A

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TESTS ON CEMENT AND AGGREGATES

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ABSTRACT

Concrete is one of the most widely used construction materials, with its properties greatly influenced by the quality of its constituent materials: cement and aggregates. This research study aims to evaluate the characteristics and performance of cement and aggregates. The investigation includes a comprehensive series of laboratory tests to assess the physical, mechanical, and chemical properties of these materials. Cement, a fundamental component of concrete, plays a critical role in the construction industry, and its performance directly impacts the strength and durability of concrete structures. This research focuses on a thorough examination of various properties and characteristics of cement through a series of comprehensive tests and analyses.

Aggregates are essential constituents of concrete and asphalt mixtures, and their quality directly influences the performance and durability of construction materials. This research project involves a thorough investigation into the properties and characteristics of various types of aggregates commonly used in construction. A wide range of laboratory tests and analyses are conducted to assess the physical, mechanical, and chemical attributes of these aggregates.

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CHAPTER-1

INTRODUCTION

1.1 CEMENT:

A cement is a binder, a chemical substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. Concrete is the most widely used material in existence and is behind only water as the planet's most-consumed resource.

Cements used in construction are usually inorganic, often lime or calcium silicate based, which can be characterized as hydraulic or the less common non-hydraulic, depending on the ability of the cement to set in the presence of water (see hydraulic and non-hydraulic lime plaster).

Cement starts to set when mixed with water, which causes a series of hydration chemical reactions. The constituents slowly hydrate and the mineral hydrates solidify and harden. The interlocking of the hydrates gives cement its strength. Contrary to popular belief, hydraulic cement does not set by drying out — proper curing requires maintaining the appropriate moisture content necessary for the hydration reactions during the setting and the hardening processes. If hydraulic cements dry out during the curing phase, the resulting product can be insufficiently hydrated and significantly weakened. A minimum temperature of 5 °C is recommended, and no more than 30 °C. The concrete at young age must be protected against water evaporation due to direct insolation, elevated temperature, low relative humidity and wind.

The interfacial transition zone (ITZ) is a region of the cement paste around the aggregate particles in concrete. In the zone, a gradual transition in the microstructural features occurs. This zone can be up to 35 micrometer wide. Other studies have shown that the width can be up to 50 micrometer. The average content of unreacted clinker phase decreases and porosity decreases towards the aggregate surface. Similarly, the content of ettringite increases in ITZ.

Cement, in general, adhesive substances of all kinds, but, in a narrower sense, the binding materials used in building and civil engineering construction. Cements of this kind are finely ground powders that, when mixed with water, set to a hard mass. Setting and hardening result from hydration, which is a chemical combination of the cement compounds with water that yields submicroscopic crystals or a gel-like material with a high surface area. Because of their hydrating properties, constructional cements, which will even set and harden under water, are often called hydraulic cements. The most important of these is portland cement.

This article surveys the historical development of cement, its manufacture from raw materials, its composition and properties, and the testing of those properties. The focus is on portland cement, but attention also is given to other types, such as slag-containing cement and high-alumina cement. Construction cements share certain chemical constituents and processing techniques with ceramic products such as brick and tile, abrasives, and refractories. For detailed description of one of the principal applications of cement, see the article building construction. Cement is an extremely fine material having adhesive and cohesive properties which provide a binding medium for the discrete ingredients.

Fig-1.1: cement

1.2 AGGREGATES:

Aggregates are often overlooked when we talk about the construction industry today. They are not appealing. They are not glamorous. They are just rocks, after all. That said, aggregates are – quite literally – the building blocks of our society. Aggregate production dates back to the Roman Empire, and it has been critical to the growth of our world ever since.

Essentially, they are the most basic material used in construction. They provide the foundation for roads, bridges, and buildings, while also making up over 90% of an asphalt pavement and up to 80% of a concrete mix. On average, 38,000 tons of aggregates are necessary to construct one lane mile of interstate highway. Construction of the average home requires 400 tons of aggregate, while the average size school or hospital requires 15,000 tons.

Every state and roughly three-quarters of the nation's counties are home to an aggregate operation, producing nearly 2.4 billion tons of material annually, valued at over $25 billion. That's a huge impact for some rocks.

Aggregates are raw materials that are produced from natural sources and extracted from pits and quarries, including gravel, crushed stone, and sand. When used with a binding medium, like water, cement, and asphalt, they are used to form compound materials, such as asphalt concrete and Portland cement concrete.

In 2018, according to the U.S. Geological Survey Mineral Commodity Summary, 75% of the 1.4 billion tons of crushed stone produced was used in construction. Meanwhile, of the almost 1 billion tons of sand and gravel produced, 24% was used in road construction, 12% in asphalt, and 44% in concrete. Not only are aggregates the building blocks of our society, they are also prevalent in our daily lives. The average American requires roughly 10,000 tons of aggregate per year. We would not have glass and plastic without sand, or pennies without zinc. Quartz gives us the silica for computer parts, limestone gives us the calcium carbonate for antacids. Aggregates are also used in the water filtration and purification process, as well as air filtration and purification.

Fig-1.2: Aggregates

Aggregates must have predictable, uniform, and consistent materials properties. They must be dry and clean before they can be used. Aggregates are only as good as their processing. They are mined, crushed, washed, and separated. The successful outcome of each step, the processing of a good aggregate, depends on the success of the previous step. That success depends on the hardworking men and women in the aggregates industry, men and women who often go overlooked and underappreciated in the construction industry.

Aggregates are here to stay. Today's machines are high performance, low maintenance, and energy efficient machines. They allow the men and women in that industry to work quickly and safely while producing high quality materials.

Aggregates are the most mined material in the world. Construction aggregate is a broad category of granular raw material of different sizes (sand, gravel, crushed stone, slag, recycled concrete etc) used in construction. Uses of aggregate in civil engineering include the following.

Aggregate can be used in a number of ways in construction. In roads and railway ballast the aggregates are used to resist the overall (static as well as dynamic) load, to distribute the load properly to the supporting ground and to drain the water off the surface. In concrete the aggregate is used for economy, reduce shrinkage and cracks and to strengthen the structure. They are also used in water filtration and sewage treatment processes. The uses of aggregates can be summarized in to the following three categories:

- As a Load Bearing Material.
- As a Filling Material.
- As an Infiltrating Material.

Uses of Aggregate in Concrete

Aggregate is an essential ingredient of concrete. The uses of aggregates in concrete is:

Increases the volume of concrete, thus reduces the cost. Aggregates account for 60-75% of the volume of concrete and 79-85% weight of PCC.

- To provide a rigid structure.
- To reduce the shrinkage and cracking.
- Concrete aggregate is used in many structures and substructures e.g. different elements of a Building, bridges, foundations.
- The smaller the aggregate size the greater its surface area and the more binding material (cement) will be required, resulting in a higher cost.

- The greater the aggregate size the larger will be the voids, resulting in wastage of binding material (cement).
- Hence a mixture of coarse and fine aggregate is used in concrete to avoid both these problems.

Uses of Aggregates in Roads

- Aggregates are used as the base, subbase, and/or surface of roads in several forms:
- Stabilized using cementitious materials (blends of cement, fly ash, slag, lime).
- Stabilized with bituminous materials (bitumen or tar).
- Stabilized with other materials (resins, fibers, geosynthetics, etc.).
- Recycled aggregate.

In roads, it is also used to help distribute the load and assist in ground water running off the road.

Properties of aggregate used in railway ballast are very different from those used in roads. The uses of aggregates in railway ballast include:

A fully loaded train weighs in thousands of tons. To avoid damage to the rails, ground and other nearby structures a very tough aggregate is needed not only to support this high weight but also to distribute and transfer it properly to the ground.

Railway ballast generally consists of a tough igneous rock (crushed), such as granite, with a larger diameter varying between 30mm to 50mm. Particles finer than this diameter in higher proportion will reduce its drainage properties. While a higher proportion of larger particles result in the load on the ties being distributed improperly.

Other uses include fills, backfills, and drainage and filtration applications.

CHAPTER-2
TYPES OF CEMENT AND AGGREGATES

2.1 Types of Cement

There are a variety of types of cement you can use depending on your project's purpose and conditions. Here are 15 types of cement:

1. Ordinary Portland cement (OPC)

Ordinary Portland cement is the most widely used type of cement manufactured and used worldwide. “Portland” is a generic name derived from a type of building stone quarried on the Isle of Portland in Dorset, England. OPC is suitable for most general concrete jobs and mortar or stucco construction projects.

2. Portland pozzolana cement (PPC)

Manufacturers create Portland pozzolana cement by grinding pozzolanic clinker, sometimes with additives of gypsum or calcium sulfate, with ordinary Portland cement. Compared to OPC, it has a higher resistance to various chemical reactions within concrete. PPC is often used for projects like bridges, piers, dams, marine structures, sewage works or underwater concrete projects.

3. Rapid-hardening cement

Contractors or construction teams may choose rapid-hardening cement for its high strength in the early stages of the hardening process. Its strength in three days is comparable to OPC strength at seven days with the same water-to-cement ratio. Rapid-hardening cement may have an increased lime content, combined with a finer grinding process, or better strength development. It is often used for projects with early-stage formwork removal or when the focus is on increasing construction rates and decreasing costs.

4. Extra-rapid-hardening cement

Extra-rapid-hardening cement may set and become durable even faster than OPC and rapid-hardening cement. Construction professionals achieve this by adding calcium chloride to rapid-hardening cement. This cement type may be useful for cold-weather concrete projects due to its fast setting rate.

5. Quick-setting cement

Similar to extra-rapid-hardening cement, this concrete type may set and become stronger even quicker than OPC and rapid-hardening cement. Its grain and strength rate are similar to OPC, but it hardens faster. Quick-setting cement may be beneficial for time-sensitive projects or those located near stagnant or running water.

6. Low-heat cement

Manufacturers produce low-heat cement by monitoring the percentage of tricalcium aluminate in the mixture to ensure it stays below 6% of the whole. This helps maintain low heat during the hydration process, making this cement type more resistant to sulfates and less reactive than other types of cement. It may be suitable for mass concrete construction or projects to help prevent cracking due to heat. However, low-heat cement may have a longer initial setting time than other types.

7. Sulfate-resisting cement

Sulfate-resisting cement helps reduce the risk of sulfate side effects on concrete. Its most common use is for constructing foundations in soil with high sulfate content. This concrete type can also be beneficial for projects like canal linings, culverts and retaining walls.

8. Blast furnace slag cement

Manufacturers make blast furnace slag cement by grinding clinker with up to 60% slag. This creates cement with many of the same properties as OPC. However, it may be less expensive to produce than other types, making it a good choice for financially conscious projects.

9. High-alumina cement

High-alumina cement is a type of rapid-hardening cement created by melting bauxite and lime together and grinding it with clinker. It has high compressive strength and may be more flexible and workable than OPC. Construction teams can use high-alumina cement for projects where cement is subject to extreme weather like high temperatures or frost.

10. White cement

White cement is a type of OPC that's white instead of gray. It's prepared from raw materials that don't include iron oxide and may be more expensive than other cement types. It's often useful in architectural projects and interior and exterior decorative projects like designing garden paths, floors, swimming pools and ornamental concrete products.

11. Colored cement

Colored cement has properties similar to OPC and white cement. Manufacturers mix 5% to 10% mineral pigments with OPC to achieve the desired colour. Like white cement, contractors often use this type for decorative purposes and projects to enhance their designs.

12. Air-entraining cement

Air-entraining cement is more workable with a smaller water-cement ratio than OPC and other types of cement. Manufacturers add air-entraining agents like glues, sodium salts and resins to the clinker during the grinding process to create this cement. A common use for this type of cement is for frost resistance in concrete.

13. Expansive cement

Expansive cement can grow slightly over time without shrinking during the hardening process. It may be beneficial for projects like grouting anchor bolts or concrete ducts. Teams can also use it in structure joints or to reinforce other concrete structures.

14. Hydrographic cement

Manufacturers create hydrographic cement by mixing in water-repelling chemicals. This cement type has high workability and strength and also repels water to prevent weather damage. Teams can use hydrographic cement for projects such as dams, water tanks, spillways and water retaining structures.

15. Portland-limestone cement (PLC)

Portland-limestone cement is a blend of Portland cement and 5% to 15% fine limestone. Its properties are similar to Portland cement for general use. However, it also has about 10% lower greenhouse gas emissions, which can help increase sustainability.

2.2 Types of Aggregates

Natural Aggregates: These are one of the types of aggregates and are obtained from naturally obtained rocks like Sedimentary, Igneous and Metamorphic rocks. Sand and gravel are also fallen into this type of aggregates. As these Aggregates are naturally obtained which may have a lot of impurities, so it should be sieved and washed before used in Concrete.

Fig-2.2(a): Natural aggregates

Artificial Aggregates: Blast Furnace Slag, Broken Bricks and Synthetic aggregates are Artificial Aggregates. Blast furnace slag aggregate is formed from slow cooling of the slag followed by crushing and are used for making precast concrete products by obtaining strong, denser particles. Broken bricks are used in Foundation for mass concerning and are not recommended for reinforced concrete works. Synthetic aggregates are made by Thermally processed materials like expanded clay and shale (finely-grained sedimentary rock, composed of mud).

Fig-2.2(b): Artificial aggregates

CHAPTER-3

TESTS ON CEMENT

3.1 LABORATORY TESTS ON CEMENT

- Field Test
- Laboratory Test

FIELD TEST ON CEMENTS

The following tests should undergo before mixing the cement at construction sites:

- **Colour Test of Cement**

The colour of the cement should not be uneven. It should be a uniform grey colour with a light greenish shade.

- **Presence of Lumps**

The cement should not contain any hard lumps. These lumps are formed by the absorption of moisture content from the atmosphere. The cement bags with lumps should be avoided in construction.

Fig-3.1(a): Lumps in cement

- **Cement Adulteration Test**

The cement should be smooth if you rubbed it between fingers. If not, then it is because of adulteration with sand.

Fig-3.1(b): Adulteration test on cement

- **Float Test**

The particles of cement should flow freely in water for sometime before it sinks.

- **Date of Manufacturing**

It is very important to check the manufacturing date because the strength of cement decreases with time. It's better to use cement before 3 months from the date of manufacturing. If hand is inserted in a bag, it should feel cool.

Laboratory Tests on Cements

1. Fineness Test
2. Consistency Test
3. Setting Time Test
4. Strength Test
5. Soundness Test
6. Heat of Hydration Test
7. Tensile Strength Test
8. Chemical Composition Test

1. Fineness test on cement

The fineness of cement is responsible for the rate of hydration, rate of evolution of heat and the rate of gain of strength. Finer the grains more is the surface area and faster the development of strength.

The fineness of cement can be determined by Sieve Test or Air Permeability test.

Sieve Test: About 100 g of cement is weighed and sieved using a 90-micron IS sieve. Air-set lumps are broken and the cement is sieved continuously in a circular and vertical motion for a period of 15 minutes. A mechanical sieve shaker may also be used. The residue left on the sieve is weighed. This weight shall not exceed 10% for ordinary cement. This test is rarely used.

Fig-3.1(c): Air penetration test

Air Permeability Test: Blaine's Air Permeability Test is used to find the specific surface, which is expressed as the total surface area in sq.cm/g. of cement. The surface area is more for finer particles.

2. Consistency test on cement

Consistency Test is conducted to find the setting times of cement, viz., initial setting time and final setting time. The test is conducted using a standard consistency test apparatus, viz., Vicat's apparatus (below figure).

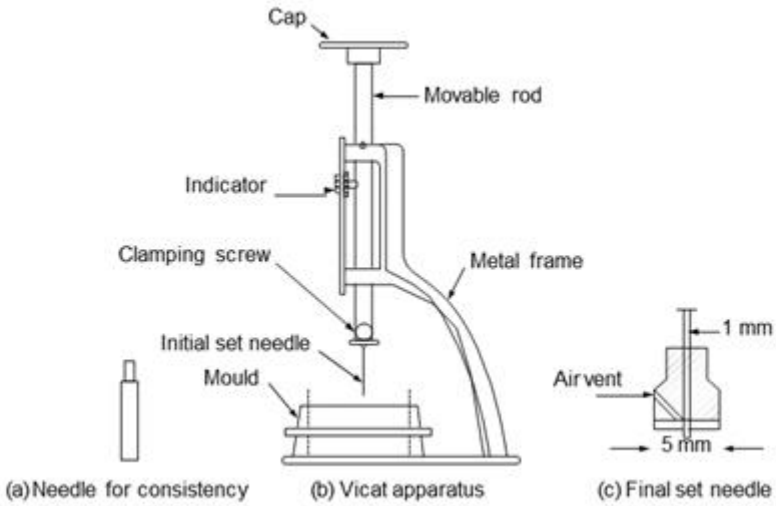

Fig-3.1(d): Vicat apparatus with various plungers

Standard or normal consistency of cement paste is defined as that water content which will permit a Vicat plunger of 10 mm diameter and 50 mm length to penetrate depths of 33–35 mm within 3–5 minutes of mixing. The test has to be repeated thrice. Each time the cement is mixed with water varying from 24 to 27% of the weight of cement. It is required that the test be conducted at a constant temperature of 27 ± 2°C and at a constant humidity of 20%.

The test procedure is simple. The paste prepared within 3–5 minutes is filled into the Vicat mould and shaken to expel air. The standard needle is brought down to touch the sur- face of the paste and quickly released allowing to sink into the paste by its own weight. The depth of the penetration is noted. Then that percentage of water that allows the plunger to penetrate only to a depth of 33–35 mm is known as the percentage of water required to produce a cement paste of standard consistency.

3. Setting Time of cement

Vicat's apparatus is used to find the setting times of cement i.e., initial setting time and final setting time.

Initial Setting Time About 500 g of the cement sample is taken and water content 0.85 P, where P is the percentage of water required as per the consistency test is added and made into a paste. The paste has to be made within a period of 3–5 minutes and filled into the mould.

For this test, a needle of 1 mm square size (needle C) is used. The needle is allowed to penetrate into the paste. The time taken to penetrate 33–35 mm depth is taken as the initial setting time.

Fig-3.1(e): vicat apparatures

Final Setting Time: The needle C is replaced by needle F. The attachment is lowered gently to cover the surface of the test block. The central needle makes an impression, whereas the circular cutting edge fails to do so. That is, the paste has attained hardness, and the centre needle does not penetrate the paste more than 0.5 mm. Thus, the time at which the needle does not penetrate more than 0.5 mm is considered to be the final setting time.

4. **Strength test of cement**

The strength of cement cannot be determined directly on cement. Instead, the strength of cement is indirectly determined on cement-mortar of 1:3, and the compressive strength of this mortar is the strength of cement at a specific period. For this test, 555 g of standard sand and 185 g of cement is mixed with water quantity P/4 + 3% of the combined weight of the cement and sand mixture. These are mixed thoroughly within 3–4 minutes. The mixed paste is filled in a cube mould of size 7.06 mm, which has a face area of 50 sq cm. The mortar is compacted by a tamping rod or in a vibrator. The moulds have to be kept in a room with a controlled temperature of 27 ± 2°C and at least 90% humidity. If this facility is not available, the moulds are kept under a wet gunny bag to simulate 90% relative humidity. The cubes are removed from the mould after 24 hours and kept immersed in clean water till taken out for testing.

Three cubes are tested for compressive strength after a specific period (viz., 3, 7 or 28 days). The period is being reckoned with from the completion of vibration. The average compressive strength of the three cubes gives the strength of cement at the specific period.

Fig-3.1(f): compression test

5. **Soundness test of cement**

This test is conducted in Le Chatelier's apparatus to detect the presence of uncombined lime and magnesia in cement. The Soundness Test is performed to detect the presence of uncombined lime and magnesia in cement. This test is conducted in Le Chatelier's apparatus (below figure). It consists of a small brass cylinder of 30 mm diameter, 30 mm height and 0.5 mm thickness, which is split along its generation with the split not exceeding 0.5 mm. On either side of the split, two indicators with pointed ends are provided.

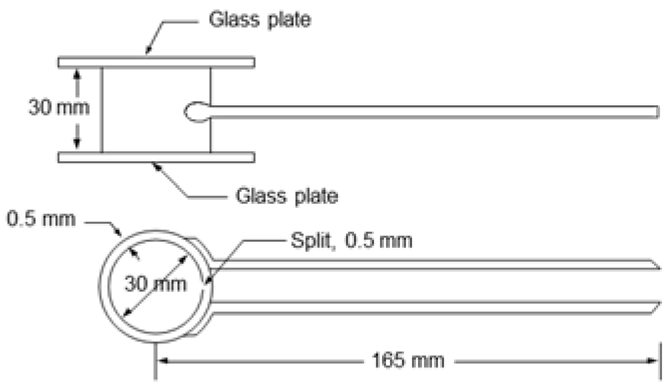

Fig-3.1(g): Le Chatelier's apparatus (a)

The cement paste is prepared with water content at consistency. The cylinder is placed over a glass plate and is filled with cement paste. It is covered with another glass plate on the top. The whole assembly is immersed in water at 24–35°C for 24 hours. After 24 hours, the gap between the indicators is measured.

The mould with the specimen is immersed in the water again and boiled for 30 minutes. After boiling for 1 hour, the mould is taken out and cooled. Again the gap between the indicators is measured after the end of cooling. The increase in the gap represents the expansion of cement.

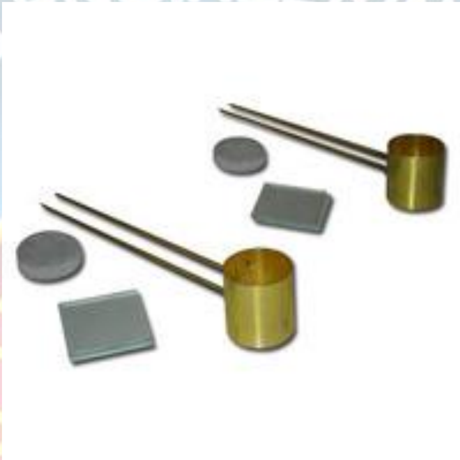

Fig-3.1(h): Le Chatelier’s apparatus (b)

6. **Heat of Hydration Test**

During the hydration of cement, heat is produced due to chemical reactions. This heat may raise the temperature of concrete to a high temperature of 50°C. To avoid these, in large scale constructions low-heat cement has to be used.

Fig-3.1(i): Heat of hydration test

This test is carried out using a calorimeter adopting the principle of determining heat gain. It is concluded that Low-heat cement should not generate 65 calories per gram of cement in 7 days and 75 calories per gram of cement in 28 days.

Tensile Strength of Cement

This test is carried out using a cement-mortar briquette in a tensile testing machine. A 1:3 cement-sand mortar with the water content of 8% is mixed and moulded into a briquette in the mould.

This test is conducted using a cement-mortar briquette in a tensile testing machine. The dimensions of the briquette are shown below figure.

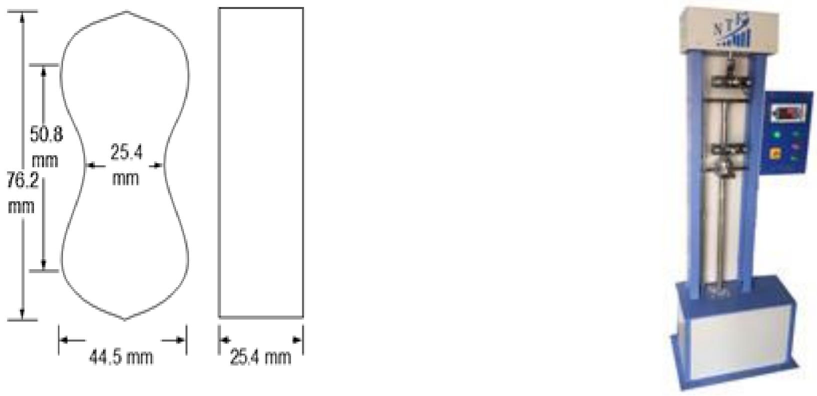

Fig-3.1(j): Standard cement-mortar briquette

This mixture is cured for 24 hours at a temperature of 25°C or 29°C and in an atmosphere at 90% relative humidity.

The average strength for six briquettes tested after 3 and 7 days is recorded.

7. **Chemical Composition Test**

Different tests are conducted to determine the amount of various constituents of cement. The requirements are based on IS: 269-1998, is as follows:

- The ratio of the percentage of alumina to that of iron oxide should not be less than 0.66.
- Lime Saturation Factor (LSF), i.e., the ratio of the percentage to that of alumina, iron oxide and silica should not be less than 0.66 and not be greater than 1.02.
- Total loss on ignition should not be greater than 4%.
- Total sulphur content should not be greater than 2.75%.
- Weight of insoluble residue should not be greater than 1.50%.
- Weight of magnesia should not be greater than 5%.

CHAPTER-4
TESTS ON AGGREGATES

4.1 LABORATORY ON AGGREGATES

Aggregate plays an important role in pavement construction. Aggregates influence, to a great extent, the load transfer capability of pavements. Hence it is essential that they should be thoroughly tested before using for construction. Not only that aggregates should be strong and durable, they should also possess proper shape and size to make the pavement act monolithically. Aggregates are tested for strength, toughness, hardness, shape, and water absorption.

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

1. Crushing test
2. Abrasion test
3. Impact test
4. Soundness test
5. Shape test
6. Specific gravity and water absorption test

1.Crushing Test

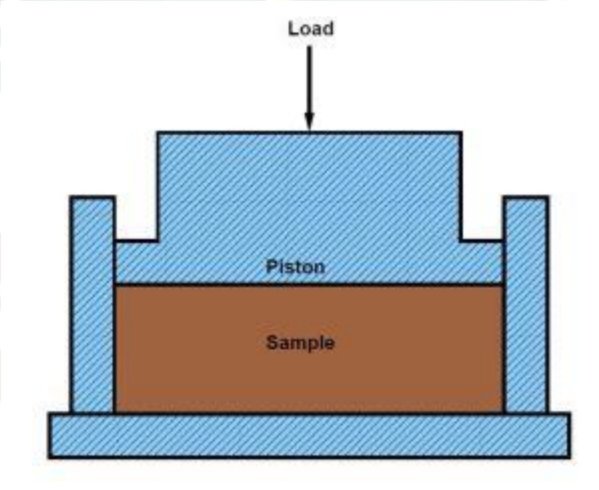

Fig-4.1(a): Crushing Test Setup

One of the model in which pavement material can fail is by crushing under compressive stress. A test is standardized by **IS: 2386 part-IV** and used to determine the crushing strength of aggregates. The aggregate crushing value provides a relative measure of resistance to crushing under gradually applied crushing load.

The test consists of subjecting the specimen of aggregate in standard mould to a compression test under standard load conditions (See Fig-1). Dry aggregates passing through 12.5 mm sieves and retained 10 mm sieves are filled in a cylindrical measure of 11.5 mm diameter and 18 cm height in three layers. Each layer is tamped 25 times with at standard tamping rod. The test sample is weighed and placed in the test cylinder in three layers each layer being tamped again. The specimen is subjected to a compressive load of 40 tonnes gradually applied at the rate of 4 tonnes per minute. Then crushed aggregates are then sieved through 2.36 mm sieve and weight of passing material (**W2**) is expressed as percentage of the weight of the total sample (**W1**) which is the aggregate crushing value.

Aggregate crushing value = (W1/W2)*100

A value less than 10 signifies an exceptionally strong aggregate while above 35 would normally be regarded as weak aggregates.

2.Abrasion Test

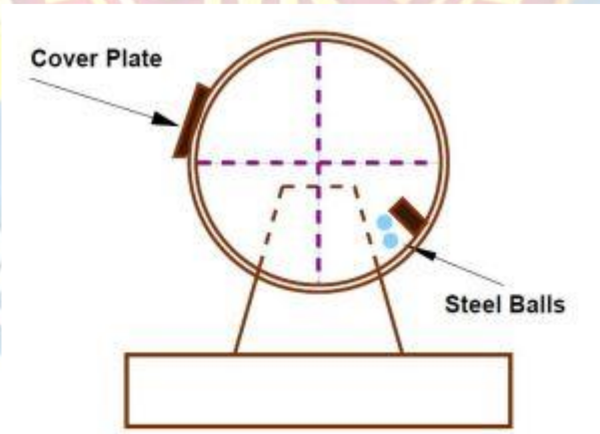

Fig-4.1(b): Los Angeles Abrasion Test Setup

Abrasion test is carried out to test the hardness property of aggregates and to decide whether they are suitable for different pavement construction works. Los Angeles abrasion test is a preferred one for carrying out the hardness property and has been standardized in India (**IS: 2386 part-IV**).

The principle of Los Angeles abrasion test is to find the percentage wear due to relative rubbing action between the aggregate and steel balls used as abrasive charge.

Los Angeles machine consists of circular drum of internal diameter 700 mm and length 520 mm mounted on horizontal axis enabling it to be rotated (see Fig-2). An abrasive charge consisting of cast iron spherical balls of 48 mm diameters and weight 340-445 g is placed in the cylinder along with the aggregates. The number of the abrasive spheres varies according to the grading of the sample. The quantity of aggregates to be used depends upon the gradation and usually ranges from 5-10 kg. The cylinder is then locked and rotated at the speed of 30-33 rpm for a total of 500 -1000 revolutions depending upon the gradation of aggregates.

After specified revolutions, the material is sieved through 1.7 mm sieve and passed fraction is expressed as percentage total weight of the sample. This value is called Los Angeles abrasion value.

A maximum value of 40 percent is allowed for WBM base course in Indian conditions. For bituminous concrete, a maximum value of 35 percent is specified.

3.Impact Test

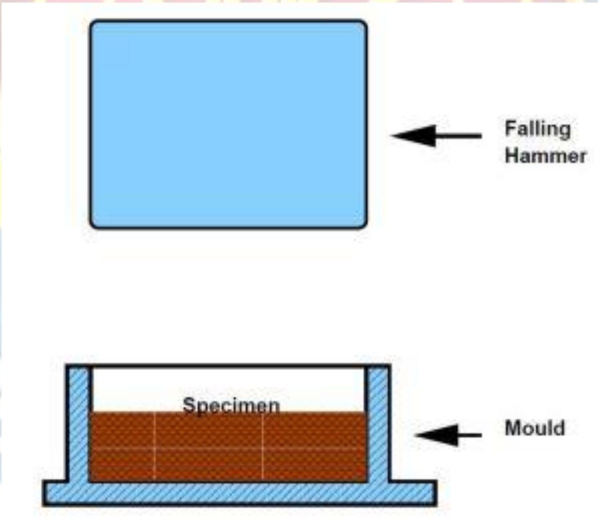

Fig-4.1(c): Impact Test Setup

The aggregate impact test is carried out to evaluate the resistance to impact of aggregates. Aggregates passing 12.5 mm sieve and retained on 10 mm sieve is filled in a cylindrical steel cup of internal dia 10.2 mm and depth 5 cm which is attached to a metal base of impact testing machine. The material is filled in 3 layers where each layer is tamped for 25 numbers of blows (see Fig-3). Metal hammer of weight 13.5 to 14 Kg is arranged to drop with a free fall of 38.0 cm by vertical guides and the test specimen is subjected to 15 numbers of blows. The crushed aggregate is allowed to pass through 2.36 mm IS sieve. And the impact value is measured as percentage of aggregates passing sieve (**W2**) to the total weight of the sample (**W1**).

Aggregate impact value = (W1/W2)*100

Aggregates to be used for wearing course, the impact value shouldn't exceed 30 percent. For bituminous macadam the maximum permissible value is 35 percent. For Water bound macadam base courses the maximum permissible value defined by IRC is 40 percent.

4.Soundness test

Soundness test is intended to study the resistance of aggregates to weathering action, by conducting accelerated weathering test cycles. The Porous aggregates subjected to freezing and thawing is likely to disintegrate prematurely. To ascertain the durability of such aggregates, they are subjected to an accelerated soundness test as specified in **IS: 2386 part-V**.

Aggregates of specified size are subjected to cycles of alternate wetting in a saturated solution of either sodium sulphate or magnesium sulphate for 16 – 18 hours and then dried in oven at 105 to 110^{0}C to a constant weight. After five cycles, the loss in weight of aggregates is determined by sieving out all undersized particles and weighing.

The loss in weight should not exceed 12 percent when tested with sodium sulphate and 18 percent with magnesium sulphate solution.

5.Shape Tests

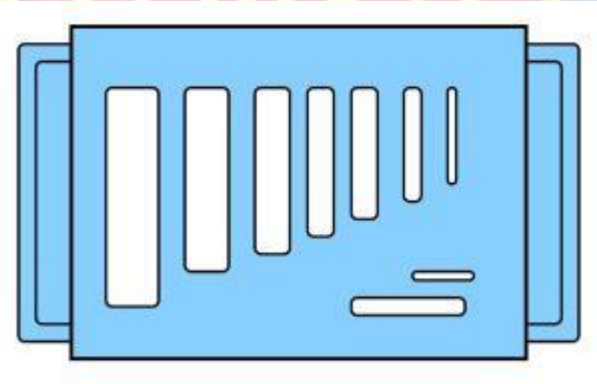

Fig-4.1(d): Flakiness Gauge

The particle shape of the aggregate mass is determined by the percentage of flaky and elongated particles in it. Aggregates which are flaky or elongated are detrimental to higher workability and stability of mixes.

The flakiness index is defined as the percentage by weight of aggregate particles whose least dimension is less than 0.6 times their mean size. Flakiness gauge (see Fig-4) is used for this test. Test procedure had been standardized in India (**IS: 2386 part-I**).

The elongation index of an aggregate is defined as the percentage by weight of particles whose greatest dimension (length) is 1.8 times their mean dimension. This test is applicable to aggregates larger than 6.3 mm. Elongation gauge (see Fig-5) is used for this test. This test is also specified in (**IS: 2386 Part-I**). However there are no recognized limits for the elongation index.

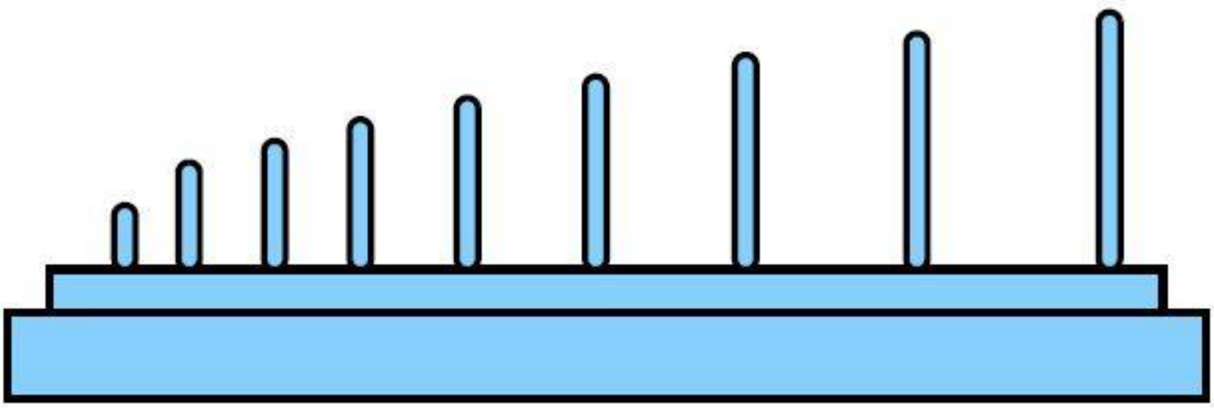

Fig-4.1(e): Elongation Gauge

6.Specific Gravity and Water Absorption

The specific gravity and water absorption of aggregates are important properties that are required for the design of concrete and bituminous mixes. The specific gravity of a solid is the ratio of its mass to that of an equal volume of distilled water at a specified temperature. Because the aggregates may contain water-permeable voids, so two measures of specific gravity of aggregates are used:

Apparent specific gravity and

Bulk specific gravity.

Apparent Specific Gravity: $\mathbf{G_{app}}$, is computed on the basis of the net volume of aggregates i.e the volume excluding water-permeable voids. Thus

$G_{app} = [(M_D/V_N)]/W$

Where,

M_D is the dry mass of the aggregate,

V_N is the net volume of the aggregates excluding the volume of the absorbed matter,

W is the density of water.

Bulk Specific Gravity: $\mathbf{G_{bulk}}$, is computed on the basis of the total volume of aggregates including water permeable voids. Thus

$G_{bulk} = [(M_D/V_B)]/W$

Where,

V_B is the total volume of the aggregates including the volume of absorbed water.

<u>Water Absorption:</u> The difference between the apparent and bulk specific gravities is nothing but the water permeable voids of the aggregates. We can measure the volume of such voids by weighing the aggregates dry and in a saturated surface dry condition, with all permeable voids filled with water. The difference of the above two is M_W.

M_W is the weight of dry aggregates minus weight of aggregates saturated surface dry condition. Thus,

Water Absorption = $(M_W/M_D)*100$

The specific gravity of aggregates normally used in road construction ranges from about 2.5 to 2.9. Water absorption values ranges from 0.1 to about 2.0 percent for aggregates normally used in road surfacing.

CHAPTER-5
CONCLUSION

- A cement test is a process carried out to check the different aspects of cement to be able to know its usability in a construction project. These tests are conducted to understand the chemical and physical properties of the building material as per laid out standards, codes, and technical aspects.
- This test helps determine the ability of cement to withstand axial loads. The conclusion may indicate whether the cement meets the specified strength requirements for a particular application.
- Not only that aggregates should be strong and durable, they should also possess proper shape and size to make the pavement act monolithically. Aggregates are tested for strength, toughness, hardness, shape, and water absorption
- The gradation of aggregates is critical for concrete mix design. A conclusion from this test ensures that the aggregates meet the specified gradation requirements.

These tests will either confirm that the cement and aggregates meet the required standards and specifications or indicate the need for adjustments or further evaluation. The specific results and conclusions will vary depending on the type of cement, the type and source of aggregates, and the construction project's requirements.

CHAPTER-6

REFERENCES

1. Hemali patel, 19th december, 2019, 7 Lab tests on aggregates to make better concrete for construction.
2. Suryakanta, September 12, 2015, 7 Lab tests on aggregate to check quality for use in road work.
3. Bhushan Mahajan, 7 Tests on aggregates you need to know before starting your project.
4. prasad, Types of testing for aggregates.
5. Matthew L. Deloney, Lab test on aggregates at site.
6. Vani Paspula, Apr 17, 2019, 8 Types of Tests on Cement to Check the Quality.
7. Lceted, 2018, laboratory tests on cement
8. Apr. 14, 2014, Testing of cement
9. Aimil Ltd, .April 7, 2023, The Benefits of Cement Testing & How It Ensures Structural Strength & Durability | An Essential Guide to Cement Testing and its Benefits.
10. Wolfram Schmidt, Herbert Uzoegbo, Gladmore Rongai, January 2013, Cement Testing in Africa – Conclusions from the First Africa-Wide Proficiency Testing Scheme.