2.6 Aggregate

- Aggregate are generally cheaper than cement and impact greater volume stability and durability to concrete.
- The aggregate is used primarily for the purpose of providing bulk to the concrete.
- To increase the density of the resulting mix, the aggregate is frequently used in two or more sizes.
- The most important function of the fine aggregate is to assist in producing the workability and uniformity in mixture.
- The aggregates provide about 75% of the body of the concrete and hence its influence is extremely important. The must be of proper shape (either rounded or approximately cubical), clean hard strong and well graded.
- The materials used for manufacture of mortar and concrete such as sand, gravel etc. are called as aggregate.

2.6.1 Natural Aggregates:

These are obtained by crushing from quarries of igneous, sedimentary or metamorphic rocks. Gravels and sand reduced to their present size by the natural agencies also fall in this category. The most widely used aggregate are from igneous origin. Aggregates obtained from pits or dredged from river, creek or sea are most often not clean enough or well graded to suit the quality requirement. They therefore require sieving and washing before they can be used in concrete.

2.6.2 REQUIREMENT OF GOOD AGGREGATE :

- It must be clean i.e. it should be free from lumps, organic materials etc.
- It should be strong.
- It should be durable.
- It should not react with cement after mixing.
- It should have rough surface.
- It should not absorb water more than 5%.
- It should not be soft and porous.
- It should be chemically inert.
- It should be of limiting porosity.

- It should preferably be cubical or spherical in shape.

2.6.3 CLASSIFICATION OF AGGREGATE

- Classification According to Geological Origin
    1. Natural Aggregate
    2. Artificial Aggregate
- Classification According to Size
    1. Fine Aggregate
    2. Coarse Aggregate
- Classification According to Shape
    1. Rounded Shape
    2. Irregular Aggregate
    3. Angular Aggregate
    4. Flaky Aggregate
- Classification Based On Unit Weight
    1. Normal Weight Aggregate:
    2. Heavyweight Or High-density Aggregate
    3. Light Weight Aggregate

1) Classification according to geological origin

- **Natural Aggregate:**
    - These aggregates are generally obtained from natural deposits of sand and gravels, or from quarries by cutting rocks.
    - The cheapest among them are the natural sand and gravel. Which have been reduced to their present size by natural agents, such as water, wind and snow, etc.
    - The river deposits are the most common and are good quality.
- **Artificial Aggregate:**
    - The most widely used artificial aggregate are clean broken bricks and air cooled fresh blast- furnace- slag.
    - The broken bricks of good quality provide a satisfactory aggregate for the mass concrete and are not suitable for reinforced concrete work if the crushing strength of brick is less than 30 to 35 Map.

- The bricks should be free from lime mortar and lime sulfate plaster.
- The bricks aggregate is not suitable for waterproof construction.
- It has poor resistance to wear and hence is not used in concrete for the road work

2) Classification according to size:

Fine aggregate: The aggregate which passes through 4.75 mm sieve and retained on 75 micron sieve are known as fine aggregate.

It is classified into

a)**Sand:** It consists of small angular or rounded grains of silica depending upon the source from which it is obtained. It is classified as:

- It is found as deposited in soil and is to be excavated out. Its grains are generally sharp or angular. It should be free from organic matter and clay. It is usually considered to be the best fine aggregate for use in mortar and concrete.

(i) **Pit or quarry sand**: Excavation of soil

(ii) **River Sand:** It is obtained from the banks and beds of rivers. It may be fine or coarse. Fine sand obtained from beds and banks of rivers is often found mixed with silt and clay so it should be washed before use. But coarse sand is generally clean and excellent for use especially for plastering.

(iii) **Sea Sand:** It consists of fine rounded grains of brown colour and it is collected from sea shores or sea beaches. Sea sand usually contains salts and while using that in mortar, etc, causes disintegration of the work in which it is used. In R.C.C work these salts will attack reinforcement if salt content is high. These salts may cause efflorescence. It should be used locally after thorough washing.

(iv) **Crushed stone:** It is obtained by crushing the waste stones of quarries to the particular size of sand. Sand obtained from by crushing a good quality stone is excellent fine aggregate.

b)Coarse Aggregate: The aggregate retained on 4.75 mm IS sieve are Known as coarse aggregate.

(i) Crushed stone:

Crushed stones are used for the construction of roads and railway tracks, etc

(ii) Gravel:

It is another very good coarse aggregate. It is obtained from river beds, quarries and seashores. The gravel obtained from sea shores should be well washed with fresh water before use in order to remove the impurities which may be clay, salts ,silt etc. It is commonly used in the preparation of concrete.

(iii) Broken pieces of bricks:

It is also a good artificial source of coarse aggregates. It is obtained by breaking well burnt bricks. It is generally used in lime concrete at places where aggregates from natural sources are either not available or are expensive. It can be used at placeswhere low strength is required. It should be watered well before using it in thepreparation of concrete. It is commonly used for mass concrete in foundations andunder floors.

3) Classification according to Shape:

1. **Rounded Shape**: The aggregate with rounded particles (river or seashore gravel) has minimum voids ranging 32 to33 %. The only disadvantage is that interlocking between its particles is less and hence the development of bond is poor, making it unsuitable for high strength concrete and pavement
2. **Irregular Aggregate**: The aggregate having partly rounded particles (pit sand and gravel) has higher of voids ranging from 35 to 38% . It required more cement paste for a given workability.
3. **Angular Aggregate**: The aggregate with sharp, angular and rough particles (crushed rocks) has a maximum of voids ranging from 38 to 40%.The interlocking between the particles is good.
4. **Flaky Aggregate:** An aggregate is termed flaky when its least dimension (thickness) is less than three-fifth of its mean dimension. The presence of these particles should be restricted to 10 to 15%.

4) Classification based on Unit Weight

1. **Normal Weight Aggregate:** The commonly used aggregate, i. e, sands and gravels; crushed rocks such as granite, basalt quartz, sandstone and limestone; and brick ballast, etc., which have specific gravities between 2.5 and 2.7 produce concrete with unit weight ranging 23 to 26 KN/m3 and crushing strength at 28 days between 15 to 40 Map are termed normal- weight concrete.

2. **Heavyweight Or High-Density Aggregate:** concrete having unit weight of about 30, 31, 35, 38, 40, 47 and 57KN/m3 can be produced by using typical goethite, limonite, baryte, magnetite, hematite, ferrophosphorus and scrap iron, respectively.
3. **Light Weight Aggregate:** The light weight aggregate having unit weight up to12KN/m3 are used to manufacture the structural concrete masonry blocks for reduction of the self weight of the structure.

2.6.4 PROPERTIES OF FINE AGGREGATE:

1. Size:

The largest size which may under the range of fine aggregate is 4.75mm. Using the largest size will give a more dense concrete, but a mixture of all sizes is more desirable and more economical.

2. Shape:

Shape of aggregate plays an important role in coarse aggregate rather than fine aggregate.

3. Strength:

The strength of aggregate alone cannot ensure strength of concrete. Strength of coarse aggregate is more important.

4. Surface Texture:

Generally rough surfaced aggregate is preferable to smooth aggregates. This property is also related with coarse aggregate.

5.Specific Gravity:

Specific gravity of aggregate is the ratio of its density to the density of water.

6. Bulk Density:

This refers to the density of aggregate considered along with volume of voids or empty spaces between the particles. The density of sand falls between 17 to 25 KN/m3.

7. Water Absorption:

Generally, for sand, water absorption is negligible, It is desirable that water absorption should be kept minimum.

8. Soundness:

This refers to expansion and contraction of the aggregate when subjected to temperature variation.

2.6.4 PROPERTIES OF COARSE AGGREGATE

1. Size: The size of coarse aggregate depends on the used to which the concrete is to be put. For mass concreting works without complicated reinforcement, larger aggregates of 80 mm, 40mm, 20mm sizes are used.
2. Shape: The shape of aggregate is an important characteristic as it affects the workability of concrete. It also affects the strength.
3. Surface Texture: It is the property of coarse aggregate deals with roughness and smoothness of aggregate. Rounded aggregate with smooth surface will require less cement paste and hence increase the yield per bag.
4. Water Absorption: Some of the aggregate water absorb and porous. Hence, it affect the water cement ratio and the workability of concrete. The porosity of aggregate also the affect if durability of concrete.
5. 7. Soundness: soundness refer to expansion and contraction of the aggregate. When subjected to temperature various. A good aggregate is that which shows minimum expansion and contraction.
6. 8. Specific Gravity: It is the ratio of dry weight of aggregate to the weight of equal volume of water.
7. 9. Bulk Density: The ratio of net weight of aggregate to the volume of aggregate gives bulk density.

2.6.5 GRADING OF AGGREGATE

The particle size distribution of an aggregate as determined by sieve analysis is termed as gradation of aggregates. If all the particles of an aggregate are of uniform size, the compacted mass will contain more voids whereas aggregate comprising particles of various sizes will give a mass with lesser voids.The particle size distribution of a mass of aggregate should be such that the smaller particles fill the voids between the larger particles. The proper grading of an aggregate produces dense concrete and needs less quantity of fine aggregate and cement waste, therefore, it is essential that coarse and fine aggregates be well graded to produce quality concrete.

Grading limits and maximum aggregate size are specified because these properties affect the amount of aggregate used as well as cement and water requirements, workability, pumpability, and durability of concrete. In general, if the water-cement ratio is chosen correctly, a wide range in grading can be used without a major effect on strength.

The Grading Curve of Aggregates:

The grading of aggregates is represented in the form of a curve or an S-CURVE. The curve showing the cumulative percentages of the material passing the sieves represented on the ordinate with the sieve openings to the logarithmic scale represented on the abscissa is termed as Grading Curve. The grading curve for a particular sample indicates whether the grading of a given sample conforms to that specified, or it is too coarse or too fine, or deficient in a particular size.

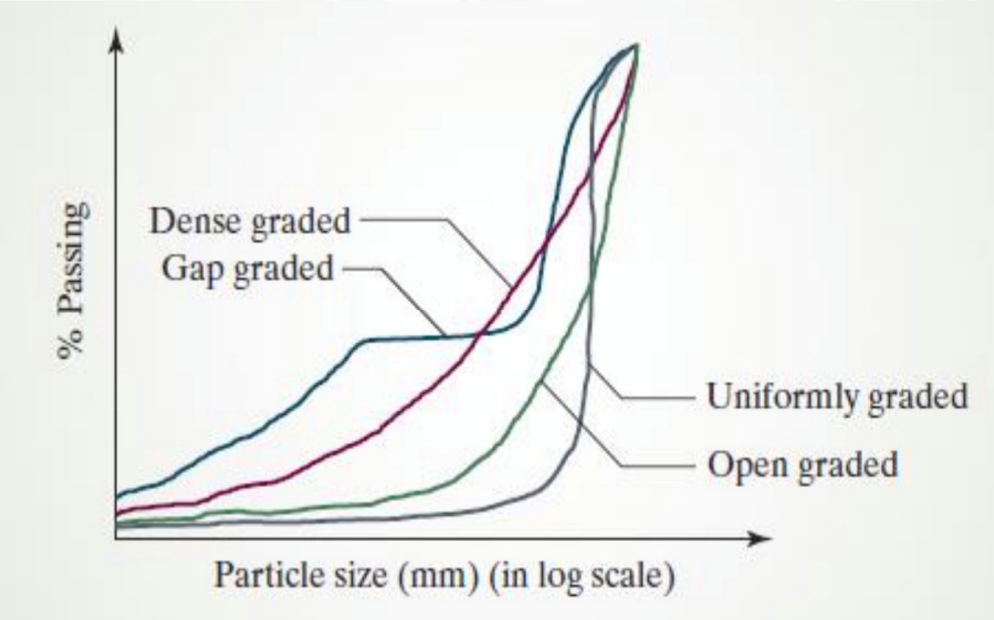

Fig Grading curve

Types of Grading of Aggregates

1) Dense-or well-graded aggregate – Has gradation close to the FWHA maximum density grading curve.
2) Gap-graded aggregate – Has only a small percentage of particles in the mid-size range.
3) Uniformly graded aggregate – Composed mostly of particles of the same size.
4) Open-graded aggregate – Contains only a small percentage of small-size particles.

1) Uniform Graded Aggregate

It refers to a gradation that contains most of the particles in a very narrow size range. In essence, all the particles are the same size. The curve is steep and only occupies the narrow size range specified.

- Narrow range of sizes.
- Grain-to-grain contact.
- High void content.
- High permeability.
- Low stability.
- Difficult to compact.

2) Open Graded Aggregate

In this type of gradation of aggregates, only a small percentage of aggregate particles are in the small range. This results in more air voids because there are not enough small particles to fill in the voids between the larger particles. The curve is near vertical in the mid-size range, and flat and near-zero in the small-size range.

3) Gap Graded Aggregate

Gap-graded aggregate contains only a small percentage of aggregate particles in the mid-size range. The curve is flat in the mid-size range. Some PCC mix designs use gap graded aggregate to provide a more economical mix since less sand can be used for a given workability. When gap-graded aggregate are specified, certain particle sizes of aggregate are omitted from the size continuum. Gap-graded aggregate are used to obtain uniform textures in exposed aggregate concrete. Close control of mix proportions is necessary to avoid segregation.

- Missing middle sizes.
- No grain-to-grain contact.
- Moderate void content.
- Moderate permeability.
- Low stability.
- Easy to compact.

4) Dense Graded Aggregate

A dense gradation refers to a sample that is approximately of equal amounts of various sizes of aggregate. By having a dense gradation, most of the air voids between the materials are filled with particles. A dense gradation will result in an even curve on the gradation graph.

- Wide range of sizes.
- Grain-to-grain contact.
- Low void content.
- Low permeability.
- High stability.
- Difficult to compact.