CERAMIC TILE INSTITUTE OF AMERICA, INC.

12061 Jefferson Blvd., Culver City, CA 90230-6219

CTIOA Field Report 88-11-1 (R-90)

SUBJECT: PORTLAND CEMENTS, LIME AND SAND

I. INTRODUCTION

A. This field report is on portland cements, lime and sand; by definition, portland cements are hydraulic cements; that is, they set and harden by reacting chemically with water. The process, called hydration, combines cement and water to form a stone-like mass.

II. PORTLAND CEMENT

A. The invention of portland cement is generally credited to Joseph Aspdin, an English mason. In 1824 he obtained a patent for his product, which he named portland cement because it produced a concrete that was the color of a natural limestone quarried on the Isle of Portland, a peninsula in the English Channel, west of the Isle of Wight. The name has endured and is used throughout the world, with many manufacturers adding their own trade or brand names. The first portland cement made in the U. S. was produced at a plant in Coplay, Pennsylvania, in 1872.

B. Portland cement is produced by pulverizing clinker consisting essentially of hydraulic calcium silicates and usually containing one or more forms of calcium sulfate as an interground addition. Materials used in the manufacture of portland cement must contain the right proportions of lime, iron, silica and alumina components.

C. There is no typical portland cement manufacturing plant; every plant has significant differences in layout, equipment, or general appearance. Selected raw materials are crushed, milled and proportioned in such a way that the resulting mixture has the desired chemical composition. Either a dry or wet process is used. In the dry process, grinding and blending are done with dry materials. In the wet process, grinding and blending operations are done with the materials in slurry form. After blending, the ground raw material is fed into the upper end of a kiln. The raw mix passes through the kiln at a rate controlled by the slope and rotational speed of the kiln. Burning fuel is forced into the lower end of the kiln where it produces temperatures of 2600°F to 3000°F, changing the raw material chemically into cement clinker. The clinker is cooled and then pulverized. During this operation, a small amount of gypsum or anhydrite is added to regulate the setting time of the cement. The finished pulverized product is portland cement. It is ground so fine that nearly all of it passes through a sieve with 40,000 openings per square inch. There are a variety of different types of portland cement that meet different physical and chemical requirements for specific purposes. The (ASTM) C150 provides for eight types of portland cements. The types are classified from Type I to Type V.

1. Type I - This is a general purpose portland cement suitable for all uses. It is used where cement or concrete is not subject to specific exposures. Its uses include sidewalks, reinforced concrete buildings, bridges, tanks, culverts, water pipes, and masonry units.

2. Type II - This cement will usually generate less heat at a slower rate than Type I. It can be used in structures of considerable mass, such as large piers, heavy abutments and heavy retaining walls. Its use will reduce temperature rise, very important when the concrete is placed in warm weather.

3. Type III - This is a high-early strength cement that provides high strengths at an early period, usually a week or less. It is used when forms.are to be removed as soon as possible or when the structure must be put into service quickly. In cold weather its use permits a reduction in the controlled curing period. Although rich mixes of Type I cement can be used to gain high early strength, Type III cement may make it better and cheaper.

4. Type IV - This cement has a low heat of hydration and is used where the rate and amount of heat generated must be minimized. It is intended for use in massive concrete structures, such as large gravity dams, where the temperature rise resulting from heat generated during hardening is a critical factor.

5. Type V - This cement is a sulfate resisting cement used only in concrete exposed to severe sulfate action, mainly where soils or ground waters have a high sulfate content.

6. Then there are three types of air entraining portland cement that correspond with Types I, II, III respectively, except that small quantities of air-entraining materials are interground with the clinker during manufacture to produce minute, well-distributed and completely separate air bubbles. These cements produce concrete with improved resistance to freeze-thaw action and to scaling caused by chemicals applied for snow and ice removal. There are more types of cement such as white, masonry, hydraulic, oil-well, waterproofed, plastic, expansive and regulated-set cements, but these are special cements that are not used in great abundance. These cements are readily available in most of the United States.

D. There are four chemical compounds in portland cement: tricalcium silicate, 3Ca0.Si02, which is the early strength and initial set; dicalcium silicate, 2Ca0.Si02, which hardens slowly and contributes largely to strength increase at ages beyond one week; tricalcium aluminate, 3Ca0.Al203, which liberates a large amount of heat during the first few days of hardening; and tetracalcium alumina ferrate, 4Ca0.A1203.Fe203, which acts as the flux in burning the clinker.

E. A few of the properties of portland cement are: Fineness of cement which affects the rate of hydration; Soundness, which is the ability of a hardened paste to retain its volume after setting; Consistency, which refers to the relative mobility of a fresh mixture or its ability to flow. There are others such as setting time, false set, compressive strength, heat of hydration, loss of ignition and specific gravity. The weight of cement is 94 lbs. to one cubic foot when freshly packed. Most cements are shipped in bulk by railroad, truck or barge.

F. Portland cement is moisture sensitive material; if it is kept dry, it will retain its quality indefinitely. The last word on cement is to be careful with it; there have been cases of cement poisoning and if handled with bare skin, mainly hands, it causes severe dryness and cracked skin.

III. **LIME**

A. Lime is a versatile chemical which is one of the oldest materials known to man. It was extensively used in building the pyramids of ancient Egypt. Until the rapid growth of the chemical process industries at the turn of the 20th century, lime was regarded almost entirely as a building and agricultural material.

B. Since 1900, progressively larger quantities of lime have been used in industry as a chemical reagent until today more than 90 percent of the total amount of lime is sold or used as a chemical in its oxide and hydroxide form. Now it is regarded as an industrial chemical instead of an agricultural material, although there is substantial usage of it in mortars, stucco and plastering material, in agriculture for soil sweetening, and is used extensively for soil stabilization in highway and airfield construction.

C. Its growth as a chemical can be largely attributed to three factors: widespread production, low cost and abundant supply. Tonnage-wise, lime ranks fourth among the largest industrial chemicals of the shipments and consumption at 12 and 14.5 million tons per year respectively.

D. Chemical uses of lime at different manufacturers:

1. Steel manufacture - Its most extensive use is as a flux in purifying steel.

2. Magnesium manufacture - This is used in most of the processes.

3. Pulp manufacture - This is used as a causticizing agent in sulfate plants.

E. For many years, calcium silicate (sand-lime) brick have been employed in standard masonry construction in the same manner as a common clay brick. Lime,"usually in the form of dolomitic lime ranks fourth behind sand, soda ash and limestone. Lime is employed with portland cement in the manufacture of light weight cellular concrete products, as large masonry units or insulation slabs that are widely used in Europe. Lime is used in food such as dairy and sugar products. We use lime in all our mortars and it gives better workability. The more lime, the easier it is to work with, but the strength of the mortar declines. Some miscellaneous uses of lime are in petroleum, leather and rubber.

F. The chemical and physical properties of lime: Chemical lime is a term designating a type of quick lime low in impurities and possessing a high degree of reactivity making it suitable for use in chemical processes. Commercially, chemical lime is obtained through the controlled calcination of high quality limestone. Quicklime consists of oxides of calcium and magne sium and in this country it is available in three forms.

1. High calcium quicklime - containing 0.5 to 2.5 percent magnesium oxide.

2. Dolomitic quicklime - containing usually 35 to 40 percent magnesium oxide.

3. Magnesium quicklime - containing usually 5 to 10 percent magnesium oxide.

G. Chemical lime is a white solid having a crystalline structure. Quicklime is highly reactive with water, generating considerable amount of heat in the hydration process. This material will react with the moisture in the air. Quicklime is commercially available by the carload, in bulk or in paper bags, in a number of more or less standard sizes.

1. Lump lime - the product diameter

2. Crushed lime - this ranges from 2½ to ¼ inches.

3. Ground lime

4. Pulverized lime - the finest

5. Pelletized lime - one inch size pellets.

H. Hydrated lime is generally shipped in 50 pound paper bags and in bulk tank trucks or rail cars. The dictionary explains lime as a "caustic solid substance, white when pure, obtained by calcinating limestone and other forms of calcium carbonate." Pure lime is also called quicklime, burnt lime and caustic lime. It is composed of calcium oxide lime water, which is an alkaline solution of slaked lime in water and is used principally in medicine as an antacid, as a neutralizer for acid poisoning, or for treatment of burns.

IV. **SAND**

A. Sand is a loose, incoherent mass of mineral materials in a finely granular condition, usually consisting of quartz, with a small proportion of mica, feldspar, magnetite and other resistant minerals. It is the product of the chemical disintegration of rocks under the influences of weathering and abrasion. The cleaner the sand is, the better the strength is in mortars. In our area, sand isn't very clean for masonry. For tile work, you use a lot of graded sand. There are different grades of sand in the silicas and you use it accordingly.

B. Measuring Moisture in Sand

1. Damp sand feels slightly damp to the touch, but which leaves very little moisture on the hands. It usually contains about 1/4 gallon of water per cubic foot.

2. Wet sand, usually available on most jobs, feels wet and leaves a little moisture on the hands after being handled. It contains about 1/2 gallon of water per cubic foot.

3. Very wet sand is dripping wet when delivered and leaves more moisture on the hands than wet sand. It carries about 3/4 gallon of water per cubic foot.

4. Fine sand usually carries more water than coarse sand although from appearance, both might seem to be equally wet.

5. It is important to be able to judge whether sand is damp, wet or very wet in order to know how much water to deduct for that carried by sand.

NOTE: This paper was written by Randal Lipe, CTC, in partial fullfillment of requirements for the Ceramic Tile Consultant's course given in Portland, Oregon, 1988.

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