Coarse Aggregate

Particles that are predominantly retained on the 4.75 mm (No. 4) sieve and will pass through 3-inch screen, are called **coarse aggregate.** Use of the largest permissible maximum size of coarse aggregate permits a reduction in cement and water requirements. In general, 40mm size aggregate used for normal strengths and 20mm size is used for high strength concrete.

Purpose & Uses of Aggregates

- In concrete, an aggregate is used for its economy factor, to reduce any cracks and most importantly to provide strength to the structure. In roads and railway ballast, it is used to help distribute the load and assist in ground water running off the road.
- Increases the volume of concrete, thus reduces the cost
- Provide dimensional stability
- Influence hardness, abrasion resistance, elastic modulus and other properties of concrete to make it more durable, strong and cheaper

Coarse Aggregate

- Rounded aggregates - Rounded aggregates result the minimum percentage of voids (32 – 33%) hence gives more workability. They require lesser amount of water-cement ratio. They are not considered for high strength concrete because of poor interlocking behavior and weak bond strength.

- Irregular or partly rounded aggregates - Irregular aggregates may result 35- 37% of voids. These will give lesser workability when compared to rounded aggregates. The bond strength is slightly higher than rounded aggregates but not as required for high strength concrete.

Coarse Aggregate

- Angular aggregates - Angular aggregates result maximum percentage of voids (38-45%) hence gives less workability. They give 10-20% more compressive strength due to development of stronger aggregate-mortar bond. So, these are useful in high strength concrete manufacturing.

- Flaky aggregates - When the aggregate thickness is small when compared with width and length of that aggregate it is said to be flaky aggregate. Or in the other, when the least dimension of aggregate is less than the 60% of its mean dimension then it is said to be flaky aggregate.

Coarse Aggregate

- Elongated aggregates - When the length of aggregate is larger than the other two dimensions then it is called elongated aggregate or the length of aggregate is greater than 180% of its mean dimension.

- Flaky and elongated aggregates - When the aggregate length is larger than its width and width is larger than its thickness then it is said to be flaky and elongated aggregates. The above 3 types of aggregates are not suitable for concrete mixing. These are generally obtained from the poorly crushed rocks.

Coarse Aggregate

Coarse aggregate Size

Fine gravel = 4mm – 8mm

Medium gravel = 8mm – 16mm

Coarse gravel = 16mm – 64mm

Cobbles = 64mm – 256mm

Boulders = >256mm

Properties of Coarse Aggregate

Size & Shape
Surface Texture
Specific Gravity
Bulk Density
Voids
Porosity & Absorption
Crushing Value of Aggregate
Impact Value of Aggregate
Abrasion Value of Aggregate.

Coarse Aggregate

In order to decide the suitability of the aggregate for use in construction, following tests are carried out:

Crushing test - The test consists of subjecting the specimen of aggregate in standard mould to a compression test under standard load conditions (See Fig-1). Dry aggregates passing through 12.5 mm sieves and retained 10 mm sieves are filled in a cylindrical measure of 11.5 mm diameter and 18 cm height in three layers. Each layer is tamped 25 times with at standard tamping rod. The test sample is weighed and placed in the test cylinder in three layers each layer being tamped again. The specimen is subjected to a compressive load of 40 tonnes gradually applied at the rate of 4 tonnes per minute. Then crushed aggregates are then sieved through 2.36 mm sieve and weight of passing material (**W2**) is expressed as percentage of the weight of the total sample (**W1**) which is the aggregate crushing value.

Aggregate crushing value = (W1/W2)*100

A value **less than 10** signifies an exceptionally **strong aggregate** while **above 35** would normally be regarded as **weak aggregates**.

Coarse Aggregate

Abrasion test

- The principle of Los Angeles abrasion test is to find the percentage wear due to relative rubbing action between the aggregate and steel balls used as abrasive charge.
- Los Angeles machine consists of circular drum of internal diameter 700 mm and length 520 mm mounted on horizontal axis enabling it to be rotated (see Fig-2). An abrasive charge consisting of cast iron spherical balls of 48 mm diameters and weight 340-445 g is placed in the cylinder along with the aggregates. The number of the abrasive spheres varies according to the grading of the sample. The quantity of aggregates to be used depends upon the gradation and usually ranges from 5-10 kg. The cylinder is then locked and rotated at the speed of 30-33 rpm for a total of 500 -1000 revolutions depending upon the gradation of aggregates.
- After specified revolutions, the material is sieved through 1.7 mm sieve and passed fraction is expressed as percentage total weight of the sample. This value is called Los Angeles abrasion value.
- A maximum value of **40 percent** is allowed for **WBM base course** in Indian conditions. For **bituminous concrete**, a maximum value of **35 percent** is specified.

Coarse Aggregate

Impact test –

The aggregate impact test is carried out to evaluate the resistance to impact of aggregates. Aggregates passing 12.5 mm sieve and retained on 10 mm sieve is filled in a cylindrical steel cup of internal dia 10.2 mm and depth 5 cm which is attached to a metal base of impact testing machine. The material is filled in 3 layers where each layer is tamped for 25 numbers of blows (see Fig-3). Metal hammer of weight 13.5 to 14 Kg is arranged to drop with a free fall of 38.0 cm by vertical guides and the test specimen is subjected to 15 numbers of blows. The crushed aggregate is allowed to pass through 2.36 mm IS sieve. And the impact value is measured as percentage of aggregates passing sieve (**W2**) to the total weight of the sample (**W1**).

Aggregate impact value = (W1/W2)*100

Soundness test –

Aggregates of specified size are subjected to cycles of alternate wetting in a saturated solution of either sodium sulphate or magnesium sulphate for 16 – 18 hours and then dried in oven at 105 to 110^0C to a constant weight. After **five cycles**, the loss in weight of aggregates is determined by sieving out all undersized particles and weighing. The loss in weight should **not exceed 12 percent** when tested with **sodium sulphate** and **18 percent** with **magnesium sulphate** solution.

Coarse Aggregate

Shape test or Flakiness Index

Flaky or elongated materials, when used in the construction of a pavement, may cause the pavement to fail due to the preferred orientation that the aggregates take under repeated loading and vibration. It is important that the flakiness and elongation of the aggregate are contained to within permissible levels. An aggregate is classified as being flaky if it has a thickness (smallest dimension) of less than 0.6 of its mean sieve size. The test is not applicable to materials passing the 6.30 mm test sieve or retained on the 63.00 mm test sieve.

Coarse Aggregate

Elongation Index

Elongation index of an aggregate is the percentage by weight of particles whose greatest dimension (length) is greater than one and four-fifth times (1.8 times or 9/5 times) their mean dimension.

Coarse Aggregate

Specific gravity and water absorption test

- The coarse aggregate specific gravity test is used to calculate the specific gravity of coarse aggregate sample by determining the ratio of the weight of a given volume of aggregate to the weight of an equal volume of water. It is similar in nature to the fine aggregate specific gravity test. Specific Gravity ranges from 2.5% to 3.0%

- It is a measure of the amount of water that an aggregate can absorb into its pore structure. Pores that absorb water are also referred to as “water permeable voids”. Water Absorption ranges form 0.1% to 2%

- As per IS: 2386 (Part III) – 1963.

Fine Aggregate

Bulking of Sand

The volume of dry sand increases due to absorption of moisture. These volume increase of dry sand is known as bulking of sand. When dry sand comes in contact with moisture, a thin film is formed around the particles, which causes them to get apart from each other. The volume of dry sand increases due to absorption of moisture. These volume increase of dry sand is known as bulking of sand. Excessive presence of moisture content in the sand makes concrete to less durable and lose its strength. Remember, excessive presence of moisture content increase the workability of concrete but loses its strength.

Bulking of Sand

2% moisture content - 15% bulking with respect to volume

3% moisture content - 20% bulking with respect to volume

4% moisture content - 25% bulking with respect to volume

5% moisture content - 30% bulking with respect to volume

The extent of sand bulking depends on the grading of sand. Finer Sand possesses more bulking than the medium and coarse sand. Thus, Bulking in the sand is high for fine sand and low for coarse sand. An increase of bulking in sand effects concrete mix and results in harsh behaviour while placing.

Bulking of Sand