHM-DG with the AR blended by ISI. The AR binder consisted of AR-4000 (Shell Martinez) blended with 19% ground tire rubber (Atlos) and 1% high natural rubber (Baker Mat 20) with 0% extender oil. The actual binder content was 7.9%. This project required that all AC aggregates be “lime slurry” treated.

This project had minor to severe surface abrasion with raveling in some of the areas in the NB lanes. The SB lanes had minor surface abrasion with the #2 lane being worse than the #1. The NB #2 lane had some segregation (appeared to be hopper segregation) and surface abrasion as well. This project is not performing well to date. However, the poor performance may be attributed to poor compaction.

The District requested that an investigation be completed on this project to find out the cause of distress. A decision was made to take core samples and the locations were provided to the District. Laboratory testing will be performed and a report will be written and provided to the District.

02-SIS-5 PM 66.6/68.7 EA 02-301204 Type 1 ARHM-DG (Hilt) Pict’s 6/1 Roll 1 AADT’s Veh. 131,000 Truck 32.2%

JVK, GH, Don Turner, and Chris Cummings reviewed this project on February 8, 1995. Due to darkness, they returned on February 9, 1995 to complete the review.

This rehabilitation project was placed during August 1994 with J.F. Shea as the Prime Contractor. It was Type 1 ARHM-DG with the AR binder blended by ISI. The AR binder consisted of AR-2000 (Witco) blended with 19% ground tire rubber (Atlos) and 0% high natural rubber with 0% extender oil. The actual binder content was 10.0%.

This project appeared to be very rich in the #3 lane and had a sheen look to it over large areas. It appeared that some of the rocks were starting to disintegrate and there was some minor surface abrasion. There was some rutting for about .2 mile at the beginning of the project. Overall this project looks good to date.

02-SIS-5 PM R36.7/R37.7, R42.5/R43.1 EA 02-233034 Type 1 ARHM-GG (Grenada) Pict’s 24/21 Roll 2 AADT’s Veh. 15,600 Truck 29.1%

JVK, GH, Don Turner, and Chris Cummings reviewed this project on February 9, 1995.

This rehabilitation project was placed during the summer 1993 with J.F. Shea as the Prime Contractor. It was Type 1 ARHM-GG with the AR binder blended by ISI. The AR binder consisted of AR-2000 (Huntway) blended with 17% ground tire rubber (ATLOS) and 2% high natural rubber (Atlos) with 0% extender oil. The actual binder content was 8.8%.

This project had some minor surface abrasion with a few transverse (T) cracks at the beginning of the section in both the #1 and #2 lanes in the SB direction. In addition, there are T-cracks in one area every 20 to 50 feet in the SB direction. It was reported by District 2 representatives that this area had extremely distressed slabs and that the crack and seat procedure
possibly had not been performed properly. This project is not resisting reflective cracks very well at the beginning of the project. However, overall the project is performing well.

02-SIS-5 PM 15.9/25.2 EA 02-289704 Type 1 ARHM-GG (Weed)
Pict’s 19/15 Roll 2 AADT’s Veh. 14,700 Truck 37.1%

JVK, GH, Don Turner, and Chris Cummings reviewed this project on February 9, 1995.

This rehabilitation project was placed during October 1993 with J.F. Shea as the Prime Contractor. It was Type 1 ARHM-GG with the AR binder blended by ISI. The AR binder consisted of AR-2000 (Huntway Benicia) blended with 17% ground tire rubber (Atlos) and 2% high natural rubber (Atlos) with 0% extender oil added. The actual binder content was 9.5%.

The SB lanes exhibited some minor surface abrasion and the NB lanes exhibited some minor surface abrasion on the incline sections only. The NB off ramp (to Weed) had some rutting and instability at the end of the ramp. Other than the isolated distress at the end of the ramp, overall the mainline looks good both NB and SB.

02-SIS-5 PM 2.7/R11.2 EA 02-300504 Type 1 ARHM-GG (Mt. Shasta City Limits) Pict’s 14/11 Roll 2 AADT’s Veh. 18,700 Truck 33.6%

JVK, GH, Don Turner, and Chris Cummings reviewed this project on February 9, 1995.

This rehabilitation project was placed during the summer 1993 with Kiewitt Pacific Company as the Prime Contractor. It was Type 1 ARHM-GG with the AR binder blended by FNF Construction. The AR binder consisted of AR-4000 (Huntway) blended with 19% ground tire rubber (Baker) and 0% high natural rubber with 0% extender oil. The actual binder content was 7.0%.

The SB lanes have some minor surface abrasion with the #2 lane being worse than the #1 lane. Both these lanes exhibit some chain wear. The NB lanes look similar to the SB lanes. The SB #2 lane has some wet spots and the inside wheel track is more abraded than the outside wheel track (OWT). Overall, this project looks good to date.

02-Sha-5 PM 56.0/60.0 EA 02-260404 Type 1 ARHM-GG (Warranty Project) Pict’s 4/1 Roll 2 and Pict’s 24/19 Roll 3 AADT’s Veh. 15,600 Truck 32.8%

JVK, GH, Don Turner, and Chris Cummings reviewed this project on February 9, 1995.

This rehabilitation project was a warranty project and was placed during October 1993 with Jaxon Baker as the Prime Contractor for the NB direction and J.F. Shea as the Prime Contractor for the SB direction.

NB was Type 1 ARHM-GG with the AR binder blended by ISI. The AR binder consisted of AR-4000 (Shell Martinez) blended with 17% ground tire rubber (Atlos) and 2% high natural rubber (Atlos) with 0% extender oil. The actual binder content NB was 7.7% with 1/2% liquid anti-strip (Pavebond) added.

SB was Type 1 ARHM-GG with the AR binder blended by ISI. The AR binder consisted of AR-4000 (Shell Martinez) blended with 17% ground tire rubber (Atlos) and 2% high natural rubber (Atlos) with 0% extender oil. The actual binder content SB was 8.7%. Liquid anti-strip was not used for SB.

There is a distinct color differential between the NB and SB lanes apparently because of different aggregate sources. The NB and SB lanes both exhibit some minor surface abrasion.

NB has patches (DGAC) in the #2 lane that is already abrading. In addition, NB has some patches in the #2 lane in the outside wheel tracks and it has been cored in the #1 lane. SB has a patch in the OWT of the #2 lane. Overall this project looks good to date.
JVK, GH, Don Turner, and Chris Cummings reviewed this project on February 8 and 9, 1995.

This rehabilitation project was placed during the summer of 1994 with Kiewitt Pacific Company as the Prime Contractor. It was **Type 1 ARHM-DG** with the AR binder blended by FNF Construction. The AR binder consisted of AR-4000 (Huntway) blended with 18% ground tire rubber (BAS) and 0% high natural rubber with 0% extender oil. This project had cryogenic processed tire rubber (then ambient ground) used in the blend. The actual binder content was 7.6%. Some of the rubber particles appeared to have an elongated shape.

Portions of this project is not performing well to date. The NB lanes had minor surface abrasion in the wheel tracks, some minor flushing, and had a sheen look. In addition, the NB lanes had rock pockets, raveling and had raveled edges in some areas. The SB lanes appeared to have no distress at this time.

The rubber on this job appeared to be bunched up and not reacted. The rubber seemed to be rather hard compared to a rubber that’s properly reacted. The District 2 representatives stated that the mixing temperatures had been reduced at the asphalt plant because of concerns by the Air Quality District. They also indicated that the ARHM was placed in the NB lanes during much colder temperatures. This project has not performed well to date in the NB direction. However, the poor performance may be due to poor compaction.

The District requested that an investigation be completed on this project to find out the cause of distress. A decision was made to take core samples and the locations were provided to the District. Laboratory testing will be performed and a report will be written and provided to the District.

JVK, GH, Don Turner, and Chris Cummings reviewed this project on February 9, 1995.

This rehabilitation project was placed during the summer of 1994 with Kiewitt Pacific Company as the Prime Contractor. It was **Type 1 ARHM-GG** with the AR binder blended by FNF Construction. The AR binder consisted of AR-4000 (Huntway) blended with 19% ground tire rubber (Baker) and 0% high natural rubber with 0% extender. The actual binder content was 7.2%.

This project has very minor surface abrasion in the NB and SB lanes. To date, it looks good.

JVK, GH, and Don Turner reviewed this project on February 9, 1995.

This rehabilitation project was placed during June 1994 with J.F. Shea as the Prime Contractor. It was **Type 1 ARHM-GG** with the AR binder blended by ISI. The AR binder consisted of AR-2000 (Witco) blended with 18% ground tire rubber (Atlos) and 2% high natural rubber (Atlos) with 0% extender oil. The actual binder content was 9.5% SB and 9.9% NB.

This project is exhibiting minor flushing intermittently both directions throughout the job. The area near the Texaco gas station has some pushing and rutting in the SB direction. It was reported by Don Turner that this area may have had twice as much binder as recommended at the asphalt plant, by mistake. There appeared to be core holes at this location as well. The area near the McDoel City Limit sign has rutting in the SB direction. Other than the areas mentioned above, the project is performing well to date.
JVK, GH, and Don Turner reviewed this project on February 9, 1995.

This project was a .08′ maintenance blanket and was placed during late summer 1992 with Klamath Pacific Corporation as the Prime Contractor. It was 1/2″ maximum aggregate Type I ARHM-GG with the AR binder blended by ISI. The AR binder consisted of PBA-2 (Witco) blended with 19% ground tire rubber (Atlos) and 0% high natural rubber with 0% extender oil. The actual binder content was 9.1%.

Distress began to appear within the first couple months after it was placed. This project has raveled, abraded, has been patched, crack filled, and has had digouts done in some areas. It has not performed well to date.

JVK and GH reviewed this project on February 9, 1995.

This was a warranty maintenance project placed during the summer of 1991 with California Pavement Maintenance (CPM) as the Prime Contractor. It was Type I Asphalt Rubber Chip Seal (ARCS) with the AR binder blended by ISI. The AR binder consisted of PBA-2 (Witco Klamath) blended with 19% ground tire rubber (Atlos) and 3% high natural rubber (Atlos) with 0% extender oil. The actual binder spread rate was .62 GSY.

Some areas of the ARCS lost rock the very first year and was re-chipped (under the warranty requirement) the following summer with a PBA chip seal at isolated locations. Some of the PBA chip seal areas have had to be patched since it was placed.

The ARCS has a couple areas that have bleeding in the wheel tracks. It has some areas that sunk and had to be patched and/or blanketed. It appeared that one of the binder distributor trucks had an application problem which may have been a factor in the early rock loss. Overall it looks good considering the pre-existing condition of the road.

JVK and GH reviewed this project on February 10, 1995.

This project (10 different test sections) was placed during the summer of 1991 with Kiewit Pacific as the Prime Contractor. It was Type I ARHM-DG/SAMI with the AR binder blended by ISI. The AR binder consisted of PBA-2 (Witco Klamath) blended with 17% ground tire rubber (Atlos) and 0% high natural rubber with 0% extender oil. The design binder content was 5.8% for the ARHM-DG. The actual binder spread rate for the SAMI was .59 GSY.

Several other rehabilitation strategies were used on this project and they are described below. PM 50.3/50.7, Polymer Modified Asphalt Concrete (PMAC) was placed at .6′ thick and looks very good both directions with no distress except for a very minor surface abrasion.

PM 48.1/50.3, ARHM-DG was placed at .25′ over a SAMI. It had surface abrasion, alligator (A) cracking and T-cracks intermittent to continuous. Some areas had been crack sealed and there was longitudinal (L) cracks in the NB OWT.

PM 46.4/48.1, ARHM-DG was placed at .15′ over a SAMI. It had A-cracks and L-cracks in both wheel tracks both NB and SB. In addition, there is L-cracks and A-cracks in other areas as well as the OWT both NB and SB. Some of these cracks have begun to spall and there has been some patching already placed.
PM 46.1/46.4, Conventional DGAC was placed at .6’. It had no distress to date and looked very good.

PM 45.8/46.1, Conventional DGAC was placed at .4’ over a SAMI. It had A-cracks intermittently to continous with L-cracks in the inside wheel tracks (IWT) and OWT in several of the areas. The last half of this section had less cracking than the first half.

PM 45.5/45.8, Conventional DGAC was placed at .25’ over a SAMI. It had L and A-cracks in the IWT NB and appeared to have no distress in the SB direction.

PM 44.0/45.5, ARHM-DG was placed at .15’ over a SAMI. It had L and A-cracks in the IWT. It had one large L-crack in the OWT in the NB direction only. T-cracks were noted in both lanes 3 to 4 ft. long with A-cracks in the NB direction. PM 45.2 A-cracks are developing in both the IWT and OWT in both directions. There are T-cracks and crack filler in the SB turn lane only. In both directions at PM 44.9, A and T-cracks have developed in the IWT and OWT and crack filler is evident in the IWT in both directions.

PM 42.0/44.0, ARHM-DG was placed at .25’ over a SAMI. In the NB and SB directions at PM 43.8 there is a L-crack in the OWT. At PM 43.7 both NB and SB, A and L-cracks exist in the OWT intermittently to continuous. A and L-cracks are noticeable in the IWT. A few cracks have been crack filled in the SB lanes. There is no distress near the barn in this area. SB at PM 42.7 there are L-cracks in the OWT. SB at PM 42.5 there are a few A-cracks for a distance of 1/2 mile, then there are L-cracks in the SB lane in the OWT. Some use of crack filler was observed in this area. NB and SB at PM 42.1 very few L-cracks were observed. The same conditions exist for the entire last mile of the section.

PM 41.7/42.0, Conventional DGAC was placed at .55’. There was no distress observed in this area.

PM 41.4/41.7, Conventional DGAC was placed at .40’. There was no distress observed in this area.

PM 41.1/41.4, Conventional DGAC was placed at .25’. There was both L and T-cracks in this area with L-cracks apparent from a shoulder widening project. NB had more distress than SB in the OWT and it was intermittent to continuous. At PM 41.3, NB had no distress but SB had a shoulder widening crack, one T-crack and one L-crack in the OWT. At PM 41.2 SB, there is a L-crack in the OWT.

Overall, this project has not performed well. One of the things being looked at is the very high deflections at this site prior to construction.

02-MOD-139 PM 27.9/34.0 EA 02-258904 Type 1 ARHM-GG (Canby) Pict’s 14/5 Roll 5 AADT’s Veh. 1,500 Truck 22.2%

JVK and GH reviewed this project on February 10, 1995.

This rehabilitation project was placed during October 1993 with J.F. Shea as the Prime Contractor. It was Type 1 ARHM-GG with the AR binder blended by ISI. The AR binder consisted of AR-2000 (Witco) blended with 18% ground tire rubber (Atlos) and 2% high natural rubber (Atlos) with 0% extender oil. The actual binder content was 10 to 10.8%.

At PM 34.0, there is evidence of flushing. At PM 33.2 there is no distress except for some minor surface abrasion. PM 33.0 is flushing in both wheel tracks NB and SB. PM 32.9 has flushing in the SB wheel tracks only. NB at PM 31.5 there is heavy flushing and SB at this same location there is no distress.

In the NB direction, at PM 31.3, there is flushing, bleeding and rutting in both wheel tracks. The shoulder stripe is pushing and has been cored at this location. At PM 30.2, both the NB and SB pavement has no distress. NB at PM 28.6, the pavement is slightly rutted in the OWT. It has also been cored at this location. Overall it is not performing well to date.
JVK and GH reviewed this project on February 10, 1995.

This rehabilitation project was placed during October 1993 with Baldwin as the Prime Contractor. It was **Type 1 ARHM-GG** with the AR binder blended by ISI. The AR binder consisted of AR-2000 (Shell Martinez) blended with 19% ground tire rubber (Baker) and 0% high natural rubber with 0% extender oil. The actual binder content was 10%.

NB shows evidence of rutting at the Main Street intersection (near Walmart); SB has T-cracks every 40’ throughout the town. T-cracks are prevalent on the shoulder from PM 26.3 to 29.4. There is surface abrasion in both the NB and SB lanes (more prominent in the SB lanes) at PM 29.4. Surface abrasion and T-cracks are evident in both NB and SB lanes at PM 27.1. Sunken pavement in the area of PM 27.9 is possible evidence of base failure problems. The SB shoulders have T-cracks that stop at the edge of the traffic lanes throughout the entire project. Overall, the performance on this project is poor to date.

JVK and GH reviewed this project on February 10, 1995.

This rehabilitation project was placed during the summer of 1994 with Baldwin as the Prime Contractor. It was **Type 1 ARHM-GG** with the AR binder blended by ISI. The AR binder consisted of AR-2000 (Shell Martinez) blended with 19% ground tire rubber (Atlos) and 0% high natural rubber with 0% extender oil added to this blend. The actual binder content was 8.6%.

Distress in the form of raveling began to appear within the first few months after it was placed. There is raveling in both the EB and WB lanes intermittent to continuous throughout the project. The traveled way is raveled and has been patched in the #2 lane at EB PM 75.9. Severe raveling has also occurred EB at PM 76.5-76.6 and has the appearance (color) of two different loads of AC. EB at PM 77.0 the #1 lane looks good, but the #2 lane has severe raveling. The overall performance on this project is poor to date.

The District requested that an investigation be completed on this project to find out the cause of distress. A decision was made to take core samples and the locations were provided to the District. Laboratory testing will be performed and a report will be written and provided to the District.

JVK and GH reviewed this project on February 14, 1995.

This rehabilitation project was placed during October of 1994 with Granite as the Prime Contractor. It was **Type 1 ARHM-GG** with the AR binder blended by Granite. The AR binder consisted of AR-4000 (Conaco) blended with 17% ground tire rubber (Baker) and 0% high natural rubber with 0% extender oil. The actual binder content was 8.5%.

This project was paved at night because of high traffic in this area. EB at PM 40.5, there are tire marks in the pavement remaining from a vehicle driving over the ARHM mat shortly after placement. EB at PM 40.4 there are stains on the shoulder interiors (near the edge of pavement), which is evidence of pumping action. EB at PM 40.8, the same conditions exist. Overall, this project looks good to date.
JVK and GH reviewed this project on March 17, 1995.

This maintenance overlay project was placed during July of 1993 with Asphalt Construction as the Prime Contractor. WB was Type 1 ARHM-GG .06” thick with the AR binder blended by ISI. The AR binder consisted of AR-2000 (Huntway Wilmington) blended with 17% ground tire rubber (Atlos) and 3% high natural rubber (Atlos) with 0% extender oil. The actual binder content was 6.3%. EB was Type 1 ARHM-OG .06” thick with the AR binder blended by ISI. The AR binder consisted of AR-2000 (Huntway Wilmington) blended with 17% ground tire rubber (Atlos) and 3% high natural rubber (Atlos) with 0% extender oil. The actual binder content was 7.3%.

WB at PM 109.9 to PM 111.0 the ARHM-GG exhibited areas that had pumping, T, A, and L-cracks, pushing, and potholes in the #2 lane near the edge line. There were other areas that looked good with no distress.

EB at PM 107.63 to 111.0 the ARHM-OG exhibited pumping, T, A, and L-cracks, pushing, and potholes in the #2. Although many of the areas are not performing well, there were areas that looked good with no distress.

Overall, this project (both locations) is not performing well. The lift was probably too thin to perform well considering the existing conditions.

JVK and GH reviewed this project on March 17, 1995.

This rehabilitation project began construction September 1994 with FNF Construction as the Prime Contractor. It was Type 1 ARHM-GG with the AR binder blended by FNF Construction. The AR binder consisted of AR-4000 (Oildale Witco) blended with 17% ground tire rubber (Baker) and 0% high natural rubber with 0% extender oil. The actual binder content was 7.2%.

The ARHM-GG placement was completed last construction season; however, this project was still in the construction phase. There were small distressed areas marked that were to be removed and replaced. These areas were small localized spots where the pavement potholed or popped out. This appeared to be caused by inadequate cracking and seating of the existing PCC. These spots were at the PCC joints and the pop-outs appeared to be a result of water forced up at the joints. In addition, many of the approaches and departures at the bridge decks were not paved. Overall this project looks good to date.

JVK and GH, reviewed this project (briefly) on March 21, 1995 and again (more thoroughly) on June 21, 1995.

This rehabilitation project was placed during August and September 1993 with Granite Construction as the Prime Contractor. It was Type 1 ARHM-GG with the AR binder blended by FNF Construction. The AR binder consisted of AR-4000 (Witco Oildale/Golden Bear) blended with 16% ground tire rubber (Atlos) and 0% high natural rubber with 0% extender oil. The actual binder content was 7.5%.
During the March 21, 1995 brief review, rutting (pushing) was evident in the #2 lane and the pushed material at the edges of the wheeltracks had been ground off. During the June 21, 1995 review at PM 124.0, rutting was noted in the #2 lane. At PM 123.7 to PM 123.0, rutting was almost continuous in the #2 lane. These same conditions existed at PM 115.0 for approximately 500 feet. Rutting in the #2 lane was also present from PM 115.0 to 114.6 near the end of the project. These areas were placed over a location that had subsurface water problems according to District 9 representatives. Other than the areas mentioned above, the rest of this project looks good to date.

### Trip # 3

**07-LA 164** Maintenance Repair Contract Type 2 ARHM-GG Mtce Blanket (Rosemead Blvd at Whitmore) Pict’s 1/3 Roll 1 AADT’s Veh. 53,000 Truck 5.5%

JVK and GH reviewed this project on March 28, 1995. This 0.08′ maintenance blanket was placed during June 1990 with Manhole Adjusting Inc. (MHA) as the Contractor. It was **Type 2 ARHM-GG** with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Edgington) blended with 15% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder content was approximately 8.0%.

This project was placed as part of a maintenance repair contract. It is a very short section (about 300 feet long) at this location. It is almost crack free. There were a few short T-cracks starting at the edge of pavement. It should be noted that pictures of the existing pavement prior to overlay show distress in the form of large cracks throughout the entire project. The blanket’s resistance to reflective cracking is very evident at the intersections. No surface treatment or crack filling was done prior to the blanket being placed. To date, this project has performed very well.

**07-LA 164** PM 4.9/10.7 EA 07-111484 Type 2 ARHM-GG/ARCS (Rosemead Blvd) Pict’s 4/13 Roll 1 AADT’s Veh. 53,000 Truck 5.5%

JVK and GH reviewed this project on March 28, 1995. This maintenance project was placed during September 1988 with MHA as the Prime Contractor. It was a **Type 2 ARCS** with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Edgington) blended with 15% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder spread rate was .61 GSY.

This ARCS was placed on a state highway with very high ADT that was scheduled for rehabilitation back in 1987. Due to budget constraints in 1987 it was decided to place the ARCS in order to “buy some time” until this section of roadway could be rehabilitated.

The ARCS developed bleeding at the intersections shortly after placement following an extreme heat spell. This ARCS is an example of “where not to place a chip seal.” As an example, if heavy traffic, signals or stop signs and hot weather are present, do not place chip seals.

For mitigation of the bleeding, **ARHM-GG** was placed at approximately 25 intersections. At several of these intersections the chip seal was first milled off, while other intersections simply had a **ARHM-GG** overlay placed at approximately 1” thick.

To date the intersections with **ARHM-GG** are performing very well. The reflective cracking is almost nonexistent and where reflective cracks have reappeared, they are extremely tight.

Even though this was not an appropriate location for a chip seal, when considering that this section of road was scheduled for rehabilitation back in 1987, it shows how well an ARCS can
perform. This section of road still has not been rehabilitated to date and it appears that it may not be done for some time in the future.

Very little maintenance has been done on this section of road during the past 7 years. The only distress noted during the project review was a few areas that are delaminating due to subsurface water problems. Overall, this project has performed well.

07-LA-19 07-42-36836 Type 2 ARHM-GG (Rosemead at Foothill) Pict’s 14/17 Roll 1 AADT’s Veh. 31,500 Truck 4.5%

JVK and GH reviewed this project on March 28, 1995.

This 0.10′ maintenance blanket was placed over old cracked PCC during June 1991 with MHA as the Prime Contractor. It was Type 2 ARHM-GG with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Paramount) blended with 15% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder content was 7.8%.

The ARHM-GG overlay has only one small T-crack at an intersection. This project is performing very well.

07-LA County Project Type 1 and 2 Cape seal (Colton) Pict’s 18/22 Roll 1

JVK and GH reviewed this project on March 28, 1995.

This LA county (Colton) project was placed during May 1987 with MHA as the Prime Contractor. It was a Type 1 and Type 2 cape seal (slurry seal/ARCS) with the AR binder blended by ISI for the Type 1 and by MHA for the Type 2.

The Type 1 AR binder consisted of AR-4000 (Edgington) blended with an estimated 20% ground tire rubber (unknown supplier) and 0% high natural rubber with unknown amount of diluent. The actual binder spread rate for the ARCS was .60 GSY.

The Type 2 AR binder consisted of AR-4000 (Edgington) blended with 15% ground tire rubber (unknown supplier) and 5% high natural rubber with 2% extender oil. The actual binder spread rate for the ARCS was .60 GSY.

The Type 2 application was used in the #1 and 2 lanes and the Type 1 application was used on the southbound shoulder lanes. The only discernible difference between the two applications appeared to be less and tighter cracks in the Type 2 process. Overall, they both have performed well.

07-LA City Project Type 1 ARHM-GG/SAMI (Diamond Bar) Pict’s 23/24 Roll 1 and Pict’s 1/5 Roll 2

JVK and GH reviewed this project on March 28, 1995.

This project was placed during December 1993 with IPS as the Prime Contractor. It was a 2″ thick Type 1 ARHM-GG/SAMI with the AR binder blended by ISI. The AR binder consisted of AR-4000 (Huntway Wilmington) blended with 17% ground tire rubber (Atlos) and 3% high natural rubber (Atlos) with 0% extender oil. The actual binder content was 8.3% and the ARCS was spread at .63 GSY.

The ARHM-GG/SAMI exhibited stripping on the surface, raveling and pumping and the pavement was highly permeable. When water was poured on the surface of the pavement, the water penetrated instantly. It is very likely that the material was placed cold or was poorly compacted, and/or low quality aggregate was used in the mix. This project is not performing well.
JVK and GH reviewed this project on March 28, 1995.

This project was a series of test sections which included ARHM-GG, dense graded asphalt concrete (DGAC), a conventional chip seal and a AR lightweight aggregate chip seal (AR-LWACS). They were placed during the summer of 1990 with MHA as the Prime Contractor. Type 2 AR binder was used in the ARHM-GG and the ARCS’s with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Edgington) blended with 15% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder content was 8.2%. In addition, the DGAC and the ARHM were placed at different thicknesses.

Both the DGAC and ARHM were placed with and without SAMI’s. The DGAC was also placed over a pavement reinforced fabric (PRF). The ARCS’s were placed with conventional aggregate and with lightweight aggregate. Both aggregates were pre-heated and pre-coated with approximately 0.8% AR-4000 for the conventional aggregate and 2.5% for the lightweight aggregate. The actual binder spread rates were .58 GSY.

The test sections were placed on a LA county road that leads into a landfill. The traffic consists of very heavily loaded trash trucks which operate 12 hours a day. Considering the extreme traffic loading it will be interesting to see how the various strategies hold up over the years.

The following test sections were utilized on this project:

**DGAC 2” thick.** It exhibited only one small T-crack.

**DGAC 2” thick over a PRF.** It exhibited one small area that had shoved (unstable).

**DGAC 1 1/2” thick.** It exhibited no distress.

**DGAC 1 1/2” over a SAMI.** It exhibited 1 large and 1 small T-crack.

**ARHM-GG 1 1/2” over a SAMI.** It exhibited no distress.

**ARHM-GG 1 1/2” and 2” thick.** Both exhibited no distress.

**ARCS (1” minus).** It exhibited secondary embedment.

**Light Weight Aggregate Chip Seal.** It had secondary embedment and exhibited a few T-cracks with a couple “very tight” alligator cracks.

It is believed that the secondary embedment of the aggregates on the chip seals was because the leveling course had only one evening to cure prior to placement of the chip seals.

Overall, these sections are performing very well to date.

JVK and GH reviewed this project on March 28, 1995.

This cape seal project was placed during March 1986 with MHA as the Prime Contractor. It was a **Type 1 cape seal (slurry seal/ARCS)** with the AR binder blended by ISI. The AR binder consisted of AR-4000 (Edgington) blended with 24% ground tire rubber (Atlos) and 0% high natural rubber with 0% extender oil. The actual binder spread rate for the ARCS was .59 GSY.
Portions of this cape seal project were recently crack sealed and other maintenance work had been performed. It appeared that other cracks were covered during this process as well. Some existing cracks were not crack sealed. Considering the cape seal is over 9 years old, it performed well.

07-LA City Project Type 2 Cape Seal (Whittier/Tigrina St.) Pict’s 3/5 Roll 3

JVK and GH reviewed this project on March 28, 1995.

This cape seal project was placed during August 1987 with MHA as the Prime Contractor. It was a Type 2 cape seal (slurry seal/ARCS) with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Edgington) blended with 15% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder spread rate for the ARCS was .60 GSY.

The cape seal exhibits reflective cracks but they are very tight and it appears the cape seal has been almost maintenance free. The performance of this cape seal after 8 years is very good.

07-LA City Project Type 2 ARHM-GG/DGAC Leveling Course (Whittier/Philadelphia St.) Pict’s 7/9 Roll 3

JVK and GH reviewed this project on March 28, 1995.

This rehabilitation project was placed during October 1989 with Blue Diamond Materials as the Prime Contractor and MHA as the subcontractor. It was 1 1/2” thick Type 2 ARHM-GG over a DGAC leveling course with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Edgington) blended with 15% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder content was 8.2%.

This project, placed in 1989, had only 1 observable T-crack. It is performing very well to date.

07-LA City Project Type 2 ARHM-GG/SAMI (Santa Ana/1st St.) Pict’s 10/11 Roll 3

JVK and GH reviewed this project on March 28, 1995.

This rehabilitation project was placed during January 1990 with RJ Noble as the Prime Contractor. It was Type 2 ARHM-GG/SAMI (3 layer system) with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Edgington) blended with 15% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder content was 8.4%. The 3 layer system consisted of a DGAC leveling course, a type 2 ARCS (SAMI), and a type 2 ARHM-GG overlay.

This project was constructed in an area that on occasion is used as a detour by Interstate 5 traffic; no distress was noted. This project is performing very well to date.

07-LA City Project Type 2 ARHM-GG/SAMI (Costa Mesa/Randolph Street) Pict’s 12/13 Roll 3

JVK and GH reviewed this project on March 28, 1995.

This rehabilitation project was placed during March 1989 with MHA as the Prime Contractor. It was Type 2 ARHM-GG/SAMI (three layer system) with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Edgington) blended with 15% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder content was 8.4%. The 3 layer system consisted of a DGAC leveling course, a type 2 ARCS (SAMI), and a type 2 ARHM-GG overlay.
This project exhibits no distress and looks very good to date.

07-LA City Project Type 2 ARHM-GG/SAMI (Costa Mesa/Enterprise St.)
Pict’s 14/15 Roll 3

JVK and GH reviewed this project on March 28, 1995.

This rehabilitation project was placed during March 1989 with MHA as the Prime Contractor. It was Type 2 ARHM-GG/SAMI (three layer system) with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Edgington) blended with 15% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder content was 8.4%. The 3 layer system consisted of a DGAC leveling course, a type 2 ARCS (SAMI), and a type 2 ARHM-GG overlay.

This project looks good and exhibits no distress to date.

07-LA-47/103 PM 2.0/3.9, 0.8/6.3 EA 07-102314 Type 2 ARHM-DG/GG/
SAMI (Terminal Island) Pict’s 16/25 Roll 3 and Pict’s 1/18 Roll 4
AADT’s Veh. 2,000 Truck 18.9%

JVK and GH reviewed this project on March 28, 1995.

This project was a series of test sections placed during July 1992 with Chumo Construction as the prime contractor. It was Type 2 ARHM-DG and ARHM-GG with and without SAMI’s with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Paramount) blended with 15% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder content was 7.8% for the ARHM-GG and was 6.5% for the ARHM-DG.

The ARHM-GG is exhibiting no distress with good performance to date.

The ARHM-DG is exhibiting some minor surface abrasion, loss of surface fines, and one ramp is very rough as a result of aggregate loss. In addition it has some minor T-cracking throughout the ramp. These ramps carry “very heavily loaded” trucks going to and from the terminals.

Other than the thinner ARHM-DG ramp exhibiting early distress, the remaining project is performing well.

07-LA City Project Type 1 Cape Seal (Coolidge Street) Pict’s 19/21
Roll 4

JVK and GH reviewed this project on March 28, 1995.

This cape seal project was placed during April 1986. It was a Type 1 cape seal (slurry seal/ARCS) with the AR binder blended by ISI. No records are available on this project but in discussions with ISI representatives, they believe the AR binder consisted of AR-4000 blended with 20 to 24% ground tire rubber and 0% high natural rubber with 0% extender oil. The actual binder spread rate was unknown.

This Type 1 cape seal project which has been in place 9 years has some open cracking, but, overall it is performing well.

07-LA City Project Type 2 Cape Seal (Concourse St.) (No Pict’s due to darkness)

JVK and GH reviewed this project on March 28, 1995.

This project was placed during June 1984. It was a Type 2 cape seal (slurry seal/ARCS) with the AR binder blended by Arizona Refining Co. (ARCO). The AR binder is believed to consist of AR-4000 blended with a 15% ground tire rubber and 5% high natural rubber with 2% extender oil. The actual binder spread rate for the ARCS was .60 GSY.
After discussions with ARCO representatives, they stated the AR binder used in 1984 was very similar to Type 2 binders used today, unfortunately they could not provide the exact percentages in their 1984 binders.

There were no pictures taken of this project because of darkness. However, the on-site review revealed some very tight reflective cracking. There were water stains on this cape seal from a center divider landscape irrigation. The cracks on this cape seal appeared to be closed and healed.

Overall, this project's performance is well.

08-Riv City Project Type 2 ARCS (Palm Springs/Racquet Club Rd.) Pict's 22/24 Roll 4

JVK and G reviewed this project on March 29, 1995.

This project was placed during May 1990 with MHA as the Prime Contractor. It was a Type 2 ARCS with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Edgington) blended with 17% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder spread rate was .58 GSY.

The reflective cracks were very tight and closed on this project. Overall this project is performing very well.

08-Riv City Project Type 2 ARHM-GG/SAMI (Palm Springs/Civic Dr.) Pict's 1/6 Roll 5

JVK and GH reviewed this project on March 29, 1995.

This project was placed during May 1990 with MHA as the Prime Contractor. It was Type 2 ARHM-GG/SAMI with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Edgington) blended with 15% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder content was 8.0%. The actual binder spread rate was .60 GSY.

This .1' thick ARHM-GG/SAMI exhibited some reflective cracking in areas near one driveway. At the driveway to the National Car Rental Company, was an area with a .1’ overlay (with no SAMI) that looked good. At the corner (in the SB lane) was a reflective crack approximately 2/3” wide which the AR had healed over the crack. At another location, a wide reflective T-crack was found. In an area where the road curves (90°) there was evidence of shoving. However, we were told this area had heavy crack filler. There was no header cut at the curb and gutter on this job which made the pavement thin at the edges. This road was severely cracked prior to rehabilitation. Considering the existing condition of this road prior to overlay, it is performing very well after five years especially in regards to resistance to reflective cracking.

08-Riv City Project Type 2 ARHM-GG (Palm Springs/Tahquitz Canyon Way) Pict's 7/9 Roll 5

JVK and GH reviewed this project on March 29, 1995.

This rehabilitation project was placed during September 1991 with Matich as the Prime Contractor. It was Type 2 ARHM-GG 1 1/2” thick with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Paramount) blended with 15% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder content was 7.8%

There were a few reflective T-cracks on this project but they were very tight or closed. Overall, this project is performing very well to date considering the existing condition of the road prior to overlay.
08-Riv City Project Type 2 ARHM-GG (Palm Springs/Calle Encilia Dr.)
Pict’s 10/13 Roll 5

HVJ and GH reviewed this project on March 29, 1995.
This rehabilitation project was placed during August 1991 with Matich as the Prime Contractor. It was Type 2 ARHM-GG 1 1/2” thick with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Paramount) blended with 15% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder content was 7.8%.
On this project, there was some reflective cracks that are tight and closed toward the intersections near the motel area. It appears that the mix has resisted the fuel/oil drippings quite well at the areas where vehicles routinely park. Overall, this project is performing very well.

08-Riv City Project Type 2 ARHM-GG (Palm Springs, Camino and Palm Canyon Dr.) Pict’s 14/15 Roll 5

JVK and GH reviewed this project on March 29, 1995.
This rehabilitation project was placed during August of 1992 with Matich as the Prime Contractor. It was Type 2 ARHM-GG 1 1/2” thick with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Paramount) blended with 15% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder content was 7.8%.
This project is showing some pumping and reflective cracking at an area that is in a low spot where water appears to collect and doesn’t drain well. Otherwise, it is performing very well to date.

08-Riv City Project Type 2 ARCS (Rancho Mirage/Morningside Dr.)
Pict’s 16/17 Roll 5

JVK and GH reviewed this project on March 29, 1995.
This project was placed during May 1991 with MHA as the Prime Contractor. It was Type 2 ARCS with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Paramount) blended with 17% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder spread rate was .58 GSY.
This ARCS which is over 4 years old has some small reflective cracks. Although the cracks have reflected through the mat, they are very tight and are not opened.
This project is performing well to date.

11-Imp/RIV-111 PM 38.0/40.0, 14.0/18.1 EA 11-163244 Type 2 ARHM-GG (Mecca/Niland) Pict’s 23/24 Roll 5 Pict’s 1/6 12/16 Roll 16 AADT’s Veh. 7,600 Truck 18.4%

JVK and GH reviewed this project on March 29, 1995.
This warranty rehabilitation project was placed during April 1994 with MHA as the Prime Contractor. It was Type 2 ARHM-GG with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Paramount) blended with 15% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder content was 7.5%.
The only distress noted on this project was a couple of isolated rich spots. This project has a warranty against defects for a period of 3 years. This project is performing very well to date.

11-Imp/RIV-86 PM 43.3/67.8, 0.0/2.5 EA 11-182644 Type 1 ARCS (Oasis) Pict’s 7/8 Roll 6 AADT’s Veh. 4,600 Truck 47.6%

JVK and GH reviewed this project on March 29, 1995.
This ARCS project was placed during March of 1990. It was a **Type 1 ARCS** with the AR binder blended by ISI. The AR binder consisted of AR-2000 (Edgington) blended with 22% ground tire rubber (Atlos) and 0% high natural rubber with 3% diluent. The actual binder spread rate was .62 GSY.

This 5 year old Type 1 chip seal is performing much better than most type 1 ARCS’s placed during the late 80’s and early 90’s for Caltrans.

The use of AR-2000 with 22% rubber and 3% diluent used on this project may be the reason for the improved performance. This project is performing very well to date. It is surprising that AR-2000 with 3.0% diluent was used in a desert environment.

**11-Imp-115** PM 9.5/21.1 EA 11-188594 Type 2 ARCS (Holtville) Pict’s 17/18 Roll 6 AADT’s Veh. 8,300 Truck 32.0%

JVK and GH reviewed this project on March 29, 1995.

This project was placed during October 1992 with J. Jennings as the Prime Contractor. It was a **Type 2 ARCS** with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Paramount) blended with 17% ground tire rubber (Atlos) and 5% high natural rubber with 2% extender oil. The actual binder spread rate was .59 GSY.

This area had severe alligator “B” cracking (ABC) prior to the placement of this chip seal. To date, the reflective cracks at the surface are very closed or very tight and is performing very well.

**11-Imp/Riv-78** PM 27.3/80.7, 0.0/16.4 EA 11-063204 Type 1 ARHM-GG Over Cold-In-Place Recycling (Glamis/Ripley) Pict’s 19/20 Roll 6 AADT’s Veh. 1,550 Truck 26.8%

JVK and GH reviewed this project on March 29, 1995.

This project was placed during April/July 1994 with Granite as the Prime Contractor. It was a **Type 1 ARHM-GG** with the AR binder blended by Granite. The AR binder consisted of AR-4000 (EOTT) blended with 16% ground tire rubber (Baker) and 0% high natural rubber with 0% extender oil. The actual binder content was 8.0 to 8.2%. This type 1 ARHM-GG was placed 0.15 foot thick over a cold-in-place recycled pavement.

To date the project looks very good and no distress was noted.

**11-Imp-78** PM 42.7/50.2 EA 11-143304 Type 2 ARCS Conv, and Lightweight Agg. (Glamis) Pict’s 21/24 Roll 6 and Pict’s 1/2 Roll 7 AADT’s Veh. 1,800 Truck % unkn.

JVK and GH reviewed this project on March 29, 1995.

This project was placed during October 1993 with MHA as the Prime Contractor. It was a **Type 2 ARCS** with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Paramount) blended with 17% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. This project used both “conventional” and “lightweight” aggregates and is a good project to compare the performance of lightweight aggregates to conventional aggregates.

The actual binder rate was .60 GSY for both the conventional aggregate and for the lightweight aggregate.

To date, this project looks good and no distress was noted.

**11-Imp City Project** Type 1 ARHM-GG (El Centro/Imperial Ave. and Main St.) Pict’s 11/15 Roll 7

JVK and GH reviewed this project on March 29, 1995.
This project was placed during May 1994 with IPS as the Prime Contractor. It was Type 1 ARHM-GG with the AR binder blended by ISI. The AR binder consisted of AR-4000 (Paramount) blended with 19% ground tire rubber (Atlos) and 0% high natural rubber with 0% extender oil. The actual binder content was 8.7%.

This Type 1 ARHM-GG overlay exhibited both T cracks and L cracks at several locations of this project. To date this project has not performed well.

Trip 4

10-SOL-37 PM 0.2/2.2 EA 10-427304 Type 1 ARHM-GG (Vallejo) Pict's 25/22 Roll 1 AADT's Veh. 2,5000 Truck 8.7%

JVK and GH reviewed this project on April 25, 1995.

This project was placed during July 1994 with Syar Industries as the Prime Contractor. It was Type 1 ARHM-GG with the AR binder blended by ISI. The AR binder consisted of AR-2000 (Shell Martinez) blended with 19% ground tire rubber (Atlos) and 0% high natural rubber with 0% extender oil. The actual binder content was 8.7%

There was no evidence of distress except for some minor surface aggregate disintegration where the pavement had been ground. There are areas where the rubber appears to be coarser than what is typically used in AR binder. In general, the project looks good to date.

04-SF-101 PM 0.0/3.0 EA 04-109674 Type 1 ARHM-OG (Candlestick) Pict's 4/1 Roll 1 AADT's Veh. 260,000 Truck 4.8%

JVK and GH reviewed this project on April 25, 1995.

This rehabilitation project was placed during 1988 with Brutaco as the Prime Contractor. The paving was performed by Desilva and Ogrady Contractors. It was a .08′ thick Type 1 ARHM-OG surface course with the AR binder blended by ISI. The AR binder consisted of AR-4000 (Chevron) blended with 20-26% ground tire rubber and 0% high natural rubber with 0% extender oil. The actual binder content was 7.1%.

There were no visible signs of distress on the project. It looks very good and has performed very well to date.

04-ALA-17 PM 13.7/15.0 EA 04-108944 Type 2 ARHM-OG (Hayward) Pict's 25/24 Roll 2 AADT's Veh. 158,000 Truck 8.2%

JVK and GH reviewed this project on April 25, 1995.

This rehabilitation project was placed during the summer of 1986 with Mcguire and Hester as the Prime Contractor. It was a .08′ thick Type 1 ARHM-OG surface course with the AR binder blended by ARCO. The AR binder consisted of AR-4000 (Chevron) blended with 15% ground tire rubber and 5% high natural rubber with 2% extender oil. The actual binder content was 7.5%.

There are no visible signs of distress on the project. It has performed very well to date.

04-Marin-101 PM 18.1/23.3 EA 04-121544 Type 2 ARCS (Novato) Pict's 23/17 Roll 2 AADT's Veh. 107,000 Truck 5.6%

JVK and GH reviewed this project on April 25, 1995.

This project was placed during September 1987 with MHA as the Prime Contractor. It was a Type 2 ARCS with the AR binder blended by MHA. The AR binder consisted of AR-4000
(Chevron Richmond) blended with 15% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder spread rate was .57 GSY.

This project was constructed at night because of the high traffic volume. Prior to construction, the road exhibited several potholes, T-cracks and areas where fines had pumped to the surface. There is evidence of binder flexibility by the healing of some of the reflective cracks and old pothole areas. There are a few areas which maintenance had patched a couple years ago that finally delaminated where the water was pumping to the surface.

This project was almost 8 years old and is performing very well especially considering the condition of this road prior to construction.

01-Men-20 PM 33.8/37.4 EA 01-295104 Type 1 ARCS (Lake Mendocino)
Pict’s 25/22 Roll 3 AADT’s Veh. 9,900 Truck 10.1%

JVK and GH reviewed this project on April 26, 1995.
This project was placed during September 1991 with Western States as the Prime Contractor. It was a modified Type 1 ARCS with the AR binder blended by ISI. The AR binder consisted of AR-2000 (Huntway) blended with 19% ground tire rubber (Atlos) and 2% high natural rubber (Atlos) with 0% extender oil. The actual binder spread rate was .62 GSY.

This project exhibited some reflective cracks but they appeared to be tightly closed at the time of this review. This 3 year old ARCS has performed well considering the existing condition of the pavement prior to placing the chip seal.

03-COL-20 PM 31.1/38.2 EA 03-307504 Type 1 ARHM-DG/SAMI (Colusa)
Pict’s 6/1 Roll 3 and Pict’s 25/20 Roll 4 AADT’s Veh. 9,200 Truck 7.0%

JVK and GH reviewed this project on April 26, 1995.
This project was placed during June 1991 with Jaxon Baker as the Prime Contractor. It utilized various Type 1 AR binder combinations (listed below) with the AR binder blended by ISI.

The AR binder for the ARHM consisted of AR-4000 (Shell Martinez) blended with 19% ground tire rubber (BAS) and 0% high natural rubber with 0% extender oil. The actual binder content was 6.4%. The actual binder spread rate for the SAMI was .65 GSY.

This Type-1 ARHM-DG/SAMI exhibits some L and T-cracks with some alligator cracking at various locations throughout the project.
This project has not performed well.

03-YOL-16 PM 82.26/36.50 EA 03-400204 Type 1 ARHM/SAMI/ARCS
(Esparto) Pict’s 19/1 Roll 4 and Pict’s 25/8 Roll 5 AADT’s Veh. 5,600 Truck 17.5%

JVK and GH reviewed this project on April 26, 1995.
This maintenance project was a series of test sections placed during September 1993 with Teichert Construction as the Prime Contractor. It utilized various Type 1 AR binder combinations (listed below) with the AR binder blended by ISI.

The AR binder for the ARHM consisted of AR-4000 (Shell Martinez) blended with 19% ground tire rubber (BAS) and 0% high natural rubber with 0% extender oil. The actual binder contents ranged from 8.4 to 9.6%.

The AR binder for the ARCS and SAMI consisted of AR-4000 (Shell Martinez) blended with 17% ground tire rubber (BAS) and 3% high natural rubber (Atlos) with 0% extender oil. The actual binder spread rate for the SAMI and the chip seal was .64 GSY.

The following strategies were reviewed:
PM 82.26/28.75 .04′ thick **Type 1 ARHM-OG** (3/8′). Exhibits large pumping areas and has T-cracks at 20′ intervals throughout the project. It is not performing well to date.

PM 28.75/29.25 .06′ thick **Type 1 ARHM-OG** (3/8′). About .20 miles into this section there is an area of delamination and some locations that exhibit pumping.

PM 29.25/29.75 .08′ thick **Type 1 ARHM-OG** (1/2″). There are no visible signs of distress and it looks good to date.

PM 29.75/30.25 .08′ thick **Type 1 ARHM-GG** (1/2″). This section has a few isolated pumping areas but overall it looks good to date.

PM 30.25/30.50 .08′ thick **Type 1 ARHM-DG** (1/2″). This section has a few isolated pumping areas but overall it looks good to date.

PM 30.75/31.20 .08′ PBA-6-OG. This site has no distress and overall looks good to date.

PM 31.65/33.0 This DGAC section has 11 T-cracks and 1 small L-crack. This section was placed prior to the other test sections being placed and is being used as a control section.

PM 33.00/33.75 PBA-6 Chip Seal (1/2″). This polymer modified chip seal has some pumping and shows mapping. It appears the mapping is caused from the crack sealing placed prior to the chip seal being placed. Overall, this chip seal looks good to date.

PM 33.50/34.0 **Type 1 ARCS** (1/2″ gradation). There is some minor flushing and mapping. However, overall this sections looks very good to date.

PM 34.00/34.50 .04′ ARHM-OG over **SAMI**. There was some minor pumping in this section. Overall, this section looks good.

PM 34.50/35.0 .06′ ARHM-OG over **SAMI**. There is some minor pumping in this section, otherwise it looks good to date.

PM 35.00/35.50 .08′ ARHM-OG over **SAMI**. This section is not showing any distress and looks good to date.

PM 35.50/36.00 .08′ ARHM-GG over **SAMI**. This section is not showing any distress and looks good to date.

PM 36.00/36.50 .08′ ARHM-DG over **SAMI**. This section has T-cracking at 20′ intervals at this time.

PM 36.50/37.0 **Type 1 ARCS**. There are T-cracks every 20′ and 1 L-crack was observed in this section.

All of the existing cracks were filled with a rubberized crack filler prior to the placement of the various strategies on this project. This project was subjected to flooding during the 1995 winter and some of the sections were under water for long periods of time. Some of the early distress very likely was affected by the flooding.
JVK and GH reviewed this project on May 8, 1995.

This project was placed during September 1991 with E.L. Yeager as the Prime Contractor. It was Type 2 ARHM-GG/SAMI and ARHM-DG/SAMI with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Paramount) blended with 15% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder content was 7.0% for the ARHM-DG and 8.0% for the ARHM-GG.

There is considerable raveling and cracking in both the ARHM-GG and the ARHM-DG. There are several areas with surface abrasion and evidence of remedial patching. The ARHM-GG is raveled to a greater degree than the ARHM-DG. However, there seems to be more maintenance effort (patching) applied to the ARHM-DG. The ARHM-DG also has alligator and L-cracking at many locations.

Part of this project was a rich mix DGAC section (0.4% more asphalt than required). This section exhibited distress similar to the other sections. It is believed that a low quality aggregate was the reason for distress on this project. This project has not performed well.

JVK and GH reviewed this project on May 8, 1995.

This project was placed during the summer of 1993 with E L Yeager as the Prime Contractor. It was Type 1 ARHM-GG (portions used a SAMI) with the AR binder blended by ISI. The AR binder consisted of AR-4000 (San Joaquin) blended with 19% ground tire rubber (Atlos) and 0% high natural rubber with 0% extender oil. The actual binder content was 7.0%. The actual spread rate for the SAMI was .62 GSY.

The ARHM-GG/SAMI sections exhibited distress that included bleeding, pumping, flushing, L and T-cracks and segregation at and through the intersections. The ARHM-GG sections with no SAMI exhibited the following distress: flushing and bleeding were evident in the #2 lane E/B and in a few isolated areas W/B of which included some pushing at the stop bar. In general, this project has not performed well.

JVK and GH reviewed this project on May 8, 1995.

This Strategic Highway Research Program (SHRP) Specific Pavement Studies (SPS-5) Test section project was placed during April 1992 with FNF as the Prime Contractor. Portions of this site was placed with a SAMI and portions were not. It was Type 2 ARHM-GG with and without a SAMI with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Paramount) blended with 15% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder content was 7.8%. The actual spread rate for the SAMI was .59 GSY.

The following conditions were found in the SPS-5 test sections:

501 (DGAC .15’) The pavement is pumping and there is evidence of A-cracking.
502 (Hot Recycled Asphalt Concrete (HRAC) .15′) The pavement is pumping and there is evidence of A and L-cracking.

503 (HRAC .25′) No distress was detected.

504 (Type A .25′) No distress was detected.

505 (Type A .15′) The pavement has A and L-cracks with interior lane pumping.

506 (Type A .17′) The pavement has a few L-cracks.

507 (Type A .19′) The pavement has some pumping and L-cracking.

508 (HRAC .19′) No distress was detected.

509 (HRAC .19′) The pavement has A, L and T-cracking with pumping in the interior lanes.

520/569 (Stone Mastic Asphalt .15′) The pavement has severe A-cracking, pumping and one area of rutting.

521/570 (Rubberized Stone Mastic Asphalt .15′) The pavement has L and T-cracks throughout. There are wheel ruts and also some areas are bleeding.

522/571 (Control Section) The pavement has A and L-cracking throughout. Also, some spalling in isolated areas.

510/560 (Chip Seal/2″ DGAC) The pavement has 2″ deep wheel rutting at 2 locations in the inside wheel tracks and at 1 location in the outside wheel track.

511/561 (2″ DGAC/PRF) The pavement has some rutting and T-cracks but appears they are due to core holes that were drilled in the pavement.

512/562 (2″ ARHM-GG/PRF) The pavement has rutting in the inside/outside wheel tracks in isolated areas near the end of the section. The ruts are approximately 3/8″ deep.

513/563 (2″ ARHM-GG) The pavement has isolated pumping areas and L-cracking. There are also areas of 1/4″ deep rutting in the outside wheel tracks.

514/564 (2″ ARHM-GG/SAMI) The pavement has bleeding and rutting for the first 200′ and 1/2″ to 1″ deep wheel track rutting continues for the remainder of the section.

515/565 (2″ DGAC/SAMI) The pavement (control section) has 1/4″ and 1/2″ deep rutting in the wheel tracks.

516/566 (.06′ OGAC/SAMI) The pavement has bleeding and has 1/2″ deep rutting in the inside wheel track. Some locations have 3/4″ deep rutting with dual wheel ruts in both wheel tracks.
517/567 (.06' OGAC/DGAC) The pavement has 3/4” deep rutting with dual ruts in both the inside and outside wheel tracks.

518/568 (4” DGAC) The pavement (control section) has isolated 1/4” deep wheel ruts, alligator cracking and pumping by the rest area.

519/559 (2” DGAC/AC Base) The pavement has 1/8” to 3/8” deep rutting in the inside wheel tracks with L-cracking and minor spalling in both wheel tracks.

In the first phase of the construction the existing pavement was milled and replaced by a depth of 0.20’ with HRAC. Construction was then shut down for winter closure. During the winter these relatively thin HRAC sections cracked under traffic. Pictures of these areas show the cracked pavement prior to the various overlays being placed. In particular, the areas where the ARHM was placed, the HRAC pavement exhibited A and L-cracks. In general, the ARHM strategies did not perform well at this location.

08-SBD-40 PM 80.4/140.0 EA 08-006714 Plusride RAC (Needles) Pict’s 14/10 Roll 3 AADT’s Veh. 11,600 Truck 51.6%

JVK and GH reviewed this project on May 8, 1995.

This project was placed during the summer of 1987. It was the dry process called “Plusride.”

On this Plusride project there were two sections placed, one at 0.20 foot thickness and one at 0.30 foot thickness. The 0.20 foot section has 1/4” deep wheel ruts in the #2 lane near the off ramp to the rest area. There is also A-cracking and pumping in several areas. The thicker section did not perform well and recycled on an earlier project (summer 1994). The thicker section did not perform well. The thin section has performed well to date.

11-Riv 10 PM 105.1/120.7 EA 11-154854 Type 1 ARHM-GG (Desert Center) Pict’s 21/9 and 2/1 Roll 4 and Pict’s 25/19 Roll 5 AADT’s Veh. 14,500 Truck 50.7%

JVK and GH reviewed this project on May 9, 1995.

This site represents 2 different projects. The original project was placed during January, February and March 1994 with FNF Construction as the Prime Contractor. It was Type 1 ARHM-GG with the AR binder blended by FNF Construction. The AR binder consisted of AR-4000 (Witco Oildale) blended with 19% round tire rubber (Baker) and 0% high natural rubber with 0% extender oil. The actual binder content was 8.0%.

The ARHM-GG developed bleeding and rutting and many of the areas had to be removed. During this review there was no distress found in the #1 lane in the EB direction. There were only a few locations exhibiting bleeding and rutting in the #1 lane in the WB direction. In the #2 lane EB and WB there was intermittent to continuous bleeding and rutting. Cores have been taken of the original ARHM-GG and an investigation was performed by METS. The second project was a repair of the ARHM-GG distress on the first project. This involved removing and replacing the ARHM-GG with DGAC. Between PM 107.0 and PM 110.1 the #2 lane had been removed and replaced with DGAC. The new DGAC was already showing signs of segregation and raveling.

11-Riv-10/86 PM 81.5/85.7-14.3/18.3 EA 11-179834 Type 1 ARHM-GG (Chiriaco Summit/Ave 54/62) Pict’s 18/17 and 10/1 Roll 5 and Pict’s 25/23 Roll 6 (10) and Pict’s 10/9 Roll 6 (Rte 86) AADT’s Veh. 14,600 Truck 47.0%
JVK and GH reviewed this project on May 9, 10 and 11, 1995.

The construction was placed during September, October and November, 1993 with Granite Construction as the Prime Contractor. It was **Type 1 ARHM-GG** with the AR binder blended by Granite. The AR binder consisted of AR-4000 (San Joaquin Refinery) blended with 16% ground tire rubber (Baker) and 0% high natural rubber with 0% extender oil. The actual binder content was 6.1%.

On the I-10 part of the project the ARHM-GG near Chiriaco Summit in the westbound direction has a dry appearance with isolated rich spots and L and T cracks both in the traveled way and shoulder areas. From the Chiriaco Summit through PM 83.9 EB, there are numerous T, L and A-cracks and pumping areas in the pavement. There is also evidence of excessive flushing in this area. At PM 82.0 EB, there is no evidence of distress. There is intermittent to continuous A-cracking and pumping in the outside wheel track at PM 83.4 EB. There are L-cracks, some spalling of aggregates, some segregation and the surface had a very coarse appearance at PM 83.9.

In the WB lanes starting at PM 83.4, there is A-cracking and pumping with 1/8” deep wheel rutting. At PM 84.9, in the wheel tracks, there is an area which had been ground that is pumping with visible L-cracks. From PM 84.3 to PM 83.3 there is 1/2” rutting in the outside wheel track and one isolated fat spot. In the WB direction from PM 82.9 to 82.7, there is a series of T-cracks in the outside wheel tracks with some pumping and L-cracking. In general, this portion of the project has not performed well.

On the Route S6 part of the project (Avenue 54/62), no distress was observed at the time of this review. This part of the project is performing very well to date.

**11-Riv-86/111** PM 18.3/22.5-28.5/L28.7 EA 11-196244 Type 2 ARHM-GG/SAMI (Coachella) Pict’s 22/11 Roll 6 AADT’s Veh. 33,000 Truck 17.0%

JVK and GH reviewed this project on May 11, 1995.

This project was placed during our review in May 1995 with Granite Construction as the Prime Contractor. It was **Type 2 ARHM-GG over a Type 2 SAMI** with the AR binder for the ARHM-GG blended by Granite. The AR binder consisted of AR-4000 (San Joaquin Refinery) blended with 16% ground tire rubber (BAS) and 4% high natural rubber (Bas 1st half and Atlos 2nd half) with 2% extender oil. The actual binder content was 7.3%.

The SAMI was a modified Type 2 ARCS with the AR binder blended by ISI. The AR binder consisted of AR-4000 (San Joaquin) blended with 16.5% ground tire rubber (Atlos) and 1.5% high natural rubber (Mat-20) with 1% extender oil The actual spread rate of the binder was .63 GSY.

The ARHM-GG was in the process of being placed over the SAMI in Coachella at the time of review. There were existing cracks on the roadway prior to the placement of the ARHM-GG/SAMI.

Lime water had been used on the new pavement surface to prevent vehicle tires from sticking to the ARHM. In the process lime stains were left on the new mat.

Bleeding from the chip seal was observed at the Dillon Road intersection prior to the placement of the overlay. This review was performed during construction and at the time no distress was observed other than the bleeding chip seal.

**11-Riv-111** PM 29.8/30.1 EA 11-187294 Type 1 ARHM-GG (Indio) Pict’s 8/6 Roll 6 AADT’s Veh. 11,700 Truck 12.2%

JVK and GH reviewed this project on May 11, 1995.

This project was placed during August, 1993 with Granite as the Prime Contractor. It was **Type 1 ARHM-GG** with the AR binder blended by Granite. The AR binder consisted of AR-
4000 (San Joaquin Refinery) blended with 18% ground tire rubber (Baker) and 0% high natural rubber with 0% extender oil. The actual binder content was 6.1%.

No distress could be found on this project and it was performing well to date.

11-SD-67 PM R0.6/R1.5 EA 11-09284 Type 2 ARHM-GG (Santee) Pict’s 5/2 Roll 6 AADT’s Veh. 72,000 Truck 6.7%

JVK and GH reviewed this project on May 11, 1995.

This project was placed during August, 1993 with Daley Construction as the Prime Contractor. It was Type 2 ARHM-GG with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Paramount) blended with 15% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder content was 8.0%.

There was no distress found on this project and it is performing well to date.

11-SD City Project Type 2 ARCS (Santee/Frontage Rd.) Pict’s 1/1 Roll 6

JVK and GH reviewed this project on May 11, 1995.

This project was placed during August, 1994 with Sim J. Harris as the Prime Contractor. It was Type 2 ARCS with the AR binder blended by MHA. MHA also placed the ARCS as a subcontractor. The AR binder consisted of AR-4000 (Paramount) blended with 17% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder spread rate was .60 GSY.

This project is performing well to date with no distress observed.

11-SD-54 PM T16.1/T16.3 EA 11-175804 Type 2 ARHM-GG (El Cajon) Pict’s 25/22 Roll 7 AADT’s Veh. 37,000 Truck 3.7%

JVK and GH reviewed this project on May 11, 1995.

This project was placed during October, 1994 with Sim J. Harris as the Prime Contractor. It was Type 2 ARHM-GG with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Paramount) blended with 15% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder content was 9.0% in one area with the remainder of the project being 8.0%.

There was no distress found on the project and it is performing well to date.

11-SD-8 PM 14.3/14.8 EA 11-126704 Type 1 ARHM-GG (El Cajon Ramps) Pict’s 21/17 Roll 7 AADT’s Veh. 142,000 Truck 4.7%

JVK and GH reviewed this project on May 11, 1995.

This project was placed during September, 1994 with Asphalt Inc. as the Prime Contractor. It was Type 1 ARHM-GG with the AR binder blended by ISI. The AR binder consisted of AR-4000 (Enron) blended with 19% ground tire rubber (Atlos) and 0% high natural rubber with 0% extender oil. The actual binder content was 8.8%.

One ramp on this project looks very good; two of the others have loss of fines on the surface and are very coarse in texture. Overall the project is performing satisfactorily.

11-SD-78 PM 12.8/17.4 EA 11-010934 Type 2 ARHM-GG (San Marcos Ramps) Pict’s 16/11 Roll 7 AADT’s Veh. 112,000 Truck 6.9%

JVK and GH reviewed this project on May 12, 1995.
This project was placed during January, 1995 with Hazard Inc. as the Prime Contractor. It was Type 2 ARHM-GG with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Paramount) blended with 15% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder content was 8.5%.

There was no distress found on this project and it is performing well to date.

11-SD-78 PM 7.7/10.8 EA 11-010924 Type 1 ARHM-GG (Mar Vista Ramps) Pict’s 10/9 Roll 7 AADT’s Veh. 90,000 Truck 5.72%

JVK and GH reviewed this project on May 12, 1995.

This project was placed during April, 1995 with Industrial Asphalt as the Prime Contractor. It was Type 1 ARHM-GG with the AR binder blended by Granite Construction. The AR binder consisted of AR-4000 (San Joaquin) blended with 16% ground tire rubber (Baker) and 0% high natural rubber with 0% extender oil. The actual binder content was 9.0%.

There was no distress found on this project and it is performing well to date.

Trip 6

03-PLA-80 PM 35/36.9 EA 03-255324 Type 2 ARHM-DG (Colfax) Pict’s 25/18 Roll 1 AADT’s Veh. 28,500 Truck 14.2%

JVK and GH reviewed this project on June 12, 1995.

This project was placed during the summer of 1984 with Granite as the Prime Contractor. It was Type 2 ARHM-DG with the AR binder blended by ARCO. A complete file is not available for this project but representatives from ARCO indicated that the AR binder consisted of AR-4000 (Conoco Elk Grove) blended with 20% ground tire rubber (Atlos/Genstar) and 5% high natural rubber with 4% extender oil. The actual binder content can not be verified.

This project was a .15’ overlay over PRF over a DGAC leveling course. It is now over 11 years old. In the EB and WB direction, some of the cracks in the underlying slabs had reflected through in the form of T and L-cracks. In addition, there was an L-crack at the pavement edge. There was some chain wear which created some minor rutting in the wheel paths and a few of the T-cracks have spalled. There was indications that some minor patching and digouts had been performed over the years. It appeared that the WB direction had been crack filled at one time but the EB direction had not. It appears that maintenance on this project was minimal. Overall the project has performed very well.

03-PLA-80 PM 38.3/43.8 EA 03-255344 Type 1 ARHM-DG and Plusride RAC (Gold Run) Pict’s 17/7 Roll 1 and Pict’s 6/4 Roll 1 Plusride Section AADT’s Veh. 28,500 Truck 14.2%

JVK and GH reviewed this project on June 13, 1995.

This project had two types of mixes placed. Plusride, a dry process and Type 1 ARHM-DG. The project was placed during August, 1988 with Granite Construction as the Prime Contractor. The AR binder for the ARHM was blended by ISI and consisted of AR-4000 (Shell Martinez) blended with 17% ground tire rubber (Crafco) and 0% high natural rubber with 0% extender oil. The actual binder content was 6.5%.

The ARHM-DG was placed over a continuous reinforced concrete section. It was placed .25’ thick over a DGAC leveling course. It exhibited T and L-cracks, raveling in the wheel paths, and had some surface abrasion. It also had very wide cracks of which has been cracked filled over the years. Some of the raveled spots had been patched and a few had been dugout and replaced. Overall, the ARHM-DG on this project has not performed well.
In the Plusride section, several digouts were required where the mix had raveled. There were also some L-cracks observed in this section. Overall the Plusride section has performed fair to date.

03-ED/SIE Var Rte’s Var PM’s EA 03-OM1004 Type 1 ARHM-GG Pict’s 15/4 Roll 2 and Pict’s 5/1 Roll 4

JVK and GH reviewed these projects on June 13 and 14, 1995.

This .06 ft thick maintenance blanket was placed at 5 locations during September, 1994 with Yuba Sierra as the Prime Contractor. It was Type 1 ARHM-GG with the AR binder blended by ISI. The AR binder consisted of AR-2000 (Shell Martinez) blended with 19% ground tire rubber (Atlos) and 0% high natural rubber with 0% extender oil. The actual binder content was 8.0%.

The following is a review of each location.

SIE-89 PM 16.4/16.6 (W/O Downieville) AADT’s Veh. 1300 Truck 14.3%
It has reflective cracks intermittently at several locations. A couple of areas have raveled through to the existing pavement.

Sie-89 PM 16.7/19.0 (W/O Downieville) AADT’s Veh. 1300 Truck 14.3%
It has reflective cracks intermittently at several locations. Several areas have raveled through to the existing pavement.

Sie-89 PM 6.2/7.2 (E/O Downieville) AADT’s Veh. N/A Truck N/A%
It has only a couple reflective cracks. Several areas have raveled through to the existing pavement.

Sie-89 PM 25.0/28.0 (W/O Sierra City) AADT’s Veh. N/A Truck N/A%
It has several areas with reflective cracks. Many areas have raveled through to the existing pavement.

ED-89 PM 25.5/27.3 (Meaks Bay) AADT’s Veh. N/A Truck N/A%
It had severe raveling throughout major portions of the project. This area had more raveled spots than the previous three spots and was in much worse condition at the time of this review.
It appeared that the mix was placed too thin and dragging occurred at the high spots in the pavement. It also appeared that the mix may have been placed too cold.
These ARHM-GG blankets have not performed well to date.

Note: We found that not only the ARHM-GG had these problems, but several of the DGAC thin blanket overlays placed nearby had similar problems as well. It has been stated by maintenance that .06’ overlays are too thin and is resulting in problems. Maintenance also has had similar problems when placing 1” DGAC overlays as well. It is evident that we need to place these lifts as a nominal thickness and plan for extra mix for leveling on the project. That was the original intent when the maintenance guidelines were developed.

03-Nev/Sie-89 PM 0.6/8.7, 0.0/5.3 EA 03-338304 Type 2 ARCS (Truckee) Pict’s 3/1 Roll 2 and Pict’s 25/21 Roll 3 AADT’s Veh. 16,600 Truck 5.4%

JVK and GH reviewed this project on June 13, 1995.
This project was placed during August, 1988 with MHA as the Prime Contractor. It was a **Type 2 ARCS** with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Chevron Richmond) blended with 15% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder spread rate was .62 GSY.

Overall, this ARCS has performed very well considering the very extreme climatic conditions. It gets very cold at this location and snow and ice conditions require chain controls and a substantial amount of snow and ice removal operations. This past year a major portion was recycled as part of a cold-in-place recycling project. The remaining portion has large thermal cracks and areas that have spalled at these cracks. Overall, the ARCS has performed quite well.

This project and the following project tie in with each other at the county line.

**03-Sie-89 PM Var. EA 03-345104 Type 1 ARCS (Sierraville) Pict’s 19/16 Roll 2 AADT’s Veh. 1850 Truck 19.7%**

JVK and GH reviewed this project on June 13, 1995.

This project was placed during September, 1989 with J. Franklin as the Prime Contractor. It was a **Type 1 ARCS** with the AR binder blended by ISI. The AR binder consisted of AR-2000 (Huntway) blended with 22% ground tire rubber (Atlos) and 0% high natural rubber with 0% extender oil. The actual binder spread rate was .58 GSY.

Right after placement, this ARCS had severe rock loss (up to 80% in some areas) which left the AR binder exposed to traffic. In addition, the reflective cracks were more open than one would expect from an ARCS. Over the years, traffic and snow removal equipment at this location has worn the exposed asphalt rubber binder away from the surface. Overall, this project has not performed well.

**03-Nev-80 PM 5.6/5.9 EA 03-386704 Type 1 ARHM-GG (W/B RSR, Castle Peak) Pict’s 12/10 Roll 3 AADT’s Veh. 26,500 Truck 11.0%**

JVK and GH reviewed this project on June 13, 1995.

This project was placed during June, 1993 with A. Teichert as the Prime Contractor. It was **Type 1 ARHM-GG** with the AR binder blended by ISI. The AR binder consisted of AR-2000 (Huntway Benicia) blended with 17% ground tire rubber (Atlos) and 0% high natural rubber with 0% extender oil. The actual binder content was 8.1%.

Other than a few T-cracks, this project is performing well to date.

**03-Nev-80 PM 5.2/5.7 EA 03-222701 Type 2 ARHM-DG (W/B Castle Peak Truck Lane) Pict’s 25/23 Roll 4 AADT’s Veh. 26,500 Truck 16.1%**

JVK and GH reviewed this project on June 13, 1995.

This project was placed during August, 1980, with Baldwin as the Prime Contractor who subcontracted to A. Teichert. It was **Type 2 ARHM-DG** with the AR binder blended by ARCO. The AR binder consisted of AR-4000 (Douglas Oil Elk Grove) blended with 15% ground tire rubber and 5% high natural rubber with 4% extender oil. The actual binder content was 6.8%.

This project is over 10 years old. It was placed as a truck climbing lane just prior to and past the Castle Peak Road Side Rest (RSR). The traveled way has been ground out as part of a rehabilitation project a few years ago. The DGAC that was placed after grinding the old ARHM-DG has already raveled to the point it needs to be overlaid again. At the end of the new DGAC remains a section of the old ARHM-DG project and it is very evident that it has less abrasion than the newer DGAC. Overall this ARHM-DG project has performed extremely well considering the severe climatic and traffic conditions.
JVK and GH reviewed this project on June 13, 1995.

This project was placed during June, 1982 with A. Teichert as the Prime Contractor. It was **Type 2 ARHM-OG** with the AR binder blended by ARCO. The AR binder consisted of AR-4000 (Douglas Oil) blended with 15% ground tire rubber and 5% high natural rubber with 4% extender oil. The actual binder content was 6.5 to 7.0%.

This project is over 13 years old. Over the years, much of this ARHM-OG has been scraped off by snow plows in the EB lane. The control section with conventional binder potholed severely and was overlayed. Unfortunately, some of the ARHM-OG was covered at the same time. But the areas that remain in place still look good to date. Overall, this project performed quite well.

JVK and GH reviewed this project on June 13, 1995.

This project was placed during June, 1992 with Teichert as the Prime Contractor. It was **Type 1 ARHM-GG** with the AR binder blended by ISI. The AR binder consisted of AR-2000 (Shell Martinez) blended with 17% ground tire rubber (Atlos) and 0% high natural rubber with 0% extender oil. The actual binder content was about 8.0%.

This project is exhibiting some T and L-cracks. Some of these cracks were spalling on the on and off ramps. A portion of the area where the large trucks park was previously PCC. The ARHM-GG was placed over PRF in this area and the pavement developed debonding between the PRF and the PCC. Therefore, the ARHM-GG was removed in this area and replaced with DGAC. The DGAC has not performed well on this project. Overall, the ARHM-GG is performing satisfactorily.

JVK and GH reviewed this project on June 13, 1995.

This project was placed during June, 1982 with A. Teichert as the Prime Contractor. It was **Type 2 ARHM-OG** with the AR binder blended by ARCO. The AR binder consisted of AR-4000 (Douglas Oil) blended with 15% ground tire rubber and 5% high natural rubber with 4% extender oil. The actual binder content was 7.0 to 7.5%.

Most of this project has been rehabilitated. This project did not perform well over the years.

JVK and GH reviewed this project on June 14, 1995.

This project was placed during 1992 with Don Milner Inc. as the Prime Contractor. It was a **Type 1 ARCS** with the AR binder blended by ISI. The AR binder consisted of AR-2000 (Huntway Benicia) blended with 18% ground tire rubber (Atlos) and 3% high natural rubber (Atlos) with 0% extender oil. The actual binder spread rate was 0.66 GSY.

This location exhibits very severe climatic conditions with heavy snow and ice removal operations. It appeared that no preparation had been done such as crack filling or pothole repairs prior to placement of the ARCS. On this project, the precoating of the aggregates were not
uniform at the time of placement and this created a checkerboard appearance. This may or may not play a role in the longevity of the chip seals on this project.

There are a few areas with some rock loss on this project. This appears to be the result of the snow removal equipment scraping off the aggregates at high spots in the pavement. Overall this project is performing very well to date.

**03-ED-50 PM 52.5/66.5 EA 03-248304 Type 2 ARHM-DG (Strawberry)**
Pict’s 13/1 Roll 5 AADT’s Veh. 11,800 Truck 3.1%

JVK and GH reviewed this project on June 14, 1995.

This project was placed during July, 1980 with Granite as the Prime Contractor. It was a Type 2 ARHM-DG with the AR binder blended by ARCO. The AR binder consisted of AR-4000 (Douglas) blended with 20% ground tire rubber and 5% high natural rubber with 4% extender oil. The actual binder content was 6.8%.

This project is over 15 years old. There are still portions of the project that have not been replaced or repaired that are still performing today. Several locations had been replaced by new construction for turnouts, passing lanes, etc. Some of the areas that were replaced with DGAC have already been scheduled for another overlay during this construction season. While reviewing this project, the leadworker for the maintenance crew in this area stopped by and stated he had worked in this area for over 25 years. He said that the areas that are still in place had required very little maintenance over the years. He added that it seems to just “keep hanging in there” so they have not done a lot with it. It is very impressive that portions of this project are still performing, considering the snow and ice conditions and routine chain requirements during the winter months in this area. Although there was early distress at some areas on this project, overall it has performed very well.

**Trip 7**

**03-ED-89 PM 8.6/10.0 EA 03-279204 Type 2 ARHM-DG (South Lake Tahoe)**
Pict’s 25/18 Roll 1 AADT’s Veh. 17,800 Truck 4.1%

JVK and GH reviewed this project on June 19, 1995.

This project was placed during 1985. It was Type 2 ARHM-DG with the AR binder blended by ARCO. Although the records for this project have not been located for verification of the blends, representatives of ARCO have stated that the AR binder consisted of AR-4000 blended with 15% ground tire rubber and 5% high natural rubber with 4% extender oil. The actual binder content can not be verified.

This project is about 10 years old and is still performing very well to date. There has been some patching done, a few T-cracks exist, and it has raveled in a few places over the years. In discussions with the Area Maintenance Superintendent and the Maintenance Supervisor of this area, they indicated that by far, they have spent less time, money and resources on this location than any other section in their entire area. This location is in a very high snow and ice removal area and is subjected to tire chain wear routinely during the winter months. Overall, it has performed very well.

**09-INY-6 PM 6.6/8.36 EA 09-262504 Type 1 ARHM-GG (Just N/O Bishop)**
Pict’s 17/12 Roll 1 AADT’S Veh. 17,500 Truck 14.0%

JVK and GH reviewed this project on June 20, 1995.

This .06′ thick maintenance overlay project was placed during Summer of 1993 with Nicholas and Nicholas as the Prime Contractor.
It was Type 1 ARHM-GG with the AR binder blended by ISI. The AR binder consisted of AR-2000 (Huntway Wilmington) blended with 18% ground tire rubber (Atlos) and 0% high natural rubber with 0% extender oil. The actual binder content was 9.0%.

This project exhibits some T-cracks, however, they are very tight and closed. This maintenance overlay is performing well to date.

09-MNO-395 PM 9.8/R12.3 EA 09-255904 Type 1 ARHM-GG (Tom’s Place) Pict’s 11/3 Roll 1 AADT’s Veh. 5,600 Truck 5.5%

JVK and GH reviewed this project on June 20, 1995.

This rehabilitation project was placed during June, 1993 with Nicolaus and Nicolaus as the Prime Contractor. It was Type 1 ARHM-GG with the AR binder blended by ISI.

The AR binder consisted of AR-1000 (Huntway Wilmington) blended with 18% ground tire rubber (Atlos) and 0% high natural rubber with 0% extender oil. The actual binder content was 6.5%.

This project exhibited T-cracks, L-cracks, block cracking, and some raveling. Maintenance forces placed a fog seal with approximately .15 GSY following the first winter to assist in stopping the raveling. The Maintenance Manager of the region stated the fog seal may have assisted in preventing further raveling. There was an isolated pothole that may have occurred from spillage during placement of the mat. Maintenance plans to crack seal this project in the very near future. This is in an area with snow and ice removal operations and tire chain requirements is quite common during the winter months. This project has not performed well to date.

09-MNO-395 PM 2.8/6.9 EA 09-269404 Type 1 ARHM-GG (Sherwin Summit S/O Tom’s Place) Pict’s 2/1 Roll 1 AADT’s Veh. 5,600 Truck 5.5%

JVK and GH reviewed this project on June 13, 1995.

This 0.6′ thick maintenance overlay project was placed during July, 1994 with BEC Construction as the Prime Contractor. It was Type 1 ARHM-GG with the AR binder blended by ISI. The AR binder consisted of AR-2000 (Merrimac Energy) blended with 19% ground tire rubber (Atlos) and 0% high natural rubber with 0% extender oil. The actual binder content was 9.6%.

This maintenance overlay was placed over existing wide cracks and is now exhibiting a few T-cracks, pumping at a couple locations, and has one raveled spot. This is in an area with snow and ice removal operations and tire chain requirements is quite common during the winter months. Considering the existing conditions at this site prior to placement of the thin maintenance overlay, it is performing well at this date.

09-MNO-395 PM 125.3/127.7 EA 09-251504 Type 1 ARHM-GG/SAMI and Plusride (Test Section/Round Valley) Pict’s 13/12 Roll 2 and Pict’s 11/7 Roll 2 (Plusride) AADT’s Veh. 4,350 Truck 6.0%

JVK and GH reviewed this project on June 20, 1995.

This project was placed during July, 1991 with Nicolas and Nicolas as the Prime Contractor. It was Type 1 ARHM-GG/SAMI with the AR binder blended by ISI. The AR binder consisted of AR-2000 (Huntway Wilmington) blended with 18% ground tire rubber (Atlos) and 0% high natural rubber with 0% extender oil. The actual binder content was 7.3%. The actual spread rate for the SAMI was 0.67 GSY.
There were two test sections reviewed on this project. The first test section was ARHM-GG/ S seven and it is exhibiting some T and L-cracks at this time. There were some construction problems during the placement of this section and may be a contributing factor to its performance. This test section has not performed well to date.

The second test section reviewed as “Plusride” and it is performing very well to date. There was no distress noted during this review except one area that appears to be exhibiting some slight flushing.

09-INY-168 PM 26.1/27.2 EA 09-262504 Type 1 ARHM-GG (Westguard Pass) Pict’s 6/2 Roll 2 AADT’s Veh. 10,000 Truck 1.0%

JVK and GH reviewed this project on June 20, 1995.
This 0.6’ thick maintenance overlay project was placed during September, 1993 with Nicolas and Nicolas as the Prime Contractor. It was Type 1 ARHM-GG with the AR binder blended by ISI. The AR binder consisted of AR-2000 (Huntway Wilmington) blended with 18% ground tire rubber (Atlos) and 0% high natural rubber with 0% extender oil. The actual binder content was 8.2%.

This maintenance blanket exhibits some T and L-cracks that are very open. It is not performing well to date.

09-INY-395 PM 67.0/73.0-91.4/96.0 EA 09-267504 Type 1 ARHM-OG (Poverty Hills/Manzanar) Pict’s 1/1 Roll 2 and Pict’s 25/21 Roll 3 and Pict’s 20/17 Roll 3 AADT’s Veh. 6,400 Truck 11.0%

JVK and GH reviewed this project on June 21, 1995.
This .06’ maintenance blanket project was placed during the Summer of 1993 with Granite as the Prime Contractor. It was Type 1 ARHM-OG with the AR binder blended by ISI. The AR binder consisted of AR-2000 (San Joaquin) blended with 18% ground tire rubber (Baker) and 0% high natural rubber with 0% extender oil. The actual binder content was 9.1%.

This maintenance blanket is exhibiting some T-cracks, L-cracks, and A-cracks at both locations at the time of this review. It is not performing well to date.

06-Ker-46 PM 49.8/50.9 EA 06-312104 Type 2 ARHM-DG/Sami (Wasco) Pict’s 25/15 Roll 4 AADT’s Veh. 8,100 Truck 38.1%

JVK and GH reviewed this project on June 22, 1995.
This project was placed during August, 1992 with Griffith Contracting as the Prime Contractor. It was Type 2 ARHM-DG (portions over a SAMI) with the AR binder blended by MHA. The AR binder consisted of AR-4000 (Paramount) blended with 15% ground tire rubber (Atlos) and 5% high natural rubber (Atlos) with 2% extender oil. The actual binder content was 6.4%.

This project is exhibiting T-cracks, L-cracks, and A-cracks intermittent to continuous in many areas, especially in the E/B direction. There were also areas that exhibited pumping in the E/B direction. Most of this distress occurred during or after the 1995 winter. It is not performing well to date.

06-KIN/FRE 33 PM 17.1/19.0 and 0.0/0.5 EA 06-329204 Type 1 ARHM-GG (Avenal) Pict’s 14/5 Roll 4 AADT’s Veh. 1,700 Truck 8.1%

JVK and GH reviewed this project on June 13, 1995.
This .08′ thick overlay project was placed during September, 1994 with Granite as the Prime Contractor. It was Type 1 ARHM-GG with the AR binder blended by ISI. The AR binder consisted of AR-2000 (Witco Oildale) blended with 18% ground tire rubber (Atlos) and 2% high natural rubber with 0% extender oil. The actual binder content was 8.3%.

This project exhibited some L and T-cracks and pumping from PM 17.1 to PM 18.6 in King County. The Fresno County portion of the project exhibited very little distress. There was some T-cracks on the improved shoulders noted but they stopped at the lane line. The Fresno County section looked much better than the King County section on this project.

The Fresno County portion of the project is performing well while the King County portion is not performing well to date.