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Concrete Pavement Maintenance and Preservation

AUTHORS
Dale Harrington
Snyder and Associates

Wayne Adaska
Portland Cement Association

SPONSOR
FHWA

MORE INFORMATION
Dale Harrington
Snyder and Associates
(515) 964-2020
dharrington@snyder-associates.com

Portland Cement Association
http://www.cement.org

Moving Advancements into Practice (MAP) Briefs describe innovative research and promising technologies that can be used now to enhance concrete paving practices.

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Full-Depth Reclamation of Asphalt Pavements with Cement

Introduction

Engineers and public works officials are discovering a cost-effective process for recycling failed asphalt pavements. The process, called full-depth reclamation with cement, rebuilds worn-out roadway by recycling the existing asphalt pavements. The old asphalt and base materials are pulverized, mixed with cement and water, and compacted to produce a strong, durable base for either an asphalt or concrete surface.

Full-depth reclamation uses the old asphalt and base material for the new road. There's no need to haul in aggregate or haul out old material for disposal. Truck traffic is reduced, and there is little or no waste. Full-depth reclamation uses the materials from the deteriorated asphalt pavement and, with the addition of cement, creates a new stabilized base. A surface consisting of a thin bituminous chip seal, asphalt, or concrete completes the road.

The recycled base will be stronger, more uniform, and more moisture-resistant than the original base, resulting in a long-lasting, low-maintenance pavement. Recycling costs are typically 25% to 50% less than the costs of removing and replacing the old pavement.

Candidates for full-depth reclamation

Full-depth reclamation is appropriate under the following conditions:

- The pavement is damaged and cannot be rehabilitated with simple resurfacing methods.
- The existing pavement distress indicates that a primary problem likely exists below the surface in the base and/or subgrade.
- The existing pavement distress would otherwise require full-depth patching over more than 15%–20% of the surface area.
- The pavement structure is inadequate for the current or future traffic.

The reasons for pavement failure can be determined by observing the types of distress that are visible. For example, alligator cracking, numerous potholes, excessive patching, or soil stains on the pavement surface are all signs of base or subgrade problems in the pavement structure (figure 1).

Figure 1. Deteriorated asphalt pavements that are candidates for full-depth reclamation with cement

Field Evaluation

After a road is selected as a candidate for FDR, a field evaluation should be performed to determine what materials make up the current pavement structure. The principal reason for the field evaluation is to determine 1) the thickness of the pavement layers and 2) the materials in each layer that will be blended for the reclaimed base. The best way to determine these will be to sample the roadway. How frequently the samples should be taken depends on how variable the existing pavement is. Normally, a road sampled every 1/4 mile (0.4 km) will provide adequate information about the characteristics of the asphalt pavement and underlying material.

Thickness Design

Thickness design for full-depth reclamation is similar to that of a cement-treated base and is calculated based on strength of the material, strength and stiffness characterizations of additional layers, anticipated loads, and performance requirements (e.g., life, serviceability, reliability). The AASHTO procedure for pavement design, for example, uses a structural layer coefficient to model base materials. The PCA thickness design procedure can also be used (PCA EB068).

The ability of a pavement base to carry loads depends on the strength of the base material and the depth of the base layer. When selecting thicknesses for reclaimed pavements, a thicker stabilized base with less strength is preferred. Today's more powerful in-place pulverizing equipment has made the job of obtaining thicker mixed-in-place layers much easier and more reliable compared with equipment used years ago. However, adequate compaction of reclaimed thicknesses greater than 12 inches (300 mm) may be difficult to achieve.

Mix Design

Designing a mix with the proper amount of water and cement for the stabilized base is not only important for obtaining a good final product, it also provides important information for quality control during construction. The *Soil-Cement Laboratory Handbook* (PCA EB052) provides comprehensive information on testing procedures for determining the appropriate cement content, water content and compaction requirements for cement-stabilized materials. A moisture-density test is used to determine the proper moisture content and maximum density for construction control and for molding the full-depth reclamation specimens for compressive strength testing.

The amount of water and cement required in the mix will depend upon the project specified strength and gradation of the final blend obtained from pulverizing and mixing the asphalt and base material during construction. Typical specifications for the combined pulverized material call for a minimum of:

- 100% passing the 3-inch (75 mm) sieve.
- 95% passing the 2-inch (50 mm) sieve.
- 55% passing the No. 4 (4.75 mm) sieve.

If the blend contains more fine-grained soil, then more cement and water will be required because of the larger surface area of the finer particles.

The required compaction density and moisture content are determined through the ASTM Standard Test Method for Moisture-Density Relations of Soil-Cement Mixtures (ASTM D558). The test procedure uses the standard compaction effort similar to ASTM D698 (Standard Proctor Test) for soils. The ASTM D558 test method is a common (as well as inexpensive) procedure for most construction testing labs. The test can be performed in either the laboratory or the field and determines the maximum dry density (unit weight) for the full-depth reclamation mix and the optimum moisture content for obtaining that density. Seven day strengths ranging from 300 psi to 400 psi are generally recommended.

Aggregate Adjustment

In some cases where full-depth reclamation is the preferred solution, the existing asphalt and base layers do not provide the desired amount of aggregate for the new base. This can happen when the original pavement structure was under-designed or traffic conditions have changed over the years and a substantially heavier pavement is required. In this situation, an aggregate adjustment can be made, where additional aggregate is placed on the pavement surface in a thin lift (figure 2) and is then blended into the base during the reclamation process.

Figure 2. Placing additional aggregate prior to reclamation

Construction

Full-depth reclamation requires a reclaimer mixer, grader, cement spreader, water truck, and roller. A reclaimer machine, sometimes called a pulvermixer, typically makes an initial pass over the existing flexible pavement, pulverizing the asphalt surface and blending it with the base and/or subgrade material (figures 3, 4 and 5). Water may be added during this mixing stage to bring the material up to optimum moisture content.

Once the existing roadway has been pulverized and blended together, the material is graded to the desired elevation and shape.

Next, cement is spread either dry (figure 6) or in slurry form (figure 7) in a controlled manner onto the surface. Excessive cement dusting can occur if dry cement is discharged under pressure in an uncontrolled manner. This should be avoided.

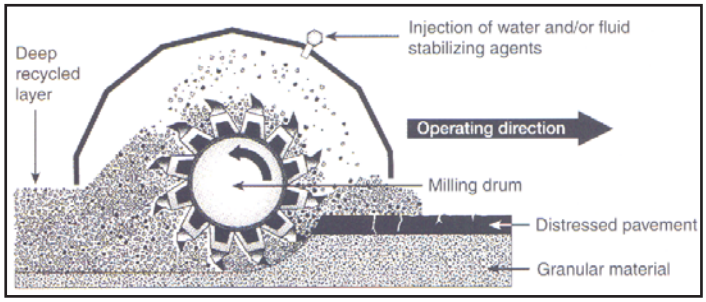

Figure 3. Schematic of reclamation mixer

Figure 4. Reclaimer milling drum

Figure 5. Reclaimer pulverizing existing asphalt and base material

Most specifications call for the application of cement in terms of weight per area (e.g., pounds of cement per square yard; kilograms of cement per square meter).

Immediately after the cement is spread, the reclaimer mixes the cement into the pulverized material. If additional water is needed, it can be added by injecting the proper amount of water into the mixing chamber (figures 3 and 8) or by placing water on the grade with a water truck prior to mixing.

Figure 6. Placing cement in dry form

Figure 7. Placing cement in slurry form

Figure 8. Water pumped directly into reclaimer

Next, the material is compacted to a minimum of 95% to 98% of the maximum density in accordance with ASTM D558. It is then shaped to the appropriate plan lines, grades, and cross-sections. Smooth-wheeled vibrating rollers or tamping rollers can be used to provide initial compaction, with smooth-wheeled or pneumatic-tire rollers used to complete the operation (figure 9). Once the cement is mixed with water and the pulverized base material, the maximum time allowed for compaction is two hours.

Proper curing is important to the quality of the final product. If the base is allowed to dry, it will develop cracks and the continued gain in strength over time will be compromised. The full-depth reclamation base must be kept moist for a minimum of seven days following compaction. Proper curing can be achieved by continuous water spraying (figure 10) or application of an approved sealing compound or membrane.

If the road will have an asphalt surface, a bituminous prime-coat can be applied at any time, as this will act as a curing membrane (figure 11). In many cases with low-volume roads, traffic is allowed to run on the compacted base until the project is ready for surfacing. For conditions where heavy truck traffic is involved, up to seven days may be required to make sure the base has gained sufficient strength for a high volume of heavy trucks.

Field Quality Control

Field quality control procedures are similar to those used for standard cement-treated base. A discussion on field inspection and testing procedures can be found in PCA PA050.

References

Portland Cement Association (PCA) EB052. *Soil-Cement Laboratory Handbook*. Skokie, IL: Portland Cement Association, 1992.

PCA EB068. *Thickness Design for Soil-Cement Pavements*. Skokie, IL: Portland Cement Association, 2001.

PCA EB234. *Guide to Full-Depth Reclamation with Cement.* Skokie, IL: Portland Cement Association, 2008.

PCA PA050. *Soil-Cement Inspectors Manual*. Skokie, IL: Portland Cement Association, 2001.

Figure 9. Compacting full-depth reclamation with vibratory and tamping rollers

Figure 10. Water curing

Figure 11. Bituminous prime coat can act as curing membrane

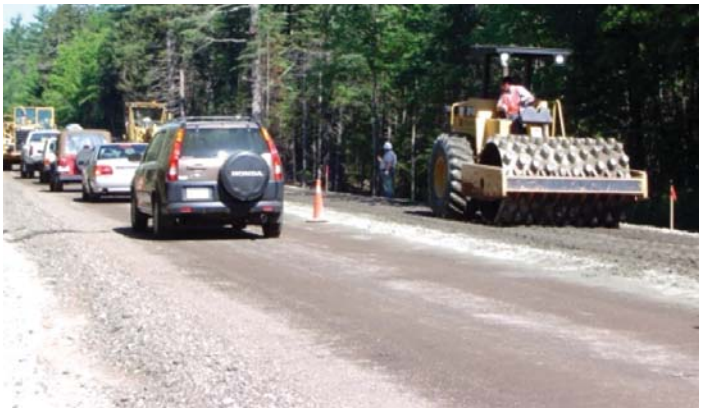

Figure 12. Traffic allowed on completed lane of full-depth reclamation prior to surfacing