# Topic 3 Aggregates

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. the aggregates occupy 70–80 per cent of the volume of concrete, their impact on various characteristics and properties of concrete

Aggregates can be classified as

(i) Normal weight aggregates,
(ii) Light weight aggregates and
(iii) Heavy weight aggregates.

In this chapter the properties of normal weight aggregates will only be discussed.

Normal weight aggregates can be further classified as natural aggregates and artificial aggregates.

Natural - Sand, Gravel, Crushed Rock such as Granite, Quartzite, Basalt, Sandstone

Artificial - Broken Brick, Air-cooled Slag. Fly ash, Bloated clay

Aggregates can also be classified on the basis of the size of the aggregates as coarse aggregate and fine aggregate.

**Source**

Almost all natural aggregate materials originate from bed rocks. There are three kinds of rocks, namely,

(i) Igneous,
(ii) Sedimentary and
**(iii)** Metamorphic.

Igneous rocks - Igneous rocks are formed by the cooling of molten magma or lava at the surface of the crest (trap and basalt) or deep beneath the crest (granite).

Sedimentary rocks - The sedimentary rocks are formed originally below the sea bed and subsequently lifted up.

Metamorphic rocks - Metamorphic rocks are originally either igneous or sedimentary rocks which are subsequently metamorphosed due to extreme heat and pressure.

**Physical Properties**

The physical properties of aggregates are those that refer to the physical structure of the particles that make up the aggregate.

- Absoprtion, Porosity, and Permeability
- Surface Texture
- Strength and Elasticity
- Density and Specific Gravity

- Aggregate Voids
- Hardness
- Particle Shape
- Coatings

**Fine Aggregate** - Sand and/or crushed stone.

< 4.75 mm.

F.A. content usually 35% to 45% by mass or volume of total aggregate.

**Coarse Aggregate** - Gravel and crushed stone.

>4.75 mm.

Typically, between 9.5 and 37.5 mm.

**Shape** - The shape of aggregates is an important characteristic since it affects the workability of concrete.

Round (spherical) concrete aggregate. | Flaky concrete aggregate. | Crushed concrete aggregate.

| *Classification* | *Description* | *Examples* |
|---|---|---|
| Rounded | Fully water worn or completely shaped by attrition | River or seashore gravels; desert, seashore and wind-blown sands |
| Irregular or Partly rounded | Naturally irregular or partly shaped by attrition, having rounded edges | Pit sands and gravels; land or dug flints; cuboid rock |
| Angular | Possessing well-defined edges formed at the intersection of roughly planar faces | Crushed rocks of all types; talus; screes |
| Flaky | Material, usually angular, of which the thickness is small relative to the width and/or length | Laminated rocks |

## Texture

Surface texture is the property, the measure of which depends upon the relative degree to which particle surfaces are polished or dull, smooth or rough.

Surface texture depends on hardness, grain size, pore structure, structure of the rock.

| *Group* | *Surface Texture* | *Examples* |
|---|---|---|
| 1. | Glassy | Black flint |
| 2. | Smooth | Chert; slate; marble; some rhyolite |
| 3. | Granular | Sandstone; oolites |
| 4. | Crystalline | Fine : Basalt; trachyte; medium : Dolerite; granophyre; granulite; microgranite; some limestones; many dolomites. Coarse : Gabbro; gneiss; granite; granodiorite; syenite |
| 5. | Honeycombed and porous | Scoria; Pumice, trass. |

## Grading

Grading is the particle-size distribution of an aggregate as determined by a sieve analysis using wire mesh sieves with square openings.

As per IS:2386(Part-1)

Fine aggregate: 6 standard sieves with openings from 150 μm to 4.75 mm. (70 μm, 150 μm, 300 μm, 600 μm, 1.18mm, 2.36mm, 4.75mm).

Coarse aggregate: 5 sieves with openings from 4.75mm to 80 mm. (4.75mm, 10mm, 12.5mm, 20mm, 40mm).

Grain size distribution for concrete mixes that will provide a dense strong mixture.

Ensure that the voids between the larger particles are filled with medium particles. The remaining voids are filled with still smaller particles until the smallest voids are filled with a small amount of fines.

## Grading of Fine Aggregate

| I.S. Sieve Designation | | Percentage passing by weight for | | |
|---|---|---|---|---|
| | Grading Zone I | Grading Zone II | Grading Zone III | Grading Zone IV |
| 10 mm | 100 | 100 | 100 | 100 |
| 4.75 mm | 90–100 | 90–100 | 90–100 | 95–100 |
| 2.36 mm | 60–95 | 75–100 | 85–100 | 95–100 |
| 1.18 mm | 30–70 | 55–90 | 75–100 | 90–100 |
| 600 micron | 15–34 | 35–59 | 60–79 | 80–100 |
| 300 micron | 5–20 | 8–30 | 12–40 | 15–50 |
| 150 micron | 0–10 | 0–10 | 0–10 | 0–15 |

### Fineness Modulus (FM)

The results of aggregate sieve analysis is expressed by a number called Fineness Modulus. Obtained by adding the sum of the cumulative percentages by mass of a sample aggregate retained on each of a specified series of sieves and dividing the sum by 100.

$$\textbf{Fineness Modulus (FM)} = \left[\frac{\text{Total of Cumulative Percentage of Passing (\%)}}{100}\right]$$

The following limits may be taken as guidance:

Fine sand: Fineness Modulus: 2.2 - 2.6.

Medium sand: F.M.: 2.6 - 2.9.

Coarse sand: F.M.: 2.9 - 3.2.

A sand having a fineness modulus more than 3.2 will be unsuitable for making satisfactory concrete.

### Flakiness Index

The flakiness index of aggregate is the percentage by weight of particles in it whose least dimension (thickness) is less than three-fifths of their mean dimension.

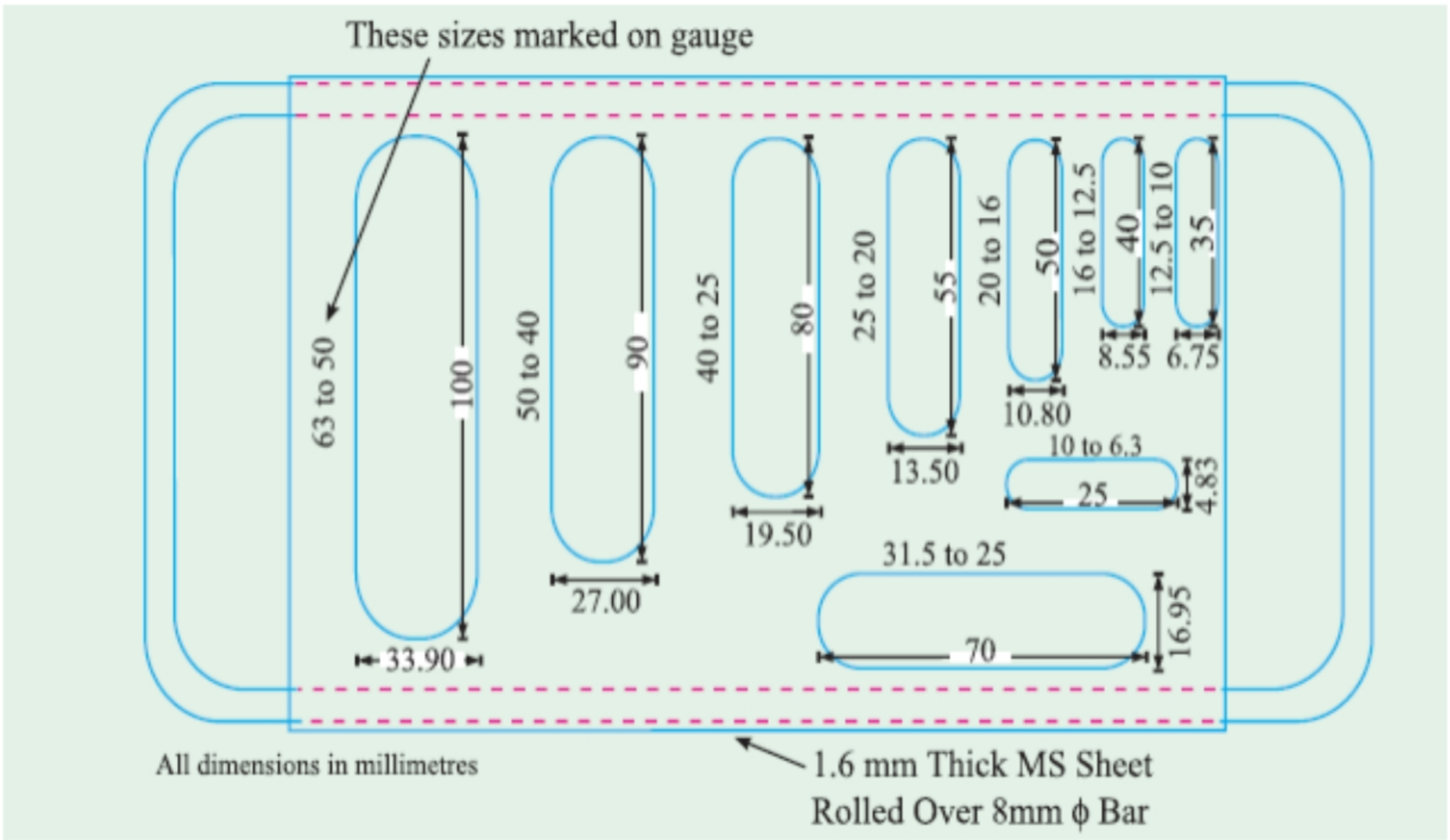
The test is not applicable to sizes smaller than 6.3 mm.

The flakiness index is taken as the total weight of the material passing the various thickness gauges expressed as a percentage of the total weight of the sample taken.

https://www.youtube.com/watch?v=acfJIG9o8iw

The Table shows the standard dimensions of thickness and length gauges.

| *Size of Aggregate Thickness* | | *Length of Gauge* mm* | *Gauge† mm* |
|---|---|---|---|
| *Passing through IS Sieve* | *Retained on IS Sieve* | | |
| 63 mm | 50 mm | 33.90 | – |
| 50 mm | 40 mm | 27.00 | 81.0 |
| 40 mm | 25 mm | 19.50 | 58.5 |
| 31.5 mm | 25 mm | 16.95 | – |
| 25 mm | 20 mm | 13.50 | 40.5 |
| 20 mm | 16 mm | 10.80 | 32.4 |
| 16 mm | 12.5 mm | 8.55 | 25.6 |
| 12.5 mm | 10.0 mm | 6.75 | 20.2 |
| 10.0 mm | 6.3 mm | 4.89 | 14.7 |

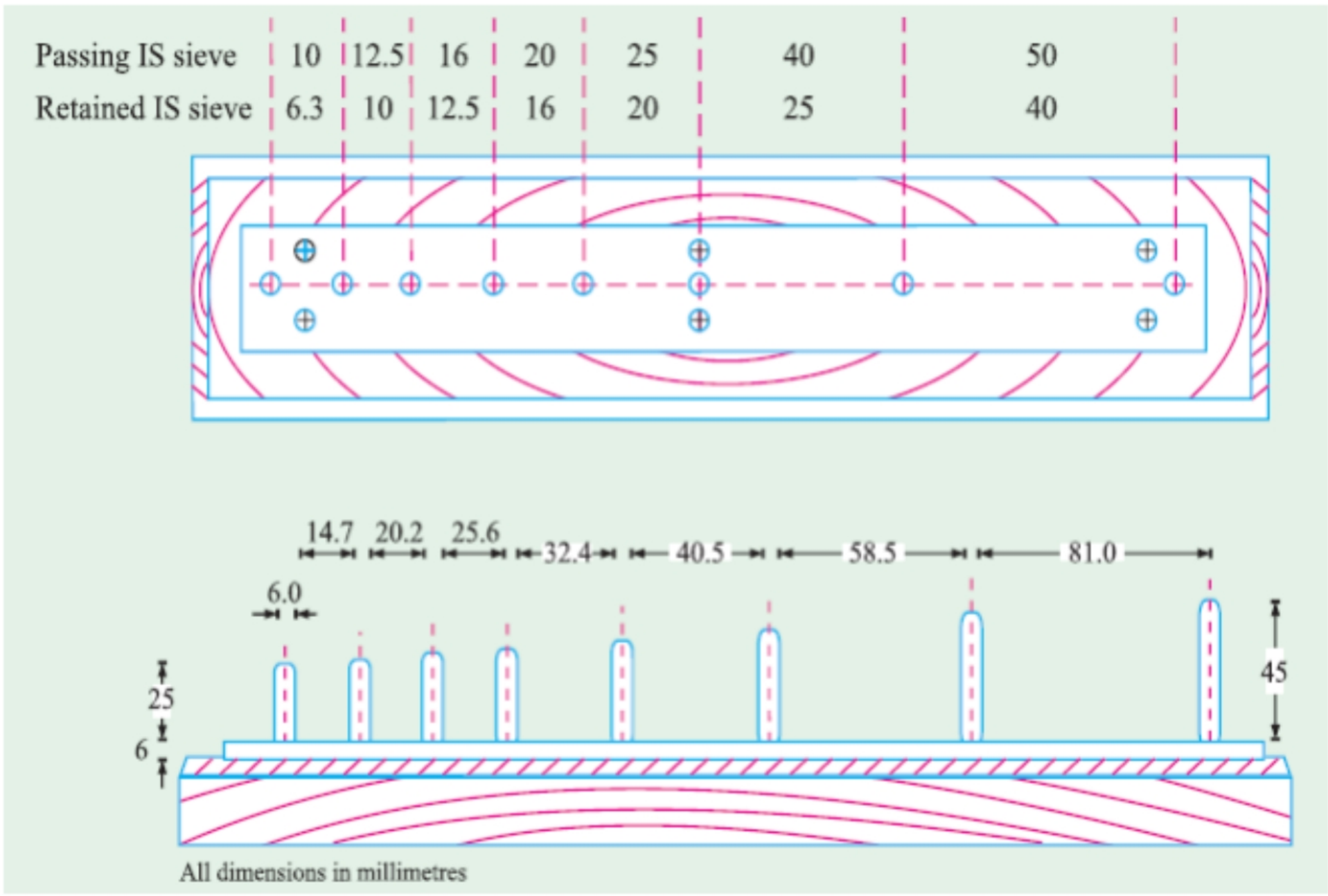


## Elongation Index

The elongation index on an aggregate is the percentage by weight of particles whose greatest dimension (length) is greater than 1.8 times their mean dimension.

The elongation index is not applicable to sizes smaller than 6.3 mm.

The elongation index is the total weight of the material retained on the various length gauges expressed as a percentage of the total weight of the sample gauged. The presence of elongated particles in excess of 10 to 15 per cent is generally considered undesirable, but no recognized limits are laid down.




## Specific Gravity

Indian Standard Specification IS: 2386 (Part III) of 1963 gives various procedures to find out the specific gravity of different sizes of aggregates.

https://www.youtube.com/watch?v=hqXFPq676iM&t=78s

Specific Gravity = $\left(\frac{C}{A-B}\right)$

Apparent Specific Gravity = $\frac{C}{C-B}$

Water Absorption = $\frac{100\ (B-C)}{C}$

A = Weight of saturated aggregate in water ($A_1 - A_2$).

B = Weight of the saturated surface - dry aggregate in air.

C = Weight of oven dried aggregate in air.

$A_1$ = Weight of aggregate and basket in water.

$A_2$ = Weight of empty basket in water.

**Bulk Density**

The cylindrical measure is filled about 1/3 each time with thoroughly mixed aggregate and tamped with 25 strokes by a bullet ended tamping rod, 16 mm diameter and 60 cm long.

The net weight of the aggregate in the measure is determined and the bulk density is calculated in kg/litre.

https://www.youtube.com/results?search_query=bulk+density+practical

$$\text{Bulk dinsity} = \frac{\text{net weight of the aggregate in kg}}{\text{capacity of the container in litre}}; \qquad \text{Percentage of voids} = \frac{G_s - \gamma}{G_s} \times 100$$

where, $G_s$ = specific gravity of aggregate and $\gamma$ = bulk dinsity in kg/litre.