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Reassessing Two-Lift Paving

tech transfer summary

RESEARCH PROJECT TITLE
Two-Lift Portland Cement Concrete Pavements to Meet Public Needs (FHWA Cooperative Agreement DTFH61-01-X-00042 Project 8)

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Objectives

- Review past and present two-lift paving experience in the United States and internationally and assess the strengths and limitations of existing projects.
- Assess the advantages and benefits offered by two-lift paving over traditional one-lift construction.
- Determine the research gaps and challenges that are restraining the use of this technique.

Problem Statement

Changes in the availability of aggregates, advances in materials knowledge and construction equipment, and increasing demands for pavement surfaces that meet specific noise, durability, and safety objectives are prompting the need to reconsider two-lift paving as a construction technique for building concrete pavements.

Certain cost, mix design, and construction concerns are inhibiting the use of two-lift paving. Currently, the greatest resistance to this technique is economic. Two-lift paving often requires the use of two plants, two slipform machines, and a special haul road, all of which add to the cost of the paving project.

If current trends continue and two-lift paving is not further researched and demonstrated, the concrete paving industry won't have enough experience to adequately take advantage of two-lift construction when it becomes cost-effective or otherwise beneficial to do so.

Technique Description

Two-lift construction involves the placement of two wet-on-wet layers or bonding wet to dry layers of concrete, instead of the homogenous single layer commonly placed in concrete paving. The bottom layer is thick and consists of lower quality (lower durability or strength), locally available aggregate or recycled aggregate (such as recycled asphalt, concrete rubble, or local aggregate). The top layer is thin and consists of high-quality aggregate designed to provide better resistance to freeze-thaw damage, reduced noise, or improved friction. The high-quality surface also increases friction and reduces noise.

Technique Experience

The idea of two-lift paving has been around for more than a century, almost as long as concrete paving itself. Between 1950 and 1970, two-lift paving was implemented extensively in many states, including Iowa, Wisconsin, Michigan, Pennsylvania, and Minnesota, to facilitate the placement of mesh in concrete interstate highway construction.

Between 1970 and 2000, the U.S. concrete paving industry moved away from a mesh pavement design and significantly shortened the design length of pavement panels, effectively eliminating the need for two-lift paving.

However, a number of different experimental two-lift projects have been constructed in the United States since 1970, with varying degrees of success. Here are some examples:

- In Iowa in 1976, a composite pavement was removed, crushed, and used as aggregate for the lower lift of a two-lift pavement. The upper lift was constructed with virgin aggregate and placed immediately following the bottom layer. This pavement is still performing well today.
- In Florida in 1978, a two-lift pavement was constructed with a lower flexural strength lower lift and a higher flexural strength upper lift. This pavement is still in service today.
- In Michigan in 1993, two-lift paving was used to replace a major freeway in downtown Detroit. Coarse exposed aggregate was used in the upper lift to provide a quiet but rough surface texture for durability and friction resistance.

Two-lift paving is currently used most prevalently in Austria, France, and Germany.

Key Findings

- The construction costs for two-lift pavements are about double those of concrete pavements constructed using a standard one-lift technique. The additional costs are primarily the result of needing two batch plants and two slip-form paving machines and the resulting additional labor, permit, land, and equipment setup, repair, and fuel costs.
- If a contractor can use less expensive aggregate in the thick lower lift, the savings might be enough to offset part or all of the additional costs of two-lift paving.
- Some of the additional costs may also be reduced with advances in two-lift paving equipment and techniques. For example, Wirtgen (a German company) and GOMACO have developed two-lift paving systems that use just one slip-form paver. The concrete for the lower lift is placed in front of the paver, and the concrete for the upper lift is transferred through a hopper located on the paver.
- A nine-inch lower lift with dowels and a three-inch upper lift is generally a good two-lift concrete pavement design.
- Waiting 30–60 minutes before placing the upper lift of concrete helps prevent mixing of the layers and create the desired bonding.
- To avoid the risk of a concrete truck delivering a load of concrete to the wrong paving machine, equipment can be clearly distinguished with different colored paint, flags, or other markings.

Implementation Benefits

- As quality aggregate becomes scarce in some regions, two-lift paving will likely become a more viable economic option.
- Two-lift paving will help some agencies around the country consume growing recycled asphalt stockpiles, which could reduce overall costs while benefiting the environment. Existing composite pavements (concrete pavements with asphalt overlays) can be successfully recycled by first separating the asphalt overlay and then using 15%–40% asphalt in the final lower lift of concrete.
- Two-lift paving has the potential to meet emerging surface characteristics needs by providing a high-quality and durable surface. Wear resistance can be improved by using higher quality aggregate in the upper lift.

Implementation Readiness

To ensure that adequate two-lift paving experience and expertise exists when two-lift paving becomes an economical or otherwise desirable option, two-lift paving needs continued research and demonstration:

- Identify characteristics and materials needed to provide a surface that meets the future durability, safety, and noise requirements of the public.
- Demonstrate two-lift construction in a very congested location where the public demands that the roadway stay open during reconstruction efforts.
- Determine the optimal amount of recycled asphalt that could be used in a lower lift.
- Identify materials that can be present in recycled material as part of the lower lift versus those materials that should not be present.
- Recommend requirements for joints and reinforcement in two-lift pavements.
- Determine whether limits exist for variability of the coefficient of thermal expansion between layers before lift debonding would occur.
- Construct two-lift projects using a variety of concrete source combinations to provide a means of comparison and evaluation: build a project with higher flexural strength in the upper lift with the same aggregates to eliminate issues of using two plants; use local ready-mix operations to build two different mixes for one two-lift paving project; use a ready-mix operation for one lift and a batch plant for the other lift of a two-lift project.