1.4 AGGREGATES

- The aggregate is a relatively inert material and it imparts volume stability.
- The aggregate provide about 75% of the body of the concrete and hence its influence is extremely important.
- An aggregate should be of proper shape and size, clean, hard and well graded.
- It must possess chemical stability and it must exhibit abrasion resistance.

Physical Properties of Aggregates

The physical properties of aggregates are;

1. Shape
2. Size
3. Color
4. Texture
5. Gradation
6. Fineness modulus

Particle Size, Grading and Dust Content

Well-graded aggregate tend to have lower water requirements than single-sized aggregate and increasing dust contents tend to increase the water requirement of aggregate.

Particle Shape

It is fact that aggregates with well-rounded particles will be less water and make more workable concrete than sands with flaky, elongated particles. However, the strength is undesirable. Aggregate with angular shape, will give moderate water and high strength to concrete by good interlocking characteristics.

Particle Surface Texture

In general, aggregate with a rough surface texture will have a higher water requirement than aggregate with smooth particle surfaces.

Water Absorption

All aggregates absorb water to a greater or lesser degree. The higher the water absorption the higher the water requirement will be, but the water absorbed into the aggregate will not affect the effective water: binder ratio or the strength. It will however lead to rapid slump loss if absorption is excessive, say >1% by mass. In general it is preferable to avoid concrete aggregate properties with water absorptions of more than 1 or 1.5% by mass

Fineness Modulus (FM)

To characterize the overall coarseness or fineness of an aggregate, a concept of fineness modulus is developed. To calculate the fineness modulus, the sum of the cumulative percentages retained on a definitely specified set of sieves needs to be determined, and the result is then divided by 100

The fineness modulus (FM) is a numerical index of fineness, giving some idea of the mean size of the particles present in the entire body of the aggregate.

$$\text{Fineness modulus} = \frac{\text{Sum of cumulative \% retained}}{100}$$

According to IS 2386-1963, the sieves that are to be used for the sieve analysis of the aggregate for concrete are 80mm, 40mm, 20mm, 10mm, 4.75mm, 2.36mm, 1.18mm, 600m, 300m and 150m. For example, a fineness modulus of 6 can be interpreted to mean that the sixth sieve, i.e. 4.75 mm is the average size.

The value of fineness modulus is higher for coarser aggregate and lower for fine aggregate.

Limitations:

The FM for fine sand = 2 - 3.5

The FM for coarse aggregate = 5.5 – 8

[Note: higher FM, the mix will be harsh and if on the other hand gives a lower FM, it produces an uneconomical mix]

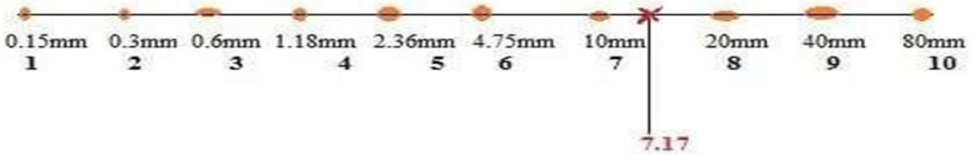
FINENESS MODULUS

Worked Example: (Take 5000 g sample)

Aggregates	Sieve size	Weight retained(g)	Cumulative weight retained (g)	Cumulative % retained (g)
Coarse aggregates	80mm	0	0	0
	40mm	250	250	5
	20mm	1750	2000	40
	10mm	1600	3600	72
Fine aggregates	4.75mm	1400	5000	100
	2.36mm	0	5000	100
	1.18mm	0	5000	100
	0.6mm	0	5000	100
	0.3mm	0	5000	100
	0.15mm	0	5000	100
		Sum	=	717

Therefore, fineness modulus of coarse aggregates = sum (cumulative % retained) / 100 = (717/100) = 7.17

Fineness modulus of 7.17 means, the average size of particle of given coarse aggregate sample is in between 7^{th} and 8^{th} sieves, that is between 10mm to 20mm.



Classification Based on Size

Fine aggregates:

It is the aggregate, which is passes through a 4.75mm IS sieve and retained on 0.7 mm. The fine aggregate may be natural sand, crushed stone sand or crushed gravel sand. According to IS 383-1970, there are four grading zones of the fine sand, Zone I, Zone II, Zone III and Zone IV.

Coarse aggregates:

The aggregates, most of which are retained on 4.75mm IS sieve are termed as coarse aggregates. The coarse aggregates may be Crushed stone, uncrushed gravel and partially crushed stone or gravel.

[*Sometimes combined aggregates are available in nature consisting of different fractions of fine and coarse aggregates, which are known as all in aggregate.]

Classification Based on Shape

Rounded aggregate:

- The aggregate with rounded particles (river or sea shore gravel) has minimum voids ranging from 32 to 33%.
- It gives minimum ratio of surface area to the volume, thus requiring minimum cement paste to make good concrete.

- The only disadvantage is that the interlocking between its particles is less, and hence the development of the bond is poor, making it unsuitable for high strength concrete and pavement.

Irregular aggregates:

- The aggregate having partly round particles (pit sand and gravel) has higher percentage of voids ranging from 35 to 38 %.
- It requires more paste for a given workability.
- The interlocking between particles, though better than that obtained with the rounded aggregate, is inadequate for high strength concrete.

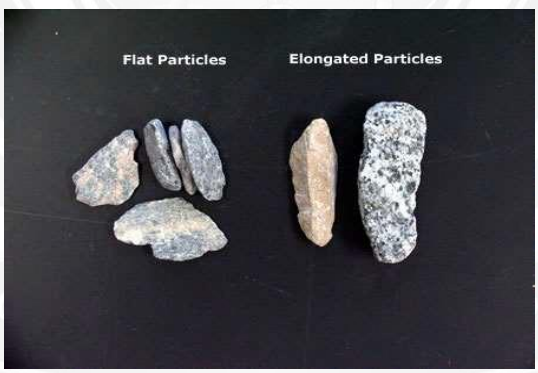
Angular aggregates:

- The aggregate with sharp angular and rough particles (crushed rock) has a maximum percentage of voids ranging from 38 to 40%.
- The interlocking between particles is good, providing a good bond.
- The aggregate requires more paste to make workable concrete of high strength.

- The angular aggregate is suitable for high strength concrete and pavements subjected to tension.

Flaky and elongated aggregates:

- An aggregate is termed flaky when the ratio of least dimension (thickness) to the mean dimension is less than three-fifth (0.6).
- The particle is said to be elongated when the ratio of greatest dimension (length) to the mean dimension is more than nine-fifth (1.8 times).



Classification based on unit weight

Normal weight aggregates:

- The commonly used aggregates i.e. sand, gravel, crushed rocks such as granite, basalt, sandstone (sedimentary) and limestone.

- It has specific gravities between 2.5 and 2.7 produce concrete with unit weight ranging from 23 to 26 kN/m^3
- The compressive strength at 28 days between 15 to 40 mpa are termed Normal weight aggregate.

Heavy weight aggregates:

- Heavy weight concrete is produced from heavy weight aggregate, which is more effective as a radiation shield.
- The unit weight of concrete varies from 30 to 57 kN /m^3.
- The specific gravity is varies from 4 – 6.8
- Example: Baryte (G_s = 4 to 4.6), Ferro phosphorus (G_s = 5.8 to 6.8), Haematite (G_s = 4.9 to 5.3) and Magnetite (G_s= 4.2 to 5.2)

Light weight aggregates:

- The light weight aggregates have unit weight up to 12 kN /m^3.
- These aggregates are obtained from pumice, volcanic cinder, Diatomite, blast furnace slag, fly ash etc.
- The weight of concrete (structure) is reduced to a great extent and it provides better thermal insulation and improved fire resistance.