

Asfaltna industrija v zvezni državi Kentucky, ZDA (recikliranje in topli asfalti, garancijska doba ...)

Asphalt industry in Kentucky USA (recycling, warm asphalt, warranty period, ...)

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Summary

The use of warm mix asphalt and reclaimed asphalt pavement has exploded in Kentucky over the past 10–15 years due to a combination of factors. The early success of both products and industry support has resulted in speedy implementation. Today, the use of RAP and WMA in Kentucky and the U.S. is commonplace with numerous contractors utilizing these technologies on a daily basis throughout the state.

Changes in pavement technology can take a long time to evaluate because years and years of traffic and weather are often needed before distresses begin to appear. KYTC has recently joined the research program at NCAT which allows some of our Kentucky mixes to be placed, trafficked and tested on the track. This accelerated loading facility will provide timely and valuable information about the quality and performance of asphalt mixtures in Kentucky.

While the driving force on adoption of new technologies may be for cost savings and a competitive advantage, the key factor in acceptance is the performance of the material on the roadway. Thus far, Kentucky has seen similar and equal performance from mixtures that contain all virgin mixes as compared with those which incorporate RAP. As it relates to warm mix, the mixtures manufactured and placed at lower temperatures using foaming or chemical additives have performed similarly to those that were produced at conventional hot-mix temperatures.

Since economic factors will always drive contractor decisions, it is likely that we will continue to see an increase in RAP and WMA use in Kentucky. As the technology and experience improves and evolves, the barriers to entry for the contractor become smaller and smaller. Both RAP and WMA are market and technology driven which suggests that they will continue to be an integral part of asphalt mixtures in Kentucky now and in the years ahead.

Overview

Asphalt is the preferred paving material throughout the state of Kentucky and across the United States. In fact, it is estimated that more than 94 percent of all the paved roadway surfaces in the United States are paved with asphalt. The Federal Highway Administration (FHWA) and local state agencies, such as the Kentucky Transportation Cabinet (KYTC), rely on the asphalt paving industry to provide safe, smooth and durable pavements for the traveling public.

Highway and roadway construction is a significant economic driver in the United States and critical to our mobility. The National Asphalt Pavement Association (NAPA) estimates that approximately 350

million tons of asphalt pavement mixtures are produced in the United State each year. At a state level, the KYTC has a goal of spending \$1 billion annually on construction projects and it purchases approximately 5 million tons of asphalt each year. This level of investment is needed to maintain the more than 27,000 miles of roadway across the state. In a climate with numerous wet-freeze-thaw cycles each year and the possibility of extreme temperature changes, Kentucky is a harsh environment for asphalt pavements. Although the public has a desire for increased capacity and improved roadway conditions, asphalt production has dropped significantly over the past decade due to increases in energy and materials costs combined with fixed

or declining budgets for roadway construction and maintenance.

Federal and state agencies invest hundreds of billions of dollars in infrastructure each year in an effort to build and maintain a world-class transportation network. Despite the large investment in roads and bridges, funding in the United States is inadequate to meet our needs, and we are facing an ever-aging infrastructure. For that reason, it is essential that the industry provide long-lasting and durable materials that can withstand the demands of time (weathering) and traffic.

In 1987, the U.S. Congress authorized the Strategic Highway Research Program (SHRP), a five-year research initiative, to develop and evaluate techniques and technologies to combat the deteriorating conditions of the nation's highways and to improve their performance, durability, safety and efficiency. One of the major outcomes of the SHRP program was the development of the Superpave system for asphalt mix designs. This system enables designers to select materials and design a mix that meets specific weather and traffic conditions for a project site.

State, federal and local agencies continue to perform research on asphalt to help to ensure pavement performance and durability. One of the most practical and interesting research projects underway today is located near Auburn, Alabama, at the National Center for Asphalt Technology (NCAT). The NCAT Pavement Test Track is a unique accelerated pavement-testing facility that brings together real-world pavement construction with live heavy trafficking for rapid testing and analysis of asphalt pavements. The test track is funded and managed as a cooperative project among highway agencies and industry sponsors.

The track itself is a 1.7-mile (2.7-kilometer) oval test track with 46 different 200-foot (61-meter) test sections. NCAT operates a fleet of heavily loaded tractor-trailers to provide 10 million equivalent single-axle loads (ESALs) during each three-year cycle. Pavement performance is monitored on a continuous basis to evaluate rutting, cracking, roughness, texture, friction and noise. In addition,

structural pavement research is conducted using embedded strain and pressure sensors to monitor pavement response to loads for validation of mechanistic-empirical pavement design procedures.

The implementation of warm-mix asphalt technologies and the use of reclaimed asphalt pavement (RAP) have exploded in the United States over the past 10-15 years. While both techniques are popular because they are environmentally friendly and sustainable, the driving force behind the use of these products has been economic considerations. Increased usage of RAP and warm mix has not been the result of agency mandates. In fact, just the opposite is true; industry has embraced these changes, and contractors are now pushing agencies and owners to open their specifications to allow for the use of these products.

The use of warm-mix asphalt technologies and reclaimed asphalt materials are completely separate issues. However, they do have one thing in common: The state and federal agencies researching the technologies have made it clear that, in order for either to be accepted and utilized, they must demonstrate the ability to provide equal performance to mixtures that do not utilize these materials and methods. There is a learning curve with all new technologies but, all in all, the performance of RAP and warm-mix asphalt has proven to be very successful.

Reclaimed Asphalt Pavement (RAP) Overview

The use of recycled materials first gained interest some 40 years ago as a result of supply issues associated with the 1973 Arab oil embargo. While some contractors recycled in modest amounts, the economic situation of the 1980s and 1990s did not provide much incentive to move in the direction of higher recycle contents. However, the combination of technological advancements in equipment and market changes has created a renewed interest in utilizing recycled products over the past decade. Asphalt mix designs have evolved to better account for the properties of the recycled products and the modern asphalt plants are better equipped to incorporate these materials. Also, rising oil prices in

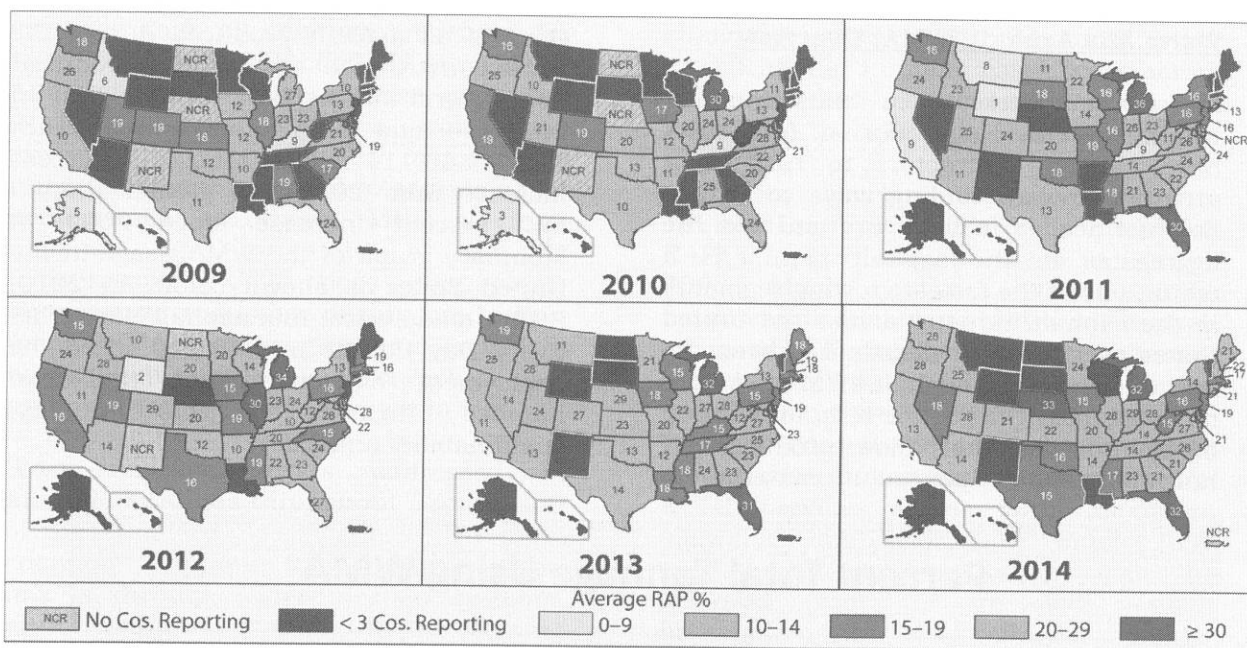
2008 led to higher liquid asphalt prices, forcing contractors to look harder at recycling to remain competitive.

Aside from economic and competitive issues, the FHWA cites numerous reasons to support the use of reclaimed asphalt pavement.

“While several factors influence the use of RAP in asphalt pavement, the two primary factors are economic savings and environmental benefits. RAP is a useful alternative to virgin materials because it reduces the use of virgin aggregate and the amount of virgin asphalt binder required in the production of hot-mix asphalt. The use of RAP also conserves energy, lowers transportation costs required to obtain quality virgin aggregate and preserves resources. Additionally, using RAP decreases the amount of construction debris placed into landfills and does not deplete nonrenewable natural resources,

such as virgin aggregate and asphalt binder. Ultimately, recycling asphalt creates a cycle that optimizes the use of natural resources and sustains the asphalt pavement industry.”

Currently the use of recycled materials has become rather commonplace. The U.S. asphalt industry remains the country’s most diligent recycler, recycling asphalt pavements at a rate of over 99 percent. The average percentage of RAP used in asphalt mixtures has increased from 15.6 percent in 2009 to 20.4 percent in 2014. In 2014, the estimated RAP tonnage used in asphalt mixes was 71.9 million tons. Assuming 5 percent liquid asphalt in RAP, this represents more than 3.6 million tons (20 million barrels) of asphalt binder conserved along with replacing some 68 million tons of virgin aggregate. Some states, such as Florida and Michigan, are consistently recycling at 30 percent or more.



NAPA/FHWA Survey Results, Average RAP Percentage, 2009–2014 (courtesy of NAPA)

Recycled Asphalt Shingles (RAS) are also commonly used in asphalt mixtures. With a higher percentage (20–30 percent) of asphalt binder in RAS, its use in asphalt mixtures has steadily increased in recent years. While this paper is specifically focused on RAP and does not address shingles, the author recognizes the importance of RAS and the frequency of its use in asphalt mixtures in Kentucky and across the United States.

Numerous states and research studies have documented that, with proper design, the performance of mixtures containing RAP can meet or exceed the performance of mixtures that consist of all-new materials. The FHWA supports the use of RAP and has created the RAP Expert Task Group (ETG), which consists of government, industry and academia, to encourage the increased use of RAP.

It is a common misperception that recycled material produces an inferior product or is low tech. The reality is just the opposite. Modern RAP mixtures are a carefully engineered combination of materials, and the consistency of RAP stockpiles is typically equal to or better than virgin aggregates. Sophisticated mix designs and tests are performed to insure that those new and recycled materials are properly accounted for and combine to produce a mixture with all the desired properties.

There has been a lot of discussion within the industry about how much actual blending actually occurs between new binder and the hardened asphalt that is coating the RAP. While some RAP binder may not fully blend with the virgin material, research shows that RAP mixtures behave like a composite where the RAP binder is fully blended and not as a black rock floating in the mix.

Warm Mix Asphalt (WMA) Overview

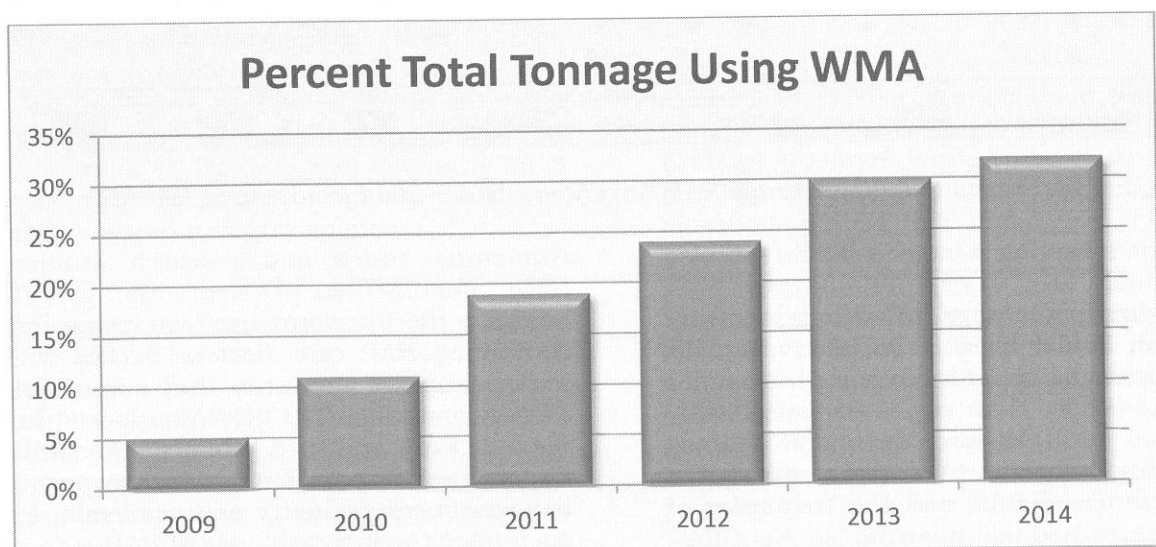
Increasing interest in sustainability combined with rising burner fuel costs have caused contractors to turn their attention toward finding ways to reduce the fuel needed to heat, dry and mix the aggregates in the asphalt plant. As a result, one of the fastest growing segments in the asphalt industry across the United States over the past decade has been the use of warm-mix asphalt (WMA). Warm-mix asphalt is the generic term for a group of technologies that allow producers of hot-mix asphalt pavement material to

lower the temperatures at which the material is mixed and placed on the road. Reductions of 25–100 degrees Fahrenheit (14–55 degrees Celsius) have been documented. Such dramatic decreases in temperature have the obvious benefit of lowering the fuel consumption needed to produce each ton of asphalt.

WMA affords contractors, agencies and owners an array of advantages:

- Lower temperatures for plant mixing, hauling and lay down
- Reduced plant emissions
- Reduced usage of burner fuels
- Ability to haul longer distances
- Pave in cooler weather
- Increased density
- Better conditions for increasing the percentage of RAP

The latest NAPA/FHWA survey of asphalt producers' use of recycled materials and warm mix asphalt finds that almost a third of all asphalt produced during the 2014 construction season was produced using warm-mix asphalt technologies. In 2014 the total WMA tonnage in the U.S. was about 114 million tons, a 7 percent increase from 2013 and greater than a 577 percent increase since 2009. A summary graph of the WMA usage in the United States is shown below. In 2010, FHWA made warm-mix asphalt part of its Every Day Counts initiative to speed the deployment of technologies that can improve highway projects' quality, sustainability and safety.



Current Kentucky Specifications

The Kentucky Transportation Cabinet develops and maintains the Standard Specifications for Road and Bridge Construction. This version of the specifications, last updated in 2012, is reviewed by FHWA and applies to all projects utilizing state and federal funding in Kentucky. These specifications allow paving contractors to utilize RAP and WMA on all KYTC projects. Since most city, county, private and industrial projects reference the KYTC Standard Specifications, it is assumed that both RAP and WMA are commonly used in all facets of the asphalt paving market.

The Kentucky Standard Specifications are "permissive" in that they allow the contractor to utilize WMA and/or RAP, but do not require their use in asphalt mixtures. They do, however, set forth parameters that the contractors must meet for material properties, mix design, production and construction. In implementing this approach, KYTC assumes that all mixtures meeting the specifications are functionally equivalent. Although KYTC must approve each mix design submitted by a contractor, mixtures that contain RAP materials or utilize WMA are assumed to provide equal performance to those with all-virgin materials and produced at hot-mix temperatures. KYTC does not specify temperature reduction during production using WMA technologies and considers any asphalt mixture using one of its pre-approved technologies to be warm mix.

Warm-mix asphalt is addressed in multiple locations throughout Section 400 of the Standard Specifications. The most common technique for producing warm mix is through water-injection systems, also called plant foaming. In the foaming process, a small, controlled amount of water is injected into the asphalt plant in such a way that the water comes in contact with the hot liquid asphalt, causing it to expand in volume. This foaming process improves the ability of the liquid to coat the aggregates and makes the mixture more workable during the haul and during placement in the

field. The moisture eventually evaporates out of the mix and the remaining materials are unaffected by the temporary foaming that occurred at the plant. Engineers from KYTC must inspect each new plant and be certain it is calibrated and can properly demonstrate the ability to produce a quality mixture and that the contractor can achieve density. Some contractors will utilize warm-mix technologies but will heat the mixture to traditional hot-mix temperatures. In this scenario, the warm mix technology is only being used as a compaction aid and for workability, not to save on fuel costs.

While not as common as foaming, chemical additives are a significant and growing portion of the market in Kentucky. These chemicals are pre-blended with the liquid asphalt at the terminal, shipped to the contractor and stored in on-site tanks for use in the asphalt mixture. The warm-mix additive is already included in the liquid, which eliminates the need for any plant modifications. In some cases, contractors utilize in-line blending systems to introduce the chemical additive at the plant.

The use of recycled materials (including RAP) is specifically addressed in Section 409, which outlines the specific parameters related to RAP in asphalt mixtures. Kentucky utilizes effective binder content, a ratio of the binder contribution from RAP to virgin binder, to carefully control the amount of recycled binder contribution to the total mixture. KYTC provides tables with maximum allowable limits for how much total asphalt binder contribution can be achieved from the recycled asphalt pavement. As the effective binder replacement increases and more hardened binder is used, the specifications require that contractors change to a softer grade of asphalt in order to maintain the desired performance characteristics.

	No Change in Virgin Asphalt Binder (Utilize PG 64-22)	Drop to Softer PG Binder Grade (Utilize PG 58-28)		
Surface Mixtures	≤ 20% Effective Binder Content	21-30% Content	Effective	Binder
Base Mixtures	≤ 25% Effective Binder Content	26-35% Content	Effective	Binder

Testing has confirmed that the binder in RAP is age-hardened and therefore stiffer than the virgin asphalt grades. With increasing percentages of RAP in an asphalt mixture, the mix becomes stiffer and, in extreme cases, it can cause the finished mixture to become brittle. With lower percentages, the inclusion of RAP does not cause a significant difference in the properties of the mixture. With higher and higher amounts of RAP, it may be necessary to utilize a softer virgin binder or a rejuvenator in order to offset the increased stiffness in the RAP. Most DOT specifications, including those in Kentucky, provide guidance on when the amount of RAP reaches a threshold when a softer liquid asphalt is needed, or additional testing may be required to maintain flexibility and performance of the mixture.

Experience with RAP

Kentucky contractors in the 1970s and 1980s were not initially interested in using RAP in their mixtures and, in some cases, considered it to be waste or used it as fill material. It wasn't until the early 1990s that contractors started to recognize RAP as a resource and started recycling in moderate amounts (15 percent maximum and typically less than 10 percent). In that era, most contractors were utilizing batch plants which limited their ability to recycle. As milling became more and more prevalent and as many contractors shifted from batch to higher production drum mix plants, the ability to recycle made it a more viable option. With the dramatic spike in liquid asphalt costs, conserving liquid asphalt became a significant issue and the use of RAP began to increase.

Moving forward to 2015, KYTC data indicates that 80 percent of all asphalt mixtures in Kentucky utilize RAP. Nearly 600,000 tons of RAP was used on KYTC projects this year and much more on private and commercial projects throughout the state. A typical base mixture in Kentucky will utilize 20 percent RAP and a typical surface mix is about 15 percent. Some contractors are utilizing as much as 37 percent RAP in base mixtures and this percentage represents the upper bound allowed by the KYTC specifications. The primary limitation in utilizing RAP in Kentucky is not the specification limits but rather the availability of materials. Urbanized areas such as Louisville, Lexington and Northern Kentucky have far more elevation constraints and therefore a much greater need for milling in order to maintain the current grade. In those areas, RAP is plentiful. The rural parts of the state are less likely to require milling, which decreases the quantity of RAP available. There are also situations where a contractor is not allowed to maintain possession of the RAP and must deliver it to a KYTC maintenance facility. Most contractors in rural areas will not push the upper limits of RAP in their mixtures because they would quickly run through their entire supply. Rather, they will determine a moderate percentage of RAP they can use on a routine basis based on the availability of RAP they receive on an annual basis.

For contractors, controlling the aggregate gradation is a critical factor in the performance of mixtures with RAP. At small percentages, the inclusion of RAP may have very little effect on the properties of the mixture. However, as percentages of RAP increase higher and

higher, it becomes increasingly important to control the gradation of the mix.

Crushing machines, similar to those used for virgin aggregates, are utilized to size and screen the RAP into multiple stockpiles. Contractors will typically produce two or three different sizes. The fine recycled asphalt pavement will have a higher percentage of liquid asphalt whereas the coarse recycled asphalt pavement typically has lower asphalt content. Fine RAP is most often used in surface mixtures, whereas the coarse RAP is commonly utilized in base mixtures. Proper blending and design of the gradation and liquid asphalt contribution is critical to the performance of the asphalt mixture.

At the asphalt plant, contractor personnel must carefully monitor the moisture content of the RAP. Some contractors utilize covered stockpiles or have erected buildings to cover both their RAP and fine aggregates to minimize the moisture content in the mix. Mix designers and plant operators are now very experienced in understanding the moisture content and asphalt content of the RAP, and are capable of factoring these variables into the equation so that the final plant-produced product meets all the KYTC specifications for volumetric properties. Small changes in RAP material properties can result in significant changes in mix volumetrics, so routine testing and quality control are critical to maintaining a quality mixture during production.

Field laydown operations with RAP mixtures have been very successful. When the asphalt mixture is properly designed, the field crews can see very little difference behind the paver. On days when the ambient air temperature is cooler, mixtures with RAP may have a tendency to be stiffer and less workable. For those colder days, the contractor will typically increase the plant temperature slightly to provide the workability in the field.

In terms of durability and field performance in Kentucky, we have found that mixtures with and without RAP have provided similar levels of service. For that reason, the Kentucky Transportation Cabinet does not distinguish between mixtures with or without RAP in the

procurement process. KYTC provides a single mix type designation, and contractors only submit one unit bid price for RAP and virgin mixes.

Experience with Warm Mix

Kentucky's first experience with warm mix asphalt dates back to 2008 at a time when the technology was rather new to the market. The upper management of KYTC had a strong desire to utilize WMA on a Kentucky project. Rather than experimenting on a low-volume roadway, it was decided to try it first on a major interstate project. KYTC management believed that if this experiment was successful on a high-volume roadway, it would lead to faster implementation of the technology.

KYTC selected multiple ongoing paving projects on Interstate 65 and Interstate 75 as trials, and allowed the contractor to produce and pave WMA on the shoulder. The initial trials were successful and KYTC then decided to utilize warm mix on the main driving lanes in order to compare the durability of the warm mix to our traditional mixtures. In total, contractors placed more than 160,000 tons of warm-mix asphalt that year. The industry and agency quickly gained experience and acceptance with the use of warm-mix asphalt technologies.

In the following year, 2009, KYTC modified the Standard Specifications to allow the use of warm-mix asphalt (plant foaming only) on a permissive basis. The change in specification lowered the allowable mixing temperature from 275°F to 230°F. Similarly, the compaction temperature requirement was reduced from 275°F down to 210°F. In 2009, the use of warm-mix asphalt increased dramatically to more than 930,000 tons of mix.

In 2010, KYTC performed a series of trial projects utilizing several different chemical additives totaling about 90,000 tons. At that time, 18 asphalt plants were approved to run warm mix asphalt and the total state-wide tonnage was about 980,000 tons. By 2011, just three years after the first pilot projects, warm-mix asphalt production in Kentucky exceeded

1 million tons and 27 plants were approved for foaming operations.

The 2014 NAPA survey of warm mix production in Kentucky indicates that 82 percent of the warm mix produced in Kentucky utilizes plant foaming techniques. The remaining 18 percent utilize chemical additives. Of the nearly 120 asphalt plants state-wide, 41 plants are approved for water injection (foaming) and 30 are approved for chemical injection. KYTC data from 2015 indicates that 43 percent of all the asphalt mixtures produced in the state utilize some type of warm-mix asphalt technology.

Many contractors across the state have invested in water-injection (foaming) systems or have made a commitment to embrace chemical additives. The initial cost for foaming systems are relatively low

and the system only requires small amounts of water. The terminal-blended chemical additives are incorporated into the mixtures (typically a dosage rate of 0.4 percent in Kentucky) but require no plant modification. Those utilizing in-line blending do require some plant modifications. Once implemented and calibrated, these systems have produced excellent results with few, if any, problems.

Similar to our experience with RAP mixtures, warm-mix asphalt mixtures have performed very well in the field. On cooler days, they are not as workable and may require some additional heat at the asphalt plant. Hand work can be more difficult on cool days but there are no issues or differences with the material that goes through the paver and is spread by the paver screed.