Full-Depth Reclamation: Recycling Roads Saves Money and Natural Resources

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Full-Depth Reclamation: Recycling Roads Saves Money and Natural Resources

What is Full-Depth Reclamation with Cement?

Full-depth reclamation (FDR) recycles the materials from deteriorated asphalt pavement, and, with the addition of cement, creates a new stabilized base.

A surface consisting of a thin bituminous chip seal, hot-mix asphalt, or concrete completes the rebuilt road. The recycled base will be stronger, more uniform, and more moisture resistant than the original base, resulting in a long, low-maintenance life. And most important, recycling costs are normally 25% to 50% less than removal and replacement of the old pavement.

Recycling Pavements

Deteriorating roads are a constant problem for cities and counties. That's why engineers and public works officials are turning to a process called full-depth reclamation (FDR) with cement. This process rebuilds worn out asphalt pavements by recycling the existing roadway. 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. FDR uses the old asphalt and base material for the new roadway base. There's no need to haul in aggregate or haul out old material for disposal. Truck traffic is greatly reduced, and there is little or no waste.

Material Conservation: A Wise Choice

FDR with cement conserves virgin construction materials and makes smart economic and strategic sense. A century of modern growth and urbanization in America has depleted once plentiful aggregate supplies. Frequently, aggregates either come from distant quarries at great expense or from local sources offering only marginal quality.

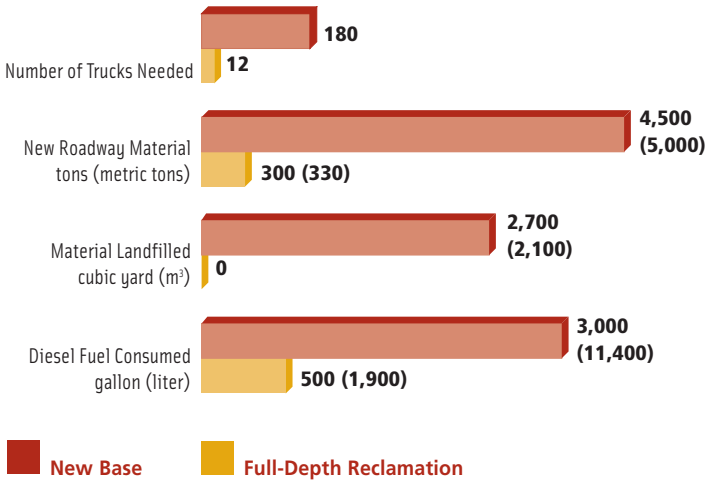
Continuing to exhaust these valuable resources to rebuild existing roads only propagates and accelerates the problem. Additionally, if old asphalt and base materials are not recycled, they must be disposed of or stockpiled, increasing transportation costs and utilizing valuable landfill space. In some locales, old asphalt can no longer be landfilled. Environmental laws are becoming stricter, thus adding to the expense of mining new materials and landfilling old.

Recycle, Rebuild

FDR with cement makes the reconstruction of old roads a largely self-sustaining process. The original "investment" in virgin road materials becomes a one-time cost, which is reclaimed through cement stabilization and addition of a new, thin surface course.

Energy Use and Materials

Full-Depth Reclamation vs. New Base



Based on 1 mile (1.6 km) of 24-foot (7.3-m)-wide 2-lane road, 6-inch (150-mm) base

PCA
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Design and Construction: Simple and Fast

The basic procedure is simple. The complete recycling process can be finished in one day, and traffic can be maintained throughout construction. The procedure includes the following steps:

Site Investigation: The site should be investigated to determine the cause of failure. Core samples or test holes should be used to determine layer thicknesses and to obtain samples of the material to be recycled. Material sampling should include the asphalt surface, base course aggregate, and subgrade soil.

Thickness Design: Pavement thickness can be determined by using PCA's *Thickness Design for Soil-Cement Pavements* (EB068). Other methods, such as the American Association of State Highway and Transportation Officials (AASHTO) Guide for Design of Pavement Structures can also be used.

Laboratory Evaluation: Material samples from the site should be pulverized in the laboratory to create an aggregate-soil mix that will be similar to that expected from the reclamation process. The mix design procedure is the same as that performed for soil-cement. (Refer to PCA publication EB052 *Soil-Cement Laboratory Handbook.)* This includes the determination of maximum dry density and optimum moisture content. If unconfined compressive strength is used to determine cement content, a 7-day strength of 300 to 400 psi (2.1 to 2.8 MPa) is recommended.

Pulverization: Construction begins with pulverizing the existing asphalt pavement using equipment that resembles a large rototiller. (This pulverizing/mixing equipment is also commonly used to mix cement with soils when stabilizing pavement subgrades.) The depth of pulverization is usually 6 to 10 in. (150 to 250 mm), which on secondary roads will typically include all of the surface and base, plus some part of the subgrade. To achieve the proper gradation after pulverization, more than one pass of the equipment may be necessary. The particle distribution should be such that 100% passes the 3-in. (75-mm) sieve, 95% passes the 2-in. (50-mm) sieve, and at least 55% passes a No. 4 (4.75-mm) sieve.

Shaping and Grading: The pulverized material is shaped to the desired cross-section and grade. This could involve additional earthwork in order to widen the roadway. Final base elevation requirements may necessitate a small amount of material removal or addition.

Spreading Cement: A measured amount of cement is spread either in dry or slurry form on the surface of the shaped roadway.

Pulverizing the old road.

Initial shaping and grading.

Application of cement.

Water Application: Water is added to bring the aggregate-soil-cement mixture to optimum moisture content (water content at maximum dry density as determined by ASTM D558). When the pulverized material is very dry (well below optimum moisture content) an initial application of water is normally added and mixed into the pulverized material prior to spreading the cement.

Mixing: The aggregate-soil-cement-water mixture is combined and blended with the pulverizing/mixing machinery. More than one pass of the mixer may be required to achieve a uniform blend of materials.

Compaction: The mixture is compacted to the required density of at least 96% of standard Proctor density (ASTM D558). The compaction is usually performed with vibratory rollers. A pneumatic-tired roller may follow to finish the surface. Final compaction should take place no more than 2 hours after initial mixing of the cement. The field density and moisture are monitored for quality control purposes.

Curing: The goal of curing is to keep the base continuously moist so the cement can hydrate. The completed base should be coated with bituminous primer to seal in the moisture. Another method of curing is to keep the base constantly moist by spraying water on the surface.

Pavement Surface: The new pavement surface consisting of a chip seal, hot-mix asphalt, or concrete is constructed to complete the FDR process.

Quality Control: FDR with cement follows the same basic procedures used for normal soil-cement operations. The success of a reclamation project depends upon the careful attention to the following control factors:

- Adequate pulverization
- Proper cement content
- Proper moisture content
- Adequate density
- Adequate curing

Mixing water and cement into the aggregate-soil mixture.

Compaction.

Curing.

Start with a Good Foundation

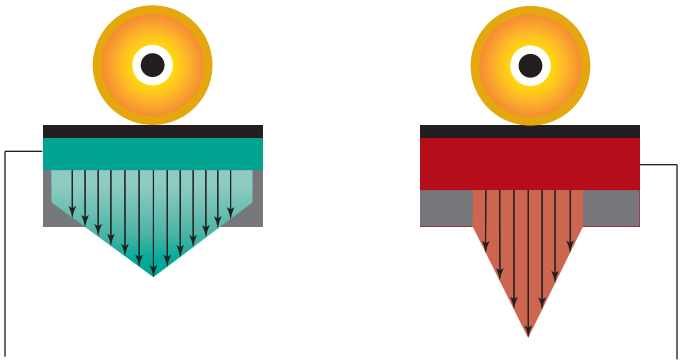
A good foundation is important for any structure, especially pavements. The pavement base provides the thickness and stiffness necessary to carry the design traffic.

Cement-stabilized bases have provided economical, long-lasting pavement foundations for more than 70 years. These pavements combine soil and/or aggregate with cement and water, which are then compacted to high density. The advantages of stabilization are many:

- Cement stabilization increases the stiffness and strength of the base material. A stiffer base reduces deflections due to traffic loads, which results in lower strains in the asphalt surface. This delays the onset of surface distress, such as fatigue cracking, and extends pavement life.
- The strong uniform support provided by cement stabilization results in reduced stresses applied to the subgrade. A thinner cement-stabilized section can reduce subgrade stresses more than a thicker layer of untreated aggregate base. Subgrade failures, potholes, and road roughness are thus reduced.
- Moisture intrusion can destroy unstabilized pavement bases, but not when cement is used to bind the base. Cement-stabilized pavements form a moisture-resistant base that keeps water out and maintains higher levels of strength, even when saturated.
- A cement-stabilized base also reduces the potential for pumping of subgrade fines.

Stabilized Base vs. Unstabilized Base

A stabilized base spreads loads and reduces stress on the subgrade.



Cement-Stabilized Base **Unstabilized Granular Base**

Old Asphalt, New Foundation

Stabilizing the old asphalt surface, granular base, and underlying subgrade soil with cement creates a strong foundation for the pavement. Usually, there is little need for material to be removed or added. The old, brittle asphalt, when pulverized, becomes a "black gravel" that will bond to hydrated cement readily. In case the existing asphalt pavement does not meet the aggregate requirements for a good stabilized base, additional aggregates can be readily incorporated into the recycled aggregate during construction.

Pulverized material.

The Problems with Old Asphalt Pavements

Asphalt pavements eventually wear out. Just like old cars or clothing, the effects of wear and climate will destroy the pavement. As the roads deteriorate, they require costly maintenance to stay in service.

Asphalt pavements typically fail in several ways. The most common include:

Fatigue cracking: Traffic causes repeated strain in the surface and eventually the asphalt cracks.

Rutting: Loads from channelized traffic shift the materials in the surface, base, and subgrade, leaving depressions or ruts in the pavement.

Recycling old asphalt pavement using FDR.

Shoving: The forces created by cars and trucks braking and stopping separate the surface material from the underlying base.

Loss of base or foundation support: Moisture degradation, traffic overloads, or subgrade failure can cause the pavement base to fail.

The type of failures mentioned above are especially prevalent in secondary roads, where pavement structures are typically light, and are often not designed for today's increased traffic levels. Repairs can be costly. A typical maintenance treatment, like a thin asphalt overlay, will only temporarily cover up the problem. Other options, such as thick overlays or removal and replacement, are expensive.

What Roads are Candidates for FDR with Cement?

FDR is most appropriate under the following conditions:

- The pavement is seriously damaged and cannot be rehabilitated with simple resurfacing.
- The existing pavement distress indicates that the problem likely exists in the base or subgrade.
- The existing pavement requires excessive patching.
- The pavement structure is inadequate for the current or future traffic.

Serious Damage or Base Failure

The engineer can evaluate the reasons for pavement failure by observing the types of distress that are visible. For example, alligator cracking, deep depressions, or soil stains on the surface are all signs of base or subgrade problems in the pavement structure.

Excessive Patching

Although patching is often necessary to keep a road serviceable, it can be expensive. In fact, once the area of full-depth patching exceeds 15% - 20%, simple economics makes it less expensive to use FDR rather than to perform the patching. Of course the final product achieved with FDR is far superior to a road that is heavily patched.

More Information

PCA offers a broad range of resources on soil-cement applications for pavements. Visit our Web site at **www.cement.org/pavements** for design and construction guidelines, technical support, and research on cement-modified soils, cement-treated base, and full-depth reclamation.

For local support, tap into the cement industry's network of regional-groups covering the United States. Contact information is available at **www.cement.org/local.**

Base distress.

Excessive patching.

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An organization of cement companies to improve and extend the uses of portland cement and concrete through market development, engineering, research, education, and public affairs work.

www.cement.org/fdr

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