CP ROAD MAP
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“Moving Advancements into Practice”

MAP Brief 13-1:

Describing promising technologies that can be used now to enhance concrete paving practices

Two-Lift Concrete Paving

AUGUST 2010

ROAD MAP TRACK 13
Concrete Pavement Sustainability

PRIMARY SOURCE
***Two-Lift Concrete Paving in Salina/Abiline, Kansas—Interstate 70.* December 2009**
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Moving Advancements into Practice (MAP) Briefs describe promising technologies that can be used now to enhance concrete paving practices. MAP Brief 13-1 provides information relevant to Track 13 of the CP Road Map, Concrete Pavement Sustainability.

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MAP Brief 13-1 is available at: http://www.cproadmap.org/publications/MAPbrief13-1.pdf

This document discusses the potential use of two-lift paving as a sustainable technique for building concrete pavements.

Background

Two-lift concrete paving involves the placement of two wet-on-wet layers instead of the homogenous single layer commonly placed in concrete paving. Two-lift paving can provide quality surface characteristics, reduce materials costs, and consume recycled aggregates (concrete and hot-mix asphalt).

Two-lift concrete pavements have been constructed in the United States for over a century. The first concrete pavement constructed in the United States— in 1891 in Bellefontaine, OH—was a two-lift pavement. That pavement is still in service today, as are other two-lift concrete pavements built in the early 1900s. These early jobs were done fixed form and are described in *Construction of Roads and Pavement as* “two-course” concrete paving (Agg 1924).

Several states used two-lift paving in the 1950s and 1960s to facilitate the placement of steel reinforcing mesh in concrete interstate highway construction.

Between 1970 and 2000, the U.S. concrete paving industry moved away from the use of mesh and the jointed reinforced concrete pavement design, which shortened the design length of pavement panels. The new design used high-quality aggregates to produce long-lasting pavements without steel reinforcement, eliminating the need for two-lift paving.

However, the high-quality, wear-resistant aggregates used to construct the U.S. concrete pavements that have lasted 50–60 years are becoming scarce. This scarcity of aggregates, combined with advances in materials knowledge and construction equipment and increasing demands for pavement surfaces

Two-lift paving operation in Saline County, Kansas

that meet specific noise, durability, and safety objectives are prompting many agencies and contractors around the country to consider two-lift paving as a sustainable solution for building concrete pavements.

Benefits of two-lift paving as a sustainable solution

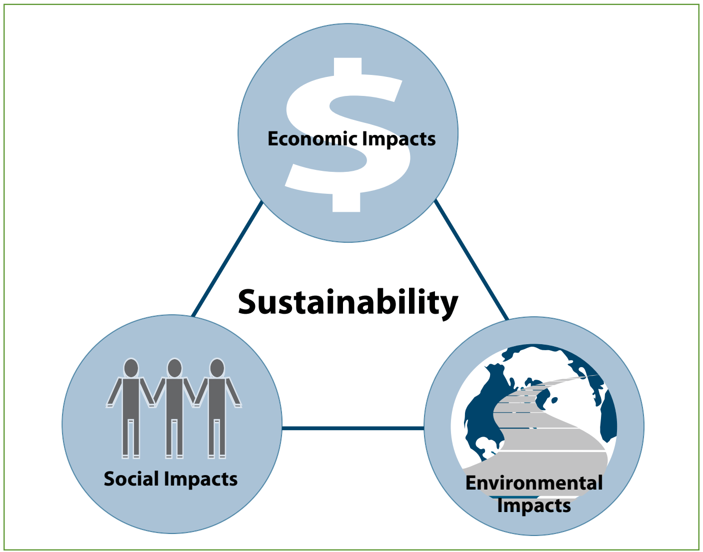
Sustainable solutions are those that balance economic, environmental, and social benefits.

The two-lift process has great potential as a sustainable paving solution. It reduces the cost of materials and materials transportation, reduces the environmental impact caused by quarrying and importing aggregates, and increases social benefits by maintaining friction and low noise levels and providing a long-lasting pavement that does not need frequent reconstruction.

Economic benefits

In two-lift paving, the bottom layer is thick—typically 80 to 90 percent of the total pavement thickness. The bottom lift generally contains locally available or recycled aggregates that may not be suitable as a wearing surface. These aggregates can be obtained at a lower cost than aggregates used in a traditional paving project. The bottom lift can also be optimized to use a variety of supplementary cementitious materials.

The top layer, on the other hand, is relatively thin and contains dense, wear-resistant aggregates that provide enhanced durability while maintaining friction and low noise. While these aggregates are more costly and frequently have to be imported, the overall cost and environmental impact of the pavement system is reduced because only a small amount of aggregates is required.



Sustainable solutions balance economic, environmental, and social impacts

Environmental benefits

Two-lift paving can be optimized for recycling and reuse.

Since the bottom lift is not subjected to as harsh an environment as the top lift, a variety of recycled aggregates—including those reclaimed from old concrete pavements—can be used in the bottom lift without sacrificing durability.

Two-lift paving can also be optimized to reduce the environmental impact caused by cement production.

One way to reduce the cement content of concrete is to use supplementary cementitious materials, such as fly ash. This strategy is commonly used in concrete paving projects and can be used in higher quantities in two-lift paving.

Social benefits

Quiet, safe, long-lasting pavements mean satisfied citizens. Two-lift pavements have the potential to meet all of these criteria through surface treatments optimized for the design requirements of the project. An exposed aggregate surface is one example of an optimized surface treatment.

Results from Europe, where exposed aggregate surfaces are commonly used, suggest that these surfaces have good tire-pavement noise characteristics and demonstrate durable skid resistance, making these pavement surfaces both safer and more comfortable.

Kansas demonstration project

In October 2008, the FHWA, National Concrete Pavement Technology Center, and Kansas Department of Transportation (DOT) coordinated a two-lift paving demonstration project and open house on I-70 in Saline County, Kansas.

Mix design

For the I-70 two-lift project, Kansas imported dense, wear-resistant rhyolite aggregates from Oklahoma for the top lift but used locally available, more porous limestone aggregates for the bottom lift, significantly lowering the cost of purchasing and transporting materials.

The contractor used a standard Kansas DOT paving mix for the 300-mm (11.8 in.) bottom lift. A combination of admixtures was used to prevent segregation.

The rhyolite was used as a coarse aggregate in the 40-mm (1.6 in.) top lift. To reduce permeability and assist in potential ASR mitigation, the contractor substituted a Class F fly ash–gypsum combination for 20 percent of the cement in the top lift.

Construction process

The Kansas DOT contracted with Koss Construction for the I-70 two-lift project.

Koss used a dual drum mixing plant to simultaneously produce the two concrete mixes. Green and red placards were used to identify which mix each truck was carrying—a green placard told the road crew the truck was delivering to the bottom lift placer (which was marked with green paint), a red placard indicated the concrete was for the top lift placer. (which was marked with red paint).

The pavement was placed on a 150-mm (5.9 in.) cement-treated recycled concrete base produced from the preexisting concrete pavement.

During the paving process, the bottom lift concrete was placed in the belt placer to deliver concrete to the base. The first paver followed behind the belt placer to form the final pavement profile for the bottom lift. Almost immediately after the bottom lift was placed, it was stiff enough to support the weight of the workers.

The concrete for the top lift was then delivered to a second belt placer, with the second paver forming the final pavement profile. The total distance of the paving operation from the first belt placer to the final paver was, on average, less than 45 m (148 ft). In this wet-on-wet application, both the bottom and top lifts were completed in about 30–60 minutes.

Worker standing on bottom lift while top lift is placed

Placement of top lift

Two-lift paving train

Exposed aggregate surface

Kansas DOT experimented with several different pavement surface textures as part of the I-70 two-lift project, including longitudinal tining, grooving, astro-turf drag, diamond grinding, and an exposed aggregate surface.

The exposed aggregate surface contained a much smaller aggregate—9.5 mm (0.4 in.) rhyolite—compared to the other surface test sections, which used 12.5-mm (0.5 in.) rhyolite in the top lift. Fine mason sand was used in the exposed aggregate section whereas standard river sand was used in other top-lift surface test sections.

To create the exposed aggregate surface, retarder was sprayed on the surface of the top lift to prevent the paste at the surface from setting. White sheeting was used to cure the retarded surface. After a five-hour curing time, the white sheeting was removed and the surface exposed for 15–20 min before brooming to remove the retarded paste from the surface and expose the aggregate. After brooming, white curing compound was applied to provide final cure for the exposed aggregate surface. Transverse and longitudinal joints were later sawed into the slab.

On-Board Sound Intensity (OBSI) tests were conducted on each of the different surface textures. All surfaces showed lower tire-pavement noise than a conventional concrete pavement textured with transverse tining.


Exposed aggregate surface (photo courtesy of Kansas DOT)

Michigan project: 15-year performance

In 1993, the Michigan Department of Transportation conducted a demonstration project to present some highly acclaimed features of European concrete pavements to U.S. practitioners. The project included a two-lift concrete pavement with an exposed aggregate surface. A control section was also constructed using standard concrete paving practices, and the performance of both sections has been monitored for over 15 years.

To date, both pavements are performing well, although there is no clear indication as to which pavement section will achieve the most cost-effective service life (Smiley 2010).

Future work

A national two-lift concrete paving open house and demonstration project will be held September 27-28, 2010 in Chesterfield, Missouri. The featured project is part of the reconstruction of Route 141 in St. Louis.

As part of this project, the Missouri Department of Transportation will place an innovative section of two-lift concrete paving and highlight sustainable engineering practices. The project will include a top lift that will be constructed using photocatalytic cement. Photocatalytic cements have the potential to remove volatile organic compounds from the air. The project will also include a pervious concrete shoulder using the same cement.

The open house will feature expert presentations on two-lift paving, photocatalytic cement, and pervious pavements. Personnel from the Missouri DOT will also discuss Missouri's plan for monitoring the environmental benefits associated with these technologies.

Additional two-lift concrete paving demonstration projects are planned throughout 2010-2011.

For more information

To learn more about the upcoming two-lift concrete paving open house, visit http://www.cptechcenter.org/t2/documents/Two-LiftProgandReg.pdf.

For more information on two-lift concrete paving, contact Tom Cackler, director, National Concrete Pavement Technology Center, 515-294-5798, tcackler@iastate.edu or view the project website at http://www.cptechcenter.org/projects/two-lift-paving/index.cfm

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