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City of Colorado Springs tests Terminal Blend Tire Rubber Asphalt

Goal to improve safety, enhance driving conditions and reduce maintenance costs

Saleem Khattak, Street Division Manager, City of Colorado Springs, Colorado; **Bob Syme**, PPRTA Program Manager, Nolte Associates, Inc., Colorado Springs, Colorado

Like many cities across the nation, Colorado Springs, Colorado, has faced a variety of complex challenges related to maintaining its roadways. Surging growth in population, escalating cost of materials, roadway safety, and pavement life are issues commonly shared with other communities. However, Colorado Springs has two additional distinctive factors to contend with: climatic extremes, which impact roadway durability, and mandated limits on government spending enacted by voters more than a decade ago, impacting state and local governments' ability to keep pace with growth.

Based on these complexities, the City of Colorado Springs Street Division (the City) determined that new thinking was required to determine how best to utilize resources in meeting both current and future demands. This led to the development of a plan of action to experiment with different paving materials to address these challenges. The first experiment implemented was the use of Terminal Blend Tire Rubber Asphalt (TBTRA).

A growing city leads to growing challenges

As the second largest city in Colorado, Colorado Springs has experienced a 46 percent growth in population since 1990, expanding from 280,995 to 407,902 people. It has also added approximately 1,500 lane miles of new roads for a total network of 7,431 lane miles of paved streets, a 32 percent increase. During the same time span, the City Street Division's workforce has been reduced by 13 percent, with significant decreases in the operating budget, despite inflation and growth.

Although the City has added preventive maintenance treatments such as chip and slurry seals to its toolbox of roadway maintenance practices, the result of years of inadequate funding in its roadway infrastructure has become more and more obvious each year. Colorado's harsh winter of 2006–2007 highlighted the negative impact of continued deferred maintenance, as pavement conditions deteriorated far beyond typical wear and tear. The City's Pavement Management System suggests an average pavement quality index below 6.0, reflecting this degradation, and requiring sustainable alternatives that will perform well under extreme and variable climatic conditions.

Funding source

In November of 2004, the voters of multiple neighboring communities approved the formation of a transportation authority known as the "Pikes Peak Rural Transportation Authority" (PPRTA). The PPRTA collects a one percent sales tax that specifically funds capital improvement projects, roadway maintenance, and expanded transit services. The collected funds are split between the five-member communities proportionally based on residential population.

Additional roadway maintenance funds provided by the PPRTA are allowing the City to expand its current pavement maintenance program, while giving the City Street Division the opportunity to investigate different techniques to improve pavement surfaces and ride quality. The use of a permeable friction course (PFC) terminal blend tire rubber asphalt is one such technique.

Product research

Asphalt mixes modified with tire rubber have been in use for decades on resurfacing projects in several states, including California, Arizona, Texas, Rhode Island, Connecticut, New York and Maine. Significant information and research are available that address the benefits of tire rubber modified asphalt mixes; however, there is limited experience with this product in the conditions found along Colorado's Front Range. Based on its successful use in other parts of the country, the City was extremely curious to find out how well tire rubber asphalts would perform in Colorado Springs.

The City Street Division, along with Nolte Associates, began researching and developing specifications for the use of tire rubber asphalt for the 2006 paving season. Saleem Khattak, the Street Division Manager, and Bob Syme, Nolte Pavement Manager, traveled to Arizona in the summer of 2005 to visit several projects using rubberized asphalts. A stop was also made at the Arizona Department of Transportation (ADOT), where they were introduced to the "wet," "dry" and "terminally blended" tire rubber asphalt manufacturing processes.

Prior to visiting Arizona, local Colorado Springs contractors expressed concerns about using the wet or dry methods due to the excessive smoke and smell that would be expelled into the atmosphere during the manufacturing process of

this material at their asphalt plants. The contractors were so concerned about losing their state environmental certifications that they indicated they would not use the wet or dry methods without some assurances that their operating permits would not be jeopardized.

The Arizona DOT staff were able to explain the differences between the manufacturing methods. Khattak and Syme determined that the terminally blended tire rubber asphalt could be the most efficient and environmentally-friendly option available and selected it for testing.

Technical process

TBTRA is produced in a closed-system plant which prevents particulates from entering the atmosphere. This process also produces a more consistent and smooth homogenous blend of tire rubber with SBS polymer-modified asphalts (70-28TR) by “cooking” the blend for approximately 16 hours under pressure at temperatures as high as 425 degrees Fahrenheit. In the wet method, there is a potential of crumb rubber not breaking down into a homogenous liquid form, which could jeopardize the quality of the final product. With the terminally blended method, there is no need for portable mixing plants, costly specialized equipment, or additional holding areas for storing the rubber product.

In the initial 2006 experiment, the City used a 10 percent content of tire rubber in the TBTRA material by weight, switching to a 15 percent content in 2007 and 2009. Both formulas will be monitored to assess potential advantages.

Aggregate gradation selection

The City of Colorado Springs was looking for a product that could be placed over existing asphalts to achieve both a durable wearing surface, as well as provide a quieter and safer traveling surface. It was decided to use an “open-graded” permeable friction course. This gradation provided an exceptionally smooth surface, which would also drain water quickly away from the surface, dramatically reducing the “splash back” of surface waters. The open-graded mix also assisted in the reduction of noise created by vehicles. Arizona DOT testing has shown that the rubber, combined with an open-graded mix, has the ability to absorb or deaden certain frequencies sensitive to the human ear.

The size and hardness of the selected aggregates have also varied over time. The 2006 specifications required a maximum aggregate size of 3/8 inch and a LA abrasion of 35% maximum loss. The 2007 and 2008 programs increased the rock size to 1/2 inch. Experiments in 2009 will utilize both sizes of aggregate on different stretches and will require a harder rock, specifically, aggregate with a LA abrasion of 20% maximum loss.

Composition: Aggregate																																				
TBTRA (PFC) Pavement		Dense Graded 1/2" City Mix Asphalt																																		
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*Note how clear the material is!

The composition of TBTRA pavement is more porous than dense-graded city mix asphalt, which expedites water drainage and reduces splash back and noise.

Advantages over traditional dense-graded asphalt pavements

Smother

- Extremely smooth surface finish due to the gradation of aggregates.
- Material is capable of filling in underlying surface irregularities (“self-leveling”).

Quieter

- External noise found to be reduced by 3 to 4 dBA over existing asphalt surfaces (using 10 percent tire rubber formula and 3/8 inch aggregate).
- Perceived noise from inside the vehicle is noticeably reduced.

Better safety during rain storms

- Better drainage, less “ponding” of water, reduced splash back, better visibility of pavement markings, and faster drying surface.
- Traction and skid resistance that exceeds CDOT’s minimum recommendations.

Production and application of TBTRA permeable friction course material

Production of the TBTRA material at the asphalt plant matches the production methods used for typical asphalt mixes. No special equipment is required at the plant. First, aggregates are combined with the terminally blended tire rubber asphalt in a continuous double drum mixer. Once the material has been properly mixed and heated, it is transferred to a standard heated silo. When the material is deposited into the hopper of the paving machine, it has the appearance of a “flowing mass” instead of the typically stiff

look of traditional asphalt. The material also has a "sticky/gooney" appearance where it emerges from the front of the hopper, a result of the inclusion of tire rubber with this gradation of material.



Prior to placement TBTRA has a sticky appearance resulting from mixing a liquefied tire rubber blend with aggregate.

Prior to placement of the TBTRA, it is imperative that the surface is smooth, clean and completely dry for a minimum of 12 hours to assure proper bonding. If the material is placed over moisture, it will not bond to the old surface. Once cleaned, the surface will require the application of a tack coat (SS-1h). When the tack has broken, placement of the TBTRA can begin.

Typical paving equipment and traditional methods are used to place the TBTRA. A standard paving machine distributes the mix approximately 1.0 to 1.25 inches in thickness and from 8 to 12 feet in width. The TBTRA should be at a minimum temperature of 300 degrees Fahrenheit, five feet behind the screed of the paver, to assure proper spreading and compaction. Two, eight-ton, smooth drum static rollers are used to compact the material.

Temperature is critical when placing this product. Ambient temperatures must be at least 70 degrees Fahrenheit and rising prior to placement. Awareness of the environment is also essential as haul distances, shaded surfaces, and wind can all bring temperatures below the minimum requirements, if not closely monitored.

When working in tight corners or narrow areas, laborers can work the material with shovels as long as the temperature of the material is at least 270 degrees Fahrenheit. Above this temperature, the material can be easily shoveled or raked into place. When temperatures fall below this mark, the material begins to stiffen, becoming impossible to move with any hand-held tools.

Cold joints are achieved by a vertical cut with a flat saw. The material is removed with a backhoe and then the joint is thoroughly cleaned and tacked. One type of cold joint not allowed is a "thin lift" cold joint, where the paving machine spreads whatever remaining material is in the hopper into a thin layer by lowering the screed to the thickness of the aggregate. Two problems occur: First, the screed can, and normally does, partially crush the aggregate, losing the asphalt coating; and second, it is difficult to lay another lift of TBTRA on this surface and achieve a smooth finish, since the total thickness is only 1 to 1.25 inches.



Once heated TBTRA is combined with the aggregate, it is hauled to the application site in tandem dump trucks (shown here).

Testing

It is imperative to have qualified testing staff and a lab available at all times during paving operations to ensure compliance to the mix design and temperature specifications. After the mix design has been created, staying strictly within the limits of the gradation and asphalt content of the design is important. Gradations are checked a minimum of twice daily: once after the third load is dispensed from the silos, and again, approximately halfway through the day's paving. This is accomplished with the use of an ignition oven, which can verify gradation, as well as the asphalt content.

An ignition oven test takes approximately four hours to run. For this reason, the asphalt content needs to be verified more frequently by the use of a nuclear asphalt content gauge. This test only takes about 15 minutes and is both consistent and accurate, largely due to the "clean" gradation of the mix.

Colorado Springs test sites

In 2006, the testing of TBTRA began. Approximately five miles of arterial/collector roads originally scheduled to receive a traditional dense-graded overlay application were instead overlaid with a permeable friction course of terminally

blended tire rubber asphalt. The four sections of roadway selected support different degrees of traffic and were treated with various combinations of milling, crack sealing, and overlay techniques. Additional sections of arterial roadway were paved in 2007, and are again planned for 2009.

As part of the testing plan, the City scheduled various performance-specific tests to learn what effect the Front Range environment has on the sustainable life of this new pavement. While preliminary observations have been very positive, comparisons between TBTRA pavements and traditional asphalt mixes will be made once testing is complete. In 2007, RII, a pavement consultant, created a baseline pavement surface distress rating for a sampling of the City's TBTRA and traditional pavements for use in future comparisons.

Noise reduction results

One of the stated advantages of this product is noise reduction. Prior to the implementation of the TBTRA project, the City retained a noise consultant, Hankard Environmental Inc., to conduct studies of the differences in noise levels between aged asphalt pavements, new asphalt pavements, and TBTRA pavements. These tests have been completed and confirm feedback from citizens, that "this new pavement (TBTRA) seems quieter." The comparative review of noise measurements has shown up to a 4 dBA reduction in noise over existing (old) asphalt, with higher reductions on roadways supporting higher traffic speeds. The 3/8 inch aggregates combined with TBTRA showed greater drops in dBA compared to the 1/2 inch aggregates. Additional testing has shown that the noise reductions are maintained over time, with only slight degradation in the noise results. Follow-up measurements will continue to be taken to track these results.

Safety outcomes

Better safety is another observed advantage. Visual observation of splash back and spray during wet weather show considerable improvement in visibility of pavement markings and splash back reduction for TBTRA pavements over the traditional dense-graded pavements. A reduction in ice build-up was also noted. The City of Colorado Springs Street Division will continue reviewing both routine and inclement weather traffic accident data and developing accident rate comparisons for the TBTRA versus traditional pavements. To date, an overall 23.5% decrease in accidents has been observed on roads paved with the Permeable Friction Course TBTRA. In addition, skid testing was performed by the Colorado Department of Transportation in 2007. Results indicate comparable traction between the TBTRA open-graded mix and traditional dense-graded mixes.

Cost evaluation

In evaluating the different aspects of TBTRA, cost consider-

ations are an important factor. In a direct comparison, adding a 1" layer of TBTRA using local aggregates has averaged approximately 55 percent more than the cost of the City's normal mill and overlay operations (2006-2009); in 2006, TBTRA cost approximately 61 percent more than a comparable chip seal.



A street section paved with open-graded TBTRA shows little to no splash back, and pavement markings are clearly visible during the same storm.

The actual cost to place TBTRA has varied significantly over the years based on the many changes made to the experiment. Modifications in rubber content, aggregate size, and thickness of milled and overlaid layers are some examples. Increases in oil prices, inflation, and the small scale of an experimental program have had additional impacts on the program costs.

Given the City's experience with how long its traditional mill and overlay-type rehabilitation lasts, it appears that if TBTRA lasts an additional three years over a traditional dense-graded mix, the extra costs would be mitigated, while providing the current and ongoing benefits of increased ride comfort, safety, sustainability, and positive citizen response.

Headed down the right road

While gathering short- and long-term test results is an ongoing process, the City of Colorado Springs is committed to seeking solutions that will enhance public safety and promote fiscal stewardship. The City is happy to share any information learned about this product with others. For more information on the Colorado Springs experiment, or to receive an expanded technical document regarding the production and application of TBTRA, contact the Street Division at (719) 385-5296 or visit www.springsgov.com (keyword search: Tire Rubber Asphalt).

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