Concrete:

Physical Properties of Aggregates

Concrete =

- 25-40% cement

  (absolute volume of cement = 7-15% ;
  water = 14-21%)

- Up to 8% air (depending on top size of coarse aggregate)

Therefore:

Aggregates make up
60-75% of total volume
of concrete.

What is an

AGGREGATE?

Aggregate: the inert filler materials, such as sand or stone, used in making concrete

Physical Properties of Aggregates:

1. Unit Weight and Voids

2. Specific Gravity

3. Particle Shape and Surface Texture

4. Shrinkage of Aggregates

5. Absorption and Surface Moisture

6. Resistance to Freezing and Thawing

Unit Weight

(unit mass or bulk density)

The weight of the aggregate required to fill a container of a specified unit volume.

- **Volume is occupied by both the aggregates and the voids between the aggregate particles.**
- **Depends on size distribution and shape of particles and how densely the aggregate is packed**
  - **Loose bulk density**
  - **Rodded or compact bulk density**

Normal-weight concrete… bulk density of aggregate is approximately 75-110 lb per cubic foot.

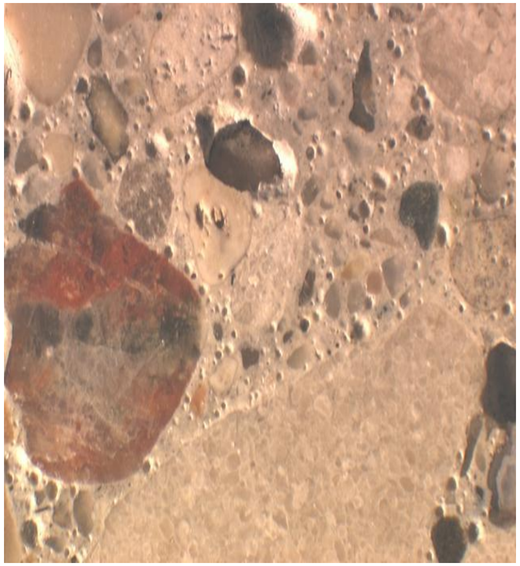
Weight	Examples of Aggregates Used	Uses for the Concrete
ultra-lightweight	vermiculite, ceramic	can be sawed or nailed, also used for its insulating properties
lightweight	expanded clay, shale or slate, crushed brick	used primarily for making lightweight concrete for structures, also used for its insulating properties
normal weight	crushed limestone, sand, river gravel, crushed recycled concrete	used for normal concrete projects
heavyweight	steel or iron shot; steel or iron pellets	used for making high density concrete for shielding against nuclear radiation

Voids

• Void content affects mortar requirements in mix design; water and mortar requirement tend to increase as aggregate void content increases.

• Void content between aggregate particles increases with increasing aggregate angularity.

• Void contents range from 30-45% for coarse aggregates to about 40-50% for fine aggregates.



• Total volume of voids can be reduced by using a collection of aggregate sizes.

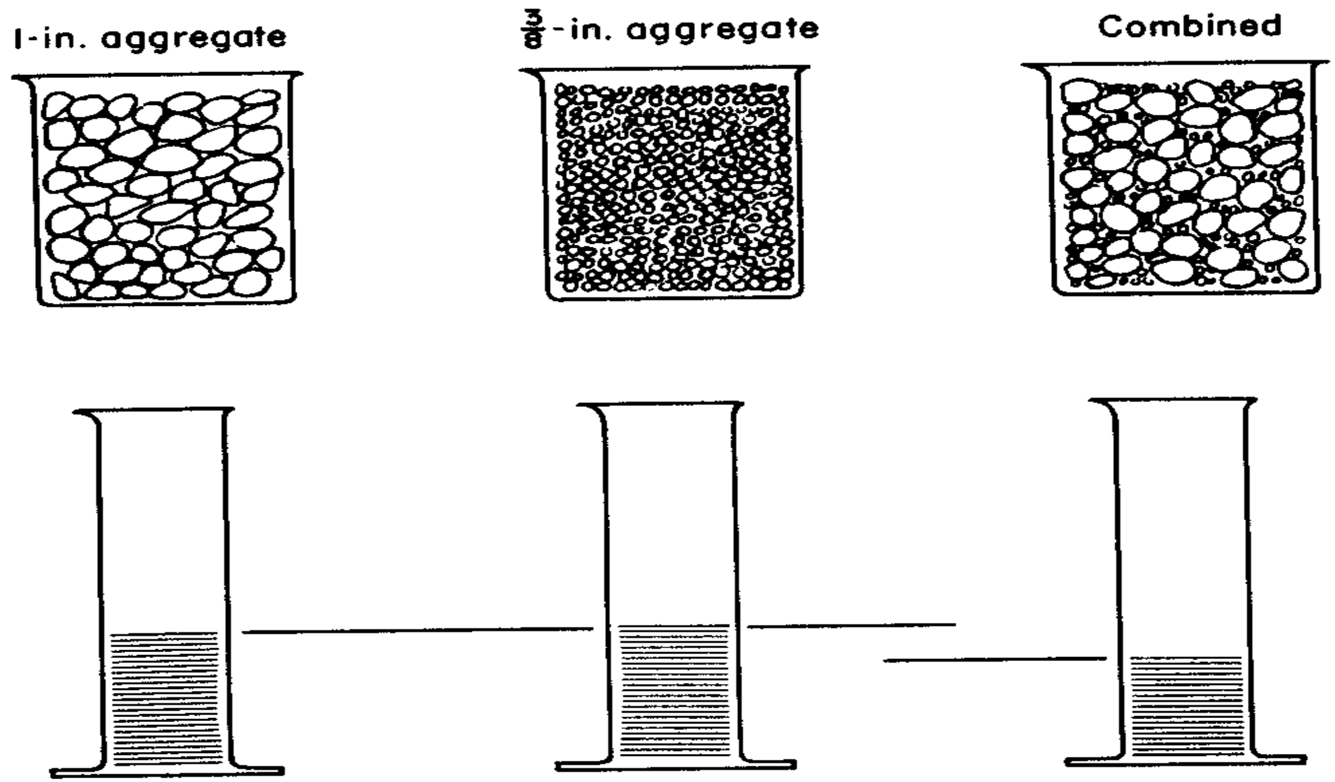


Fig. 4-4. The level of liquid in the graduates, representing voids, is constant for equal absolute volumes of aggregates of uniform but different size. When different sizes are combined, the void-content decreases. The illustration is not to scale.

The cement paste requirement for concrete is proportional to the void content of the combined aggregate.

Specific Gravity (Relative density)

Absolute: the ratio of the weight of the solid to the weight of an equal volume of water (both at a stated temperature)

- refers to volume of the material excluding all pores

Apparent: ratio of the weight of the aggregate (dried in an oven at 212- 230ºF for 24 hours) to the weight of water occupying a volume equal to that of the solid including the impermeable pores

- volume of solid includes impermeable pores (but not capillary pores)

Used for calculating yield of concrete or the quantity of aggregate required for a given volume of concrete.

Particle Shape and Surface Texture

- Rough textured, angular, elongated particles require more water to produce workable concrete than do smooth, rounded, compact aggregates.

- Aggregates should be relatively free of flat and elongated particles (limit to 15% by weight of total aggregate).

- Important for coarse and crushed fine aggregate - these require an increase in mixing water and may affect the strength of the concrete, if cement water ratio is not maintained.

Shrinkage of Aggregates:

Large Shrinkage = fine grained sandstones, slate, basalt, trap rock, clay-containing

Low Shrinkage = quartz, limestone, granite, feldspar

What happens if abnormal aggregate shrinkage occurs?

• Excessive cracking

• Large deflection of reinforced beams and slabs

• Some spalling (chipping or crumbling)

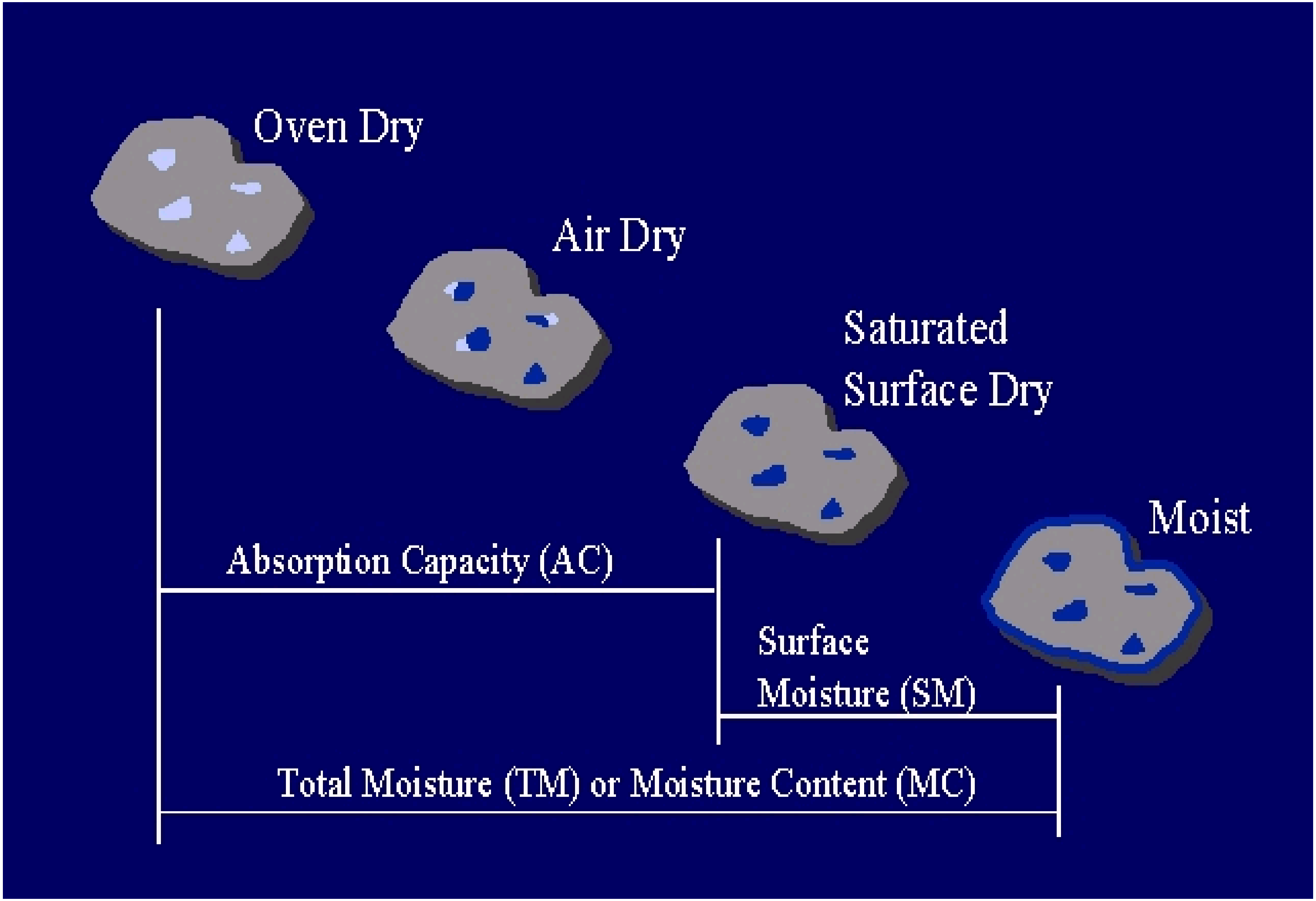
If more than 0.08 percent shrinkage occurs, the aggregate is considered undesirable.

Absorption and Surface Moisture

If water content of the concrete mixture is not kept constant, the compressive strength, workability, and other properties will vary from batch to batch.

Moisture Conditions of Aggregates:

1. **Oven dry-** fully absorbent
2. **Air dry-** dry at the particle surface but containing some interior moisture
3. **Saturated surface dry (SSD)** –neither absorbing water nor contributing water to the concrete mixture
4. **Wet or moist-** containing an excess of moisture on the surface


Oven Dry
Air Dry
Saturated
Surface Dry
Moist
Absorption Capacity (AC)
Surface
Moisture (SM)
Total Moisture (TM) or Moisture Content (MC)

Absorption Capacity: maximum amount of water aggregate can absorb

- Absorption Capacity (%) = $[(W_{SSD} - W_{OD})/W_{OD}] \times 100$

Surface Moisture: water on surface of aggregate particles

- Surface Moisture (%) = $[(W_{WET} - W_{SSD})/W_{SSD}] \times 100$

Moisture Content: of an aggregate in any state

- Moisture Content (%) = $[(W_{AGG} - W_{OD})/W_{OD}] \times 100$

Resistance to Freezing and Thawing

- Important for exterior concrete.
- Affected by an aggregate's high porosity, absorption, permeability and pore structure.
- If aggregates or concrete absorbs so much water that when the water freezes and expands the concrete cannot accommodate the build up of internal pressure, pop–outs may occur.