Asphalt-Rubber Chip Seal and Polymer Modified Asphalt-Rubber Two Layer System, Case Studies

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ABSTRACT. *This paper discusses the design and construction of two recently completed projects. One project represents the largest tonnage of asphalt-rubber placed as part of a highway chip sealing operation in Arizona. The other project describes a related asphalt rubber like seal coat project placed in a residential area. These two specific project case studies provide substantial detail about the application of asphalt-rubber chip seal and polymer modified asphalt rubber two layer pavement preservation system (double chip seal). The paper describes the initial pavement preservation concept introduction to each specifying agency, drafting of specifications, project advertisement, bidding and the construction of each project. Although only these two projects are reviewed they represent asphalt-rubber pavement preservation systems that have become viable alternative strategies when considering pavement preservation of severely deteriorated asphaltic concrete pavements that have very little remaining options for rehabilitation.*

Focus is directed towards these two specific projects, the binder/chip seal design and application techniques which were specified to successfully complete these two very important projects. Further discussion reviews the life cycle cost benefit associated with each project, along with initial cost compared to alternative construction methods, in-place performance under traffic and the varied climatic conditions associated with each project. Pre-existing pavement condition will also be discussed as part of the determining factor(s) for materials application rates and construction procedures which have proven to effect long term performance.

KEYWORDS: *asphalt-rubber, chip seal, polymer modified, two layer system*

1. Background

Asphalt-rubber (AR) is a binder used in various types of flexible pavement construction including surface treatments and hot mixes. According to the ASTM definition asphalt-rubber is “a blend of asphalt cement, reclaimed tire rubber, and certain additives in which the rubber component is at least 15 percent by weight of the total blend and has reacted in the hot asphalt cement sufficiently to cause swelling of the rubber particles” [1]. In addition asphalt-rubber physical properties fall within the ranges listed in ASTM D 6114, [2]. Recycled tire rubber or scrap tire crumb rubber is used for the reclaimed tire rubber portion of asphalt-rubber binder. The asphalt-rubber is formulated and reacted at elevated temperatures and under high agitation to promote the physical interaction of the asphalt cement and scrap tire crumb rubber constituents, and to keep the scrap tire crumb rubber particles suspended in the blend. The two projects described in this report applied AR as a chip seal coat in a manner as shown in Figure 1.

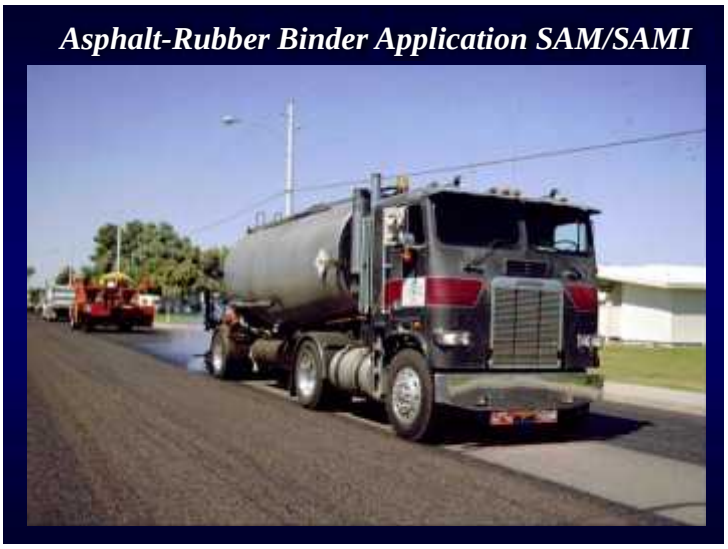

Figure 1. *Asphalt Rubber chip seal operation*

The AR binder properties are such that it can be applied at a much higher application rate than an ordinary chip seal coat. The chip seal application rate of AR binder can range from 2.4-3.4 liters/square meter (0.50 – 0.70 gallons/ square yard) depending upon many factors such as chip seal size, embedment, pavement porosity and traffic. The application rate of stone chips can vary from 11.0-16 kg per square meter (20-30 pounds/square yard). Oftentimes it is recommended that the aggregate be pre-coated with 0.5-1.0 percent asphalt. The Federal Highway

Administration (FHWA) recommended an AR chip seal coat, also referred to as a stress absorbing membrane (SAM), binder and aggregate design procedure [3]. The AR SAM design procedure is further elaborated on in ASTM D 7564 [4].

2. Navajo Nation AR Chip Sealing Project

The Navajo Nation is located in the four corners area of the southwest United States and encompasses an area that is within the states of Arizona, Utah and New Mexico, Figure 2. The Navajo Nation covers an area of 71000 km^2 (25000 square miles) and has a population of 300000. It is located in the Four Corners area and is considered a high desert, albeit it also has high mountains as well. The climate is very severe with air temperatures in the winter as low as -30 ºC (-22 ºF) to as high as 38 ºC (100 ºF) in the summer. Precipitation comes in the form of thunderstorms in the summer and snowfall in the winter but overall the precipitation is 0.2 to 0.5 m (8 to 20 inches) per year. Due to the sparse population traffic is very light generally less than 1000 ADT with many routes with less that 200 ADT. Heavy truck traffic is minimal.

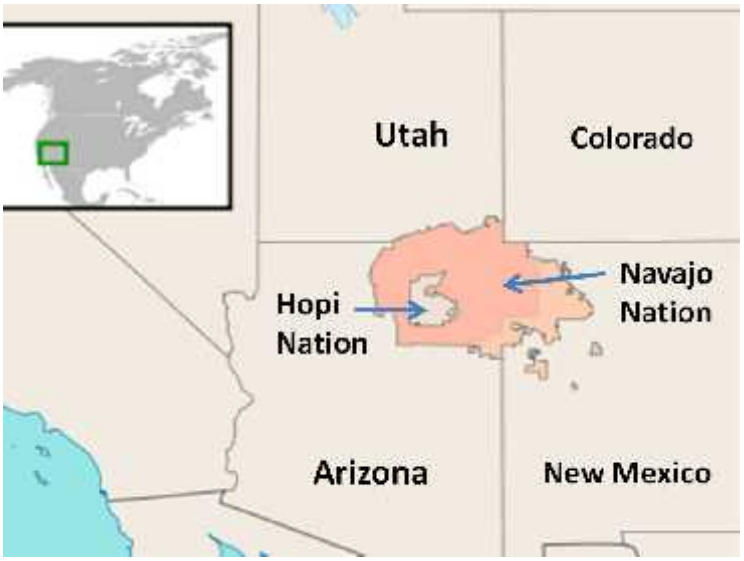

Figure 2. *Navajo Nation*

The largest AR chip seal project ever constructed was awarded by the Bureau of Indian Affairs (BIA) on behalf of the Navajo Nation in 2010 and the work completed in 2011. AR chip seal was selected because it is robust enough to withstand the extreme climate. The following is a list of the project facts:

- Total Mileage – Approximately 615 centerline Kilometers (370 centerline miles)

- Square Yardage – Approximately 7 Million Square Meters (6 million square yards)
- Asphalt-Rubber Binder – Approximately 16700 Metric Tons (18370 tons)

Standard AR Binder 81.5% PG 64-22/18.5% 14 Mesh Crumb Rubber

- Tires Recycled – Approximately 550000 Tires
- Aggregate – Approximately 115000 Metric Tons (4 Suppliers) (125000 tons)

Standard 9.5 mm (3/8 inch) Aggregate (Bureau of Iindian Affairs Stringent Requirements)

- Fog Seal Emulsion – Approximately 2900 Metric Tons (3200 tons)
- Man Hours – Approximately 35,000 Hours

The work was complicated by the vastness and remoteness of the Navajo Nation which is very sparsely populated. The pavements were in fair to poor condition and in places needed considerable pre-work preparation before the AR chip seal could be applied, Figure 3.

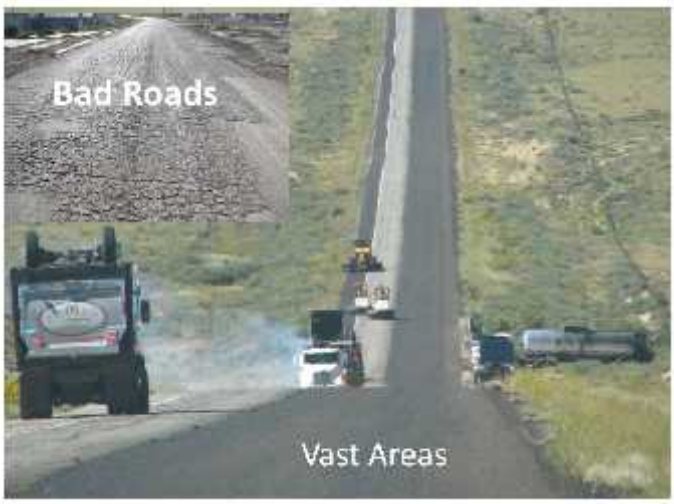

Figure 3. *Navajo Nation pavement*

Summer dust storms and thunderstorm rains contributed to delays. Even with logistical and weather constraints a very successful chip seal project was completed, Figure 4 and Figure 5.

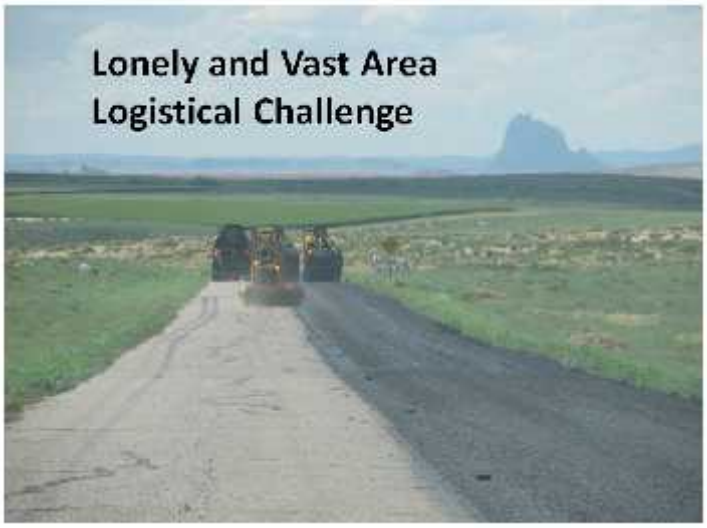

Figure 4. *Navajo Nation AR construction*

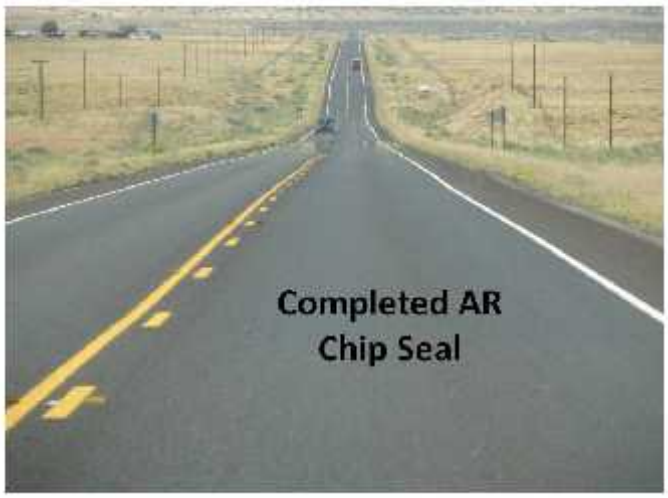

Figure 5. *Navajo Nation AR completed construction*

2. Scottsdale Residential AR Chip Sealing Project

In Scottsdale, Arizona a home owners association (HOA) contracted for an asphalt-rubber chip seal as the first layer followed by a polymer modified rubberized second layer. The HOA is located in the northern reach of Scottsdale in the foothill area, Figure 6. It is a desert area with some freezing in the winter. Air

temperature is as high as 44 C in the summer and as low as -4 C in the winter. It is mild to hot climate. Annual rainfall is less than 0.2 m (8 inches) per year and snowfall is very rare. The traffic is residential in nature and very light. The pavements to be chip sealed were in a wide range of conditions from excellent to poor in a few locations, Figure 7. Most of the distress was related to transverse cracks caused by aging of the pavement. The first chip seal layer was a typical AR SAM chip seal. The second layer is referred to as a rubberized asphalt binder (RAB). The RAB consisted of 91 percent PG 64-14 asphalt, 7 percent #30 mesh crumb rubber from scrap tires and 2 percent SBS polymer [5]. The three materials are blended together and sheared in a Sieffert mill in such a many as to make particulate type of rubberized asphalt [6]. The blended RAB can be tested in a Dynamic Shear Rheometer in a manner consistent with the AASHTO PG grading [7]. Table 1 shows the properties of the RAB. The RAB was applied at a rate of 1.14 to 1.32 liters per square meter (0.25 to 0.28 gals/square yard). A 12mm (1/2 inch) top size aggregate was applied to the RAB at a rate of 6 to 9 kilograms per square meter (11 to 16 pounds per square yard) and after sweeping and brooming the chip seal was completed and in excellent condition, Figure 8.

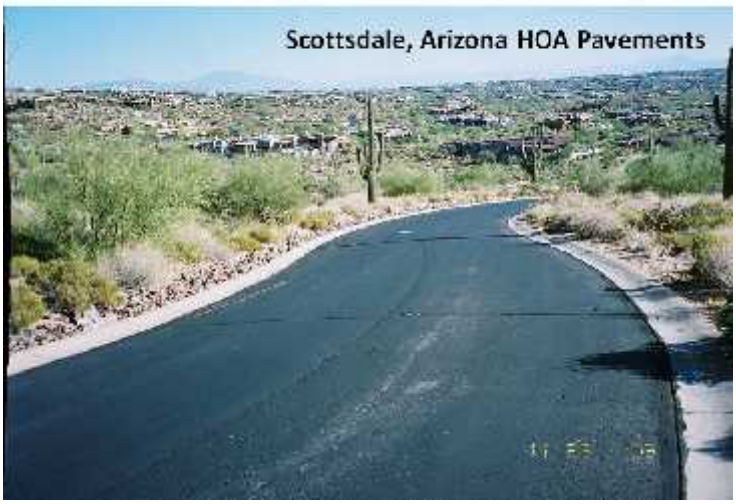

Figure 6. *Scottsdale HOA area*

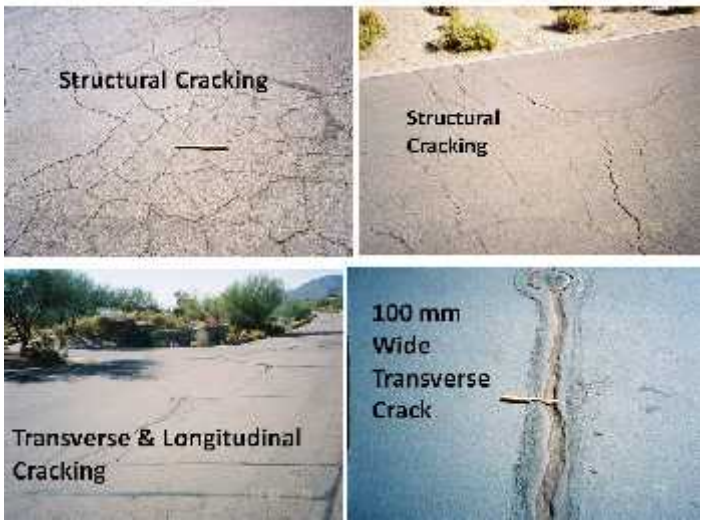

Figure 7. *Scottsdale HOA pavement condition*

Figure 8. *Scottsdale HOA completed double AR chip seal*

Table 1. *RAB Physical Properties*

Orig. RAB Binder Test	Test method	Spec.	Test Result
Apparent Viscosity, 177 C, cPs	ASTM D6114	200-1000	303
Penetration, 25 C, 100g/sec, dmm	ASTM D5	40-80	45
Softening Point, ºC	ASTM D36	60 min.	61
Resilience, 25 ºC, %	ASTM D5329	20 min.	27
Dynamic Shear, G*/sinx, kPa, 76 ºC	AASHTO T315	1.00	1.57
Elastic Recovery @ 25 ºC, 20 cm, Elongation 5cm/min, 1hr Recovery	AASHTO T301	55 min.	64.6

3. Conclusions

These two projects demonstrate two types of rubberized asphalt used in a seal coat type application. The Navajo Nation chip sealing project was the AR binder with more that 15 percent particulate crumb rubber used in a traditional manner and placed over a very badly distressed pavement as shown in the figures. This use of AR chip seal preservation system has typically been used on pavements in the Navajo nation on pavements in poor condition and with exceptionally low traffic and severe climate.

The second type of rubberized asphalt used on the Scottsdale project is a combination of the AR chip seal with the RAB binder used in a manner similar to a Cape Seal ASTM D7564 [8]. The RAB binder with seven percent ground tire crumb rubber and two percent SBS is a new innovation which is made in a non-proprietary manner. RAB binder can be tested and AASHTO PG graded. The combination of the two rubberized materials anecdotally appears to provide a smoother riding surface than a typical seal coat and it can typically maintain good skid resistance comparable to a typical chip seal coat.

Rubberized asphalt binders (RAB) using ground tire rubber (GTR) in amounts more or less than 15 percent by weight of the binder are beginning to cover a wider

range of formulations employing particulate GTR which may be helpful to wider acceptance. The ability to PG grade these binders containing GTR in a particulate form is under investigation and may soon become common which may very well make such binders more acceptable in all types of uses including chip seal coating.

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