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UNIT - II

Aggregates

Earlier aggregates were considered as chemically inert materials but now it has been recognised that some of the agg are chemically active + exhibit chemical bond at the interface of agg + paste.

→ 70 - 80 % of volume of concrete is occupied by agg.

Aggregates effect the properties of concrete

1. Strength
2. Durability
3. Structural performance
4. Economy

Classification of Aggregates :-

Natural Aggregates:-

→ These are originally formed a part of larger parent mass.

→ Many properties of agg depend entirely on properties of parent rock.

eg :- chemical + mineral composition, spec grav etc.

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Eg:- Sand, Gravel, crushed rock such as Granite, Quartzite, Basalt, Sandstone.

Artificial Aggregates:-

They are obtained either as a by product (or) by a special Manufacturing process such as heating (blast furnace slag etc).

Eg:- Broken brick, air-cooled slag, Bloated clay.

Classification according to petrological

① Igneous rocks:- formed by solidification of molten lava (granite)

② Sedimentary rocks:- obtained by deposition of weathered & transported pre-existing rocks. (limestone)

③ Metamorphic rocks:- formed under high heat & pressure alteration of either Igneous & Sedimentary (marble)

Classification According to size:-

① fine aggregates:- particles of fine aggregates pass through 4.75mm sieve. Eg:- Sand, ash, Surkhi

② Coarse Aggregates:- particles retained on 4.75mm sieve.

4.75mm – 37.5mm – coarse aggregates.

Eg - Gravel, Crushed stones.

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Classification According to unit weight :-

① Heavy weight Agg :- It is used where high mass-to-volume desired. Sp. gr ≥ 2.8 — Magnetite.

② Normal weight Agg :- Sp. gr. $2.8 < G_S < 2.4$ — gravel, limestone, stones

③ Light weight agg :- Sp. gr. $G_S < 2.4$ — crushe brick, Expanded clay

Recycled agg to produce light weight geopolymer blocks with satisfactory density & strength.

Particle Shape & Suface Texture :-

In addition to petrological characte, the external characteristics, i.e The shape & suface texture of agg are of Importance.

Particle Shape :-

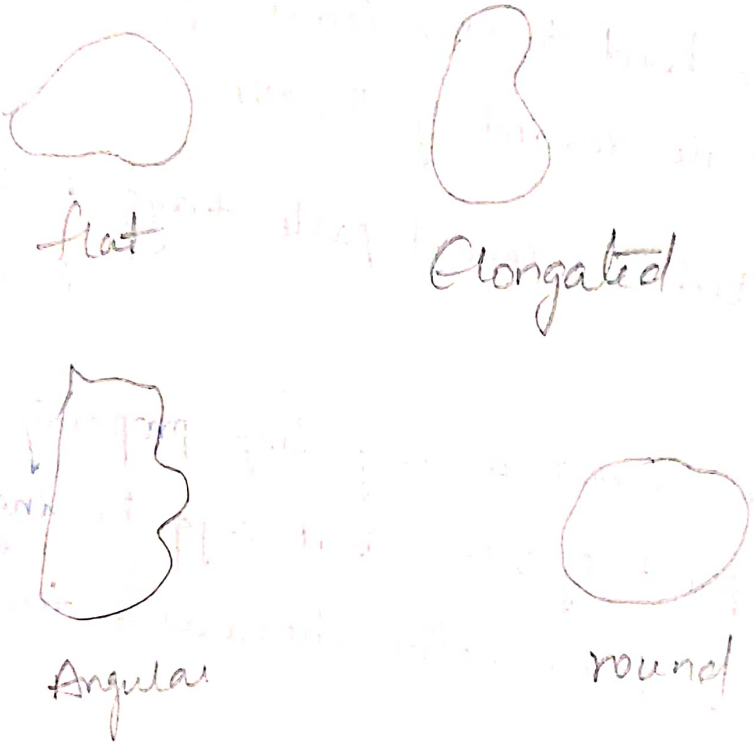
Rounded :- Completely water worn & fully shaped by attrition (River Gravel)

Irregular :- partly shaped by attrition So it contains some rounded edges (Land Gravel)

Angular :- It has sharp corners, show little evidence of wear (crushed stone)

Flaky :- Thickness is relatively small with respect to two other dimensions. (Laminated Rocks)

Elongated :- It has lengths considerably larger than two other dimensions.



→ Rounded aggregates are suitable to use in concrete because flaky & elongated particles reduce workability, increase water demand & reduce strength

→ Angular particles, the bond b/w agg particles is higher due to interlocking but due to higher surface area, angular particles increase water demand & therefore reduce workability.

Surface Texture :-

→ This effects the bond to the cement paste & also influences the water demand of the mix.

Smooth - Bond b/w cement paste & agg is weak

Rough - " " " is strong.

→ Surface texture is not a very imp property from comp. strength point of view but agg having rough surface texture perform better flexural & tensile stresses.

Properties of Aggregates :-

① Strength - Majority of Normal Agg are considerably stronger than concrete.

· Crushing Strength - 200 N/mm²

Hardness :

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- It is the ability of the agg to withstand wear or load or applied pressure
- → Test that can obtain hardness is Abrassion test.
- → Not more than 30 %.

Toughness

- → The resistance of Agg to failure by Impact.
- → This can be determined by Aggregate Impact Test.
- → Should not exceed 45 %. for wearing surfaces (Not)
  30 %. "

Durability

① Durability is ability of the aggregate to withstand with Exterinal or interinal damaging attack or in otherwords Soundness of aggregates.

Porosity :- Agg will absorb water when it is dry but normally release water in the concrete mix when it is wet. — depends on size & vol of agg.

Tests on Aggregates :- [lab methods]

① Specific gravity :- procedure for specific gravity for Agg Coarse than 6.3mm

study from lab manual

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Bulk Density of Aggregate :-

The bulk density of an aggregate is the mass or weight of the aggregate that is required to fill a container of a specified unit volume.

Bulk density = Mass/volume.

factors affecting bulk density of Aggregates

1. How densely the agg are packed
2. Particle Size & shape
3. Grading of agg
4. Moisture content of Agg.

Determination of bulk density :-

4.75mm	– 3 litre
4.75 to 40mm	– 15
over 40mm	– 30

→ fill the container in three equal layer.

→ each layer being temped with 25 stokes by a bullet Ended tamping rod, 16mm dia & 60 cm long.

→ container is carefully struck off level using tamping rod or straigh edge.

$$= \frac{\text{wt of agg}}{\text{Capacity}}$$

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Soundness test on Aggregates.

It is carried out to learn the resistance to weathering actions like thawing, freezing, alternate wetting et.

Is : 2386 part-5

Apparatus - Balance, oven, Sieves, wire mesh Basket, containers, Chemical solution (Sodium sulphate soln) (Magnesium sulphate)

Preparation :- wash & dry agg retained on 4.75mm IS Sieve in oven

→ Different fractions 80mm, 63mm, 40mm, 20mm, 10mm & 4.75mm.

→ Take proper weight of sample from each fraction & place it in separate containers.

→ Test → Take individual samples in a wire mesh Basket & immerse in solution. (16hrs - 18hrs)

→ Remove the samples from solution & allow to drain for 15min & place it in oven.

→ After cooling again immerse in solution. (cycles)

→ After completion of final cycle & sample has been cooled and wash it free from soln.

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→ Dry the sample & weight it.

→ Wt of Agg retained on 6mm Sieve

Result :- Avg loss of weight should not exceed 12% to 18%.

$$\text{Soundness value} = \frac{\text{passing from 6mm}}{\text{Total weight of sample}} \times 100$$

Deleterious Substance in Aggregate :-

Deleterious Substance are harmful or injurious Substance found in the Suface of the aggregate.

→ They are harmful to concrete performance.

→ These Substance affect or weakens the bond blw Cement & Aggregate & break easily.

They may be

1. Salt
2. organic Impurities
3. clay lumps
4. coal, lignite
5. Lightweight chert.

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① Salt particles :- Sand from seashore or a river, as well as Desert Sand contains salt

→ Salts coming through agg cause reinforcement corrosion & also absorb moisture from the air and calls efflorescence

[BS 882:1992 limits on chloride ion]

② Organic Impurities :- It is found in sand & consists of products of decay of veg matter.

→ It can be remove from sand by washing.

→ Interfere with the process of hydration of cement.

→ Calorimetric Test. (ASTM)

③ Clay :- Clay may coat the surface of agg which impair bond strength b/w agg & cement paste.

Other particles may be in the form of silt, crushed dust.

→ It Impacts the concrete

→ low wear resistance

→ Reduce durability

→ Result popouts..

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④ Coal & Lignite :- Result staining on Concrete

→ Cause popouts
→ Air Entrapment

⑤ Lightweight chert :- Chert is a microcrystalline sedimentary rock material composed of Silicon Dioxide. ($S_p < 2.40$)

→ Reduce durability
→ popouts

⑥ unsound particles :- Two major classes of unsound particles are materials fail to maintain their integrity, & substances lead to disruptive Expansion on freezing.

→ wood, gypsum, iron, clay Ex of unsound.
→ affect the Strength of Concrete.

Alkali - Aggregate Reaction :-

→ Reaction b/w alkali from cement and silica or carbonate from agg is called "Alkali-aggregate reaction".
→ Most common reaction is that b/w the active silica & alkali is called alkali-silica reaction.
→ Another reaction is that b/w dolomitic limestone (carbonate) & alkali is called alkali-carbonate reaction.

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→ These reactions cause deterioration of concrete mainly cracking.

→ gel formation on the surface of agg particles destroy the bond b/w the agg & cement paste.

→ Swelling, Internal pressure lead to expansion.

Controlling

→ Non reactive agg. - Selective quarring.

→ lithium based admixtures.

→ limit aggregate size.

→ ASTM C 1105

Sieve Analysis :- Coarse agg are particles greater than 4.75mm. generally 9.5mm - 37.5mm. (lab test)

This test used to determine the particle size of fine & coarse aggreagates.

Is coade - 2386 part 1

→ Take the sample & weight (dry) 100°c to 110°c.

Sieve size	wt retained	Cumulative weight retained	Cumulative % retained	Cumulative % passing
37.5mm				
⋮				
150μ				

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fineness modulus :-

$$\text{fineness modulus} = \frac{\text{cumulative \% retained}}{100}$$

The fineness modulus is an empirical fig obtained by adding the total % of the sample of an agg retained on each of a specified series of sieves, dividing the sum by 100.

Grading of curves :- The grading of aggregates is represented in the form of a curve. The curve showing the cumulative percentage 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.

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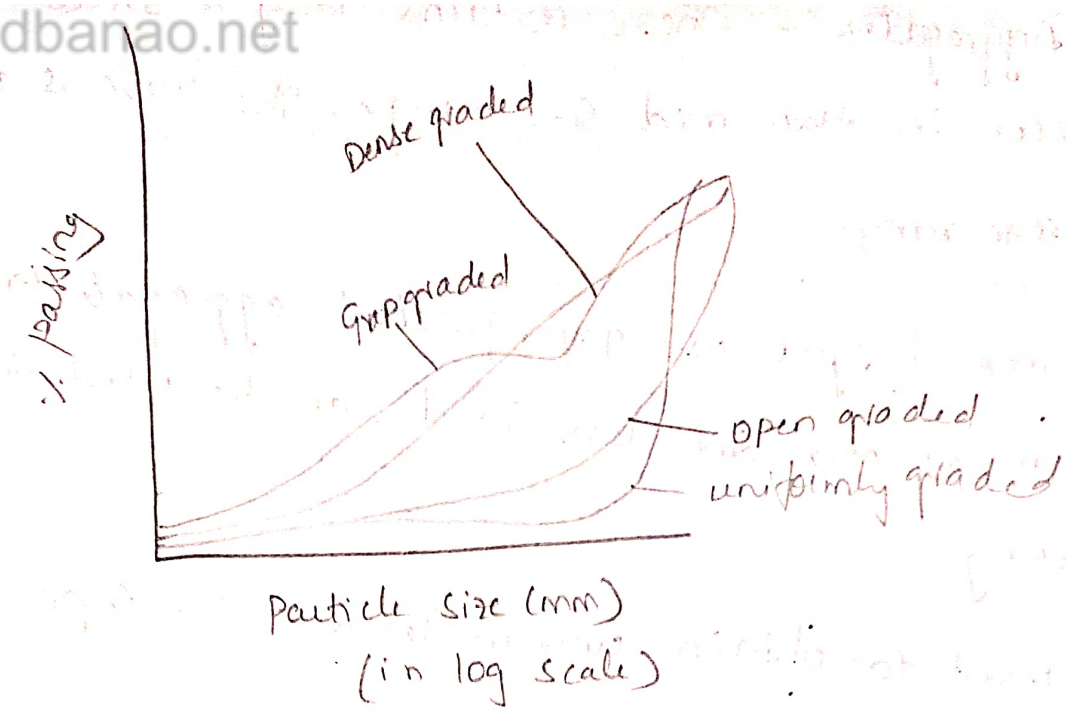

Types of Grading of Aggregates :-

uniform Graded Aggregate :- It refers to a gradation that contains most of the particles is very narrow size range. all particles are same size.

1. Narrow range of sizes.
2. Grain- to Grain contact.
3. High void content.
4. Low stability.
5. High permeability.
6. Difficult to compact.

Open graded aggregate :- Small % of agg particles are in the small range. This results in more air voids because there are not enough small particles to fill the voids b/w the larger particles.

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Gap graded Aggregates :- These contains only a small % of agg 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 given workability.

→ These are used to obtain uniform textures in exposed aggregate concrete.

(i) No grain-to grain contact
(ii) Moderate void content
(iii) Moderate permeability
(iv) low stability.

Dense Graded Aggregate :- A dense gradation refers to a sample that is approx of equal amounts of various sizes of agg. Most of the air voids b/w the material are filled with particles.

(i) Grain to Grain contact
(ii) low void
(iii) low permeability
(iv) High stability.

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Thermal properties of Aggregate :-

These properties of agg affect the durability & other qualities of concrete.

→ The properties of a material that determine how it reacts when it is subjected to excessive heat, or heat fluctuations over time is called thermal properties.

(i) **Coefficient of Expansion** :- It determines the thermal Expansion of concrete to a considerable extent.

→ It also governs the degree of physical compatibility of the components and hence affects the durability of concrete.

→ The ratio of the increase of length, area, or vol of a body per degree rise in temp to its length, area at specified temp.

5.8×10^{-6} per °C to 14×10^{-6} per °C.

(ii) **Specific heat** :- It represents the heat capacity of concrete.

→ It increases with the moisture content of concrete & is affected by mineralogical characters of the aggregates.

→ Specific heat increases with an increase in temp & also increases with a decrease in the density of concrete.

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(iii) Thermal conductivity :- The ability of an aggregate to conduct heat is called the thermal conductivity of aggregate

1.163 - 8.6 w/mk.

Manufactured Aggregate :- Manufacture of coarse and fine aggregates are produced by crushing parent rocks by stone Crushing Machines.

→ Manufactured aggregates differ from gravel and sand in their grading, shape & texture.

→ As a result of crushing operation, manufactured agg often have a rough surface texture and angular shape, tend to be cubical or elongated in shape, and bad in size distribution.

→ By using appropriate crushing techniques and machines, better shape & size distribution, as well as for sand.

→ Manufactured aggregates are likely with less deleterious substances.

→ large crusher powder content in the major concern for crushed sand.

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→ Crushed powder content may affect the water & workability.

→ Manufactured sand is more & more imp due to lack of natural sand.

→ company Name - Svedala for agg manufacture Machine Supply — Jaw Master Crusher or Barmac Rock on Rock VSI

Recycled aggregates :- These are manufactured from waste concrete or demolished concrete of various construction works.

→ we can say that, it is the byproduct of concrete building demolished

→ first the demolished concrete is cleaned from dirt and other loose particles.

→ After that broken into smaller pieces to produce agg.

→ It is also known as Crushed concrete agg.

→ Size 20mm to 50mm.

→ Comp Strength - 22% ↑ than Natural.

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Properties :-

① Adhered Mortar content :- RCA contains residual adhered Mortar particles on the surface.

→ RCA consists of both hydrated + unhydrated cement

→ It effect the aggregate properties such as absorption, resistance etc.

② Density :- Due to adhere mortar density of RCA is normally lower than the natural.

→ Because Adhered is lighter in weight compare to same volume of Natural agg, which decreases the density.

③ porosity & water absorption :-

→ Greater absorption capacity due to high porosity.

④ Specific gravity :- Lower specific gravity.

⑤ Shape & Gradation - Rounded & spherical shape & can be grainy in Texture.

⑥ Strength is weaker compared to Natural, Crushing & abrasion value is also low about 27%.

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Maximum Aggregate Size :-

Maximum aggregate size in concrete is the smallest sieve through which 100% of the aggregates will pass.

→ The nominal size of aggregate is the smallest sieve which can retain more than 15% of the total agg, though this is sometimes taken as the next sieve size down from the max agg size.

→ using the maximum nominal aggregate size avoids any issues with very small quantities of slightly oversized agg bumping the whole coarse agg grading into a higher band which is not really appropriate.

→ The max agg size effects many properties of fresh & hardened concrete including the w/c, workability, durability and shrinkage.

Max size agg use in

① Thickness of concrete slab - 1/3 - 1/5 of slab thickness to get homogenizes distribution of concrete components.

② Spacing b/w reinforcement - 3/4 clear space b/w reinforcement bars to make compaction of concrete looks better.

③ Clear cover :- The max size of agg should not

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be greater than 5mm less than covers provided.

[if concrete cover is 30mm, size <25mm)

→ for reinforcement concrete works, max size 20mm.