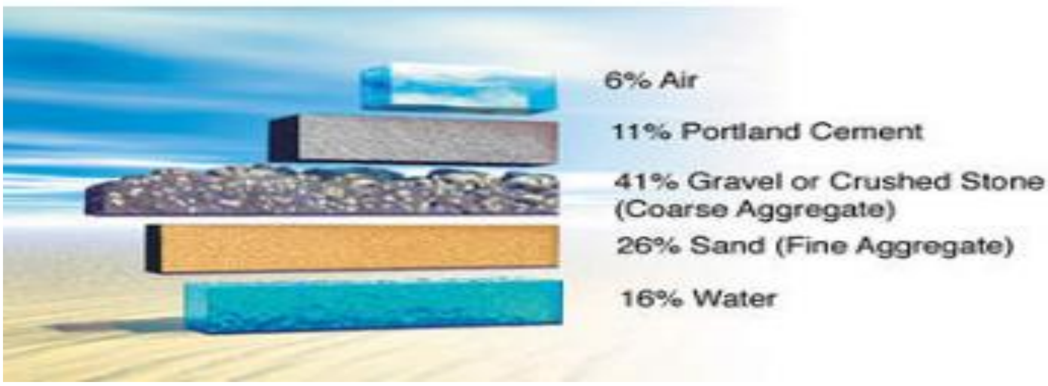
MATERIAL QUALITY CONTROL AND PRODUCTION

****CONCRETE PROPORTIONING AND PLACEMENT****

→ Essential components of concrete are portland cement, aggregate, and water. Admixtures/additives are usually added to impart certain specific properties to the concrete mix. A unit weight of 150 lbs/cf is usually assumed for designed purposes. Also the 28day compressive strength for normal concrete ranges from 2000-4000 psi with a slump of 1-3 inches.



→ **Cement**: There are five types of Cement as classified by ASTM, Type I-V;

- Type I: Normal, used for general purposes
- Type II: Modified better resistance to alkali attack and produces less heat of hydration than Type I.
- Type III: High Early Strength → provides 190% of Type I strength after 1 day of curing.
- Type IV: Produces only 40% to 60% of the heat hydration than Type I.
- Type V: Provides highest resistance to alkali attack, 7 day strength is only 75% of normal cement. Use this when the concrete is in contact with soil or water is very high in sulfate.

There are other characteristics for special cement according to ASTM;

- Type IA, IIA, IIIA: Same as Type I, II, III except with the addition of an air entrainment agent.
- Type IS: Same as Type I except produced from a mixture of blast furnace slug.
- Type IP: Same as Type I except contains Pozzolan.

→ **Aggregates:** Use to reduce cost of the mix and to reduce shrinkage. It makes up 60–75% of the concrete volume.

→ **Water:** Need to provide moisture required for hydration of the cement to take place. Hydration is the chemical reaction between cement and water which produces hardened cement.

Water/Cement Ratio:

- The strength, water tightness, durability and wear resistance of the concrete are related to the Water/Cement Ratio of the concrete mix design.
- The lower the Water/Cement Ratio the greater the strength/durability
- Usually the Water/Cement Ratio is between .40 - .60 by weight
- Seawater can be used but strength is 10-20% lower than normal.

How to do a Mix Design:

- Typical a Mix is about 10-15% cement, 60-75% aggregate and 15-20 water. Entrained air in many concrete mixes my also take up another 5-8 %.
- The goal of the Mix Design is selecting the most economical concrete mix that meets the requirements of the hardened concrete while providing acceptable workability. This is accomplished by using the highest ratio of aggregate to cement while providing acceptable workability at the required water/cement ratio. Follow these steps;
- Step 1: Select a Water/Cement ratio that satisfies requirements for concrete strength, durability, and water tightness.

Table 3-1. Maximum W/C ratios for various exposure conditions

Exposure Condition	*Normal-Weight Concrete (Absolute W/C Ratio by Weight)*
Concrete protected from exposure to freezing and thawing or the application of deicer chemicals	Select a W/C ratio on the basis of strength, workability, and finishing needs
Watertight concrete* • In freshwater • In seawater	 0.50 0.45
Frost-resistant concrete* • Thin sections; any section with less than a 2-inch cover over reinforcement and any concrete exposed to deicing salts • All other structures	 0.45 0.50
Exposure to sulfates* • Moderate • Severe	 0.50 0.45
Concrete placed underwater	Do not use less than 650 pounds of cement per cubic yard (386 kg/m3).
Floors on grade	Select W/C ratio for strength, plus minimum cement requirements described in table 3-7, page 3-14.

* For the properties of watertight concrete, frost-resistant concrete and exposure to sulfates, use designing strength for air-entrained concrete.

Table 3-2. Maximum permissible W/C ratios for concrete

*Specified Compressive Strength, in psi**	*Maximum Absolute Permissible W/C Ratios by Water*	
	Nonair-Entrained Concrete	*Air-Entrained Concrete*
2,500	0.67	0.54
3,000	0.58	0.46
3,500	0.51	0.40
4,000	0.44	0.35
4,500	0.38	**
5,000	**	**

Note. 1,000 psi = 7 MPa.

*28-day strength. The W/C ratios will provide average strengths that are greater than the specified strengths.

**For strength above 4,500 psi (nonair-entrained concrete) and 4,000 psi (air-entrained concrete), proportions should be established by the trial-batch method.

➢ Step 2: Select the workability or slump required.

Table 7-5 Recommended slumps for various types of construction (Courtesy of Portland Cement Association)

	Slump, mm (in.)	
Concrete construction	**Maximum***	**Minimum**
Reinforced foundation walls and footings	75 (3)	25 (1)
Plain footings, caissons, and substructure walls	75 (3)	25 (1)
Beams and reinforced walls	100 (4)	25 (1)
Building columns	100 (4)	25 (1)
Pavements and slabs	75 (3)	25 (1)
Mass concrete	75 (3)	25 (1)

*Many be increased 25 mm (1 in.) for consolidation by hand methods, such as rodding and spading.
Plasticizers can safely provide higher slumps.
Adapted from ACI 211.1

➢ Step 3: Mix a trial batch:

→ A number of different methods have been used to proportion concrete ingredients including 1. Void Ratio, 2. Fineness modulus, 3. Surface Area of aggregate, 4. Cement content, also just plain 5. Arbitrary assignment(1:2:3). However, the best approach is to use past experience combined with reliable test data with established relationships between the strength of concrete and w/c ratio for the material being used.

→ During the PE test, they will give you the mix design. You will just have to figure out a few things about it. Which I will go over next:

➢ Trick of Trade #1: Some formulas you should know:

- → Water/Cement Ratio = Weight of Water (lbs) / Weight of Cement (lbs)
- → Air Content (%) = Volume of Air (cf) / Total Volume of Concrete (cf)
- → Volume of material (cf) = $\dfrac{\text{Weight of material (lbs)}}{(62.4) \times \text{specific gravity of material}}$
- → If you know the density of the material then, V = $\dfrac{\text{Weight of material (lbs)}}{\text{density of material (lbs/cf)}}$

➢ Trick of Trade #2: Some things you should know:

- → Bag/sack of cement = 94 lbs
- → One gallon of water = 8.34 lbs
- → Density = Weight(lbs)/Volume(cf)
- → Specific gravity = Density of material/Density of water
- → Density of Water = 62.4 lbs/cf or 1000 kg/cubic meter
- → Total Volume of Concrete = Vol(cement) + Vol(sand) + Vol(Aggregates) + Vol(water) + Vol(air)
- → 1 liter = 1 kg
- → A mix design written as 1: 2: 2.5 and is stated by weight, means 1 lbs of cement has to be mixed with 2 lbs of sand and 2.5 lbs of coarse aggregates