
Normal Aggregates

Definition

Aggregates are particles of natural or artificial origin having sizes smaller than 100 mm.

Role of Aggregate in Concrete

- **70 – 80 % of the volume of concrete is composed of aggregate.**
- **Aggregate is an inexpensive material dispersed throughout the cement paste to produce a large volume. (economical)**
- **aggregate physical, thermal, and sometimes chemical properties would improve volume stability and durability of concrete as compared to those of cement paste.**

Classification of Aggregate

- **According to origin**

-Natural : crushed stone, natural sand, gravel

-Artificial: industrial byproduct, some processed aggregate (fly ash, air cooled slag, perlite, expanded shales, vermiculite.

- **According to weight**

-Normal weight Aggregate:

Bulk Specific Gravity, BSG: (2.5-3)

-Light weight Aggregate, BSG:(<2)

-Heavy weight Aggregate, BSG:(>3)

Figure 6-2. Coarse aggregate. Rounded gravel (left) and crushed stone (right).

Classification of Aggregate

- **According to particle size**
- **Fine Aggregate: is defined as that portion of aggregate passing sieve #4 and retained on sieve #200**
- **Coarse Aggregate: is defined as that portion of aggregate retained on sieve #4.**

- **According to particle shape and surface texture (Affect concrete in fresh and hardened states.)**
- **Shape: rounded, irregular, angular, flaky, elongated, needle like.**
- **Surface Texture: smooth, glassy, granular, rough, crystalline, honeycombed.**

Classification of Aggregate

-Angular Aggregate with rough texture:
More water for workability → less strength
Good bond with cement paste → more strength

-Rounded Aggregate with smooth texture:
Less water for workability
Poor bond with cement paste → Less strength

- **Geological Classification:**

1. Volcanic (Igneous) [الصخور البركانيه]
2. Sedimentary Rocks. [الصخور الرسوبيه]
3. Metamorphic Rocks [الصخور المتحوله]

1- Volcanic Rocks

- Solid formed from Molten magma

- It has usually crystalline structure

-Relatively strong, hard, dense with low porosity and absorption

Examples: Basalt, granite, tuffs, scoria, and pumice.

2. Sedimentary Rocks

-Formed by consolidation of rock fragments transported (by wind, water, and ice) and deposited in layers.

- It has layered structure: (stratified)

-They have relatively less strength and hardness than those of volcanic origin.

- They have relatively higher porosity and absorption than those of volcanic origin.

Examples: Limestone, Shale, Sandstone, Chert, Conglomerates, dolomite.

3. Metamorphic Rocks:

- Formed by changing structures of sedimentary and Igneous rocks due to heat and pressure.

- Mixed structure (crystalline and/or layered)

-Average properties between igneous and sedimentary Rocks

Examples:

1. Marble (From Limestone: sedimentary)

2. Gneiss (From Granite: igneous, volcanic)

3. Quartze (From Sandstone: sedimentary)

4. Slate (From Shale: sedimentary)

- **Strength development of concrete depends on:**

- Paste cementing value

- Bond (Between aggregate & paste)

-Strength of aggregate

Mechanical Properties

- ***Bond***

Bond strength is influenced by:

-Shape of aggregate: Angular Aggregate

(Higher Surface Area) → (bond strength) ↑

- Texture of aggregate : rough texture → bond strength ↑

:smooth texture → bond strength↓

Bond Test [No standard test exists]

- ***Strength***

A- Crushing strength of prepared rock sample
B- Crushing value of bulk aggregate
C- Performance of aggregate in concrete
(Previous experience or Trial use)

<u>A- Crushing Strength:</u>

- **Average compressive strength ≅ 80-200 MPa.**
- **Usually aggregate strength is larger than that of normal range concrete**
- ***Note*** **that moderate to low strength aggregate are valuable in preserving concrete integrity (when exposed to volume changes) because of their compressible nature.**

- **Hardness (or Abrasion Resistance):**
  Los angles Test [ASTM C131-81].

Hardness : resistance to abrasion and wear.

Place a specific weight of aggregate in the standard Los Angles machine; rotate for 500 revolutions; then sieve on #12. The measuring parameter for this test is given by

$$\text{Abrasion Resistance} = \frac{\text{Broken Materials (passing \# 12)}}{\text{Total mass of aggregate}} \quad (\%)$$

This test gives results which show a good correlation not only with the actual wear of the aggregate in concrete, but also with the compressive and flexural strengths of concrete when made with the same aggregate. In general the Los Angles value should be lower than 50%.

Moisture Conditions of Aggregates

(Details will be Given in the Laboratory)

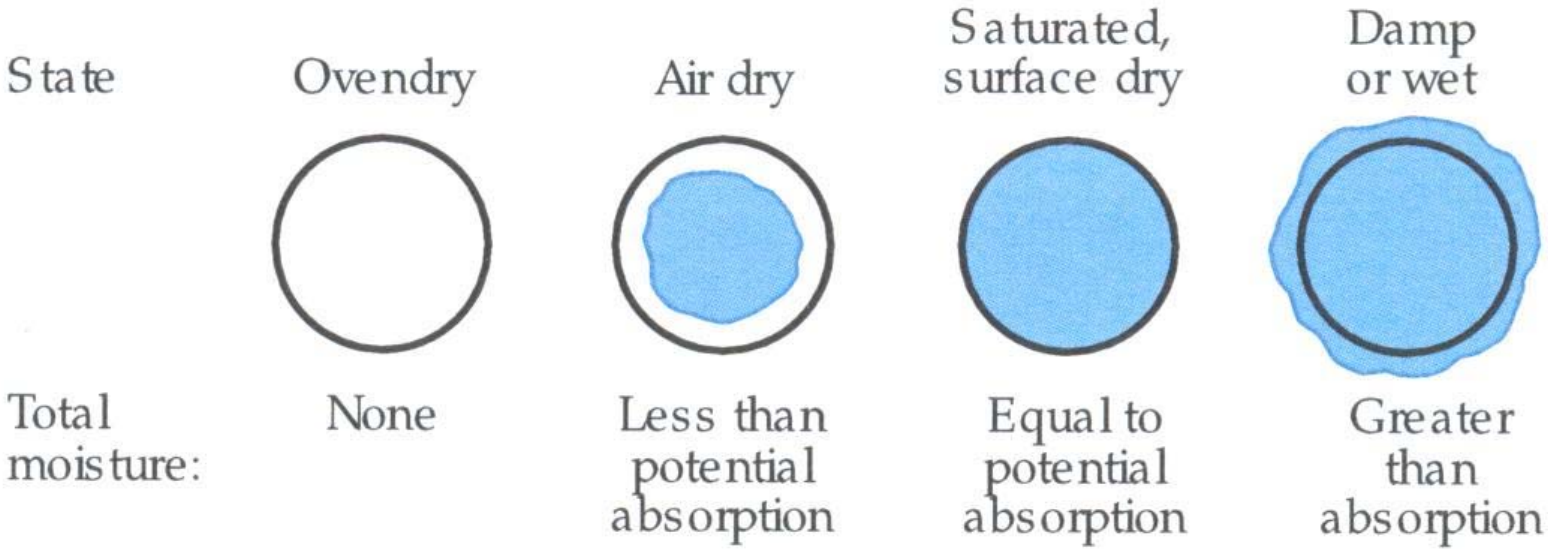


Fig. 5-12. Moisture conditions of aggregate.

Physical Properties

- **Specific Gravity**

It is defined as the ratio of mass (or weight in air) of a unit volume of material to the mass of the same volume of water at the stated temperature, thus, we write;

$$SG = \frac{\rho_s}{\rho_w}; \rho_s = \frac{W_s}{V_s}$$

2) The Apparent specific Gravity (ASG) : Refers to the volume of solid material including the impermeable pores, but not the capillary ones.

3) The bulk Specific Gravity (BSG)
Refers to the volume of solid material including the permeable and impermeable pores.

The BSG (SSD) value is used in the mix Design; since the water contained in all the pores does not participate in the chemical reaction of cement and is therefore, considered as part of the aggregate.

- ***Absorption:***

Absorption of aggregate tests are performed according to ASTM C127 and C128.

$$Absorption = \frac{W(SSD) - W(OD)}{W(OD)}$$

The actual water absorption of the aggregate has to be deducted from the total water requirement of the mix to obtain the effective W/C ratio, which controls both the workability and the strength of concrete.

Moisture content:

or in general = $\frac{\text{(Moist-Dry) weight}}{\text{Dry weight}}$

Determination of Specific Gravity & Absorption Experimentally

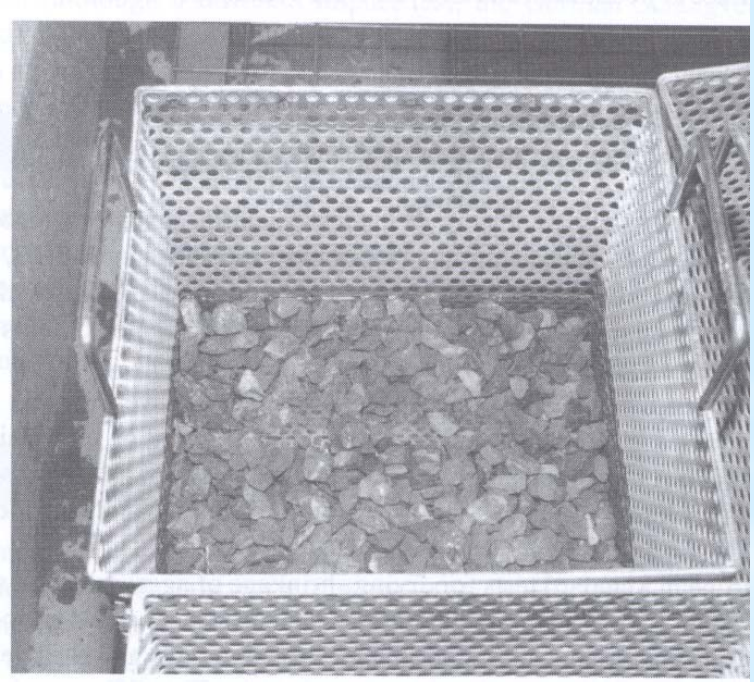
- **Coarse Aggregate**
- **Method: ASTM C 127**
- **Sample: See Table**
- **Specifications: Standards**

  BSG (D) or BSG (SSD) $\geq$ 2.4

- **Fine Aggregate**
- **Method: ASTM C 128**
- **Sample: 400-1000 Grams**

Specific Gravity - Coarse Aggregate (Displacement Method)

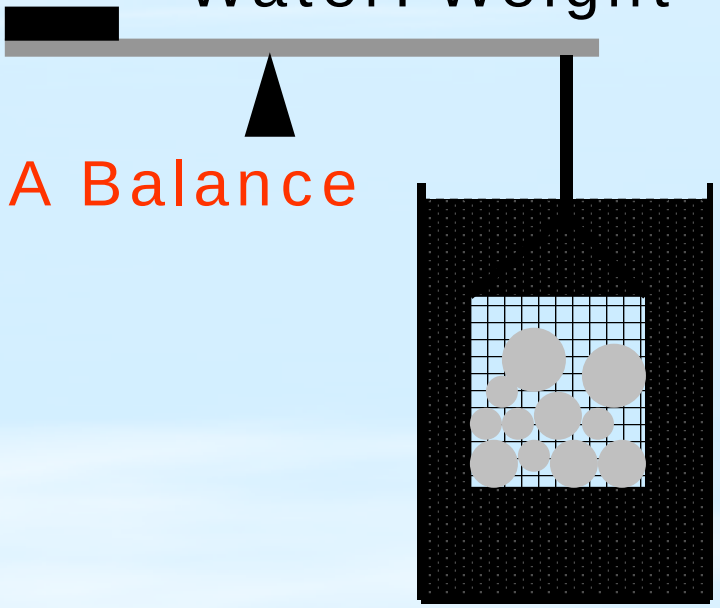
A. Soaking in Water



B. Dry with A Cloth: Weight = B

Specific Gravity-Coarse Aggregate

C. Immerse in Water: Weight = C

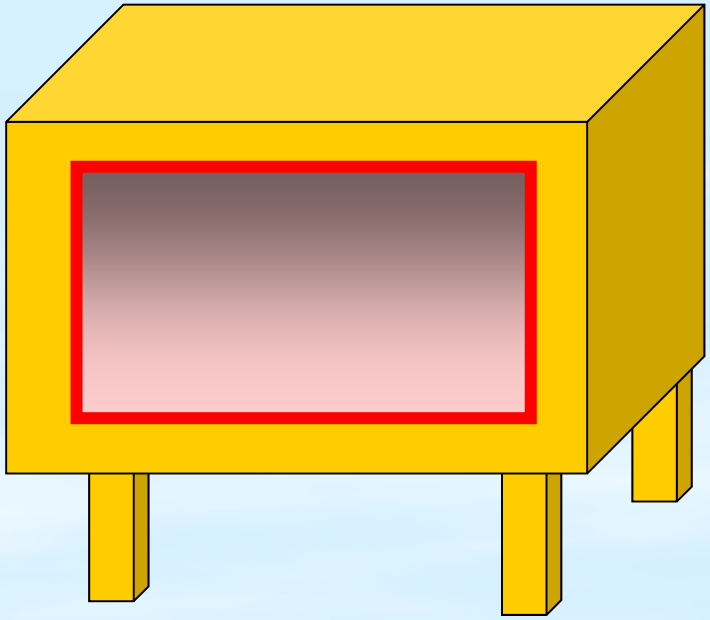


A Balance

A Basket

Water Container

D. Dry in Oven: Weight = A



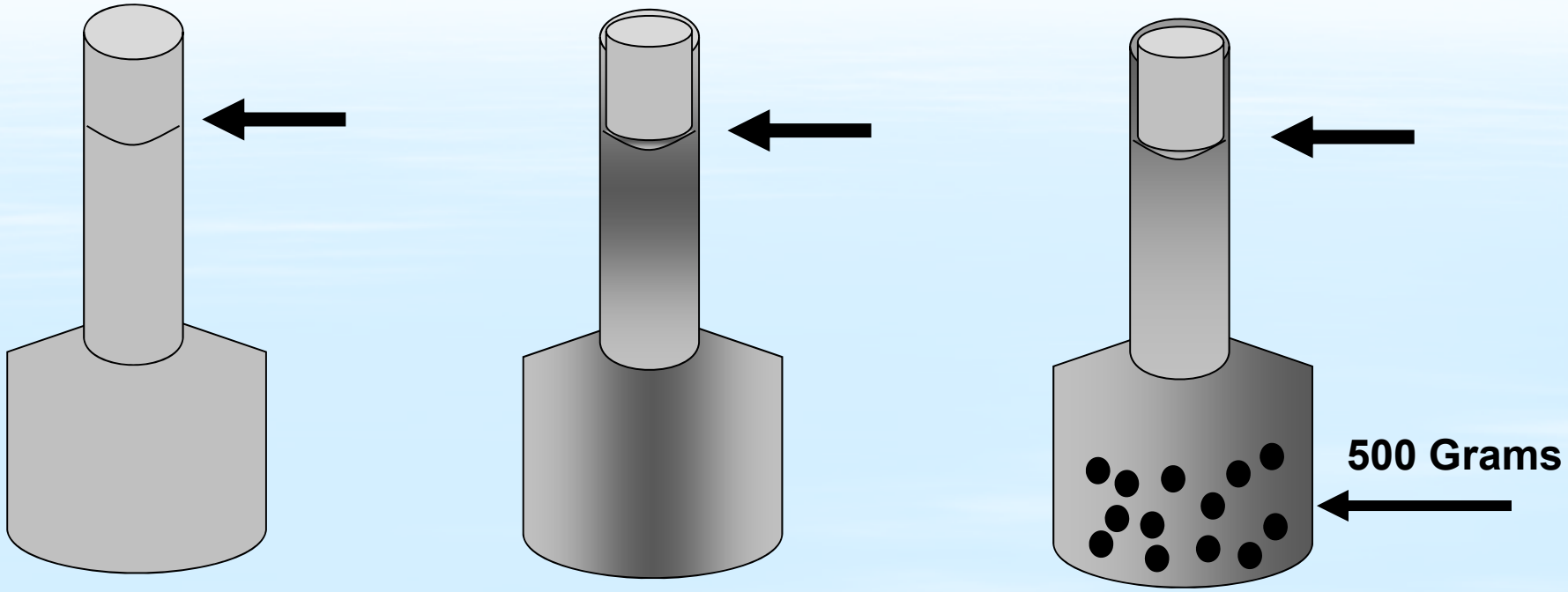
Specific Gravity-Coarse Aggregate

- **Calculations**
  - **Bulk Specific Gravity (BSG)**
  - **Apparent Specific Gravity (ASG)**
  - **Absorption (AC)**

$$BSG\,(OD) = \frac{A}{B - C} \qquad BSG\,(SSD) = \frac{B}{B - C}$$

$$ASG\,(OD) = \frac{A}{A - C} \qquad \text{Absorption (AC)} = \frac{\text{B - A}}{\text{A}}\,\%$$

Specific Gravity-Fine Aggregate
(Le chatelier Flask (Pycnometer)



Mass of the Flask Empty

Mass of the Flask Filled with Water to the Sign

Mass of the Flask + Filled Water + Aggregate

Definitions:

A: Mass of the oven dried fine aggregate.

B: Mass of the Flask filled with water to the mark;

C: Mass of the aggregate (SSD) + Flask+ water filled to the mark

Specific Gravity-Fine Aggregate

- **Calculations**
  - **Bulk Specific Gravity (BSG)**
  - **Apparent Specific Gravity (ASG)**
  - **Absorption (AC)**

$$BSG\,(OD) = \frac{A}{500 + B - C} \qquad BSG\,(SSD) = \frac{500}{500 + B - C}$$

$$ASG\,(OD) = \frac{A}{A + B - C} \qquad \text{Absorption (AC)} = \frac{500 - A}{A}\,\%$$