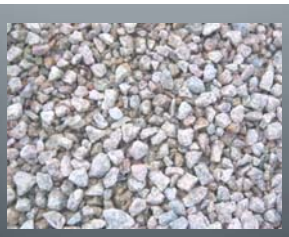
Aggregates



Introduction

- The aggregate component of a concrete mix occupies 60-80% of the volume of concrete.
- The selection of aggregate will determine the mix design proportion and the economy of the resulting concrete.
- Aggregate selected must be clean, hard, strong and durable particles, free of chemicals, Coatings of clays or other materials that will affect the bond of the cement paste.
- Aggregates consist of fine aggregate, coarse aggregate and mineral fillers.

Sources of aggregates

Sources of aggregates

- Natural sources include gravel pits, river run deposits, and rock quarries.
- Gravel comes from pits and river deposits, whereas crushed stones are the result of processing rocks from quarries.
- Manufactured aggregate include slag waste from steel mills and expanded shale and clays to produce lightweight aggregates

Evaluation of aggregate sources

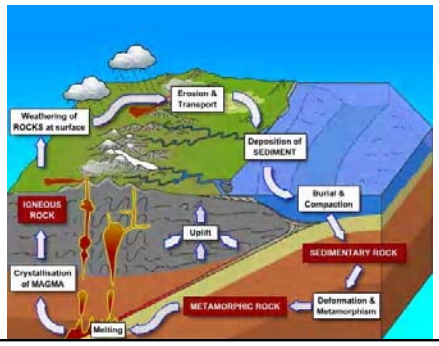
- Selection aggregate is based on their ability to meet specific project requirement:
  - The physical and chemical properties of the rocks
  - The cost availability of the aggregates ie. Locally available material in the most cost-effective manner.
  - The nature and amount of fine material
  - The gradation of aggregates
  - The usage ie. For based material, in asphalt concrete or in portland cement concrete.

Geological classifications

Geological classification

- All natural aggregate result from breakdown of large rock masses.
- Rock is classified into 3 basic types: igneous, sedimentary and metamorphic.

Geological classification

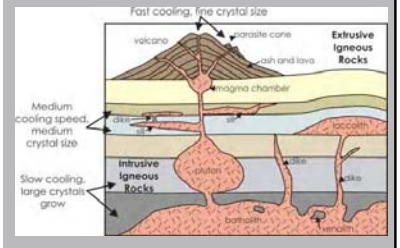


Igneous rocks

Igneous produce by volcanic action whereby the magma being hardened or crystallized.

The magma cool either at the earth's surface, when it is exposed to air or water, or within the crust of the earth.

The extrusive rock (cooling at the surface) have a fine grain size and potentially to include air voids and other inclusions.



Igneous rocks

The intrusive rock (cooling underground) have larger grain sizes and fewer flaws.

Igneous rock are classified based on;

- Grain size: coarse grains are larger than 2mm and fine grains are less than 0.2mm.
- Composition: is a function of silica content, specific gravity, colour and the presence of free quartz.

Sedimentary rocks

Sedimentary rocks produced from deposits of disintegrated existing rocks or inorganic remain of marine animals.

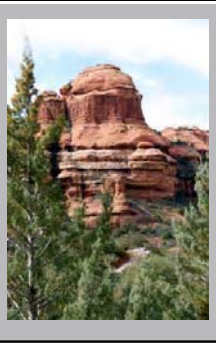
Wind, water, glaciers, or direct chemical precipitation transport and deposit layer of material that become sedimentary rocks, resulting in stratified structure.

Sedimentary rocks

Natural cementing binds the particles together.

Classification is based on the predominant mineral present:

calcareous (limestone, chalk)
siliceous (sandstone)
argillaceous (shale).



Metamorphic rocks

Metamorphic rocks produced from igneous or sedimentary rocks that are drown back into the earth crust and exposed to heat and pressure, reforming and the grain structure. Metamorphic rocks generally have a crystalline structure, with grain sizes ranging from fine to coarse.

Purpose of aggregates

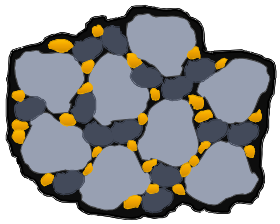
Purpose of aggregates

- The large, solid coarse aggregate particles form the basic structural members of the concrete.
- The voids between the larger coarse aggregate particles are filled by smaller particles.
- The voids between the smaller particles are filled by still smaller particles.
- Finally, the voids between the smallest coarse aggregate particles are filled by the largest fine aggregate particles.

Purpose of aggregates

- In turn, the voids between the largest fine aggregate particles are filled by smaller fine aggregate particles, the voids between the smaller fine aggregate particles by still smaller particles, and soon.
- Finally, the voids between the finest grains are filled with cement.

Purpose of aggregates



Purpose of aggregates

- The better the aggregate is graded (that is, the better the distribution of particles sizes), the more solidly all voids will be filled, and the denser and stronger will be the concrete.

Purpose of aggregates

- The cement and water form a paste that binds the aggregate particles solidly together when it hardens.
- In a well-graded, well-designed, and well-mixed batch, each aggregate particle is thoroughly coated with the cement-water paste.
- Each particle is solidly bound to adjacent particles when the cement-water paste hardens

Aggregates can be divided into several types based on the types of rock from which they are derived, the method of manufacture, the size or the density

Types of aggregates

Based on source or method of manufacture

- SAND
- A granular material made up of fine mineral particles.
- It is a naturally occurring, finely divided rock.
- Sand comprises particles, or granules, ranging in diameter from 0.0625 (or 1⁄16 mm) to 2 millimeters.
- An individual particle in this range size is termed a sand grain.

Based on source or method of manufacture

- SAND
- The next smaller size class in geology is silt: particles smaller than 0.0625 mm down to 0.004 mm in diameter.
- The next larger size class above sand is gravel, with particles ranging from 2 mm up to 64 mm
- Sand feels gritty when rubbed between the fingers (silt, by comparison, feels like flour).

Based on source or method of manufacture

- SAND
- Sand is commonly divided into five sub-categories based on size;

- 1. very fine sand (1/16 - 1/8 mm diameter)
- 2. fine sand (1/8 mm - 1/4 mm)
- 3. medium sand (1/4 mm - 1/2 mm)
- 4. coarse sand (1/2 mm - 1 mm)
- 5. very coarse sand (1 mm - 2 mm)

Based on source or method of manufacture

- SAND

Based on source or method of manufacture

- GRAVEL OR RIVER GRAVEL
- Consists of materials with round and smooth edges and of size varying between 4.75mm and 76mm
- In natural deposits around lakebeds, adjacent to streams, gravel are typically layered with sand

Based on source or method of manufacture

- GRAVEL OR RIVER GRAVEL

Based on source or method of manufacture

- CRUSHED STONE
- Obtained by mechanically crushing rocks, boulders or cobbles resulting in particles that are angular in shape and have rough surface texture
- Can also be manufactured by crashing waste concrete and clay bricks

Based on source or method of manufacture

- CRUSHED STONE

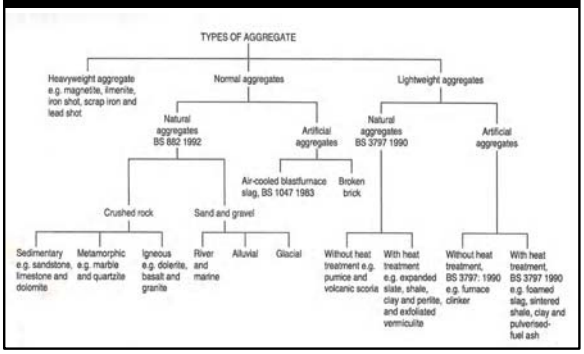
Based on size

- FINE AGGREGATE
- Also called sand
- Consists of natural and manufactured particles ranging in size from 0.006in to 4.75mm

Based on size

- COARSE AGGREGATE
- Consists of rounded river gravel, crushed stone or manufactured aggregated with particles size equal to or larger than 4.75mm

Bases on density



Bases on density

- LIGHTWEIGHT
- Lightweight fine aggregate is any aggregate with bulk density less than 1120kg/m^3.
- Lightweight coarse aggregate with bulk density less than 880kg/m^3
- Lightweight aggregates are being used as ingredients in the manufacture of light weight concrete, for making lightweight blocks, floor or roof slab

Bases on density

- NORMAL WEIGHT
- E.g. crushed stones, gravel and ordinary sand
- The density of normal weight aggregates is around 1520 to 1680kg/m^3
- Commonly used in manufacture of normal weight concrete, asphalt concrete and roadway sub-base

Bases on density

- HEAVY WEIGHT
- An aggregate of high density and is used primarily in the manufacture of heavyweight concrete, employed for protection against nuclear radiation and as bomb shelters.
- The density varies from 2400kg/m^3 to 6400kg/m^3

Shapes of aggregates

Angular

Stronger concrete than round shape due to its texture and surface that cement paste will bind the aggregates

Need more water for better workability during mixing but too much water could effect the concrete strength

Round

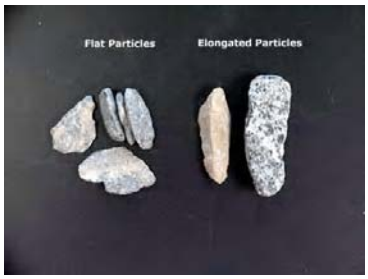
Smooth edges

Flat

Elongated

Flat or elongated particles tend to lock up more readily during compaction making compaction more difficult.

They also have a tendency to fracture during compaction along their weak, narrow dimension, which can effectively make aggregate gradation finer



Sieve analysis (Gradation test)

Sieve analysis

- To determined the gradation of aggregates
- A representative sample of the aggregate is passed through a series of sieves and the weight retained in each sieve (as percentage of the sample weight) is compared with the grading limits

Sieve apparatus

Sieve apparatus

- Round or square shape
- The size is identified by numbers
- The higher the number the smaller the opening is
- The standard sieve for coarse aggregate is No 4 (4.75mm)
- The standard sieve for fine aggregate are Nos. 100 (0.15mm), 50 (0.30mm), 30 (0.60mm), 16 (1.18mm), 8 (2.36mm) and 4 (4.75mm)

- To find the percent of aggregate passing through each sieve, first find the percent retained in each sieve. To do so, the following equation is used,
- $\%\text{Retained} = \frac{W_{sieve}}{W_{total}} \times 100$
- where W_{sieve} is the weight of aggregate in the sieve and W_{total} is the total weight of the aggregate

Example for 307g aggregate

Sieve size	Wsieve(g)	% sieve	%
37.5 mm	-	-	
20 mm	-	-	
14 mm	-	-	
10 mm	0	0	100
5 mm	6	2	98
2.36 mm	31	10.1 (10)	88
1.18 mm	30	9.8 (10)	78
600 µm	59	19.2 (19)	59
300 µm	107	34.9 (35)	24
150 µm	53	17.3 (17)	7
75 µm	-	-	-
Penadah	21	6.8 (7)	-
Total	307	100	0

A number of physical and mechanical properties affect durability, strength, and performance of construction products made with aggregates. Although aggregates themselves can be put to use as a construction material – as in railroad ballast – it is more common to use them along with a binder such as portland cement or asphalt. In this regards, the aggregate particles should bond well with the bonding agent and also retain their strength, shape and texture throughout the service life

Properties of aggregates

Toughness and abrasion resistance

- Aggregates should be hard and tough enough to resist crushing, degradation and disintegration from activities such as manufacturing, stockpiling, placing and compaction.

Particle shape and surface texture

- Particle shape and surface texture are important for proper compaction, load resistance and workability.
- Generally, angular-shaped particles with a rough surface texture are best.

Durability and soundness

- Aggregates must be resistant to breakdown and disintegration from weathering (wetting/drying) or else they may break apart and cause premature distress.

Cleanliness and deleterious materials

- Aggregates must be relatively clean
- Vegetation, soft particles, clay lumps, excess dust and vegetable matter may affect performance by quickly degrading, which causes a loss of structural support and/or prevents binder-aggregate bonding

Transportation of aggregates

Transportation of aggregates

- By lorry
- Considers:
  - Quantity
  - Clean – free from unwanted materials
  - Grades – ensure the size
  - Types and shape
  - Delivery notes

Storage of aggregates

Storage of aggregates

- On construction site, it should be placed near to concrete mixer
- Well kept to avoid contamination with other materials and to avoid wastage
- Aggregates could lost due to wastage for up to 50%
- It is best to place it on a layer of lean concrete
- Otherwise, ensure that the site has proper drainage

Storage of aggregates

- Avoid placing near trees and ensure that it will not disturb the work on site
- Determine sufficient storage area

Thank you