

## Soil-Cement for Commercial Sites

The low-cost alternative for heavy-duty industrial pavements



### What is Soil-Cement?

Soil-cement is a simple, highly-compacted mixture of soil, portland cement, and water. As the cement reacts, or hydrates, the mixture gains strength and improves the engineering properties of the raw soil. Its improved strength and durability, combined with its low first cost and ease of construction, make soil-cement an outstanding value for use as a base and subbase material. [» more](#)

## What is Soil-Cement?

continued



The major variables that control the properties and characteristics of soil-cement mixtures are the type of soil or aggregate material, the proportion of cement in the mix, the moisture conditions, and the degree of compaction. It is possible, simply by varying the cement content, to produce soil-cement that ranges from a basic modification of the compacted soil (termed cement-*modified* soil) to fully-hardened soil-cement that is strong, durable, and frost resistant.

### Soil-Cement Materials in a Pavement Section



- Due to its versatility, soil-cement is widely used as either a low-cost pavement subgrade or base material for many commercial applications, including:
- ▶ Building pads
  - ▶ Container ports
  - ▶ Warehouses
  - ▶ Rail and truck terminals
  - ▶ Parking areas
  - ▶ Truck docks
  - ▶ Materials handling and storage areas
  - ▶ Composting facilities

Although soil-cement is known by various local and regional names, the three most commonly used terms are described below.

**“There are times when jobs call for a high-performance subgrade for use under building slabs – especially those with super-flat floor requirements. We have found that cement dries out moisture-sensitive subgrades and provides us with the stability we need to complete these types of projects.”**

*Robert Guymer, Project Manager  
Foushée and Associates, Inc.  
Bellevue, Washington*

**Cement-modified soil (CMS)** - describes a soil that has been treated with a relatively small amount of cement in order to improve its engineering properties so that it is suitable for construction. For example, CMS may be used to decrease a clay or silty clay soil’s cohesiveness (plasticity), decrease its volume change characteristics, increase its bearing strength, or transform a wet, soft subgrade into a surface that will support construction equipment.



**Cement-treated base (CTB)** - refers to all hardened soil-cement that meets the project specified minimum durability and strength requirements for a base. CTB uses more cement than CMS, resulting in a strong, durable, frost resistant layer for the pavement structure.



**Full-depth reclamation (FDR)** - describes a special case of CTB, where aggregate for the cement-treated base is obtained by pulverizing and recycling the old asphalt surface and base material into a new fully-hardened, durable, frost resistant base.

## What Materials Can be Used for Soil-Cement?

The soil material in soil-cement can be almost any combination of sand, silt, clay, shell, gravel, or crushed stone. By-product materials, including cinders, fly ash, foundry sands, and screenings from quarries and gravel pits, can all be utilized as soil material. Old granular-base roads, with or without their asphalt surfaces, can also be recycled into an excellent soil-cement base. In many cases, these materials already exist at commercial sites and eliminate the need for importing select materials for construction.

Prior to construction, simple laboratory tests are conducted on a representative sample of the soil material to determine the appropriate cement content, maximum dry density, and optimum moisture content required for construction.

## How is Soil-Cement Built?

Soil-cement construction is simple. Many contractors have the equipment and know-how to build soil-cement efficiently and economically. Prior to the start of construction, a survey is made of the construction site and design parameters for the soil-cement, such as thickness and strength, are determined. Next the soil materials are sampled and tested; usually a commercial laboratory is required for this work. After plans and specifications are prepared, construction is ready to begin.

**“I think we found something good. We’re impressed with it. It’s way better than what we’ve done before.”**

*Skip DeFalco, President  
DeFalco Lee Construction  
Longmont, Colorado*

Soil-cement can be mixed in place or in a central mixing plant. There are five basic steps in mixed-in-place construction:

- ▶ Initial shaping and grading of the site
- ▶ Application of the cement in either dry or slurry form
- ▶ Mixing the cement and water with the soil material
- ▶ Compacting and fine grading
- ▶ Curing



Central mixing plants or pugmills can be used where granular borrow material or select aggregate is involved. The mixed material is then hauled to the placement area in dump trucks and spread on the prepared subgrade using a grader, dozer, paver, or jersey spreader. Compaction, fine grading, and curing are the same as for mixed-in-place construction.

Depending on the size of the project, the entire construction process often can be completed in a day. With soil-cement there is no mellowing period for the cement to react or other delays in construction. Traffic can be maintained throughout construction and in most cases the site is available for use immediately after final grading and curing.

## Why Use Soil-Cement?



**Soil-cement parking lots offer low initial cost and fast construction**

The use of soil-cement can be of great benefit to both owners and users of commercial facilities. Its cost compares favorably with that of granular-base pavement. When built for equal load-carrying capacity, soil-cement is almost always less expensive than other low-cost site treatment or pavement methods. The use or reuse of in-place or nearby borrow materials eliminates the need for hauling of expensive, granular-base materials; thus both energy and materials are conserved.

**“There is not another base material which compares with (CTB) based on its durability, consistency, availability, and ease of installation.”**

*Jeff Joaquin, Vice President  
Kearney Construction Company, Inc.  
Tampa, Florida*

This low cost has made soil-cement an attractive alternative to designers of heavy-duty industrial pavements. In addition, soil-cement has considerably more load-carrying capacity than flexible pavements, requiring less thickness to carry a given load. Pavement engineers praise soil-cement's performance, its low first cost, long life, and high strength. Soil-cement is constructed quickly and easily – a fact appreciated by commercial owners and users alike.

## Economic and Environmental Benefits

### 1. Low First Cost

Soil-cement is often more economical to construct than granular bases through the use of soil material on or near the commercial paving site. Generally, any in-place non-organic, low plasticity soils can be used. Also, nearby granular borrow soil can provide an excellent material source, requiring lower cement contents than clay and silt soils. Borrow soils do not have to be expensive base-course material; almost any granular material is suitable.

### 2. Fast Construction

Modern methods and equipment make soil-cement processing simple and efficient. In-place soils are processed at the paving site. When borrow soil is used, it is usually mixed in a central plant at the borrow source, then hauled to the paving site to be compacted, finished to grade, and cured. There is no mellowing period or other delays in the construction process. In addition, soil-cement is stable immediately after construction and gains strength rapidly.

### 3. Recycling of Existing Materials

Making good soil-cement out of old flexible pavement is nothing new; it has been done for years. Failed flexible pavements contain materials that can be salvaged economically by recycling – breaking them up, pulverizing them, and stabilizing them with a minimum quantity of portland cement to make a new soil-cement base. There is no disposal problem as is commonly found when old pavements are dug out. Since approximately 90% of the material used is already in place, handling and hauling costs are cut to a minimum. Many granular and waste materials from quarries and gravel pits can also be used to make soil-cement, thus conserving high-grade materials for other purposes.

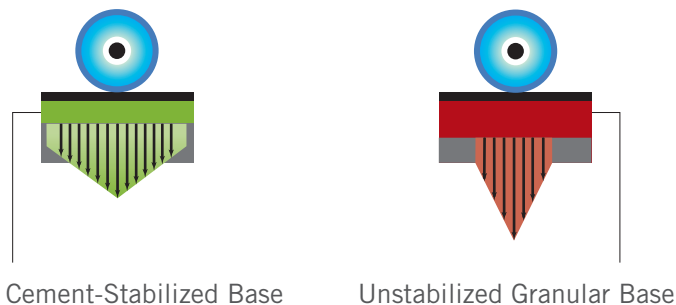
## Engineering Benefits

### 1. Stiffness

Soil-cement is a low-cost pavement base offering the feature most essential for long-lasting parking and storage areas – stiffness. Large paved areas must maintain their original grade and must not develop depressions or potholes if they are to drain freely during rains, thereby preventing puddles and damage from water that seeps through and weakens the underlying soil. The stiffness of a cement-stabilized base acts to distribute loads over a wider area, reducing subgrade stresses and allowing the base to maintain its original grade for many years without costly resurfacing or repairs.

### Stabilized Base vs. Unstabilized Base

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



Soil-cement does not rut or consolidate. As a cemented material, it does not soften when exposed to water. When rutting occurs in an unstabilized base material or the underlying subgrade soil, a simple overlay of the pavement surface is insufficient to correct the cause of the rutting. With a stabilized base, rutting is confined to the asphalt surface layer and is relatively simple and less expensive to correct.

## 2. Great Strength



**Pavement core proves strength of CTB. Even in severe climates the strength of CTB increases due to continued cement hydration.**

Cores taken from soil-cement pavements furnish proof of its strength. Samples taken after 15 to 20 years show considerably greater strength than samples taken when the pavement was initially built. Because the cement in soil-cement continues to hydrate for many years, soil-cement has “reserve” strength and actually grows stronger.

Soil-cement thickness requirements are less than those for granular bases carrying the same traffic over the same subgrade. This is because soil-cement distributes loads over broad areas. Its slab-like characteristics and beam strength are unmatched by granular bases. Strong, stiff soil-cement resists cyclic cold, rain and spring-thaw damage.

## 3. Superior Performance

More than 70 years of collective experience have demonstrated that different kinds of soil-cement mixtures can be tailored to specific pavement applications, all achieving superior performance as a result of soil-cement’s strength and durability. Thousands of miles of old soil-cement pavements in every state in the United States and in all the Canadian provinces are still providing good service at low maintenance costs.

Cement-treated bases are designed to be virtually impermeable, so that even under frost conditions no ice lenses can form in the base layer. With a granular, unbound material, if poor drainage exists or groundwater rises, the base can easily become saturated, causing significant strength losses. The cement-stabilized layer, on the other hand, will maintain significant strength even in the unlikely event it becomes saturated.

The higher stiffness of cement-treated bases leads to lower pavement deflections and lower asphalt strains, resulting in longer fatigue life for the asphalt surface. The use of soil-cement actually reduces the occurrence of fatigue cracking, a common pavement failure.

## Reference Materials

The following reference materials are available from the Portland Cement Association on planning, design, construction, and inspection of soil-cement:

- ▶ *PCA Soil Primer*, EB007
- ▶ *Soil-Cement Laboratory Handbook*, EB052
- ▶ *Thickness Design for Soil-Cement Pavements*, EB068
- ▶ *Thickness Design of Soil-Cement Pavements for Heavy Industrial Vehicles*, IS187
- ▶ *Suggested Specifications for Soil-Cement Base Course*, IS008
- ▶ *Soil-Cement Construction Handbook*, EB003
- ▶ *Soil-Cement Inspector's Manual*, PA050
- ▶ *Soil-Cement Technology for Pavements: Different Products for Different Applications*, IS327
- ▶ *Properties and Uses of Cement-Modified Soils*, IS411
- ▶ *Cement-Treated Aggregate Base*, SR221
- ▶ *Guide to Full-Depth Reclamation (FDR) with Cement*, EB234
- ▶ *Full-Depth Reclamation: Recycling Roads Saves Money and Natural Resources*, SR995
- ▶ *The Right Choice for Recycling Roads: Full-Depth Reclamation with Cement*, CD032

## More Information

PCA offers a broad range of resources on soil-cement applications for pavements. Visit our Web site at [www.cement.org/pavements](http://www.cement.org/pavements) for design and construction guidelines, technical support, and research on cement-modified soils, cement-treated bases, 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](http://www.cement.org/local).

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