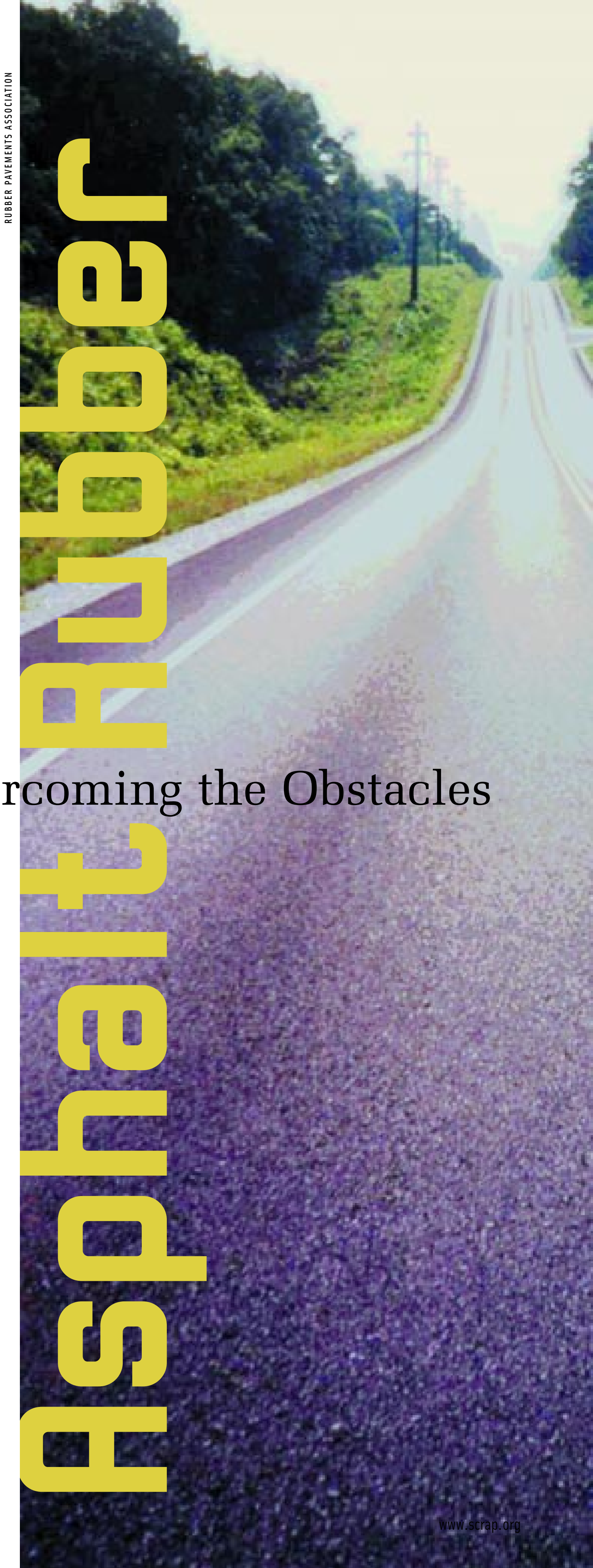
Asphalt Rubber

Overcoming the Obstacles



RUBBER PAVEMENTS ASSOCIATION

WHILE THE USE OF ASPHALT RUBBER IS GROWING, THE PRODUCT STILL FACES MANY HURDLES ON THE ROAD TO ITS FULL POTENTIAL.

BY JONATHAN V.L. KISER

Of all the markets for scrap-tire rubber, one of the most promising—and challenged—is asphalt rubber. That's the product in which granulated or crumb rubber is blended in a mix with asphalt and aggregate, then applied to roadways.

Asphalt rubber (AR), also called rubber-modified asphalt, is promising because it could reportedly consume all of the scrap tires generated annually in the United States. In fact, Doug Carlson, deputy director of the Rubber Pavements Association (RPA) (Tempe, Ariz.), says it would only take 17 percent of this country's asphalt roadway projects to consume the 281 million scrap tires generated in 2001.

That year, however, only about 33 million scrap tires—or 12 percent of the total—were processed into ground rubber for use in asphalt rubber and other applications, reports the Rubber Manufacturers Association (RMA) (Washington, D.C.).

That figure begs a question: Why isn't more scrap-tire rubber going into asphalt rubber? After all, the product has many advantages compared with traditional asphalt, and it offers states an effective way to manage their scrap tires. So what's the problem?

MAKING ASPHALT RUBBER

Asphalt rubber's origins can be traced to about 1966 when Charles McDonald, an engineering supervisor for the city of Phoenix, became the first person to mix crumb rubber with asphalt. The product, first used as a stress-absorbing membrane on the city's airport runways and area roads, made its debut on Arizona highways in 1975.

To make asphalt rubber, you must first process scrap tires to an almost powder-like product called crumb rubber modifier. This product is produced by initially shredding old tires to 2-inch chips, explains pavement engineer Barry Takallou, president of CRM Co. (Compton, Calif.). Two granulation steps follow—the first reducing the material to 3/4 inch and the second to 1/4 inch. The rubber is then ground to a size of about 1 mm (10 mesh) or a little larger, depending on the asphalt rubber process to be used. Along the way, tire wire and fibers are extracted. Such separation is important because the final crumb rubber modifier can only contain 1 percent of contaminants to meet asphalt-rubber quality specifications.

There are three main processes for making AR—wet, dry, and terminal blend, with the wet process being the most widely used. It should be noted, however, that states tend to modify AR formulas to meet their specific needs.

Generally speaking, in the wet process the crumb rubber

modifier is mixed with oil in a blender in a ratio of about 20 percent rubber to 80 percent oil. This mixture is agitated for about 45 minutes at 350 to 400 degrees F. Eventually, the rubber starts to get absorbed into the oil and vice versa. This blending of the two materials creates a thick fluid—the asphalt rubber binder—that holds the aggregate material together. Contractors then simply apply the asphalt rubber hot mix in the same way and with the same equipment used to lay conventional asphalt. It's also possible to spray-apply asphalt rubber as a seal coat and in other applications.

In the dry process, crumb rubber modifier is first mixed with the stone-based aggregate (such as shale, granite, or limestone) at a ratio of 3:97 by weight. The oil is then introduced to the mix, and the material is then ready for application.

The third asphalt rubber process—called terminal blend—uses up to 10 percent crumb rubber modifier and is created by the liquid asphalt petroleum producers, notes Jim Copley, quality control director for Sully-Miller Contracting Co. (Anaheim, Calif.), an asphalt and concrete manufacturer. The terminal-blend product is mixed at the asphalt refinery prior to shipment to the hot-mix plant. The rubber used in these applications is a finer grind and is melted to the point of nondetection, says RPA's Doug Carlson.

In addition to these three asphalt-rubber processes—all of which work well, according to Copley—the Federal Highway Administration (FHWA) has developed a chemically modified crumb rubber mix. Though this patented material was created using the wet formula developed by Charles McDonald, it also includes peroxide as a coating for the crumb rubber. The resulting rubber modifier performs better at a lower cost, asserts Jason Harrington, asphalt engineer with FHWA's Office of Pavement Technology (Washington, D.C.).

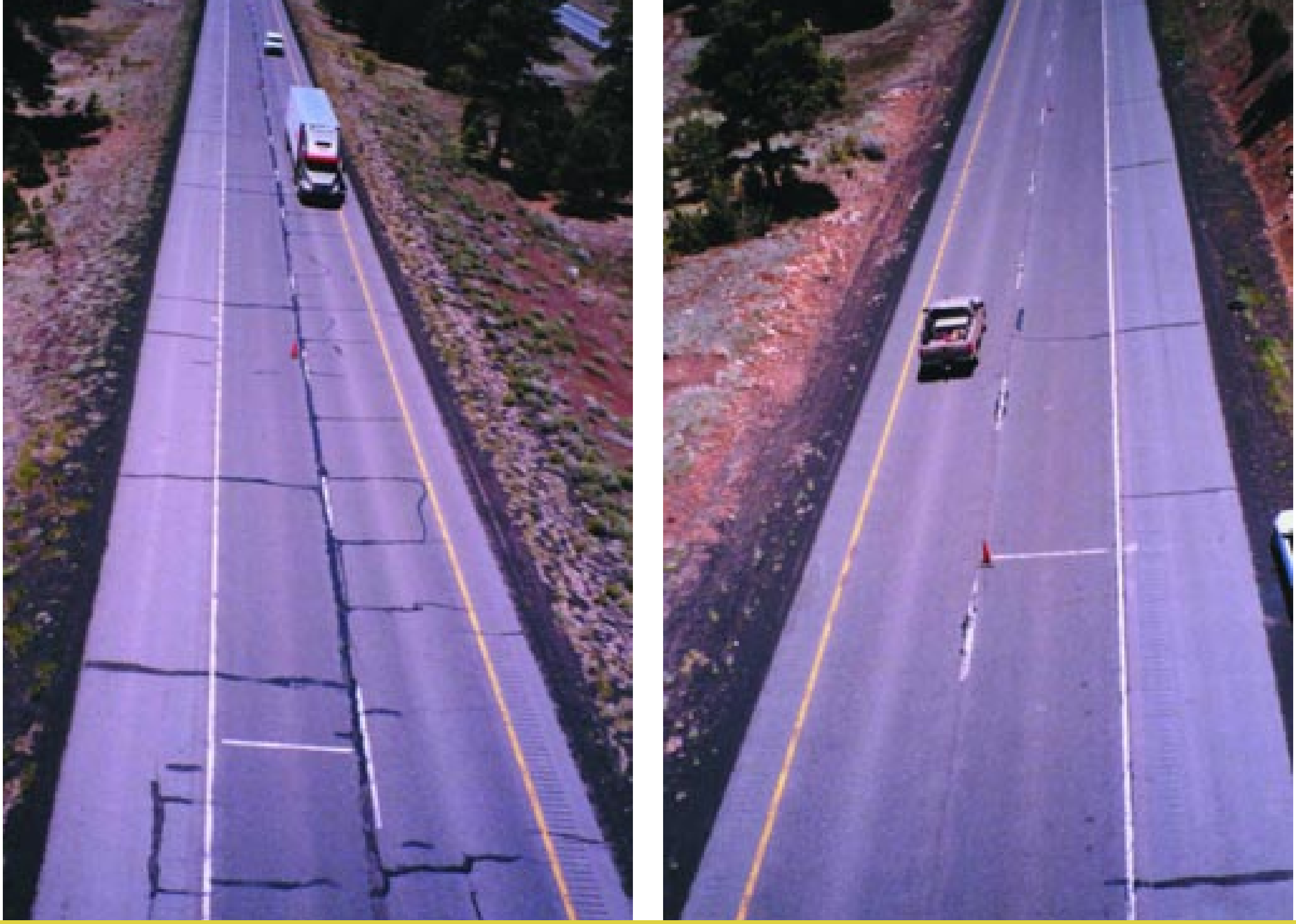
COUNTING THE BENEFITS

As with any product, asphalt rubber wouldn't have survived for the past 37 years if it didn't have redeeming features.

On the recycling side, asphalt rubber can consume huge quantities of crumb rubber, thus providing a sizable end-use market for scrap tires. As Doug Carlson notes, "About 30 pounds of crumb rubber is used for each ton of AR mix." That translates into about 3,000 pounds of crumb rubber, or 300 scrap tires, per lane mile at 1-inch thick in the minimum overlay application, he says.

Asphalt rubber's ability to consume large quantities of scrap rubber makes it one of the most important tire recycling options, states Barry Takallou. The product's recycling potential also can help preserve landfill space as well as reduce or eliminate the cost of managing and disposing of scrap tires, including stockpile liabilities and tire fire expenses.

Beyond recycling and scrap tire management issues, AR offers a long list of physical and performance benefits compared with traditional asphalt. Here are just a few of them:



An FHWA project paved two sections of Interstate 40 near Flagstaff, Ariz., for test purposes–one with conventional paving material (a 2-inch surface course on a 2-inch leveling course over aged concrete), and the other with asphalt rubber (a 2-inch gap-graded rubber mix on a 2-inch leveling course over aged concrete). These photos from 1998 show the different levels of cracking and wear exhibited by the conventional pavement (above left) and the asphalt rubber (above right) after eight years.

Stronger, Better Roads: Thanks to their rubber component, asphalt rubber roads are more flexible than conventional pavement. This elasticity enables AR roads to hold up better under traffic loads and resist both cracking and weather-related damage in hot, cold, and wet conditions. Asphalt rubber roads are also more resistant to aging because the rubber is believed to slow the asphalt's oxidation process. Far from being idle boasts, these performance advantages have been proved in both lab and field tests in several states, in some cases spanning decades of usage. As George Way, chief pavement design engineer with Arizona's Department of Transportation (Phoenix), notes, "36 years of use in Arizona show that AR works fine."

Safe and Sound: Traditional asphalt is a dense-graded product, which means that it creates an ultra-smooth road surface that can form puddles and slick conditions when it rains. In contrast, asphalt rubber is a gap-graded mix, which means it creates a smooth surface with small crannies that allow water to run off, enhancing safety for drivers. The rubber component can also afford better tire traction under varying conditions. And while the hard nature of conventional asphalt can lead to tire-noise problems in densely populated areas, asphalt rubber can be 30 to 50 percent quieter thanks to its gap-graded structure and the sound-deadening ability of its rubber component. One paving project in San Antonio, Texas, for instance, found that AR reduced road noise by 10 decibels, while an Arizona project showed a 9-decibel improvement. But FHWA suggests more research is needed to see if this benefit decreases over time.

Cost Advantages: There's no denying that AR's upfront material and production costs are higher than those of conventional asphalt. Depending on factors like the project location and access to aggregate, asphalt rubber gap-graded hot mixes typically cost $13 to $15 a ton more than conventional hot mixes, says Joe Cano, a materials engineer with the Bureau of Indian Affairs' western regional office (Phoenix).

Even so, AR can still be more cost-effective when applied correctly. For starters, the cost of asphalt rubber has dropped over the past 10 years due to the expiration of patented processes, the development of nonpatented processes, and reduced raw-material costs as crumb rubber production has grown. For example, the average low bid for patented asphalt rubber in Arizona in 1989 exceeded $500 a ton. When the patent expired in 1993, the average low bid dropped to $325 a ton. Today, Doug Carlson says, "a typical bid price for a liquid ton of asphalt rubber would be $250 to $300 a ton."

Another AR cost advantage is that it can be applied at half the thickness of traditional pavement, thus saving on material and installation costs as well as construction time. As Cliff Ashcroft, a highway contractor with FNF Construction Inc. (Fullerton, Calif.), points out, "While asphalt rubber costs about 25 percent more than regular asphalt on a per-unit basis, it requires half the material to complete the same job and is therefore cost-effective from the start."

Also, asphalt rubber's durability means lower long-term maintenance costs per lane mile and less-frequent need to resurface roadways. In the end, AR roads can reportedly last twice as long as conventional asphalt roads, thus making them cheaper on a life-cycle basis.

Aside from the major benefits above, asphalt rubber has other more peripheral attributes and advantages:

- AR is a versatile product that can be used in hot mixes, chip seals, stress-absorbing membrane layers, and other applications;
- AR can spur economic development since tire collection, transport, and processing contribute to the local economic base and add material value; and
- Replacing conventional pavement with AR reduces demand for petroleum products and stone-based aggregates, thus conserving natural resources.

THE ISTEA INCIDENT

With so many positives, you'd think that asphalt rubber would have had an easy road to widespread use. And in 1991, its success seemed almost assured following the passage of the federal Intermodal Surface Transportation and Efficiency Act, dubbed ISTEA. In short, Section 1038 of ISTEA directed state departments of transportation to spend a portion of their federal highway money on asphalt rubber. Under that section, FHWA was also charged with transferring AR technology to the states to ensure that the product would be used successfully.

As it turned out, ISTEA's mandate came up against heavy opposition from some state highway officials as well as traditional paving interests, who managed in 1993 to persuade Congress to repeal the ISTEA funding provisions pertaining to the use of asphalt rubber. Though ISTEA supporters tried to get Congress to reauthorize that funding in 1994 and 1995, their efforts were ultimately unsuccessful.

While this was a major blow to AR, the debates over ISTEA answered important questions about the product's emissions, safety, recyclability, economics, and more. Even so, ISTEA's demise and a lack of clear technical guidance from FHWA left states confused about what construction and design approaches would yield a successful AR project.

Nevertheless, numerous states forged ahead with using AR. Arizona and California led the way, with states such as Florida, Texas, and South Carolina following their lead. In the Arizona and California DOTs alone, RMA reports that an estimated 18,000 tons of scrap-tire rubber is being consumed annually in AR applications—equivalent to more than 3.6 million tires.

K.C. EVANS

This road sign near Crane, Texas, refers to a project by Texas DOT's Odessa District. In the project, 2 inches of asphalt rubber hot mix was placed over a hot rubber underseal, which is a spray-applied asphalt rubber membrane with rock chips spread and rolled into place.

A ROAD FULL OF OBSTACLES

Though asphalt rubber is gaining momentum in a handful of states, it has encountered and still faces many obstacles to its implementation around the country. These barriers are often based on a combination of political, technical, economic, and perception factors.

The ISTEA Effect: In George Way's view, ISTEA got everything off on the wrong foot and left a bad taste in many people's mouths. "Residual resentment from ISTEA still exists," he states, "and some states may still view AR as a conspiracy."

Not only did states not appreciate being told what to do through ISTEA, but the mandate actually gave asphalt rubber a black eye through poorly executed projects, sources say. When San Antonio was forced to use AR 10 years ago, before the proper mix formulas were established, the road project failed, says Dale Rand, director of the Texas Department of Transportation's flexible pavement branch (Austin). Similarly, in the same period, New York state unsuccessfully attempted to use about 5-percent crumb rubber in an asphalt-rubber mix.

A Lack of Specifications: The biggest obstacle to broader use of AR is the lack of applicable specifications, asserts RPA's Doug Carlson. In the mid-1990s, FHWA designed a nationwide pavement standard known as SHRP (short for Strategic Highway Research Program). "This has inhibited the use of asphalt rubber in many states since the material cannot readily be tested with SHRP equipment or be used in SHRP mix-design procedures," Carlson explains.

Also, in rural areas of the United States, it's still sometimes the case that he who controls the project specifications controls the area market from a business perspective. In more urban areas, as the number of competing contractors increases, the less resistance there tends to be to new specifications for products like asphalt rubber.

Proper Project Design: For asphalt rubber to gain momentum, each AR roadway project must be constructed correctly—which has not always been the case, says Joe Cano, adding that "it's important to use the proper mix designs and specifications to meet the desired road conditions." In other words, proper engineering design and construction decisions are essential components to the proper application of asphalt rubber. Only through proper construction can each new AR project build upon the success of previous ones.

Skeptical State DOTs: While asphalt rubber has been widely studied and is clearly a proven technology, "states still want to complete their own 10-year study rather than rely on the successful results of others," says Bill Vincent, CEO of Colt Scrap Tire Centers Inc. (Scott, La.) and chair of ISRI's tire and rubber division. Such skepticism delays the adoption and wider use of asphalt rubber. Many state DOT officials as well as traditional pavement contractors also remain skeptical about the cost/benefit analysis of asphalt rubber, despite the evidence that it can be more cost-effective when applied correctly.

New Equipment Needs: Though AR can be applied using conventional paving equipment, special blending equipment is typically needed. Before the crumb rubber modifier and asphalt are mixed at the hot plant with aggregate, they must first be blended together with mixing equipment. Once the two components are mixed at the hot plant, the material must be pumped into a specially designed holding tank that can keep it heated and circulating. The mixing equipment and holding tank can cost $200,000 to $1 million. Some traditional pavers are resisting AR, says Dale Rand, because "they aren't interested in hiring another company to blend the rubber and asphalt, nor are some interested in buying new mixing equipment."

Uncertain Crumb Rubber Markets: An insufficient supply of crumb rubber is another factor limiting the spread of asphalt rubber. "Producing more crumb rubber is a challenge given the high cost of investment to open a facility," Bill Vincent says, adding that "the lack of stability in the U.S. crumb rubber market has limited the growth of AR use." In Arizona, for instance, there's only one crumb rubber producer to serve the entire state, notes George Way.

These 40 tires and the space they cover represent the number of tires that are typically granulated and incorporated into that area of roadway in an Arizona pavement section.

Competition and economics are two reasons for the limited crumb rubber capacity in the United States. "It's difficult to get into the tire processing business and make any money," Way says. "The business is cutthroat, seasonal, very competitive, and offers small profit margins." Crumb rubber production, in particular, is a capital- and labor-intensive business with high energy costs. A processing plant capable of processing 4 million tires annually costs about $7 million, says Doug Carlson. Securing enough scrap tires to feed such a plant consistently is another challenge for crumb rubber producers.

Also, while crumb rubber can be sold for about 15 cents a pound, that isn't enough to fully cover the cost of scrap-tire collection, transportation, and processing. Processors need 20 to 25 cents a pound to cover those costs, says Vincent. Those prices are difficult to charge, however, due to inexpensive rubber exports from Canadian processors, who typically have the advantage of a $3-a-tire, government-imposed fee to support their pricing. In California, Barry Takallou notes, "our company must compete with not only the Canadians, but also inexpensive landfills. Consequently, we don't charge a tip fee for tires delivered."

There's also a quality issue to consider: Of the 50 or so crumb rubber producers in the United States, only about 10 can produce material clean enough for AR use, according to Doug Carlson.

Health & Environmental Issues: In the early 1990s, concerns surfaced about air emissions and worker exposure during the production of asphalt rubber. In response, a June 1993 report from FHWA and the U.S. EPA indicated that there were no increased emission risks. Further, a December 2000 EPA report on emissions from hot-mix asphalt plants concluded, "Measured emissions of particulate and specified toxic compounds during production of AR were not significantly greater, if greater at all, than the emissions during production of conventional asphalt."

Currently, "there isn't much member concern regarding any health or environmental problems associated with asphalt rubber," says Margaret Cervarich, vice president of marketing and public affairs for the National Asphalt Pavement Association (Lanham, Md.).

Recyclability: Early on, there were also concerns that it could be difficult to recycle asphalt rubber pavement at the end of its useful life. In response, state and federal agencies conducted tests and found no trouble recycling asphalt rubber material, notes FHWA's Jason Harrington. Some, however, believe that more insights will come from additional investigation. As Jim Copley points out, "The industry is now on the threshold of having to recycle many 15-year-old asphalt rubber roads. In California, state agency dollars still need to be allocated to address this issue."

MOVING ASPHALT RUBBER AHEAD

It won't be easy to overcome the lingering negative perceptions and various barriers to the use of asphalt rubber. Still, there are ways to broaden its appeal and adoption, as AR experts note here:

Increase State DOT & Contractor Involvement: States have the ultimate authority over scrap tire management from a regulatory perspective, notes Pam Swingle, an environmental scientist in U.S. EPA, Region 4. As a result, it's critical to get state DOT officials to the table to discuss AR. "You really have to involve these folks since they control the project finances and also are connected to the local level where the roads are paved with asphalt rubber," she says.

Doug Carlson concurs, stating that "the state engineers must be involved, and we must strive to educate a new generation of engineers who are now becoming familiar with this issue."

State DOTs must also make a long-term commitment to using AR in the form of contract specifications. Otherwise, paving contractors won't be willing to invest in new blending equipment that will enable them to perform the work, says Joe Cano. As Pam Swingle adds, "If DOT specifications call for the use of AR, the contractors will find a way to make it happen."

A paving crew from FNF Construction adds a thin asphalt-rubber overlay on a residential street in Phoenix in the summer of 2000, using the same paving equipment as that used to lay conventional asphalt.

Still, such efforts will be challenging because, as Carlson observes, "most state transportation engineers are resistant to change." RPA, he notes, has to provide each and every state with proof that AR can work. Adding to the challenge are the many asphalt rubber products that failed in the past. "These failures cause some engineers to be biased against asphalt rubber today, despite the industry's advances," says Carlson.

Emphasize the Engineering Advantages: According to Texas DOT's Dale Rand, "The use of asphalt rubber is less driven by the desire to keep tires from landfills and more by its use as an engineering application option."

From an engineering perspective, AR needs to offer an economic advantage and outstanding performance compared with traditional asphalt. The best way to achieve widespread commercial use of asphalt rubber, Rand says, is to find the right applications that take advantage of AR's engineering properties.

Gary Fitts, senior district engineer for the Asphalt Institute (San Antonio), adds that further refinement in the production of asphalt rubber will increase its use. "Design procedures need to be improved, with the petroleum companies preferring AR specifications that are closely aligned with those of traditional materials," he says.

Improve Market Conditions: Imagine if states passed legislation requiring the use of crumb rubber from only U.S. scrap tires in asphalt rubber projects. That would limit the effect of Canadian crumb rubber on the U.S. market, improve market conditions for U.S. scrap tire processors, and provide an incentive for more U.S.-based crumb rubber production. Arizona has already adopted such legislation. Under its law, any contractor who knowingly and willingly violates the law could face felony charges and end up in jail.

States with scrap tire management fees could also use some of those funds to stimulate AR use, says Joe Cano.

Education Outreach: Educational outreach programs are another tool for expanding and speeding the adoption of AR in the states. In particular, playing up the noise-reduction benefits of asphalt rubber could generate enough public support to convince more state officials to use the material, says Donna Carlson, director of RPA.

In addition, the crumb rubber industry is pursuing a fresh approach to promoting AR use. "The idea is to educate each state about the value of AR use and make federal dollars available to them on a voluntary basis," Bill Vincent says. But he stresses: "We are absolutely not proposing any type of mandate."

Instead, states interested in using asphalt rubber would be able to tap FHWA money to cover expenses related to their AR demonstration projects. This idea, though promising, would require congressional approval.

FHWA's Jason Harrington says states with an interest in using AR should look at those states that are currently using the material, learn from them, and apply existing knowledge to their own states. This process is already happening, says Donna Carlson, who explains that RPA has worked with Arizona's DOT to partner with other states interested in using asphalt rubber. "Being able to show other state representatives successful AR pavement applications, in both warm and cold climates, is a big help," she says.

Creative Federal Incentives: ISTEA flopped, says George Way, because "the federal government used a stick rather than a carrot to initially promote asphalt rubber." In his view, a credit system would work much better. Under such a system, states that use AR would get a credit that they could use to secure money from the federal highway trust fund. While states that didn't use AR wouldn't lose money, those that did try the material would receive a higher percentage of the allocation, he explains.

Another option, says Barry Takallou, would be for FHWA to offer rebates—for instance, $5 per ton of asphalt rubber hot mix used—on a competitive basis to encourage state DOTs to pursue asphalt rubber projects.

While asphalt rubber will likely face ongoing resistance, its long-term future is outstanding, asserts FNF's Cliff Ashcroft, who acknowledges that "it takes years to build market momentum." This momentum appears to be on the rise—a trend that is both needed and welcome. As Dale Rand concludes, "Asphalt rubber is slowly gaining acceptance, and success breeds success." S

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