STABILIZED AGGREGATE AND SOIL (OTHER THAN SURFACING)

FLY ASH

GENERAL INFORMATION

Generic Name(s): Fly Ash, Coal Ash, Bottom Ash

Trade Names: N/A

Product Description: Fly ash is a residue of coal combustion that occurs at power generation plants throughout the United States. Fly ash can be used to lower the water content of soils, reduce shrink-swell potential, increase workability, and increase soil strength and stiffness. Two types of fly ash can be used to stabilize soils: Class C and Class F. Both classes of fly ash contain pozzolans, but Class C fly ash is rich in calcium that allows it to be self-cementing. Class F fly ash requires an activation agent (e.g. lime or cement) for a pozzolanic reaction to occur and create cementitious bonds within the soil.

Product Suppliers: Representative list of producers can be obtained from: American Coal Ash Association, 15200 East Girard Avenue, Suite 3050, Aurora, CO 80014, (720) 870-7897, www.acaa-usa.org.

APPLICATION

Typical Use: Soil stabilizer.

Traffic Range: Fly ash-stabilized soils/aggregates are not used as a surfacing material. Fly ash-stabilized subgrade and subbase materials can be used for very low to high traffic volume applications.

Restrictions:

Traffic: None.

Climate: None.

Weather: None.

Terrain: None.

Soil Type: Fly ash can be used to modify/stabilize a variety of materials, including clays, silts, sands, and gravel.

Other: For fly ashes with greater than 10% sulfates, high initial strengths have been observed for fly ash stabilized materials, but the durability of the stabilized material may be reduced.

Other Comments: Fly ash stabilization is often used as a construction expedient when wet soil conditions are present and weather conditions or time constraints prevent the contractor from processing the soil to dry it out. The fly ash lowers the water content and plasticity of the soil and improves workability; this allows for construction of an adequate working platform for construction operations. Fly ash is also used to reduce the shrink/swell potential of clay soils.

DESIGN

SLC: 0.10 to 0.20. Value will vary with soil type and fly ash mixing percentage. Laboratory mixing should be performed to determine the strength of the stabilized material. Using laboratory strength testing results, an estimate of the SLC can be made using correlations, local practice, or engineering judgment.

Other Design Values: Fly ash stabilization of clay soils can increase CBR values from 2 to 3 (untreated) to 25 to 35 (treated). Unconfined compressive strengths for fly ash-stabilized clay soils can vary from 700 to 3,500 kPa (100 to 510 psi), depending on fly ash source and application rate and the material being stabilized.

Base/Subbase Requirements: The use of fly ash stabilized subgrade can reduce the design thickness for base and/or subbase layers.

Other Comments: The base thickness and appropriate road surfacing should be selected based on anticipated traffic volumes.

CONSTRUCTION

Availability of Experienced Personnel: Fly ash stabilization is relatively straightforward and qualified contractors are, in general, widely available.

Materials: Fly ash and water are required for fly ash stabilization. Fly ash is a residue of coal combustion that occurs at power generation plants throughout the United States. Two types of fly ash can be used to stabilize soils: Class C and Class F. Class C fly ash is produced from burning lignite and subbituminous coal mostly found in the western United States. Class F fly ash is produced from burning anthracite or bituminous coal mostly found in the eastern, southern, and midwestern United States.

Equipment: Equipment required for fly ash stabilization includes: mechanical spreader, tanker or water truck with spray bar, rotary mixer or disc, grading equipment (i.e. bulldozer or motor grader), and light sheepsfoot or pneumatic roller. Equipment is widely available in most areas, but availability may be limited in remote areas.

Manufacturing/Mixing Process: Subgrade and base materials are usually treated with fly ash using in-place mixing.

Placement Process: The fly ash is uniformly applied to the existing surface and water is sprayed on the surface. A rotary mixer or disc is then used to mix the fly ash, soil, and water together. If water can be added by the rotary mixer during processing, this approach is recommended. Maximum strengths are obtained when the moisture content is 0 to 7 percent below the optimum water content, depending on the material being treated. Subgrade soils are usually treated to a depth of 200 mm (8 in.). For deeper mixing and stabilization, the material should be mixed and compacted in 200 mm (8 in.) lifts. Once mixed, the loose surface is graded and compacted. Delays in compaction can result in lower maximum strengths for the stabilized material. Therefore, construction specifications often require that mixing, grading, and compaction must be finished within 2 hours of fly ash spreading.

Weather Restrictions: Avoid construction during heavy rain or snow events and when the soil is frozen. Fly ash stabilization should only be performed when air temperatures are greater 10 ºC (50 ºF).

Construction Rate: Fly ash application rates are in the range of 2,950 to 4,200 m^2/day (3,500 to 5,000 yd^2/day).

Lane Closure Requirements: The roadway lane should be closed during construction. If possible, it is recommended that the lane remain closed until a wearing surface can be applied; however, the treated material can be opened to temporary traffic after one day.

Other Comments: The required application rate will vary based on the characteristics of the fly ash and the material to be treated and the degree of modification/stabilization desired. Application rates can be in the range of 10% to 20%. Laboratory testing is recommended to determine/verify the appropriate application rate.

SERVICEABILITY

Reliability and Performance History: Fly ash stabilization has been used for soil stabilization for roads for more than 50 years. Research, design and construction information, and project experience are available.

Life Expectancy: Life expectancy varies depending on traffic, degree of stabilization, total road structure, and weather conditions. Fly ash-stabilized materials should not be used as a permanent surfacing material. Typical life expectancy for fly ash-stabilized subgrade or base materials, assuming that the roadway has a proper structural design, is more than 20 years and will generally last for the lifetime of the roadway.

Ride Quality: N/A; not a surfacing.

Main Distress / Failure Modes: The road surfacing distress mode should not be directly impacted by the use of fly ash stabilization. Where a stabilized subbase layer is used, any differential movement of the underlying subgrade, due to expansive soils or frost action, could in turn crack the stabilized subbase and lead to cracking of the road surfacing.

Preservation Needs: N/A; not a surfacing.

SAFETY

Hazards: None.

Skid Resistance: N/A; not a surfacing.

Road Striping Possible?: N/A; not a surfacing.

Other Comments: None.

ENVIRONMENTAL CONCERNS

Source of Raw Materials: Fly ash is a residue of coal combustion that occurs at power generation plants throughout the United States.

Delivery and Haul Requirements: Fly ash must be transported to the site from the distributor. Haul distances may be significant for remote sites.

Potential Short-Term Construction Impacts: Construction process can damage vegetation adjacent to the road.

Potential Long-Term Environmental Impacts:

Leachate: Fly ash stabilization can lower the permeability of the treated soil, but the treated material is still susceptible to leaching. Fly ash composition varies depending on the source of coal and the type of power plant that generated the fly ash. Most fly ashes contain heavy metals, as well as other compounds, that could potentially impact the environment. A water leach test should be performed on the soil-fly ash mixture to determine if the leachate meets regulatory standards for use.

Surface Runoff: Since it is not used as a surfacing, fly ash does not impact surface runoff.

Erosion: Fly ash-stabilized materials are a bound material and not very susceptible to erosion, especially considering that the stabilized material is not used as a surfacing material.

Water quality: Fly ash-stabilized materials have the potential to leach out heavy metals and other compounds that may affect groundwater and nearby surface waters. Laboratory testing and transport modeling may be required to determine potential water quality impacts if water sources are located near the stabilized area.

Aquatic species: Fly ash-stabilized materials have the potential to leach out heavy metals and other compounds that may affect aquatic species. Laboratory testing and transport modeling may be required to determine potential aquatic species impacts if water sources are located near the stabilized area.

Plant quality: None.

Air Quality: None.

Other: None.

Ability to Recycle/Reuse: The treated soil/aggregate can be reused as a construction material.

Other Environmental Considerations: N/A

AESTHETICS

Appearance: Fly ash stabilization does not significantly alter the appearance of a soil/aggregate material. The appearance will be of a soil/aggregate surface with the overall color determined by the material type and source. However, the fly ash-stabilized material is typically covered with a wearing surface.

Appearance Degradation Over Time: Fly ash-stabilized materials do not experience appearance degradation over time.

COST

Supply Price: N/A

Supply+Install Price: \$2.50 to \$4.50/m^2 (\$2.10 to \$3.80/yd^2)

EXAMPLE PROJECTS

Ozark National Forest, AR.
Newark International Airport, Newark, NJ.

SELECT RESOURCES

Acosta, H.A., Edil, T.B., and Benson, C.H. (2003). "Soil Stabilization and Drying Using Fly Ash," Geo Engineering Report No. 03-03, University of Wisconsin-Madison, 137 pp.

Ferguson, Glen (1993). "Use of Self-Cementing Fly Ashes as a Soil Stabilization Agent," *Fly Ash for Soil Improvement*, American Society of Civil Engineers, pp. 1-14.

LIME

GENERAL INFORMATION

Generic Name(s): Lime, Quicklime, Hydrated Lime

Trade Names: N/A

Product Description: Lime can be obtained in the form of quicklime or hydrated lime. Quicklime is manufactured by calcination of limestone at high temperatures, which chemically transforms calcium carbonate into calcium oxide. Hydrated lime is created when quicklime chemically reacts with water. Lime can be used to stabilize clay soils and submarginal base materials (i.e. clay-gravel, caliche, etc.). When added to clay soils, lime reacts with water in the soil and reduces the soil's water content. The lime also causes ion exchange within the clay, resulting in flocculation of the clay particles. This reaction changes the soil structure and reduces the plasticity of the soil. These changes will increase soil workability and can increase the soil strength and stiffness. In the long term, calcium hydroxide in the water reacts with the silicates and aluminates (pozzolans) in the clay to form cementitious bonds that further increase the soil strength.

Product Suppliers: Representative list of manufacturers, suppliers, and contractors can be obtained from: National Lime Association, 200 North Glebe Road, Suite 800, Arlington, VA 22203, (703) 243-5463, www.lime.org.

APPLICATION

Typical Use: Soil stabilizer.

Traffic Range: Lime-stabilized subgrade and subbase materials can be used for very low to high traffic volume applications.

Restrictions:

Traffic: None.

Climate: None.

Weather: None.

Terrain: None.

Soil Type: Lime works best for clayey soils, especially those with moderate to high plasticity (plasticity index greater than 15). Lime does not work well with silts and granular materials because the pozzolanic reaction does not occur due to a lack of sufficient aluminates and silicates in these materials. For lime to effectively stabilize silts or granular materials, pozzolanic admixtures (i.e. fly ash) should be used in addition to lime.

Other: For soils with high sulfate contents (greater than 0.3%), lime stabilization is generally not recommended.

Other Comments: Lime stabilization is often used as a construction expedient when wet soil conditions are present and weather conditions or time constraints prevent the contractor from processing the soil to dry it out. The lime lowers the water content and plasticity of the soil and improves workability; this allows for construction of an adequate working platform for construction operations. Lime is also used to reduce the shrink/swell potential of clay soils.

Lime-stabilized soils/aggregates are rarely used as a surfacing material, except for possible use as temporary construction or haul roads. Unprotected lime-stabilized materials have poor resistance to the abrasive action of continued traffic. Therefore, lime-stabilized materials should be covered with some type of wearing surface.

DESIGN

SLC: 0.08 to 0.14. Value will vary with soil type and lime mixing percentage. Laboratory mixing should be performed to determine the strength of the stabilized material. Using laboratory strength testing results, an estimate of the SLC can be made using correlations, local practice, or engineering judgment.

Other Design Values: For clayey soils treated with lime, unconfined compressive strengths of greater than 690 kPa (100 psi) are common and can be 2,750 kPa (400 psi) or greater, depending on the soil.

Base/Subbase Requirements: Roadway should be designed with adequate base and/or subbase support.

Other Comments: The road surface should be graded to promote surface drainage and prevent ponding on the road surface that can promote softening of the treated materials. The base thickness and appropriate road surfacing should be selected based on anticipated traffic volumes.

CONSTRUCTION

Availability of Experienced Personnel: Lime stabilization is commonly used for soil modification and stabilization and experienced contractors are, in general, widely available.

Materials: Quicklime or hydrated lime and water are required for lime stabilization. Quicklime is highly reactive with water and releases large quantities of heat during the chemical reaction. A detailed safety program is needed when constructing with quicklime. Although quicklime is more effective (25% more reactive), hydrated lime is commonly used because it is safer to work with.

Equipment: Equipment required for lime stabilization includes: mechanical spreader, tanker or water truck with spray bar, rotary mixer, grading equipment (i.e. bulldozer or motor grader), and light sheepsfoot or pneumatic roller. Equipment is widely available in most areas, but availability may be limited in remote areas.

Manufacturing/Mixing Process: Lime can be mixed with base materials at the aggregate plant; however, subgrade and base materials are usually treated with lime using in-place mixing.

Placement Process: The lime is uniformly applied to the existing surface and water is sprayed on the surface. A rotary mixer is then used to mix the lime, soil, and water together. If water can be added by the rotary mixer during processing, this approach is recommended. Enough water should be added to raise the soil moisture content to 3% above optimum moisture content, to allow for hydration of the lime. Subgrade soils are usually treated to a depth of 200 mm (8 in.). For deeper mixing and stabilization, the material should be mixed and compacted in 200 mm (8 in.) lifts. Once mixed, the loose surface is graded and compacted. For lime stabilization, the lime treated soil must be given time for the chemical reactions to change the material, or for the soil to “mellow”; the mellowing period is typically 1 to 7 days. After the mellowing period is over, the soil should be remixed, graded, and compacted. For drying or soil modification, mellowing is not usually required.

Weather Restrictions: Avoid construction during heavy rain or snow events and when the soil is frozen. Warm temperatures are required for the chemical reactions to occur between the lime and soil; therefore, the air temperature should be above 4 ºC (40 ºF) for soil stabilization applications.

Construction Rate: Lime application rates are in the range of 2,950 to 4,200 m^2/day (3,500 to 5,000 yd^2/day).

Lane Closure Requirements: The roadway lane should be closed during construction. If possible, it is recommended that the lane remain closed until a wearing surface can be applied; otherwise, the treated material can be opened to traffic after one day for temporary use.

Other Comments: The required application rate will vary based on the characteristics of the material to be treated and the degree of modification/stabilization desired. For soil modification purposes, lime application rates are normally 2% to 3% (by weight). Larger quantities of lime are required for pozzolanic reactions, and thus strength gain, to occur. For soil stabilization, lime application rates are normally 5% to 6% (by weight). Laboratory testing is recommended to determine/verify the appropriate application rate.

SERVICEABILITY

Reliability and Performance History: Lime is a commonly used product for soil/aggregate modification and stabilization and has been used for well over 40 years. Significant research, design and construction information, and project experience are available.

Life Expectancy: Life expectancy varies depending on traffic, degree of stabilization, and weather conditions. Lime stabilized materials can be used as a temporary road surfacing, but should not be used as a permanent surfacing material. For soils treated with a low percentage of lime and not adequately protected from moisture, some studies claim that the lime can leach out of the treated soil and the soil will regain the properties of the untreated material. This leaching process has been observed in projects after 5 to 12 years or more. For higher application rates associated with soil stabilization, the lime is bound to the soil particles through the pozzolanic reactions that occur and is not susceptible to leaching. As a result, typical life expectancy for lime stabilized subgrade or base materials, assuming that the roadway has a proper structural design, is more than 20 years and can be greater than 45 years for some projects.

Ride Quality: Lime treated materials can provide fair to good ride quality, depending on the material characteristics, when used as a temporary road surfacing.

Main Distress / Failure Modes: Cracking of the stabilized layer due to differential movement of the underlying subgrade.

Preservation Needs: None.

SAFETY

Hazards: Quicklime is highly reactive with water and releases large quantities of heat during the chemical reaction. A detailed safety program is needed when constructing with quicklime.

Skid Resistance: Lime stabilized materials can provide marginal to adequate skid resistance when used as a temporary road surfacing.

Road Striping Possible?: N/A; not a surfacing.

Other Comments: None.

ENVIRONMENTAL CONCERNS

Source of Raw Materials: Lime and water are required for lime stabilization. Lime is manufactured from limestone through a very energy intensive process. In addition to significant energy consumption during the manufacturing process, lime manufacturing produces large amounts of carbon dioxide (CO_2).

Delivery and Haul Requirements: Lime must be transported to the site from the distributor. Haul distances may be significant for remote sites.

Potential Short-Term Construction Impacts: The construction process and equipment can damage vegetation adjacent to the road. If the lime-stabilized material is not protected from surface runoff, some lime could be washed into the surrounding environment and have an environmental impact by raising the pH of the water (lime treated soils have a pH of around 10). However, lime has a relatively low solubility in water, so the amount of lime product carried by the surface runoff should be small. Best Management Practices (BMPs) should be employed during construction to prevent the surrounding environment and water bodies from being exposed to large quantities of lime.

Potential Long-Term Environmental Impacts:

Leachate: For soils treated with a low percentage of lime and not adequately protected from moisture, the lime can leach out of the treated soil. The amount of movement due to leaching for calcium oxide particles is on the order of 125 mm (5 in.). Therefore, leaching of lime from the stabilized material should not adversely affect the surrounding environment.

Surface Runoff: Lime-stabilized soils generally have relatively low permeability and, thus promote surface runoff. However, surface runoff water quality is not generally impacted by lime stabilization. In parking areas, oil and other vehicle fluids can be collected by surface runoff, affecting the water quality.

Erosion: Lime-stabilized materials are a bound material and not very susceptible to erosion. At lower application rates, lime-modified soil may still be subject to erosion when exposed to fast-moving waters; however, the lime-modified soil will usually be protected by a surfacing layer that will protect it from erosion.

Water quality: None.

Aquatic species: None.

Plant quality: None.

Air Quality: None.

Other: None.

Ability to Recycle/Reuse: The treated soil/aggregate can be reused as a construction material.

Other Environmental Considerations: None.

AESTHETICS

Appearance: Lime stabilization does not significantly alter the appearance of a soil/aggregate material. The appearance will be of a soil/aggregate surface with the overall color determined by the material type and source. However, the lime-stabilized material is typically covered with a wearing surface.

Appearance Degradation Over Time: Lime stabilized materials do not experience appearance degradation over time.

COST

Supply Price: N/A

Supply+Install Price: \$1.60 to \$2.40/m^2 (\$1.30 to \$2.00/yd^2) for 200 mm (8 in.) mixing depth.

EXAMPLE PROJECTS

Natchez Trace Parkway, Madison, MS.
Bald Knob National Wildlife Refuge, White County, AR.

SELECT RESOURCES

Little, Dallas (1987). *Fundamentals of the Stabilization of Soils with Lime*, Bulletin No. No. 332, National Lime Association, Arlington, VA, 21 pp.

Little, Dallas (1999). *Evaluation of Structural Properties of Lime Stabilized Soils and Aggregates, Volume 1: Summary of Findings*, National Lime Association, 97 pp.

National Lime Association (2004). *Lime-Treated Soil Construction Manual: Lime Stabilization & Lime Modification*, Bulletin 326, National Lime Association, Arlington, VA, 41 pp.

PORTLAND CEMENT

GENERAL INFORMATION

Generic Name(s): Portland Cement, Cement, Cement-Modified Soil (CMS), Cement-Treated Base (CTB), Soil-Cement

Trade Names: N/A

Product Description: Portland cement can be used to stabilize any soil except highly organic soils. Portland cement increases soil strength, decreases compressibility, reduces swell potential, and increases durability. Cement stabilization creates a hard, bound, impermeable layer. Cement stabilized materials are rarely used as a surfacing material because they can become brittle and crack under traffic loads; Cement-treated soils are most frequently used as a stabilized subgrade or road base.

Product Suppliers: Representative list of manufacturers, suppliers, and contractors can be obtained from: Portland Cement Association, 5420 Old Orchard Road, Skokie, IL, 60077-1083, (847) 966-6200, www.cement.org.

APPLICATION

Typical Use: Soil stabilizer.

Traffic Range: Cement-stabilized materials are rarely used as a surfacing material. Cement-stabilized subgrade and base materials can be used in roads for very low to high traffic volume applications.

Restrictions:

Traffic: None.

Climate: Cement stabilized bases should not be used in areas subject to seasonal frost heave.

Weather: None.

Terrain: None.

Soil Type: Cement stabilization should not be used for soils with high organic content or containing sulfates.

Other: None.

Other Comments: Portland cement can be used for soil modification (e.g. decrease plasticity of marginal aggregate to make it acceptable for use as a base material) or soil stabilization (e.g. increase strength of existing soft subgrade material). Portland cement binds the surface particles and reduces dust generation when used as a temporary road surfacing.

DESIGN

SLC: 0.12 to 0.25 (increases with increasing compressive strength).

Other Design Values: For fine-grained soils, unconfined compressive strengths of 860 to 3,450 kPa (125 to 500 psi) are common. CBR values for weak soils (CBR of 2) can be increased to a CBR of 40.

Base/Subbase Requirements: Roadway should be designed with adequate base and/or subbase support. For cement stabilized subgrades, a subbase layer is usually not required and a bound base should be used. Where cement is used to provide a treated base, the surfacing can consist of a range of materials including PCCP and HACP.

Other Comments: The road surface should be sloped to promote surface runoff and prevent ponding on the road surface that can lead to softening of the treated materials. The base thickness and appropriate road surfacing should be selected based on anticipated traffic volumes.

CONSTRUCTION

Availability of Experienced Personnel: Portland cement stabilization is a commonly used soil stabilizer and experienced contractors are, in general, widely available.

Materials: Portland cement and water are required for cement stabilization.

Equipment: Equipment required for portland cement stabilization includes: tanker or water truck with spray bar, pulverizer, grading equipment (i.e. bulldozer or motor grader), and roller. Equipment is widely available in most areas, but availability may be limited in remote areas.

Manufacturing/Mixing Process: Portland cement is typically mixed with base materials at the aggregate plant; stabilization of subgrade soils with cement is normally achieved by in-place mixing.

Placement Process: For new construction projects where aggregate must be hauled to the site, the cement can be mixed with the aggregate in a pugmill before transporting to site. This method provides the most uniform mixing. Alternatively, if the soil/aggregate is in place, the cement is uniformly applied to the existing surface and then mixed into the surface using a rotary mixer. Subgrade soils are usually treated to a depth of 150 mm (6 in.). For deeper mixing and stabilization, the material should be mixed and compacted in 150 mm (6 in.) lifts. Once mixed, the loose surface is sprayed with water using a water truck and then graded and compacted. The compacted surface should be sprayed with water again to ensure that enough water is provided for cement hydration.

Weather Restrictions: Avoid construction during heavy rain or snow events and when the subgrade is frozen.

Construction Rate: Portland cement application rates are on the order of 2,950 to 4,200 m^2/day (3,500 to 5,000 yd^2/day).

Lane Closure Requirements: The roadway lane should be closed during construction, but can be opened to light traffic once construction is complete.

Other Comments: The required application rate will vary based on the characteristics of the material to be treated and the degree of stabilization desired; typical application rates are 3% to 5% by weight. Laboratory testing is recommended to determine/verify the appropriate application rate.

SERVICEABILITY

Reliability and Performance History: Portland cement is a commonly used product for soil/aggregate modification and stabilization and has been used for well over 50 years. Significant research, design and construction information, and documented project experience are available.

Life Expectancy: Life expectancy varies depending on traffic, weather conditions, and surfacing type. Cement stabilized materials can be used as a temporary road surfacing, but should not be used as a permanent surfacing material because they can become brittle and crack under traffic loads. Typical life expectancy for cement stabilized subgrade or base materials, assuming that the roadway has a proper structural design, is more than 20 years and can be greater than 45 years for some projects.

Ride Quality: Portland cement-treated materials can provide fair to good ride quality, depending on the material characteristics, when used as a temporary road surfacing.

Main Distress / Failure Modes: Cracking (due to nonuniform subgrade support and frost action, when used as a road base layer)

Preservation Needs: None.

SAFETY

Hazards: None.

Skid Resistance: Cement-stabilized materials can provide adequate skid resistance when used as a temporary road surfacing.

Road Striping Possible?: N/A; not a surfacing.

Other Comments: None.

ENVIRONMENTAL CONCERNS

Source of Raw Materials: Portland cement and water are required for cement stabilization. Portland cement is manufactured from limestone through a very energy intensive process. In addition to significant energy consumption during the manufacturing process, portland cement manufacturing produces large amounts of carbon dioxide (CO_2); various reports claim that cement manufacturing is responsible for 2% to 7% of CO_2 produced by humans.

Delivery and Haul Requirements: Portland cement must be transported to the site from the distributor. Haul distances may be significant for remote sites.

Potential Short-Term Construction Impacts: Construction process can damage vegetation adjacent to the road, but off-site impacts can be mitigated by careful handling.

Potential Long-Term Environmental Impacts:

Leachate: None.

Surface Runoff: None.

Erosion: None.

Water quality: None.

Aquatic species: None.

Plant quality: None.

Air Quality: None.

Other: None.

Ability to Recycle/Reuse: The treated soil/aggregate can be crushed/pulverized and reused a general construction fill material.

Other Environmental Considerations: None.

AESTHETICS

Appearance: Cement stabilization does not significantly alter the appearance of a soil/aggregate material. The appearance will be of a soil/aggregate surface with the overall color determined by the material type and source. However, the cement-stabilized subgrade and base layers are typically not visible once the roadway is constructed.

Appearance Degradation Over Time: N/A

COST

Supply Price: N/A

Supply+Install Price: \$3.30 to \$4.10/m^2 (\$2.80 to \$3.40/yd^2) for 150 mm (6 in.) mixing depth.

EXAMPLE PROJECTS

Joshua Tree National Park, CA.

SELECT RESOURCES

Portland Cement Association (2003). *Soil-Cement Information: Properties and Uses of Cement-Modified Soils*, IS 411.02, Portland Cement Association, 12 pp.