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Report about:
Concrete Technology

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Unit3:Water cement ratio.

Unit 4: Work ability.

Unit5 : Concrete mix.

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Concrete technology

Unit 1 Introduction

Definition of concrete:

Concrete is the most commonly used man-made material on earth. It is an important construction material used extensively in buildings, bridges, roads and dams. Its uses range from structural applications, to kerbs, pipes and drains.

Concrete is a mixture of binding material, aggregates and water in a definite proportion

1. Types of concrete:

1. Cement concrete: It is a mixture of cement, fine aggregates, coarse aggregates and water in a definite proportion.

2. Lime concrete: Here binding material is lime (CaO):

RCC: Steel reinforcing is done in the Cement Concrete.

4: Prestressed cement concrete:

This concrete is a form of concrete used in construction which is "pre-stressed" by being placed under compression prior to supporting any loads beyond its own dead weight. This compression is produced by the tensioning of high-strength "tendons" located within or adjacent to the concrete volume, and is done to improve the performance of the concrete in service.

2. Uses of concrete:

Many structural elements like footings, columns, beams, chejjas, lintels, roofs are made with R.C.C. Cement concrete is used for making storage structures like water tanks, bins, silos, bunkers etc. Bridges, dams, retaining walls are R.C.C. structures in which concrete is the major ingredient in storage structures like water tanks, bins, silos, bunkers etc.

3. Benefits of concrete:

There are numerous positive aspects of concrete:

1. It is a relatively cheap material and has a relatively long life with few maintenance requirements.
2. It is strong in compression.
3. Before it hardens it is a very pliable substance that can easily be shaped.
4. It is non-combustible.

4. Limitations of concrete:

The limitations of concrete include:

1. Relatively low tensile strength when compared to other building materials.
2. Low ductility.
3. Low strength-to-weight ratio.
4. It is susceptible to cracking.

Unit 2

Ingredient of concrete

A. **Cement:** cement is a binding material used in the masonry.

Physical Properties of Cement

Different blends of cement used in construction are characterized by their physical properties. Some key parameters control the quality of cement. The physical properties of good cement are based on:

Fineness of cement

Soundness

Consistency

Strength

Setting time

Heat of hydration

Loss of ignition

Bulk density

Specific gravity (Relative density)

These physical properties are discussed in details in the following segment. Also, you will find the test names associated with these physical properties.

1. Fineness of Cement

The size of the particles of the cement is its fineness. The required fineness of good cement is achieved through grinding the clinker in the last step of cement production process. As hydration rate of cement is directly related to the cement particle size, fineness of cement is very important.

2. Soundness of Cement

refers to the ability of cement to not shrink upon hardening. Good quality cement retains its volume after setting without delayed expansion, which is caused by excessive free lime and magnesia.

Tests: Unsoundness of cement may appear after several years, so tests for ensuring soundness must be able to determine that potential.

2.1 Le Chatelier Test

This method, done by using Le Chatelier Apparatus, tests the expansion of cement due to lime. Cement paste (normal consistency) is taken between glass slides and submerged in water for 24 hours at $20 \pm 1^\circ\text{C}$. It is taken out to measure the distance between the indicators and then returned under water, brought to boil in 25-30 mins and boiled for an hour. After cooling the device, the distance between indicator points is measured again. In a good quality cement, the distance should not exceed 10 mm.

3. Consistency of Cement

The ability of cement paste to flow is consistency.

It is measured by Vicat Test.

In Vicat Test Cement paste of normal consistency is taken in the Vicat Apparatus. The plunger of the apparatus is brought down to touch the top surface of the cement. The plunger will penetrate the cement up to a certain depth depending on the consistency. A cement is said to have a normal consistency when the plunger penetrates 10 ± 1 mm.

4. Strength of cement

Three types of strength of cement are measured – compressive, tensile and flexural. Various factors affect the strength, such as water-cement ratio, cement-fine aggregate ratio, curing conditions, size and shape of a specimen, the manner of molding and mixing, loading conditions and age. While testing the strength, the following should be considered:

Cement mortar strength and cement concrete strength are not directly related. Cement strength is merely a quality control measure.

The tests of strength are performed on cement mortar mix, not on cement paste.

Cement gains strength over time, so the specific time of performing the test should be mentioned.

5. Compressive Strength

It is the most common strength test. A test specimen (50mm) is taken and subjected to a compressive load until failure. The loading sequence must be within 20 seconds and 80 seconds.

Tensile strength

Though this test used to be common during the early years of cement production, now it does not offer any useful information about the properties of cement.

Flexural strength

This is actually a measure of tensile strength in bending. The test is performed in a 40 x 40 x 160 mm cement mortar beam, which is loaded at its center point until failure.

Standard test: ASTM C 348: Flexural Strength of Hydraulic Cement Mortars

6. Setting Time of Cement

Cement sets and hardens when water is added. This setting time can vary depending on multiple factors, such as fineness of cement, cement-water ratio, chemical content, and admixtures. Cement used in construction should have an initial setting time that is not too low and a final setting time not too high. Hence, two setting times are measured:

Initial set: When the paste begins to stiffen noticeably (typically occurs within 30-45 minutes) Final set: When the cement hardens, being able to sustain some load (occurs below 10 hours) Again, setting time can also be an indicator of hydration rate.

Standard Tests:

AASHTO T 131 and ASTM C 191: Time of Setting of Hydraulic Cement by Vicat Needle AASHTO T 154: Time of Setting of Hydraulic Cement by Gillmore Needles

ASTM C 266: Time of Setting of Hydraulic-Cement Paste by Gillmore Needles

7. Heat of Hydration

When water is added to cement, the reaction that takes place is called hydration. Hydration generates heat, which can affect the quality of the cement and also be beneficial in maintaining curing temperature during cold weather. On the other hand, when heat generation is high, especially in large structures, it may cause undesired stress. The heat of hydration is affected most by C3S and C3A present in cement, and also by water-cement ratio, fineness and curing temperature. The heat of hydration of Portland cement is calculated by determining the difference between the dry and the partially hydrated cement (obtained by comparing these at 7th and 28th days).

Standard Test: ASTM C 186: Heat of Hydration of Hydraulic Cement

8. Loss of Ignition

Heating a cement sample at 900 - 1000°C (that is, until a constant weight is obtained) causes weight loss. This loss of weight upon heating is calculated as loss of ignition. Improper and prolonged storage or adulteration during transport or transfer may lead to pre-hydration and carbonation, both of which might be indicated by increased loss of ignition.

Standard Test: AASHTO T 105 and ASTM C 114: Chemical Analysis of Hydraulic Cement

9. Bulk density

When cement is mixed with water, the water replaces areas where there would normally be air. Because of that, the bulk density of cement is not very important. Cement has a varying range of density depending on the cement composition percentage. The density of cement may be anywhere from 62 to 78 pounds per cubic foot.

10. Specific Gravity (Relative Density)

Specific gravity is generally used in mixture proportioning calculations. Portland cement has a specific gravity of 3.15, but other types of cement (for example, portland-blast-furnace-slag and portland-pozzolan cement) may have specific gravities of about 2.90.

Standard Test: AASHTO T 133 and ASTM C 188: Density of Hydraulic Cement

B. Chemical Properties of Cement

The raw materials for cement production are limestone (calcium), sand or clay (silicon), bauxite (aluminum) and iron ore, and may include shells, chalk, marl, shale, clay, blast furnace slag, slate. Chemical analysis of cement raw materials provides insight into the chemical properties of cement.

1 Tricalcium aluminate (C3A)

Low content of C3A makes the cement sulfate-resistant. Gypsum reduces the hydration of C3A, which liberates a lot of heat in the early stages of hydration. C3A does not provide any more than a little amount of strength.

Type I cement: contains up to 3.5% SO₃ (in cement having more than 8% C3A) Type II

cement: contains up to 3% SO₃ (in cement having less than 8% C3A)

2. Tricalcium silicate (C3S)

C3S causes rapid hydration as well as hardening and is responsible for the cement's early strength gain an initial setting.

3. Dicalcium silicate (C2S)

As opposed to tricalcium silicate, which helps early strength gain, dicalcium silicate in cement helps the strength gain after one week.

4. Ferrite (C4AF)

Ferrite is a fluxing agent. It reduces the melting temperature of the raw materials in the kiln from 3,000°F to 2,600°F. Though it hydrates rapidly, it does not contribute much to the strength of the cement.

5. Magnesia (MgO)

The manufacturing process of Portland cement uses magnesia as a raw material in dry process plants. An excess amount of magnesia may make the cement unsound and expansive, but a little amount of it can add strength to the cement. Production of MgO-based cement also causes less CO₂ emission. All cement is limited to a content of 6% MgO.

6. Sulphur trioxide

Sulfur trioxide in excess amount can make cement unsound.

7. Iron oxide/ Ferric oxide

Aside from adding strength and hardness, iron oxide or ferric oxide is mainly responsible for the color of the cement.

8. Alkalis

The amounts of potassium oxide (K₂O) and sodium oxide (Na₂O) determine the alkali content of the cement. Cement containing large amounts of alkali can cause some difficulty in regulating the setting time of cement. Low alkali cement, when used with calcium chloride in concrete, can cause discoloration. In slag-lime cement, ground granulated blast furnace slag is not hydraulic on its own but is "activated" by addition of alkalis. There is an optional limit in total alkali content of 0.60%, calculated by the equation $\text{Na}_2\text{O} + 0.658 \text{K}_2\text{O}$.

9. Free lime

Free lime, which is sometimes present in cement, may cause expansion.

10. Silica fumes

Silica fume is added to cement concrete in order to improve a variety of properties, especially compressive strength, abrasion resistance and bond strength. Though setting time is prolonged by the addition of silica fume, it can grant exceptionally high strength. Hence, Portland cement containing 5-20% silica fume is usually produced for Portland cement projects that require high strength.

11.11.

Cement containing high alumina has the ability to withstand frigid temperatures since alumina is chemical-resistant. It also quickens the setting but weakens the cement.

Aggregates:

What is an Aggregate?

Aggregates are the important constituents of the concrete which give body to the concrete and also reduce shrinkage. Aggregates occupy 70 to 80 % of total volume of concrete. So, we can say that one should know definitely about the aggregates in depth to study more about concrete.

Classification of Aggregates as per Size and Shape

Aggregates are classified based on so many considerations, but here we are going to discuss about their shape and size classifications in detail.

Classification of Aggregates Based on Shape

We know that aggregate is derived from naturally occurring rocks by blasting or crushing etc., so, it is difficult to attain required shape of aggregate. But, the shape of aggregate will affect the workability of concrete. So, we should take care about the shape of aggregate. This care is not only applicable to parent rock but also to the crushing machine used.

Aggregates are classified according to shape into the following types

- Rounded aggregates
- Irregular or partly rounded aggregates
- Angular aggregates
- Flaky aggregates
- Elongated aggregates
- Flaky and elongated aggregates

Rounded Aggregate

The rounded aggregates are completely shaped by attrition and available in the form of seashore gravel. Rounded aggregates result the minimum percentage of voids (32 – 33%) hence gives more workability. They require lesser amount of water-cement ratio. They are not considered for high strength concrete because of poor interlocking behavior and weak bond strength.



FIG-1

Irregular Aggregates

The irregular or partly rounded aggregates are partly shaped by attrition and these are available in the form of pit sands and gravel. Irregular aggregates may result 35- 37% of voids. These will give lesser workability when compared to rounded aggregates. The bond strength is slightly higher than rounded aggregates but not as required for high strength concrete.



FIG-2

Angular Aggregates

The angular aggregates consist well defined edges formed at the intersection of roughly planar surfaces and these are obtained by crushing the rocks.

Angular aggregates result maximum percentage of voids (38-45%) hence gives less workability. They give 10-20% more compressive strength due to development of stronger aggregate-mortar bond. So, these are useful in high strength concrete manufacturing.



FIG-3

Flaky Aggregates

When the aggregate thickness is small when compared with width and length of that aggregate it is said to be flaky aggregate. Or in the other, when the least dimension of aggregate is less than the 60% of its mean dimension then it is said to be flaky aggregate.



FIG-4

Elongated Aggregates

When the length of aggregate is larger than the other two dimensions then it is called elongated aggregate or the length of aggregate is greater than 180% of its mean dimension.



FIG-5

Flaky and Elongated Aggregates

When the aggregate length is larger than its width and width is larger than its thickness then it is said to be flaky and elongated aggregates. The above 3 types of aggregates are not suitable for concrete mixing. These are generally obtained from the poorly crushed rocks.

FIG-6



Classification of Aggregates Based on Size

Aggregates are available in nature in different sizes. The size of aggregate used may be related to the mix proportions, type of work etc. the size distribution of aggregates is called grading of aggregates.

Following are the classification of aggregates based on size:

Aggregates are classified into 2 types according to size

- Fine aggregate
- Coarse aggregate

Fine Aggregate

When the aggregate is sieved through 4.75mm sieve, the aggregate passed through it called as fine aggregate. Natural sand is generally used as fine aggregate, silt and clay are also come under this category. The soft deposit consisting of sand, silt and clay is termed as loam. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent.

Fine aggregate	Size variation
Coarse Sand	2.0mm – 0.5mm
Medium sand	0.5mm – 0.25mm
Fine sand	0.25mm – 0.06mm
Silt	0.06mm – 0.002mm
Clay	<0.002

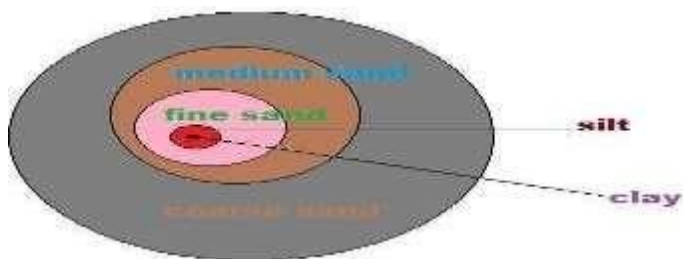


FIG-7

Coarse Aggregate

When the aggregate is sieved through 4.75mm sieve, the aggregate retained is called coarse aggregate. Gravel, cobble and boulders come under this category. The maximum size aggregate used may be dependent upon some conditions. In general, 40mm size aggregate used for normal strengths and 20mm size is used for high strength concrete. the size range of various coarse aggregates given below.

Coarse aggregate	Size
Fine gravel	4mm – 8mm
Medium gravel	8mm – 16mm
Coarse gravel	16mm – 64mm
Cobbles	64mm – 256mm
Boulders	>256mm

Bulking of Sand

The increase in moisture of sand increases the volume of sand. The reason is that moisture causes film of water around sand particles which results in the increase of volume of sand. For a moisture content percentage of 5 to 8 there will be an increase in volume up to 20 to 40 percent depending upon sand. If the sand is finer there will be more increase in volume. This is known as bulking of sand.

Graphical representation of bulking of sand is shown below.

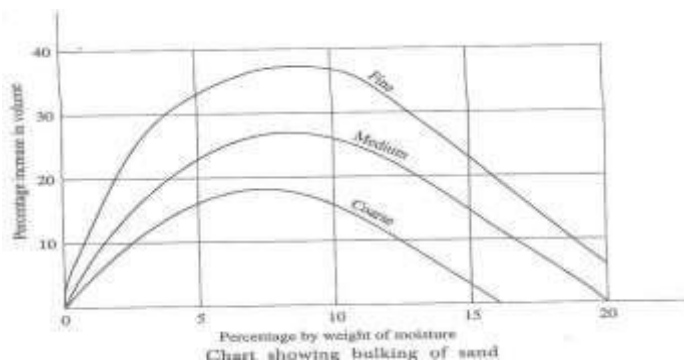


FIG-8

When the moisture content of sand is increased by adding more water, the sand particles pack near each other and the amount of **bulking of sand** is decreased. Thus, it helps in determining the actual volume of sand, the dry sand and the sand completely filled with water will have the exact volume.

The volumetric proportioning of sand is greatly affected by bulking of sand to a greater extent. The affected volume will be great for fine sand and will be less for coarse sand. If proper allowance is not made for the bulking of sand, the cost of concrete and mortar increases and it results into under-sanded mixes which are harsh and difficult for working and placi

SPECIFIC GRAVITY AND WATER

ABSORPTION TEST AIM:

i) To measure the strength or quality of the material ii) To determine the water absorption of aggregates

-

APPARATUS:

The apparatus consists of the following

- (a) A balance of capacity about 3kg, to weigh accurate 0.5g, and of such a type and shape as to permit weighing of the sample container when suspended in water
- (b) A thermostatically controlled oven to maintain temperature at 100-110° C
- (c) A wire basket of not more than 6.3 mm mesh or a perforated container of convenient size with thin wire hangers for suspending it from the balance. (d) A container for filling water and suspending the basket
- (e) An air tight container of capacity similar to that of the basket
- (f) A shallow tray and two absorbent clothes, each not less than 75x45cm.

-

THEORY:

The specific gravity of an aggregate is considered to be a measure of strength or quality of the material. Stones having low specific gravity are generally weaker than those with higher specific gravity values.

-

PROCEDURE:

- (i) About 2 kg of aggregate sample is washed thoroughly to remove fines, drained and placed in wire basket and immersed in distilled water at a temperature between 22- 32° C and a cover of at least 5cm of water above the top of basket
- (ii) Immediately after immersion the entrapped air is removed from the sample by lifting the basket containing it 25 mm above the base of the tank and allowing it to drop at the rate of about one drop per second. The basket and aggregate should remain completely immersed in water for a period of 24 hours afterwards.
- (iii) The basket and the sample are weighed while suspended in water at a temperature of 22° – 32°C. The weight while suspended in water is noted = W_1 g.
- (iv) The basket and aggregates are removed from water and allowed to drain for a few minutes after which the aggregates are transferred to the dry absorbent clothes. The empty basket is then returned to the tank of water jolled 25 times and weighed in water = W_2

(v) The aggregates placed on the absorbent clothes are surface dried till no further moisture could be removed by this cloth. Then the aggregates are transferred to the second dry cloth spread in single layer and allowed to dry for at least 10 minutes until the aggregates are completely surface dry. The surface dried aggregate is then weighed =W3 g

(vi) The aggregate is placed in a shallow tray and kept in an oven maintained at a temperature of 110° C for 24 hrs. It is then removed from the oven, cooled in an air tight container and weighed=W4 g

Specific gravity = (dry weight of the aggregate /Weight of equal volume of water)

(1) Apparent specific gravity = (dry weight of the aggregate/Weight of equal volume of water excluding air voids in aggregate)

OBSERVATIONS

Weight of saturated aggregate suspended in water with basket = W1 g Weight of basket suspended in water = W2 g

Weight of saturated aggregate in water = W1 - W2 g Weight of saturated surface dry aggregate in air = W3 g

Weight of water equal to the volume of the aggregate = W3-(W1-W2)g Weight of oven dry aggregate = W4 g

(1) Specific gravity = $W3 / (W3 - (W1 - W2))$

(2) Apparent specific gravity = $W4 / (W4 - (W1 - W2))$ (3)

Water Absorption = $((W3 - W4) / W4) \times 100$

RESULT:

(1) Specific gravity =

(2) Apparent specific gravity =

(3) Water Absorption =

RECOMMENDED VALUE:

The size of the aggregate and whether it has been artificially heated should be indicated. ISI specifies three methods of testing for the determination of the specific gravity of aggregates, according to the size of the aggregates. The three size ranges used are aggregates larger than 10 mm, 40 mm and smaller than 10 mm. The specific gravity of aggregates normally used in road construction ranges from about 2.5 to 3.0 with an average of about 2.68. Though high specific gravity is considered as an indication of high strength, it is not possible to judge the suitability of a sample road aggregate without finding the mechanical properties such as aggregate crushing, impact and abrasion values. Water absorption shall not be more than 0.6 per unit by weight.

Unit 3

Water cement Ratio

Hydration of

Cement

Introduction

Portland cement is a hydraulic cement; hence it derives its strength from chemical reactions between the cement and water. The process is known as hydration.

Cement consists of the following major compounds (see [composition of cement](#)):

- Tricalcium silicate, C_3S
- Dicalcium silicate, C_2S
- Tricalcium aluminate, C_3A
- Tetra calcium aluminoferrite, C_4AF
- Gypsum, CSH_2

Water-cement ratio

The **water-cement ratio** is the ratio of the weight of water to the weight of [cement](#) used in a [concrete](#) mix. A lower ratio leads to higher strength and durability, but may make the mix difficult to work with and form. Workability can be resolved with the use of [plasticizers](#) or [super-plasticizers](#).

Often, the ratio refers to the ratio of water to cement plus [pozzolan](#) ratio, $w/(c+p)$. The pozzolan is typically a [fly ash](#), or [blast furnace slag](#). It can include a number of other materials, such as silica fume, rice husk ash or natural pozzolans. Pozzolans can be added to strengthen concrete.

Duff Abrams' law

The notion of water-cement ratio was first developed by [Duff A. Abrams](#) and published in 1918.

Concrete hardens as a result of the chemical reaction between cement and water (known

as hydration, this produces heat and is called the heat of hydration). For every pound (or kilogram or any unit of weight) of cement, about 0.35 pounds (or 0.35 kg or corresponding unit) of water is needed to fully complete hydration reactions.

However, a mix with a ratio of 0.35 may not mix thoroughly, and may not flow well enough to be placed. More water is therefore used than is technically necessary to react with cement. Water-cement ratios of 0.45 to 0.60 are more typically used. For higher-strength concrete, lower ratios are used, along with a plasticizer to increase flowability.

Too much water will result in segregation of the sand and aggregate components from the cement paste

Effect of Water Cement Ratio on Strength of Concrete:

The water-cement ratio is one of the most important aspect when it comes to maintaining the strength of Concrete. The ratio depends on the grade of concrete and the structure size. We generally prefer a W/C ratio of 0.4 to 0.6, but it can be decreased in case of high-grade concrete, we reduce the amount of water and use plasticizers instead.

W/C ratio affects the workability of concrete and thus should be taken into careful consideration. Also, if the ratio exceeds the normal value, segregation of concrete occurs and the coarse aggregate settles at the bottom, thus affecting the strength of concrete greatly.

Limitation of Water Cement Law:

1. The internal moisture condition of hydration of cement continues till the concrete gain full strength.
2. The concrete specimen is cured under standard temperatures.
3. The concrete specimens should of same size.
4. The concrete specimens should of same age

Unit 4

work ability

Workability is defined as the amount of energy required to overcome internal friction and cause complete compaction.

Workability is completely depending upon the properties of various ingredients of concrete.

Factors Affecting Workability

-Cement content of concrete

Water content of concrete Mix

proportions of concrete Size of

aggregates

Shape of aggregates

Grading of aggregates

Surface texture of aggregates Use

of admixtures in concrete

Use of supplementary cementitious materials

Following are the general factors affecting concrete workability:

1. Cement Content of Concrete

Cement content affects the workability of concrete in good measure. More the quantity of cement, the more will be the paste available to coat the surface of aggregates and fill the voids between them. This will help to reduce the friction between aggregates and smooth movement of aggregates during mixing, transporting, placing and compacting of concrete.

Also, for a given water-cement ratio, the increase in the cement content will also increase the water content per unit volume of concrete increasing the workability of concrete. Thus, increase in cement content of concrete also increases the workability of concrete.

2. Type and Composition of Cement

There are also affect of type of cement or characteristics of cement on the workability of concrete. The cement with increase in fineness will require more water for same workability than the comparatively less fine cement. The water demand increased for cement with high Al_2O_3 or C_2S contents.

3. Water/Cement Ratio or Water Content of Concrete

Water/cement ratio is one of the most important factors which influence the concrete workability. Generally, a water cement ratio of 0.45 to 0.6 is used for good workable concrete without the use of any admixture. Higher the water/cement ratio, higher will be the water content per volume of concrete and concrete will be more workable.

Higher water/cement ratio is generally used for manual concrete mixing to make the mixing process easier. For machine mixing, the water/cement ratio can be reduced. These generalized method of using water content per volume of concrete is used only for nominal mixes.

For designed mix concrete, the strength and durability of concrete is of utmost importance and hence water cement ratio is mentioned with the design. Generally designed concrete uses low water/cement ratio so that desired strength and durability of concrete can be achieved.

4. Mix Proportions of Concrete

Mix proportion of concrete tells us the ratio of fine aggregates and coarse aggregates w.r.t. cement quantity. This can also be called as the aggregate cement ratio of concrete. The more cement is used, concrete becomes richer and aggregates will have proper lubrications for easy mobility or flow of aggregates.

The low quantity of cement w.r.t. aggregates will make the less paste available for aggregates and mobility of aggregates is restrained.

5. Size of Aggregates

Surface area of aggregates depends on the size of aggregates. For a unit volume of aggregates with large size, the surface area is less compared to same volume of aggregates with small sizes

When the surface area increases, the requirement of cement quantity also increases to cover up the entire surface of aggregates with paste. This will make more use of water to lubricate each aggregate.

Hence, lower sizes of aggregates with same water content are less workable than the large size aggregates.

6. Shape of Aggregates

The shape of aggregates affects the workability of concrete. It is easy to understand that rounded aggregates will be easy to mix than elongated, angular and flaky aggregates due to less frictional resistance.

Other than that, the round aggregates also have less surface area compared to elongated or irregular shaped aggregates. This will make less requirement of water for same workability of concrete. This is why river sands are commonly preferred for concrete as they are rounded in shape.

7. Grading of Aggregates

Grading of aggregates have the maximum effect on the workability of concrete. A well graded aggregates have all sizes in required percentages. This helps in reducing the voids in a given volume of aggregates.

The less volume of voids makes the cement paste available for aggregate surfaces to provide better lubrication to the aggregates.

With less volume of voids, the aggregate particles slide past each other and less compacting effort is required for proper consolidation of aggregates. Thus, low water cement ratio is sufficient for properly graded aggregates.

8. Surface Texture of Aggregates

Surface texture such as rough surface and smooth surface of aggregates affects the workability of concrete in the same way as the shape of aggregates.

With rough texture of aggregates, the surface area is more than the aggregates of same volume with smooth texture. Thus, concrete with smooth surfaces are more workable than with rough textured aggregates.

9. Use of Admixtures in Concrete

There are many types of admixtures used in concrete for enhancing its properties. There are some workability enhancer admixtures such as plasticizers and superplasticizers which increases the workability of concrete even with low water/cement ratio.

They are also called as water reducing concrete admixtures. They reduce the quantity of water required for same value of slump.

Air entraining concrete admixtures are used in concrete to increase its workability. This admixture reduces the friction between aggregates by the use of small air bubbles which acts as the ball bearings between the aggregate particles.

Measurement of Workability:

Slump Test.

Concrete slump test is to determine the workability or consistency of concrete mix prepared at the laboratory or the construction site during the progress of the work. Concrete slump test is carried out from batch to batch to check the uniform quality of concrete during construction.

The slump test is the simplest workability test for concrete, involves low cost and provides immediate results. Due to this fact, it has been widely used for workability tests since 1922. The slump is carried out as per procedures mentioned in **IS 456: 2000**

Generally **concrete slump value** is used to find the workability, which indicates water-cement ratio, but there are various factors including properties of materials, mixing methods, dosage, admixtures etc. also affect the concrete slump value.

Factors which influence the concrete slump test:

-Material properties like chemistry, fineness, particle size distribution, moisture content and temperature of cementitious materials.

- Size, texture, combined grading, cleanliness and moisture content of the aggregates,

-Chemical admixtures dosage, type, combination, interaction, sequence of addition and its effectiveness,

-Air content of concrete,

-Concrete batching, mixing and transporting methods and equipment,

-Temperature of the concret

- Sampling of concrete, slump-testing technique and the condition of test equipment,
- The amount of free water in the concrete, and
- Time since mixing of concrete at the time of testing.

Equipment's Required for Concrete Slump Test:

Mould for slump test, non-porous base plate, measuring scale, tamping rod. The mould for the test is in the form of the frustum of a cone having height 30 cm, bottom diameter 20 cm and top diameter 10 cm. The tamping rod is of steel 16 mm diameter and 60cm long and rounded at one end.

Sampling of Materials for Slump Test:

A concrete mix (M15 or other) by weight with suitable water/ cement ratio is prepared in the laboratory similar to that explained in 5.9 and required for casting 6 cubes after conducting Slump test.

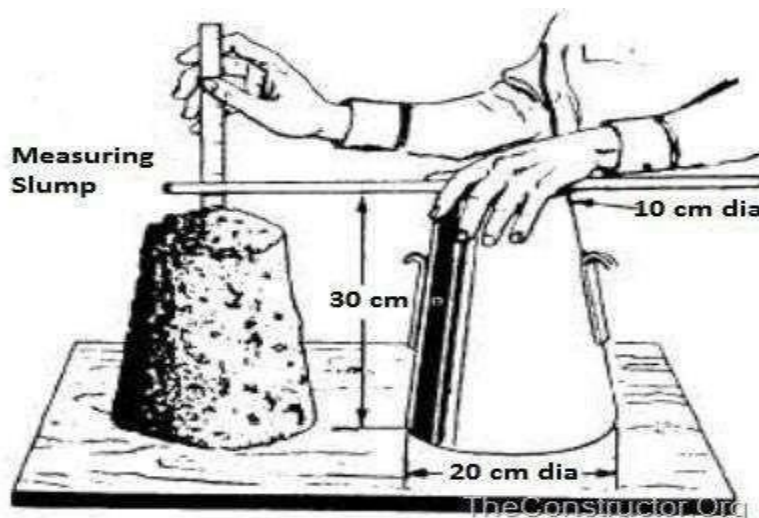


FIG-1

1. Compaction Factor Test

Compaction factor test is the workability test for concrete conducted in laboratory. The compaction factor is the ratio of weights of partially compacted to fully compacted concrete. It was developed by Road Research Laboratory in United Kingdom and is used to determine the workability of concrete.

The compaction factor test is used for concrete which have low workability for which slump test is not

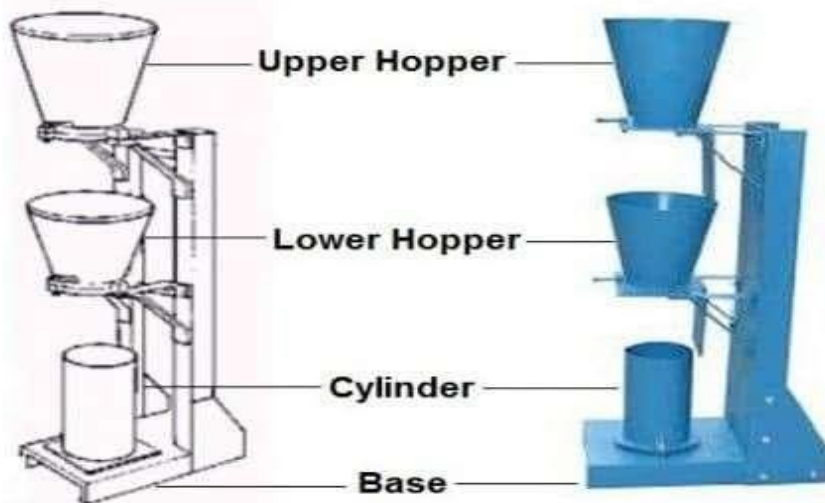
suitable.

Apparatus

Compaction factor apparatus consists of trowels, hand scoop (15.2 cm long), a rod of steel or othersuitable material (1.6 cm diameter, 61 cm long rounded at one end) and a balance.

Sampling

Concrete mix is prepared as per mix design in the laboratory.



Compaction Factor Test on Concrete

FIG-2

Procedure of Compaction Factor Test on Concrete

- Place the concrete sample gently in the upper hopper to its brim using the hand scoop and level it.
- Cover the cylinder.
- Open the trapdoor at the bottom of the upper hopper so that concrete fall into the lowerhopper. Push the concrete sticking on its sides gently with the road.
- Open the trapdoor of the lower hopper and allow the concrete to fall into the cylinderbelow.
- Cut of the excess of concrete above the top level of cylinder using trowels and level it.
- Clean the outside of the cylinder.
- Weight the cylinder with concrete to the nearest 10 g. This weight is known as the weight of partially compacted concrete (W1).

-Empty the cylinder and then refill it with the same concrete mix in layers approximately 5 cm deep, each layer being heavily rammed to obtain full compaction.

-Level the top surface.

-Weigh the cylinder with fully compacted. This weight is known as the weight of fully compacted concrete (W_2).

-Find the weight of empty cylinder (W).

2. VEE-BEE CONSISTOMETER TEST



FIG-3

SUITABILITY

This method is suitable for dry concrete having very low workability

PROCEDURE

The test is performed as given described below

1. Mix the dry ingredients of the concrete thoroughly till a uniform colour is obtained and then add the required quantity of water.

2. Pour the concrete into the slump cone with the help of the funnel fitted to the stand.
3. Remove the slump mould and rotate the stand so that transparent disc touches the top of the concrete.
4. Start the vibrator on which cylindrical container is placed.
5. Due to vibrating action, the concrete starts remoulding and occupying the cylindrical container. Continue vibrating the cylinder till concrete surface becomes horizontal.
6. The time required for complete remoulding in seconds is the required measure of the workability and it is expressed as number of Vee-bee seconds.

**COMPARISON OF WORKABILITY MEASUREMENTS
BY VARIOUS METHODS**

Workability Description	Slump in mm	Vee-bee Time in Seconds	Compacting Factor
Extremely dry	–	32 – 18	
Very stiff	–	18 – 10	0.70
Stiff	0 – 25	10 – 5	0.75
Stiff plastic	25 – 50	5 – 3	0.85
Plastic	75 – 100	3 – 0	0.90
Flowing	150 – 175	–	0.95

CHAPTER-5

CONCRETE MIX DESIGN

5.1 INTRODUCTION

The common method of expressing the proportions of ingredients of a concrete mix is in the terms of parts or ratios of cement, fine and coarse aggregates. For e.g., a concrete mix of proportions 1:2:4 means that cement, fine and coarse aggregate are in the ratio 1:2:4 or the mix contains one part of cement, two parts of fine aggregate and four parts of coarse aggregate. The proportions are either by volume or by mass. The water-cement ratio is usually expressed in mass.

Concrete mix design may be defined as the art of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength & durability as economically as possible.

5.2 Objectives of Mix Design

- To achieve the designed/ desired workability in the plastic stage
- To achieve the desired minimum strength in the hardened stage
- To achieve the desired durability in the given environment conditions
- To produce concrete as economically as possible.

5.3 Factors to be considered for mix design

- The grade designation giving the characteristic strength requirement of concrete.
- The type of cement influences the rate of development of compressive strength of concrete.
- Maximum nominal size of aggregates to be used in concrete may be as large as possible within the limits prescribed by IS 456:2000.
- The cement content is to be limited from shrinkage, cracking and creep.
- The workability of concrete for satisfactory placing and compaction is related to the size and shape of section, quantity and spacing of reinforcement and technique used for transportation, placing and compaction.

5.4 Basic Considerations

- Cost
- Specification
- Workability
- Strength and Durability

5.4.1 Cost

The cost of concrete is made up of

- Material Cost

- Equipment Cost
- Labour Cost

The variation in the cost of materials arises from the fact that cement is several times costlier than aggregates. So, it is natural in mix design to aim at as lean a mix as possible. Therefore, all possible steps should be taken to reduce the cement content of a concrete mixtures without sacrificing the desirable properties of concrete such as strength and durability.

5.4.2 Specifications

- Minimum Compressive Strength required
- Minimum water/ cement ratio
- Maximum cement content to avoid shrinkage cracks
- Maximum aggregate / cement ratio
- Maximum density of concrete in case of gravity dams

5.4.3 Workability

The consistency of concrete should no more than that necessary for placing, compacting and finishing. For concrete mixes required high consistency at the time of placing, the use of water-reducing and set-retarding admixtures should be used rather than the addition of more water.

Wherever possible, the cohesiveness and fishability of concrete should be improved by increasing sand/ aggregate ratio than by increasing the proportion of the fine particles in the sand.

5.4.4 Strength and durability

Strength and durability require lower w/c ratio. It is usually achieved not by increasing the cement content, but by lowering the water at given cement content. Water demand can be lowered by throughout control of the aggregate grading and by using water reducing admixtures.

Grade of Concrete		
Group	Grade designation	Characteristics compressive strength of 150 mm cube at 28 days, N/mm ²
Ordinary Concrete	M10	10
	M15	15
	M20	20
Standard Concrete	M25	25
	M30	30
	M35	35
	M40	40
	M45	45
	M50	50
	M55	55
High Strength Concrete	M60	60
	M65	65
	M70	70
	M75	75
	M80	80

TABLE 5.1

5.5 TYPES OF CONCRETE MIXES

A. NOMINAL MIX

The wide use of concrete as construction materials has led to the use of mixes of fixed proportion, which ensures adequate strength. These mixes are called nominal mixes.

They offer simplicity and Under normal circumstances, has margin of strength above that specified. Nominal mix concrete may be used for concrete of grades M5, M 7.5, M10, M15 and M20.

Mixes of fixed proportions, IS:456-2000 permits nominal mixes for concretes of strength M20 or lower

Grade	Proportions C: FA: CA
M5	1: 5:10
M 7.5	1:4:8
M 10	1:3:6
M 15	1:2:4
M 20	1:1.5:3

TABLE 5.2- Proportions of Ingredients in Nominal Mixes

B. DESIGN MIX

Designed on the basis of requirements of the concrete in fresh and hardened states.

5.6 Factors Influencing Choice of Mix Design

According to IS 456:2000 and IS 1343:1980 the important influencing the design of concrete mix are

- Grade of Concrete
- Type of Cement
- Maximum nominal Size of Aggregate
- Grading of Combined aggregate
- Maximum Water/ Cement Ratio
- Workability
- Durability
- Quality Control.

5.6.1 Grade of Concrete

The grade of concrete gives characteristic compressive strength of concrete. It is one of the important factors influencing the mix design. The grade M 20 denotes characteristic compressive

strength of 20 N/mm². Depending upon the degree of control available at site, the concrete mix is to be designed for a target mean compressive strength applying suitable standard deviation.

DESIGNATION	MIX PROPORTION	CHARACTERIS TIC COMPRESSIVE STRENGTH IN N/MM ²	GROUP AS PER IS 456-2000
M 5	1:5:10	5	LEAN MIX
M 7.5	1:4:8	7.5	
M 10	1:3:6	10	ORDINARY CONCRETE
M 15	1:2:4	15	
M 20	1:11/2:3	20	
M 25	1:1:2	25	STANDERD CONCRETE
M 30	DESIGNED	30	
M 35		35	
M 40		40	
M 45		45	
M 50		50	
M 55		55	
M 60		60	

TABLE-5.3

5.6.2 Type of Cement

The rate of development of strength of concrete is influenced by the type of cement. The higher the strength of cement used in concrete, lesser will be the cement content. The use of 43 grade and 53 grades of cement, gives saving in cement consumption as much as 15 % and 25 % respectively, as compared to 33 grades of cement. For concrete of grade M25 it is advisable to use 43 and 53 grades of cement.

5.6.3 Maximum nominal Size of Aggregate

The maximum size of C.A is determined by sieve analysis. It is designated by the sieve size higher than larger size on which 15 % or more of the aggregate is retained. The maximum nominal size of C.A. should not be more than one-fourth of minimum thickness of the member.

For heavily reinforced concrete members as in the case of ribs of main beams, the nominal maximum size of the aggregate should usually be restricted to sum less than the minimum clear distance between the main bars or 5 mm less the minimum cover to the reinforcement, whichever is smaller.

5.6.4 Grading of Combined aggregate

The relative proportions of the fine and coarse aggregate in a concrete mix is one of the important factors affecting the strength of concrete. For dense concrete, it is essential that the fine and coarse aggregate be well graded. In the case when the aggregate available from natural sources do not confirm to the specified grading, the proportioning of two or more aggregate become essential

5.6.5 Maximum Water/ Cement Ratio

Abram's water/Cement ratio states that for any given condition of test, the strength of a workability concrete mix is dependent only on water/cement ratio. The lower the water/Cement ratio, the greater is the compressive strength.

5.6.6 Workability

Workability of fresh concrete determines the ease with which a concrete mixture can be mixed, transported, placed, compacted and finished without harmful segregation and bleeding.

5.6.7 Durability

Durability requires low water/Cement ratio. It is usually achieved not by increasing the cement content, but by lowering the water demand at a given cement content. Water demand can be lowered by through control of the aggregate grading and by using water reducing admixtures.

5.6 Procedure for Concrete Mix Design – IS456:2000

- Determine the mean target strength f_t from the specified characteristic compressive strength at 28-day f_{ck} and the level of quality control.
- $f_t = f_{ck} + 1.65 S$
- Where, S is the standard deviation obtained from the Table of approximate contents given after the design mix.
- Obtain the water cement ratio for the desired mean target using the empirical relationship between compressive strength and water cement ratio so chosen is checked against the limiting water cement ratio. The water cement ratio so chosen is checked against the limiting water cement ratio for the requirements of durability given in table and adopts the lower of the two values.
- Estimate the amount of entrapped air for maximum nominal size of the aggregate from the table.
- Select the water content, for the required workability and maximum size of aggregates (for aggregates in saturated surface dry condition) from table.
- Determine the percentage of fine aggregate in total aggregate by absolute volume from table for the concrete using crushed coarse aggregate.
- Adjust the values of water content and percentage of sand as provided in the table for any difference in workability, water cement ratio, grading of fine aggregate and for rounded aggregate the values are given in table.
- Calculate the cement content from the water-cement ratio and the final water content as arrived after adjustment. Check the cement against the minimum cement content from the requirements of the durability, and greater of the two values is adopted.

- From the quantities of water and cement per unit volume of concrete and the percentage of sand already determined in steps 6 and 7 above, calculate the content of coarse and fine aggregates per unit volume of concrete from the following relations:

$$V = \left[W + \frac{C}{S_c} + \frac{1}{p} \frac{f_a}{S_{fa}} \right] \times \frac{1}{1000}$$

$$V = \left[W + \frac{C}{S_c} + \frac{1}{1-p} \frac{C_a}{S_{ca}} \right] \times \frac{1}{1000}$$

-

Where, V = absolute volume of concrete = gross volume (1m³) minus the volume of entrapped air
 S_c = specific gravity of cement

W = Mass of water per cubic metre of concrete, kg

C = mass of cement per cubic metre of concrete, kg

p = ratio of fine aggregate to total aggregate by absolute volume f_a,

C_a = total masses of fine and coarse aggregates, per cubic metre of concrete, respectively, kg,
 and S_{fa}, S_{ca} = specific gravities of saturated surface dry fine and coarse aggregates, respectively

- Determine the concrete mix proportions for the first trial mix.
- Prepare the concrete using the calculated proportions and cast three cubes of 150 mm size and test them wet after 28-days moist curing and check for the strength.
- Prepare trial mixes with suitable adjustments till the final mix proportions are arrived at.

5.7 Difference between nominal and controlled concrete

- **NOMINAL MIX**

It is used for relatively unimportant and simpler concrete works. In this type of mix, all the ingredients are prescribed and their proportions are specified.

Therefore, there is no scope for any deviation by the designer. Nominal mix concrete may be used for concrete of M-20 or lower.

- **DESIGN MIX**

It is a performance-based mix where choice of ingredients and proportioning are left to the designer to be decided. The user has to specify only the requirements of concrete in fresh as well as hardened state. The requirements in fresh concrete are workability and finishing characteristics, whereas in hardened concrete these are mainly the compressive strength and durability.

Nominal Mix	• DESIGN MIX (CONTROLLED CONCRETE)
When the concrete is produced by taking standard arbitrary proportions of concrete	It can be defined as the process of selecting suitable ingredients of concrete and

ingredients, it is known as nominal mix concrete	determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible
Nominal mix is a mix considering all ratio involume where Strength and cost of concrete and strength of concrete varies	Design mix is a mix considering all ratio ofmix is by weight where strength of concrete is constant cost of concrete can be reduced
It is Prescriptive type concrete.	It is Performance based concrete.
It is used in ordinary concrete involving concrete grade not higher than M20	It is adopted for higher grade concrete
There is no quality control	It has Quality control
Water cement ratio is based on durability criteria, experience & practical trials	Water cement ratio based on concrete grade & 28 days compressive strength of concrete & durability of concrete.
Water content can be modified by slump value (field-based test)	Water content could be modified taking in to account the compaction factor value (laboratory-based test)
No entrapped air content is considered	Entrapped air content considered according nominal maximum size aggregates
Trial mixes concept is mentioned	Not much consideration for trial mixes

CH-6

Introduction to Admixtures

Admixtures are chemicals, added to concrete, mortar or grout at the time of mixing, to modify the properties, either in the wet state immediately after mixing or after the mix has hardened. They can be a single chemical or a blend of several chemicals and may be supplied as powders but most are **aqueous solutions** because in this form, they are easier to accurately dispense into, and then disperse through the concrete.

- Admixtures are ingredients other than basic ingredients cement, water and aggregates that are added to concrete batch immediately before or during mixing to modify one or more of the specific properties of concrete in fresh and hardened state.
- Added in small quantity either in powder or liquid form
- Combination is used when more than one property to be altered.

1 Admixtures can be divided into three categories: -

- Active materials are those which react chemically with a component within the Cementations materials.
- Surface active admixtures (surfactants). These are generally split into two components (one positively charged and the other negatively charged) and react with the air - water - solid material interface within the mortar thereby resulting in orientation and adsorption.
- Passive or inert admixtures. These do not change their form but have a physical effect such as light absorption and reflection as in the case of pigments.

2 Function

- Increase slump and workability;

- Retard or accelerate initial setting;
- Reduce or prevent shrinkage;
- Modify the rate or capacity for bleeding;
- Reduce segregation;
- Decrease weight of concrete
- Improve durability
- Decrease the rate of heat of hydration
- Reduce permeability
- To make porous concrete To
- make coloring concreteTo
- protect chemical attack
- Increase bond of concrete to steel reinforcement
- Increase strength (compressive, tensile, or flexural)
- Increase bond between existing and new concrete

3 Types of admixture

1. Accelerating admixtures
2. retarding admixtures
3. Water-reducing admixtures
4. Air-entrainment admixtures
5. Super plasticizers admixtures
6. Pozzolana admixtures
7. Grouting admixtures
8. Waterproofing admixtures
9. Air-detraining admixtures
10. Bonding admixtures
11. Corrosion inhibiting admixtures
12. Gas forming admixtures
13. Colouring admixtures
14. Alkali-aggregate expansion inhibiting admixtures
15. Fungicidal, germicidal, insecticidal admixtures

4.1 . Accelerators: -

Main objective of using accelerators in concrete is to increase speed of setting and hardening.

Advantages of using Accelerators: -To

- remove formwork quickly.
- To reduce the curing time
- To use structure earlier.
- To finish the surface fast.
- To increase the speed of construction.

- For quick repairing work.

Main Accelerators: - Calcium

- Chloride (CaCl_2) Soluble
- Carbonates Silicates

CaCl_2 is a most using accelerator in construction. If 2% CaCl_2 by weight of cement is added in concrete, then it decreases the setting time from 3 to 1 hour and final setting time from 6 to 2 hour. We can get a two days strength in 1 day at 21°C temperature. If the proportion of CaCl_2 is ~~not~~ more than 3% then flash set of concrete take place and drying shrinkage and creep will increase.

4.2. Retarders: -

To decrease the speed of Hydration and setting, Retarders are used in concrete. Retarders make concrete plastic and workable for long time.

Objectives of using Retarders: -

- To decrease the setting time.
- To increase strength by decreasing W/C Ratio. To
- do concreting in hot area.
- For grouting of oil wells.

Main Retarders: -

- Calcium Sulphate (Gypsum)
- Starches
- Sugars
- Cellulose Products
- Acids or Salts

Gypsum is most commonly used retarder. Generally, 2 to 3% gypsum is added. We can also use gypsum as a plaster of parries. By use more of gypsum expansion of concrete will occur and setting of concrete will be very slow.

4.3. Plasticizers: -

Workability is a most important property of concrete. Workability of concrete will change according to situation of construction. For deep beam, light partition wall, beam-column junction, concrete pumping,

tremie concreting high workable concrete is used. Many time plasticizers also known as “Water Reducing Admixture”. Plasticizer increases the workability without adding much water. It decreases the W/C Ratio which increases the strength.

Main plasticizers used in Construction: -

- Calcium lignosulphonates
- Sodium lignosulphonates
- Ammonium lignosulphonates

Quantity of this type of plasticizers is up to 0.1 to 0.4%.

By Using this admixture, we can reduce the use of water up to 5 to 15% without changing workability. **Main function of plasticizers is to improve the workability.**

4.3.1 Uses of plasticizers

The plasticizers are used:

- To achieve a higher strength by decreasing the water cement ratio at the same workability as an admixture free mix.
- To achieve the same workability by decreasing the cement content to reduce the heat of hydration in mass concrete.
- To increase the workability to ease placing in accessible locations. Water reduction more than 5% but less than 12%
- The commonly used admixtures are Ligno-sulphonates and hydrocarbolic acid salts.
- Plasticizers are usually based on lignosulphonate, which is a natural polymer, derived from wood processing in the paper industry.

The plasticizers have a retarding effect:

- Plasticizers get adsorbed on the surface of the cement particles and form a thin sheath.
- This sheath inhibits the surface hydration reaction between water and cement as long as sufficient plasticizers molecules are available.

4.3.2 Effects of plasticizers on the properties of concrete

The effect of water-reducing admixtures is dependent on: dosage of the admixture, cement type, aggregate type and grading, mix proportions and temperature.

- Workability: Typically, an initial slump in the range 25—75 mm can be increased by 50-60 mm.
- Compressive Strength: The compressive strength of concrete is increased by using water reducing admixtures to reduce water content while maintaining workability. The increase in strength is a direct result of the lower water/cement ratio.

4.4. Super Plasticizers: -

In 1960, Japan made a first Super plasticizer and then in 1970 Germany made it. By using Super Plasticizers, we can reduce the 30% of water. It is also called “High Range Water Reducers”. It is strong dispersing agent.

4.4.1 Advantages and disadvantages of Super-plasticizers

The advantages of Super-plasticizers are:

- Significant water reduction
- Reduced cement contents
- Reduce water requirement by 12-30%
- Increased workability of concrete
- Reduced effort required for placement
- More effective use of cement
- More rapid rate of early strength development
- Increased long-term strength
- Reduced permeability of concrete

The disadvantages of Super-plasticizers are:

- Additional admixture cost (the concrete in-place cost may be reduced)
- Slump loss greater than conventional concrete
- Modification of air-entraining admixture dosage
- Less responsive with some cement
- Mild discoloration of light-coloured concrete

4.4.2 Polymers used as super plasticizers

- Sulphonates melamine formaldehyde condensates (SMF)
- Sulphonates naphthalene formaldehyde condensates (SNF)
- Modified ligno - sulphonates (MLS)
- Acrylic polymer (AP)
- Poly carboxylate ester (PC)

4.5. Air Entraining Admixtures: -

Air entraining agent is used to get an air entrained concrete. This air entraining agent produces small air bubbles in concrete and works as ball bearing. So the properties of the concrete like workability, segregation, bleeding ...etc. will change.

Some Air entraining agents: -

- Aluminium Powder Hydrogen
- peroxide
- Alkali salts
- Vegetable Oils and Fats.
- Zinc Powder.
- Natural wood resins ...etc.

Effect of Air entraining agents: -

- Decrease in strength of concrete.
- Decrease in volume of concrete.
- Increase in permeability of concrete.
- Workability increase.
- Decrease in Alkali-aggregate reaction.
- Resistance against Sulphate attack.
- Decrease in heat of hydration.4.6

SILICA FUME CONCRETE

Y Silica fume is an artificial pozzolana having high pozzolonic activity.

Y It is a By- product from an electric arc furnace used in manufacture of silicon metal or silicon alloy.

Y It has high silica content of more than 80%.

Y It is an excellent for use as a portland cement supplement.4.6.1

CHEMICAL COMPOSITION

Chemical composition depends on the product being made by the furnace.

Y Composition is also influenced by the furnace design.

Y It is mostly made of silica having percentage of more than 80.

γ The other chemical composition include $Fe_2O_3, Al_2O_3, CaO, Na_2O, K_2O$ in small percentages.

γ Unlike the other By- products like Fly Ash, Silica fume from a single source has little or no variation in chemical composition from one day to another.

4.6.2 PHYSICAL CHARACTERISTICS

γ It should be in premium white and standard grey colors.

γ The specific gravity of the silica fume concrete is 2.2.

γ Its specific surface area is to be 20,000 sq.meters / kg.

γ Particle size is less than 1 micron with average diameter of 0.1 micron.

γ The shape of the particle is spherical.

γ It should be in Amorphous in nature.

4.6.3 ADVANTAGES OF SILICA FUME

γ High early compressive strength.

γ High tensile flexural strength and modulus of elasticity.

γ Very low permeability to chloride and water intrusion.

γ High bond strength.

γ High electrical resistivity and low permeability.

4.7 Rice husk

- They are the hard-protecting coverings of grains of rice.
- It is used as fuel in the boilers for processing of paddy producing energy through direct combustion and / or by gasification.
- for every 1000 kgs of paddy milled, about 220 kgs (22 %) of husk is produced



FIG- RICE HUSK

4.7.1 Applications

- a) High performance concrete
- b) Insulator
- c) Green concrete
- d) Bathroom floors
- e) Industrial factory flooring
- f) Concreting the foundation
- g) Swimming pools
- h) Water proofing and rehabilitation

4.7.2 Advantages

- Improves compressive strength, flexural strength and split tensile strength of concrete when mixed with RHA.
- RHA mixed with concrete shows better bond strength as compared to OPC concrete.
- RHA makes a role to increase resistance to chemical reactions.
- RHA would result in a reduction of the cost of concrete construction,

- Reduction of the environmental greenhouse effects. 4.7.3

Disadvantages

- Suitable incinerator /Furner as well as grinding method is required for burning and grading rice husk in order to obtain good quality ash
- Transportation problem
- Unburnt RHA is not suitable for concrete production