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EVALUATION OF ASPHALT-RUBBER CONCRETE (ARC)

by

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Evaluation of Asphalt-Rubber Concrete

(ARC)

Introduction -

ARC is defined as the use of reacted Asphalt-Rubber as a binder in asphalt concrete. Asphalt-Rubber has been successfully used as a seal coat for more than 19 years. This survey reports on 35 projects, throughout the United States, where Asphalt-Rubber was used as a binder in asphalt concrete.

There are no standard tests or design standards for Asphalt-Rubber Concrete mix. This has deterred the design process, but design engineers are now able to use an accepted standard.

However, some engineers have questions on the use of Asphalt-Rubber as a binder concerning:

- Durability under traffic
- Flexibility under traffic and varying climatic conditions
- Expected life cycle
- Performance

This survey provides performance data and answers these questions, based on trial mixes and 13 years of use under traffic and in various climatic conditions.

Background -

Since the concept of mixing asphalt as a binder with rock and sand, in the late 1800’s, engineers and technicians have endeavored to improve the binder.

Asphalt-Rubber is a continuation of these improvements, and made by mixing of 22% ± 3% crumb rubber, from scrap tires, with hot asphalt cement to create a gel. The use of Asphalt-Rubber has been
well documented for seals such as a SAM (Stress Absorbent Membrane) and SAMI (Stress Absorbent Membrane Interlayer). (Ref.: 1, 3, 4, 6, 13 & 15)

Engineers have found that Asphalt-Rubber seals extend pavement life by 2.0 to 3.0 times that of conventional seals. Asphalt-Rubber has also been proven to reduce maintenance costs, increase durability, reduce oxidation and retard cracking.

With these advantages, it was only logical that Asphalt-Rubber should be considered as a binder in asphalt concrete. Many test sections have been placed under variable traffic, subgrade and climatic conditions.

Early design mixes were established from information and known properties of asphalt concrete. These standards did not apply to Asphalt-Rubber. Modifications and adjustments were made in the field while placing early ARCs.

This study evaluates these ARC applications and provides the design engineer and technicians additional information to best utilize Asphalt-Rubber Concrete.

Pavement Evaluation Procedures -

A survey was conducted in 1988. It reports on 35 projects placed since 1975, using Asphalt-Rubber as a binder in asphalt concrete.

They are:

1. Arizona SR 87 1975 - K
3. Arizona US 80 1981
5. Arizona (Phoenix) 19th Street 1985 - OK
<table>
<thead>
<tr>
<th></th>
<th>California</th>
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<tbody>
<tr>
<td>6</td>
<td>California</td>
<td>US 50</td>
<td>1980-0K</td>
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<td>California</td>
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<td>1982-0K</td>
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</tr>
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<td>California</td>
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<td>1985-0K</td>
</tr>
<tr>
<td>14</td>
<td>California</td>
<td>I-880</td>
<td>1986- ?</td>
</tr>
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<td>California</td>
<td>US 101</td>
<td>1987- ?</td>
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<td>16</td>
<td>California</td>
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<td>SR 79 &amp; 80</td>
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<td>Dover Downs</td>
<td>1986</td>
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<tr>
<td>21</td>
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<td>1A</td>
<td>1980- ?</td>
</tr>
<tr>
<td>22</td>
<td>Minnesota</td>
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<td>1984- ?</td>
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Seventy percent of the projects were constructed by Arizona Refining Company, nine percent were built by Sahuaro Petroleum & Asphalt Co. and 21% by such methods as PlusRide, etc. Files were not kept by Sahuaro, and information on type of asphalt, rubber, percentage of binder, mix designs and quality control are unknown. Also, there is no record of construction procedures or methods.

File information on designs, materials, contractors and correspondence was found for Arizona Refining applications. This information is included as a part of Appendix "A".

The survey includes:
1. Available file information
2. Interviews of administrators, engineers, directors, inspectors and applicator crews.
3. Interviews of maintenance personnel responsible for the pavements.
4. Research - published and unpublished findings by various agencies.
5. Inspection of each project recording:
   a) Cracks
   b) Raveling
   c) Rutting
   d) Ride
   e) Surface Texture
   f) Required Maintenance

The evaluation and opinions are those of the author, based on 28
years of pavement design and construction experience in the United States and South America. Each project was photographed for texture, type of cracks, raveling and overall appearance. See Appendix "A".

Where possible, comparisons were made between asphalt concrete of similar age and exposure to the Asphalt-Rubber Concrete. The conclusions of this survey can only add to the knowledge that Asphalt-Rubber Concrete out-performs conventional asphalt concrete.

Survey General Evaluation -

Asphalt-Rubber Concrete has performed well, in spite of the early unscientific methods used to design and maintain quality control. All projects contained 6.0 to 8.0% Asphalt-Rubber binder. Each had similar aggregate gradations with the exception of open graded mixtures. Thirty three of the 35 projects in this study have performed equal to or better than standard mixtures used by the agency. One project had to be overlayed two years after construction. See survey report Appendix A.

Several comparisons were made in the study by the state agency involved. Comparisons were made using two types of Asphalt-Rubber binders: "Arm-R-Shield", produced by Arizona Refining Company and "Overflex", by Sahuaro Asphalt and Petroleum Company.

Fabrics were used as interlayers. Asphalt-Rubber was also tested as an interlayer. Adjustments of rubber contents were made in field applications. Rubber content and types of rubber were changed experimentally. Several different sources and types of rubber were included in the changes. Natural rubber contents were changed. Vulcanized and devulcanized rubber contents were altered or varied.

Mixing temperatures of Asphalt-Rubber binders and/or the hot mix
were not maintained to assure complete reaction between the rubber and the asphalt cement.

Densities of in-place Asphalt-Rubber Concrete mixes were not measured and, if they were, little is known of the control or laboratory density.

Engineers and agency inspectors did not have testing methods to maintain quality control. Therefore, quality control could not be used to compare with a standard mix. Because Asphalt-Rubber was a new material, all quality control was the responsibility of the contractor.

Conventional asphalt concrete needs a continuous quality control procedure and so does Asphalt-Rubber.

Regardless of the unscientific designs, changes in the mixtures, types of rubber, various contractors and lack of quality control, these Asphalt-Rubber Concrete projects have continued to perform for 13 years.

Asphalt-Rubber Concrete indicates pavement sections can be reduced by 25 to 50 percent of conventional asphalt mix.

Specific Condition Evaluations -

Airports - Six airport runways received Asphalt-Rubber Concrete overlays. One failed within two years. Four are functioning very well and one is to beoverlayed again in 1990.

Three of the airports have high volumes of light aircraft traffic, while the remaining three are very light.

Riverside and Salt Lake #2 have had little or no maintenance for 3 and 8 years, respectively. These surfaces have less than 5% cracking and no rutting.
St. George runway has cracked. However, based upon the pre-existing crack pattern prior to the overlay, less than 20% of the surface is cracked, due to the pre-existing cracks. Future construction plans call for overlaying the runway with ARC.

Rock Springs Airport has ARC on the new east-west runway and ARC on the old diagonal runway. This surface is 10 years old. New construction does not have any cracks, except at turn-out joints. The overlay on the old cracked surface has cracked. Little is known of the old surface condition to compare reflection percentages.

The Rock Springs Airport runway is a very good example of a successful ARC project. Engineering preventative maintenance has designed a friction course of ARC for 1989 or 1990 construction.

Roadways - US 50 in California, above 5,000 foot elevation, proves Asphalt-Rubber Concrete does resist chain wear, based on side by side comparisons. ARC has performed very well with over 300 freeze-thaw cycles per-year on US 50 and Donner Pass.

Several comparisons were made on I-80, in California’s Sierra Nevada Mountains, for this survey. Asphalt-Rubber has withstood the chains, freeze-thaw cycles and high moisture contents two to three times better than conventional mixes of asphalt concrete. A comparison was made on I-80 between a standard asphalt concrete with a high asphalt cement content without rubber and an ARC. The theory was that a high AC content would perform as well as an A-R. The high AC mix has cracked and did rut, whereas ARC has some cracking but no rutting.

Route 395 had 13 test sections, compared to a design required standard overlay by CALTRANS, of 7 inches of asphalt concrete. (Ref.: 16, Robert Doty Report). This data shows the 7-inch overlay can be replaced with a 3-inch ARC to prevent reflective cracking and meet
structural value requirements.

Oklahoma compared ARC with the state's standard mix. Three basic mixes were used in the ARC. Overflex, Arm-R-Shield and Plus-Ride. (Ref.: 11, "Chemkrete and Rubber Mixtures at Seiling Oklahoma")

Oklahoma research concluded the cost far exceeded the benefits of Asphalt-Rubber. Further, all test sections were overlayed with a micro-pavement except the Overflex section. Cracking and raveling developed early on the Plus-Ride and the Arm-R-Shield. The Overflex does not have one crack on the entire test section, and surface is very good for texture and rutting. However, the surface has the appearance of bleeding, because it is darker than the remaining pavement. Based upon comparisons with the state's standard, ARC is very cost effective as a long term investment.

Minnesota Route 7 (Ref.: 17, "Asphalt-Rubber for Construction and Maintenance") had cracks every 15 to 30 feet in an area that had construction problems. Rubber could not be identified in the mix. The second section of ARC had cracks every 75 to 150 feet with most of the cracks stopping at the Asphalt-Rubber mix. Surface texture was good with little or no secondary cracking, as seen in the standard mix. Minnesota had the shortest life expectancy for ARC than all of the other 34 projects. However, it appears to last longer than a standard mix without rubber.

Wyoming ARC was placed without regard to temperatures, both ambient and mix. The percentage of rubber was based upon how much time they had to make the mix. Compaction was accomplished only to give a smooth surface, with little or no regard towards quality control.

Yet, in spite of this lack of controls, the pavement has performed very well. Transverse cracking exists, however, secondary
cracking and alligator cracking has not occurred. The roadway has been closed down except for occasional hunters and campers. The surface is exposed to the Wyoming high desert conditions that would normally oxidize and deteriorate the surface and allow grass and weeds to grow through the cracks. The ARC has not oxidized, nor has the pavement deteriorated.

Arizona has the oldest Asphalt-Rubber Concrete that continues to serve as a good surface on Highway SR 87. Several mixtures of ARC were placed in 1975. (See Inspection Survey Data in Appendix "A") These sections were open graded ARC containing five different types of Asphalt-Rubber mixtures. Some were pre-reacted and some were not. The non-reacted rubber mixes have been replaced or overlayed. The non-reacted test sections however, did show that the addition of an additive, such as reclaimite, did promote some reaction between the rubber particles and the asphalt cement. Dr. Zaniewski's report (Ref.: 18, "Summary of Arizona Department of Transportation Experience with Asphalt-Rubber") indicates Asphalt-Rubber that has been reacted as a binder in open graded mixes is excellent.

Arizona's SR 92, US 80 and SR 68 are considered successes because the surfaces are not as seriously cracked as the standard mix is without rubber.

City of Phoenix ARC has shown several excellent properties, by its outstanding performance under heavy traffic and high ambient temperature, with a very high binder content. The concept of a gap graded mix has offered allowance of a high binder content. Stability of the mix is in its aggregate gradation. Asphalt-Rubber has allowed a heavy aggregate coating or film thickness to maintain a high structural value and still be flexible to the loads and climatic
Phoenix has been using Asphalt-Rubber as a SAM or SAMI on over 800 miles of streets for more than 18 years. Results were reported by this author. (Ref.: 3 & 13)

Problems to be Solved -

A standard, acceptable engineering design method is needed to properly design an Asphalt-Rubber Concrete. Essentially the following questions need to be addressed:

1. What is the appropriate level of design voids for dense graded mixtures? Evidence exists, based upon this survey and other work, that Asphalt-rubber Concrete is not as susceptible to additional densification under traffic as are conventional mixes. This indicates lower void contents can be achieved and would increase the resistance to oxidation and/or aging.

2. What properties are appropriate for Asphalt-Rubber Concrete? Asphalt-Rubber Concrete does respond differently to most known test procedures, such as the Marshall and Hveem.

3. How does a composition of Asphalt-Rubber in a hot mix affect such properties as fatigue? Rutting? (Ref.: 2, 4, 5, 7, 9, 15, 16 & 18) Aging? Documented research has shown (Ref.: 1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 13, 14, 15, 16 & 18) when Asphalt-Rubber is used as a seal or membrane, resistance to these properties have improved.

4. What structural equivalency factors apply to Asphalt-Rubber Concrete? This survey and research by others indicates increases in the AASHTO structural numbers can be up to 150%.

5. What is the appropriate percentage of Asphalt binder in an open graded mixture? The quantity of asphalt used in a standard open graded
mix is limited by its segregation, or drain off, during hauling and is generally about 6%. Asphalt-Rubber, because of its high viscosity, does not experience this problem, and Asphalt-Rubber open graded mixes have been placed with up to 13% binder. Criteria is needed to determine the appropriate percentage of Asphalt-Rubber binder.

Over the past 13 years, industry has developed equipment to add Asphalt-Rubber in hot mixing. The current equipment is unable to reach the high production of standard asphalt concrete. The construction industry must and will improve these methods.

Conclusions and Observations -

Regardless of the many conditions and problems caused by changes in the job mix formulas, construction methods and general lack of knowledge, Asphalt-Rubber Concrete has been forgiving. This same philosophy existed with Asphalt-Rubber as a seal. Many of the early projects were felt to be, or about to become, failures.

Asphalt-Rubber worked in spite of the early learning processes and is still working today.

This survey bares out the fact that Asphalt-Rubber has added to several significant properties of asphalt concrete, resulting in reduced maintenance and cost effectiveness.

Because Asphalt-Rubber concrete has performed well on these 35 projects, without quality control, then we should expect even greater advantages with quality designs and construction control.

The future of Asphalt-Rubber as a binder in asphalt concrete is a bright one. Asphalt-Rubber Concrete will offer a longer life for our nations’ pavements and will use a waste product that is a major concern throughout the world.

-11-
ARC Survey References

7. "Design of Asphalt-Rubber and Aggregate Mixture", Arizona DOT, October 1979, Jimenez, Dr. R.A.
11. "Chemkrete and Rubber Mixtures at Seiling, Oklahoma", Research and Development Division, Brewer, W.B. Jr., 1984
15. ASTM Special Technical Publication 724 - "New Materials and Techniques", 1979


Appendix A
Asphalt-Rubber Concrete (ARC)
1988 Survey Data

State: Arizona  Date Constructed: 1975
Date of Survey: August 1988  Highway Number: S.R. 87
Location: MP 195.36 - 198.60  - 11 Test Sections:

A/B) MP 193.87 to 194.875  G) MP 197.39 to 197.80
C)  MP 194.875 to 195.37  H) MP 198.80 to 198.13
D)  MP 195.37 to 195.81  E) MP 198.13 to 198.55
D-1) MP 195.61 to 196.90  I) MP 198.55 to 199.0
F)  MP 196.90 to 197.39  X) Control

Contractor: Bentson Construction Co.

Asphalt-Rubber Type and Supplier: Arizona Refining Company,
Sahuarao Petroleum & Asphalt Company.
Flow Mix, Long Strand Rubber, Latex Rubber.

Mix Design: Open graded

Section A - 2-1/2% Vulcanized Rubber, No. 10 Sieve, (Not pre-reacted) with 8% AR-1000
B - Same as A, except 7% AR-1000 and the surface was fog sealed with Reclamite.
C - 8% AR-8000 with "Flow-Mix" - a devulcanized reclaimed rubber and extender oil. (Not reacted).
D - 7% AR-1000 with long strands chopped rubber (Not reacted)
D1 - 7% AR-1000 with long strand rubber from another source. (Not reacted)
F - 3/4" lift open graded 4% AR-1000 followed by reacted Asphalt-Rubber, with 25% rubber spray (SAMI) using AR-1000, then chipped and rolled. Then the surface was sanded and followed by open graded 3/8" agg. 6% AR-1000 overlay followed by a emulsified asphalt fog seal with latex.
G - Open graded reacted Asphalt-Rubber Concrete with 10.5% binder.
H - Open graded reacted Asphalt-Rubber Concrete with 8.5% binder.

E - Open graded asphalt concrete with 2-1/2% long strand unreacted rubber with 6% AR-1000 followed by a fog seal of Reclamite.

I - Open graded asphalt concrete with 6%, hot rubber binder, 88% AR-8000 and 12% extender oil. Then fog sealed 2% latex modified CSS-1h emulsified asphalt.

X - (Control Section) - Open graded plant mix seal with 6% AR-1000 and fog sealed with latex emulsified asphalt.

1988 Survey Observations and Photo Reference:

Section A - Traveled lane has been patched, alligator cracking in all wheel paths.

B - No patching, alligator cracking in outside wheel path. Appears that reclamite helped to react the rubber with the asphalt.

C - Good surface with some raveling (Surface has been chip sealed.)

D - Has been reconstructed or overlayed

D-1 - Overlayed and/or seal coat

F - 40% cracked surface with raveling

G - Excellent surface with minor side cracks that stop in the ARC.

H - Very good condition, no cracks, some bleeding and rutting, rutted area has been overlayed.

Typical surface for Sections G & H with 8.5 & 10.5% Asphalt-Rubber binder.

After 13 years, this is an outstanding example of Asphalt-Rubber Concrete performance.
Reflective crack in ARC Section H, over old cattle guard.

E - Reconstructed

I - Good condition with some thermal cracks. Excellent texture.

X - (Control) Sealed several times and has been skin patched. (Reflective cracked seal)

Reference Reports by Others: "Summary of Arizona Department of Transportation Experience with Asphalt-Rubber" by Dr. J.P. Zaniewski. (Ref.: 18)

Comments from Reports: "If rutting is not considered, then the overall performance of Sections C, F, G and H are excellent". The pre-reacted ARC’s are in very good condition after 13 years, which has doubled the pavement life compared to the standard mix.
State: Arizona
Date of Survey: June 1988
Location: MP 341 - 345
Highway Number: S.R. 92
Asphalt-Rubber Type and Supplier: Arizona Refining Company
Mix Design: Open graded
Comparison Mixtures and Applications: See photos for standard AC overlay. Note cracking: alligator, block, transverse and longitudinal.

1988 Survey Observations and Photo Reference: ARC surface texture is good, the ride is good. However, block cracking has occurred. MP 344 - Severe block cracking exists and less severe in other areas. Little is known about the design. However, the ARC does appear to be better than the non-rubber overlay.

Typical surface condition of ARC after 7 years.

Typical Standard AC cracked surface requiring maintenance at end of ARC.
Reflective shoulder cracks stopping in traveled way of ARC.

State: Arizona  Date Constructed: 1981
Date of Survey: June 1988  Highway Number: U.S. 80
Location: Bisbee MP 340 - 342
Asphalt-Rubber Type and Supplier: Arizona Refining Company
Mix Design: Semi open graded
Comparison Mixtures and Applications: See below

1988 Survey Observations and Photo Reference: The section from the tunnel to the beginning was used as a comparison and control. Cracking in the ARC is about 1/3 that of the control section. Subgrade failure showing alligator type cracking exists over the piped drainage crossings. Noted shoulder cracking stopped 2 to 3 feet into the ARC. Good surface texture. Refer to photos for comparisons.
Control overlay condition to tunnel. Note cracking.

ARC begins at manhole. Standard AC pavement in foreground.
Transverse reflective crack from shoulder, stopping 1/3 way into the ARC.

General surface condition. No cracks in this area.
State: Arizona                      Date Constructed: July 1981
Date of Survey: 1988                  Highway Number: U.S. 68
Location: Kingman, beginning at Intersection of I-40 Northwest to Intersection of US 93; 0.88 miles
Contractor: Tanner Company
Asphalt-Rubber Type and Supplier: Arizona Refining Company
Mix Design: Open graded Asphalt-Rubber Concrete
    10.4% Asphalt-Rubber binder
    3/8" Max aggregate
    3/4" Thick lift

Construction Notes: Asphalt-Rubber blend was held for three days prior to incorporation into the ARC mix. The south end towards Kingman was very soft and sticky. It had to be sanded which lost the effect of open graded surface.

1988 Survey Observations and Photo Reference: 1987 observations indicated much of the south end had peeled off. The north end had a good non-cracked surface.

August, 1988 survey showed an overlay had been placed on the south end. The north end has developed block cracking and does not appear to be any different than the standard pavement without rubber.

General condition with small percentage of cracks.
Fair to good surface with some cracks, no rutting.

Reference Reports by Others: Arizona Research Reports - Very little said about this project.

Comments from Reports: Early construction problems noted, perhaps due to holding the Asphalt-Rubber blend too long, creating a very soft, non-effective binder.

State: Arizona (City of Phoenix) Date Constructed: 1985

Date of Survey: December 1988 Highway Number: 19th Street

Location: Right turn lane from Glendale to 19th Street North

Contractor: City Maintenance

Asphalt-Rubber Type and Supplier: Arizona Refining Company

Mix Design: 3/4" gap graded mix, 13% Asphalt-Rubber binder

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<tr>
<td>3/4</td>
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<td>7</td>
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<td>200</td>
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Comparison Mixtures and Applications: The mix was applied to develop a super elevated curve varying from 1" thick on the low side of the curve to 5" thick on the high side. Rolling equipment did not obtain desired densities. Due to the harshness of the mix, it could not be handled by hand. Traffic was turned on the surface immediately.

1988 Survey Observations and Photo Reference: The thicker section has rutted and bled. This took place within three months after construction. May be due to lack of density. The thin section has performed very well. There are no cracks in this pavement. Little or no rutting has developed since early consolidation. The test section has shown a great potential for ARC mixes in city streets.

ADT - 1988 45,000

Reference Reports by Others: City of Phoenix yearly evaluation by Mr. Joe Cano.

Comments from Reports: Asphalt-Rubber binder should have been set at 11% max.

State: California Date Constructed: 1980

Date of Survey: August 9, 1988 Highway Number: U.S. 50

Location: From 3.2 miles east of Kyburz to Echo Summit, only the following portions were constructed with ARC.

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<td>58.1 to 59.0</td>
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<td>4</td>
<td>61.5 to 63.7</td>
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<td>5</td>
<td>64.9 to 66.5</td>
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Contractor: Granite Construction Company

Asphalt-Rubber Type and Supplier: Arizona Refining Company

Mix Design: 6.8% Binder Asphalt-Rubber, 80% AC AR-4000

| 20% Rubber, Standard Binder 5.5% AC |

Agg. Gradation

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</table>

Test Sections were as follows: Truetex Fabric; 2.4" dense graded asphalt concrete (DGAC) and 1.2" rubberized DGAC 3/4" max. aggregate.

1988 Survey Observations and Photo Reference:

- MP 52.8 - Excellent surface, very few cracks. (Photo 1)
- MP 55.00 - Excellent surface, few cracks, some snow plow scrapes. No major chain wear, short narrow cracks. (Photos 2 & 3)
- MP 58-59 - Deep snow area; some chain wear, little or no cracks. (Photo 4)
- MP 60.19 - Steep climb, heavy snow with 25-40% cracked surface. Cracks have been sealed.
- MP 61-63 - Note difference in chain wear without rubber. Cracked surface at El. 6000.
Reference Reports by Others: Caltrans 1st year inspection, 1981 - Rubber exhibited pitting and slight raveling. No cracking in all sections. Ravel occurred on all test sections. Overall appearance was good.

Comments from Reports: 350" of snow annually, 7000' Elevation. No reports after second year.

The chain wear on the standard asphalt mix is considerably more than the rubber mix. No measurements have been made. Note chain wear conditions as shown in the traveled way with Asphalt-Rubber compared to the shoulders that had the standard mix.

State: California       Date Constructed: 1980
Date of Survey: August 1988    Highway Number: I-80
Location: 10 miles west of Truckee - Westbound lane and on a ramp. 16,000 ADT, 13% trucks.
Contractor: Baldwin & A. Teichert
Asphalt-Rubber Type and Supplier: Arizona Refining Company
Mix Design: Dense graded ARC
  6.8% Asphalt-Rubber   1" Max. Agg.
  Standard DGAC, Caltran Specifications
State: California  Date Constructed: October 1981

Date of Survey: August 1988  Highway Number: I-80

Location: 6 miles west of Truckee - Westbound lane 2.2 miles east of Castle Peak Crossing to 0.3 miles east of Donner Lake Crossing.

Contractor: A. Teichert

Asphalt-Rubber Type and Supplier: Arizona Refining Co.; Arm-R-Shield:
- 40% Devulcanized
- 60% Vulcanized
- 10 Mesh

Mix Design: Dense graded asphalt concrete; 1" max. on PCCP. 20% Rubber.

Comparison Mixtures and Applications:
- First lift - 1.5" on PCCP using 6.2% AR-4000
- Second lift - 0.25 gal./sq. yd. Tack coat AR-4000
- Third lift - Petromat
- Fourth lift - 4000' of 1.2 inches of ARC with 7.6% Asphalt-Rubber. 4000' DGAC using 6.2% AC-AR-4000

Purpose was to compare high AC content and Asphalt-Rubber binder.

1988 Survey Observations and Photo Reference: Some longitudinal and transverse cracking in both sections. High AC content section is very rich and indicating rutting.

This portion of rubberized AC looked good.
Comparison Mixtures and Applications: 1.2 inches on PCCP to compare chain wear.

1986 Survey Observations and Photo Reference: Good surface with minimal chain wear. After 8 years the chain wear cannot be measured. 1987 survey indicated no cracked surface. 1988 survey cracks are beginning to appear.
This section was regular AC over Petromat. Some cracks had re-appeared.

State: California  
Date Constructed: June 1982

Date of Survey: August 1988  
Highway Number: I-80

Location: Between Floriston and Boca - MP 23.8 to 24.8; 9 test sections, 3 Asphalt-Rubber Concrete (See Mix Designs)

Contractor: A. Teichert

Asphalt-Rubber Type and Supplier: Arizona Refining Company

Mix Designs and Comparison Mixtures and Applications:

Section A (130 to 135+50) - 1.2" open graded with 7.0% AR followed by 1.2" dense graded ARC with 7.5% Asphalt-Rubber.

Section B (137+50 to 145) - 1.2" open graded with 7.0% AR followed by 2.4" dense graded ARC with 7.5% Asphalt-Rubber.

Section C (145 to 152+50) - 1.2" open graded with 7.0% AR followed by 2.4" dense graded Asphalt Concrete with 6.5% AC.

Section D (152+50 to 160) - Open graded with 6.5% AR-4000, 1.2" followed by 2.4" of open graded no rubber.

Section E (160 to 167+50) - Open graded with 5.5% AR-4000 followed by a SAM, followed by a 1.2" DGAC with 6.8% AR-4000 and 1% Bonifibers.

Section F (167+50 to 171+00) - 2.4" of DGAC with 6.8% AR-4000 and 1% Bonifibers.
Section G (171 to 175) - 3.6" DGAC with 6.8% AR-4000 and Bonifibers.

Section H (175 to 177+50) - Membrane (fabric) followed by 3.6" DGAC 6.5% AR-4000

Section I (177+50 to 180) - Control Section - 4.2" DGAC with 6.5% AR-4000.

1988 Survey Observations and Photo Reference:

Section A - Surface cracked with raveling. Fair overall condition with large cracks through the overlay.

Section B - Longitudinal and transverse cracked surface. Some raveling. Fair overall condition.
Section C - Longitudinal and transverse cracked surface showing.
Raveled surface with some rutting due to raveling.

State: California          Date Constructed: 1983
Date of Survey: June 1988    Highway Number: I-80
Location: Near Colfax from Long Ravine crossing to Cape Horn crossing.
Contractor: Granite Construction Company
Asphalt-Rubber Type and Supplier: Arizona Refining Company
Mix Design: AR-4000 with Arm-R-Shield
Comparison Mixtures and Applications: Cracked, rough, raveled surface.
Lots of maintenance. Difficult to find rubber.

1988 Survey Observations and Photo Reference: Asphalt-Rubber Concrete
appeared to serve as well as the standard mix. Both were in very poor
condition. August 1988 this surface was overlayed with 3 inches of ARC.
State: California  Date Constructed: June 1982

Date of Survey: August 1988  Highway Number: S.R. 20

Location: 20 miles west of I-80 at White Cloud campground; west 1.3 miles. At I-80 west 1.3 miles.

Contractor: A. Teichert

Asphalt-Rubber Type and Supplier: Arizona Refining Co.; Arm-R-Shield. Open graded Asphalt-Rubber Concrete.

Mix Design: 1/2" max. aggregate open graded with 6.5 and 7.0% Asphalt-Rubber binder.

Comparison Mixtures and Applications: Project was done in conjunction with I-80 project Floriston and Boca. Placed to compare crack reflection and chain wear against standard open graded asphalt concrete. No inspection or reports have been done to date.

State: California  Date Constructed: September 1983

Date of Survey: June, 1988  Highway Number: Route 395

Location: US 395 MP 92.0 to 102

Asphalt-Rubber Type and Supplier: Arizona Refining Company, Plus Ride, Dense Graded Asphalt Concrete (DGAC), and Sahuaro Petroleum

Mix Design: Aggregate 3/4 maximum

- Asphalt-Rubber binder 8.0% 80% AC & 20% Rubber
- Plus-Ride binder 9.41% -- 3% rubber in total mix
- DGAC control mix 4.6% with AR-4000

Comparison Mixtures and Applications: 13 Sections on 395

1. - 3" ARC over SAMI  9. - 3.6" DGAC control
2. - 1.8" ARC over SAMI  10. - 2.4" DGAC control
3. - 1.8" ARC (2-Parts)  11. - Single SAM
4. - 1.8" DGAC control  12. - Double SAM (2 Parts)
5. - 2.4" DGAC control  13. - Plus Ride (3 Parts)

1988 Survey Observations and Photo Reference: The ARC is performing very well. The standard DGAC have, with the exception of the 6-inch overlay, been sealed or overlayed by maintenance. The Plus Ride has some raveling problems on all sections with some bleeding at the beginning of the Plus Ride test sections. Cracking is less than 5% in both the ARC and Plus Ride. The SAM & SAMI were not adequate or effective after 5 years of use. (See attached photos)
Segment Number 2, Milepost 93 -
Asphalt-Rubber SAMI with .15' AC with Asphalt-Rubber overlay surface Arz. Ref.

Segment Number 3, Milepost 95 -
No SAMI AR AC .15' overlay
Segment number 4, milepost 93.15 - 93.5 -
Plus Ride .15' overlay. Overall view.

Segment number 7, milepost 98.45 -
0.15' AC overlay. 60 to 90 % cracked.
Control Section.
Segment number 8, milepost 98.6 - control: .20' and .30' overlay
Note new chip seal required Right lane 60% cracked.

Segment number 9, milepost 98.60 - control: .20' overlay 90% cracked.
Segment number 10, milepost 98.7 - 98.8 -
Control: 0.5' overlay. Good shape.

Robert N. Doty

Comments from Reports: The comparison results indicate that a 3-inch Asphalt-Rubber Concrete overlay is equivalent to 6 inches of a standard dense graded AC in performance. Conclusion to date: "This would suggest that the service life of Asphalt-Rubber DGAC overlays under study may be considerably greater than those of equivalent thickness of conventional DGAC, at least with some combinations of traffic and climate." This also makes the initial cost of the asphalt-rubber system less than a comparable AC overlay.
State: California  
Date Constructed: 1985

Date of Survey: August 1988  
Airport: Oceanside

Location: Runway 6/24 Rehabilitation

Contractor: Sully Miller

Asphalt-Rubber Type and Supplier: Arizona Refining Company
Asphalt-Rubber porous Friction Course

Mix Design: 1/2" Max. aggregate
5-7% binder
Required 70% Immersion Compression Retention Ratio

Comparison Mixtures and Applications: No comparison - Existing surface had alligator cracks and had base failures with high percentage of cracks.

1988 Survey Observations and Photo Reference: Excellent surface. No cracks/no problems. (No photos)

State: California  
Date Constructed: August 1986

Date of Survey: August 1988  
Highway Number: I-880 (Old 17)

Location: Nimitz Freeway, near Hayward California, between Whipple Road and industrial interchanges.

Contractor: McQuire & Hester
Granite Rock Construction

Asphalt-Rubber Type and Supplier: Arizona Refining Co.; Arm-R-Shield
Project change order for experiment.
Atlus Rubber.

Mix Design: 8% Asphalt-Rubber binder
3/4" Max.

Comparison Mixtures and Applications: PCCP cracked over a mud flat area and had to be overlayed with a series of hot asphalt overlays. Reflective cracks continued to return. 1/2" of Asphalt-Rubber Concrete was tested.

1988 Survey Observations and Photo Reference: No photos, good surface and little maintenance to date.
State: California  
Date Constructed: 1987

Date of Survey: 1988  
Highway Number: U.S. 101

Location: From San Mateo County Line to 0.1 mile north of Army Street crossing. (3 miles)

Asphalt-Rubber Type and Supplier: International Surfacing Inc.

Mix Design: Asphalt-Rubber open graded  
1/2 max. aggregate  
7.5% A-R binder.

1988 Survey Observations and Photo Reference: Good surface with very high ADT, no maintenance to date. No photos.

State: California  
Date Constructed: 1987

Date of Survey: 1988  
Highway Number: I-40

Location: I-40 west bound beginning at MP 106.4  
1st mile - Asphalt-Rubber Concrete (ARC) (MP 106.4 - 106.9)  
2nd mile - Plus Ride (MP 106.9 - 107.9)

Contractor: Desert Construction

Asphalt-Rubber Type and Supplier: Rubber - Atlas Rubber (16%)  
AC - Edginton

Mix Design: 6-7% Asphalt-Rubber binder

Comparison Mixtures and Applications: ARC, Plus Ride & standard mix

1988 Survey Observations and Photo Reference: 1988 - 11/19 - 
Asphalt-Rubber performing very well.  
Plus Ride showing signs of bleeding in several areas.

ARC
After one year, no problems.
Comments from Reports: Caltrans will evaluate project periodically and will report.

State: California  Date Constructed: August 1987
Date of Survey: 1988  Highway Number: San Jose Streets
Location: San Jose, California
Contractor: Raisch Products
Asphalt-Rubber Type and Supplier: International Surfacing, Inc.
Mix Design: 3/4" dense graded with 7.2% Asphalt-Rubber binder
82% AR-4000 & 18% rubber
Lab density 149.5 PCF
2% air voids, 2500 stability with 18 flow.

Comparison Mixtures and Applications: City designed overlays reportedly cracked within 2 years after placement. The ARC design called for planing off the top 1 to 2-inch existing asphalt concrete. The ground surface received a fabric membrane or interlayer followed by 1 to 2 inches of Asphalt-Rubber concrete. No crack preparation nor valve adjustment was done. Excellent surface to date.
1988 Survey Observations and Photo Reference: Pavement is performing very well.

Pre-prepared street surface by grinding to correct the ride and grade.

ARC compaction and finished surface.
State: Connecticut Date Constructed: 1980
Date of Survey: 1988 Highway Number: S.R. 79 & 80
S.R. 79 N.B.L. 898 feet.
Contractor: Connecticut DOT Maintenance Forces
Mix Design: 20% Rubber
80% AC-20
7.5% Total binder in mix
1.5% Rubber of total mix
Comparison Mixtures and Applications: Standard mix had, after six years, 10 times the longitudinal cracks than the ARC mix and about 7 times more transverse cracking.
1988 Survey Observations and Photo Reference: (No photos)
Report by Conn. DOT (Ref.: 8 and 12) is available.
Reference Reports by Others: "Six-year Evaluation of an Asphalt-Rubber Hot Mix Pavement", Dr. Charles Dougan, Director of Research and Materials (Ref. No. 12).
Comments from Reports: The mix design was not a pre-reacted Asphalt-Rubber binder with as high as 3.0% rubber in the total mix. Time indicates that a reaction has occurred, although it is not complete.

State: Delaware Date Constructed: 1986
Date of Survey: (Telephone) 1988 Highway Number: Dover Downs
Location: Dover Downs Race Track; Dover, Delaware
Contractor: Tilcon Delaware, International Seal Inc. and others
Asphalt-Rubber Type and Supplier: International Seal, Inc.
Mix Design: Petromat followed by A-R Concrete leveling course. Existing surface oxidized and cracked.
1988 Survey Observations and Photo Reference: Pavement performed very well with little or no problems.

1986 Construction of Dover Downs surface.

Comments: New pavement has added higher average speeds for drivers.

State: Maine
Date Constructed: 1978-79
Date of Survey: July 28, 1988
Highway Number: 126
Location: From I-95 west towards Sabattus and Litchfield
Contractor: Maintenance Forces
Asphalt-Rubber Type and Supplier: 20% unknown rubber
Mix Design: Standard maintenance mix with 1/4" max aggregate. Used 5-6% AC without rubber. Used 6.8-7.0% with rubber. Mixed in trucks without pre-reaction. No mix design nor quality control. Approximately 1" thick.
Comparison Mixtures and Applications: Rubber in the E.B.L. and no rubber in the W.B.L. The two mixes were comparable for 3 years, then cracking began.
1988 Survey Observations and Photo Reference: Photos show the general condition of the mix with and without rubber. The first observation indicates no differences between lanes. However, the close examination does show an improvement, due to rubber. Considerably less secondary cracking in the rubber with less spalling at the cracks and less pot holes.

Foreground - no rubber. Other lane - ARC maintenance mix.

Note little cracking in ARC on right. No Rubber on left.

Comments: This trial does not appear to contain a reacted Asphalt-Rubber. However, reaction has occurred with time, which does continually improve the mix. The Asphalt-Rubber content needs to be increased. Also, the original surface did not receive a crack filling maintenance. This is strongly recommended for cracks over 3/8" width.
State: Massachusetts  Date Constructed: November 1980
Date of Survey: July 22, 1988  Highway Number: 1A
Location: Wrentham to W. Foxboro

Design: 1-mile section on PCCP
Open graded seal with 27% voids
Band-Aids were used over joints. Mastic, followed by a fabric,
followed by a mastic, followed by the overlay.

1988 Survey Observations and Photo Reference: Excellent surface
texture with high skid resistance. The overlay was saw cut directly
over the PCCP joints. Note photo (right) shows saw cut in wrong area.

Joint response
to saw cutting.
Note filled
crack.

Saw cut joints over PCCP
used band-aids. Overall view.
State: Minnesota  
Date Constructed: October 1984

Date of Survey: July 29, 1988  
Highway Number: Minnesota S.R. 7

Location: Cosmos Jct. State Route 4 and ends at Highway 22.


Asphalt-Rubber Type and Supplier: Arizona Refining Company,  
Sparton WT24, Baker WT20 & WT16  
100% passing the No. 8 sieve.

Mix Design: AC-120/150 with 20% ± 3% rubber  
% binder 6.9 to 7.9  
% 20.2% rubber  
3/4" semi open graded (See Ref. Report 17)  
Rice's Void % 7.1 to 8.2  
Marshall stability 2,000 to 3,000

Comparison Mixtures and Applications: Comparative study to be concluded in the winter of 1988-89 by MN DOT

1988 Survey Observations and Photo Reference: Test section #1 has transverse cracking every 15 to 30 feet. Cracks were filled as shown in the photos. This section had 1-1/2" A-R hot mix wearing course. Difficult to find rubber in mix. Surface texture is very good as compared to the standard mix.

Test Section #1: Cracked surface filled. No apparent rubber.
(Above) Test Section #2
No Asphalt-Rubber in shoulder, note crack.
Asphalt-Rubber surface very good, little or no cracks.

(Right) Test Section #2
Overall view. No cracks.
Very good condition.

(Below) Test Section #2
Note excellent condition.
Shoulder cracks in Non-ARC.
Test section #2 had cracks from 75 to 150 feet, excellent surface. Shoulders did not have A-R. Photos show shoulder cracks stopping in the A-R.

Non-ARC shoulder cracks stop at ARC surface.

Reference Reports by Others: Construction report - Physical Research Study 389 (PRS 389) "Asphalt-Rubber for Construction and Maintenance" Minnesota Department of Transportation. (Ref.: 17)

Comments from Reports: Based upon the report by MN DOT, the time of the year was questionable for the construction of ARC. Densities were not obtained, although the mix design appeared to be proper. Rain caused some problems. However, the control sections were placed under identical conditions. The test section #2 appears to be performing very well. There is no indication of the pavement condition prior to the overlay.

State: Oklahoma
Date of Survey: July 22, 1988
Date Constructed: July 1982
Highway Number: State Hwy 3, US 270
Location: 6.5 northwest of major county line and extended 7.5 miles into Woodward County northwest of Selings. S.R. 282 (71)
Contractor: Broce Construction Company
Asphalt-Rubber Type and Supplier: Plus Ride by Plus Ride; Overflex by Sahuaro Petroleum and Asphalt Company; Arm-R-Shield by Arizona Refining Company; Fabric Interlayer by Dupont and Oklahoma Standard Mix
Mix Design:

<table>
<thead>
<tr>
<th></th>
<th>Plus Ride</th>
<th>Overflex</th>
<th>Arm-R-Shield</th>
<th>Standard</th>
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<tbody>
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<td>8.2</td>
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Comparison Mixtures and Applications: All test sections were 2-inch overlays on a 1978 asphalt concrete exhibiting transverse cracking at intervals of 15 to 35 ft. with 0.2-inch ruts.

1968 Survey Observations and Photo Reference: The Arm-R-Shield has been overlayed in the traveled way with micro surfacing. The surface reflected the existing pavement cracks six months after construction. 60% of cracks returned according to ODOT. The overlaid surface is cracked every 20 to 50 feet. Very little cracking on shoulder where seal had not been applied. Plus-Ride has been overlayed with a micro surface. Several cracks exist with raveling and secondary cracking.

Arm-R-Shield overlaid with micro surfacing. Note shoulder cracks.

Plus Ride left on shoulder. Note rubber particles.
Overflex No cracks or rutting, excellent surface.
Standard (with the fabric) has cracks every 30 to 50 feet with secondary cracking developed.


Comments from Reports: The costs were considerably higher for the rubber mixtures but, if reflective cracking is retarded and higher performance levels are met, then the Asphalt-Rubber mixtures may be useful. Arm-R-Shield cracked the first six months and had to be overlayed, plus other maintenance. Overflex is performing excellent. Plus Ride has been overlayed and is bleeding. The standard has cracked to reflect the crack pattern in the original pavement.
State: Oregon  
Date Constructed: 1984-85

Date of Survey: 1988  
Highway Number: 97

Location: 9.9 miles south of Bend on Highway 97. 16.86 miles total test sections. Asphalt-Rubber Concrete: 1 mile.

Contractor: R. L. Coats

Asphalt-Rubber Type and Supplier: Arizona Refining: Arm-R-Shield

Mix Design: Oregon DOT Class E and Class C. Asphalt-Rubber Range set at 4.8 to 9.6 for Class C and 4.8 to 10.8 for Class E.

% Rubber: 20 ± 2

Paving placement temperature - Class "C": 340° F.  
Class "E": 240° F.

Comparison Mixtures and Applications:

Section 1 (MP 155.3 to MP 155.8) - 3/4" of Plus Ride 8

Section 2 (MP 155.8 to MP 156.3) - 3/4" of Class "E" Mixture with Fibers

Section 3 (MP 156.3 to MP 156.8) - 3/4" of Class "E" Mixture with Arm-R-Shield

Section 4 (MP 158.7 to MP 159.2) - 1-3/4" of Plus Ride 12

Section 5 (MP 159.2 to MP 159.7) - 1-3/4" of Class "C" with Fibers

Section 6 (MP 159.7 to MP 160.2) - 1-3/4" of Class "C" with Arm-R-Shield

1988 Survey Observations and Photo Reference: Below photo: Asphalt-Rubber mix section showing how crack in shoulder, which is regular mix with Pave Bond and lime added, stops when it gets to Asphalt-Rubber.
General good appearance of Asphalt-Rubber mix section.

State: Oregon  Date Constructed: 1985
Date of Survey: 1988  Highway Number: County Road 367

Location: From So. Jefferson Junction, MP 235 south 2.6 miles to Murder Creek Interchange on I-5. Linn County.

Contractor: Wildish Sand & Gravel Co.

Asphalt-Rubber Type and Supplier: Arizona Refining Co.: Arm-R-Shield

Mix Design: Asphalt-Rubber Concrete - Placed on a chipped SAMI at 1-inch thickness using open graded with 8% Asphalt-Rubber binder.

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<th>Sieve Size</th>
<th>% Passing</th>
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Comments: ADT 2,000 to 2,500.
No photos or survey observations.
State: Oregon  
Date Constructed: July 1986

Date of Survey: 1988  
Highway Number: County Road 24

Location: From Lacomb Road to State Highway 226, a distance of 3.9 miles - Linn County.

Contractor: Morse Brothers

Asphalt-Rubber Type and Supplier: Arizona Refining Company

Mix Design: SAMI - 0.55 to 6.0 gal./sq. yd. followed by 3/8" nominal aggregate.

Asphalt-Rubber Concrete - placed on the chipped SAMI. ARC placed 1" thick using open graded with 8% Asphalt-Rubber.

<table>
<thead>
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<tr>
<td>200</td>
<td>0-2.5</td>
</tr>
</tbody>
</table>

1988 Survey Observations: Cracked surface with some maintenance seals, etc. Fair condition. ~ ? In 1987, it was perfect

Comments from Reports: ADT is 1400 with 30% logging trucks.

State: Utah  
Date Constructed: 1980

Date of Survey: (Telephone) 1988  
Airport: No. 2 - Salt Lake City

Location: Airport No. 2 - Salt Lake City

ACAP 7-49-0032-03
El. 4,200 feet
Runway & taxiway

Contractor: Geneva Rock Products

Asphalt-Rubber Type and Supplier: Arizona Refining Co.: Arm-R-Shield

Mix Design: % binder 10
% Rubber in binder 20
% Rubber total 2.0
Stability 1200
Flow 30
1/2" open graded slag agg.
Comparison Mixtures and Applications: Existing surface was crack filled and overlayed with A-R followed by a 3/4" overlay.

1988 Survey Observations and Photo Reference: Both runway and taxiways have less than 5% crack reflection with little or no maintenance except for some crack filling. (No photos) Sherry Seal was applied to runway only in 1989.

Reports by Others: "Maintenance has been zero since applications" (quote from maintenance supervisor)

State: Utah Date Constructed: 1981
Date of Survey: June 13, 1988 Airport: St. George
Location: St. George City Airport - St. George, Utah El. 2880 ADAP 6-49-0030-05

Contractor: Childs Construction
Asphalt-Rubber Type and Supplier: Arm-R-Shield
Mix Design: 7.5-8.0

Comparison Mixtures and Applications: 1-inch overlay on cracked asphalt concrete surface. 7.0% binder was used. 1" cracks existed in original surface with no crack preparation prior to overlay.

1988 Survey Observations and Photo Reference: No cracks have reflected through the Asphalt-Rubber overlay as pointed out by the inspector. The surface needs to be sealed. Surface has lost fines. Some crack filling has been done with asphalt by UDOT. The general surface is very good considering the reported pre-existing condition of the surface.

Looking south at runway: note crack filling outside center.
Shoulder cracks in original pavement stopped by Asphalt-Rubber overlay.

Comments from Reports: The mix needs 1 to 2% more binder to stop the raveling. Also aggregate had too many tiny fines.

State: Utah  Date Constructed: 1982
Date of Survey: July 14, 1988  Airport: Knab Utah
Location: Knab Utah Airport  
El. 4925 ft.
ADAP 7-49-0013-02
6200 x 75' Runway plus parking area

Contractor: Dunn Construction Company

Asphalt-Rubber Type and Supplier: Arizona Refining Co.: Arm-R-Shield with 1/2" aggregate

Mix Design:
% Binder  7.5-8.0
% Rubber AC  20
3/4" Open graded mix

Comparison Mixtures and Applications: Quality control and design by Creamer and Noble at St. George, Utah. No comparisons were made.

1988 Survey Observations and Photo Reference: Very good runway surface. Note cracks stop in rubber mix. See photo --. Note longitudinal cracking at construction joints. The thicker the overlay, the more cracks show. No cracks in 1-inch or less overlay. The parking area (an undesigned area) was added to the construction. It has 1" wide cracks with water rising to the surface. The thickness is unknown. However, it is working well under the high water table problem. See photos.

Comments from Reports: Comments by the airport users and managers are that no maintenance has been done and it is in excellent shape.
Knab Utah Airport

Shoulder condition indicating the pavement condition before Asphalt-Rubber overlay.

Surface texture of Asphalt-Rubber overlay. No cracks.
Knab Utah Airport

Runway looking north. No cracks.

Note transverse crack stops at Asphalt-Rubber.
State: Utah                      Date Constructed: 1983

Date of Survey: June 13, 1988   Airport: Milford

Location: City of Milford Airport
          AIP 3-49-0019-01
          El. 4962 feet
          5000 ft. runway

Contractor: R.A. Childs, Inc.

Asphalt-Rubber Type and Supplier: Arizona Refining Co.: Arm-R-Shield

Mix Design:
  % Binder 8
  % Rubber in AC 20
  1/2" Semi open graded 3/8" mix

Comparison Mixtures and Applications:

1988 Survey Observations and Photo Reference: Runway was overlayed in 1987 due to cracked raveled surface. There was little or no quality control on the rubber mix by the contractor or the consulting engineer. Those that were involved indicated the binder varied from 4 to 10%. The mix was not rolled to obtain densities nor was the aggregate in specifications. The project was completed in the late fall, causing some cold weather problems. This project had every potential ingredient in it to cause a failure, whether it had rubber or not.

![End of runway is the original ARC. Good condition.](image)

Comments from Reports: The rubber is in the mix as shown on the shoulders and ends at the runway. The project failed in about 3 years. However, most any applications would surely fail under the same conditions.
State: Washington  Date Constructed: 1983
Date of Survey: 1988  Highway Number: I-405
Location: Renton, Washington - S Curve

Asphalt-Rubber Type and Supplier: Arizona Refining Company

Comparison Mixtures and Applications: Standard overlay with standard mix, Plus-Ride and Arm-R-Shield

1988 Survey Observations and Photo Reference: Standard has cracked. Arm-R-Shield (ARC) is in excellent condition with one flush spot.

Southbound lanes were hot-mix overlay with Asphalt-Rubber binder.

This one flushed spot in right wheel path was the only blemish.
Northbound lanes were overlayed with Plus Ride. Plus Ride bleeding and has been patched.

State: Washington
Date Constructed: 1983-84

Date of Survey: 1988
Highway Number: (Park road)

Location: Lake Crescent Highway, Olympic National Park, Log Road. 1,200 log trucks per day.

Asphalt-Rubber Type and Supplier: Arizona Refining Company
Mix Design: 7.2% binder.
Testing for stripping action.

Comparison Mixtures and Applications: Immersion compression comparison test with and without additives and/or fillers. The four options which were considered to repair the Lake Crescent project are:

1) Place a double chip seal with either polymerized CRS-2 or with rubberized asphalt, like Arm-R-Shield.
2) Place a friction course using Arm-R-Shield or polymerized asphalt.
3) Place a thin lift of Plus-Ride aggregate rubber system.
4) Place a 2-inch overlay, after repairing structurally inadequate sections (for skid resistance, a chip seal or friction course will be placed over this)

Comments from Reports: By Liddle and Richardson (Ref.: 20)
State: Washington  Date Constructed: 1986
Date of Survey: 1988  Highway Number: I-5
Location: Vancouver Columbia River to 39th Street  
MP 0.28 to 2.42
Contractor: Cascade Construction Co.
Asphalt-Rubber Type and Supplier: Arizona Refining Company
Mix Design:  
AC-20  
20% Rubber  
7% Total Binder  
Open graded friction course
Comparison Mixtures and Applications:  
1) Control  
2) Polymer-Asphalt  
3) Asphalt-Rubber with fog seal  
4) Asphalt-rubber without fog seal
1988 Survey Observations and Photo Reference: Asphalt-Rubber sections have retained a dark color, indicating perhaps less oxidation. (See photos) All test sections, including the control, are performing very well after three years. Very high traffic count.
Reference Reports by Others: "Asphalt-Rubber Open-Graded Friction Course", Washington DOT, Keith W. Anderson (Ref.: 19)
Comments from Reports: Concern expressed about testing for quality control has been solved by industry. Quality tests and standardization of ASTM testing for quality have been used.

Three lanes on left (northbound) are hot-mix overlay with Asphalt-Rubber binder.
3 lanes (southbound) - The slow (truck) lane is hot-mix with C-20R. The other two lanes are hot-mix with Asphalt-Rubber.

State: Wyoming
Date of Survey: July 7, 1988
Location: Rock Springs
Date Constructed: 1979
Airport: Rock Springs
Location: Rock Springs
E1. 6750
New Construction - 10,000 x 150' Runway
Exist. with overlay - 4,500 x 75' Runway
Contractor: Brasel & Sims
Asphalt-Rubber Type and Supplier: Arizona Refining Company
Mix Design: Open to dense graded ARC
Mix Unknown
Indications by Eng. 20% Rubber
Files are lost.

Comparison Mixtures and Applications: Two designs were used:
1) ARC directly over existing stressed asphalt concrete.
2) New asphalt concrete, full depth, with ARC in top 2 inches.

1988 Survey Observations and Photo Reference: New runway with ARC does not have any cracks except at the cross taxiway longitudinal contact or construction joints. The runway has small pop out areas in the ARC varying from 3 to 6 inches wide. Water has settled in the semi-open graded mix and has frozen, causing the ARC to pop out.

The overlayed runway did have reflective cracking and these cracks have been filled as shown in photo.

The surface of both runways is excellent with little or no maintenance, except a flush coat of SS-1h, in 9 years.

This project is one of the most impressive ARC applications to show the Asphalt-Rubber does extend the pavement life.
Rock Springs, Wyoming Airport

East-west runway exit.
No cracks, good surface.

East-west runway with new construction capped with ARC.
No cracks for 10,000 feet, except for turn out construction contacts.
Diagonal runway condition with ARC on to an existing AC. Note cracks filled.

East-west runway on new construction with full depth AC with ARC surface. Note construction joint crack.

Comments from Reports: The new runway pavement should be cored to obtain the physical properties of the sealed asphalt concrete to verify Schnormeier's and Way's reports on reduction of aging or hardening of the binder. (Ref.: 3 & 20)

1990 planned airport development will place a 1-inch ARC friction course on total runways and taxiways for continued preventative maintenance.
State: Wyoming  Date Constructed: November 1981
Date of Survey: July 8, 1988  Highway Number: No number
Location: U.S. Highway 287 north of Rawlins at MP 15.1
Union Oil Sweetwater Uranium Project
2" overlay
Asphalt-Rubber Type and Supplier: Rubber blend 50%, IMT-20, 50% G-362.
Source of rubber unknown.
Mix Design: Extender oil use 4%
Asphalt Cement  76%
Rubber  20%
Comparison Mixtures and Applications: Placed in November under snow conditions with no quality control or tests. The densities are not known. Uranium project closed down in 1984. 5 to 10 vehicles per day use the road since 1984.

1988 Survey Observations and Photo Reference: The pavement has not been used since 1984. Most pavement surfaces oxidize and harden without use. A standard AC mix normally cracks and allows grass to grow and water to enter the subgrade, causing further cracking. This pavement has transverse cracks every 15-25 feet, with some shoulder longitudinal cracks. The overall surface is 20-40% cracked, with a good surface texture and smooth ride.

The Asphalt-Rubber is very dead and the rubber has lost some of its elastic properties.

There has not been any maintenance on the pavement for 8 years.

The surface can be renewed by rejuvenating the asphalt and sealing the cracks.

General condition.
Longitudinal cracks on edges.
Not a rubber problem.

Typical transverse crack condition after eight years.