Where the Rubber Meets the Road

Written by Frank Hill
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Crumb rubber content proves to be a key porous asphalt ingredient in successful Chicago Green Alley program.

Despite perceived problems following a federally mandated program in the 1990s, rubberized asphalt has proven to be one of the biggest success stories in a highly successful Chicago program. The results have been so positive that Chicago officials are looking for other ways to incorporate the rubberized formula in more traditional pavement applications.

The Chicago Green Alley program started as a pilot project to address stormwater run off problems for both residents and the City. The program incorporates three porous pavement systems: asphalt, concrete and pavers. The open-graded mixes that allow water to pass through the asphalt and concrete products require specific formulas and processes.

Typically a hot-mix porous asphalt uses polymer modified asphalt (PMA) and/or fibers (mineral or cellulose-based) to improve performance. The PMA increases the stiffness of the mix at high temperatures. Both PMA and fibers help prevent draindown during storage and transportation of the mix. Testing the draindown characteristics of a mix is very important for porous asphalt mixes.

A supplier in the Chicago area, Seneca Petroleum, offers what is called a “terminal-blended” asphalt-rubber (AR), which incorporates recycled, ground tire rubber (GTR) in the standard neat AC. The crumb rubber takes the place of polymer additives, according to Cindy Williams, quality assurance manager for the Chicago Department ofTransportation (CDOT). Polymers exist in both natural and synthetic rubber.

“They have an additive to help keep the crumb rubber suspended in the liquid,” Williams said, which allows for uniform blending later when it is added to the aggregate at the plant during the hot-mix process.

There are two process for adding GTR to hot-mix asphalt (HMA) – dry process and wet process. In the dry process the GTR is added to the mix like an aggregate at the hot-mix plant. In the wet process the GTR is blended with the asphalt cement and is then metered into the mix at the HMA plant like AC. The wet process is the most common process used in the U.S. Terminal blended AC is a “wet” process. When the producer orders a tanker of this AC, it arrives at the hot mix plant ready to go. The plant doesn’t have to do any modifications.

One of CDOT’s material consultants, S.T.A.T.E. Testing, LLC, had a sample of GTR liquid blend.

“They found that they didn’t need the fibers, just use the GTR modified AC. They weren’t getting the drain down. It was sticking to the rock,” Williams said. “We are also finding that the GTR modified acts similarly if not better than the polymer modified.”

CDOT is looking at other uses for the GTR terminal blend. The standard asphalt cement, or neat AC, is typically used for less intensive traffic use, such as residential streets. The polymer mixes are specified for the higher-traffic roadways because of their increased durability.

“The City paved an arterial with the blend in the summer of 2007. We took the standard liquid in that asphalt mixture and substituted a GTR modified,” Williams said.

“We’re finding it’s comparable to the polymer modified.”

Further, the City’s standard formula for residential streets is to use neat AC and incorporate up to 30 percent reclaimed asphalt pavement (RAP) which is asphalt pavement that has been milled off the streets, crushed and screened for reuse. Two years ago, CDOT decided to increase the recycled content to 45-percent RAP and also incorporated 15-percent recycled concrete aggregate—one of the first cities to do so. Last year, they took that high-recycled content mix and added GTR.

“There is 11-percent crumb rubber in the GTR blend, which makes up 5.5 percent of the hot mix,” Williams said. An added benefit of using the reclaimed asphalt is that it also includes asphalt cement which will reduce the amount of new asphalt cement that is needed in the new hot mix.

CDOT is also giving the ground tire rubber mix a try as a cold patch to fill pot holes.

“I think anywhere you are going to use an asphalt pavement product, it has a real possibility,” Williams said of the GTR rubberized asphalt. “It is showing us that it performs as well as, if not superior to, our polymer-modified asphalt cements. We don’t do a lot of parking lots, but I don’t see why you couldn’t use it there as well.”

Federal Mandate:

More Harm than Good?

There was a push in the 1990s to encourage the use of recycled tire rubber in asphalt pavements. But the approach in some cases had mixed results and may have produced the opposite effect by giving rubberized pavements a bad name.

“The Intermodal Surface Transportation Efficiency Act (ISTEA) required each state to use rubber in increasing proportions until it had 20 percent rubber usage rate. If they didn’t they would have their funding withheld,” said Doug Carlson, executive director of the Rubber Pavement Association.

Perhaps to encourage innovation, the legislation did not have any specifications to follow, which complicated matters.

At the time the only viable process was a wet process that involved having a special blending unit attached to the hot-mix plant to agitate the liquid to keep the crumb rubber in suspension before it was mixed with the aggregate. The process was patented and tightly controlled by the holders. Very few suppliers were franchised. They were looking forward to capturing this huge national market, according to Carlson.

“To circumvent that, states like Florida developed their own process that was similar but different enough to not violate any patents,” he said. Other states looked at the dry process, which happened to originate in Sweden, where they used larger pieces of rubber as an aggregate in the hot mix.

Kent Hansen is director of engineering for the National Asphalt Pavement Association and was in the asphalt rubber industry at that time.

“I think the problem was (rubberized pavement) was forced down the throat of many state DOTs, so they tried to scramble to see if they could make something work.

They didn’t have a lot of luck,” he said. The best results came in cases where state agencies had a chance to build on experience and know what mixes worked best.

“Possible errors occurred early when they tried to use rubberized asphalt in standard, dense graded mixes. We found it works best in gap-graded and open-graded mixes,” Hansen said. Gap-graded mixes are those where an amount of the sand in the standard hot mix was taken out, which allows more asphalt rubber binder into the mix. The open-graded mix contains same-sized stone for aggregate and is used as porous pavement.

The ISTEA era created a great disfavor toward rubber technology, according to Carlson.

Many tried the dry process or tried to use a regular dense graded mix, like standard hot mix and swap out the binders. Instead of using neat asphalt, they’d use rubberized asphalt.

“None of the materials had good quality control or design. It was very hard to get a uniform material placed throughout the length of a project,” he said.

Hansen said that such unfunded mandates need to go by the wayside.

“It actually hurt the asphalt rubber industry for a time,” he said. “You have to find out what are the properties you want from the material, and let the market place decide if it’s going to be cost-effective.”

Cost versus performance
Hansen contends that rubberized asphalt is sold more on performance than on reduced costs. When used in the gap-graded and open-graded mixes, more of the base AC has to be used. But the end result can be a more durable pavement.

“It always increases the cost. If 20 percent (of the AC) is made up of crumb rubber, the remainder is the asphalt binder. So you’re increasing that quite a bit over what would be the normal mix,” he said. “The idea is to get the performance, primarily by modifying the binder, which improves its high-temperature performance, and put in more of the binder to improve durability.”

However, Carlson points out that the blends that use a rubber particle have cost-saving potential.

“Rubber right now is pretty cheap, about 12 to 17 cents a pound where asphalt is going for about 25 cents a pound,” he said. “I think in this market today, the actual raw materials costs are less than a neat asphalt, when you look at a ton-for-ton comparison.”

As for performance, he said that there are some mixes that were placed in the 1990s that are still performing extremely well, predominantly through resistance to cracking due to the effect of the rubber particles.

Meanwhile, recent successes with the terminal blends, such as the one used in the Chicago

Green Alley program, have drawn others to the market. They promote the same benefits and properties but they are not sustained through the life of the pavement.

“Not all rubber-modified asphalts are the same. Those that have a dissolved rubber component are completely different from those that have a rubber particles left in the binder when it goes into the mix,” Carlson warned. “Dissolved rubber tends to under perform in various tests compared to other polymer asphalts which are easier and cheaper to manufacture.”

Growing market share

With better mix designs and new processes coming on line, Carlson said that the use of rubber in asphalt is becoming increasing popular because the materials tend to last longer and have cost advantages initially and throughout the life of the project. Its production also helps the environment by using a waste product.

With 300 million scrap tires generated each year, there is ample product to go into asphalt mixes. Most are used for fuel. Right now about 20 million tires are used in asphalt each year.

“In general the market will be looking up and up. I would expect a jump from the standard 10-percent growth that we’ve experienced in the last five years. We should approach a 15-percent growth rate in the next few years,” he said.

According to Williams, like anything today that is “green” or “recycled,” industry needs to get on board to make it a success.

“There is a need for innovators who will make the product and for agencies, developers, and public/private partnerships to be willing to try the product,” she said. **SLDT**

Chicago Green Alley Program

Chicago’s 1,900 miles of alleyways is comparable to the total hard surface of five mid-sized airports and nearly equal to the total lane miles of the Illinois Interstate Highway system. That’s a lot of hard, impermeable surface.

Begun as a pilot project in 2006, the Chicago Green Alley program took off in 2007 with an increased demand for the benefits it offered to residents and the city. At the heart of the program are several porous pavements designs, which allow stormwater to seep into the soil and recharge aquifers, rather than run off into the city’s combined sewer system or adjacent property.

The program changed the traditional paving methods that raised the crown in favor of a reverse crown to channel water to the center of the roadway. Several basic design techniques can be tweaked to fit the varying conditions of specific alleys. All but one incorporates porous pavements.

The porous pavements can be used full width with a one-foot or greater sub grade of same-sized rock to hold water until it can seep away. Another technique is to pour solid concrete in the wheel paths with pervious concrete down the middle over a five-foot-deep trench lined with a water-proof membrane on either side. This “center trench” model is used to protect basements that are adjacent to the alley.

Installation can be tricky because of the tight quarters and the need to create a lower roadway center. For instance, a typical vibrating screed won't work to install the pervious concrete because the shaking action causes the cement paste to fill the voids between the aggregate. A special rolling screed has been used that acts like a weighted rolling pin.

Paving stones, which have been used extensively in Europe for many years to deal with stormwater runoff, are the most established system. They also provide a different look that can be very popular with residents, especially those who had a cobble stone alleyway.

The only non-permeable surface in the program is high albedo concrete, which is made with recycled slag from ore-smelting operations to make it lighter in tone to reflect sun light and reduce the urban "heat island" effect. It helps to cut summer-cooling costs, makes life easier on urban vegetation and improves air quality

For more on the Chicago Green Alley program, see "*A Pilot Project Takes Off,*" in the spring issue of **Sustainable Urban Redevelopment,** or go online to www.SURmag.com.

Asphalt from Corn Stalks?

Researchers at Iowa State University at Ames, Iowa have produced promising results for an additive to asphalt cement (AC) that is derived from biomass, such as corn stalks and switch grass as well as ethanol and forestry byproducts.

The study is focused on utilizing a substance called lignin to enhance AC performance while reducing the overall amount of the binder, which is rising in cost like other petroleum-based products.

Heated to 500C in an oxygen-free container, the renewable material yields bio-oil which can be further reduced to other substances. The heaviest of these is tar like and contains the lignin, which is an anti-oxidant. Asphalt pavement is adversely affected by oxygen in the atmosphere, which causes the petroleum-based binder to stiffen and eventually crack. The anti-oxidant properties of the lignin retard that process.

The lignin also widens the temperature range of the binder and shows positive interactions with polymers, according to Dr. Christopher Williams of the ISU Department of Civil, Construction, and Environmental Engineering, and lead researcher on the project.

The study looked at blends that replaced up to nine-percent of the AC.

"We think we can go much higher than that and in fact we think it is very possible to replace the asphalt component and thus have a 100 percent bio binder," Williams said.

The study is a joint project of the Center for Sustainable Environmental Technologies and the Center for Transportation Research and Education at ISU and is sponsored by the Iowa Energy Center. **SLDT**