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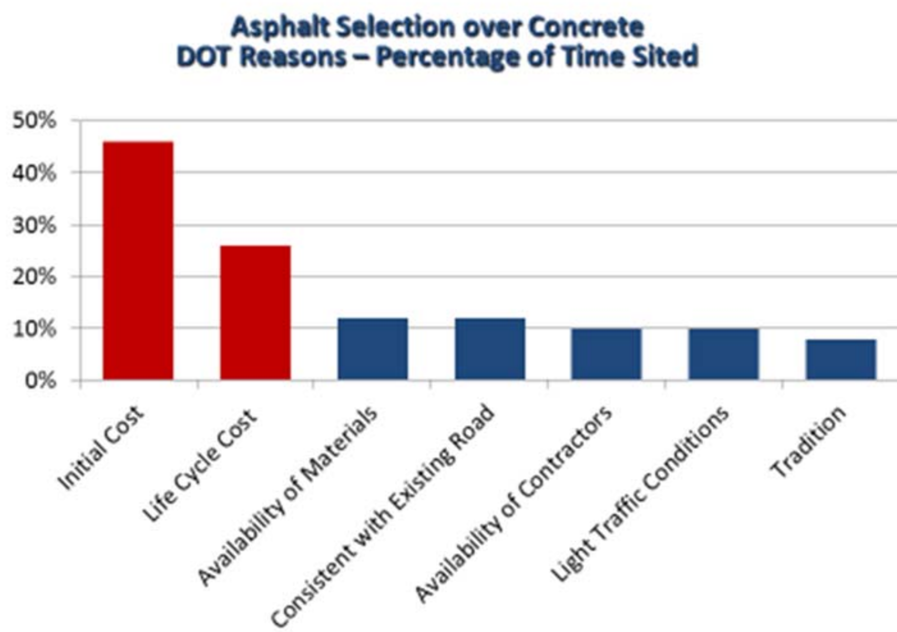
Asphalt Technology Assessments

Overview

Many factors determine market share and its movement. Based on previous research, cost effectiveness of asphalt versus concrete plays an important role in the material paving decision. To this end, PCA estimates the initial bid and life cycle bid for both asphalt and concrete paved roads that are designed for urban use.

Some have suggested that new asphalt mixes and processes may reduce asphalt paving costs. The asphalt industry has put forth several products aimed at alleviating the high material costs of traditional hot-mix asphalt (HMA). Two in particular are rubberized asphalt and warm-mix asphalt (WMA). These materials exhibit several benefits over traditional HMA, including cost. They are worth tracking as both could pose a more intense competitive threat to concrete pavement.

PCA has assessed the costs associated with these new technologies, namely hot-mix asphalt and rubberized asphalt. The factor costs surrounding oil are critical inputs into PCA's estimate for relative costs. This report examines the potential threat to concrete paving opportunities of these "nontraditional" asphalt alternatives to hot-mix asphalt mixes.



Source: Attitudes & Perceptions: Paving 2008

Rubberized Asphalt

Threat level: *Moderate* **Reason:** *Several benefits over hot-mix asphalt including cost*

Rubberized asphalt consists of regular asphalt paving mixed with “crumb rubber" which is ground, used tires that would otherwise be discarded or take up space in landfills.[1] Commonly referred to as Rubberized Asphalt Concrete (RAC), it is claimed by rubber experts to have several benefits over hot-mix. In addition to the environmental benefits of recycling old tire rubber, the pavement reduces road noise, shortens braking distance, reduces road spray from freshly fallen precipitation, and is said to last longer – thus reducing the costs of maintenance. Recycling the tires also alleviates over-piling at landfills, reducing the risk of fires at storage locations.

The biggest market for scrap tires is Tire-Derived Fuel (TDF), in which many industries, including cement, burn tires to fuel machinery, kilns, boilers, etc. Over half (52%) of the 300 million scrap tires generated annually are consumed as TDF in these facilities, with over a third of this number going to cement kilns alone (58 million tires in 2005, 55 million in 2014). The next largest segment is called ground rubber or crumb rubber, accounting for about 25 percent of the volume of scrap tires. While most crumb rubber goes to other applications like playgrounds, sports surfaces, about 7 percent (5.25 million tires in 2014) goes to the asphalt industry for rubber-modified, or rubberized asphalt. In other words, the cement industry consumes ten times as many recycled tires each year.

Every lane-mile paved with rubberized asphalt accounts for an estimated 500-2,000 scrap tires depending on the desired goal, displacing a significant number of tires that would normally end up in a landfill.[2] Depending on the type of mix used, anywhere from 5 to 23 percent of the virgin liquid asphalt binder may be replaced with crumb rubber.

When mixed into the asphalt, the rubber absorbs more sound than a traditional asphalt roadway.[3] Because of the way the rubber pieces align with the aggregate in the asphalt mix, it can be more porous. This allows more water to flow through the pavement, reducing the risk of skidding or hydroplaning.

Despite the upfront costs associated with special equipment and training needed to properly install the pavement, with asphalt prices now significantly higher than rubber, rubberized asphalt is now a cheaper alternative to traditional hot-mix asphalt. According to the Rubberized Asphalt Foundation (RAF), savings range from $2 - $5 per ton when compared to conventional polymer-based asphalt. With rubber as an additive, the pavement thickness can be reduced without sacrificing durability. In addition, because rubberized asphalt is said to be more resistant to cracking, less maintenance is required, reducing life-cycle costs. These arguments sound very familiar to why concrete pavement has a life-cycle cost advantage over traditional HMA.

History of Rubberized Asphalt

Outside of Arizona, California, Florida, and Texas, there are sparse examples of use throughout the country. Many states have been reluctant to use the product due to some unfavorable history which rubber experts claim are outdated perceptions. Few states have specifications for using the modified

[1] Arizona DOT.

[2] There are three major types of asphalt pavement that use crumb rubber: Rubber-Modified Surface Course (R-M SC), Rubber-Modified Open Graded Friction Course (R-M OGFC), and Stress Absorbing Membrane Interlayer (SAMI).

[3] There are different claims as to the reduction of road noise, averaging approximately four decibels lower when measuring from a nearby resident’s perspective, which translates to a four-fold difference. At the point of pavement contact from a vehicle’s tire, this reduction can be up to ten decibels.

pavement. Regulations and outright bans on the stockpiling of scrap tires also play a role. States that use rubberized asphalt operate contractually with the recycled rubber industry.[4,5]

In the early 1990s, the recycled rubber industry suffered large financial losses. As part of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, states were mandated, beginning in 1994, to use annually increasing percentages of rubberized asphalt in federally funded highway projects as a requirement to continue receiving federal funds. The goal was to incorporate more sustainable options. The requirements began with five percent and were to increase to 20 percent by the end of the specified period. In response to the federal mandate, rubber recycling entities invested significant capital to accommodate the increasing production requirements.

According to a 2010 article from Rubber & Plastic News, *Long Memories*: “in 1991, most rubberized asphalt technology still was patented, making it expensive to use… the technology still had certain technical problems and was surrounded by controversy…[s]everal state pilot projects using rubberized asphalt turned out disastrously.”

In 1995, the mandate from ISTEA was repealed, with the federal government instead providing individual grants to states of up to $500,000 toward research and expansion of rubberized asphalt in pavements. While the majority of recycled rubber use remained in tire-derived fuel, it was believed that a significant portion of the crumb rubber manufacturing (CRM) capacity went out of business as a result of the mandate’s reversal.

In the early 1990s, rubber was more expensive than asphalt. It was also widely believed that the modified pavement would only hold up in warmer climates, a myth according to rubber experts. Several applications performed in colder climates resulted in failure; however, these were attributed to unfamiliarity with the material.

Combine all this with the unfavorable history of the product and you get many state transportation officials entrenching their practices without it. With the prices of asphalt significantly higher today, and improvements in technology and familiarity with the product, many rubber advocates believe the tables have turned in their favor and may be poised for regional market share gains.

Warm-mix Asphalt

Threat level: *High* **Reason:** *Initial cost savings over HMA, traditional material bias*

In 2014, the U.S. Department of Transportation featured a program aimed at reducing transportation project costs through innovation and best practices. Warm-mix asphalt was listed as one of these proposed cost-saving innovations. Warm-mix asphalt (WMA) is defined by the Federal Highway Administration (FHWA) as “a general term for technologies that reduce the temperature needed to produce and compact asphalt mixtures for the construction of pavements. WMA temperatures generally start 30° - 70°F lower during mixing and remain lower during trucking, placement, and compaction.”

[4] Arizona, California, and Florida have longstanding ties with the crumb rubber industry, operating with multi-year deals that call for recycled tire rubber to be used in asphalt pavements. According to PCA’s Oman data, California DOT has used the vast majority of rubberized asphalt, 75 percent in terms of tons since 2005, followed by Arizona and Florida at 11 percent each. Ten other states, including Texas, made up the remaining three percent.

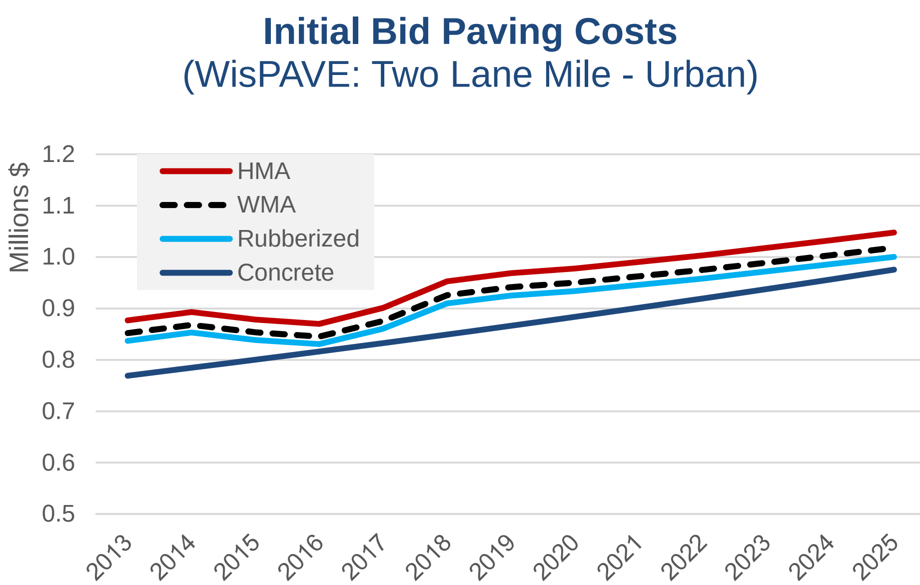
[5] Since 1989, the recycled rubber industry has had dealings with the Arizona DOT. Most recently in 2013, the “Quiet Pavement Program” was introduced, described as a “three-year, $34 million project to surface about 115 miles of Phoenix-area freeways with rubberized asphalt…working toward a smoother ride for motorists and quieter neighborhoods for those who live adjacent to the roads.”

This equates to lower energy costs, specifically the amount of burner fuel used in asphalt production (heating the mix). Because lower temperatures are required to dry the aggregate and heat the final asphalt mix for pavement use, less fuel is burned in the process – resulting in the implied savings.

While warm-mix asphalt can lead to lower production costs initially, the net effect of the additional measures required to perform as well as HMA may offset a large portion of these savings. For several production methods, slightly colder asphalt mix temperatures require additives to provide adequate coating of the liquid asphalt binder – at extra cost. These come in the form of chemicals and organic waxes. Other production methods use special equipment that injects water directly into the mix, creating a foaming effect that aids in coating the aggregate with the asphalt binder. To combat potential moisture problems, other materials called anti-stripping agents can be introduced as well – also at extra cost. [6]

Cost Comparisons

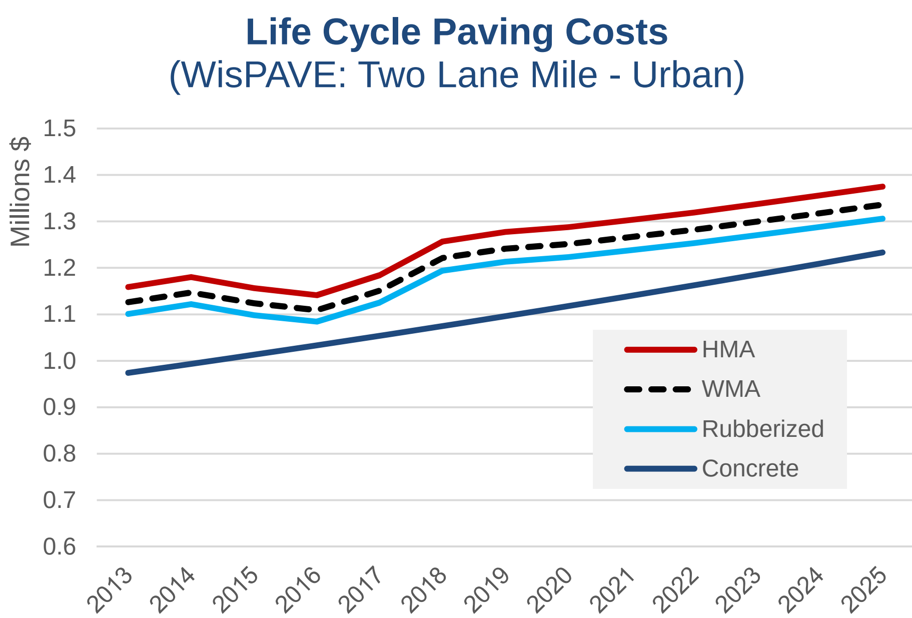
Even after assessing the lower costs associated with warm-mix and rubberized asphalt compared to HMA, concrete pavement remains the least expensive choice for roadway pavement among certain roadways. Since 2008, concrete has been cost competitive on initial bids for an equivalent, urban roadway – even with the proposed energy cost savings associated with warm-mix and rubberized asphalt. Because less maintenance is required and the life span is much longer than with an asphalt roadway, concrete exhibits a life cycle cost advantage for the same urban road.



[6] Refer to PCA's report examining WMA in more detail: *Paving Cost Comparisons: Warm-Mix Asphalt Versus Concrete*, July 2014.

The strongest cost savings scenario for warm-mix asphalt was used in our estimates since it does not include additive or anti-stripping costs.[7] Therefore the dotted line represents the bottom line for warm-mix asphalt's cost savings. Admixture and anti-stripping agent costs further augment concrete's cost advantages. The light blue line represents the strongest savings case stated for rubberized asphalt - $5 per ton.

There are cautions with these cost estimates as they represent one case of specified inputs for an urban road. This particular example, using third party software from the Wisconsin DOT (WisPAVE), resulted in both an initial and life cycle cost advantage for concrete. For a more detailed cost approach, stochastic models provide a more robust result set, accounting for many different scenarios. The result is a range of cost estimates, calculated over several simulations. A confidence interval is used to bracket more probable results. Probabilistic models provide much more insight into the typical cost estimates, particularly if relative price changes are accurately accounted for. The model used for this report is an example of a discrete model that assumes concrete costs rising at a general rate of inflation and asphalt costs rising according to a conservative price index projection tied to the EIA's latest oil price outlook (March 2016).



Source: EIA, PCA

Takeaways

Lower cost alternatives to HMA must be tracked as they represent threats to concrete's competitiveness. Rubberized asphalt has been around for decades but has been used more recently in several states as it mitigates a portion of the high liquid asphalt costs normally associated with asphalt pavement. It carries other advantages over traditional hot-mix asphalt, including noise reduction, skid-resistance, and increased durability. Warm-mix asphalt has been growing in popularity

[7] Paving cost calculations were obtained using Wisconsin DOT's life cycle cost analysis software, WisPAVE. The totals represent initial and life cycle costs for a two-lane mile-long stretch of urban road, paved with either HMA, WMA, or concrete.

as it reduces the temperature required to “cook” the asphalt mix. This not only improves working conditions for the people handling it, but also reduces the amount of fuel used during production, thus lowering initial costs. In order to maintain the quality offered by traditional hot-mix asphalt, warm-mix requires the use of additives which may offset a large portion of these initial savings. More research is needed to fully understand the pros and cons of using WMA as it is a fairly recent innovation.