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Use of warm mix asphalt continues to increase both nationally and in Colorado. According to the National Asphalt Pavement Association (NAPA), approximately 30 million tons of WMA is being placed in 2010 and all but eight or nine state DOT’s have constructed WMA pilot projects. In Colorado, a three section WMA pilot project was constructed in 2007 on I-70, west of the Eisenhower Tunnel. These sections are under evaluation but appear to be performing equally or better than the control sections (ie. non WMA).

Also, approximately twenty-five state DOTs have developed permissive specifications that allow the use of WMA. For example, in Alabama, ALDOT has a spec allowing contractor option to do warm mix on all Superpave mixes with a 20 year ESAL design of 10,000,000 ESALs or less. All other specs remain same. In Illinois, WMA has been used on 22 DOT projects as an experimental feature. In Iowa, WMA is optional to the contractor unless specified in the plans.

In Colorado, the asphalt industry through CAPA has partnered with CDOT to develop a new CP (Colorado Procedure 59) that provides guidance to contractors on the submittal and approval process of Non-Standard Mixes. This would include WMA mixes. A number of contractors have installed foaming processes at their production facilities. For example, McAtee Construction Co. Inc. of Sterling has installed a MAXAM Aqua Black Foaming System at its Sterling HMA plant. According to Chris Bellinder, Plant Operator, the use of WMA has resulted in a noticeable reduction in fuel at the plant and improved workability in the field. “Our plant mixing temperatures have dropped approximately 60 degrees when using WMA and the crews love the workability of the mix,” stated Bellinder. He added, “Warm mix reduces fumes at the job site and improves the workability of the mix on long haul projects.” McAtee Construction partnered with Logan County to use WMA on a portion of the county paving work in 2010. Chad Wright of Logan County Road & Bridge Department stated, “We see the

Larimer County allowed the use of warm mix asphalt (WMA) and recycled asphalt pavement (RAP) on County Road 17. The material was produced and placed by Lafarge West Inc. and included four different sections, WMA only, WMA with RAP, RAP only, and a control section with no WMA and no RAP. The RAP included 20% in the top mat.

Warm Mix Asphalt Implementation Continues In Colorado

Warm mix asphalt reduces the lay-down temperature of the mix approximately 50 degrees or more. Crews consider WMA mixes easier to work with and having the ability to reduce segregation and improves longitudinal joint construction.
opportunity in using WMA and we now have sections in place where we can evaluate performance.”

Of the 60 or so stationary HMA plants in Colorado, 12 are now equipped with WMA foaming systems. Most of these producers are routinely using WMA in commercial and maintenance mixes. The number of systems installed is expected to increase as more and more agencies allow the use of the technology. “Both the construction and early performance of WMA in Colorado thus far has been very good and it is clear that it is here to stay,” stated Tom Clayton, CAPA Director of Training and Member Services. For more information on WMA, contact Tom at tomclayton@co-asphalt.com or visit the CAPA website at www.co-asphalt.com

I-70 WMA test section placed in 2007 near Eisenhower Tunnel. Note the transverse cracks diminish in the middle lane, which is the WMA test section. The outside lane that is cracked is the control (i.e., non-WMA) section.
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2010 Sets Record Use of Rubblization Plus Asphalt Overlay in Colorado

Rubblization specialty subcontractors RMI Inc. of Oklahoma and Antigo Construction of Wisconsin are both getting to know Colorado better. This year has seen four projects use rubblization technology plus asphalt overlay to rehabilitate older concrete pavements. The technology “rubblizes” the concrete pavement into a base material. The broken pavement is then seated, compacted and paved with a minimum of 6-in. of asphalt material.

Two of the projects have been on I-25 in CDOT Region 4 between Longmont and Ft. Collins, a third project was on the US 85 Greeley by-pass between O and 5th streets and the fourth project was at Sterling Municipal Airport.

The rubblization specification for each project sets sizing requirements for the rubblized material, but allows the contractor to select the method of rubblization. Antigo Construction uses a multi-head hammer approach to fracture the pavement, while RMI Inc. uses a resonant breaker approach.

Rubblization technology provides a significant cost savings over the alternative of pavement removal and replacement or bond breaking and installing 8- to 10-in. of concrete pavement. In addition, it provides a reduction in time of construction. All rubblization on the Sterling Airport project was completed in only four working days. For more information, visit the CAPA website and view one of the recorded webinars on rubblization.

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Significant improvements are underway at Sterling Municipal Airport that will result in an attractive, longer runway (a longer, more attractive runway). The runway is being extended and the deteriorated concrete surface is being rehabilitated with an innovative technology to leave the existing material in place. A project open house was held on August 26 where local officials and members of the Logan County Economic Development Council reviewed the construction and met with the contractor, the airport consultant and representatives of the Federal Aviation Administration, as well as other interested parties.

“The airport improvements are a top priority in our local economic development plan and it is exciting to see the construction progress,” stated Rich O’Connell, Executive Director, Logan County Economic Development Council. “The improvements will provide a big help in our efforts to attract businesses looking to expand and relocate to the Sterling area.”

Sterling-based McAtee Construction is the general contractor on the $3.7 million project that is expected to be complete by mid-October.

A technology termed “rubblization” is being used to convert the runway’s existing concrete pavement into a base material. Twelve-feet wide machines with multi-head hammers pound the pavement surface to convert it into suitable base, which is then compacted and resurfaced with three lifts of asphalt.

““This is the first use of this technology to rehabilitate an airport pavement in Colorado,” stated Mike Garcia, Project Manager for Armstrong Consultants Inc. of Grand Junction. “The alternate is to remove and replace the concrete material.”

Antigo Construction, a Wisconsin-based specialty subcontractor, is performing the rubblization.

“The benefits of this technology are significant,” stated Jim Allen, City of Sterling Public Works Director. “With rubblization, we conserve materials by converting the old concrete pavement into base material. It also speeds the construction process, resulting in less days that the runway cannot be used, and reduces the cost of the project.”

Chris Schaffer and Ron Niehoff, representatives of FAA from Denver, attended the event and were pleased with the ongoing work. It is expected that this technology will be considered as a viable option for planned improvements to the Yuma Airport.
After 20 years of increasingly high traffic volumes, Colorado Highway C-470 was admirably exceeding its design life in 2005, yet in obvious need of major improvement. A significant number of the highway’s 8.5-in.-thick concrete panels had cracked, heaved, sunk or all of the aforementioned due to subgrade issues, and some panels had been affected by rutting. Maintenance over the years centered on patching with asphalt, knowingly performed as just a band-aid effort until the highway could be reconstructed and widened. Complaints about the highway’s poor ride were regularly expressed to CDOT.

In its 2006 Environmental Assessment of C-470 between I-25 and Kipling St., CDOT and FHWA identified the need to provide congestion relief, decrease travel delay and improve corridor reliability, yet recognized that traditional transportation funding was “in short supply.” CDOT and FHWA collaborated with cities, counties and other agencies within the project area to investigate non-traditional funding strategies and assess the extent to which each was practical. It was concluded the preferred alternative – adding four tolled Express Lanes – was financially self-supporting and, in fact, the only alternative with demonstrated financial ability to be implemented at the time. But the following year, as the nation fell into financial recession that continues significantly today, implementing the preferred alternative could not realistically be expected anytime soon.

When the American Recovery and Reinvestment Act of 2009 made funding available for shovel-ready projects, CDOT reconsidered its C-470 preferred course of action. While adding additional lanes was not immediately possible, improvements that would extend the life of the highway and enhance the quality of its ride could be achieved. CDOT focused on the 8.2-mile stretch between Yosemite St. and US 85, and being able to maintain traffic volumes while making the improvements would be the project’s overriding challenge.

Overlaying the concrete pavement with asphalt was the obvious solution, but doing so first required improving concrete panels in disrepair. While some panels could be improved by patching cracks, others were severely affected by a compromised subgrade, even though it had been treated with lime during the highway’s original construction. Correcting these areas required tear out of consecutive panels and reconstruction of the road base before placement of new concrete. Once these improvements were made, asphalt could then be paved over the concrete.

“Repairing sections of the subgrade was absolutely necessary,” explains CDOT Project Engineer Doug Liame. “In the worst areas, muck was excavated to a depth of three feet. In one stretch, water was actually trapped to a depth of three feet. In one stretch, water was actually trapped between the shallow sandstone and the pavement and was seeping through the joints.”

Work was performed at night and on weekends when one lane could be closed to traffic. Concrete removed was crushed and classified and used to reconstruct the subgrade. All cracks and spalls in pavement that was not replaced were addressed, with some, depending upon their severity, sealed with asphalt and others routed and sealed with silicone. A 900-ft.-long edge drain was installed in the worst area to further protect the new base here from water infiltration.

CDOT originally planned to fill the tire ruts – some
of which were an inch deep – with asphalt once the sub-grade and concrete repairs were complete, then overlay the entire highway with asphalt. It was proposed, however, that micro-surfacing be performed the entire width of the pavement before it was overlain with a single 2-in. lift of stone matrix asphalt.

“Micro-surfacing is a polymer-modified cold mix asphalt paving process similar to an asphalt slurry seal,” Liane continues, “but it has added capabilities that make the process ideal for this situation. Micro-surfacing involves a chemical reaction that reduces cure time – to as little as one hour – which would allow us to open the highway to traffic by the end of the work shift. Just as importantly, it creates a bond course for the asphalt wear surface to adhere to.”

Micro-surfacing creates a new, stable surface without the need to mill the existing pavement, and differs from slurry seal in its ability to stack lifts to further improve road smoothness. Micro-surfacing on C-470 is also expected to protect against reflective cracking from the joints between the concrete panels.

Approximately 52,000 tons of stone matrix asphalt was placed with the use of a material transfer unit. To maintain sufficient clearance under bridges, only one 2-in. lift was allowed. Bridge decks were milled and new expansion joints were installed to improve the smoothness of the bridge approaches.

The project began in late 2009, with panel replacement and repairs continuing through the winter when ambient temperature was 50 degrees or higher. Centennial-based prime contractor Castle Rock Construction Company was able to replace between 1500 and 6000 square-yards of pavement each weekend, depending primarily on the extent of subgrade removal necessary.

To help ensure completion within the time allowed, CRCC kept back-up equipment on the jobsite in case any mechanical problems arose. By June of this year, micro-surfacing began by Denver-based A-One Chipseal.

“Ambient temperature is important but is not a critical factor in the curing of the material we use in micro-surfacing,” explains Ben Vagher, A-One Chipseal’s president. “The chemical additive to the emulsified asphalt mix sets the wheels in motion for curing. If it’s warm and humidity is low, the material applied cures that much faster, so working weekends allowed for optimal productivity.”

Leveling the pavement was a prime objective of the micro-surfacing process, so A-One Chipseal installed a 15-ft.-long ski on each side of its micro-surfacing paver. This helped in filling the 26 years of tire rutting, not only width-wise but also length-wise between old and new panels.

Golden-based APC began overlaying the micro-surfaced pavement with SMA in June using a material transfer unit that kept the material mixed while maintaining a constant volume in the paver’s hopper to minimize the paver’s vertical deflection.

“The project was bid as a night job,” explains APC Project Manager Keary Brown. “With A-One working
weekends and us working nights, we had few problems. It was important for there to be at least 48 hours between the micro-surfacing and the SMA paving to ensure the micro-surfacing had cured and was dry when the tack coat was applied.”

The SMA overlay was complete in mid-August, and profiling of the pavement to measure vertical deflection speaks for the smoothness quality of the entire scope of work.

“The final pavement averages between 50 and 60 inches of vertical deflection per mile for each lane,” Liane points out. “That’s very good. CDOT requires corrective action if the deflection measures 90 or more.”

Profiling was also performed after concrete repairs and after micro-surfacing, with ratings averaging 300 and 150, respectively.
Micro-Surfacing Focuses On Pavement Preservation

Micro-surfacing, a polymer-modified paving system, is a versatile tool for road maintenance. Like its parent product, slurry seal, micro-surfacing is a pavement surface treatment that begins as a mixture of dense-graded aggregate, asphalt emulsion, water and mineral fillers that preserves the life of pavement. Micro-surfacing, however, has additional capabilities over slurry seal due to the inclusion of advanced polymers and other modern additives that allow the product to remain stable even when applied in multiple lifts, making it also ideal for leveling pavement.

Micro-surfacing is performed using a specially-designed paving machine that carries and constantly mixes all components before spreading it onto the pavement surface. High-quality materials are specified, precisely measured and continuously delivered to the paver. The paver’s pugmill thoroughly combines the material and continuously feeds the mixture into a full-width surfacing box that incorporates a screed to spread the material while feathering the edges. The semi-liquid material profiles the surface and transitions to a dense cold-mix material that is able to support traffic as quickly as one hour after placement, making it ideal for arterial roads that need to be put back into service promptly. Slurry seal, conversely, is applied on residential streets and requires three to four hours to cure before traffic can be safely allowed on the sealed pavement.

“On the C-470 project,” explains Ben Vagher of A-One Chipseal, “we used a Type III (3/8-in.-minus aggregate), which is too rough to serve as a finish course but is perfect for filling ruts since the largest aggregate particles are delivered into the deepest part of the rut. Many of our pavement preservation projects, however, involve paving with a Type II material, which utilizes smaller aggregate to create a less-aggressive mixture that is suitable for a finish course.”

The micro-surfacing material is initially a dark brown color and changes to black as the water is chemically ejected to the surface as the material cures. The cured material can also increase skid resistance and reduce hydroplaning. As a thin, restorative surface course on urban arterials, micro-surfacing does not affect drainage since there is no loss of curb reveal.

“Micro-surfacing is designed for collector or arterial streets with high volume and or heavy loads,” Vagher continues, “Because micro-surfacing can be applied to most surfaces at 3/8 of an inch or less, more area per ton of mix is covered, making the process very cost effective. The material is environmentally safe, emitting no pollutants and the finished product is tough, durable and resistant to snow plow damage.”

Successful micro-surfacing projects depend on strict adherence to technical specifications. Many users find it helpful to design their individual job specifications around those recommended by The International Slurry Surfacing Association. The resulting mix design and job specifications are carefully adhered to in the field, where ISSA member contractors use specialized job-calibrated equipment and thoroughly trained crews to maintain consistent quality control.

“Micro-surfacing and slurry sealing are ideal processes for pavement preservation,” concludes Vagher. “By undertaking a program of planned maintenance, pavement milling and overlaying can be deferred. Application of the proper asphalt slurry system significantly extends pavement life by protecting it from oxidation from sunlight that leads to cracking that leads to further damage from water infiltration. Many Colorado municipalities are choosing pavement preservation to help protect their initial investment in street construction.”
The Importance of Hot Mix Asphalt to the National Economy

Of the 2.3 million miles of paved roads in the U.S., about 94 percent are surfaced with asphalt.

In 2002, the estimated production of HMA totaled 550 million tons valued at nearly $20 billion.

There are approximately 4,000 HMA plants in the U.S.

Overall, the asphalt industry, directly and indirectly, supports 300,000 employees.

For more information on Jobs in the Asphalt Industry, visit www.asphaltroads.org

AsphaltRoads.com Introduces New Publications

AsphaltRoads.org, a joint effort between NAPA, the Asphalt Institute and the state asphalt pavement associations, continues to introduce NEW publications. Here are a few of the recent ones developed by Asphalt Roads:

"Asphalt Jobs by the Numbers – Jobs in the Asphalt Industry" (6-10)

"Life Cycle Cost Software" (6-10)

"Perpetual Asphalt Pavements, A Synthesis" (5-10)

"Smoothness Matters, Smooth Pavements Save Fuel and Even Small Changes Can Make a Big Difference" (4-10)

"Asphalt Pavements, A White Paper" (3-10)

23 Organizations Welcomed Into CAPA Membership In 2010

Even in these tough economic times, organizations see the value of being a member of the Colorado Asphalt Pavement Association. We are pleased to welcome 23 organizations to CAPA membership in 2010, including the City of Pueblo Public Works Department as our newest Affiliate Agency Member organization. Our Affiliate Agency member list now includes 63 cities, towns and counties from throughout Colorado.
CAPA and the APWA Colorado Chapter would like to extend a BIG thank you to all of you that attended and supported the 19th annual CAPA CUP Scholarship Fund Raising Golf Tournament. We have once again, because of all of your support, been successful in raising funds to send a recipient to the NCAT Technology program at Auburn University early in 2011. This is an exceptional opportunity for individuals in our industry to be exposed to the technology and research for the design and construction of Asphalt pavements. CAPA and the APWA are excited and thankful to be able to continue to participate in helping to promote increased knowledge in asphalt technologies. All of your support is what makes this possible and in these times we congratulate you and acknowledge your sacrifice for contributing to this program.

We are already planning the 2011 tournament, mark your calendar for Friday September 16, 2011.

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Congratulations, Team Brannan!

CAPA Scholarship Golf Tournament was a great success thanks to all of the Sponsors, Golfers and Volunteers. The 2010 winning Team consisted of Dean Rossi, Fred Marvel, Bob Allison and Delbert Martin. Tom Clayton presents the CAPA Cup to the winners, who will have the honor of holding it for the next year.

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Asphalt Takes The LEED!
*Asphalt Pavements & LEED Certification*

Environmental sustainability is now the way of doing business and is truly changing Colorado’s construction landscape. A central factor that is contributing to the greening of Colorado is governmental entities requiring LEED certification for new buildings and major renovations. In response, the asphalt industry is working diligently to advance sustainability concepts and be a vital element of LEED certification and building green.

**Understanding LEED Certification**

Leadership in Energy and Environmental Design (LEED) is a program that encourages the design of buildings, homes, schools and developments that advance sustainability concepts. Developed by the U.S. Green Building Council, the LEED Green Building Rating System is the nationally accepted benchmark for the design, construction and operation of high performance green buildings. LEED promotes a whole-building approach to sustainability by recognizing performance in five key areas of human and environmental health: sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality.

**Earning LEED Certification**

To earn certification, a building project must meet certain prerequisites and performance benchmarks (“credits”) within each category. Projects are awarded Certified, Silver, Gold or Platinum certification depending on the number of credits they achieve.

**Asphalt Pavements Contribute to LEED Credits**

Asphalt pavements contribute to LEED credits in a variety of ways. Asphalt pavements are 100% recyclable. As such, credits associated with recycling and waste management are attainable. Porous asphalt pavements reduce the quantity and improve the quality of storm water runoff. LEED credits can be attained for porous asphalt pavement use under categories for storm water management (both quantity and quality) and heat island reduction.

In recent times, coating materials have been introduced to the industry. These allow designers to express their creativity and ingenuity while at the same time improving pavement reflectance and capturing credit for heat island reduction. From conventional to porous to pattern-stamped, asphalt pavements provide flexibility and options to architects and engineers designing sustainable pavements.

**LEED Credit for Asphalt Pavement**

Six LEED credit points can be obtained by using asphalt pavement. Tables have been developed to show for the different LEED programs the potential credits attainable by using asphalt pavements. Each table provides the rating category, credit description, available points and a discussion of the applicability/contribution that asphalt pavements have in attaining credits. This information has been provided for a variety of LEED programs. The tables can be downloaded from the Resources section of the CAPA website – www.co-asphalt.com.

**Paving Greener With Asphalt Conference**

NAPA and FHWA, with the support of CAPA and other state associations, will present NAPA’s first-ever conference on the topic of environmentally sustainable pavements, Nov. 17 — 18, 2010 at the Crowne Plaza – DIA (I-70/Chambers Road). The Conference is designed for contractors and their agency/consultant partners looking for ways to compete in a greener environment, and to assist plant operators and paving contractors in their environmental and occupational health compliance obligations. Subjects include: Climate change & Carbon Footprints, LEEDing for Asphalt Pavement & Greenroads Rating System, Sustainable practices for Pavement Technologies. To Register, visit www.hotmix.org/pgwa.
NA PA has introduced two new publications, a sustainability report and a companion brochure. In announcing the new publications, NA PA President Mike Acott commented, “For decades, the asphalt pavement industry has been proactive in reducing the impact of its operations on the environment. The new report discusses some of the products we have developed – warm mix asphalt, reuse/recycling, porous asphalt, and Perpetual Pavements – and shows how an accelerated deployment program could lead to even greater achievements.”

Contact the CAPA office to obtain your complimentary copy.

Sustainable Asphalt – Now & Tomorrow

Architects and engineers today are faced with more pressure than ever before to deliver sustainable or “green” buildings. Sustainable designs are growing in popularity, especially with publicly-funded projects such as judicial centers and schools. Asphalt pavements can play an important role in the Leadership in Energy and Environmental Design (LEED) Green Buildings System. Understanding how asphalt pavements can earn LEED credits is important as the next facility is planned.

Asphalt pavements can earn LEED credits in three areas: Sustainable Sites (SS), Materials and Resources (MR) and the Innovation and Design Process (ID). Sustainable Sites discourages development on previously undeveloped land and to minimize the impact of the development on the ecosystem and waterways. This is where porous asphalt can help! SS Credit 6.1 and SS Credit 6.2 relate to storm water runoff quantity and quality. By reducing the amount of impervious surfaces on a developed site, porous asphalt can get credit for storm water design for both quantity and quality. Porous asphalt helps to reduce site storm water discharge and infiltration of runoff, and it has the highest pollutant removal efficiency of the many possible options.

The Materials Resource category promotes the reduction of wastes as well as encouraging the reuse and recycling of materials generated both on and off the construction site. Asphalt pavements are 100% recyclable. In fact, asphalt is the most recycled product in America. A project can get LEED credits for allowing/specifying the use of recycled asphalt pavement (RAP) in the materials. For example, a project that reuses 5-10% of all site materials can gain one or two credits for this category. Recycling asphalt pavements can make these credits readily available. Another MR credit to which asphalt can contribute is the use of regional materials. Materials that are manufactured within 500 miles of a project will decrease the impact that extended transportation requirements may have on the environment. Asphalt can help here as it is locally manufactured and locally supplied.

The third LEED category in which asphalt pavements can enhance the opportunity for credits is Innovation in Design. This category can allow credit for exemplary performance as it relates to recycling over and above the norm. High RAP content mixes (greater than about 30%) in conjunction with warm mix asphalt (WMA) can be applied to the total project goals to receive up to three credits. WMA has the ability to increase the workability and compaction of high RAP mixes.

The asphalt industry is a leader in recycling and environmental innovation. If the overall goal of a sustainable scorecard (i.e. LEED credit) is to eliminate waste, increase recycling of products, improve water quality, divert construction debris from landfills and maximize the use of local products, asphalt pavements more than meet these needs. Not only do these concepts make good environmental sense, they make good business sense. Your local asphalt producer can work with you to develop a porous asphalt system to meet your needs, a high RAP content mix to help with your recycling or a WMA to minimize your energy consumption. For more information, contact the CAPA office at (303) 741-6150 or contact Tom Clayton at tomclayton@co-asphalt.com.
CARBON FOOTPRINT:
HOW DOES ASPHALT STACK UP?

Environmental consciousness is on the rise and many transportation officials are striving to make their practices and policies greener or more sustainable. But how do you measure the greenness of a pavement? It's all about the carbon — how, when, and whether it is counted.

A useful guide is ISO 14040 — Environmental Management — Lifecycle Assessment — Principles and Framework [2006(E)], which outlines the basic definitions and procedures that should be used in looking at the environmental impact of a product throughout its life. It has two important principles: make sure you count everything and make sure you don't count anything twice.

To analyze the carbon footprint of a pavement, one must look at the greenhouse gas (GHG) emissions associated with the construction and maintenance of a pavement. Greenhouse gases include carbon dioxide (CO₂), nitrous oxide (N₂O), methane (CH₄) and hydrofluorocarbon (HFC) leakage from air conditioning systems. Although not usually included, water vapor is the most abundant greenhouse gas. Greenhouse gas emissions are typically measured in terms of carbon dioxide equivalents [CO₂e].

The analysis for asphalt pavements is complicated by the fact that the cementing material, the asphalt cement or bitumen, has high carbon content. The average carbon content of asphalt cement is about 82 percent, and asphalt cement makes up about 5 percent of an asphalt pavement, with the rest being aggregates — stone, sand, and gravel. Currently in North America, at least 95 percent of the asphalt pavement removed from the road is either reused in new asphalt pavements or recycled as base or shoulder material. The material not reused or recycled is still not burned and thus the embodied carbon is never released into the atmosphere. In essence, when we pave with asphalt, we put the aggregate and the asphalt cement in the bank for future generations.

Carbon Footprint of HMA and PCC Pavements¹, a paper presented at the 2009 International Conference on Perpetual Pavements, examined the carbon footprint of asphalt and concrete pavements for typical residential, collector, and freeway pavements constructed in Ontario, Canada. In addition, the paper looked at the carbon footprint of an equivalent asphalt freeway pavement built as a Perpetual Pavement. Both the carbon footprint of the initial construction and the carbon footprint of the maintenance activities over a 50-year life cycle were evaluated and compared.

The paper used an analysis method designed by VicRoads, a state authority in Australia, to carry out a trial carbon-neutral project. In this case, VicRoads chose to plant 7,463 trees at the completion of the project to achieve carbon neutrality. The trees will absorb carbon from the atmosphere over their life to remove the carbon generated by the extraction, manufacturing, and placement of the material used, as well as the transportation of the materials to and on the site. To carry out the calculation, VicRoads developed a table of typical carbon dioxide equivalent values for the various materials used on the site. Table 1 gives the values used by VicRoads in their analysis.

The most striking feature of this table is the difference in the values for the asphalt and concrete pavements. One reason for the divergence is the chemical processes that occur in the production of Portland cement, the cementing material that binds concrete pavements together. For every 1,000 kg of Portland cement, approximately 730 kg of carbon dioxide is produced. Heating the aggregate and clay used to produce Portland cement to a temperature of around 1,450°C in the kiln causes the dissociation of the limestone and the production of about 60 percent of the carbon dioxide, which is released to the atmosphere. The remaining carbon dioxide comes from the combustion of the fuel used to heat the raw materials.

² VICROADS. HTTP://WWW.VICROADS.VIC.GOV.AU/HOME/NEWSRoom/NEWS+ARCHIVE/JAN-MAR+2008/MICKLEHAMROAD.HTM
TABLE 1 — CO₂ EQUIVALENT CONVERSION VALUES

<table>
<thead>
<tr>
<th>Material</th>
<th>CO₂eEmissions (Tonnes/Tonne)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt Pavement</td>
<td>0.0103</td>
</tr>
<tr>
<td>{at 5.0 percent asphalt cement}</td>
<td></td>
</tr>
<tr>
<td>Granular A</td>
<td>0.0080</td>
</tr>
<tr>
<td>{crushed, screened and washed aggregate}</td>
<td></td>
</tr>
<tr>
<td>Granular B</td>
<td>0.0053</td>
</tr>
<tr>
<td>{screened and washed aggregate}</td>
<td></td>
</tr>
<tr>
<td>Concrete Pavement</td>
<td>0.1073</td>
</tr>
<tr>
<td>{at 32 MPa (4640 psi)}</td>
<td></td>
</tr>
<tr>
<td>OGDL*</td>
<td>0.0090</td>
</tr>
<tr>
<td>* Asphal-stabilized open-graded drainage layer at 1.8 percent asphalt cement</td>
<td></td>
</tr>
</tbody>
</table>

It should be noted that VicRoads chose not to include the carbon content of asphalt cement in the calculation because the purpose of the carbon footprint calculation is to calculate the actual emissions of greenhouse gases into the atmosphere. The carbon in the asphalt cement will never be released into the atmosphere. It is neither consumed nor wasted in the process. In a way, the carbon has been sequestered in the form of an asphalt pavement. In addition, 100 percent of the asphalt cement can be reused in new asphalt pavement at the end of its life by simply reheating the material, thus reusing the energy invested in the initial production of the material.

The pavement sections used for the analysis are given in Tables 2 and 3. The asphalt sections for residential and collector pavements are taken from typical asphalt pavements constructed in Ontario. The concrete pavement sections for the same road class are taken from the Streetpave program published by the Portland Cement Association. Due to environmental conditions in Ontario [i.e. wet freeze/thaw], the concrete pavement sections may be considered to be thinner than required.

TABLE 2 — ASPHALT PAVEMENTS ANALYZED

<table>
<thead>
<tr>
<th>Material</th>
<th>Residential</th>
<th>Collector</th>
<th>Freeway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt Pavement</td>
<td>90 mm / 3.5 in</td>
<td>130 mm / 5.1 in</td>
<td>240 mm / 9.5 in</td>
</tr>
<tr>
<td>OGDL*</td>
<td></td>
<td></td>
<td>100 mm / 3.9 in</td>
</tr>
<tr>
<td>Granular Base</td>
<td>150 mm / 5.9 in</td>
<td>150 mm / 5.9 in</td>
<td>150 mm / 5.9 in</td>
</tr>
<tr>
<td>Granular Subbase</td>
<td>300 mm / 11.8 in</td>
<td>450 mm / 17.7 in</td>
<td>450 mm / 17.7 in</td>
</tr>
<tr>
<td>* Asphal-stabilized open-graded drainage layer at 1.8 percent asphalt cement</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TABLE 3 — CONCRETE PAVEMENTS ANALYZED

<table>
<thead>
<tr>
<th>Material</th>
<th>Residential</th>
<th>Collector</th>
<th>Freeway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Pavement</td>
<td>145 mm / 3.5 in</td>
<td>170 mm / 5.1 in</td>
<td>240 mm / 9.5 in</td>
</tr>
<tr>
<td>OGDL*</td>
<td></td>
<td></td>
<td>100 mm / 3.9 in</td>
</tr>
<tr>
<td>Granular Base</td>
<td>100 mm / 5.9 in</td>
<td>100 mm / 5.9 in</td>
<td>300 mm / 5.9 in</td>
</tr>
<tr>
<td>* Asphal-stabilized open-graded drainage layer at 1.8 percent asphalt cement</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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Military Seeing Benefits of Porous Asphalt

As part of an environmental evaluation process, porous asphalt pavement was recently produced and paved alongside conventional HMA at Fort Carson Army Base by CAPA member Rocky Mountain Materials and Asphalt (RMMA) of Colorado Springs. Porous asphalt pavement was constructed in three areas and will be evaluated over the next several years to see its benefits, especially with respect to vegetation.

The area to be paved was excavated to approximately 2.5 feet below finished grade and filled with CU-Soil™, a product developed and patented by Cornell University. CU-Soil, a composite of organic and natural fertilizers blended with coarse aggregates, safely supports pavements while providing a nutrient source for nearby trees and other vegetation. The porous asphalt pavement allows stormwater to drain into the soil and eventually down to the water table. RMMA followed the “recipe” from Cornell to make CU Soil from the company’s own locally-mined materials.

RMMA prepared a standard ¾-inch porous mixture using PG 64-22 binder supplied by Valero Energy to yield 23% void space. Approximately 100 tons of the material was produced and placed on this project.

The Army is anticipating the benefits of the porous asphalt evaluation site to be in richer vegetation and stronger, hardier trees lining the parking lot.
At Buckley Air Force Base, an approximate 27,000-sq.-ft. porous asphalt parking lot was recently completed for the storage of RVs, trailers, campers and boats. The size of lot allows for 31 parking stalls and to date is the largest installation of porous asphalt in Colorado.

The condition of the lot prior to re-construction was very poor, with several potholes and alligator cracking throughout. (It was reported that many people did not realize the lot actually had an asphalt surface!) Constructed many years ago without adequate slope, water pooled on the existing surface during storm events. Rebuilding the lot to allow for adequate runoff with the existing terrain would be difficult and expensive to achieve. This presented an ideal situation for porous asphalt pavement and was the primary reason it was chosen.

The lot has a 24-inch section of base coarse aggregate (#2 and #3) under four inches of smaller angular aggregate (#67) and four inches of porous asphalt. This will create a detention pond area under the lot large enough to handle a 100-year storm event and will allow the water to slowly recharge the natural water table in the area. When the placement was nearly complete, a demonstration of the system took place for several of the Base engineers and other interested parties. A water tank was used to release water on the mat, which spread less than two feet from where it was dumped, disappearing into the recharge bed. Those who witnessed the demonstration were highly impressed and surprised at the effectiveness of the porous asphalt system.

CAPA member Brannan Sand and Gravel Company performed the reconstruction and produced and paved the porous asphalt. This project also used a standard ¾-inch porous mixture using PG 76-28 binder supplied by Suncor Energy with 23% void space. Geotechnical testing was performed by CAPA member De-Rey Engineering.
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