

## TYPES OF PORTLAND CEMENT

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Portland cement is a closely controlled chemical combination of calcium, silicon, aluminum, iron and small amounts of other compounds, to which gypsum is added in the final grinding process to regulate the setting time of the concrete. Some of the raw materials used to manufacture cement are limestone, shells, and chalk or marl, combined with shale, clay, slate or blast furnace slag, silica sand, and iron ore. Lime and silica make up approximately 85 percent of the mass (1).

The term "Portland" in Portland cement originated in 1824 when an English mason obtained a patent for his product, which he named Portland Cement. This was because his cement blend produced concrete that resembled the color of the natural limestone quarried on the Isle of Portland in the English Channel.

Different types of portland cement are manufactured to meet different physical and chemical requirements for specific purposes. The American Society for Testing and Materials (ASTM) Designation C 150 provides for eight types of portland cement:

### **TYPE I**

Type I is a general purpose portland cement suitable for all uses where the special properties of other types are not required. It is used where cement or concrete is not subject to specific exposures, such as sulfate attack from soil or water, or to an objectionable temperature rise due to heat generated by hydration. Its uses include pavements and sidewalks, reinforced concrete buildings, bridges, railway structures, tanks, reservoirs, culverts, sewers, water pipes and masonry units.

### **TYPE II**

Type II portland cement is used where precaution against moderate sulfate attack is important, as in drainage structures where sulfate concentrations in groundwaters are higher than normal but not unusually severe (Table 2). Type II cement will usually generate less heat at a slower rate than Type I. With this moderate heat of hydration (an optional requirement), Type II cement can be used in structures of considerable mass, such as large piers, heavy abutments, and heavy retaining walls. Its use will reduce temperature rise -- especially important when the concrete is placed in warm weather.

(1) "Concrete Pipe Handbook", page 2-2, American Concrete Pipe Association, 1988.

### **TYPE III**

Type III is a high-early strength portland 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 richer mixtures of Type I cement can be used to gain high early strength, Type III, high-early-strength portland cement, may provide it more satisfactorily and more economically.

### **TYPE IA, IIA, IIIA**

Specifications for three types of air-entraining portland cement (Types IA, IIA, and IIIA) are given in ASTM C 150. They correspond in composition to ASTM Types I, II, and III, respectively, except that small quantities of air-entraining materials are interground with the clinker during manufacture to produce minute, well-distributed, and completely separated air bubbles. These cements produce concrete with improved resistance to freeze-thaw action.

### **TYPE IV**

Type IV is a low heat of hydration cement for use where the rate and amount of heat generated must be minimized. It develops strength at a slower rate than Type I cement. Type IV portland cement is intended for use in massive concrete structures, such as large gravity dams, where the temperature rise resulting from heat generated during curing is a critical factor.

### **TYPE V**

Type V is a sulfate-resisting cement used only in concrete exposed to severe sulfate action -- principally where soils or groundwaters have a high sulfate content. Table 1 describes sulfate concentrations requiring the use of Type V portland cement. Low Tricalcium Aluminate ( $C_3A$ ) content, generally 5% or less, is required when high sulfate resistance is needed.

***NOTE: For concrete pipe and precast box manufacturing, Type I or II cements are generally used.***

Table 1

**ATTACK ON CONCRETE BY SOILS AND WATERS CONTAINING VARIOUS  
SULFATE CONCENTRATIONS**

<b>Relative Degree of Sulfate Attack</b>	<b>Percentage Water-Soluble Sulfate (as SO<sub>4</sub>) in Soil Samples</b>	<b>Sulfate (as SO<sub>4</sub>) in Water Samples, Ppm</b>	<b>Cement Type</b>
Negligible	0.00 to 0.10	0 to 150	I
Positive	0.10 to 0.20	150 to 1500	II
Severe	0.20 to 2.00	1500 to 10,000	V*
Very Severe	2.00 or more	10,000 or more	V plus pozzolan **

Source: U.S. Bureau of Reclamation, Concrete Manual, 1975, pg. 11.

\* Or approved portland-pozzolan cement providing comparable sulfate resistance when used in concrete.

\*\* Should be approved pozzolan that has been determined by tests to improve sulfate resistance when used in concrete with Type V cement.