(Sourced)

Definition and Types of Aggregate

Aggregates include sand, gravel, crushed stone, crushed bricks and recycled concrete.

- Aggregates are a component of composite materials such as concrete and asphalt concrete; the aggregates serve as reinforcement to add strength to the overall composite materials.
- Aggregates are also used as base material under foundations, roads and railroads.
- **Aggregate Types**:

  - Coarse aggregate:
    - Retained on or above #4 sieve
  - Fine aggregate:
    - Retained on the #200 sieve and passing #4 sieve
  - Soil / Fines / Mineral filler:
    - Passing #200 sieve

(Sourced)

Coarse Aggregate

- Any type of pavements, either rigid or flexible , coarse aggregate is the prime material used in them
- In case of flexible pavements, coarse aggregates constitute about 90% or even more of the total construction material
- Coarse aggregates bear stresses occurring on road surface and also resists wear and tear due to abrasive action of traffic
- Aggregates are specified according to their size, shape, texture and gradation
- For different thickness and types of aggregates size and gradation are specified differently
- AAASHTO, ASTM, BS have specified grading for highway construction.
- Most of the aggregates are obtained from natural rocks by crushing

(Sourced)

Properties of Aggregate

- Particle size and Gradation
- Hardness or resistance to wear
- Durability or resistance to weathering
- Specific gravity and Absorption
- Chemical stability
- Particle shape and surface texture
- Freedom from deleterious particles or substances

Aggregate tests

In order to decide the suitability of the aggregate for use in pavement construction, following tests are carried out:

- Crushing test
- Abrasion test
- Impact test
- Soundness test
- Shape test
- Specific gravity and water absorption test
- Bitumen adhesion test

(Sourced)

Properties of Aggregate

Particle size and Gradation

- A key property of aggregates used for highway bases and surfaces is the distribution of particle sizes in the aggregate mix.
- The gradation of aggregates, that is, the blend of particle sizes in the mix affects the density, strength and economy of the pavement structure.
- When particles are to be bounded by a Portland cement or a bituminous binder, a variation in the gradation will change the amount of binder needed to produce a mix of given stability and quality.
- Particle size and gradation also affects workability and permeability of a bituminous mix.
- **A grain size analysis** is used to determine the relative proportions of various particle sizes in an aggregate mix.

(Sourced)

Hardness and Resistance to Wear

- Under heavy traffic loads, aggregates in flexible pavement are subjected to continuous slight movements and distortion.
- This action causes different pieces of aggregate to rub and grind against each other.
- Mats used in pavements should be hard and resist wear due to these polishing effects of traffic and the internal abrasive effects of repeated loading.
- ACV, AIV, LAA Test

(Sourced)

Durability or Resistance to Weathering

- The aggregates are subjected to physical and chemical action of rain, ground water and other atmospheric impurities.
- So aggregates used in highway construction should be capable to withstand such weathering action.
- Durability and resistance to weathering of aggregates is measured by **soundness test.**
- The test measures the **resistance of aggregates** to disintegration in a saturated solution of sodium or magnesium sulfate. It simulates the weathering of aggregates that occur in nature.
- This property is helpful to prolong the life of pavement.

(Sourced)

Specific Gravity

- Specific gravity is a measure of a material's density , in other words, strength and quality. Stones having higher specific gravities are considered **strong**. [limestone SG 2.6 and density 165-170 lb/sft, lead SG 11.0 and density 680-690 lb/sft]
- Specific gravity of a coarse aggregate is calculated by determining the ratio of the weight of a given volume of aggregate to the weight of an equal volume of water.
- Aggregates may contain water-permeable voids(WPV).Two measures of specific gravity of aggregates are used: apparent specific gravity (excluding WPV) and bulk specific gravity(including WPV).

(Sourced)

Absorption

- Absorption is a measure of the amount of water that an aggregate can absorb into its pore structure.
- Aggregate absorption is a useful quality because:
  - High values can indicate non-durable aggregate.
  - Absorption can indicate the amount of asphalt binder the aggregate will absorb.
- It is generally desirable to **avoid highly absorptive** aggregate. This is because asphalt binder that is absorbed by the aggregate is not available to coat the aggregate particle surface and is therefore not available for bonding.
- Therefore, highly absorptive aggregates (often specified as over 5 percent absorption) require more asphalt binder to develop the same film thickness as less absorptive aggregates making the resulting mix more expensive.

(Sourced)

Particle Shape

Classification	Description
Rounded	Fully water-worn or completely shaped by attrition
Irregular	Naturally irregular or partly shaped by by attrition and having rounded edges
Flakey	Thickness is smaller relative to other two dimensions
Angular	Possessing well defined edges
Elongated	Usually angular, length is larger than other two dimensions
Flakey and elongated	Length considerable larger than thickness

(Sourced)

Particle Shape and Surface Texture

- Shape and texture provide guidance about **internal friction** properties (interlocking of particles and surface friction) which resist the movement of aggregates past each other under the action of an imposed load.
- Flaky and elongated particles are **less strong and durable**.
- Rounded particles are have **less interlocking capability** and not preferred in WBM and bituminous road construction.
- Angular particle is **preferred** in bituminous pavement.
- **Rough-textured** aggregates contribute more to the **stability** of a pavement than smooth surface textures.

(Sourced)

Chemical Stability of Aggregate

Composition

- Certain Aggregate may be unsuitable for a particular highway construction because of the chemical composition of the aggregate particle
- Limestone consists of calcium carbonate and has a tendency to polish smooth under traffic and therefore is limited to use in low traffic volume.
- Dolostone [sedimentary calcium magnesium carbonate rock] under traffic maintains a higher friction, skid-resistance surface and is used in higher traffic volume locations.

(Sourced)

Chemical Stability of Aggregate

Bitumen Adhesion

- In asphalt mixes, certain aggregates that have an excessive affinity for water may contribute film stripping, leading to disintegration of asphalt surfaces.
- 'Hydrophobic' or 'water-hating' aggregates exhibits high degree of resistance to film stripping.
- Opposite is 'hydrophilic' or 'water-loving'.
- Bituminous pavement> bituminous material> thin film> fill void and adhere to aggregate> increase shearing resistance and cohesion.
- Exposed to water> water replace the film.

(Sourced)

Chemical Stability of Aggregate

Deleterious Substances

- Aggregates that contain deleterious [harmful] substances react harmfully with the alkalis present in the cement.
- Detrimental alkali-aggregate reactions result in abnormal expansion of the concrete.
- Aggregates used in cement concrete mixes must be free of deleterious substances such as clay lumps, silt and organic impurities.

Other Properties of Aggregates

➢ Good aggregate having sufficient *cementation property*

Test for Road Aggregate

(Sourced)

- Los Angeles Abrasion Test (Resistance to wear)
- Aggregate Crushing Value (ACV) Test (Strength or toughness)
- Aggregate Impact Value (AIV) Test (Strength or toughness)
- Soundness Test (Durability)
- Gradation Test (Grain size distribution)
- Unit Weight and Void Test
- Specific Gravity and Water Absorption Test
- Bitumen Affinity or Stripping Test
- Clay Lump Test
- Organic Impurities Test
- Flakiness Index Test (Shape)
- Elongation Index Test (Shape)
- Angularity Number Test (Shape)

(Sourced)

BRICK AGGREGATES

Source- Crushed brick

- **Uses- Base , Sub-base courses, Low cost roads, Surface course (for light traffic)**

(Sourced)

RHD Specification for CA for Bituminous Mix

S.No.	Name of Test	Testing Procedure	Wearing Course	Base Course
1	Aggregate Crushing Value (ACV) (%)	STP 7.7.1	Less than 25%	Less than 30%
2	Los Angeles Abrasion (LAA) (%)	AASHTO T96	Less than 30%	Less than 35%
3	Water absorption	STP 7.5.4	Not more than 2%	Not more than 2%
4	Soundness	AASHTO T104	Loss in weight (after 5 cycles) with Sodium Sulphate solution- not more than 10%	
5	Coating & Stripping Test	AASHTO T182	Min. 95% retained coating	

When crushed gravel is used, not less than 90% by weight of the particles retained on a 5 mm sieve shall have at least two fractured faces.

The flakiness index as determined in accordance with STP 7.3.1 shall not exceed 30%.

(Sourced)

Fine Aggregates (Sand)

General points

- Sand is a naturally occurring granular material composed of finely divided rock and mineral particles.
- Sand is a form of silica.
- Sand grains may be sharp, angular or rounded in shape.

Classification of Sand

- According to source- Pit sand, River Sand and Sea sand
- According to size- Fine sand (passing no. 16 sieve), Moderately coarse sand (passing no. 8 sieve) and Coarse sand (passing no. 4 sieve)

Fine Aggregates (Sand)

(Sourced)

Properties of Sand

- Sand should be pure silica.
- Should be free from clay, silt, organic matter and salt.
- Should drain groundwater freely.
- Should not expand or contract with changing moisture content.
- Resist high load without sliding or compacting.

Uses of sand

- Making cement concrete for rigid pavement.
- Stabilized road construction.
- Making bases and sub-bases.
- To fill up the gaps between bricks in brick road.