



The

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REPORT

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The Green Issue

Carbon Footprint: How Does HMA Stack Up?

By Brian Prowell, Ph.D., P.E.

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In the past, agencies and contractors determined pavement type selection by evaluating performance and cost. In the near future, a new factor may be considered – sustainable development.

Sustainable development can be defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”¹

Sustainable development considers environmental impacts, such as greenhouse gas production and depletion of non-renewable resources, such as fossil fuels.

The term “carbon footprint” generally refers to the total amount of all greenhouse gas emissions (generally CO₂) caused directly and indirectly by a given process, product, or event. When looking at the carbon

footprint of asphalt pavement, for example, one can envision summing the amount of CO₂ emissions from the extraction of aggregate at a quarry and the production of bitumen binder at a refinery, plus those associated with transporting raw materials, processing raw materials into finished pavement, constructing the pavement, and other miscellaneous activities associated with pavement production and maintenance.

A number of studies compare the energy consumption, waste produced, and environmental impacts from different

pavement materials. These studies use environmental life-cycle assessments to make meaningful comparisons over the design life, taking into account raw material acquisition, manufacture, transportation, installation, and waste management.

Horvath and Hendrickson² performed an economic input-output based life-cycle assessment to compare an 11.8-inch thick HMA pavement with an 8.7-inch thick continuously reinforced concrete pavement (CRCP) placed on the same subgrade. The four-lane pavements were designed to carry 10 million equivalent single axle loads (ESALs). The study estimated that it takes approximately half of the energy per mile to produce the HMA pavements as compared to the equivalent CRCP pavement (0.93 million kW hr versus 1.85 million kW hr).²

LIFE-CYCLE APPROACH

Other studies have used the life-cycle approach recommended by the Society for Environmental Toxicology and Chemistry (SETAC)

and the U. S. EPA. This method tracks environmental flows or impacts upstream. For example, HMA pavement would be tracked to stone quarrying and asphalt binder production, and asphalt binder would be tracked to impacts from recovering and transporting crude oil.

A Swedish study using this method indicates that it takes 36 percent more energy to produce a Portland cement concrete (PCC) than a comparable HMA pavement.³ A similar study conducted in

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From the Desk of the E.V.P.

With all our focus on “Environmental Sustainability” it seems that now everyone is working overtime to demonstrate how “Green” their products are. Well, not to be a “Me Too”, but you need to understand that the HMA industry has been proactively developing such technology and practicing green-build techniques since the 1960’s. For example, between 1960 and 1999, the asphalt industry has decreased total emissions from asphalt plants by 97% while increasing production by 250%. From 1996 through 1998, EPA conducted an extensive emissions testing program which resulted in 6,000 pages of test results, and estimated to have cost in excess of \$1.5 million. It was stated that “Few, if any, industries have been evaluated as thoroughly as the HMA industry.” The result from these intensive tests is that emissions from asphalt plants are so low the EPA does not consider them a major source of industrial pollution. In addition to industry’s focus on air quality, other technological advancements dramatically contribute to the HMA’s roll in environmental sustainability.

Perpetual pavements are full depth HMA pavements designed so that distresses occur in the top layer only. The only rehabilitation needed is a periodic removal and replacement of the surface layer. The main structure is designed to remain intact indefinitely. Perpetual pavements are the ultimate in sustainable design and construction. The reclaimed material can be recycled back into the new mixture. Designing a pavement where the main structure remains indefinitely and the reclaimed material is recycled back into new mixtures greatly reduces our impact

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“...it takes approximately half
of the energy per mile to
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CRCP pavement...”

(EVP – Continued from page 1)
on natural resources.

The latest advancement is in what Europe has been developing and using for more than a decade now. It's called Warm-Mix Asphalt (WMA). This is technology that allows industry to produce and construct asphalt pavements at dramatically lower temperatures (50° F. to 100° F. cooler). Producing pavements at lower temperatures further reduces plant emissions, and premature aging of the asphalt binder. In addition, WMA technology allows pavements to be constructed in cooler temperatures extending the paving season, reduces odors at the plant and work site, and further reduces energy consumption at the plant.

This is just the tip of the iceberg, so to speak. Asphalt pavements are the most environmentally sustainable pavement available and contribute in a multitude of areas from energy reduction and recycling to improving water quality and stormwater management to cleaner air and cooler cities. More information can be found by either visiting our website at www.apai.net, or by going to www.asphaltalliance.com

APAI Asphalt Design Guide

The APAI Interactive Asphalt Design Guide is available. The Design Guide is an easy to use reference for the novice and experienced designer alike. Included on the same CD is a Thickness Program for Iowa's designing engineers.

For your FREE copy, please contact the APAI office to request a copy (phone: 515-233-0015, fax: 515-233-0017, e-mail: apai@apai.net)



(CARBON FOOTPRINT – continued from page 1)

the U.S. using the same pavement sections used by Horvath and Hendrickson, found that the HMA pavement required 21 to 92 percent less energy than the CRCP pavement, depending on the estimate used for the energy required to produce the asphalt binder.⁴⁻⁵ Why the big deal about energy use? Simply put, the more energy that is used, the more greenhouse gases are produced and the bigger the carbon footprint. This is the same concept used with warm-mix asphalt (WMA) where fuel savings from lower temperatures result in reduced carbon dioxide (CO₂) emissions.

The energy consumed to produce an HMA pavement deserves a closer look. Asphalt production consumes 39 percent (using the high estimate) of the energy used to produce an HMA pavement, while heating, drying, and mixing the aggregates and binder uses 49 percent. All of the studies noted that a significant advantage of HMA pavements is the fact that they can be readily recycled. The use of RAP in a mixture reduces the virgin asphalt demand and therefore reduces energy consumption. Recycling rates for CRCP pavements are much lower, in some part due to the difficulty in removing the reinforcing steel. WMA technologies also have the potential to significantly reduce the energy required to construct an HMA pavement.

The studies also cited the need for a method to make routine comparisons. One such method is BEES® 4.0 – Building for Environmental and Economic Sustainability – developed by the National Institute of Standards and Technology (NIST).

PARKING LOTS

BEES allows economic and environmental life-cycle comparisons for a variety of parking lot options. Figure 1 shows a comparison of the carbon

emissions between HMA with conventional maintenance, PCC, and PCC with 15 percent of the cement replaced with fly ash. The comparison is based on typical PCC and HMA construction practices. The environmental impacts for the HMA

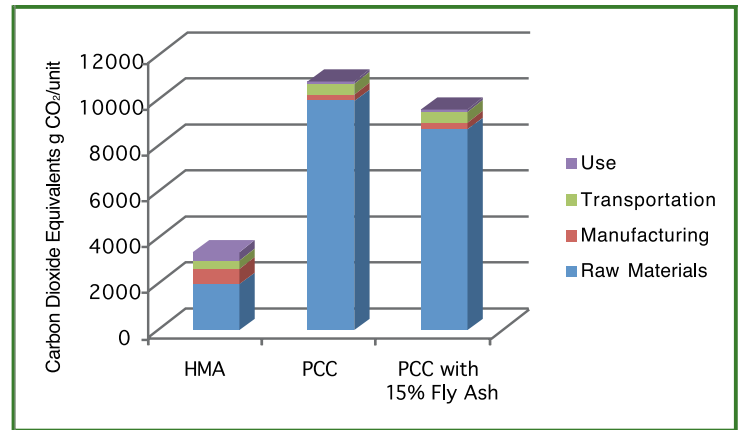


Figure 1. BEES Carbon Dioxide Equivalent Comparison

are based on a 15 percent RAP content.⁶ Maintenance for the HMA parking lot includes a 1.5-inch overlay every 15 years. All comparisons used a haul distance of 20 miles.

Based on Figure 1, the PCC pavement options produce significantly more CO₂, even when fly ash is substituted for cement. In the BEES analysis, HMA is preferred both economically and environmentally on a life-cycle basis.

Although the differences between HMA and PCC are significant during the construction of the pavement, construction impacts as a whole are dwarfed by the energy used and greenhouse gases emitted by traffic. One study determined that traffic levels of only 5,000 cars per day used 10 times more energy over a 40 year period than that used to construct the pavement.³ The inclusion of RAP and the potential fuel savings from WMA technologies allow for even greater reductions in the carbon footprint of HMA pavements.

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ISU Dedicates Materials Lab

The Department of Civil, Construction and Environmental Engineering at Iowa State University dedicated their newly renovated asphalt materials laboratory on April 8th. The funding for the equipment and facilities was



▲ Students, faculty, and APAI members were present for the ISU Lab dedication.



▲ ISU Asphalt Lab after renovation.

possible through the generous donations of the APAI members and the College of Engineering at Iowa State. Iowa State President Dr. Gregory Geoffroy commented: "It raises the quality of our educational programs for students and professionals in the field, and significantly expands our asphalt materials research capabilities. Providing better-educated and trained professionals to the asphalt materials industry and governmental agencies will help improve the quality of life for people throughout our state and nation by providing safer, longer-lasting and more efficient surfaces for transportation and other purposes."

The asphalt lab has already begun educating students in asphalt materials and

Iowa State will be planning on competing in the upcoming year's national asphalt mix design competition. "Now that we have the facilities and are providing a high quality educational program to our students, we want to go out and demonstrate our students are amongst the best educated in our industry", said Dr. Chris Williams.

The research work in progress includes developing alternative binders for use in flexible pavements and was recently the lead news story on KCRG in Cedar Rapids. Research work is also underway at implementing newer pavement design methods, moisture sensitivity testing, and improved QC/QA test methods utilizing electromagnetic gauges.

The State of HMA Recycling in the U.S.

By Dave Newcomb, P.E., Ph. D.
and Cecil Jones, P.E.

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National Asphalt Pavement Association*

Hot-mix asphalt (HMA) is by far the most recycled product in the nation, with 80 percent of the HMA that is taken up each year finding its way back into roadways. While this is laudable from both an environmental and economic point of view, when one considers the amount used in producing new hot mix, it is obvious that more can and should be done to promote recycling of HMA back into HMA as its best and highest use. Oil and energy prices are at their highest levels ever, and this has profound consequences on the availability of virgin asphalt and the production of aggregates and HMA. Aggregate and polymer costs are rising in proportion to production and transportation costs. On top of this, zoning requirements are making it more difficult to site new plants, exploit convenient aggregate sources, and to stockpile reclaimed asphalt pavement (RAP) at existing plant sites. It is clear that an industry-agency partnership is needed to advocate technology which allows for greater recycling, and this advocacy comes in the form of the RAP Expert Task Group (ETG). The RAP ETG was formed by the Federal Highway Administration in 2007 in order to encourage the use of RAP by agencies that do not currently optimize the amount of RAP in their mixtures or those that do not allow RAP at all in their HMA. The ETG decided that the approach to this

encouragement would include:

- Defining the state-of-recycling
- Identifying barriers to increased recycling
- Initiating research to address barriers
- Promoting best practices in recycling
- Assisting in high-RAP demonstration projects

In order to accomplish the first two of these items, a survey was conducted of all 50 state DOTs and Ontario. The research addressing barriers to higher RAP content in HMA mixtures is being conducted under the National Cooperative Highway Research Program (NCHRP) Project 9-46, "Improved Mix Design,

There tends to be an **excess of RAP in urban areas**, while the available RAP tends to be **completely used in rural areas**.

Evaluation, and Materials Management Practices for Hot Mix Asphalt with High Reclaimed Asphalt Pavement Content." Promotion of best recycling practices is being accomplished through presentations by ETG members and NAPA publications Designing HMA Mixtures with High RAP Content (QIP-124) and Recycling Hot-Mix Asphalt Pavements (IS-123). High-RAP demonstration projects are receiving technical assistance from FHWA and the National Center for Asphalt Technology (NCAT).

The first step for the ETG was to discover the current level of RAP usage and limitations from the states in order to find out how much room for improvement exists. Responses were gathered from all 50 states as well as Ontario. It should be noted that the survey took place between last June and this spring, and that the situation is changing constantly as states consider the economic benefits of moving to greater levels of recycling.

The survey asked how much RAP is allowed in mixtures, how much is actually used, and what are the main roadblocks to greater usage of RAP. Figures 1 through 3 show the amount of RAP allowed by the states and the amount generally used in base, intermediate, and surface courses, respectively. Figure 1 shows the survey results for base courses, and it can be seen that, in general, the majority of states have no problem in allowing RAP contents of 20 percent or more in the HMA base course, and that the actual RAP contents are generally 15 percent or above.

Figure 2 shows the results for intermediate or binder courses. Again, the majority of states allow more than 20 percent RAP in intermediate course mixtures. Although there are a number of states that see average RAP contents in intermediate courses in excess of 20 percent, the majority of states see actual RAP contents in intermediate mixes to be on the order of 15 percent or more.

Figure 3 shows the amount of RAP allowed versus the average actually used in surface courses. While there are some agencies which allow more than 20 percent

RAP, many others are reluctant to allow more than 10 percent and, in fact, there are some which allow no RAP in the mixtures.

The survey queried the states on the barriers restricting the amount of RAP in mixtures. Basically, the responses could be categorized according to specifications, lack of RAP availability, lack of processing, and past experiences. Three of these four issues may be addressed through changes in practice and application of technology. Availability is a local issue that tends to be divided along urban versus rural locations. There tends to be an excess in urban areas, while the available RAP tends to be completely used in rural areas. Considering the value of the binder and aggregate in RAP, there may be some economy in transporting RAP from areas of excess availability to areas deficit in RAP.

SUPERPAVE

Superpave was adopted in the early 1990s, and being a new mix design system, many DOTs were reluctant to allow much, if any, reclaimed asphalt pavement in their HMA. Although these restrictions were generally loosened over the years, agencies and industry did not press for higher RAP contents.

For the rest of the story visit our website at www.apai.net.

GIAC 2009 in Planning Stage

Planning for the 2009 Greater Iowa Asphalt Conference (GIAC) is underway. The committee recently met and the 2009 conference promises to deliver information for all.

The major change for this coming year is that the meeting has been shifted to Thursday and Friday, March 5-6, 2009, to better accommodate vendors exhibiting at the event.

So mark your calendars now for March 5-6, 2009 to attend the 2009 Greater Iowa Asphalt Conference. It is not too early to book your rooms at the Des Moines Holiday Inn Convention Center at the Airport.

Figure 1

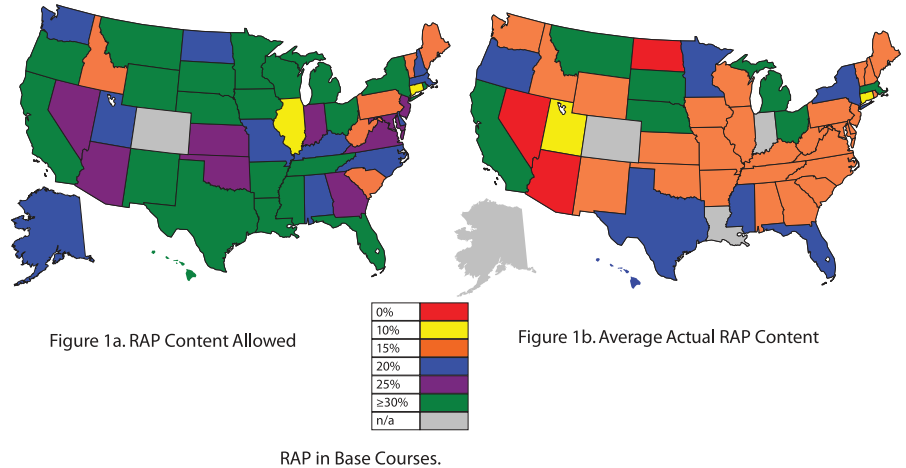


Figure 2

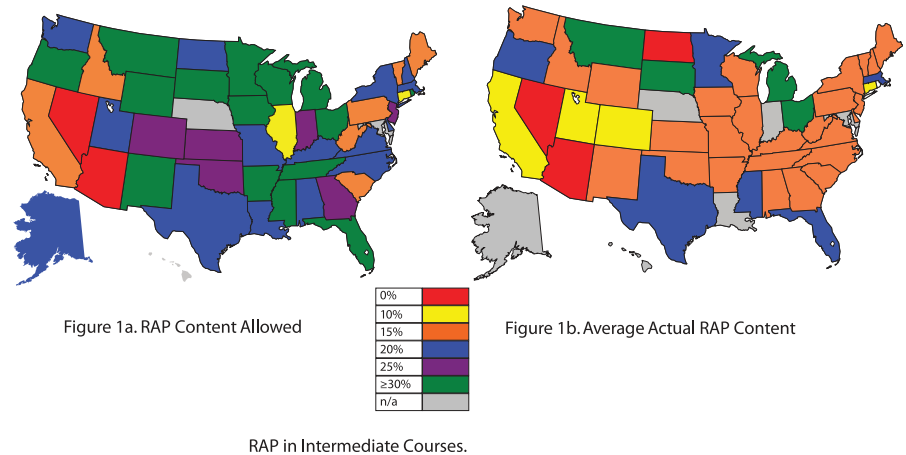
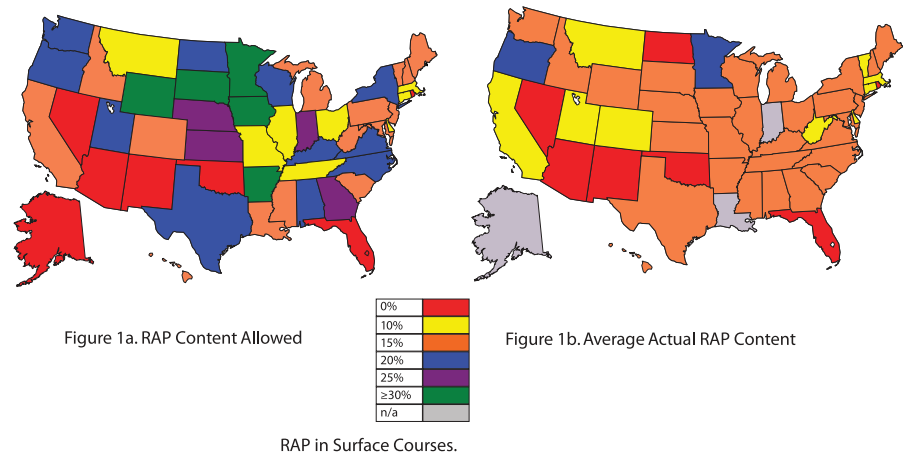


Figure 3



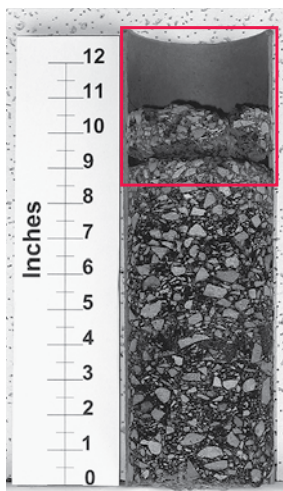
Eugene Discovers More Miles in its Roads

By Jim Huddleston

Used with the permission of the Asphalt Pavement Association of Oregon

Though its engineers and contractors didn't realize it at the time, Eugene, Ore., was making some groundbreaking advances in road construction during the 1960s and 1970s. Ironically, it took more than 20 years for the discovery to surface.

"We became aware that our full-depth pavements were acting as long-lasting pavements in the early 1990s, when we hired a consultant to evaluate a main arterial," said Paul Klope, P.E., principal engineer for Eugene. "We expected an extensive repair, given all the pop-outs and raveling on the surface," he said, "but it turns out the pavement was 10-12 inches thick, requiring only two inches of milling and overlay. It's the first time I witnessed pavement failing from the top-down, rather than the bottom-up."



More examples of long-lasting pavements were discovered in Eugene when a pavement preservation program was initiated in 2002. Though hard numbers are not available, Klope says there are several full-depth pavements within the city's jurisdiction, proving that early discoveries of these pavements were not isolated incidents. One of the city's

streets originally constructed in 1952 is still in service, and has had only one structural overlay (in 1969). While the base is 55 years old, it is still functioning like new with no signs of deterioration.

"...the bases were found to be in "like new" condition with no signs of distress, even after more than 30 years of service."

Long-lasting or "perpetual" pavements are defined as those "built for long life without requiring major structural rehabilitation or reconstruction, and needing only periodic surface renewal in response to distresses confined to the top of the pavement." As defined, the "perpetual" label could easily be applied to these aging full-depth pavements in Eugene, most of which received no overlay treatments within their first 25 years of use.

According to Klope, the city of Eugene had several reasons for building full-depth pavements in the 60s and 70s. First, it was faster. Constructing full-depth pavement requires only one operation rather than two, since multiple paving layers are not involved. This minimizes traffic disruption and other impacts.

Full-depth pavements often require less excavation as well. This reduces the potential for disruption of (or conflict with) utility services, and lowers construction costs.

Finally, full-depth pavements were found to be less expensive to construct—not only over the life of the pavement when lower maintenance costs are factored, but also at original installation (referred to as "first cost").

Klope said no hard figures have been calculated at the city of Eugene to quantify the cost benefits of constructing full-depth pavements, but notes that "milling and filling" the surface typically averages about one-fourth the cost of the complete reconstruction that would be required in pavements demonstrating full-depth failures.

Many lessons have been learned in Eugene from the City's experience with full-depth pavements. Beyond the fact that full-depth installations outlast traditional structures and cost less to rehabilitate, several other points came to light upon further examination.

One is that traditional gauges may not be the best method for assessment of pavement condition. The pavement condition index (PCI), for example, is based on surface deficiencies like cracking, rutting, raveling and showing. Klope said that PCI is a fine method of assessment for applications involving traditional pavement structures that fail from the bottom-up, but can falsely signal poor conditions beneath the surface when pavement fails from the top-down.

This actually happened in Eugene. Pavements in Eugene that showed typical surface distress, like raveling, pop-outs, and alligator or age-related cracking, required only surface rehabilitation, though the PCI figures based on these distress marks pointed to deficiencies beneath the surface that were not there. Upon further inspection, the bases were found to be in "like new" condition with no signs of distress, even after more than 30 years of service.

In this regard, the City also learned the value of testing to obtain accurate assessments of a pavement's true structural condition. Core samples and other methods are used to accomplish this, rather than



▲ (Above left) This section, built in 1975, was recently rehabilitated. (for the first time) with a four-inch mill and fill. (Above right) Full-depth pavements in Eugene have performed well, despite poor soils.

relying too heavily on the conditions that surface appearances might imply.

As for future construction, will the City of Eugene intentionally make full-depth pavements the structure of choice? “That’s where I’m starting the discussion for debate,” Klope said. “We should consider full-depth pavements because of how they’ve performed in the past, especially if first cost is competitive with that of other paving options.” The City is also discussing changes to its design standards based on what’s been learned. “We’ve been making practical changes along the way,” Klope said, “but the concept of changing design standards has not been on the table until now.”

As an aside, Klope mentioned the poor quality of soils in Eugene, as it pertains to conductivity to paving. Most “r values” — measuring relative strength of the soil — fall in the poor to very poor range.

Because the soils are so poor in Eugene, our inclination might be to avoid full-depth pavement. But with addition of some sub-base material (“we can’t just work on mud,” he said) the method actually worked quite well.

“My point in bringing that up,” he said, “is that if it worked here, it should work even better in locations with more conducive soils.”

Jim Huddleston is the executive director of the Asphalt Pavement Association of Oregon.

Iowa Holds WMA Open House for the Des Moines Metro Area.

25 participants attended a regional open house on Warm Mix Asphalt (WMA) sponsored by The Asphalt Paving Association of Iowa (APAI) and Des Moines Asphalt & Paving Company, a division of Oldcastle Materials Group – Midwest. Recent emphasis on environmentally sustainable construction, reducing greenhouse gases and minimizing the impact of rising fuel costs, has accelerated the implementation of strategic technology in the asphalt industry worldwide.

The event began at the Best Western in Ankeny, IA with an intro to WMA technologies by APAI and a more specific presentation on the WMA technology being demoed that day by Jeff Chapman, of Des Moines Asphalt & Paving Company. The participants then made a field trip to a WMA demonstration project just north of town on Polk County Route F22.

APAI has been discussing this fast moving green technology with the Iowa Department of Transportation (IA DOT). The IA DOT is showing a high level of interest and may look at conducting one



▲ Field trip to a WMA demonstration project just north of Ankeny on Polk County Route F22.

or more demonstration projects this late summer/early fall.

Upcoming Events

APAI 53rd Annual Convention

December 10-11, 2008

West Des Moines Marriott

West Des Moines, IA

Further information will be forthcoming at www.apai.net

Greater Iowa Asphalt Conference

March 5-6, 2009

Des Moines Airport Holiday Inn

Further information will be forthcoming at www.apai.net



HMA Notes: Is Your RAP Pile Growing?

By Bob Nady

The answer to that, if it is “yes”, is clear: Use more RAP in HMA. First off, I say a resounding “no” to using the RAP in aggregate-only applications, i.e., shouldering, culvert fill, and any application that does not make full use of the binder contained in the RAP. Why? Let’s say you use 100 tons of RAP which contains 5% binder. That is 5 tons of binder. At a price of \$300 per ton, you have lost the value of the binder. In this case you won’t need to do the math; I have done it for you. Does anyone here like to lose \$1,500, even in a craps game? I thought not. Your turn to do the math is coming up.

The next thing you need to do is to find the most efficient ratio of RAP to Virgin aggregate that your drying/heating equipment can handle. Start with 30% RAP and 70% aggregate. How much fuel per hour does it take to bring that mix up to temperature? Write this number down; now try 40/60 RAP to aggregate. Write down that fuel usage. And so on through 50/50, 60/40, etc. Somewhere along the line your fuel usage will bottom out. That is your best RAP/Virgin ratio. (I am assuming drum plant with RAP collar). Now it is time to try out your ratio. Set it on your materials feeds and run awhile. Do the math and make sure your ratio gives you the best (least) fuel consumption.

You are making progress. You have determined the most efficient amount of RAP that you can put in your mix. But we are not done yet.

Do you know how much binder your RAP contains? Do you know the true gradation of the RAP aggregate? This must be determined by sampling the RAP burning the binder, and analyzing the remaining aggregate. You will then know

the blend of the aggregate, which with the RAP will give you a total aggregate blend, which satisfies the project requirements.

One thing you may notice: Here we are considering RAP material generated by milling. Milled RAP has about ten percent passing the 200 sieve. Because of the milling operation, the amount of RAP may, therefore, be limited. Don’t sweat it. We can do something about that. We can screen (fractionate) the RAP to reduce the fines content. Caution: do not throw away the fine, it contains more binder percentage-wise than the original RAP. It will be necessary to determine the binder content and gradation of each of the RAP fractions, coarse and fine. Now you can probably use more of the coarse screened RAP, without violating the gradation requirements. You can develop a mix using the fine-screened RAP probably with clean virgin aggregate. Now you have two mixes with higher RAP contents than you are now using. It is important to know more about the materials you have been using so that you can try various amounts and come up with economical mixes that your plant can handle. You can run trial lab sized batches to find the amount of binder your mix needs for good performance. Just accounting for the binder in the RAP and add new binder to make up the difference needed to reach the total binder content of the mix. Isn’t it worth the price of the binder in the RAP of which you are now making full use?

So far we have been talking about milled RAP because of its wider distribution and high fines content. Let us now consider what has been called Random RAP. Several stationary plant operators invite local contractors to bring in removed asphalt materials from their

local projects – city streets, county roads, parking lots, and which, for whatever reasons, was removed from a project. The material piled (no PC concrete, please) to be crushed during the winter months. A typical pile will have slabs of various sizes and thicknesses, chunks, sections of asphalt curb, any HMA materials. The pile is ugly, but the pile is HMA. There was an opportunity to sample the crusher run product, daily or twice daily, and to test the samples for composition, binder content and aggregate gradation. Despite the appearance and the random nature of the contents of the pile, the end product was uniform and consistent, over one season product and over seasons. This was reported in the Journal of AAPT, Vol. 66. One salient feature the fact that the P200 content was about 5%, significantly less than the milled RAP. The basic gradation of the HMA material was not upset by the crushing operation. This indicates that high percentages of Random RAP can be used in a mix without violating the filler/bitumen ratio or the P200 specifications. So, it is important to keep them in separated piles, milled in one pile, Random in another pile. But again, it is important to have each pile analyzed, preferably when the pile is built and the composition is known. It is much easier, and more accurate to test the RAP as it is processed.

A word about binder: asphalt ages in service. It gets stiffer, but is still a good binder material. When using small amounts of RAP, the virgin binder can be the typical asphalt grade in every day use, such as in this area. However, as we are discussing much higher proportions of RAP, using a blending chart, the correct grade of virgin binder may be selected so that the total binder in the mix is of the proper grade.

In summary, it is not rocket science:

1. Know your materials, Virgin and RAP,
2. Keep your piles separate,
3. High percentages of RAP can be successfully used,
4. A history of 15 years is behind these remarks,
5. When in doubt, call your friendly testing lab.