MATERIALS OF CONSTRUCTION LABORATORY
DEPARTMENT OF CIVIL ENGINEERING
METU

TESTS ON PORTLAND CEMENTS

Definitions:

Portland cement- a hydraulic cement produced by pulverising clinker consisting essentially of hydraulic calcium silicates.

Air-entraining portland cement- a hydraulic cement produced by pulverising clinker consisting essentially of hydraulic calcium silicates and with which there has been interground an air-entraining addition.

ASTM C 150 " Standard Specification for Portland Cement" covers eight types of portland cements, as follows:

Type I	for use when the special properties specified for any other type are not required
Type IA	Air-entraining cement for the same uses as Type I, where air-entrainment is desired
Type II	for general use, more especially when moderate sulfate resistance or moderate heat of hydration is desired
Type IIA	Air-entraining cement for the same uses as Type II, where air-entrainment is desired
Type III	for use when high early strength is desired
Type IIIA	Air-entraining cement for the same uses as Type III, where air-entrainment is desired.
Type IV	for use when a low heat of hydration is desired
Type V	for use when high sulfate resistance is desired

Chemical Composition - Portland cements shall conform to the respective standard chemical requirements prescribed in Table 1.

Physical Properties - Portland cements shall conform to the respective standard physical requirements prescribed in Table 2.

TABLE 1 Standard Chemical Requirements

	Type I	Type II	Type III	Type IV	Type V
SiO_2, min%	-	20.0	-	-	-
Al_2O_3, max%	-	6.0	-	-	-
Fe_2O_3, max%	-	6.0	-	6.5	-
MgO, max%	6.0	6.0	6.0	6.0	6.0
SO_3, max%	3.0-3.5	3.0	3.5-4.5	2.3	2.3
Loss on Ignition, max %	3.0	3.0	3.0	2.5	3.0
Insoluble Residue, max %	0.75	0.75	0.75	0.75	0.75
C_3S, max%	-	-	-	35	-
C_2S, min%	-	-	-	40	-
C_3A, max%	-	8.0	15	7	5

TABLE 2 Standard Physical Requirements

	Type I	Type II	Type III	Type IV	Type V
Fineness, specific surface, m^2/kg Air permeability test, min	280	-	280	280	280
Autoclave expansion, max%	0.80	0.80	0.80	0.80	0.80
Compressive Strength, not less than the values shown for the ages indicated below in MPa:					
1 day	-	-	12.4	-	-
3 days	12.4	10.3	24.1	-	8.3
7 days	19.3	17.2	-	6.9	15.2
28 days	-	-	-	17.2	20.7
Time of setting by Vicat test					
Initial, not less than (minutes)	45	45	45	45	45
Final, not more than (minutes)	375	375	375	375	375

TEST METHODS:

Density (ASTM C 188) : The determination of the density of a cement is particularly useful in the design and control of concrete mixtures.

Test Procedure: A flask filled by Kerosine or Naphtha to a point on the stem is immersed in the water bath and the first reading is recorded. The final reading is recorded after 64g of cement is introduced in the flask. The difference between the first and the final readings represents the volume of the liquid displaced by the mass of the cement used in the test, thus the density is calculated as mass of cement, g / displaced volume, cm^3.

Fineness (ASTM C 204): This test method covers the determination of the fineness of portland cement, using the Blaine air permeability apparatus, in terms of the specific surface expressed as total surface area in cm^2/g or m^2/kg, of cement.

Nature of the apparatus: The Blaine apparatus consists essentially of a means of drawing a definite quantity of air through a prepared bed of cement of definite porosity. The number and size of the pores in a prepared bed of definite porosity is a function of the size of the particles and determines the rate of air flow through the bed.

Test Procedure: Bed of cement is prepared by a specific procedure described in detail in ASTM C 204. A flow of air is passed through the bed of cement by a means of manometer and the time interval of air flow is recorded. The specific surface is calculated by a formula, the parameters of which are time of flow, porosity of prepared bed of cement, density of cement, viscosity of air and apparatus constant.

Normal Consistency (ASTM C 187): This test is used to determine the amount of water required to prepare cement pastes of standard consistency for testing.

Test Procedure: The paste prepared by mixing 650g of cement and a measured quantity of water in accordance to standard procedures is inserted into the Vicat ring and the Vicat rod is tightened in contact with the surface of the paste. The paste shall be of normal consistency when the rod settles to a point 10+1 mm below the original surface in 30 sec., after being released. Trial pastes with varying percentages of water are made until normal consistency is obtained.

Setting Time (ASTM C 191): This test is used to determine the time of setting of cement by means of the Vicat needle.

Test Procedure: The test specimen used for the determination of normal consistency may be used. The specimen is stored in a temperature of $23^{o}C+1.7^{o}C$ and a relative humidity of not less than 90%. The penetration of the 1mm needle is determined at every 15 min . The initial setting time is recorded as the time that corresponds to a penetration of 25mm and the final setting time is when the needle does not sink visibly into the paste.

Soundness (ASTM C 151): Autoclave expansion test is performed to determine the soundness of portland cement.

Test Procedure: The paste used for the determination of normal consistency may be used to prepare specimen. After curing the specimen in a moist room for 24 hours, a length comparator reading is obtained. Then, the specimen is subjected to a pressure of 2MPa for 3hrs in the autoclave. The change in length of the specimen calculated as the difference in the length comparator readings before autoclaving and after autoclaving is reported as percent of initial gage length as the autoclave expansion.

Determination of Strengths

Preparation of Mortar (ASTM C 109): The proportions of materials for the standard mortar shall be one part of cement to 2.75 parts of graded standard sand by weight. A water-cement ratio of 0.485 is used for all portland cements and 0.460 for all air-entraining portland cements. The amount of mixing water for other than portland cements shall be such as to produce a flow of 110+5. The materials are mixed mechanically in accordance with the procedure given in ASTM C 305.

Flow (ASTM C 109): This test is used to determine the amount of water required to prepare mortars of standard consistency for testing.

Test procedure: The fresh mortar is filled in the mold placed at the center of the flow table, immediately after completion of the mixing. Then, the mold is lifted away from the mortar and the table is dropped through a height of 13 mm. for 25 times in 15 sec. The flow is determined by measuring the diameter of the mortar mass and reported as percentage of increase of the original base diameter.

To prepare specimens of strength tests, the mortar is filled in prism molds (4*4*16cm) and stored in a moist room for 24 hours. Then, the specimens are removed from the molds and immersed in water, except those for the 24-h test.

Flexural Strength (ASTM C 348): The centre-point loading method shall be used in making flexure tests. The total maximum load indicated by the testing machine is recorded and the flexural strength is calculated as: $Sf = 2.8 \times P$, where Sf: flexural strength in kPa, P:total maximum load in N.

Compressive Strength (ASTM C 349): Both portions from each prism broken in flexure shall be used for compression testing as modified cubes (4*4*4cm) by placing two bearing plates at the top and at the bottom.