



Warm-Mix Asphalt

As the United States goes green, asphalt is keeping pace with the times. Warm mix is an important step in sustainable development, simultaneously conserving natural resources, reducing the carbon footprint of the industry, and improving the quality of the pavements that Americans rely on.



THE Future OF Asphalt

People, businesses, government agencies, and entire industries are changing their ways in order to reduce their impact on the environment. Sustainability – the use of resources that allows us to meet the needs of the present while providing for the needs of future generations – is the primary goal.

Asphalt pavement is a basic building block for American life; of the more than 2 million miles of paved roads in this country, 94 percent are surfaced with asphalt. Wherever we go, we see – and use – asphalt. The asphalt network takes us to school, to work, to the doctor, to worship, to shopping, to recreation. When we need emergency services such as ambulances and firefighting, asphalt gets them to us.

But is this fundamental material a sustainable one? Will it be a part of the green future? Will the asphalt industry be able to continue to find ways to reduce emissions and cut fuel consumption? Will the industry be able to recycle? Will the industry build pavements of high quality that will remain serviceable for decades without the need for traffic-disrupting repairs or replacement?

The answer to all these questions is Yes. Asphalt is already a sustainable material, and currently new technologies known as warm-mix asphalt are making it even more so. Warm-mix technologies employ a variety of methods and materials; what they have in common is the ability to drastically reduce the temperatures at which pavement material is produced and placed on the road.

The warm-mix technologies' temperature reductions – in the neighborhood of 50 to 100 degrees Fahrenheit – have the obvious benefits of saving fuel and cutting emissions. What may be surprising to some is that they also have the potential for benefits in construction that may extend the paving season in cold climates, improve quality, and lengthen the lifespan of the pavement.

Where warm mix comes from

In 2002, leaders of the National Asphalt Pavement Association learned of warm-mix technologies that were being introduced in Europe. They quickly organized a study tour and visited Denmark, Germany, and Norway in order to view several technologies in action. Research began immediately at the National Center for Asphalt Technology to validate the benefits and explore the opportunities of warm mix. Educational sessions at conferences, magazine articles, and other communication activities followed quickly. The first warm-mix demonstration sections in the U.S. were constructed in 2004.

Since that time, U.S.-based innovators have seized the opportunity and introduced a number of new technologies – at last count, there were 12 in the marketplace. Contractors, state departments of transportation, the Federal Highway Administration, and technology providers across the country have embraced warm mix. Scores of test



sections have been constructed and numerous open houses have been conducted to provide education about the possibilities.

How do warm-mix technologies work?

The processes and equipment used for warm-mix asphalt are, in many ways, the same as traditional hot-mix asphalt: an engineered mixture of aggregates (stone, sand, and gravel) and asphalt cement (a petroleum product, sometimes called bitumen) is produced at an asphalt plant. Usually, the ratio is about 95 percent aggregates to 5 percent asphalt cement. Asphalt cement is the binder, the glue that holds the pavement together.

At the plant, the aggregates are heated, driving off moisture. The hot aggregate is then mixed with asphalt cement; the heat facilitates the mixing and coating process. About 500 million tons of asphalt pavement material is produced each year in the U.S. using these methods.

Warm-mix technologies fall into two basic categories; one uses a small quantity of water to create foaming of the asphalt, and the other uses a chemical additive. Both groups of technologies result in a mix that can be placed on the roadway at reduced temperatures when compared to conventional practice. Hot-mix asphalt is usually produced at about 280° to 340° F. Warm-mix technologies allow production temperatures to be reduced to approximately 215° to 275° F.¹

Warm mix and recycling

The asphalt industry is already America's number one recycler. Every year, more than 100 million tons of asphalt pavement are reclaimed. About 75 million tons of the reclaimed asphalt pavement (RAP) is mixed with virgin materials and incorporated into new asphalt pavement. This is called the *highest and best use* because the asphalt cement in the old pavement is reactivated, becoming part of the binder for the new pavement and replacing some of the virgin binder that would otherwise be required. (Incidentally, another 20 million tons of RAP is reused in other ways in highway building.)

Asphalt's recycling record is impressive, and warm mix promises to continue this legacy. Expanding the *highest and best use* of RAP can produce pavements that are equal to or better in quality than those made of all-virgin materials, while saving road agencies (and taxpayers) money and conserving precious natural resources.



The difference between hot mix and warm mix is very evident at the point where the paving material is loaded into trucks at the plant. Hot mix produced at 320° F is in the truck on the left. Warm mix at 270° F is on the right.

Energy and the Environment

Warm mix reduces fuel usage and emissions while producing long-lasting pavements to meet society's transportation needs.

FUEL SAVINGS

Reducing the production temperatures at the asphalt plant reduces the amount of fuel that needs to be used to heat the aggregate. Actual fuel savings will vary depending on a number of factors such as the temperature reduction and the aggregate moisture content. A 30 percent reduction in fuel consumption has been reported in Europe^{2,3,4}. Using a more conservative estimate of a 15 percent reduction in fuel usage through the implementation of warm-mix technologies, it can be calculated that the U.S. would save about 150 million gallons of No. 2 fuel oil per year. This is about half the amount of gasoline consumed in a single day in the U.S.

WARM MIX AND OUR COMMUNITIES

Between 1970 and 1999, the asphalt industry increased production of its product by 250 percent, while reducing total emissions by 97 percent. Emissions from asphalt plants are low and well-controlled. Warm mix offers the opportunity to further reduce emissions.

EMISSIONS

The emissions of asphalt pavement production facilities and paving operations are very low and well-controlled. The majority of the emissions from an asphalt plant are produced from the combustion of fuel to heat the aggregates, so that, if fuel usage decreases, emissions decrease. European studies² representing a range of WMA technologies indicate that a 30 percent reduction in carbon dioxide (CO₂) production may be possible with some plant designs and warm-mix technologies. If we calculate a 15 percent reduction, full-scale implementation of WMA throughout the United States would reduce CO₂ emissions by an equivalent of 210,000 cars per year. (About 243 million cars are registered in the U.S.)

Benefits at the paving site

When the paving material leaves the asphalt plant, it is trucked to the paving site, where an asphalt paving machine places it on the road. The next step is compaction, which is accomplished by rollers. Compaction is critical to the long-term performance of the pavement. And one of the critical factors in compaction is the workability of the mix at the paving site.

The warm-mix technologies are compaction aids which improve the workability of the mix. Temperature is also a factor. Cooling of warm mixes is slower than cooling of hot mixes, because the difference in temperature between the warm mix and the ambient air is smaller.

Warm mix can therefore be used for paving in cooler weather than hot mix, and it can be hauled for longer distances. Also, “stiff mixes” – pavements that use stiffer grades of asphalt cement – become more forgiving and easier to construct.

Working with warm mix at the paving site is very similar to working with hot mix. With some mixes, handwork is easier; sometimes, the tendency of a mix to stick to tools and machines is reduced. Workers also report that they enjoy the improved conditions at the paving site.

A VARIETY OF PAVEMENT TYPES

Demonstration projects of warm mix have been extended to a variety of pavement types. Mixes incorporating rubber and polymers have been produced. Also, open-graded pavements – which have interconnected pores that allow rain to sink in and run off to the sides – have been constructed.



While each mix has its challenges and requires careful engineering, successful results have been achieved with each type of paving material. To aid in the thoughtful implementation of warm mix, the industry and researchers have developed guidelines for best practices in warm-mix asphalt production and construction.⁵

PERFORMANCE

Warm-mix technologies are being tested at the National Center for Asphalt Technology's Pavement Test Track. At this track, trucks hauling loads that are much heavier than normal inflict about 10 to 12 years' worth of traffic damage on pavements in just two years. The warm-mix sections are performing very well and showing low rutting.⁶

The first warm-mix sections in the U.S. were constructed in 2004. To assess longer-term performance, the Federal Highway Administration and the American Association of State Highway and Transportation Officials sponsored a scanning tour to Europe in summer 2007. The team of agency officials, contractors, and researchers viewed pavements and talked to the owner agencies. What they found is that the European agencies expect warm mix to perform as long as, or longer than, hot mix. There is speculation that lowering the production temperature reduces aging of the asphalt binder, which may reduce the potential for cracking. Improved compaction is also a factor in the expectation of improved performance.

For more information

More information on WMA can be found at www.warmmixasphalt.com, the official site of the Federal Highway Administration's Warm-Mix Asphalt Technical Working Group. The site, which is updated frequently, contains articles, presentations, and scholarly publications on WMA.



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