NAPA
NATIONAL ASPHALT PAVEMENT ASSOCIATION

BLACK AND GREEN

Sustainable Asphalt, Now and Tomorrow

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Long before "sustainability" became an eagerly pursued part of the American business plan, the asphalt industry initiated research and field practices that have constantly enhanced the viability of asphalt as an environmentally sound building material.

To date, the monumental accomplishment of this initiative lies in recycling. Asphalt is the most recycled material in America. About 100 million tons of old pavement are reclaimed every year, with about 60 million tons reused in new asphalt mixes, and some 40 million used in other pavement-related applications, such as aggregate road base.[1]

Asphalt pavement is unique not only in the volume recycled, but also its renewability. It is comprised of approximately 95 percent aggregates (stone, sand and gravel) and about 5 percent asphalt cement. When asphalt pavement is reused in a new asphalt mix, the old asphalt cement is rejuvenated so that it becomes an active part of the glue that holds the new pavement together, just like the old aggregate becomes part of the aggregate content of the new mix. These singular properties make asphalt a uniquely renewable pavement.

Powering the trend to recycling/reusing asphalt is economics. Decades of research and engineering have improved the cost efficiency of converting old asphalt into a reusable resource that has tangible value. Today, pavement engineers, government agencies and contractors regard old asphalt as an asset, not waste, and the trend to recycling and reuse continues to gain momentum as a result.

The industry has worked on other technologies that reduce air emissions including greenhouse gases and other contributors to climate change. These technologies include warm-mix asphalt, with lower emissions due to reduced temperatures, and long life pavements which reduce greenhouse gas emissions by reducing the frequency of repair and replacement.

And modern asphalt technology has delivered asphalt pavement designs that actually enhance the quality of stormwater runoff even as they improve driving safety by reducing the amount of spray produced by vehicle tires.

Past, current and future advancements in asphalt as an environmentally sustainable paving material are especially important because asphalt is such a primary component of America's transportation system and because the quantities of material used annually are so large.

Of the 2.6 million miles of paved roads in the United States, over 94 percent are surfaced with asphalt. Approximately 85 percent of the nation's airfield pavements and 85 percent of the parking lots are also surfaced with asphalt. There are about 4,000 asphalt mixing plants located in the United States and the industry employs, directly or indirectly, 300,000 U.S. workers. Because of the vast extent of use of this material, even small changes in asphalt pavement technology can make a big difference in terms of greenhouse gas emissions.

THE ROAD AHEAD

None of the advancements in asphalt technology would have been possible without a vibrant research and technology deployment program. Leading the asphalt research effort is the National Center for Asphalt Technology (NCAT) in Auburn, Alabama, which originally was endowed by industry and today is directed by a public-private partnership. With its 1.7-mile pavement test track and its 40,000-square-foot research facility, NCAT conducts a productive, $5 million per year research program that focuses on innovations that directly affect and improve the roads we drive on every day.

An important aspect of the industry's research program is that it is based on partnering. Partners in current and past initiatives include the National Asphalt Pavement Association (NAPA), the Federal Highway Administration (FHWA), the Federal Aviation Administration (FAA), the American Association of State Highway and Transportation Officials (AASHTO), the state Departments of Transportation (DOTs), the Transportation Research Board (TRB), the U.S. Army Corps of Engineers, the Environmental Protection Agency (EPA), related industry associations, the Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health (NIOSH), and the labor unions. There is also a broad range of international partners with whom the industry shares knowledge, conducts joint research, and cooperates on industry matters.

One of the first breakthroughs in asphalt pavement technology achieved by this partnership was Superpave, a pavement design system that has enhanced pavement performance and durability in many ways. It was developed with federal funding under the Strategic Highway Research Program (SHRP) in the late 1980s and early 1990s. Superpave has become so widely accepted that use of the term is actually disappearing – what used to be called the Superpave design system is now the norm for designing asphalt pavements in much of the U.S.

Another example of partnering was the initiative that began in the late 1980s in which NAPA worked with EPA on research into air emissions, including greenhouse gases from asphalt plants. The studies showed that emissions from asphalt plants are low and well controlled; they resulted in EPA declaring that asphalt plants are not major sources of hazardous air pollutants.[2]

Nonetheless, the industry continued to work to reduce emissions. In fact, total emissions from asphalt operations decreased by 97 percent from 1970 to 1999, while production of asphalt pavement material increased by 250 percent.[3] The industry is proud of its record of environmental stewardship and its proactive position of continuously reducing emissions, including greenhouse gas emissions.

As impressive as our gains have been in recent years, we can still achieve significant gains in addressing climate change in the coming years by accelerating research and deployment of technologies that reduce greenhouse gas emissions. We can increase use of warm-mix asphalt to represent the majority of all the pavement material produced in the U.S.; we can double the reuse/recycling of asphalt pavements; we can make Perpetual Pavements the standard design method; and we can have porous pavements accepted as a best management practice for reducing stormwater runoff and improving water quality. More information about these strategies follows.

Converting to Warm-Mix Asphalt

Warm-mix technologies allow for production and placement of asphalt pavement material at lower temperatures than conventional hot mix technologies. Conventional asphalt pavement material is produced at around 320º F and warm mix is typically produced at temperatures ranging from 280º F down to 212º F.[4] The potential for warm mix has won broad support among road managers and contractors. In five years following the first public demonstration of warm mix in the U.S. in 2004, scores of warm mix projects have been constructed in 40 states.

Warm mix was originally explored for its environmental benefits, which include reduced fossil fuel consumption and reduced emissions, including greenhouse gas emissions. Contractors and agencies have also discovered numerous construction and performance benefits, including the potential to extend the paving season in northern climates, the potential to store pavement mix for longer periods, a longer window of opportunity for compacting pavement, and increases in recycling rates.

Running warm mix can reduce energy consumption during the manufacturing of the asphalt pavement mixture by an average of 20 percent, which decreases total life-cycle greenhouse gas emissions by 5 percent. In terms of greenhouse gas emissions, this equates to cutting 1 million tons of asphalt production annually. Combining warm mix with reuse/recycling yields even greater benefits. Warm mix with 25 percent reclaimed asphalt pavement could potentially offset asphalt pavement life-cycle greenhouse gas emissions by 15 to 20 percent. The potential for total savings in greenhouse gas emissions using both warm mix and recycling is about 3 million tons per year.

NAPA, FHWA, AASHTO, and researchers created a Technical Working Group whose purpose is to evaluate warm-mix technology performance, quantify environmental benefits, develop performance specifications, provide technical guidance, and disseminate information. The partnering approach has been of immense support to efforts to deploy warm mix.

So far, implementation has proceeded with virtually no complications.[5, 6, 7, 8, 9, 10] Demonstration projects, trials, and test projects have included the full variety of asphalt mixture types. At least 10 states have adopted permissive specifications, clearing the way for contractors to produce and place the mix at low temperature as long as it meets all other criteria.

Experience with applied research and technology development suggests that warm mix may make it possible to increase the rates of reuse/recycling even more. Applied research on this topic will be helpful in speeding the rate of acceptance of combining the two technologies.

Another opportunity for applied research is full documentation of emission reductions, with specific focus on greenhouse gas emissions. Such research would also assist agencies in taking full advantage of warm mix to meet air quality guidelines.

Doubling the Use of Reclaimed Materials in Asphalt Pavements

The use of reclaimed asphalt pavement (RAP) has been widespread for about 30 years.[11] Asphalt pavement is America's most recycled material. Every year, more than 100 million tons of asphalt pavement material is reclaimed and virtually all of it is reused or recycled into new pavements. Materials from other industries, including roofing shingles and ground rubber from used tires, can also be beneficially incorporated into asphalt pavements. The key to this is sound engineering, design, and technology.

Increased use of RAP as a percentage of the total asphalt mix can significantly reduce greenhouse gas emissions by eliminating the significant fuel consumption required to acquire and process raw materials for virgin mix. Currently, RAP makes up 12 percent of the average asphalt mix by volume, with the remainder comprised of virgin aggregate and asphalt cement.

Contributing to this average are states that routinely use 30 percent RAP and states that permit minimal use. If we increase RAP usage to 25 percent of the average mix, we will reduce total life-cycle greenhouse gas emissions by 10 percent, which equates to 2 million tons offset annually.

One of the unique qualities of asphalt cement is that it is rejuvenated when RAP is incorporated into new pavement, becoming an integral part of the binder. This is referred to as the highest and best use.

In view of the high reuse/recycling rate in lead states, including a preponderance of evidence that the quality of asphalt pavements incorporating RAP is equal to or better than pavements using all virgin materials, there is ample opportunity to double the quantity of RAP used within five years.

Part of the challenge is to encourage agencies in rural areas to allow milling on pavements prior to the placement of asphalt overlays. This will provide more material for recycling in areas where RAP is scarce, and it will improve the performance of the rehabilitated pavement by removing distresses from the existing surface.

FHWA has organized the RAP Expert Task Group (ETG), which brings together stakeholders from government, industry, and academia to investigate obstacles to increasing RAP use. As part of this mission, the ETG has identified states with particularly high and particularly low levels of reuse/recycling. The ETG is also charged with achieving the desired increases through technology transfer/accelerated deployment strategies, and eliminating artificial and arbitrary barriers to increased recycling in favor of performance-based pavement criteria.

There are also opportunities for applied research, including quantifying the environmental benefits of increased RAP use, developing technologies and procedures to recycle high percentages of reclaimed material, developing technologies and procedures to better preserve the aggregate gradation in RAP, and improving performance testing methods and specifications for use of RAP and roofing shingle mixtures. All these activities would contribute to increasing the overall rate of recycling and therefore provide reductions in emissions of greenhouse gases.[12]

Economic Sustainability

Reuse/recycling is not only an environmentally sustainable practice, it is an economically sustainable one. NAPA estimates that we have 18 billion tons of asphalt pavement already in place on America's roads and highways. Because of the ability to reuse and recycle this material indefinitely, our highways are a resource for future generations. Not only are our roads a primary engine of the economy, they have a high residual value as a source of construction materials. As a note, the process of reclaiming and processing these materials has a very low environmental impact.

Expanding Implementation of Perpetual Pavement

Perpetual Pavement is the name given to an asphalt pavement that is designed not to fail. Construction is in layers whose properties serve a combination of different functions; they all add up to an extraordinarily long-lasting pavement. Surface distresses may occur eventually, but they do not penetrate deep into the pavement's structure. Routine maintenance involves infrequent milling of the top layer for recycling, then placing a smooth, quiet, durable, safe new overlay. A Perpetual Pavement never needs to be completely removed and replaced. In the world of pavements, this is the ultimate in economic and environmental sustainability.

Perpetual Pavements can mitigate climate change by reducing greenhouse gas emissions, both now and for generations to come. Perpetual Pavements reduce greenhouse gas production in several ways.

- Since only the surface is renewed, the base structure stays in place, thereby significantly reducing greenhouse gases associated with virgin raw materials acquisition and placement.
- Greenhouse gas emissions associated with complete removal and replacement of pavements that have reached the end of their useful life is avoided.
- Greenhouse gas emissions associated with construction delays are greatly reduced because maintenance and rehabilitation can be done quickly in off-peak hours, unlike the remove-and-replace option, which necessitates 24-hour road closures. Limiting closures to off-peak hours can reduce delays for road users by at least a factor of 12, i.e., a 2 1/2-minute delay versus a 30-minute delay.

Perpetual Pavements are more cost-effective than traditional asphalt pavements while enhancing durability, performance, and long life. Reuse/recycling is part of the maintenance and rehabilitation process.[13] All these factors conserve construction materials and reduce greenhouse gases.

Once the road is constructed, it becomes a permanent asset within the transportation infrastructure system. A Perpetual Pavement does not become a reconstruction problem for future generations.

Perpetual Pavements can also keep roads smoother. Significant fuel savings are associated with smooth pavements. It has been documented under tightly controlled conditions that driving a heavily loaded truck on a smooth road consumes about 4.5 percent less diesel than driving on a rough one.[14]

The history of Perpetual Pavements goes back to the 1960s, although the term was not used until around 2000. Full-depth asphalt pavements first achieved wide acceptance in the 1960s as a way of minimizing materials use and construction costs.[11] At that time, it was assumed that the design would result in a "20-year design life," but experience has shown that such pavements have lasted for over 40 years with no sign of structural failure. Engineering studies in the states of Kansas,[15] Minnesota,[16] Ohio,[17] Oregon,[18] and Washington[18] have validated these observations.

Beginning in 1999 and 2000, asphalt pavement researchers initiated efforts to understand the engineering features and performance characteristics of Perpetual Pavements. Research has been conducted at NCAT, the Asphalt Institute, the University of California at Berkeley, the University of Illinois, and other leading institutions in the U.S. and around the world. The research has led to the development of materials, design methods, and performance criteria to enable agencies to design pavements that ensure long life without wasting materials due to overdesign.

There are already many pavements around the United States that fit the Perpetual Pavement definition. In recognition of that fact, in 2001 the asphalt industry created a program to identify Perpetual Pavements and honor the agencies that have designed and maintained them. Fifty-nine Perpetual Pavement Awards have been presented through 2008.

In addition to working toward the full integration of Perpetual Pavement technologies into pavement design guides, the asphalt industry will continue to pursue research to advance Perpetual Pavement best practices.

There are currently two national studies on Perpetual Pavement through the National Cooperative Highway Research Program (NCHRP) focused on the engineering characteristics that will be critical to the design of long-life pavements. Pavements have been constructed with instruments embedded in the various layers to ascertain their responses to truck loadings at a variety of locations. These include the NCAT Pavement Test Track and the Minnesota Road Research Project, as well as in highways located in Kansas, Ohio, Pennsylvania, Wisconsin, and other states. These will provide crucial information on the field behavior of Perpetual Pavements.

Significant opportunities for applied research on Perpetual Pavements include an investigation of high-stiffness base materials, which have the potential to reduce both costs and greenhouse gas emissions, and research on the impact of these long-life pavements on climate change, specifically greenhouse gases.

In summary, Perpetual Pavements conserve natural resources, reduce life-cycle costs, save fuel, and reduce fuel consumption and greenhouse gas emissions.

Accelerating Appropriate Use of Porous and Open-graded Pavements

Porous and open-graded asphalt pavements have been shown to have a dramatic beneficial effect on water quality. These pavements have been used widely for over 30 years with an excellent record of success. Open-graded pavement is made with same-size rocks, creating a web of interlocking pores that allow water to flow through the surface.[19]

Open-graded pavements are used mainly in two types of applications. First, open-graded friction courses are widely used for surfacing roads and highways. The pavement layer directly beneath this is impermeable. During a rainstorm, instead of pooling on the surface or bouncing off it, rain drains through the surface and out to the sides. Splash and spray are greatly reduced, enhancing safety.

Second, porous pavement systems are stormwater management tools with an open-graded surface over a stone recharge bed. The system is designed and constructed to collect stormwater, which then infiltrates into the ground. Porous pavement systems are used mostly for parking lots, but they have also been used successfully for roads in communities like Pringle Creek in Salem, Oregon.[20]

Both applications can be used to improve water quality. Porous asphalt surfaces allow roads and highways to function as linear stormwater management systems. Porous parking lots store stormwater, reduce runoff, promote infiltration and groundwater recharge, allow evaporative cooling of the atmosphere, diminish erosion on stream banks, reduce particulates in stream water after storms, and improve water quality.[21]

Porous asphalt pavements are accessible and affordable. They can be produced and constructed by any qualified contractor. Open-graded highway surfaces have additional environmental and safety benefits. They reduce road noise significantly.[22, 23, 24, 25, 26] Texas DOT reported that replacing a conventional surface with open-graded friction course in a high-accident area reduced wet-weather accidents by 93 percent and reduced fatalities by 86 percent.[27]

With respect to porous pavement systems for stormwater management, some local authorities may allow the construction of porous pavement systems but still require total redundancy with the use of conventional stormwater management structures. Applied research documenting the effectiveness of porous pavements, together with a program of continuing education, could be helpful in expanding the use of these pavements and avoiding using them inappropriately.

The industry and partners will use applied research, demonstration projects, open houses, Web-based tools, and other continuing education efforts to accelerate the deployment of porous asphalt solutions in the months and years to come. Industry will also assist federal and state agencies in developing design guidance for porous asphalt applications. And we will look for opportunities to document the environmental effectiveness and cost benefits of porous asphalt pavement, improve materials and mix designs, and evaluate highways as linear stormwater management systems.

CONCLUSION

The engineers, scientists, contractors and managers who guide the development of asphalt pavement have made it one of the most environmentally advanced building materials in the world by constantly improving its cost effectiveness and safety.

By extending pavement life – by improving materials, designs, or best practices – these professionals reduce the cost to the environment and to the taxpayer. By improving the desirability of reclaimed asphalt in new mixes, they have reduced the cost of the mix and the demand for virgin asphalt cement and virgin aggregates.

Going forward, the industry and its partners will pursue the same mandate. It is not enough that the asphalt industry is capable of cutting greenhouse gas emissions or reducing energy usage or enhancing the quality of stormwater runoff. Solutions must also make sense economically for the agencies and companies that buy them.

Going forward, there will be more research, not less. As we conceive and prove new warm-mix technologies, more pavement managers will use warm mix in more applications. As we document the long life and long-term cost effectiveness of Perpetual Pavement, more engineers will adopt this design system for high-load, high-volume roads. As we test and verify new mix dynamics for porous asphalt, road managers will find more ways to use it.

That is how we will make warm-mix asphalt the primary pavement material – and reduce energy consumption and greenhouse gas emissions in the process. That is how we will double the reuse/ recycling of asphalt pavements – and reduce energy consumption, emissions, and the use of virgin natural resources. That is how we will make Perpetual Pavements the standard design method for roadways – and completely redefine the life-cycle expectations and economics of highways in America. And that is how we will make porous pavements accepted as a best management practice for reducing stormwater runoff and improving water quality.

In responding to these challenges, the asphalt pavement industry and its partners will continue to improve the environmental performance of asphalt, already one of the most sustainable pavement materials on earth.

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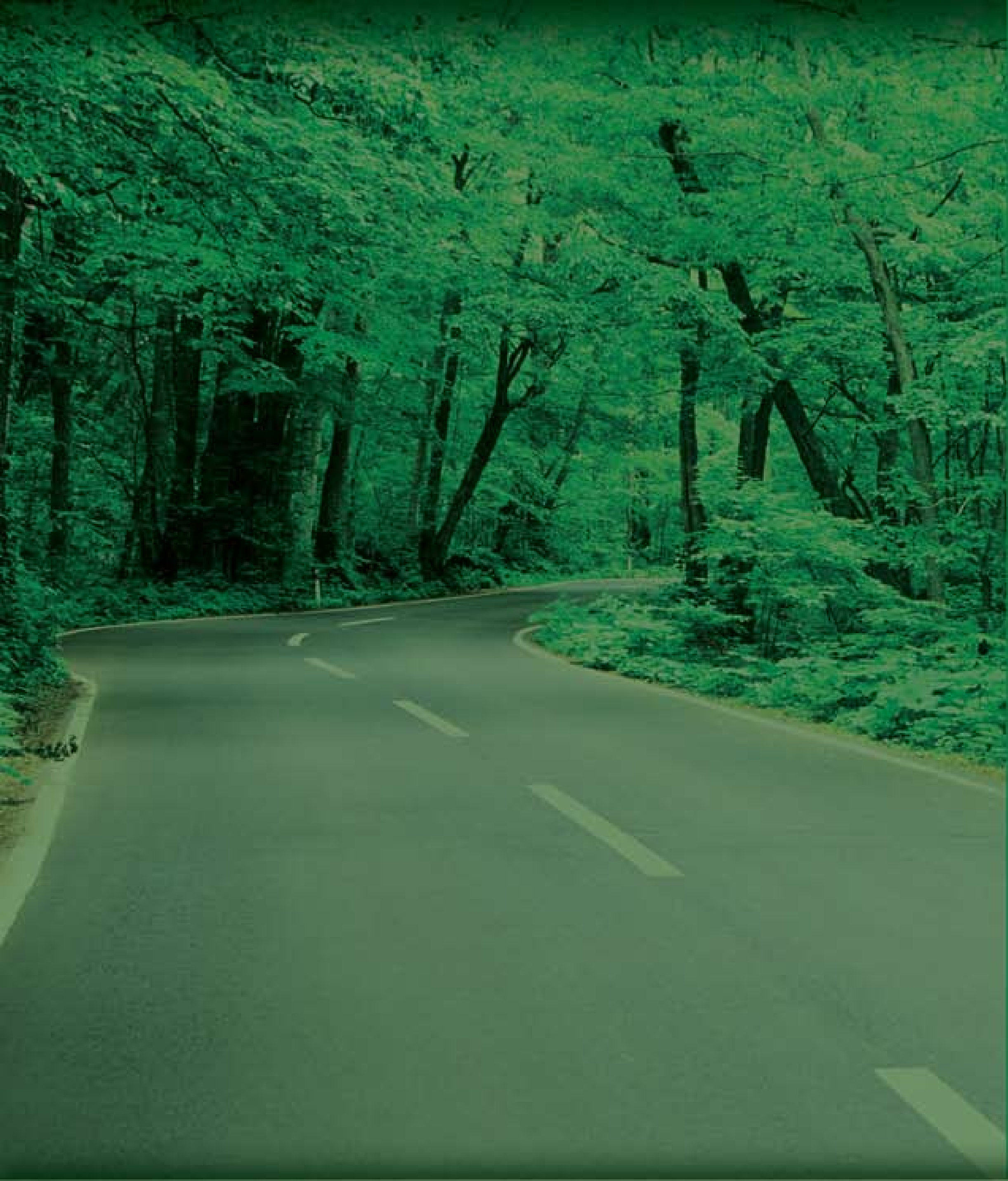

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NAPA Building • 5100 Forbes Blvd. • Lanham, Maryland 20706-4407 U.S.A.
www.hotmix.org/sustainability • napa@hotmix.org
Tel: 301-731-4748 • Toll-Free: 888-468-6499 • Fax: 301-731-4621

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