Session 4.0

Historical Development

by

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4.0 Contents

4.1 McDonald Technology .................. 4-3
4.2 PlusRide Technology .................... 4-5
4.3 Generic Dry Technology ................. 4-6
4.4 Continuous Blending Technology ....... 4-6
4.5 References .............................. 4-7
History of Use of Crumb Rubber in Asphalt Paving Materials

The potential benefits of adding rubber to asphalt cement have been discussed for many years however its use was delayed due to lack of technology and equipment to economically mix the rubber in asphalt cement. The use of natural rubber in asphalt cement was first introduced in the 1840's. The concept of adding tire rubber to asphalt cement was developed in the 1950's. Flintseal Corporation and U.S. Rubber Reclaiming reacted crumb rubber and asphalt cement in the laboratory in the early 1960's. But it was not until 1964 that the use of crumb rubber modifier (CRM) in asphalt mixtures was first applied on an existing pavement.

In 1964 Charles McDonald who worked for the city of Phoenix developed a method to add small ground scrap rubber to asphalt cement. The waste tires used vulcanized rubber to provide a material that would provide desirable properties in the asphalt cement. These techniques allowed the rubber to be processed and added to asphalt cement at a lower cost than had earlier been practical.

A “band-aid” test patch of asphalt rubber was placed in 1964 at Sky Harbor Airport in Phoenix and on U.S. Route 666. Extensive field testing was performed at Sky Harbor Airport in 1965. This mixture, which was placed by hand, appeared to perform satisfactory and encouraged the city to continue to evaluate this material. The primary use of this “band-aid” patch was to delay or prevent cracks from reflecting through the asphalt rubber surface. This material did seal the existing cracks and provided a waterproof seal for many years.

After placing the section in 1964 in Phoenix, no more asphalt rubber was placed until 1967. During this time the original sections were monitored to evaluate potential performance. The performance of these sections was satisfactory for three years and additional sections were placed by hand in 1967.

In 1968 the first asphalt rubber sections were placed with a slurry seal machine. During this year the liquid asphalt rubber was also applied with an asphalt distributor followed by an application of chips. This is commonly referred to as a stress absorbing membrane (SAM). Use of the slurry seal machine and asphalt distributor improved the quality of the application and also greatly increased the production capacity.
allowed the construction cost of the asphalt rubber section to drop considerably. At this time the supplier of SAMs was the Sahuaro Petroleum and Asphalt Company.

The biggest problem with most surface treatments is loose aggregate, and the same is true with SAMs. Partly because of this loose aggregate problem, some of the SAMs were overlaid with Hot Mix Asphalt (HMA) to minimize the problem. When a SAM is used prior to an overlay, it is called a Stress Absorbing Membrane Interlayer (SAMI). The first SAMI was placed in 1971 by the city of Phoenix. Arizona DOT placed its first SAMI in 1972 on I-40 along with several other test sections followed by a second section in 1975 again on I-40.

The consistency of the asphalt rubber was initially very thick. It had to be heated to a higher temperature than conventional asphalt cement and was still difficult to pump and spray. In 1972 kerosene began to be added to the asphalt rubber to lower the viscosity. This addition of kerosene improved the workability of the asphalt rubber and thus improved quality of construction.

In 1974 this mixture of asphalt cement and crumb rubber began to be used as a crack sealer. Previous work had shown this material to be very elastic and flexible, two primary properties of a crack sealer. In 1992, a survey of states to determine types of crack sealers being used showed that approximately 10 states were using asphalt rubber as their primary sealant.

Arizona Refinery Company (ARCO) in 1975 developed an asphalt rubber mixture to compete with that of the Sahuaro mix. The ARCO mix used 80 percent asphalt cement and 20 percent crumb rubber, including de-vulcanized CRM, along with an extender oil instead of kerosene. These two technologies eventually merged between 1983–1985 and became known as the McDonald technology.

Some initial problems with the SAMI were caused by the roughness of the existing pavement being overlaid. When the surface is rough the SAMI is difficult to construct with consistent quality resulting in less than desirable performance. In 1975 a three-layer system was developed and constructed to help solve the roughness problem. This three-layer system consisted of a level course followed by the SAMI and overlaid with a HMA. It was effective in improving performance but the cost of a three-layer system often prohibits its use.
The first use of asphalt rubber in HMA in Arizona was in 1975. Two sections of asphalt rubber in an open-graded friction course were placed on State Route 87. One section contained 10.5 percent binder having 25 percent vulcanized rubber and the other section contained 8.5 percent binder having 20 percent devulcanized rubber. In 1978 three additional sections of HMA with asphalt rubber were placed. These three sections consisted of an open-graded friction course with three different blends of CRM and asphalt. A blender was developed to premix the CRM and asphalt in 1981-1982.

Most asphalt rubber work in the U.S. has been performed in Arizona. Between 1972 and 1978 approximately 30 miles of SAM per year were placed. Since that time, very little has been used probably because of the loose aggregate problem. Between 1975 and 1980 approximately 50 miles of SAMI were placed per year. Since that time, approximately 10 miles per year have been placed. Until 1989, approximately 55 percent of all asphalt rubber work in Arizona had been SAMI, 40 percent SAM, 6 percent moisture membrane, 3 percent open graded friction course with asphalt rubber, 1 percent three-layer system, and 1 percent low volume road construction.

California first began using McDonald’s asphalt rubber in 1978. During the ten years after 1978 California placed approximately 20 overlay projects using asphalt rubber. This work has been done with dense-graded mixes, as well as gap-graded mixes.

California first began using the asphalt rubber to improve the durability of HMA. With additional experience, California developed a design guideline in 1992 that allows for reduced overlay thickness for a gap-graded HMA with asphalt rubber on specific types of applications.

The original concept was developed by two Swedish companies, Skega AB and AB Vaegfoerbaetringar, in the late 1960’s, as a product named Rubit. The Swedish incorporated 3 to 4 percent CRM (by weight of total mix) into a HMA surface mixture. The rubber particles were 1.6 to 6.4 mm (No. 16 to 1/4-inch sieve), which were relatively large compared to CRM used in McDonald mixtures. This is a dry process which considers the crumb rubber as part of the aggregate. The Swedish technology was patented for use in the United States in 1978 under the trade name PlusRide. The mix design was refined in the mid-1980’s establishing the gap-graded mix now commonly used. This method has
been used in Alaska, Washington, Minnesota, Oregon, Arizona, and California as well as other locations.

Four corporations have marketed the PlusRide technology since it was introduced in the United States, originally All Seasons Surfacing Corp., then PlusRide Asphalt Inc., PaveTech Corp., and presently EnvirOtire Inc. All of these companies were based in the Seattle, Washington, area. EnvirOtire Inc.* retains all patent rights and establishes specific licensing agreements with contractors on a project-by-project basis. Two United States Patent Nos. 4,086,291 and 4,548,962 cover this technology. EnvirOtire, Inc. markets this technology as PlusRide II.

4.3 Generic Dry Technology

The first generic dry technology system for adding crumb rubber to HMA was developed by Takallou in 1986 as a result of his research on RUMAC at Oregon State University. This system selects a grading of crumb rubber to best fit the gradation of the aggregate to be used. This generic dry technology system is sometimes referred to as generic RUMAC or the TAK system. The first field evaluation sections of this system were placed on two projects in the State of New York in 1989. These projects placed generic dry technology RUMAC sections with 1 percent, 2 percent, and 3 percent CRM, as well as a control section and PlusRide section. It has also been examined in a number of other places including Ontario, Oregon, Illinois, and California.

Other designs using generic dry technology are also being developed. Some agencies (like Iowa and Oregon) are examining the generic RUMAC system while others are combining the theory of wet process—continuous blending with dry process construction practices. This latter system might be defined as a generic dry technology asphalt rubber system. It was first examined in Florida and is also being evaluated in Kansas.

4.4 Continuous Blending Technology

In 1988 the Florida Legislature passed Senate Bill 1192 on Solid Waste Management. This Bill required the state DOT to consider the use of CRM in HMA. Florida DOT funded a study to the National Center for Asphalt Technology (NCAT) to look at the feasibility of using scrap tires in HMA. The study was completed, Florida built test sections in

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1990 and 1991, and they have been using scrap tires in some of their mixes since that time. This was the initial development of the wet process-continuous blending technology. Since that time other states including Kansas and Iowa have used this process.


