Basic Cement/Concrete Information

Cement VS Concrete:

Cement is to concrete as flour is to a cake mix. While this analogy is very simplistic, it is applicable and accurate. Cement, whichever type, is never used by itself, but in combination with other materials such as sand, slag and other additives or chemicals and water (the cement paste) plus aggregate (stone) to make the collective mix of concrete. The cement is the "binder" or "glue" that holds the concrete matrix together. Critical to the performance of any given concrete element is the water/cement (w/c) ratio or the ratio of water to the cement paste. Hardened concrete is the dimensional solid that is the result of the chemical reaction of the concrete mixture and water or hydration (curing) process of this cement paste, concrete mixture.

Basic Cement Chemistry:

Tricalcium Silicate (C_3S): hardens rapidly and is largely responsible for initial set and early strength. In general, the early strength of Portland cement concrete is higher with increased percentages of C_3S.

Dicalcium Silicate (C_2S): hardens slowly and contributes largely to strength increases at ages beyond 7 days.

Tricalcium Aluminate (C_3A): liberates a large amount of heat during the first few days of hardening and, together with C_3S and C_2S may somewhat increase the early strength of the hardening cement (this effect being due to the considerable heat of hydration that this compound evolves). It does affect set times.

Tetracalcium Aluminoferrite (C_4AF): contributes very slightly to strength gain. However, acts as a flux during manufacturing. Contributes to the color effects that makes cement gray

The "Five Types" of Cements:

	Classification	Characteristics	Applications
Type I	General purpose	Fairly high C_3S content for good early strength development	General construction (most buildings, bridges, pavements, precast units, etc)
Type II	Moderate sulfate resistance	Low C_3A content (<8%)	Structures exposed to soil or water containing sulfate ions
Type III	High early strength	Ground more finely, may have slightly more C_3S	Rapid construction, cold weather concreting
Type IV	Low heat of hydration (slow reacting)	Low content of C_3S (<50%) and C_3A	Massive structures such as dams. Now rare.
Type V	High sulfate resistance	Very low C_3A content (<5%)	Structures exposed to high levels of sulfate ions

Blended Cements:

ACI (American Concrete Institute), 116, *Cement and Concrete Terminology 1*, defines blended cements as hydraulic cements "consisting essentially of an intimate and uniform blend" of a number of different constituent materials. They are produced by "inter-grinding Portland cement clinker with the other materials or by blending Portland cement with the other materials or a combination of inter-grinding and blending."

TABLE 2.4

COMPARISON OF CHEMICAL AND PHYSICAL CHARACTERISTICS — PORTLAND CEMENT, FLY ASH, SLAG CEMENT, AND SILICA FUME

Note that these are approximate values. Values for a specific material may vary from what is shown. (Note 1)

PROPERTY	PORTLAND CEMENT	CLASS F FLY ASH	CLASS C FLY ASH	SLAG CEMENT	SILICA FUME
SiO_2 content, %	21	52	35	35	85 to 97
$Al2O_3$ content, %	5	23	18	12	
Fe_2O_3 content, %	3	11	6	1	
CaO content, %	62	5	21	40	< 1
Fineness as surface area, m^2/kg *(Note 2)*	370	420	420	400	15,000 to 30,000
Specific gravity	3.15	2.38	2.65	2.94	2.22
General use in concrete	Primary binder	Cement replacement	Cement replacement	Cement replacement	Property enhancer

Note 1. Information from SFA and Kosmatka, Kerkoff, and Panarese (2002).
Note 2. Surface area measurements for silica fume by nitrogen adsorption method. Others by air permeability method (Blaine).

Water/Cement Ratio:

The character of concrete is determined by the quality of the paste. The strength of the paste, in turn, depends on the ratio of water to cement. The water-cement ratio is the weight of the mixing water divided by the weight of the cement. Lowering the water-cement ratio as much as possible without sacrificing the workability of the fresh concrete produces a higher quality concrete. Generally, using less water produces a higher quality concrete provided the concrete is properly placed, consolidated and cured.

"Regular" Concrete VS "Lightweight" Concrete:

REGUAR: A rule of thumb for most (average) concrete mixtures is 150 pounds per cubic foot. If you fill a 5-gallon bucket with readymix you have nearly 100 pounds of concrete. Fill a standard contractor-size wheelbarrow and you could be pushing more than 800 pounds @ a compressive strength of ~ 3,000 to 4,000 psi.

LIGHTWEIGHT: The American Concrete Institute (ACI) defines Structural Lightweight Concrete (SLC) as concrete with a minimum compressive strength of 2,500 psi and an equilibrium density of between 70 and 120 pounds per cubic foot. It consists of entirely lightweight aggregate, or a combination of lightweight and normal-density aggregates.