Pre-proposal Overview for Asphalt Rubber Demonstration Projects

Information provided in this overview has been obtained from various sources where indicated. A complete list of references is included in the last section of the document.

Problem Statement

According to the U.S Census Bureau, the State of Oklahoma has an estimated population of 3.4 million. Oklahomans generate approximately one tire per person annually. Over 3 million tires are collected by recyclers on an annual basis. Based on the reporting period 2011-2013, an average of approx. 55,000 tons of tires per year and 3,429,325 tires were collected and processed. In 2014, 54,204.23 tons of tires and 3,338,570 tires were processed. Current used tire markets in Oklahoma include burning whole tires in cement Kilns for fuel, Shredding whole tires for use at landfills as daily cover, leachate collections systems and other civil engineering projects; and the production of crumb rubber for use in rubber products, mulch, and play ground material.

Recently, the use of Oklahoma used tires as fuel at cement Klins has decreased and more tires are used at landfills. In 2014, 28.60% of used tires were burned as fuel, 19.03% were used in the production of crumb rubber, and 52.37% were used at landfills as shreds which is a 10% increase from 2013. There is a need to create higher end markets that use Oklahoma used tires. The use of ground tire rubber (GTR) in asphalt is a potential new market in Oklahoma.

According to EPA (http://www3.epa.gov/epawaste/conserve/materials/tires/ground.htm), asphalt rubber is the largest single market for ground rubber, consuming an estimated 220 million pounds, or approximately 12 million tires. California and Arizona use the most asphalt rubber in highway construction (over 80% of asphalt rubber utilized). Florida is the next largest user. Ground tire rubber can be blended with asphalt to beneficially modify the properties of the asphalt in highway construction. Size-reduced scrap tire rubber can be used either as part of the asphalt rubber binder (also known as, asphalt rubber), seal coat, cap seal spray or joint and crack sealant, or as an aggregate substitution (rubber modified asphalt concrete).

Benefits of using asphalt rubber include longer lasting road surfaces; reduced road maintenance; long term cost effectiveness; lower road noise; and shorter breaking distances. For this reason, asphalt rubber is being used in greater amounts by state Departments of Transportation (DOTs). Arizona and Florida have been leaders in asphalt rubber utilization. Texas and Nebraska are currently using greater amounts of asphalt rubber. South Carolina is also pursuing utilization of asphalt rubber in construction of county and state roads. Other states that have studied and/or used rubberized asphalt include New York and New Mexico. The State of Oklahoma uses a minimal amount of GTR in road construction applications primarily consisting of chip and fog seal applications. However, the GTR currently used in these applications does not contain Oklahoma tires.

Project Scope

In order to create a more diverse demand for products that use Oklahoma used tires, the Oklahoma Department of Environmental quality (DEQ) and the University of Oklahoma (OU) School of Civil Engineering and Environmental Science (CEES) have partnered on two demonstration projects that propose the use of asphalt rubber including a three (3)-mile chip seal in Tulsa County and a hot mix overlay in Wagoner County. The demonstration projects will allow DEQ to collect metrics and data that will help in promulgating rules as required by statute. Additionally, the demonstration projects will allow us to meet the following objectives:

1. Determine feasibility of integrating Oklahoma used tires in asphalt;
2. Determine durability of roads that use asphalt rubber in construction;
3. Determine the process and cost benefit of using Oklahoma tires in GTR;
4. Encourage and increase the use of rubberized asphalt in construction of Oklahoma Roads;

Site Selection

Chip seal and fog seal project - Tulsa County

The chip seal will be constructed in Tulsa County. Located at 171st South Street and Hwy75 east to Lewis Street. The total distance for chip seal is three (3) miles long and 21 ft wide.

Hot Mix Overlay- Wagoner County

This project will be on Midway Road (257th E Ave.) a north-south road between 111th Street South and 131st Street South and will continue west on 111th Street South from the intersection of 111th Street South and Midway Road. The project is a total of 4 miles at 24ft wide. The project consists of overlaying and building on varying road and subgrade conditions which are outlined in the attachment.

Design plan

Chip Seal:

First, the road surface needs to be properly cleaned of debris and any holes patched. Next, an asphalt distributor truck starts by spraying each lane with hot liquid asphalt to assure an even application. The asphalt used is applied at a temperature between 150 and 185 degrees Fahrenheit. A chip spreader follows as rapidly as possible with a rock application, preferably within one minute. The asphalt must be fluid so the rock will be embedded by the displacement of the asphalt. The rocks are an aggregate crushed to a special specification for size and cleanliness. Next, a rubber-tire roller is used to set the rock into the liquid asphalt. Rolling orients the flat sides of the rock down and produces a tighter chip seal. It takes two to four passes of the roller to set the rock. Sweeping is done at the completion of the chip seal process to remove surplus rock from the surface. This loose rock can grind and loosen rock set in the chip seal and damage the project. Sweeping is done within four (4) hours of the rolling operation, and typically again a day or two later.

Asphalt – Hot mix Overlay:

Different states use different method. Some of the methods used by different states are discussed below. The most convenient and effective method will be selected by the group.

Summary - Arizona Department of Transportation (ADOT)

Crumb rubber is blended with the asphalt cement to form an asphalt-rubber binder. For this purpose the rubber is blended with asphalt binder at temperatures between 325°F (163°C) and 375°F (191°C) for at least one hour. This blend can be used to produce Asphalt-rubber asphaltic concrete friction course (ARACFC). The technical specification associated with ARACFC is similar to standard Asphalt Concrete Friction Course (ACFC) specifications (item 407) used in Arizona. The ACFC is used to increase safety in scenarios where high surface friction is needed to prevent accidents. The plant processes and field operations used for these mixes are nearly identical to non-asphalt rubber-modified binders. Mix design is performed according to the Arizona Test Method 814, used for other mixes, except the allowable range of percent absorbed asphalt - rubber shall be 0-1.0. However, some modifications are needed to be applied to this method when a rubberized binder is used. Mineral aggregate in the plant shall be separated into at least two stockpiles. Coarse mineral aggregate shall consist of crushed gravel, crushed rock, or other approved inert materials with similar characteristics, or a combination thereof. Fine mineral aggregate or blend material shall consist of natural sand, sand prepared from rock, or other approved inert materials, or a combination thereof**.** Bituminous material shall be asphalt - rubber conforming to the requirements as described in Section 1009 of the specifications. According to section 1009, crumb-rubber shall meet the following gradation requirements when tested in accordance with Arizona Test Method 714.

TABLE 1009-1		
Sieve Size	Percent Passing	
	Type A	Type B
No. 8	100	
No. 10	95 - 100	100
No. 16	0 - 10	65 - 100
No. 30		20 - 100
No. 50		0 - 45
No. 200		0 - 5

Table 1: Arizona department of transportation, standard specification for road and bridge construction, section 1009-1. Ref: http://www.azdot.gov/docs/business/2008-standards-specifications-for-road-and-bridge-construction.pdf?sfvrsn=0

Also, The crumb rubber shall have a specific gravity of 1.15 ± 0.05 and shall be free of wire or other contaminating materials, except that Type A crumb rubber shall contain not more than 0.1 percent fabric and Type B crumb rubber shall contain not more than 0.5 percent fabric. Calcium carbonate, up to four percent by weight of the crumb rubber, may be added to prevent the particles from sticking together. Also, The asphalt - rubber shall contain a minimum of 20 percent crumb rubber by the weight of the asphalt cement. Furthermore, asphalt rubber shall conform to the following specifications when it is produced using PG 64-16, PG 58-22, and PG 52-28 base binders:

TABLE 1009-2			
Property	**Requirement**		
	CRA Type 1	**CRA Type 2**	**CRA Type 3**
Grade of base asphalt cement	PG 64-16	PG 58-22	PG 52-28
Rotational Viscosity*: 350 °F; Pascal·seconds	1.5 - 4.0	1.5 - 4.0	1.5 - 4.0
Penetration: 39.2 °F, 200 g, 60 sec. (ASTM D 5); 0.1 mm, minimum	10	15	25
Softening Point: (ASTM D 36); °C, minimum	57	54	52
Resilience: 77 °F (ASTM D 5329); %, minimum	25	20	15
* The viscotester used must be correlated to a Rion (formerly Haake) Model VT-04 viscotester using the No. 1 Rotor. The Rion viscotester rotor, while in the off position, shall be completely immersed in the binder at a temperature from 350 to 355 degrees F for a minimum heat equilibrium period of 60 seconds, and the average viscosity determined from three separate constant readings (± 0.5 Pascal·seconds) taken within a 30 second time frame with the viscotester level during testing and turned off between readings. Continuous rotation of the rotor may cause thinning of the material immediately in contact with the rotor, resulting in erroneous results.			

Table 2: Arizona department of transportation, standard specification for road and bridge construction, section 1009-2. Ref: http://www.azdot.gov/docs/business/2008-standards-specifications-for-road-and-bridge-construction.pdf?sfvrsn=0

In order to establish the asphalt – rubber design, at least two weeks prior to the use of asphalt - rubber, the contractor shall submit an asphalt - rubber design prepared by an approved laboratory. The design shall be formulated using asphalt cement and crumb rubber that are representative of the materials to be utilized in production. The design shall show the values obtained from the required tests, along with the following information: percent, grade and source of the asphalt cement used; and percent, gradation and source(s) of crumb rubber used.

The temperature used for mixing of the asphalt cement shall be between 350 and 400 °F at the time of addition of the crumb rubber. No agglomerations of crumb rubber particles in excess of two inches shall be allowed in the mixing chamber. The contractor shall document that the amount of crumb rubber used does not deviate more than plus or minus 1.0% from the percentage specified in the accepted asphalt - rubber mix design. The temperature of the asphalt – rubber immediately after the initial dispersion of the crumb rubber into the asphalt cement shall be between 325 and 375 °F. The contractor shall ensure that the crumb rubber and asphalt cement are thoroughly mixed prior to the beginning of the react ion period. The reaction period shall be a minimum of one-hour, during which time the asphalt - rubber is continued to be mixed while a temperature between 325 and 375 °F is maintained. The reaction period shall be completed before the asphalt - rubber is used. The contractor shall demonstrate that the crumb rubber particles have been uniformly incorporated into the mixture and that they have been "wetted". The occurrence of crumb rubber floating on the surface or agglomerations of crumb rubber particles shall be evidence of insufficient mixing. Prior to use, the viscosity of the asphalt - rubber shall be tested by the use of a rotational viscotester. [An explanation for this test is given at the end of this document].

Once the asphalt - rubber has been mixed, it shall be kept thoroughly agitated to prevent settling of the crumb rubber particles. The temperature of the asphalt - rubber shall be maintained between 325 and 375 °F. If in the first ten hours after the completion of the reaction period the temperature of the asphalt - rubber drops below 325 °F, it may be reheated to a temperature between 325 and 375 °F. In no case shall the asphalt - rubber be held at a temperature between 325 to 375 °F for more than 10 hours after the completion of the reaction period. Asphalt - rubber held for more than 10 hours shall be allowed to cool and gradually reheated to a temperature between 325 and 375 degrees F before use. The reheating of asphalt - rubber that has cooled below 325 °F shall not be allowed more than one time. Asphalt - rubber shall not be held at temperatures above 250 °F for more than four days after the completion of the react ion period.

For establishing asphalt mix design using approved aggregates and the crumb-rubber binder the percent of asphalt - rubber used shall be based on the weight of total mix (asphalt - rubber, mineral aggregate and mineral admixture). In no case shall the asphalt - rubber be diluted with extender oil, kerosene, or other solvents and so contaminated asphalt rubber shall be rejected. Aggregate shall be free of deleterious materials, clay balls, and adhering films or other material that prevent thorough coating of the aggregate with the bituminous material.

When asphalt-rubber is used, a reaction tank is introduced between the asphalt cement storage tank and the drum mixer. The reaction tank is used to blend together the asphalt cement and crumb rubber. Typically a line will lead directly from the reaction tank to drum mixer with no automated control system that regulates the flow of the asphalt-rubber based on the flow of the mineral aggregate and admixture. This type of set up is unacceptable to the Department. An automated control system needs to be in place for asphalt-rubber asphaltic concrete mixing just like it does for regular asphaltic concrete mixing. Do not allow the Contractor to manually control the addition of asphalt-rubber. This method is imprecise and prone to human error that will adversely affect the consistency of the mix produced by the contractor and is unacceptable.

Summary - Missouri Department of Transportation (MoDOT)

When GTR-modified binder is characterized AASHTO T 111, Inorganic Matter or Ash in Bituminous Materials, may be substituted for AASHTO T 44, Solubility of Bituminous Materials, at the specification value indicated prior to the addition of ground tire rubber (GTR.) All blends containing GTR shall include 4.5 percent transpolyoctenamer rubber (TOR) by weight of the GTR. Trans-polyoctenamer rubber (TOR) is a mixture of linear and macrocyclic polymers that exhibit four special structural features when added to rubberized asphalt concrete: (1) Low initial viscosity during the initial mixing operation; (2) Increased viscosity after polymerization to prevent drain down; (3) Chemical bonding of the GTR to the asphalt (4) chemical bonding of the final rubberized asphalt to the aggregate to reduce stripping (5) Conversion of the thermoplastic asphalt to a thermoset polymer, which reduces cracking and rutting. Also specific requirements should be met in terms of elastic recovery and separation test.

Ground tire rubber shall be ambient ground, free of wire or other contaminating materials and not contain more than 0.1 percent fabric. Cryogenically ground rubber may be used by demonstrating that the GTR is satisfactorily suspended during all phases of production and storage. The gradation (particle size distribution) of the GTR shall be as follows:

Ground Tire Rubber	
Sieve Size	**Percent Passing by Weight**
No. 8	100
No. 16	100-96
No. 30	100-90
No. 50	20 min.

Table 3: Missouri standard specifications for highway construction, division 1000, section 1015.10.4. Ref: http://www.modot.org/business/standards_and_specs/Sec1015.pdf

FTR Modification Process: The modification process can be either in the plant (blending GTR with hot-mix asphalt in plant) or in the terminal.

Asphalt binder shall be capable of being stored at the project site without separation or settling. Automatic blending will be allowed, except no intermediate blending of asphalt binder and any other modifiers will be allowed at the project site.

Summary – Wright Asphalt Products Company Specifications for PG 64-22TR

The minimum requirements for mechanical/rheological properties of a GTR-modified asphalt binder are given in this specification, where PG 64-22 is blended with GTR to produce PG 64-22TR binder. PG64-22TR contains a minimum of 10% GTR. The whole scrap tire rubber should completely be dispersed into the asphalt cement. The product of blending (PG 64-22TR) as final material is a homogenous, stable material that is shipped from the manufacturing terminal to the jobsite. The product does not phase or separate and remains consistent over time. The following specifications are designed to ensure the performance ability of this material in the described applications it has been designed for. Explanation of each item is given below to the extent feasible:

***Original Material*:** Original material is the asphalt binder without any aging. Laboratory aging is usually performed to simulate the oxidation of binder as result of mixing in the plant (short-term aging) or during the service life of the pavement (long-term aging). Short-term aging in the lab is performed using a Rolling-Thin Film Oven (RTFO) and long-term aging is performed using a Pressure Aging Vessel (PAV).

G*/Sin δ : This parameter is called rutting factor. G* is indicator of the binder stiffness and Sin δ is indication of the viscous behavior (phase angle). These parameters are measured using a Dynamic Shear Rheometer (DSR) in laboratory (AASHTO T 315). Higher the rutting factor (**G***/Sin δ) of a binder, better the rutting resistance.

The Rotational Viscometer (RV): RV is used to determine the viscosity of asphalt binders in the high temperature range of manufacturing and construction. The RV test can be conducted at various temperatures, but since manufacturing and construction temperatures are fairly similar regardless of the environment, the test for Superpave PG asphalt binder specification is always conducted at 275°F (135°C). The RV test helps ensure that the asphalt binder is sufficiently fluid for pumping and mixing. The standard Rotational Viscometer procedure is found in AASHTO T 316 and ASTM D 4402.

Solubility: Asphalt binder, as used for HMA paving, should consist of almost pure bitumen. Impurities are not active cementing constituents and may be detrimental to asphalt cement performance. Mineral impurities can be quantified by dissolving a sample of asphalt cement in trichloroethylene or 1, 1, 1 trichloroethane through a filter mat. Anything remaining on the mat is considered an impurity. Water impurities are quantified through distillation. The standard solubility test procedure is found in AASHTO T 44 and ASTM D 2042.

Flash Point: A typical flash point test involves heating a small sample of asphalt binder in a test cup. The temperature of the sample is increased and at specified intervals a test flame is passed across the cup. The flash point is the lowest liquid temperature at which application of the test flame causes the vapors of the sample to ignite. The test can be continued up to the fire point – the point at which the test flame causes the sample to ignite and remain burning for at least 5 seconds. The standard flash point test procedure is found in AASHTO T 48 and ASTM D 92.

Creep Stiffness: As surrounding temperatures drop, pavements contract and build up internal stresses. If this contraction occurs fast enough the pavement may crack because it does not have time to relax these stresses. This type of crack, typically called a “thermal crack”, or transverse crack (because of the direction of cracking in relation to the direction of traffic). In this process thermal shrinkage initiates and propagates flaws or cracks in the asphalt binder portion of the HMA. The Bending Beam Rheometer (BBR) is a test designed to measure this stiffness and the rate of stress relaxation. Asphalt binders that are not too stiff at low temperatures and able to relax built up stresses are desirable. In this test the asphalt binder’s creep stiffness is determined as a function of time. These data can be converted to a stress relaxation modulus, which is then multiplied by a constant to predict the thermal stress produced in a HMA pavement using the constituent asphalt binder.

M – Value: Originally, the key reporting values were creep stiffness at 60 seconds and the slope of the master stiffness curve at 60 seconds, commonly called the “m-value”.

Preliminary Time Schedule:

Chip seal and fog seal project - Tulsa County.

This will be a short term project. Work can commence immediately. The time duration for this project is 2-3 days and a fog seal can be done in about two (2) weeks time. The time period for fog seal is about 1 day.

Hot Mix Overlay-Wagoner County

This project is a longer term project and may take up to six (6) to eight (8) months. Prep-work will be conducted over the winter months and asphalt will be laid in the Spring.

Budget:

Chip seal and fog seal project - Tulsa County.

The estimated material cost for the chip seal project is approx. $15,000.00. The breakdown of material cost is as follows

CRSTR Oil-4,681.60 @$2.05 gal. =$9597.28

1/2 in Chip rock-104.72 T. @$9.25= $968.66

Fog Seal Oil-1601.60 gal @ $2.00 gal =$3203.20

*This only an estimate and quantities may vary

Hot mix overlay- Wagoner County.

DEQ may provide up to $750,000.00.

References

http://www.rma.org/scrap-tire/scrap-tire-markets/

http://www3.epa.gov/epawaste/conserve/materials/tires/ground.htm

http://www3.epa.gov/epawaste/conserve/materials/tires/ground.htm

http://www.lisbonme.org/vertical/sites/%7B23BCC392-4131-4737-99E0-6C6FCE7FB2A2%7D/uploads/Chip_Seal_Fact_Sheet(1).pdf

http://www.azdot.gov/business/ContractsandSpecifications/Specifications http://www.azdot.gov/docs/business/2008-standards-specifications-for-road-and-bridge-construction.pdf?sfvrsn=0

http://www.modot.org/business/standards_and_specs/highwayspecs.htm

http://www.modot.org/business/standards_and_specs/Sec1015.pdf