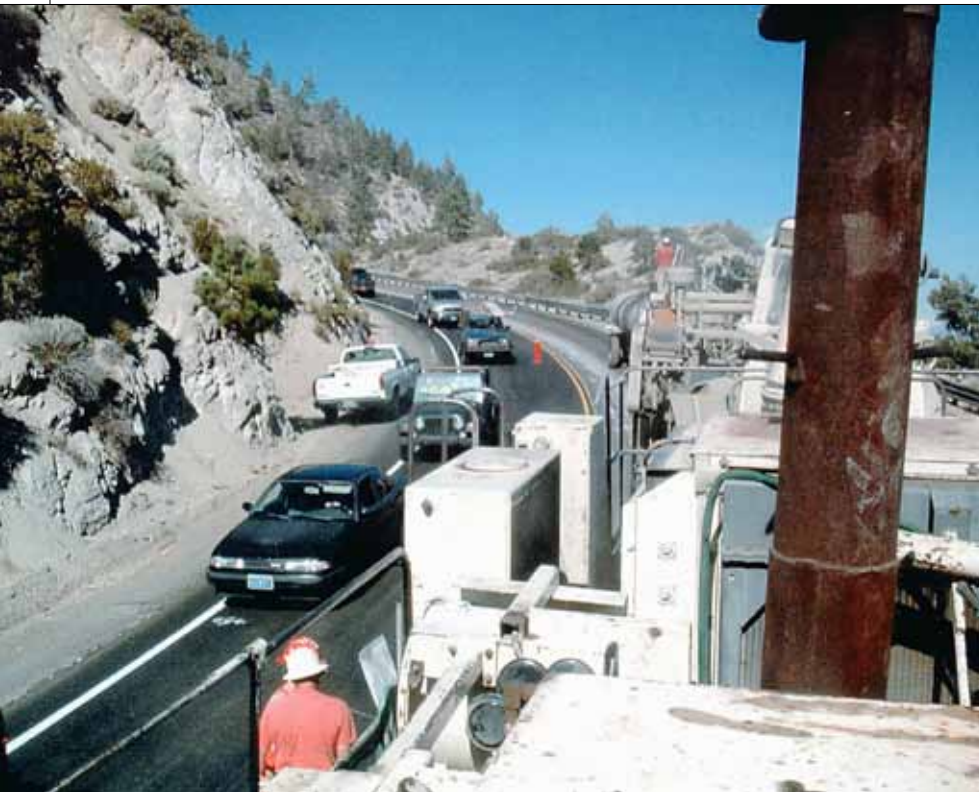


Hot, Cold and Green (and the 3Es)



In-place pavement recycling meets a variety of needs.

◀ ***In tight quarters in the Pacific Northwest***, a cold-in-place recycling train of Valentine Surfacing climbs a mountain grade.

Photo courtesy of Valentine Surfacing

Green construction now is the No. 1 theme in roadbuilding, and hot-in-place pavement recycling (HIR) and cold-in-place pavement recycling (CIR) have taken on the “green” mantle big-time as the industry positions itself to new customers.

While reuse of materials and fuel savings always have been major sales themes of HIR and CIR recycling, the environmental benefit of these two processes has waxed large as green construction rises in desirability among road agencies.

In the regions where HIR and CIR specialty contractors operate, in-place recycling has been recognized as an environmentally sound road reconstruction application by the American Association of State Highway and Transportation Officials, via AASHTO's *Center for Environmental*

Excellence (<http://environment.transportation.org/>).

In-place recycling, both hot and cold, is likewise encouraged by the Federal Highway Administration (FHWA) as it implements its environmental stewardship policy.

In-place recycling (instead of conventional hot-mix asphalt paving) now is being encouraged in regions where air quality is an issue. For example, in 2011, California's wine country agencies of the City of Napa and County of Sonoma are teaming up to promote cold-in-place recycling technology as a means to reduce carbon emissions.

And the in-place recycling contractors are putting money down to support this interest.

Late last year, the national association that represents HIR and CIR specialty contractors among others – the Asphalt Recycling & Reclaiming Association – launched a new research center for asphalt recycling technologies. The *Pavement Recycling and Reclaiming Center* (PR²C) opened Oct. 1 and is a partnership between ARRA, California State Polytechnic University (Cal Poly) and the state Caltrans agency.

Feds Boost HIR, CIR Recycling

HIR and CIR processes are among the road reconstruction methods encouraged by the Federal Highway Administration as being exemplary green roadbuilding processes. This follows FHWA's policy of encouraging recycling and use of recycled materials wherever possible in roadwork (<http://www.fhwa.dot.gov/legisregs/directives/policy/recmatpolicy.htm>).

"In-place recycling is another technology that we are promoting very heavily within federal highways in conjunction with our partner around the country, ARRA," says Steve Mueller, P.E., pavement and materials engineer, Federal Highway Administration Resource Center, Lakewood, Colo. "There is cold-in-place recycling, and hot-in-place recycling, as well as full-depth recycling, so there is a lot more that we can do [to recycle building materials] with the material right on the road, instead of having to bring in new materials.

"We issued our recycling policy in 2002 with six key points," Mueller said last year during a National Highway Institute webinar on *Recycled Material in Highway Construction*. "First, recycled and reused materials are viable resources. Many times, the best materials are those already out on the road. Our policy says that recycled materials should get first consideration when we are looking at building new roads or preserving existing roads. We want to consider use of recycled materials early in the planning and design process. If we can use recycled materials, we should.

"The economic benefits should be considered in the material selection process; the economics need to be



▲ **In Kansas, a Mobile Asphalt Resurfacing System** of Dustrol Inc. hot-in-place recycles U.S. 75.

Photo courtesy of Dustrol, Inc.

good in order to use recycled materials," Mueller added. "Restriction on the use of materials should be technically based. If you are saying you cannot use recycled materials in pavements, you should have a good reason why not. There are still jurisdictions that completely prohibit the reuse of certain recycled materials and we need a technical foundation for that. Lastly, the material should not adversely impact the environment and should perform as intended."

Thus, green roadbuilding like HIR and CIR recycling has become part of the essential "3 Es" of FHWA:

- **Engineering** means good engineering design must be used to assure long-life pavements,
- **Economics** means lifecycle cost analysis should be used in project selection, and
- **Environment** means recycling should be considered first, and that roadbuilders should be good stewards of the environment.

The complete webinar may be viewed at <http://fhwa.adobeconnect.com/n1340832010march>.

New Roads, Less Greenhouse Gases

In California, north of the Bay Area, the agencies of Sonoma County and the City of Napa will take advantage of a \$2 million grant from the Metropolitan Transportation Commission's *Climate Initiatives Program* to demonstrate how CIR recycling can slash

greenhouse gas emissions associated with conventional road reconstruction.

According to the MTC, \$5,288,000 was requested for the work. The 37 percent of requested funding awarded was significantly less than percentages awarded to electric auto and bicycle projects, but the agencies are glad to have it.

The *North Bay Business Journal* quotes Sonoma County pavement preservation manager Stephen Urbanek as saying, "We got a lot less than we asked for, but it's enough to get pavement management issues into the conversation when it comes to greenhouse gas reduction. CIR is a wonderful process, green in so many different ways." The *Journal* says Urbanek and his team, along with Marlene Demery, special projects manager for the Napa Transportation Agency, and her team, will work with the University of California at Berkeley to develop educational materials on the process, and several road projects are planned for this spring.

CIR reduces the cost to \$30 to \$40 per installed ton, versus \$75 to \$100 for traditional methods, the newspaper says, adding road materials can be recycled over and over again.

Although CIR can't pave new roads or other surfaces, for repaving it can eliminate nearly 80 percent of greenhouse gas emissions from aggregate mining and asphalt production operations compared to starting from

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scratch, officials say. It also eliminates the need for trucks hauling old material off the site and new material onto the site, reduces stress on the surrounding roads and city arteries, and quells related work zone congestion.

"CIR's time has come in Sonoma County," Urbanek is quoted by the newspaper. "This technology can help the state meet its clean air goals and at the same time save our network of back county roads."

ARRA Plunges into Research

In the meantime, the Asphalt Recycling and Reclaiming Association (ARRA) has partnered with a university to create a research center for asphalt recycling research. In October 2010, ARRA announced the creation of the Pavement Recycling and Reclaiming Center (PR²C) in conjunction with California State Polytechnic University and the California Department of Transportation.

In this it follows the paths of the National Asphalt Pavement Association (National Center for Asphalt Technology at Auburn University), the concrete pavement industry (National Concrete Pavement Technology Center at Iowa State University) and the pavement preservation industry (National Center for Pavement Preservation at Michigan State University).

"The recycling and reclaiming industry has grown over the past few years," says Don Matthews, P.E., chairman of ARRA's Committee on Research and Education, who is also manager, Re-New Pavement Division, and director of research and development, Pavement Recycling Systems, Mira Loma, Calif.

The new center will help the industry maintain high standards. "ARRA has been very active in the establishment of the Pavement Recycling and Reclaiming Center," Matthews says, "the ultimate purpose of which is to provide pavement contractors, design professionals and public agencies such as DOTs, cities and counties with the knowledge and tools necessary to use pavement recycling and reclaiming as a feasible and competitive alternative to traditional pavement maintenance

and rehabilitation strategies."

The center, he says, is the first in the United States, and possibly the world, to focus specifically on pavement recycling and reclaiming.

Goals of the center include serving as a champion for, and facilitator of, the successful implementation of pavement recycling and reclaiming strategies by public agencies through the development of standards, specifications and technical guidelines. It plans to act as a credible third party for public agencies and industry. It will provide technical assistance, training and certification programs to public agencies and industry. And it will disseminate information relative to pavement recycling and reclaiming in the form of reports, presentations, technical sheets and newsletters.

Tasks for the PR²C include development and maintaining of a website for the center that will be used to disseminate information on pavement recycling and reclaiming strategies, the center's activities, newsletters, reports and technical sheets.

It plans to develop and maintain a database of pavement recycling projects' construction and performance. The information will include project location, limits, traffic, environment and pavement condition before and after recycling, materials testing results during and after construction, and other pertinent information. The data will be used in support of the center's research activities.

PR²C intends to develop and maintain a library of reports, technical papers, presentations, photographs and videos related to pavement recycling and reclaiming. The library will be made available online on the center's website.

It will provide technical support (via a help desk) to agencies and contractors who register their projects with the PR²C, engage in externally-funded research in pavement recycling and reclaiming, and promote effective pavement recycling/reclaiming practices and technologies both within the United States and internationally.

At this time, the center is led by Dr. Dragos Andrei, P.E., associate professor and Pavement Recycling Systems



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So what, precisely, is in-place recycling? According to FP², a foundation supporting pavement preservation, in-place asphalt recycling processes are a variety of pavement preventive maintenance treatments that provide safe and efficient roadways, while at the same time drastically reducing reconstruction's environmental impact and energy (oil) consumption, compared to conventional pavement reconstruction.

Cold-in-place recycling, according to FP², is an onsite recycling process in which an asphalt pavement with structural failures is reconstructed using 100 percent reclaimed asphalt pavement (RAP) to a typical treatment depth of 2 to 6 inches, using a mobile train of equipment that may include tanker trucks, a milling machine, crushing and screening equipment, a mixer, binder rejuvenating additives and a paver.

With CIR recycling, existing pavement materials are removed, crushed, sized (if needed) and rejuvenated with a recycling agent. Its benefits include major pavement structural improvement via overhaul of the existing pavement materials, and CIR can cure most types of pavement distress. As with HIR, material hauling costs are minimized, while the blue smoke associated with HIR is eliminated.

Laydown may be by asphalt paver, or in some instances the material can be placed with a motor grader. Compaction to obtain the required density can be achieved by either a heavy pneumatic, vibratory or static steel roller, or any combination of rollers. Typically, the pavement can be opened to traffic at the end of the work day.

AASHTO's Center for Environmental Excellence defines CIR recycling as a process involving specialized plants or processing trains, whereby the existing pavement surface is milled to a depth of up to 6 inches, processed, mixed with asphalt emulsion (or foamed asphalt), and placed and compacted in a single pass.

CIR is suitable for roadways with moderate to severe distresses where reflection cracking is a concern, AASHTO says. CIR involves milling the existing pavement, screening for oversize, addition of asphalt emulsion, and mixing; then, this cold renewed material is spread, reprofiled and compacted on the roadway in one continuous operation. There is no processing required prior to the actual recycling operation.

An alternate to cold-in-place recycling, **in-plant cold mix recycling**, mixes RAP with an asphalt emulsion or foamed asphalt at a central or mobile plant facility. A rejuvenating agent can be added to improve the recycled asphalt binder viscosity, and new aggregate can also be added to improve overall performance. The resulting cold mix is typically used as a stabilized base course. RAP is trucked to the plant and recycled mix is returned by truck.

Hot-in-place recycling heats a pavement and removes it to a certain depth, or surface-scarifies it, prior to application of a new or recycled surface, FP² says. It may be performed either as a single-pass, one-phase operation that monolithically combines the recycled pavement with virgin material, or as a two-pass procedure, in which the restored, recycled material is recompact prior to placement of a new wearing surface.

The AASHTO Center for Environmental Excellence defines HIR as a process of repaving that is performed as either a single- or multiple-pass operation using specialized heating, scarifying, rejuvenating, laydown and compaction equipment.

HIR recycling can treat surface defects like corrugation, rutting and cracks, but like the CIR method, needs room for the equipment train. Heating the asphalt surface may produce blue smoke. The process can result in a pavement being opened to traffic just minutes after passage of a recycling train.

With heater scarification, the pavement's surface only is heated with radiant heaters, then scarified or disturbed using a bank of nonrotating teeth, rejuvenated using an additive to improve the recycled asphalt binder viscosity, mixed and leveled, then compacted using conventional compaction equipment.

Repaving is a process that heats, scarifies and applies a recycling agent to an existing, aged driving course, and then replaces that material as a new leveling course. A screed on the same machine immediately tops that recycled leveling course with a virgin hot-mix asphalt overlay fed into the repaver from the front, which bonds thermally with the recycled leveling course to form a durable, monolithic pavement.

The repaving process also eliminates the longitudinal joint between two lanes of pavement, because repaving also reheats the edge of adjacent paved lanes, resulting in a more durable, higher-density seam between the driving lanes. In essence, the longitudinal joint is eliminated.

Full-depth reclamation (FDR) — not covered in this article — reclaims and treats the entire HMA layer, plus a planned depth of underlying materials, to produce a stabilized base course. CIR does not treat the underlying materials. With FDR, a pavement is pulverized, mixed with additive or stabilizer, shaped or graded, and compacted, followed by an optional thin surface or wearing course.

"Foamed" or "expanded" asphalt is a type of CIR recycle or FDR — depending on depth — in which hot performance-grade asphalt is foamed with water and air, and is injected into reclaimed materials and aggregate in a mixing chamber of a mobile unit or stationary plant, and offers a cost-effective option for FDR.

Precise addition of water allows control of the rate of asphalt expansion and the amount of expansion. The expanded asphalt has a resulting high surface area available for bonding with the aggregate, leading to a stable road base using the existing in-place materials. The benefit is substantial cost savings over use of asphalt emulsions for base stabilization, and complete elimination of the cure or "break" period. The foamed base then is graded and compacted, and can permit traffic — including heavy trucks — almost immediately.

RoadScience

Fellow in the Civil Engineering Department at Cal Poly Pomona. A search is underway for a permanent executive director. It was anticipated that the center's website would go live in January 2011, but was not available when this issue went to press.

New Preservation Alliance

Also, in late 2010, taking a page from the collaboration of three asphalt industry associations that formed the Asphalt Pavement Alliance, after more than a decade of working together the boards of the Asphalt Emulsion Manufacturers Association, the Asphalt Recycling and Reclaiming Association and the International Slurry Surfacing Association have agreed to launch a new *Pavement Preservation and Recycling Alliance* (PPRA).

PPRA will not be an organization, or a separate entity, and AEMA, ARRA and ISSA will continue to exist as they do today. PPRA is more a formal recognition of an agreement to work together, more efficiently, to cooperatively represent and promote the technologies, processes and applications currently represented and promoted individually by AEMA, ARRA and ISSA.

For several years, AEMA, ARRA and ISSA have conducted a joint annual meeting. In 2010, they published a collective newsletter. PPRA will be an extension of those types of cooperative programs. It is well understood the three groups participate in many of the same activities, such as workshops, seminars, newsletters, certain trade shows and more. The alliance concept will allow the three to more formally combine forces effectively, efficiently and economically, and to show a greater return on investment to its members, as it has done with its annual meeting.

The Power of a Partnership

That's not all. In August 2010, the leaders of ARRA and NAPA — representing 150 million tons a year of asphalt recycling — signed a cooperative agreement aimed at doubling the rate of reuse/recycling of asphalt pavements within five years. Letters of support were provided by the FHWA and the

U.S. EPA. FHWA officials say that the initiative is in keeping with the U.S. DOT's policy on recycling.

Under the agreement, NAPA and ARRA pledge to support each other's efforts to deal with common challenges, and build on each other's strengths regarding asphalt recycling issues.

"Asphalt pavement is America's most recycled material," says NAPA president Mike Acott. "There are more than 18 billion tons of asphalt pavement already in place on the roads, streets and highways of this country. These same roads that Americans use every day are also a resource that future generations can use. Our goal is to increase the rate of recycling even further."

Adds Mike Krissoff, executive director of ARRA: "Reclaiming and recycling asphalt roads brings America the best possible pavements while conserving precious natural resources. The members of both ARRA and NAPA are proud of the industry's long track record of delivering quality and value."

HIR Recycling Processes

In-place recycling is a "school" of road construction that is separate from conventional cold milling of reclaimed asphalt pavement (RAP), and subsequent paving with blends of RAP and virgin hot-mix asphalt.

Instead, HIR and CIR recycling methods are devised by specialty contractors, who use their own equipment designs – and creations – to execute in-place recycling in Canada, Mexico and the United States on a regional basis. They also will sell such machines to other contractors.

One such HIR contractor that began as a contractor and now sells equipment is Ecopave Systems, a wholly-owned subsidiary of Pyrotech Holdings. Ecopave says it's a pioneer of the two-stage, hot-in-place asphalt recycling business, and now manufactures the Ecopaver 400 two-stage, hot-in-place asphalt recycling system.

The patented system or train consists of a preheater, two self-propelled heater/miller units and a pugmill. Following the train are a conventional paver and rollers. The Ecopaver 400 not only performs the recycling of existing roads

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to exacting standards, the maker says, but it also incorporates a full emission control system that makes the system virtually smoke free. The Ecopaver 400 is manufactured in British Columbia.

Re-Recycling Pavements

Roads can be recycled again and again using HIR recycling technology, says Patrick O'Connor, president, Pavement Savers, Cocoa, Fla.

"There is no reason a pavement manager could not continue to 're-recycle' a road for as long as the road exists," O'Connor tells *Better Roads*. "After all, what is asphalt made of? It's 95 percent sand and stone, both a 50 million-year-old-plus material that does not change, and the other 5 percent is asphalt, another 50 million-year-old-plus material. The only change that takes place during the time it is on the road is the light ends of the 5 percent asphalt content that is lost, mostly to weathering."

Pavement Savers employs a single-pass HIR recycling method in which the asphalt surface is heated by a preheater using radiant heating with no flames.



Driving surface is placed immediately behind HIR heater-scarifying process.

Photo courtesy of Pavement Savers

This heating panel produces almost 2,000 degrees F of radiant heat in one minute, O'Connor said, distributing more than 80,000 BTUs per square foot evenly throughout the entire heating panel. "It's the cleanest, safest, most economical and virtually smoke-free heating system in the world," he says.

The preheater is followed by Pave-

ment Saver's hot-in-place recycler, which also uses radiant heater technology. After the surface has been heated, Pavement Savers applies an exclusive recycling oil just ahead of the scarifiers, using a spinner-droplet application. Then, the heated asphalt is scarified and the rejuvenating oil is mixed with

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▲ **In Mason County, Ill., Highway 15 is CIP-recycled** to a depth of 3 to 4 in., depending on depth of existing asphalt.

Photo courtesy of Dunn Company

the scarified asphalt not once, but twice, before it is re-leveled by a screed. A fresh asphalt overlay then can be placed with an asphalt paver.

A Train in Illinois

Recently, a self-propelled, single-pass recycling machine was put to work by contractor Dunn Company to cold-in-place recycle Mason County Highway 15 in central Illinois. Dunn reported an average cost on the job for the base course of about \$26 per ton, compared to fresh hot-mix asphalt selling around \$75 per ton at that time.

Following CIR recycling, a structural (intermediate) course layer was to be placed, followed by a friction course. The project length on the two-lane blacktop road was 17.4 lane miles, a total of approximately 112,000 square yards.

The road was in bad shape. Some pavement sections were more than four decades old, and the pavement was highly oxidized, alligator-cracked, with many irregular cold patches. Extensive transverse block cracking had occurred. Coring and as-built data showed the existing asphalt pavement thickness ranging from 5 to 6 inches in thickness. The project was to be divided into two recycling depths – two miles at a depth of 3 inches and the remainder at 4 inches. The emulsion content was calculated on a medium-

to-coarse gradation percentage as 2.25 to 3.75 percent.

Bid documents for the CIR required a self-propelled, cold-milling machine capable of pulverizing the existing bituminous material in a single pass, with a minimum width of not less than 10 feet. The machine had to have automatic depth controls to maintain the cutting depth to within plus or minus 1/4 inch of specification, and had to have a positive means for controlling cross slope elevations. No heating device to soften the pavement was allowed.

The machine used was a Wirtgen 3800 CR recycler. In this compact recycling train, the 3800 CR pushed an emulsion tanker while simultaneously milling (downcutting) the existing pavement. The 3800 CR added the design percentage of emulsion, proportional to working speed, and a metered amount of compaction moisture to suit varying in-situ conditions, with water taken from an onboard tank.

The 3800 CR then placed the recycled, stabilized material to design slope with an attached screed with working width up to 14 feet. Compaction of the re-claimed, stabilized base followed immediately behind the screed using a high-frequency, double-drum vibratory roller.

Because the recycled pavement was placed immediately behind the recycler, no windrow elevator or pickup machine – or additional paver – was required,

saving labor, fuel and equipment costs, in addition to reducing the carbon footprint of the project.

On Mason County Highway 15, the average working speed was 28 fpm, including base recycling and stabilization, with resulting material paved to slope, pre-compacted, at a rate of approximately 410 tons per hour with minimal disruption to traffic.

HIR Boosts Pavement Management

Hillsborough County, Fla., is maximizing the value of its pavement management dollars – while enhancing its program's environmental sustainability – by using hot-in-place pavement recycling topped with a virgin lift of asphalt in one pass.

The county, which covers the heart of metro Tampa, is responsible for 3,250 centerline miles, with less than 5 miles of unpaved road. "It's a good-sized inventory for a county of our size," says W. Roger Cox, P.E., senior professional engineer, Engineering Division, Hillsborough County Department of Public Works.

The county uses MicroPAVER pavement management software to inventory streets, track condition and plan maintenance. "We transitioned from a previous system, using an overall condition index on a 1 to 10 scale," Cox says. "This took into consideration seven defects, and evaluated the ride indexes.

"MicroPAVER is different," Cox continues. "It allows us to break our system into segments, within which you perform samples. We then do an in-depth evaluation of those samples within the section. It's a visual inspection system, with 19 defects available. We developed our own pavement inspection truck."

Using its new system, Hillsborough County has achieved an audited pavement condition index (PCI) of 76. "Our goals are established by the county board of commissioners, and our goal is to be at a 55 or higher system-wide," Cox says.

The county's pavement management program tracks streets suited for resurfacing, although resurfacing of pavements is considered a capital expense, as opposed to a maintenance expense. "The resurfacing budget is not contained in the transportation maintenance division, but is more of a planned expense,"

Cox states. These resurfacing capital pavement projects include mill-and-fill, hot-mix asphalt overlays and HIR repaving.

"You have to have the right treatment on the right road at the right time," Cox says. "It's the absolute key to a cost-effective program. If you put the wrong treatment out there, it will not have the survival rate that you need. Our hot-in-place repaving is aimed at our arterials, for the most part."

For its growing hot-in-place recycling program, Hillsborough County uses a process from Cutler Repaving, of Lawrence, Kan. With HIR repaving, the existing pavement is heated to 300 degrees F. When in the resulting softened, pliant condition, the pavement is scarified to a depth of 1 inch, and in the mobile repaving unit, a recycling agent that restores the viscosity of the aged asphalt is mixed into the scarified, reclaimed asphalt.

This reclaimed material then is reapplied and distributed with a screed as a 1-inch leveling course. While that material remains at a minimum 225 degrees F, a virgin hot-mix asphalt overlay is placed over the recycled leveling course. Cutler's repaving machine scarifies, applies a recycling agent, places the leveling course, and applies the new overlay simultaneously in one pass. That benefits road users because there is no delay between the time the pavement is recycled and the time a riding or friction course is placed, resulting in a safer work zone for road users and for contractor personnel.

Because the hot virgin mix is placed over the heated, recycled leveling course, the process achieves a thermal bond between the recycled layer and the new layer.

"It's an accepted methodology," Cox says. "The thing I like about it is that the recycled mat and placement of the virgin lift on top takes place simultaneously. The bond between the two lifts is homogeneous, laid flat-in. Also, the top lift is made to our asphalt spec; we know exactly what it is, so I know what my customers are driving on. And with the bond between the lifts as strong as it is, we've never had a delamination with that treatment. We've put it on roads with tremendous volumes of traffic, and we've not had a failure."

The county has done cores of repaved pavements and found the lifts to be seamless. "We have roads that were repaved a decade ago and they are not coming apart," Cox says. ♦

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