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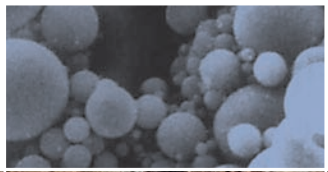


Self-Cementing Fly Ash

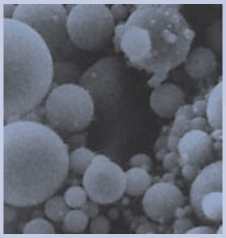
in Geotechnical Applications

LAFARGE

Fly Ash A Solid Idea
Lafarge A Solid Supplier!

"Meet customer needs." It's such a business basic, yet so necessary for success. This is why Lafarge is a reliable source of supply. We've developed a company-wide sourcing system that transports product from areas with surpluses to those in need. Lafarge has invested in over 225,000 tons of ash storage, hundreds of rail cars, and dozens of pneumatic truck trailers.

In addition to reliable product supply, our customers need reliable product performance. To meet this need, Lafarge has established a rigorous quality assurance program, rigid product standards, and an ongoing research and development program that provides continuous research studies and product tests at Lafarge laboratories in the U.S., Canada and Europe.



What is Fly Ash?

Fly ash is an extremely fine powder consisting of spherical particles less than 50 microns in size. Fly ash is one of the construction industry's most commonly used pozzolans. Pozzolans are siliceous or siliceous/alumino materials possessing the ability to form cementitious compounds when mixed with lime [calcium hydroxide (CaOH)] and water.

The word "pozzolan" is named after the small Italian town of Pozzuoli where some of the first hydraulic cements were created over 2000 years ago. The ancient Romans used volcanic ash as a pozzolan in their structures, some of which still stand today.

In North America over 26 million tons of pozzolans are consumed each year in concrete, concrete products, and geotechnical applications.

Self-Cementing Fly Ash in Geotechnical Applications

What is Self-Cementing Fly Ash?

Self-cementing fly ash is a hydraulic cementitious material possessing pozzolanic properties and a high calcium oxide content which allows it to set and harden through chemical interaction with water. The chemical reaction that occurs during the hydration process of self-cementing fly ash is similar to the hydration process of portland cement.

There are three separate chemical reactions that take place when self-cementing fly ash is mixed with soil and water.

The first is the reaction between the tricalcium aluminate (C3A) and water. This is the primary cementitious reaction. The C3A is responsible for the early strength gain and fast setting characteristics of the self-cementing fly ash soil mixture.

The second reaction is the pozzolanic reaction. The silicates and aluminates are oxides present in the self-cementing fly ash and in most soils, although not all soils contain these oxides. It should be noted that lime stabilization depends on the silicates and aluminates present in the soil, whereas the self-cementing fly ash will inherently contain these oxides. The reaction of the pozzolanic oxides forms the basis for the long-term strength gain in self-cementing fly ash stabilized soils.

The third reaction which takes place in the self-cementing fly ash soil mixture is the carbonate reaction. This reaction is ineffective in terms of soil stabilization and adds little strength.

Where Does Fly Ash Come From?

Fly ash is produced by coal-fired power plants during the combustion of coal. Fly ash consists mainly of inorganic glassy particles formed from the mineral matter in the coal. During combustion, these minerals are heated to a molten state and chemically combined and solidified while suspended in the exhaust gas. They are then collected by electrostatic precipitators or bag houses.

Fly ash is classified based on the chemical and physical composition of the ash.

Self-cementing fly ash is normally produced from lignite or sub-bituminous coal that meets the applicable requirements.

Fly Ash and the Environment

Using self-cementing fly ash reduces the amount of by-product material that is landfilled, enables aggregate manufacturers to minimize mining and processing virgin materials, and reduces the export and import of materials to the job site, thereby reducing the emission of carbon dioxide.

Self-Cementing Fly Ash in Geotechnical Applications

Applicable Standards

Although ASTM C 618 *Standard Specification for Coal Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete* is often referenced for use of fly ash in concrete, this standard should not be a requirement for use in geotechnical applications. The performance of the fly ash in geotechnical applications should be confirmed using ASTM D 5239 *Standard Practice for Characterizing Fly Ash for Use in Soil Stabilization*.

When fly ash is specified to mitigate shrink/swell properties of clay soils, procedures outlined in ASTM D 4829 *Standard Test Method for Expansion Index of Soils* should be conducted to verify performance.

Other applicable resources:

ASTM E 1861 *Guide for Use of Coal Combustion By-Products in Structural Fills*

FHWA-IF-03-019 *Fly Ash Facts for Highway Engineers* (revised June 2003)

This brochure describes the advantages of using self-cementing fly ash in geotechnical applications and covers many of the steps required to successfully achieve desired results. Since in-situ materials may vary from site to site and even within a given project location, Lafarge recommends working with a local geotechnical firm to provide testing and establish proper mix proportions.

Self-Cementing Fly Ash for Mitigating Shrink/Swell Properties in Expansive Clay Soils

Basic Use

Self-cementing fly ash can be successfully used for the treatment of clay soils to reduce their shrink/swell potential. Self-cementing fly ash, when added to clay soil, cements the soil grains together and restricts the expansion potential.

Applications

In soils containing expansive clays, fluctuations in moisture content can change the soil volume by as much as 20 percent. If this volume change is not controlled, premature failure can occur to the overlaying structures.

Typically, contractors utilize two solutions to the expansive clay problem: replace the clay with more stable fill or treat with a lime-containing material. A third approach uses self-cementing fly ash to stabilize clay soils by physically binding the soil particles together, restricting expansion and contraction of the clay soil.

Other benefits include:

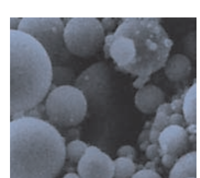
1) increased strength, creating a more stable work platform and

2) less sensitivity to additional moisture infiltration, thereby reducing potential delays during the construction process.

Self-cementing fly ash treatment of clay soils is faster and generally more economical than lime treatment. Hydrated lime [$Ca(OH)_2$] treatment of soil is a chemical reaction which agglomerates the clay particles. Lime treatment is usually a two-stage process with a required mellowing period, ranging from 24 to 48 hours providing time for the chemical reaction to occur. Self-cementing fly ash treatment is a single stage process which greatly speeds construction. The effectiveness of lime treatment of clay soils is evaluated by the determination of the clay's plasticity index. The plasticity index is the subjective indicator of a soil's potential to swell and not an absolute determination. Due to the cementation of the soil particles and the small quantity of free lime available, the determination of the plasticity index before and after self-cementing fly ash treatment as a means of assessing treatment effectiveness is not valid. To accurately evaluate a material's influence on a plastic soil, an actual shrink/ swell measurement must be made with an expansion test such as ASTM D 4829.

Mix proportions are first determined with job site materials in a geotechnical laboratory. The section to be treated should be shaped to the correct grade. Self-cementing fly ash is then placed on the soil at the recommended mix design application rate. The proportions are based on the dry weight of the soil. The self-cementing fly ash soil mixture is then thoroughly mixed with water added to the specified moisture content. Final moisture content at the time of compaction should not exceed the specified moisture content. Additional self-cementing fly ash can be added to lower the moisture content to specified limits. Compaction should begin immediately after mixing the self-cementing fly ash, soil and water. Final compaction should be completed within the compaction delay specified and to the specified density.

The self-cementing fly ash soil mixture should be cured to protect against rapid drying for at least three days or until a pavement or slab is placed over the completed section. The soil can be cured by either continuously sprinkling with water or by covering with a two-inch layer of soil on the completed course.



Self-Cementing Fly Ash for Hot Mix Asphalt (HMA) Pavement Recycling

Basic Use

Deteriorated asphalt pavements can be effectively and economically rehabilitated using self-cementing fly ash as a strength-enhancing agent. Existing HMA pavement is pulverized to create a new base course material. Self-cementing fly ash is added to the pulverized materials, providing additional strength. The new, enhanced base course is then paved with a new HMA wearing surface. This process will provide a high quality pavement structure quickly and economically. Self-cementing fly ash stabilized bases demonstrate structural values over twice that of natural crushed aggregate bases and provide the added benefit of being open to traffic during construction.

Applications

The use of self-cementing fly ash in recycled asphalt pavements is a very attractive alternative for state departments of transportation (DOTs), county engineers and commercial owners wanting to upgrade the performance and durability of their pavements and parking lots. Many counties and most paving contractors have pulvamixers and other equipment required to complete HMA recycling projects.

Asphalt pavement recycling generally is either full depth recycling (FDR) where the existing HMA pavement and base course is pulverized to provide a new base, or partial depth recycling where the HMA is milled, enhanced and re-laid in place. Both of these applications are commonly referred to as cold-in-place recycling (CIR). FDR is applied to rural highways that are old, under-designed and which are usually low volume roads with occasional heavy loadings. Many FDR candidate roads have deteriorated beyond the point where maintenance procedures are effective.

Full depth recycling consists of pulverizing the existing HMA surface and most or all of the base course layer, providing a uniform blend. This material is then compacted and graded. Self-cementing fly ash is then spread evenly over the pulverized material, pulverized again with the ash to provide a homogeneous mixture, compacted with a vibratory pad-foot roller, graded to final width and cross slope and compacted with a smooth drum roller. As the self-cementing fly ash is being blended, water is injected into the pulvamixer so that the predetermined densities and moisture content are achieved. Both self-cementing fly ash concentrations and moisture content are pre-determined by lab testing.

Frequently, this new base course material is reopened to traffic before the new HMA wearing surface is constructed.

Some counties require that the new base be left unpaved for up to three days and kept moist-cured before the new HMA surface is applied. Occasionally, the design thickness of the new HMA surface is reduced because the self-cementing fly ash-enhanced, recycled base is so much stronger.

Partial depth asphalt recycling applications often require more specialized equipment. The types of roads conducive to this type of application have high traffic and loading. These roads have typically been engineered and constructed as opposed to having evolved over time. Because this type of recycling is fast, traffic can be returned quickly, making this application a good choice for congested urban areas.

As the name implies, the asphalt road is recycled within the pavement layers and only removes the top several inches. Self-cementing fly ash is most often placed directly in front of the milling machine. Water is then added to the mixture and, in some cases, retarders can be added in hot weather conditions to control the setting of the fly ash. The recycled asphalt pavement (RAP), self-cementing fly ash and water can be screened and crushed if conditions warrant. The self-cementing fly ash and RAP mixture is typically placed with a conventional asphalt lay-down machine and quickly compacted. The material should be sealed to allow the mixture to cure and reach maximum strength. This recycled material is now ready for the new HMA wearing surface. As with a full depth recycling technique, traffic can quickly resume on the new base until the wearing surface is applied.

Self-Cementing Fly Ash for Structural Fill Applications

Basic Use

Self-cementing fly ash is an effective and economical material for the construction of engineered structural fill projects, building sites and foundations, levees and dikes, embankments for highways, railroads and other public works requiring a compacted fill material.

Applications

The use of coal combustion products (CCPs), such as self-cementing fly ash and bottom ashes, for structural fills is becoming more prevalent due to the decreased supply and increased cost of virgin fill materials. Transportation of these materials to a remote project location can be very costly. CCPs provide a self-supporting stabilized back fill, which remains stable and durable over time. Because CCP structural fills have higher densities they are often less susceptible to water infiltration than native soil or rock fills. Site construction procedures generally proceed in a manner similar to clay structural fill projects with a few exceptions related to the chemical and physical nature of CCPs.

The site should be grubbed of vegetation and stripped of all topsoil. Provisions should be made for surface drainage control, particularly during the CCP placement process. Clay underlining and/or subsurface drainage provisions should be installed, if deemed necessary by the engineer. Self-cementing fly ash, which is naturally a dry powder, must be moisture conditioned into a soil-like consistency. Such processing can occur at the source (the generating station), or at a separate facility located at or near the construction site. Most bottom ashes are produced in a consistency acceptable for use without additional processing.

Delivered in standard end dumps, CCPs are spread and placed using a bulldozer that may (but not necessarily) be equipped with a spreader box. On small projects, placement can be accomplished with a motor grader. CCPs should be placed in 8- to 10-inch (loose) lifts and compacted to specified standards using a vibratory steel wheel roller. Compaction should occur quickly following placement to limit moisture loss and to ensure proper consolidation prior to initiation of the strength-gain process. Filling should proceed in lifts until the design elevations are achieved. CCP in-place densities should be certified at regular intervals to ensure the structural integrity of the project.

Measurements are generally completed using nuclear density testing equipment. Facility construction may proceed immediately following the completion of placement operations. Building foundations, necessary underground facilities, pavements, etc., may be constructed directly above or within the CCP structural fill. Project sections located outside of the facility footprint should be covered with clay and/or other suitable soils for the purpose of sustaining vegetative growth and limiting vertical surface water migration. Membrane capping materials and geotextiles may also be used in these areas.

Self-Cementing Fly Ash for Stabilizing Aggregate Bases

Basic Use

Stabilized aggregate bases can be constructed using self-cementing fly ash as the cementing agent.

Applications

The stabilization of aggregate bases has many benefits. The supply of high-quality aggregates for road base construction continues to diminish in many communities, while new reserves are increasingly more difficult to permit due to zoning and environmental regulations. Sometimes quality aggregates have to be transported long distances, resulting in high construction costs. Using self-cementing fly ash to stabilize poor quality aggregates is often a cost-effective solution. The cementing of the aggregate particles increases both the durability and strength of the aggregate base.

With the advent of in-place methods of stabilizing aggregates, high volumes of base material can be stabilized without the expense of batch plants, transportation and pug mill operations. Also, the workability issues associated with the use of a pug mill with self-cementing fly ash is not a concern with in-place methods. Additionally, the strength of the self-cementing fly ash aggregate mixture is improved by eliminating delivery time of materials from the pug mill operation to the site of placement. The aggregate mix design proportions and compaction delay time are established in the laboratory prior to commencement of construction. The correct quantity of self-cementing fly ash is then placed over the aggregate. The self-cementing fly ash aggregate mixture is then thoroughly mixed as water is introduced to the process. The water can be introduced either just prior to mixing or more preferably, injected into the pulvamixer as the aggregate and self-cementing fly ash are being mixed. The stabilized aggregate is then ready to be compacted and shaped to final grade.

Compaction immediately following mixing operations is imperative due to the reaction time of self-cementing fly ash. Shorter compaction delay times provide higher compressive strengths.

Basic Use

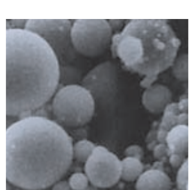
Self-cementing fly ash has been used effectively for increasing the subgrade support capacity of pavements and for increasing the shear strengths of soils in embankment sections. In addition to providing additional subgrade support, the self-cementing fly ash stabilized area provides a more stable section for paving operations and reduces the potential for disturbance due to construction traffic and adverse weather.

Applications

Self-cementing fly ash has been used for over 20 years for the stabilization of soils. Because self-cementing fly ash is cementitious, it can be used in many soil stabilization applications as a stand alone material.

The mix proportions for a soil stabilization project are first determined in the laboratory with job site materials. Lab testing includes proctor testing for optimum strength and moisture content. The field section to be treated should be shaped to the correct grade. Based on the dry weight of the soil, self-cementing fly ash is applied at the recommended mix design application rate. The self-cementing fly ash soil mixture is then thoroughly mixed with water added to the specified moisture content. Final moisture content at time of compaction should not exceed the specified moisture content. If too much water is added, additional self-cementing fly ash should be added to lower the moisture content to that which is specified. Compaction should begin immediately after the self-cementing fly ash, soil and water are mixed. Final compaction should be completed within the compaction delay specified and to the specified density. Delays in compaction will result in lower strengths of the stabilized materials.

The self-cementing fly ash soil mixture should be cured to protect against rapid drying for at least three days or until a pavement or slab is placed over the completed sections. The soil can be cured by either continuous sprinkling with water or by covering with a two-inch layer of soil on the completed course.



Self-Cementing Fly Ash for Soil Drying

Basic Use

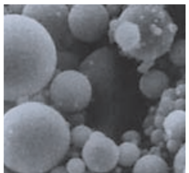
Self-cementing fly ash has been found to be a very effective drying agent, capable of reducing soil moisture content by 30 percent or more within a matter of hours. Drying soils is faster and less expensive than replacing with dry soil, aggregates or other materials. Since the drying effect is immediate and the soil is made resistant to further moisture infiltration, self-cementing fly ash can be of great benefit to owners and contractors when construction schedules require immediate, unimpeded construction.

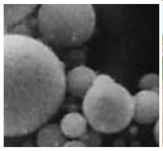
Applications

The use of self-cementing fly ash to dry soils is an economical alternative to traditional methods. Structures must be constructed on stable soils. For a soil to be stable it must be compacted to its maximum practical density. Because of the relationship between a soil's density and water content, the moisture content of the soil must be tightly controlled. If a soil is on the dry side of optimum for maximum density, the solution is simple. The contractor simply adds water until the soil's moisture content is close to optimum, usually specified to be 95% of maximum. But if a soil is too wet for maximum compaction, the soil must be dried or replaced with alternate materials.

A contractor and owner have several options. One option is to remove and replace the soil with a more suitable material. This is usually an expensive option given the cost of removing and replacing the soil assuming a suitable soil is locally available. Another option is to wait for the weather to dry the soil. The soil can be manipulated or aerated to speed the drying process. The disadvantage is the possibility that additional precipitation can further delay the project. Another option is to add stone to the soil in an attempt to build a working platform. If the site receives more precipitation, more stone must be added.

Self-cementing fly ash is an option for drying soils which presents several inherent benefits, such as creating a more stable work platform, reducing job site dusting from construction traffic, adding strength to an existing soil, and making the soil more resistant to further moisture infiltration. If self-cementing fly ash is used to dry a site, the stabilized soil tends to shed water from the surface, not allowing the water to penetrate. Therefore, as soon as the surface becomes dry, construction can proceed. When self-cementing fly ash is used to dry a site, typically a contractor familiar with local conditions simply calculates a reasonable application rate and then begins to manipulate the self-cementing fly ash into the soil until the proper moisture content is reached.




Company Profile

Lafarge North America is part of the Lafarge Group. The world leader in building materials, active on five continents, the Lafarge Group holds top-ranking positions in all four of its divisions – cement, aggregates and concrete, roofing and gypsum.

By focusing on the development and improvement of building materials, Lafarge puts the customer at the core of its strategy and offers the construction industry and the general public innovative solutions that will bring more safety, comfort and beauty to our everyday lives.

Please contact your Lafarge Office for specific product information, availability and ordering.

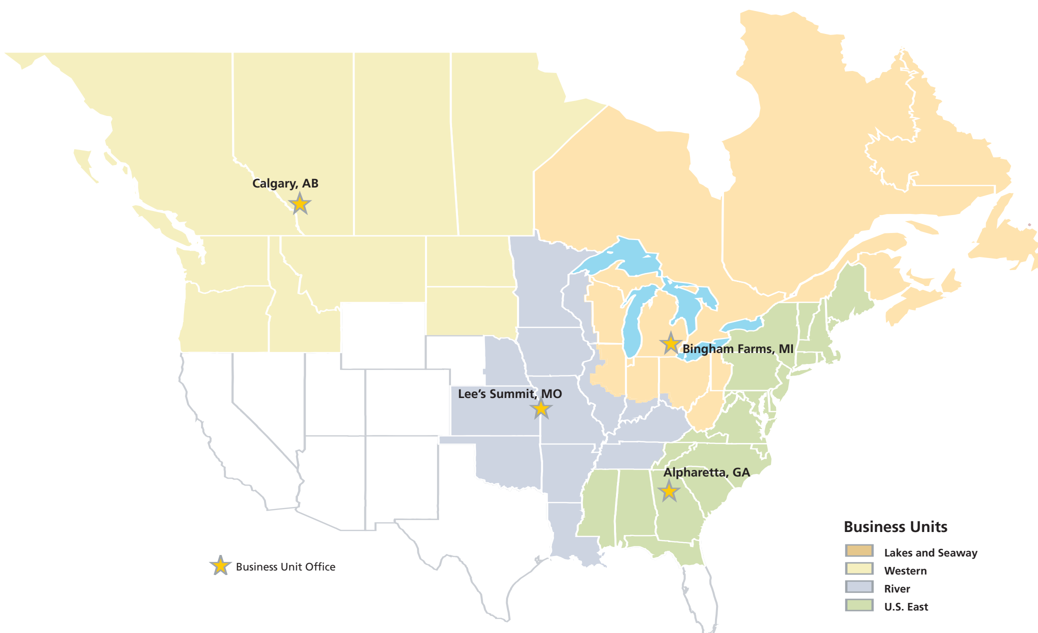
Lakes and Seaway Business Unit
Bingham Farms, Michigan
Phone: 248-594-1991

U.S. East Business Unit
Alpharetta, Georgia
Phone: 678-746-2000

River Business Unit
Lee's Summit, Missouri
Phone: 816-251-2100

Western Business Unit
Calgary, Alberta
Phone: 403-271-9110

Lafarge North America Cement Operating Areas



Limited Warranty
Lafarge warrants that Lafarge Self-Cementing Fly Ash meets applicable ASTM and CSA requirements. Lafarge makes no other warranty, whether of merchantability or fitness for a particular purpose with respect to this product. Having no control over its use, Lafarge will not guarantee finished work in which this product is used.

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Lafarge North America Inc.
12950 Worldgate Drive, Suite 500
Herndon, VA 20170

Lafarge Canada Inc.
606 Cathcart Street
Montréal, Québec H3B 1L7

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