

WHITE CEMENT & SWIMMING POOL PLASTERING

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White cement meeting ASTM C150, ASTM C595, or ASTM C1157 (“white cement”) is used in plaster, concrete, and masonry materials for a variety of architectural and decorative applications. White cement is specified in these applications for its color consistency, appearance and the ability to create a durable, rock-like material. Understanding the basics of cement chemistry and other factors that affect concrete color may help reduce some misconceptions about discoloration of cementitious materials. Color is an important quality control issue in the white cement industry in order to achieve consistency in brightness and tone (see Figure 1). The gray color that is common for most portland cement is due to the iron and manganese oxide compounds present in cement. However, to produce white cement, raw materials having very low levels of these metals are selected. In addition, the firing process is controlled to minimize how those metals are bound up in the clinker structure, which improves its whiteness, consistency and color tone.



Figure 1

The Chemistry of Portland Cement

While ASTM C595 and ASTM C1157 white cements are often used, the Standard Specification for Portland Cement ASTM C150 is used herein as an example because it best describes the chemical and physical characteristics of portland cement. The most common cement designation in C150 is Type I, for normal or general use. Table 1 compares the chemistry of two typical Type I portland cements, one gray and one white, which have similar characteristics. One difference between white and gray portland cements is that one of the six major oxides that describe their chemical composition is significantly lower in white cement than in gray cement. White cement typically contains 0.4% or less iron oxide (Fe_2O_3) rather than 2.6% for gray portland cement (“gray cement”).

As Table 1 shows, four chemical compounds characterize portland cement: C_3S , C_2S , C_3A , and C_4AF . Calcium aluminoferrite, or C_4AF in shorthand notation, is the compound that most influences cement color. Also known as the ferrite mineral phase, C_4AF can be light brown, amber, deep brown, reddish brown, greenish brown, or almost black. Cement particles are typically smaller than 45 microns (average size around 10 - 15 microns), so they are essentially fine powders and act like pigments (Hime and Erlin 2008).

Type of portland cement	Chemical composition %						Loss on ignition, %	Na ₂ O eq	Potential compound composition %				Blaine fineness, M ² /kg	Color L Value**
	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	SO ₃			C ₃ S	C ₂ S	C ₃ A	C ₄ AF		
White I	22.5	4.5	0.4	66.3	1.0	2.8	1.7	0.17	60	19	11	1	464	93.5
Gray I	20.5	5.4	2.6	63.9	2.1	3.0	1.4	0.61	54	18	10	8	369	54.0

Table 1. Chemical and Compound Composition, Color Value, and Fineness of Cements

* Values represent the mean of combined statistics. Air-entraining cements are not included. Adapted from Gebhardt, Ronald F.,

“ Survey of North American Portland Cements: 1994,” in Cement, Concrete, and Aggregates, Vol. 17, No. 2, ASTM, West Conshohocken, Pennsylvania, December 1995, pages 145-189.

**Color values are based on CIE Lab Lightness (L*) Values and are typical of tested values for white and gray cement.

White cements are very low in ferrite phases because they are made with raw ingredients having low iron content. Whereas the potential compound composition of C₄AF is typically around 8% or even higher for gray cement, it is only 1% for white cement (see Table 1). The white color of the product is directly attributable to the low ferrite and manganese content.

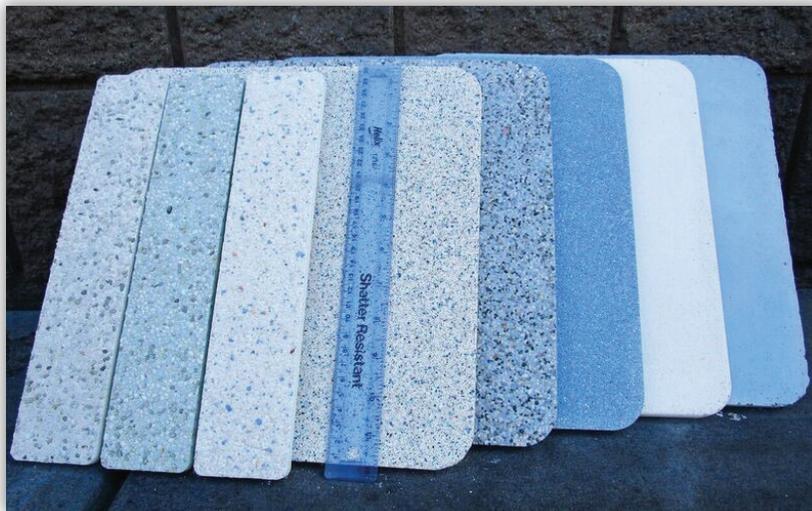


Figure 2

Swimming Pool Plastering and Color

White cement is typically specified for pool plasters to ensure clean, bright, consistent colors, including light pastels. Colors are brighter and more intense because the white cement provides a neutral base color. By combining white cement with pigments and colored aggregates, and by varying surface finishes, treatments, and textures, decorative finishes available to customers are greatly expanded (see Figure 2).

The color of plaster, concrete, or mortar of any cement-based material is primarily dependent on the cementitious portion (cement and any supplementary cementitious material “SCM” that might be used) as well as the color of the fine aggregate. Anyone seeking dynamic color or decorative finishes can benefit from cement-based products that exclusively use white cement. White cement has all the strength, toughness and structural characteristics of gray cement, but the added benefits, as listed above, are the principal considerations for its selection.



Plastering contractors and designers rely on careful selection of materials and attention to mixing and placement details to achieve eye-catching finishes.



Cement Hydration and Color

As explained above, white cements are white because they have very low ferrite contents. In any cement the ferrite phases (C_4AF) normally become lighter in color as the cement chemically reacts with water, a process called hydration. Accelerators are used to speed up hydration in concrete mixes placed during cold weather. One common accelerator, calcium chloride ($CaCl_2$), has a retarding effect on the hydration of the ferrite-containing compound C_4AF . When $CaCl_2$ is added to gray cement concrete it will retard hydration of the ferrite phases which may remain dark colored (Greening and Landgren 1966). This effect associated with $CaCl_2$ does not apply to white cement-based mixes. There is very little risk of discoloration due to adding calcium chloride to white cement-based materials/mixtures because white cement contains almost no ferrite. Research associated with C_4AF discoloration by the Portland Cement Association has been done exclusively on gray cement and is discussed in several of their publications.

Using white cement for various applications is the topic of PCA publications WC001, WC002, and WC003.

PRACTICE AND MATERIALS UNIQUE TO THE PLASTERING TRADE

Supplementary Mix Water

The process of adding supplementary water above mix design water is used to combat substrate absorption and evaporation. Thicker materials like concrete maintain a reservoir of water, while thin cementitious coatings do not. This extra water is not part of the design water:cement (w/c) ratio, and is used up (removed from the system) during application and prior to final set.¹

Calcium Chloride - Set Accelerator

For cementitious materials that contain metal reinforcement or that have some metal structure embedded within them, limits on CaCl_2 prevent the deterioration of the passivation layer around metal reinforcement and the subsequent corrosion of the reinforcement. However, there is no metal reinforcement within a pool finish coating, so CaCl_2 is not harmful or damaging to cementitious interior finishes for swimming pools when used properly.²

Using CaCl_2 as a set accelerator in amounts not exceeding 2% of the cementitious binder does not cause the finish coating to be weak or inferior, nor does it promote deterioration or surface etching of the swimming pool finish.

Swimming Pool Water Chemistry

One of the leading causes of deterioration of the finish coating in swimming pools is due to unbalanced water chemistry. Good water chemistry, as per APSP³ and NPC⁴, is the key to prolonging the life of the finish coating, and preserving the aesthetic beauty of the surface from etching deterioration, discoloration, and mineral salt scale.

REFERENCES

Hime, William, and Erlin, Bernard, Color, Color, Color, Concrete Construction, Hanley-Wood Media, Washington, D.C., February 2008, p. 18.

Greening, N. R., and Landgren, R., Surface Discoloration of Concrete Flatwork, reprinted from the Journal of the PCA Research and Development Laboratories, 8, No. 3, p. 34-50, RX203, Portland Cement Association, September, 1966.

Miller, F. MacGregor; Powers, Laura J.; Taylor, Peter C., Investigation of Discoloration of Concrete Slabs, SN2228, Portland Cement Association, 1999.

Taylor, Peter C.; Detwiler, Rachel J.; Tang, Fluvio J., Investigation of Discoloration of Concrete Slabs (Phase 2), SN2228b, Portland Cement Association, 2000.

¹ *NPC Technical Manual, 8th Edition*, Section 4.1, National Plasterers Council, 1000 N Rand Road, Suite 214, Wauconda, Illinois 60084, info@npconline.org

² *NPC Technical Manual, 8th Edition*, Section 2.6.1, National Plasterers Council, 1000 N Rand Road, Suite 214, Wauconda, Illinois 60084, info@npconline.org

³ *Association of Pool & Spa Professionals, ANSI/APSP/ICC -5*, Appendix A, 2111 Eisenhower Avenue, Alexandria, VA 22314, www.apsp.org, National Plasterers Council, 1000 N Rand Road, Suite 214, Wauconda, IL 60084, info@npconline.org

⁴ *NPC Technical Manual, 8th Edition*, Section 7.6.1.1, National Plasterers Council, 1000 N Rand Road, Suite 214, Wauconda, IL 60084, info@npconline.org



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