Lecture No. 1

Topic(s) to be covered	Cement, Different Types.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	The term of cement and the uses of cement	Remembering
LO2	Different types of cement	Understanding.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen, Discuss

Lecture Notes

Introduction:-

* Concrete is the most widely used manmade Construction material in the world. It can be easily made by mixing a binding material (lime or cement), fine aggregate (Sand) and coarse aggregate (crushed stone) and water in the required proportion.

Cement:-

* Cement is a finely ground material which on addition of requisite quantity of water is capable of hardening

both under water and in air by the chemical interaction of its constituents with water, and is also capable of building together with appropriate materials

* (Hydraulic cement more commonly known as cement is one of the extensively used basic material in almost all civil engineering constructions.) → 2 mark.

Different Types of Cement and Their Uses :-

⇒ Portland Cement :

⇒ Ordinary portland cement (OPC)
⇒ Rapid Hardening portland cement (RHPC)
⇒ Portland slag cement (PSC)
⇒ Portland pozzolana Cement (PPC)
⇒ Hydrophobic portland cement (HPC)
⇒ Low Heat portland cement (LHPC)
⇒ Sulphate-Resisting portland cement (SRPC)

⇒ Other Types of Cement :-

⇒ High Alumina Cement
⇒ Masonry Cement
⇒ Oil-well cement
⇒ Quick-Setting cement
⇒ Expanding cement
⇒ Acid-Resistant Cement
⇒ white cement
⇒ Coloured cement.

* Ordinary Portland Cement :-

Various Constituents of an Ordinary Portland Cement.

* Lime (62%)
* Silica (22%)
* Alumina (5%)
* Calcium sulphate (4%)
* Iron oxide (3%)
* Magnesium oxide (2%)
* Sulphur Trioxide (1%)
* Alkalies (1%)

* Rapid Hardening portland Cement (RHPC) :-

* This is similar to ordinary Portland Cement
* Here the percentage of C_2S is less and ground more finely.
* It has the quality of attaining high strength in a short period of time.

* Portland slag cement (PSC) :-

* This cement is made by intergrinding portland cement clinker and granulated blast furnace slag
* It is suitable for environments exposed to Sulphates.

* Portland pozzolana Cement (PPC) :-

⇒ Pozzolanic material is siliceous or aluminous material which by itself has no cementious Properties.

⇒ Fly ash and calcinated clay are pozzolanic materials used in the manufacture of PPC.

⇒ The cement takes more times for initial setting time which helps in works which involves delayed construction.

*** Hydrophobic portland cement (HPC) :-**

⇒ This type of cement is obtained by inter grinding Portland cement with **0.1 to 0.4%** of oleic acid or stearic acid.

⇒ This water repellent property is due to the formation of water-repellent flim around each particle of cement.

*** Low Heat Portland Cement (LHPC) :-**

⇒ This type of cement contains high quantities of dicalcius silicate and low quantities of tricalcium aluminate.

⇒ In comparision with PPC the hydration process is slow because of which generation of heat is also low

*** Sulphate- Resisting Portland Cement (SRPC) :-**

⇒ This cement contains only about 5% of tricalcium aluminate and is ground finer than OPC. This cement is highly sulphate resistant caused by the reaction of C_3A in hardened cement.

Lecture No. 2

Topic(s) to be covered	Chemical Composition and Properties.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	The Constituents and Chemical Composition	Remembering
LO2	Physical properties of opc	Understanding
LO3	Chemical Properties of Portland Cement	Remembering.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen

Lecture Notes

chemical Composition :-

The raw material used for the formation of cement consists of mainly of lime, silica, alumina, and iron oxide. In the kiln at high temperature. the constituents of cement interact with one another. The oxides of thes materials in proper quantities are responsible for influencing the various properties of cement including the rate of cooling and finess of grinding

⇒ The raw material high temperature Combine with each other and form complex compounds. The four compounds usually regarded as major compounds are Tricalcium silicate (3 CaOSiO₂ or C₃S). Dicalcium silicate (2 CaOSiO₂ or C₂S) Tricalcium aluminate (3 CaOAl₂O₃ or C₃A) and Tentra calcium alumino ferrite (4 CaOAl₂O₃Fe₂O₃ or C₄AF).

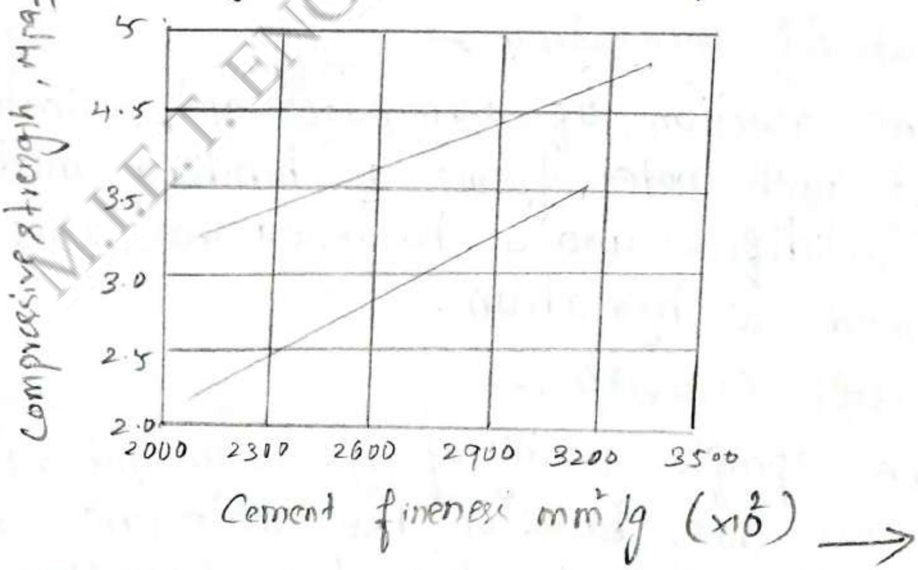
Constituents	Chemical Composition	Function.
Lime	CaO	Major ingredient Contributing for the strength of cement.
Silica	SiO_2	Formation of dicalcium and tri-calcium silicates add to the strength.
Alumina	Al_2O_3	Gives quick setting quality to Cement.
Calcium Salfate	$CaSO_4$	Presents in the form of gypsum and helps in increasing the initial setting time.
Iron Oxide	Fe_2O_3	Provides colour, hardness and strength to cement.
Magnesium oxide	MgO	Imparts hardness and colour.
Alkali oxides	K_2O and Na_2O	Excess quantity causes efflorenscence and failure.

physical proporties of opc :-

⇒ Fineness
⇒ Setting time.
⇒ Soundness
⇒ Compressive strength.
⇒ Heat of Hydration
⇒ Specific gravity.

⇒ Fineness :-

* Fineness of Cement is a measure of the size of Particles of the cement. It expressed as the specific surface of cement.
* The rate of strength and uniformity of cement are governed by the specific surface.



* The rate of hydration also increase with the finess of the cement. This is evident as large surface area is available for chemical reaction.
* This action leads to earliear developement of strength.

⇒ Setting Time :-

When water is added to the cement and mixed it forms a paste. This paste gradually becomes less plastic and finally forms a hard material. The time taken for the entire process is called the setting time. This time is divided into initial setting time and Final setting time.

⇒ Soundness :-

Expansive qualities of cement when mixed with water is termed the soundness of cement.

⇒ Compressive strength :-

It is One of the important properties of cement. The strength of cement is generally assed from Compression tests on cement morter cubes (1:3) with an area of 5000 mm^2.

⇒ Heat of Hydration :-

The reaction of aluminates and silicates of Cement with water forms a binding medium which solidifies into a hardened mass. This process is termed as hydration.

⇒ specific Gravity :-

The specific gravity of opc is around 3.15. The value may vary based on the materials used for manufacturing cement other than limestone and clay.

chemical properties of portland cement :

⇒ loss of ignition

⇒ Insoluble Reside

Lecture No. 3

Topic(s) to be covered	Hydration of Cement, Test on Cement.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Rate of hydration of Cement and mechanism of hydration	Remembering
LO2	Various laboratory test on Cement	Understanding.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen and Discuss.

Lecture Notes

Hydration of cement :-

Anhydrous Cement does not bind fine and Coarse aggregates. It aquires adhesive property only when mixed with water. The chemical reaction that take place between cement and water is reffered to as hydration of cement.

Rate of Hydration :-

The amount of sulfate must, therefore, be

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Lecture Notes

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Rate of Hydration :-

The amount of sulfate must, therefore, be

Carefully. Controlled to leave little excess C_3A to hydrate directly. The hardening of C_3S is catalyzed by C_2A so that C_3S becomes solely responsible for the gain of strength up to about 28 days by growth and interlocking **C-S-H**. Further, increase in strength is due to the hydration of C_2S. The rate of strength developement can be achieved by change the relative quantities of these Compounds.

⇒ Laboratory Tests on Cement :-

1. Fineness Test
2. Standard Consistency Test
3. Setting Time Test
4. Compressive strength Test
5. Tensile strength Test
6. Soundness Test
7. Heat of hydration Test
8. Chemical Composition Test.

1. Fineness Test :-

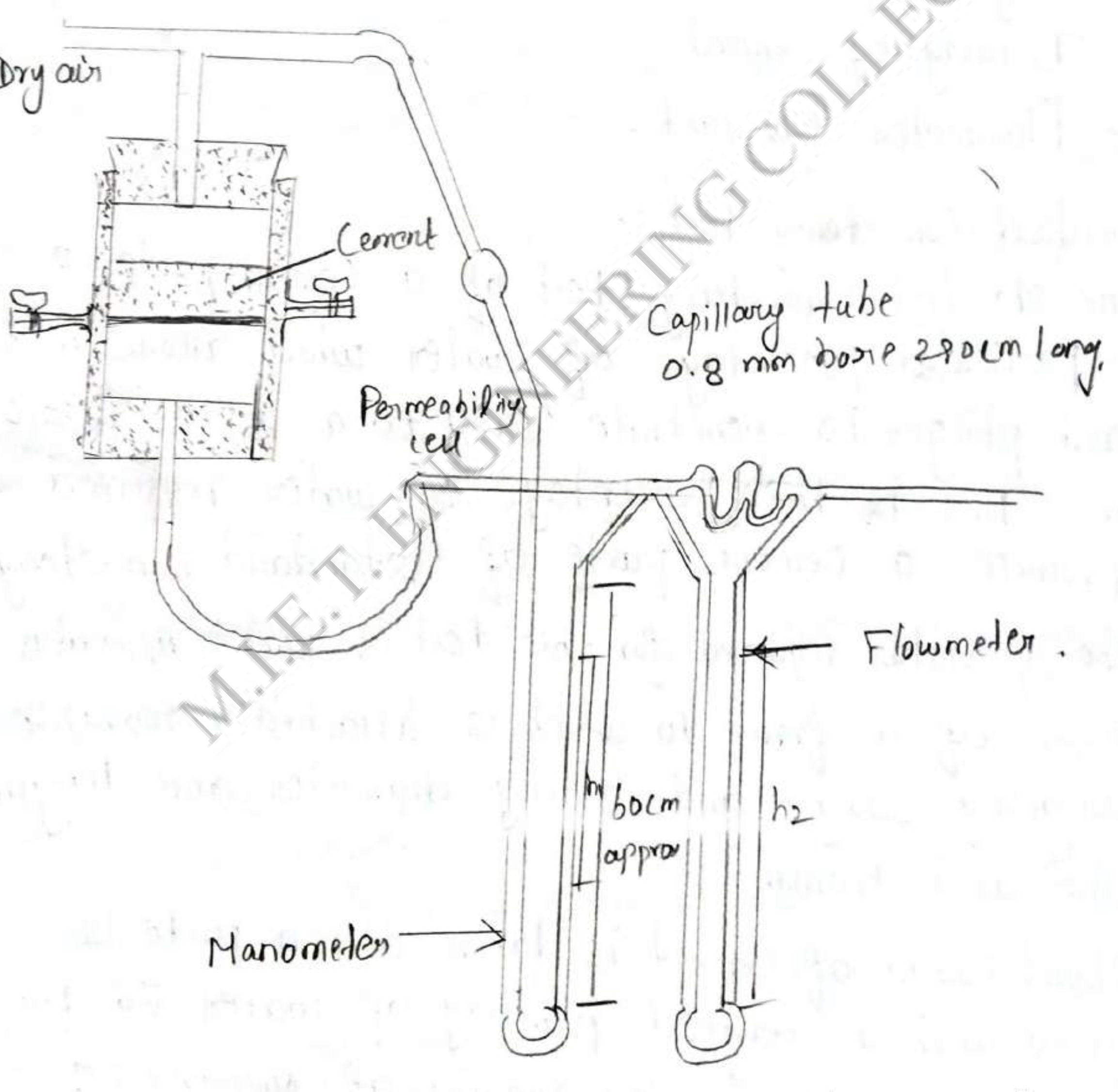
i) Sieve test
ii) Air permeability Test.

i) Sieve test :-

About 100g of Cement is weighed and sieved using a 90- micron IS sieve. Lumps if any are broken and sieve is Continued for 15 minutes is a circular and vertical motion.

⇒ 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.

Air permeability Test:-



Permeability apparatus with manometer and flowmeter

$$S_w = K\sqrt{\frac{h_1}{h_2}} \longrightarrow (1)$$

$$K = \frac{14}{d(1-\epsilon)}\sqrt{\frac{\epsilon^2 A}{CL}} \longrightarrow (2)$$

ε - Porosity
A - Area of cement bed
L - Length of Cement bed
d - Density of Cement
C - Flowmeter Constant.

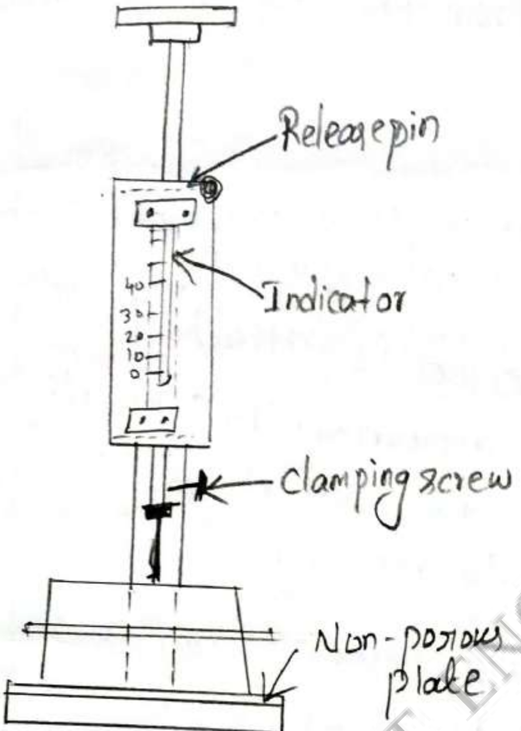
2. Standard Consistency Test :-

⇒ The standard Consistency test of a cement paste is that particular percentage of water which allows a standard plunger to penetrate only to a depth of 33 to 35 mm. This is the percentage of water required to produce a cement paste of standard Consistency

⇒ The apparatus required for this test is Vicat Apparatus. It consists of a frame to which is attached a movable rod weighing 300gm and having diameter and length as 10mm and 50mm.

⇒ About 500gm of Cement is taken and a paste is Prepared with a weighed quantity of water. For the first trial about 24% by weight of Cement is taken., the mould is shaken to expel air.

A standard plunger of 10m diameter and 50mm long is attached and brought down to touch the surface of the paste in the test block. It is released quickly allowing to sink into the paste by its own weight. The depth of penetration of plunger is noted.



Vicat apparatus.

2. Setting Time Test :-

i) Initial setting Time :-

Cement weighing about 500gm is taken and mixed with water as done in Consistency test. The cement paste is filled in the Vicat mould.

The squre needle of 1mm x 1mm Cross section is attached to the moving rod of the Vicat apparatus. The needle is released quickly and allowed to penetrate the cement paste. In the intial stage the needle penetrates completely. It is then taken out and placed on a fresh plate., needle should penetrate up to about 5mm from the bottom.

⇒ The initial setting time is noted which is the time interval between the addition of water to cement and the time at which the needle penetrated the test block to a depth equal to 33 to 35 mm from the top is taken as initial setting time.

ii) Final setting Time :-

⇒ The cement paste is prepared as done in initial setting time and is filled in the vicat mould.

⇒ The needle with annular collar is attached to the moving rod of the Vicat apparatus. This needle has a sharp point projecting in the centre with annular collar. The needle gently released

⇒ The time at which the needle makes an impression on test block and the collar fails to do so is noted. the final setting time is the difference between the time at which water has added to cement and the time recorded.

4. Compressive strength test :-

Cement sand mortor of 1:3 proportion is made. water is added to the morted with a weter cement ratio of 0.4. Cement required is 185 gm. The mortor is placed in the mould and compacted in vibrating maching for two minutes.

Lecture No. 4.

Topic(s) to be covered	Test on Cement

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Find the tensile strength on cement with laboratory test.	Understanding
LO2	Field testing of Cement.	Remembering

Teaching Learning Material	Student Activity
Chalk & Talk	listen

Lecture Notes

Tensile strength test:-

⇒ This is a simple test done using a specially shaped specimen called briquette made out of 1:3 cement mortar and tested in a direct tension test.

⇒ Cement mortar of 1:3 is prepared with 8% quantity of water. The mortar is placed in the briquette moulds. After filling the mortar a small heap of mortar is formed at its top. It is beaten down by a standard spatula till water appears on

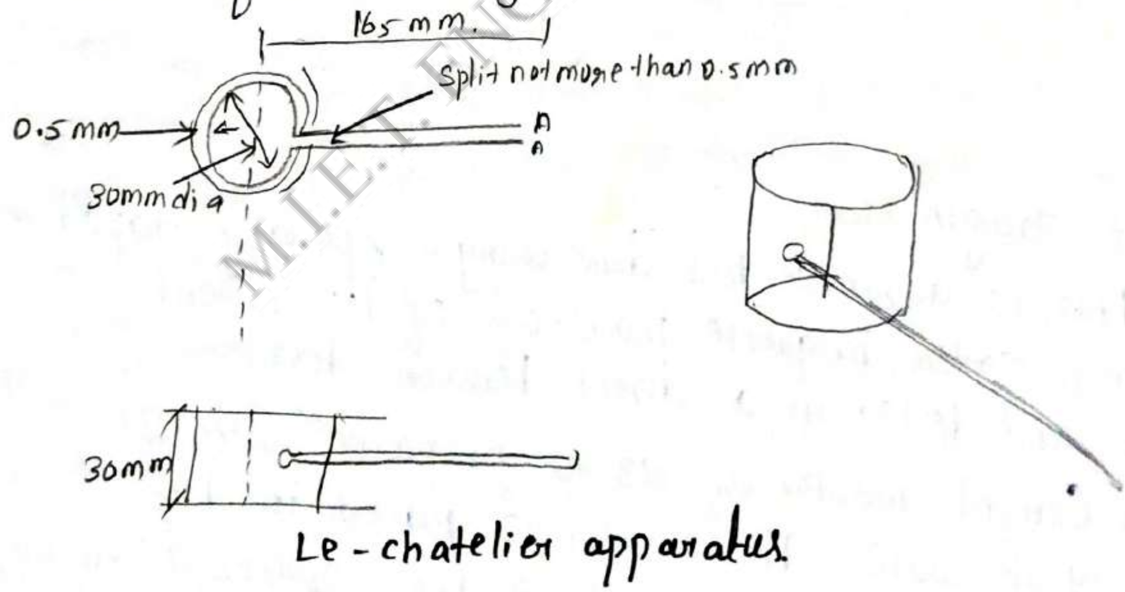
On the surface. Same procedure is repeated for the other face of briquette. Twelve such standard briquettes are prepared. The cement required to prepare 12 such briquttes is about 600 gm of cement.

⇒ At the end of 3 days and 7 days the briquttes are tested in testing machine.

$$\text{Ultimate tensile stress} = \frac{\text{Failure load}}{6.45}$$

6. Soundness test :-

⇒ Le-chatelier apparatus is the apparatus used. It consists of a brass mould of 30 mm diameter and height of 30mm. A slit is provided in the mould which is not exceeding 0.5mm. There are two indicators on either side of the split. The thickness of mould cylinder is 0.5mm.



Le-chatelier apparatus

→ The mould is placed on a glass plate and is filled by the cement paste. The mould is covered at top by another glass plate.

⇒ A small weight is placed at top and the whole assembly is submerged in water for 24 hours. The temperature is maintained between 24°c to 35°c. The distance between the points of indicator is noted.

⇒ The mould is again placed in water and heat is applied in such a way that boiling of water is reached in about 30 minutes.

⇒ The mould is taken out of water and is allowed to cool down. The distance between the points of indicator is again measured.

7. Heat of Hydration Test:

⇒ This test is Carried out by Vaccum flask method or in an adiabatic calorimeter. This test is essentially required to be Carried out for low Cement only

⇒ when tested on a standard manner the heat of hydration of low heat portland cement shall not be more than 65 cal/gm 7 days and 75 cal/gm at 28 days.

8. chemical Composition test :-

• Routine chemical composition tests are Carried out to determine the chemical constituents of Cement.

i) Ratio of percentage of alumina to that of iron oxide } Not less than 0.66

ii) Ratio of Percentage of lime to those of alumina, iron oxide and silica. } - Not less than 0.66 - Not greater than 1.02

This ratio is called lime saturation factor

iii) Total loss of ignition - Not greater than 4%

iv) Total sulphate Content - Not greater than 2.75%.

v) Weight of insoluble residue - Not greater than 1.5%

vi) Weight of magnesia - Not greater than 5%.

Field Testing of Cement :-

* when a hand is introduced in a bag of cement, the Cement should be cool to feel.

* A Small Sample of cement when rubbed between fingers should feel smooth.

* A hand full of cement thrown into a bucket of water should gradually sink. floating stuff indicates presence of ashes

* No lumps should present in the cement. Presence of lumps indicates that the cement has already set.

* The colour of good cement should be of uniform colour and of greenish grey.

Initial setting time observed.

Lecture No. 5

Topic(s) to be covered	Is specification. Aggregates, classification.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Understand the various grades of Concrete	understanding
LO2	Aggregate and their classification	Remembering

Teaching Learning Material	Student Activity

Lecture Notes

Is specification

For general Construction applications, there are three types of opc available namely 33, 43 and 53 grade Ordinary Portland Cement. Specifications for these different grades of cement shall Conform to IS 269:2013, IS 8112 :2013, IS 12269:2013 respectively.

Aggregate and their Classification:

Aggregates are the major and important constituent of concrete. They form the whole body of concrete as it occupies 70 to 80% of the volume of concrete.

Two Categories → Fine Aggregate → Particle size ~~bigger~~ less than 4.75 mm

→ Coarse Aggregate → " bigger than 4.75 mm.

1. Based on weight: → Coarse Aggregate.
   1. Normal weight aggregate
   2. light weight aggregate
   3. Heavy weight aggregate.

⇒ Normal weight Aggregates:-

1. Natural aggregates → Gravel, crushed rocks
2. Artificial aggregates → brick, air cooled slag, fly ash and bloated clay.

⇒ light weight Aggregates:-

In Order to redue the self weight of a structure light weight aggregates are used.

In general, the unit weight of light weight aggregates is 12 kN/m³. These aggregates may be from natural ones → such as diatomite, Pumice, volcanic cinder,

⇒ Heavy weight Aggregates :-

Heavy weight aggregates are barytle, goethite, hematite, ilmenite, limonite, magnetite etc. This materials have specific gravity varying from 3.5 to 8.0.

Based On shap :-

i) Rounded Aggregates
ii) Angular Aggregates
iii) Flaky and Elongated Aggregates
iv) Irregular Aggregates.

⇒ Rounded Aggregates :

Rounded aggregates provide minimum voids and minimum ratio of surface area to the volume. This aspect demands a minimum Cement Paste to make a good concrete.

⇒ Angular Aggregates :-

These aggregates are round particles with sharpness and angularity and provide a maximum Percentage of voids up to 40%.

Further good interlocking is possible between particles resulting in good bond In order to get high strength concrete, the workability can be achieved with more cement Paste.

Hence angular aggregates are not suitable for high strength concrete and for pavements subjected to tension.

⇒ Flaky and Elongated Aggregates:-

When the least dimension is less than three-fifth of its mean dimension, then the aggregates are reffered to as flaky.

When the greatest dimension, then the aggregates are reffered to as flaky. when the greatest dimension is greater than nine-fifth of its mean dimension, then the aggregates are reffered to as elongated. Flaky and elongated aggregates adversely affect the durability of concrete and their presence should be restricted to 10 to 15%.

iv) Irregular Aggregates:-

Aggregates having partly rounded particles are called irregular aggregates.

It provides voids about 40% and it requires more cement paste for a given workability.

These aggregates provide better interlocking compared to rounded aggregates.

Lecture No. 6.

Topic(s) to be covered	Mechanical properties and tests as per BIS

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Mechanical properties of Coarse aggregates and fine aggregates	Remembering
LO2	laboratory test for Coarse aggregate	Understanding

Teaching Learning Material	Student Activity
Chalk & Talk	listen

Lecture Notes

Properties of Coarse Aggregates

1. Strength of Coarse aggregates

As general acceptance, the strength of Concrete Can not exceed the bulk of aggregate contained therein. Thus it is sufficient to have a stronger coarse aggregates which evidently yield a strong concrete.

Mechanical properties of coarse aggregate which have a bearing on strength are,

1) Toughness
2) Hardness
3) Freezing and Thawing
4) Modulus of Elasticity,
5) Compressibility.

⇒ Toughness:

→ Toughness of aggregate is measured as the resistance of aggregate to failure by impact. may be used instead of its crushing value.

→ The aggregate impact value shall not exceed 45% by weight of aggregate

⇒ Hardness :-

→ Hardness of the aggregate defined as its resistance to wear obtained in terms of aggregate abrasion value.

→ A satisfactory aggregate should have an abrasion value of not more than 30%.

⇒ Freezing and Thawing :-

strength of an aggregate as measured by its resistance to freezing and thawing is an important characteristics for concrete exposed to severe weather.

⇒ Modulus of Elasticity :-

An aggregate with higher modulus of elasticity generally produces a concrete with higher modulus of elasticity.

The modulus of elasticity of aggregate also affect the magnitude of creep and shrinkage of concrete.

v) Compressibility :-

Compressibility of aggregat would reduce distress in concrete during its volume change while a strong and rigid aggregate might lead to cracking of the surrounding cement paste.

Partical shape and Texture :

The physical characteristics such as shape, texture and roughness of aggregates play a major role on the workability of concrete. Aggregates may have shapes like rounded, irregular, angular, flaky.

specific Gravity : -

$$\text{specific gravity of C.A} = \frac{\text{Mass of solid}}{\text{Volume}}$$

Porosity and Absorption of Aggregate :-

Air bubbles present in rocks during formation and so minute holes or cavities are formed which are termed as pores.

The porosity of the aggregate varies from 0 to 20%.

The quantity of water absorbed by an aggregate when immersed in water termed as absorption of aggregate represented in percentage.

Moisture Content of Aggregates :-

Moisture Content of agg. is the surface moisture expressed as a percentage of the weight of the saturated surface dry aggregate.

Bulk Density :-

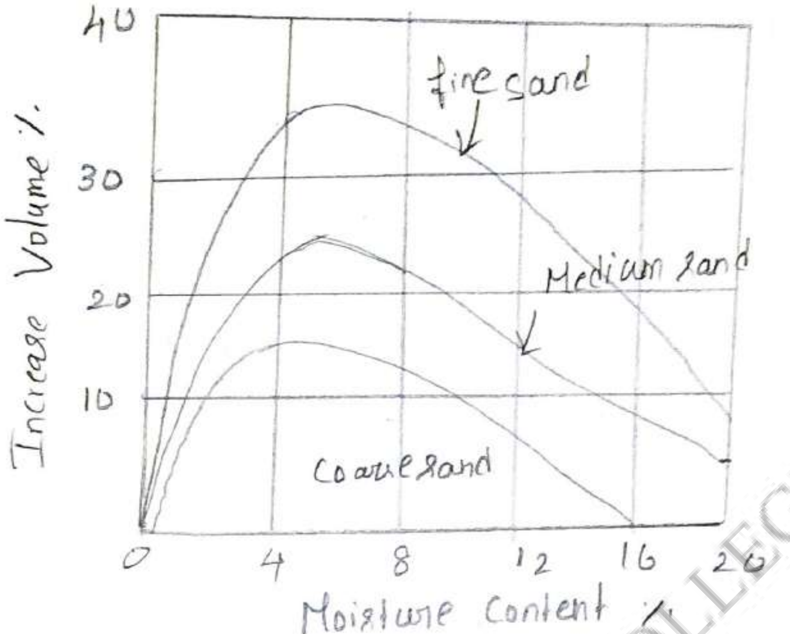
Bulk density of a coarse aggregat is defined as the mass of the material in unit volume.

It is expressed as kg/litre.

Voids :-

Voids are the empty space between the aggregate particles. It is difference between the whole volume less the volume occupied by the aggregte.

Properties of Fine Aggregates :-



Bulking of sand.

⇒ Bulking of sand is a special property which is of concern in construction works.

⇒ The increase in volume of a given mass of fine aggregate due to the presence of water is called bulking.

⇒ This is caused by the formation of thin films of water surrounding the particles which push the fine aggregate particles.

Aggregates of Common properties:

1. Shape 2. Texture 3. Strength 4. Specific Gravity 5. Water Absorption 6. Bulking factor 7. Cleanliness 8. Soundness 9. Chemical properties

10. Thermal properties 11. Sieve Analysis 12. Grading 13. Bulk Density and voids 14. Specific Surface and surface Index.

Shape:

Classification	Description	Examples
Rounded	Fully water Completely shaped by attrition	River or seashore gravels, desert, seashore and windblown.
Irregular or Partly rounded	Naturally irregular or partly shaped by attrition having rounded edges.	pit sands and gravels; land or dug flints, Cuboid rock.
Angular	Possessing well-defined edges formed at the intersection of roughly planar faces.	Crushed rocks of all types talus screes.
Flaky	Material usually angular of which the thickness is small relative to the width	laminated rocks

Texture :-

Glassy - Black flint

Smooth - Chert, slate, Marble, ~~some~~ r

Granular — Sandstone, oolites.
Crystalline — Basalt, Trachyte

1. Direct methods:-
i) Making a cast of the surface and magnifing a section of this.
ii) Tracing the irregularities by drawing a fine Point over the surface and drawing a trace magnified by mechanical, Optical or electrical means.

2. Indirect Methods:-
i) Measurement of the degree of dispersion of light falling on the surface.
ii) Determining the weight of a fine powder required to fill up the interstices of the surface to a truly smooth surface.

Strength:-
Strength of aggregates do not directly imply on the strength of the parent rock from which the aggregate are produced.

Specific Gravity and Bulk density:-
⇒ Average specific gravity of rocks vary from 2.6 to 2.8 and sand from 2.65 to 2.67

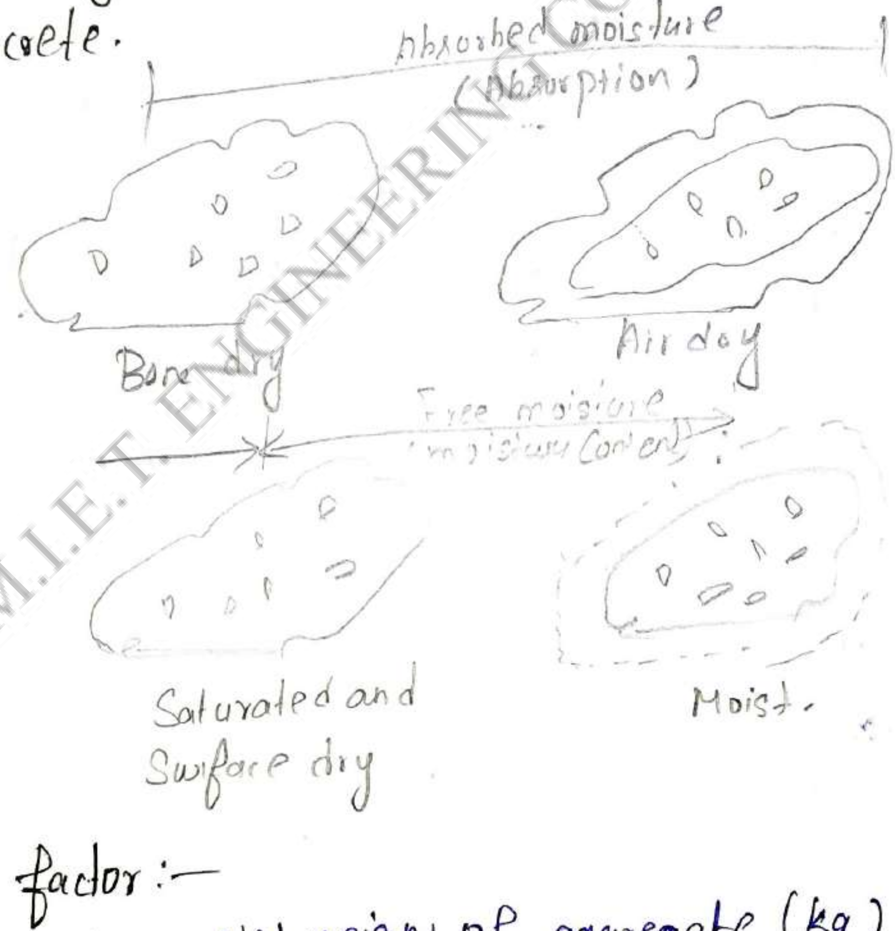
Bulk density :-

The bulk density depends on the particle size distribution and the shape of the particles.

Water Absorption :-

water absorption of aggregates will affect the water cement ratio and hence workability of Concrete.

Absorption quality is directly related to porosity as porosity will also affect the durability of concrete.



Bulking factor :-

$$\text{Bulk density} = \frac{\text{Net weight of aggregate (kg)}}{\text{Capacity of Container (lt)}}$$

$$\%\ \text{voids} = \frac{G_s - \gamma}{G_s} \times 100$$

Lecture No. 7

Topic(s) to be covered	Test as per BIS

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Tests on Coarse aggregates as per BIS	Understanding
LO2	Tests on fine aggregates	Understanding.

Teaching Learning Material	Student Activity
Chak & Talk	Listen & Discuss

Lecture Notes

Following are the tests Conducted on Coarse Aggregates:

1. Crushing Test
2. Abrasion Test
3. a) Los Angles Test
   b) Deval's Test
3. Impact Test
4. Soundness Test
5. Water absorption Test
6. Shape Tests

a) Flakiness index Test

b) Elongation Test.

1. Crushing Test :-

Procedure:

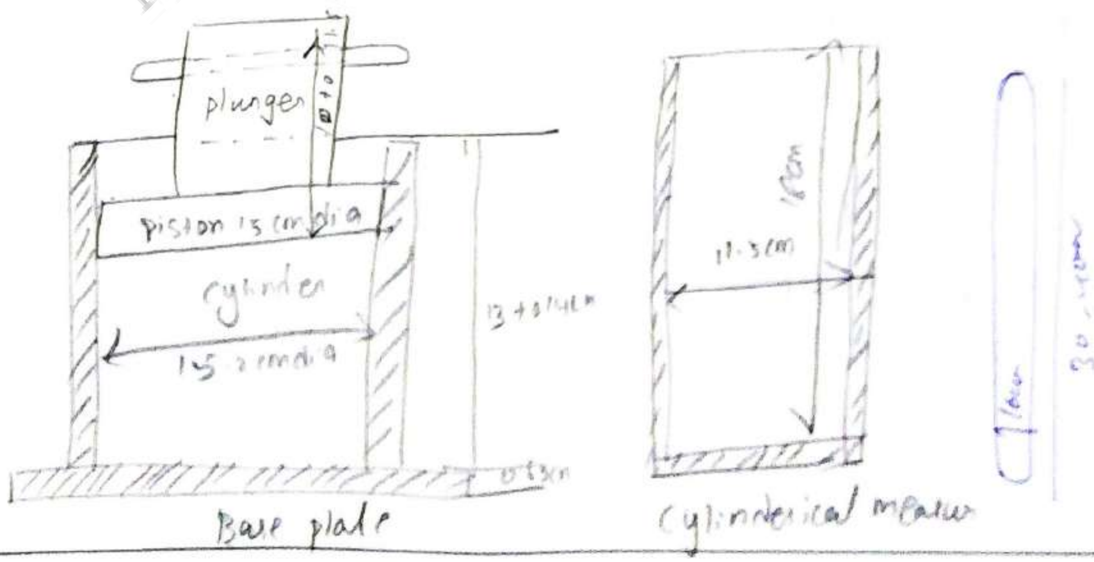
Dry agg. of 6.5kg passing 12.5mm IS sieve and retained on 10mm sieve is taken. The agg. is filled into the cylinder. Each layer is tamped 25 times with tamping rod.

The weight of sample contained in cylinder measure (M_1)

The plunger is placed on the top of sample with the cylinder. which is turn placed on compression testing machine. The sample is loaded uniformly of 40 tones. whole of the cylinder material removed and sieved 2.36 IS sieve.

The material passed through the sieve is weighed (M_2)

$$\text{Aggregate Crushing value} = \frac{M_2}{M_1} \times 100$$



1. Los - Angles Abrasion Test :-

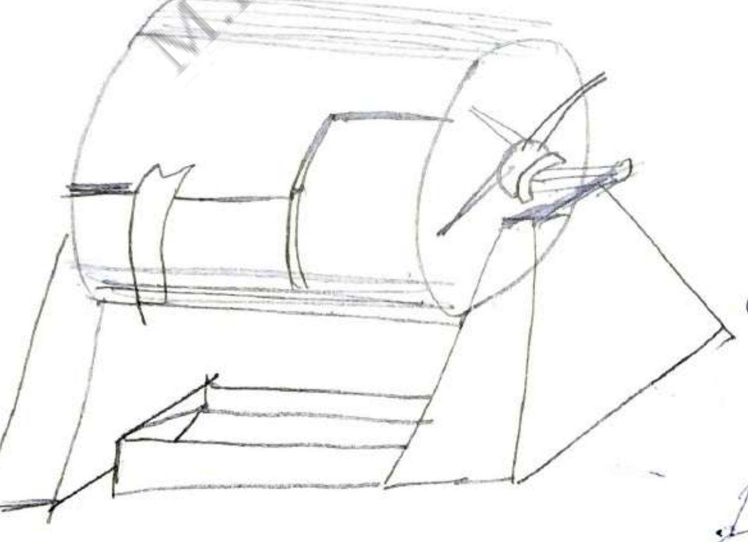
los Angles machine Consists of a hollow cylinder closed at both ends having inside diameter 70cm and length 50cm and mounted so as to rotate about horizantal axis.

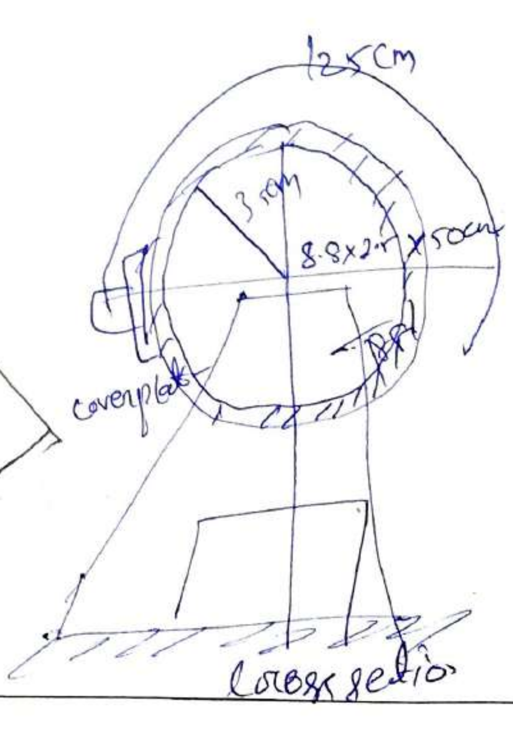
The specified weight of aggregate is added to the machine.

The machine is rotated at a speed of 20 to 33 rev/min. The machine is roated 500 revolutions After the Completion of the above number of revelutions the material is discharge from the machine.

Premliminary seperation of the sample is made on a sive carser than 1.7mm sieve. Finer portion is then seived on 1.7mm IS sieve.

$$= \frac{M_2 - M_1}{M_1} \times 100.$$





Deval's Abrasion Test:

→ Deval's machine Consists of two hallow cylinder 20cm diameter and 34cm length mounted

→ cylinder rotate about the horizontal axis 30°

→ The abrasive charges Consist of 6 Cast iron or steel sphere of about 4.8 cm diameter and total weight 2500g.

→ dry aggregates placed in the cylinder.

→ The machine is rotated at a speed 30 to 33 rpm for 10,000 revolutions.

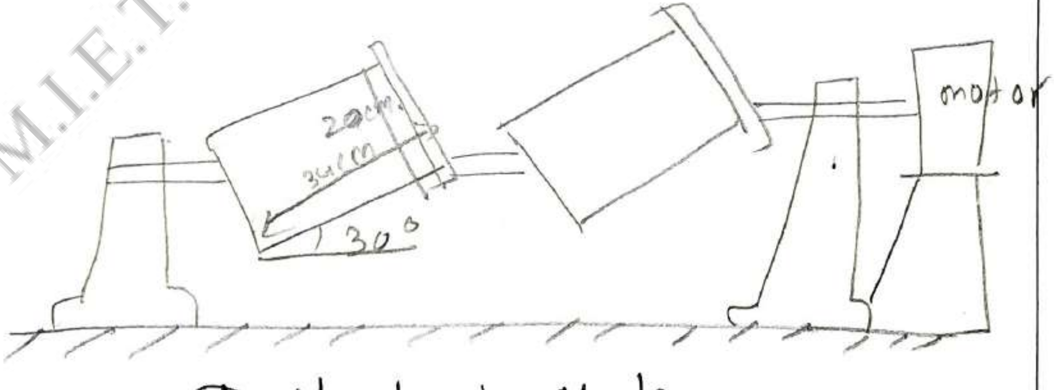
→ After Completion of revolutions the material is sieved through 1.7 mm

→ Is sieve and washed dried and Weight

$$= \frac{M_1 - M_2}{M_1} \times 100.$$

M_1 → Initial wt. of sample

M_2 → Final " "



Devil abrasion Machine

Aggregate Impact test:-

→ The sample is filled in the cylinderical measure in 3 layers by tamping each layer by 25 blows.

→ The net weight of the aggregate in the cylinderical measure is determined (M_1)

→ The whole sample is transferred from the measure to the cup of aggregate impact machine and compacted by tamping rod.

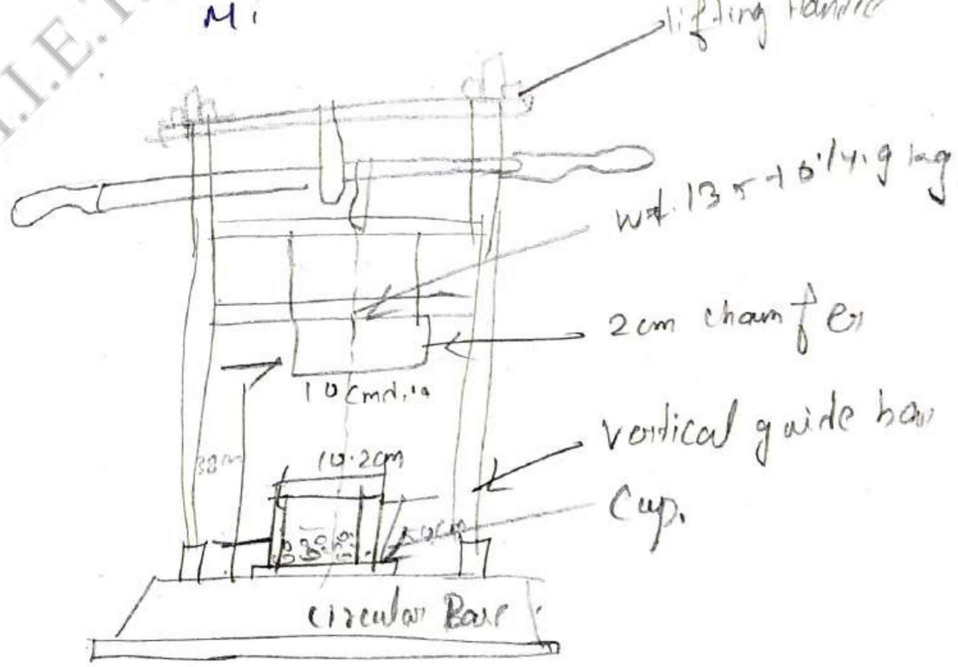
→ The hammer is raised to a height of 380mm above the upper surface of the cup allowed to fall freely on the aggregate sample in the cup.

→ The fraction passing the sieve is weighed to an accuracy of 0.1gm (M_2) The fraction retained on the sieve is also weighed (M_3)

total weight ($M_2 + M_3$) is less than the In.wt

M_1

$$= \frac{M_2}{M_1} \times 100.$$



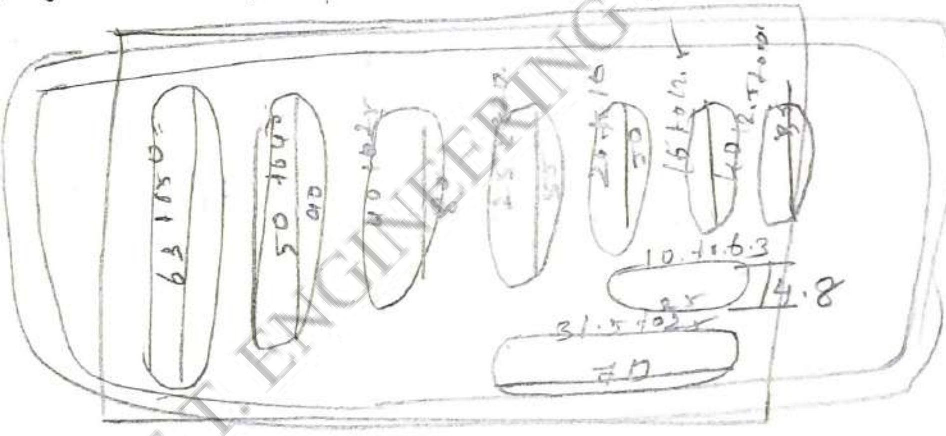
Aggregate soundness Test :-

Graded aggregates of known (M_1) is taken. The sample is soaked in a solution of magnesium sulphate for 16 to 18 hrs. The sample is dried in an oven 105 to 110°C as constant wt.

Aggregate Water Absorption test :-

$$\text{Water Absorption} = \frac{\text{Mass of water absorbed}}{\text{Dry mass of aggregates}} \times 100$$

Aggregates shape test :-



$$\text{Flakiness Index} = \frac{\text{Mass of materials passing through slots}}{\text{Intial mass of material taken}} \times 100$$

$$\text{Flakiness Index} = M_f / M_i \times 100$$

Aggregates Elongation Index Test :-

$$\text{Elongation Index} = \frac{\text{Mass of materials retained through}}{\text{Intial mass of material taken}} \times 100$$

Lecture No. 8

Topic(s) to be covered	Test as per BIS. Grading Requirements.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	The tests on fine aggregates	Understanding
LO2	Grading Requirements of Aggregates	Remembering.

Teaching Learning Material	Student Activity
Talk & chalk	listen

Lecture Notes

Aggregate Elongation Index Test :-

Apparatus Required i) standard length guage
ii) set of sieves,
iii) Weighing machine.

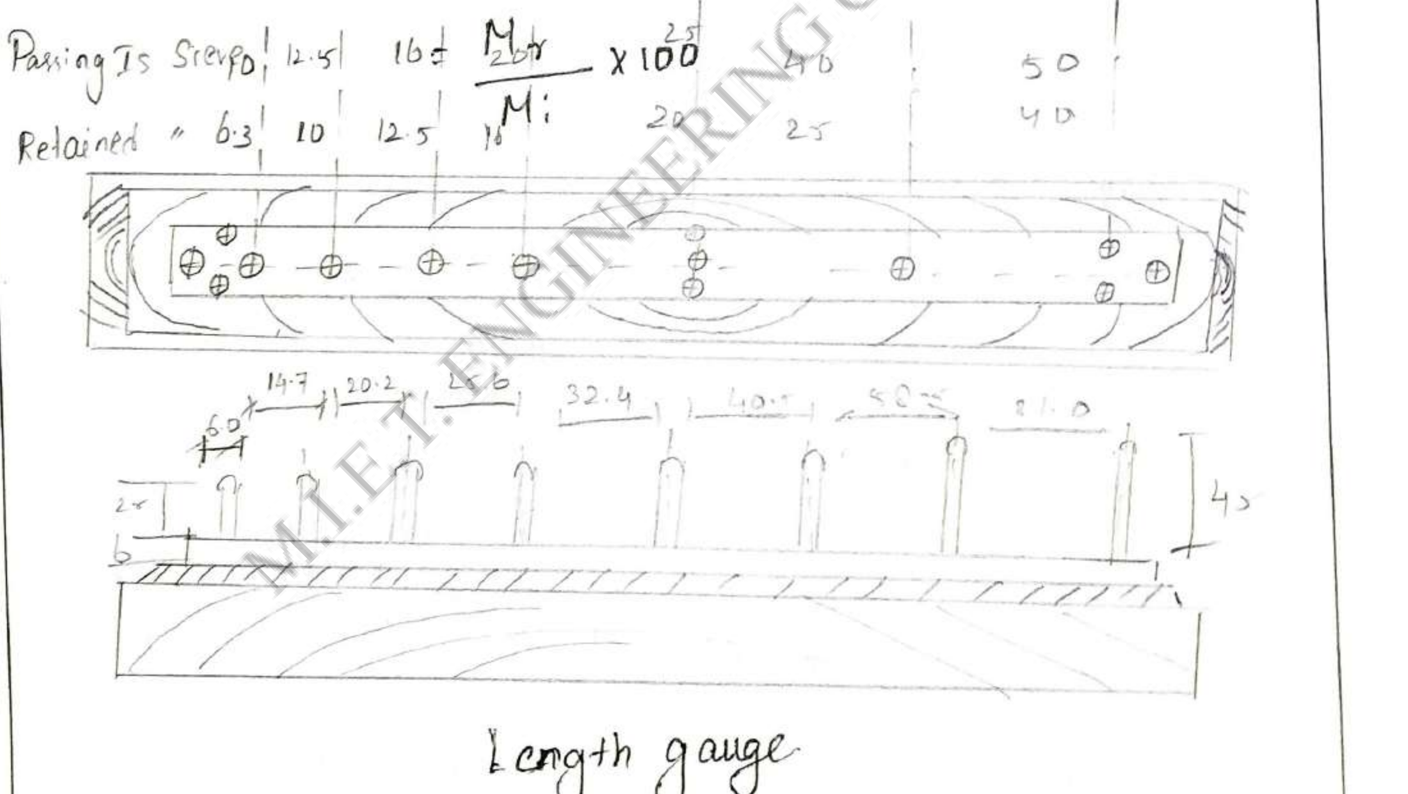
Sample of aggregates is sieved through a set of sieves and separated into specified size ranges.

A minimum of about 200 pieces are taken in each size.

The aggregates from each of the size - range is then individually passed through the appropriate gauge of the length gauges with the longest side in order to seperate the elongated particles. The gauge length should be 1.8 times the mean size of the agg.

let the total weight of the size- range be Mi. The amount of agg. retained by each gauge length is weighed and added (M1, M2, Mn = M2)

Elongation Index = $\frac{\text{Mass of materials retained throuqe gauge}}{\text{Initial mass of material taken}} \times 100$



Length gauge

Test on fine aggregates:

→ Organic Impurities test
→ Clay and fine silt and Fine dust test
→ Bulking of sand test.

Grading Requirements of Aggregates :-

⇒ Grading limits of Coarse aggregates.

Source IS : 383- 1970.

IS Sieve designation, mm	Percentage passing for graded aggregate of nominal size mm			
	40	20	16	12.5
80	100		–	–
40	95-100	100	–	–
20	30-70	95-100	100	100
16	–	–	95-100	–
12.5	–	–	–	90-100
10.0	10-35	25-55	30-70	40-85
4.75	0-5	0-10	0-10	0-10
2.36	–	–	–	–

Grading limits for fine aggregate

IS Sieve designatio mm,	Percentage Passing by weight			
	Zone I	Zone II	Zone III	Zone IV
10mm	100	100	100	100
4.75mm	90-100	90-100	90-100	95-100
2.36mm	60-95	75-100	85-100	95-100
1.18mm	30-70	55-90	75-100	90-100
600μm	15-34	35-59	60-79	80-100
300μm	5-20	8-30	12-40	15-50
150μm	0-10	0-10	0-10	0-15
Finess modulus	4.0-2.71	3.71-2.10	2.78-1.71	2.25-1.35

Lecture No. 9

Topic(s) to be covered	water quality of water for use in Concrete

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
1.	qualities for the mixing of water	Remember
2	limits of permissible impurities	Remembering

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

Water :-

water is an important ingredient of Concrete As a general guidence, if the water is fit for making Concrete. However, some water Containing a small quantity of sugar is not suitable for Concrete.

Although water is an impartant Constituent of Construction.

Qualities of mixing water:-

⇒ If the water is obtained from unknown source the strength of mortar or concrete made with questionable water is compared with similar mortar or concrete with pure water.

⇒ If the pH value of water lies between 6 and 8 the water is taken as free from organic matter and adopted as suitable.

⇒ If the quality of water is not known concrete is made with the available water and its cube strength at 7 days and 28 days are compared with ones made with distilled water.

⇒ Imupritics of water :-

1. Suspended particles :-

Muddy water should be used only after remaining in settling basins. In general, suspended particles of clay and silt are present the properties of concrete are not affected 0.02%. suspended particles present.

IS 456-2000 permits 2000 mg/lit of suspended matter.

2. presence of salts :-

Setting time of cement is affected by the presence of carbonates and bicarbonates of sodium and pottassium.

Higher percentage of these chemicals may adversely affect the strength of Concrete.

3. presence of Acids and Alkalies :-

The effluents from sewage works, and industries like paint, textile, sugar, fertilizer and gas are harmful for Concrete If the Effluent containing acids or alkalies is unsuitable for Concrete Construction.

Presence of Algae :-

Presence of algae in water or on the surface of aggregates reduces the bond between aggregate and cement paste.

The following guide lines may be adopted.

1) To neutralise 100 ml sample of water using phenophaline as an indicator it should not require more than 5mm of 0.02 normal NaOH.

2) To nalutralize 100ml sample of water, using mixed indicator, it should not require more than 25 ml of 0.02 normal H_2SO_4.

Limits of permissible impurities:-

Type of Impurities	permissible %
Organic	0.02
In Organic	0.30
sulfate SO_3	0.04
a) plain Concrete	0.20
b) Reinforce Concrete	0.05
c) Suspended	0.02

Lecture No. 10

Topic(s) to be covered	Accelerators, Retarders, plasticisers

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Type of chemical Admixtures used for Construction	Understanding
LO2	Application of chemical Admixtures	Remember

Teaching Learning Material	Student Activity
Chalk & Talk	Listen

Lecture Notes

Introduction :-

Admixtures and Construction chemicals are the chemicals added along with the ingredients of Concrete (or) afterwards to get the required mix to fit in for the desired strength and durability

Chemical Admixtures

Accelerators

Retarders

plasticizers
superplasticizers
Air entraining Admixture
Damp proofing Admixtures
Water proofing chemicals.

~~Retard~~ Accelerators :-

Accelerators are another very useful type of Admixture which are added to get the early strength. Such situation may occur under following conditions.

1. when early removel of formwork is needed
2. when reduction of period of curing is needed
3. when to put the structure early to use.
4. when accelerating the setting time in cold weather.
5. For emergency repair work.

The commonly used accelator is calcium chloride. It is not use in now, but soluble ~~ftuos~~ carbonates, silicates, fluosilicate and some of the organic compounds are used. Some of accelerators available now can make the cement set into stone hard in a matter of 5 minutes

plasticizers
superplasticizers
Air entraining Admixture
Damp proofing Admixtures
Water proofing chemicals.

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Retardars:-

A retardar is an admixtures which slows the Process of hydration because of that the Concrete remains plastic and workable. If Concreting is done in hot weather, retardars overcome the accelerating effect of high temperature. The retarders are used in consolidating large number of powrs without the formation of cold Joints and in grounting oil wells.

Calcium sulphate is Commonly used retarder. other admixtures used as retardars are lignosul-phonic acids and their salts, hydroxylated Carboxylic acid and their salts.

This admixtures which increase the Compressive strength by 10 to 20%

Plasticizers:-

High degree of workability is needed in different situations. Addition of excess water will only help the fluidity and not the workability of Concrete. But addition of plasticizers will improve the the desirable qualities demanded for plastic Concrete.

Application of plasticizers:

⇒ Allows greater workability to be achieved for given water cement ratio.

⇒ Retains Workability while reducing water content

⇒ Limitation of extent of water reduction

⇒ Conventionally increase slump by about 35 to 50mm without addition of water.

⇒ Usually Combined with other admixtures such as superplasticisers.

Super plasticizers :-

special properties of super plasticizers

⇒ Enhancement of workability at given water content.

⇒ Simultaneous improvement in workability of strength.

⇒ Can reduce water Content from 12 to 40 %.

⇒ Can produce Concrete slumps >200 mm.

Plasticizers are based on the following Constituents.

i) Anionic surfactants such as lignosulphonates and their modifications.

Lecture No. 17

Topic(s) to be covered	Super plasticizers, water proofers.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Workability condition for superplasticizer	Remember
LO2	Application of Air entraining Admixtures	Remember.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

Superplasticizers :-

These are chemically different from conventional plasticizers. The special quality of superplasticizers are the powerful action as dispersing agents and they are high range water reducers.

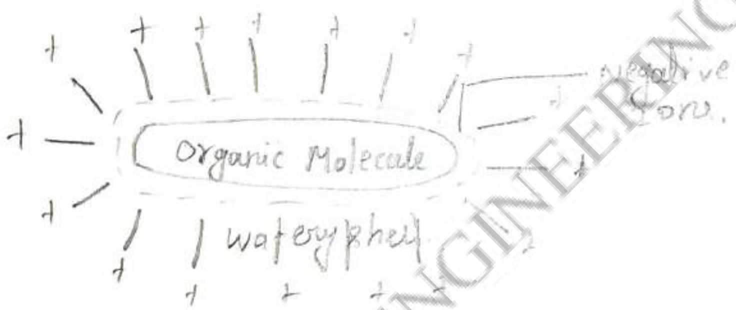
Superplasticizers permit reduction of water up to 30% without reduction in workability.

⇒ The superplasticizer molecule and mode of adsorption on Cement grains.

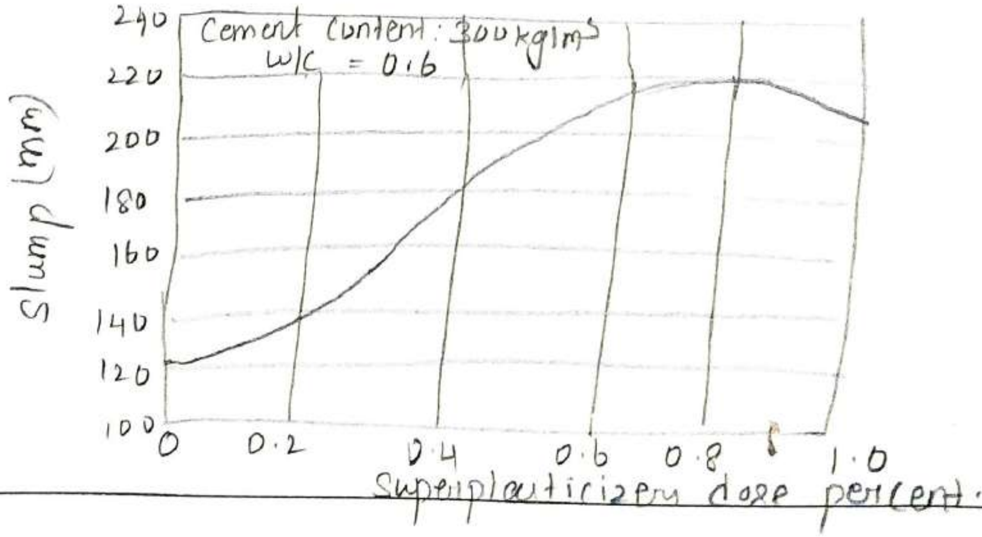
⇒ The average molecular mass of the plasticizer is of prime importance for its effectiveness in reducing water content in portland cement mixes.

⇒ The higher the molecular mass beyond which the dispersion effect is decreased.

Super plasticizer molecule.



The workability interms of slump increases with increase in amount of superplasticizers for the Same water Cement ratio.



Air entraining Admixtures :-

Air-entrained Concrete is made using an air entrained or addition of air entraining agent.

Air entraining agents produce a large quantity of air bubbles which act as flexible ball bearing and modify the properties of concrete regarding workability, segregations, bleeding and finishing quality of concrete.

Air entraining Agents :-

→ Natural wood resins
→ animal and vegetable fats
→ wetting agents (alkali salts)
→ water soluble soaps of resin acids

Application of air entraining admixtures :-

1. Necessary for Concrete in freeze - thaw Conditions.

2. Improvement in workability especially for lean Concretes.

3. Used in Production of light weight Concrete.

4. Used for partial replacement of Conventional Sand since entrained air bubbles act as frictionless sand.

5. Used in shotcreting.

Damp - proofing Admixtures :-

Two important properties of concrete should posses with reference to water are.

1. To resist when subjected to presence of water.

2. To product the absorption of surface water by capillary action.

⇒ In general a properly designed and constructed Concrete should be impermeable.

⇒ But it has been accepted that addition of some damp - proofing admixtures may prove to be of some advantages in reducing the permeability.

⇒ Damp - proofing admixtures are available in powder (or) liquid form.

⇒ They have the properties of pore filling Or water repellant materials.

⇒ Filling admixtures are silicate of soda, aluminium and zinc sulphates and aluminium and calcium chloride.

Lecture No.13

Topic(s) to be covered	Water proofers

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	performance of water proofing chemicals for Concrete	Understanding
LO2	Application of chemical Admixtures	Remember.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

Water proofing chemicals :-

Many of the admixtures discussed in the previous section directly or indirectly reduce the permeability of Concrete and thereby making the materials water-proof.

However, water proofing of roofs, walls, bathrooms, toilets, kitchens, basements, swimming pools, and water tanks etc...

⇒ Different materials are availabe to make the concrete perfectly water proof.

⇒ They are integral water-proofing compounds acrylic based polymer, mineral based polymer chemical DPC, water proofing adhesive for tiles, silicon based water repellent materials, injection grout, joint sealants and protective and decorative coatings.

Factors Affecting performance of chemical Admixtures:

1. chemical base of chemical admixtures
2. Dosage level
3. chemical composition, fineness and particle size distribution of cement.
4. Ambient temperature
5. Time of addition of admixtures.
6. Method of mixing of concrete ingredients.
7. Mode of addition of admixtures.
8. Water cement ratio and water content of concrete.
9. Method of transportation, placing and vibration.

10. Solid Content of chemical admixtures.
11. Storage conditions.

Application of chemical Admixtures :-

1. Slipform - To defer the setting time of Concrete depending on the rate of slipping.
2. Masswork - To avoid cold Joints
3. RMC - To Retain workability of Concrete for long haul operations
4. Pumping - To increase the workability without affecting strength.
5. Tremic - To increase the workability without affecting strength.
6. High strength - To increase the strength by reducing the water Content but maintaining workability.
7. RCC Walls - To make Concrete more Cohesive and less sensitive to over vibration.

8. Water Retaining - To make a dense, workable concrete with less water.

Lecture No. 13

Topic(s) to be covered	Mineral Admixtures like Fly Ash.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	properties of fly Alsh	Remember
LO2	Mineral Admixtures Reaction for Concrete.	Remember.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen

Lecture Notes

Mineral Admixtures :-

Pozzolanic or mineral admixtures have been in use since advent of concrete. Application of pozzolanic modify certain properties of fresh and hardened Concretes. Proper addition of pozzolanic admixtures to Cement improves many qualities of Concrete, such as lower the heat of hydration, increase the water tightness, reduce the alkali - aggregation reaction, resist sulphate attack, improve workability etc...

Siliceous materials and aluminous, do not posses any cementitious materials. But on reacting with cement and moisture, chemically react with calcium hydroxide liberated on hydration and form compounds possessing cementitious properties. This reaction is called pozzolanic reaction.

Naturally available pozzolanic materials are clay and shales, diatomaceous earth, volcanic tuffs and pumicites. Artificially available pozzolanic materials are fly ash, silica fume, ground granulated blast - furnace slag and metakaoline. Other mineral admixtures are finely ground marble, quartz and granite powder.

Fly Ash :-

⇒ Fly ash is a finely divided residue resulting from the combustion of powdered coal and transported by flue gases and collected by eletrostatic precipitator.

It is also called as pulverised fuel ash (PFA)

⇒ Now-a-days the importance and use of fly ash has grown up and it has almost become a common ingredient in concrete.

⇒ This is particularly used for making high strength and high performance concrete. One of the practical solutions to economise cement is to replace cement with supplementary cementitious materials like fly ash and slag.

⇒ Fly ash can be used in two ways, one way is to intergrind certain percentage of fly ash with cement clinker at the factory to the produce portland pozzolana cement. and the second way is to use fly ash an admixtures at the time of making concrete at the site of work.

⇒ The latter method gives freedom and flexibility to the user regarding the percentage addition of fly ash.

⇒ Quality of fly ash generated at different plants have varied propertize.

Properties of fly ash from different sources.

Property / Source	A	B	C	D	E
Specific Gravity	1.91	2.12	2.10	2.25	2.146 2.429
Wetsieve Analysis	16.07	54.65	15.60	5.00	51.00
Specific Surfaces (cm²/g/ Blaines)	2759	1325	2175	4016	2800to 3250
lime reactivity	86.8	56.0	40.3	79.3	56.25 70.31

Chemical Requirements (Source IS: 3812 -1981)

1\. Characteristics Requirements.

1\. Silicon dioxide (SiO) plus aluminium oxide (Al_2O_3) plus iron oxide (Fe_2O_3) percent by mass — 70.0

2\. Silicon dioxide (SiO_2), percent mass. min. — 35.0

3\. Magnesium Oxide (MgO), percent by mass, Max — 5.0

Lecture No:15

Topic(s) to be covered	Fly Ash.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	physical and chemical Requirement of fly Ash	Remember

Teaching Learning Material	Student Activity
Chaks Talk	Listen.

Lecture Notes

Chemical Requirements :-

4. Total sulphur as sulphur trioxide (SO_3), percent by mass, Max - 2.75

5. Available alkalis, as sodium oxide (Na_2O) percent by mass, Max - 1.5

6. Loss on ignition, percent by mass - max - 12.0

Physical Requirements :- (Source IS 3812-1981)

S.NO	Characteristics	Requirements Grade of fly Ash	
		I	II
1.	Fineness - Specific Surface in m^2/kg by Blaine's permeability method - Min.	32.0	250
2.	Lime reactivity - Average Compressive strength in N/mm^2 Min.	4.0	3.0
3.	Compressive strength at 28 days in N/mm^2 Min.	Not less than 80% of the strength corres-ponding to plain cement mortar cubes.	
4.	Drying shrinkage, percent, Max.	0.15	0.10

1. Effect of fly Ash Fresh Concrete:-

⇒ Use of right quality fly ash, reduces the water demand for the desired slump in fresh concrete.

⇒ Because of the reduction of unit water content, bleeding and drying shrinkage will be reduced.

⇒ As the fly ash is not highly reactive, the heat of hydration can be reduced through replacement of part of cement with fly ash.

2. Effect of fly ash on Hardened Concrete:

⇒ Due to pozzolanic reactivity, fly ash contributes to the strength of concrete. Since the pozzolanic reaction proceeds slowly. the initial strength of fly ash concrete tends to be lower than that of the concrete without fly ash.

⇒ However, due to continued pozzolanic reactivity concrete develops greater strength at later age, which may exceed that of the concrete without fly ash.

⇒ The pozzolanic reaction Contributes for the reduction in water and gas permeability and increase in denseness of the Concrete.

⇒ It is to be realised that the pozzolanic reaction Can only proceed in the presence of enough moisture.

⇒ Fly ash Concrete needs to be Cured for a longer period.

2. Effect on Durability :-

⇒ Use of good quality fly ash and sufficiently cured Concrete can show dense structure offering high resistance to the infiltration of deleterious substances.

⇒ Addtion of fly ash reduces the calcium hydroxide Content along with the dense paste gives more Resistance to the Corrosion of Reinforcement.

⇒ Addition of fly ash Contributes to the reduction of the expansion due to alkali aggregate reaction.

	At the end of this lecture, students will be able to	Bloom's Level
LO1	Various Effects for Concrete using silica fume	Understanding

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

Silica Fume:

It is also referred to as microsilica or Condensed silica fume, is another material added to Concrete as an artificial pozzolanic admixtures.

It is a light to dark grey or pink or white cementing material. It is composed of at least 85% Ultra fine, amorphous non-crystalline (glassy) spherical silicon dioxide (SiO_2) Particles.

⇒ It is a product resulting from reduction of high purity quartz with Coal in an electric arc furnace in the manufacture of silicon or ferrosilicon alloy. It rises as an oxidised vapour.

⇒ It cools, Condenses and is collected in Cloth bags. It is further processed to remove impurities and to control particle size.

⇒ The use of silica fume in conjuction with superplasticizer has been the back bone of mordern high performance Concrete.

Silica fume is availabe in the following forms:-

i) Undensified forms with bulk density of 200 - 300 kg/m^3.

ii) Densified forms with bulk density of 500-600 kg/m^3.

iii) Micro-pelletised forms with bulk density of 600-800 kg/m^3.

iv) Slurry forms with density 1400 kg/m³.

⇒ Silica fume is much more reactive than fly ash or any natural pozzolana. The reactivity of a pozzolana can be quantified by measuring the amount of $Ca(OH)_2$ in the cement paste at different times.

Effect on fresh Concrete:

⇒ Water demand increases in proportion to the amount of microsilica added.

⇒ Increase in water demand of Concrete with silica fume will be about 1% for every 1% of cement subtituted. This increase may be avoided by adjusting the aggregates grading and using superplasticizers.

⇒ Addition of silica fume may lead to low slump but of high mix

⇒ The silica fume makes the fresh concrete stickly in nature and hard to handle.

Effect on hardened Concrete:

⇒ Concrete with silica fume showed remarkable strength increase.

⇒ The combination of high reactivity and extreme fineness results in the possibility of producing more dense Concrete.

⇒ Such concrete has a very low porosity and with pores small and discontinous resulting in high strength and low penetrability.

⇒ At the same level of compressive strength, silicafue Concrete shows less modulus of elasticity than that of the Concrete with out silica fume.

Lecture No. 7

Topic(s) to be covered	Ground Granulated Blast furnace Slag

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Importance and specification of GGBS.	Understanding

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

Ground Granulated Blast furnace Slag:

⇒ It is a Waste Industrial by-product obtained during the production of iron.

⇒ The blast furnace slag is non-metallic product having oxide Composition similar to Clinker.

⇒ That is it Consists essentially of silicates and aluminates of calcium and other bases but it contains lesser calcium oxide

⇒ Air-cooled crystalline slag has no cementing properties. But once cooled rapidly it solidifies into a granulated (glassy) form which is reative with water having alkaline medium.

⇒ The granulated material when further ground less than 45 micron will have specific surface of about 400 to 600 m^2/kg (Baline)

⇒ The chemical Composition of Ground Granulated Blast furnace slag (GGBS) is similar to that of Cement Clinker.

Oxide Composition of cement clinker, GGBS fly ash.

S.NO	Constituents	Percentage Contents		
		Cement Clinker	Blast Furnace	Fly Ash
1.	CaO	60-67	30-45	1.0 - 3.0
2.	SiO_2	17-25	30-38	35-60

3.	Al_2O_3	3.0-8.0	15-25	10-30
4.	Fe_2O_3	0.5-6.0	0.5-2.0	4-10
5.	MgO	0.1-4.0	4.0-17.0	0.2-5.0
6	MnO_2	-	1.0-5.0	-
7	Glass	-	85-98	20-30
8.	Specify Gravity	3.15	2.9	2.1-2.6

The performance of slag largly depends on the chemical composition, glass content and fineness of grinding.

The quality of slag is governed by IS: 12089-1987.

Importance specifications of GGBS (IS: 12089-1987).

S.NO	Constituents	Limits	Value.
1.	Manganese Oxide %	→	5.5 Max
2.	Magnesium Oxide %	→	17.0 Max
3.	Sulphide Sulphur %	→	2.0

4.	Glass Content %	→	85.0 Min
5.	$\frac{CaO + MgO + 1/3\ Al_2O_3}{SiO_2 + 2/3\ Al_2O_3}$	≥	1.0
6.	$\frac{CaO + C_2S + 1/2\ MgO + Al_2O_3}{SiO_2 + MnO}$	≥	1.5
7.	$\frac{CaO + MgO + Al_2O_3}{SiO_2}$	≥	1.0

	At the end of this lecture, students will be able to	Bloom's Level
LO1	Effects of GGBS on fresh and Hardened Concrete.	Understanding
LO2	properties of meta koling	Remember.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

Effects of GGBS on Fresh Concrete:

⇒ The replacement of cement with GGBS shall reduee the unit water content necessary to obtain the same slump

⇒ This reduction shall be predominant with increase in slag cement and also on the fineness of slag.

⇒ It is attributed to the Surface Configuration and particle shape of slag being different than cement particle.

⇒ As the surface hydration of slag is slightly slower than the Cement, water used for mixing is not immediately lost.

⇒ Reduction of bleeding is not significant with slag 4000 cm^2/g fineness. But significant effect is observed with slag fineness of 6000 cm^2/g and above.

2. Effects of GGBS on Hardned Concrete:-

Use of GGBS leads to the enhancement of intrinsic properties of Concrete in both fresh and hardened Conditions. The major advantages are...

⇒ Reduced heat of hydration.

⇒ Refinement of pore structure.

⇒ Reduced permeabilities to the external agencies

⇒ Increase Resistance to chemical attack.

⇒ The effect of GGBS on the workability are much less than those of fly ash due to lesser specific surface of 325 ± 25 m²/kg. The improvement in workability is probaly equivalent to about 5% increase in water content which is insignificant.

Metakaolin :-

⇒ Natural pozzolanas, namely thermally activated ordinary clay and kolinitic clay have been often called as Metakolin.

⇒ Although it showed certain amount of pozzolanic properties, they are not highly reative.

⇒ Highly reactive metakaolin is made by water processing to remove unreactive impurities to make 100% reactive pozzolana,

⇒ Such a product, white or Cream in colour, purified thermally activated is called High Reactive Metakaolin.

⇒ High reactive metakaolin shows high pozzolanic reactivity and reduction in $Ca(OH_2)$ Further the paste undergoes distinct densification.

⇒ This densification shows an increase in strength and decrease in permeability.

⇒ Metakaolin is having the potential to complete with silica fume.

Lecture No. 18

Topic(s) to be covered	Effects on Concrete properties.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Concrete Curing Compounds	Remember
LO2	Function of polymer Bonding Agents	Remember

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

Construction Materials :-

⇒ The discussion made so far is centered on the modification of the properties of Concrete using admixtures, other chemicals which are used to enhance the performance are discussed in this section.

⇒ Such chemicals are reffered to as Construction chemicals or building chemicals

Concrete Curing Compounds (Water).

⇒ In Order to prevent the loss of water from the Surface due to evaporation or Otherwise, it has to be retained for which Certain measures are taken which is called curing.

⇒ Surface loss of water from concrete depends upon air temperature, relative humidity, fresh concrete temperaratur and wind velocity

⇒ Liquid membrane forming curing compounds are used. Curing compounds are used with the following bases, synthetic resin, wax, acrylic and chlorinated rubber.

⇒ Resin and wax based compounds effectively seal the concrete from surface evaporation.

⇒ Acrylic based membrane Compounds have additional advantage of better adhsion of subsequent plaster

⇒ chlorinated rubber curing Compounds form a thin flim on the surface of the concrete which protects drying at the same time they fill the pores on the surface of the

- Concrete which protects drying at the same time they fill the pores on the surface of the concrete. The surface flim will wear out.

Polymer Bonding Agents:-

Many a times new concrete is required to be placed over an old concrete surface.

In such cases a perfect bond is required.

By providing a bond coat between the new and old surfaces of concrete a bond can be achieved.

A mixing of a bonding agent with the new concrete helps to provide a better bond.

Such mixtures also improve the workability and reduce shrinkage.

Many types of commercial products such as Roof Bond ERB, Nitobond PVA, are available.

Polymer modified repair materials are available for repair of concrete works

Such repair works may be ceiling of Concrete roof, hydraulic structures prefab -ricated members, pipes, poles etc.

Such repair works may be ceiling of Concrete roof, hydraulic structures prefab -ricated members, pipes, poles etc.

Lecture No. 19

Topic(s) to be covered	Principals of Mix proportioning.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Types of Cement Concrete	Remember
LO2	Grades of cement Concrete	Remember

Teaching Learning Material	Student Activity
chalk & Talk	Listen.

Lecture Notes

Introduction:-

Selection of proper quantity of Cement, Coarse aggregate, Sand and Water to obtain the desired quality is known as proportioning of Concrete.

Types of Cement Concrete:-

1. plain Cement concrete.
2. Reinforced cement Concrete.
3. Prestressed Cement Concrete.

Plain Cement Concrete :-

It is the simplest form of concrete made with Cement, Sand, Coarse aggregate and Water. It is used for variety of works where in structural members are subjected to compression.

Reinforced Cement Concrete :

The cement concrete provided with steel reinforcement for taking tension, bending, torsion, fatigue is referred to as Reinforced Cement Concrete (R.C.C)

The steel used in R.C.C Works are : Mild steel bars, Medium tensile steel bars, Hot rolled deformed bars, Cold twisted bars, Hard-drawn Steel wire fabric or Rolled steel.

It is used in various structural members, coloumns, beams, footings, slabs, stair-cases, shelters, basements, water tanks, retaining Walls folded plates, shells, domes. etc.-

Pre-stressed Cement Concrete :

High tensile steel wires are used as reinforcement instead of mild steel bars. High tensile steel wires are stretched initially to the desired level and concrete is placed.

After setting and completion of Curing the Concrete is put into use. As the steel wires are initially stretched the concrete so casted is known as pre-streessed Concrete.

This type of concrete is used for large span bridges, Girders, beams, railway sleepers, electric poles,

Grades of cement Concrete (Source IS456:2000)

Table 2.

S.No	Group	Grade designation	Specified characteristic compressive strength of 150 mm cube at 28 days N/mm²
1.	Ordinary Concrete	M10	10
		M15	15
		M20	20
2.	Standard Concrete	M25	25
		M30	30
		M35	35
		M40	40
		M45	45
		M50	50
		M55	55

		M60	60
		M65	65
3.	High strength Concrete.	M70	70
		M75	75
		M80	80

Principals of mix propotioning

As per Indian standard (IS 456-2000) following are the factors, which influence the mix Proportioning

- → Grade designation
- → Type and Grade of cement
- → Maximum nominal size of aggregate.
- → Grading of combined aggregates
- → Water cement ratio
- → Durability
- → Quality control.

Lecture No. 20

Topic(s) to be covered	Principales of Mix proportioning - Properties of Concrete Related to Mix design.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	General properties of Concrete.	Remember

Teaching Learning Material	Student Activity
chalk & Talk	Listen.

Lecture Notes

General properties of Concrete:

→ Weight

→ Compressive Strength

→ Tensile strength

→ Elastic deformation

→ Shrinkage.

→ Creep of Concrete.

→ Thermal expansion.

→ Workability
→ Durability
→ poisson's Ratio
→ Freezing and Thawing.

1. Weight:

Unit Weight of plain Cement Concrete and Reinforced Cement Concrete with Sand, Crushed natural stone aggregate may be taken 24000 N/m² and 25000 N/m² Respectively.

2. Compressive strength:

Based on the properties of aggregate the Compressive Strength of Concrete depends primarily on Cement Content, water-cement ratio and age. The characteristic Compressive strengths are based on the strengths at 28 days

The strength at 7 days is about two thirds of that at 28 days with OPC and it is the Correct indication of strength likely to be attained.

A member should not be subjected to its full design load or stress with in a period of

28 days after casting of the member.

Age factor of compressive strength (IS456-2000)

Minimum Age of member when full design load / stress expected	Age factor
1	1.00
3	1.10
6	1.15
12	1.20

Tensile strength:

Tensile strength of concrete may be obtained by conducting flexural and spiliting tensile strength on specimens. When it is intended to estimate the flexural strength from compressive strength the formula as suggested in code IS 456 - 2000 may be used.

Flexural strength $f_c = 0.7\sqrt{f_{ck}}$ N/mm^2

where f_{ck} is the characteristic cube compressive strength of concrete in N/mm^2.

Elastic Deformation:

This modulus of elasticity is primarily influenced by the elastic properties of the aggregate and to a lesser extent by the conditions of curing and age of the concrete, the mix proportions and the type of cement, The modulus of elasticity is normally related to the compressive strength of concrete.

The modulus of elasticity of concrete

$$E_c = 5000\sqrt{f_{ck}}$$

E_c is the short term static modulus of elasticity in N/mm^2.

Shrinkage:

The total shrinkage of concrete depends upon the constituents of concrete, size of the member and environmental conditions. The approximate value of the total shrinkage strain for design may be taken as 0.0003

Creep of Concrete:

Creep of concrete depends, in addition to the factors that effect shrinkage on the stress in concrete, age of loading and the duration of loading.

As long as the stress in concrete does not exceed one-thirds of the characteristic compressive strength, creep may be assumed to be proportional to the stress.

Age of loading	Creep co-efficient.
7 days	2.2
28 days	1.6
1 year	1.1

Thermal Expansion:

The co-efficient of thermal expansion depends on the nature of cement, the aggregate, the cement content, the relative humidity and the size of sections. The value of co-efficient of thermal expansion for concrete with aggregates co-efficients of thermal expansion (IS456-2000)

S.NO	Type of Aggregate	co-efficient of thermal expansion of concrete
1.	Quartzite	1.2 to 1.3×10^{-3}
2.	Sandstone	0.9 to 1.2×10^{-3}
3.	Granite	0.7 to 0.95×10^{-3}
4.	Basalt	0.8 to 0.95×10^{-3}
5	Limestone	0.6 to 0.90×10^{-3}

Workability

The concrete mix proportions chosen should be such that the concrete is of adequate workability for the placing conditions of concrete and can properly be compacted with the means availab.

Workability of concrete: (IS456-2000)

S.NO	placing condition	Degree of Workability	Slump (mm)
1.	Mass Concrete	Low	25-75
2.	light reinforced sections in slab, beams and columns	Low	25-75
3.	Strip footing	Medium	50-10.

Durability :

A durable Concrete is one that performs satisfactory in the working environment during its anticipated exposure conditions during the service. The materials and mix proportions specified and used should be such as to maintain its integrity, if applicable to protect embedded metel from corrossion.

Poisson's Ratio :

poisson's ratio enables to determine the Secondary stresses which occurs due to primary stresses. poisson's ratio for concrete varies from 0.15 to 0.3

Freezing and Thawing :

When freezing and thawing actions under wet conditions exist, enhanced durability can be obtained by the use of suitable air entraining admixtures when concrete by volume ~~of the fresh Concrete~~ lower than M50 grade is used under these conditions, the mean total air content by volume of the fresh concrete at the time of construction.

Lecture No. 21

Topic(s) to be covered	Properties of Concrete Related to Mix deign

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Various Methods of Controlling Sulphate Attach	Remember

Teaching Learning Material	Student Activity
Chalk & Talk	Listen

Lecture Notes

Sulphate attach:-

Causes of sulphate Attach:

Sulphate attach is the common occurrence in natural or industrial situation. solid sulphates do not attach the concrete severly but when the chemicals are in solution. they find entry into porus concrete and react with the hydraked cement products.

The term sulphate attach denotes an increase in the volume of cement paste in concrete or mortar due to chemical reaction between the products of hydration of cement and solution containing sulphates.

Methods of controlling Sulphate Attach:-

i) Use of sulphate Resisting cement:-

By using cement with the low C_3A content significantly resist the sulphate attach. In general, it has been found that a C_3A content of 7% gives a rough division between cements of good and poor performance in sulphate water.

2) Quality concrete:-

A high resistance to sulphate attach is achieved by using a well designed, placed and compacted concrete with high density. Similarly, a concrete with low water-cement ratio is also provide a high resistance to sulphate attach.

3) Use of air entrainment:

Sulphate Resisting qualities of concrete is achieved by use of air entrainment to the extent of about 6%. The benefit is due to reduction of segregation improvement of workability, reduction in bleeding and in general good impermeable concrete.

4) Use of pozzolana.

Sulphate attach is also reduced by incorpora-tion of or replacing a part of cement by a pozzolanic material. Use of pozzolana converts the leachable calcium hydroxide into insoluble non-leachable cementitious product.

5) High pressure steam curing:

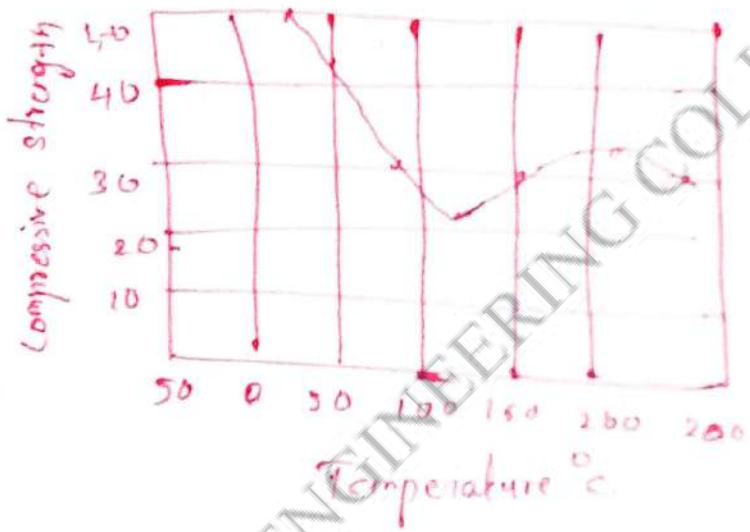
By high pressure steam curing the Resistance of concrete to Sulphate attach can be improved.

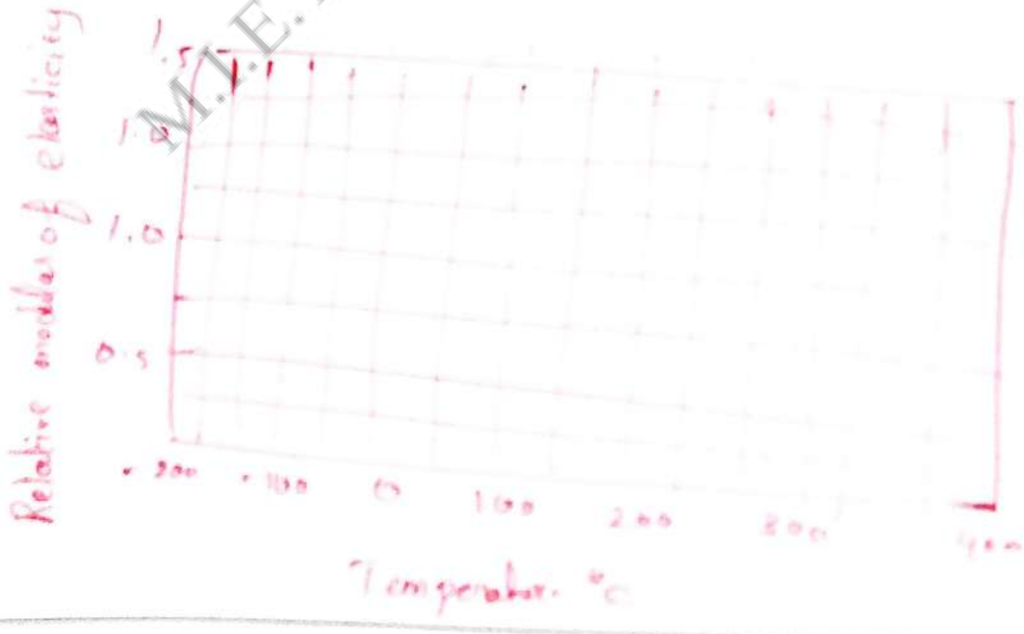
6) Use of high Alumina cement:

The cause of sulphate attach by use of high alumina cement is atributed in part to the absence of any free calcium hydroxide in the set cement. High alumina cement contains approximately 40% alumina, a compound very susceptible to sulphate attach.

Fire Resistance of Concrete :-

Although Concrete is not a refractory material, it is incombustible and has high fire- Resistant properties. subjected high temperature the concrete surface layer tend to seperate and spall of from the cooler interior.





Lecture No. 12

Topic(s) to be covered	Properties of concrete Related to Mix design

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	General Requirements to produce high quality Concrete, more workable and high strength of Concrete	Remember

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

Quality Control of Concrete:

Following are the general requirements to produce high quality concrete, more workable and high strength :-

→ Air bubbles should be completely removed from the concrete.

→ Compaction of concrete should be such that a maximum void is present.

3. Adequate curing for 28 days have to be effected

A carefully constructed concrete work with high quality claims the following advantages.

→ Failure possibility is minimised.

→ Lower cost of construction with long life

→ Low maintenance cost

→ possibility of using low grade materials for some other purpose.

Extreme Weather Concreting :-

Concreting in Hot Weather:-

→ The amount of water needed for obtaining a certain workability increases, requiring a high water - cement ratio.

→ The workability of fresh concrete decreases more rapidly

→ The probality of cracking of the concrete, from surface down, is due to plastic shrinkage

→ Accentuation of thermal gradients due to additional heat released from hydration of cement.

Concreting in Cold Weather:

The 28 days strength will be of 50% if cured at 0°c and of 30% if cured at 10°c. This delay in setting of concrete results in increase of labour cost, material cost, waiting time, etc... It is is the condition that freshly laid concrete under no condition should be below 4°c.

Principles of mix proportioning:

→ Grade designation
→ Type and grade of cement
→ Maximum nominal size of aggregate
→ Grading of combined aggregates
→ Water cement ratio
→ Workability
→ Durability
→ Quality control.

1. Grade designation :-

Grade designation gives characteristic compressive strength requirements of the concrete. characteristic compressive strength is that value below which not more than 5% of the test Results are expected to fall. It is the major factor which influences the mix design.

Type and Grade of cement:

The available grades of cement have been reported to maintain standard deviations as low as 0.5, 1.5 and 1.0 Mpa respectively 33, 45 and 53 grade of cement. The strength of cement to be used in mix design computations is not the mean strength

$$f_{ck} = f_m - ks.$$

Maximum Nominal size of Aggregates:

According to the code, the maximum nominal size of aggregate should not be more than one fourth of the minimum thickness of the member.

Grading of Combined Aggregate:

The locally available aggregates do not conform to the standard combining aggregates is aimed at obtaining a grading close to the coarsest grading of the standard grading curves, the most economical mix having highest permissibility aggregate cement ratio.

Water Cement ratio:

The strength of cement to be used is determined. Generally, a minimum seven day strength of 22 Mpa is adopted in india.

When cement strength data are availabe, the corresponding curve is closer, to select the water - cement ratio.

Workability :-

i) Size and shape of section to be concreted.

ii) Quantity and spacing of Reinforcement

iii) Methods to be employed for transportation.

iv) placing

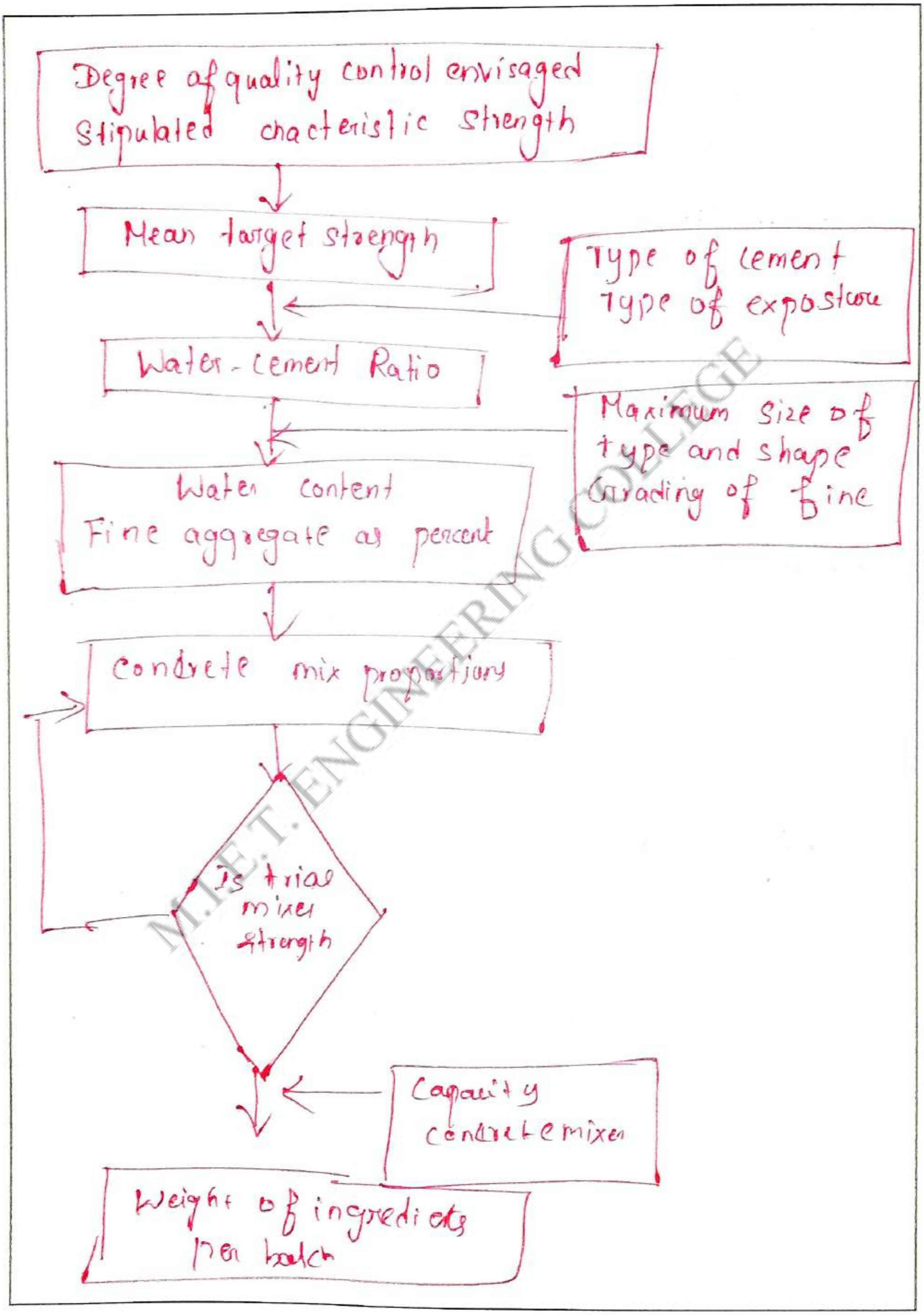
v) compaction.

Durability :

Permeability of cement paste increases exponentially with increase in water - cement ratio above 0.45 to 0.55 except in mild environment.

Quality Control :

It is to summarise that the principal aim of proportioning and mix design to obtain a most practical and economical combination of materials that will products hardened concrete of Required strength and durability.


Degree of quality control envisaged
Stipulated chacteristic strength
Mean target strength
Type of cement
Type of exposure
Water-cement Ratio
Maximum size of
type and shape
Grading of fine
Water content
Fine aggregate as percent
Condrete mix proportions
Is trial
mixer
strength
Capacity
concrete mixer
Weight of ingrediets
per batch

Lecture No. 23

Topic(s) to be covered	Physical properties of materials Required for mix design

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	physical properties of Concrete using Mix design	Remember

Teaching Learning Material	Student Activity
Chalk & Talk	Listen

Lecture Notes

Properties of Concrete Related to Mix Design :

→ Mixability
→ Stability
→ Flowability or mobility
→ compactability.
→ finishability.

Mixability :-

The Constituent materials of fresh concrete should be capable of undergoing suitable mixing under the action of mixing forces so as to produce a homogeneous fresh concrete.

Stability :

The fresh concrete should be stale enough during transportation such that there is no tendency of bleedings.

Flowability :

The fresh concrete mix should be cohesive and around the adequately mobile such that while placing in the formwork and around the reinforcement it should be easy enough to cast to the required shape.

Compactability :-

The fresh concrete should be in a position to get compacted with a minimum void under a given type of compaction.

Finishability :

The fresh concrete should be able to give to good surface finish while trowelling without any honey comb.

Mix Design Concept :-

The four factors to be considered in the design of concrete mix.

- → Water cement ratio
- → Cement - aggregate Ratio
- → Gradation of aggregate
- → Consistancy

Physical properties of materials Required for mix design :

→ Water Cement Ratio :-

$$S = K\left[\frac{c}{c+e+a}\right]^2$$

s → Strength of Concrete

c → Volume of cement

e → Volume of Water

a → Volume of Air

K → Constant.

Mix Design Concept :-

The four factors to be considered in the design of concrete mix.

- Water cement ratio
- Cement - aggregate Ratio
- Gradation of aggregate
- Consistancy

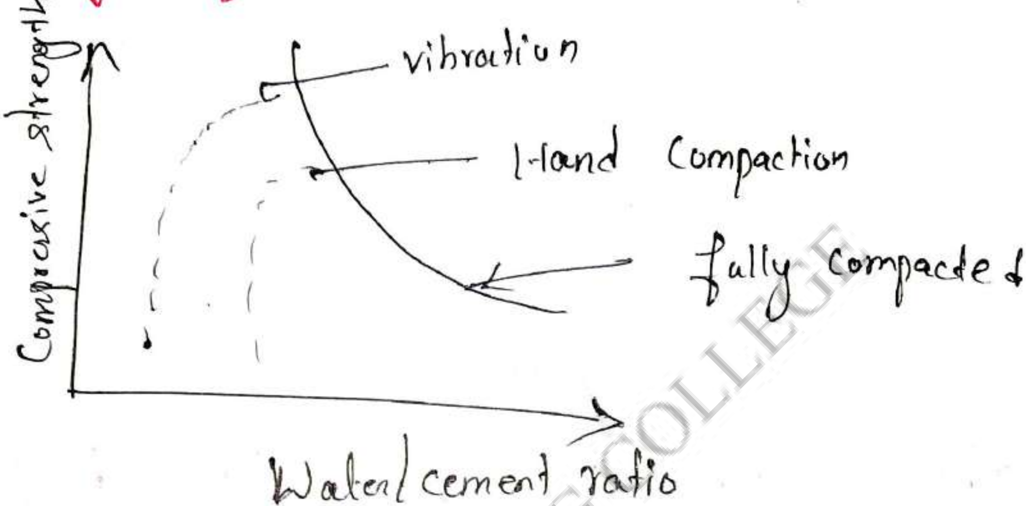
Physical properties of materials Required for mix design :

→ Water Cement Ratio :-

$$S = K\left[\frac{c}{c+e+a}\right]^2$$

S → Strength of Concrete
c → Volume of cement
e → Volume of Water
a → Volume of Air
K → Constant.

The Relationship b/w the water- cement ratio and strength of concrete is...



Cement Aggeragate Ratio :-

The Resistance to deformation depends on the shape and texture of the aggregate, the richness of the mixture, the water - cement ratio and the type of cement used

Consistency :-

It is the relative mobility or ability of a freshly mixed concrete to flow and the usual measurements are: slump for concrete, flow for mortor or grout and penetration Resistance for neat cement paste

Nominal Mix Design Mix :-

Cement + Water } Admixture → Cementpaste + Fine Aggregate → Mortar + Carse Aggregat → Concrete.

Nominal Mix :-

Wide use of concrete for Construction Works has led to the use of mixes of fixed proportions, which ensure adequate strength. Such mixes are called as nominal mixes. A nominal mix is expressed in terms of aggregate cement Ratio..

Design Mix :

Design mix is the one which is obtained after the process of selecting suitable ingredients of concrete and determining the Relative Proportions with the object of producing Concrete of a certain minimum strength and durability as economically as possible.

Lecture No. 24

Topic(s) to be covered	Design Mix and Nominal Mix BIS Method of Mix Design.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	step by step Approach for mix design Concept	Understand

Teaching Learning Material	Student Activity
Chalk & Talk	Listen

Lecture Notes

Bureau of indian standards (BIS) Method of mix design:

→ Data for mix proportioning:

1. Grade designation
2. Type of Cement
3. Maximum nominal size of aggregate
4. Minimum Cement content.

5. Maximum Water Cement Ratio
6. Workability
7. Exposure conditions
8 Maximum temperature of Concrete at the time of placing.
9. Method of transporting, if Required.
10. Early age strength Requirements.
11. Type of aggregate
12. Maximum Cement Content
13. Weather an admixture.

Step by step Approach:

→ Target mean Compressive strength
→ Number of Test Results of samples
→ In case of significant changes in Concrete
→ Standard Deviation to be brought up to Date..

Water Cement Ratio:

Strength and Water Cement Ratio.

S.No	Exposure condition	Max. Water Cement Ratio	Minimum density strength
1.	a) Exposed to fresh concrete	0.50	25
2.	Exposed to brackish or sea water	0.45	30.
3.	a) Kerbs, gutters, guard Rails or thin section	0.45	30.

Air Content:

Approximate air content.

10	208	3.0
20	186	2.0
40	165	1.0.

Water Content:

Maximum size of Aggregate.	Water Content	Sand as percent of total
	M35	
10	200	40
20	186	35
40	165	30
	M35 (above)	
10	200	28
20	180	25

Cement Content:

$$\text{Mass of Cement} = \frac{\text{Water Content}}{\text{Water-Cement Ratio.}}$$

Quantity of Aggregate:-

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

$$C_a = \frac{1-p}{p} \times f_a \times \frac{S_{ca}}{S_{fa}}$$

V = Absolute volume of fresh Concrete

W = Mass of Water per m3

C = Mass of Cement per m^3

S_c = specific gravity

P = Ratio of fine aggregate.

f_a C_a = Total masses of fine and coarse aggregate

S_{fa} S_{ca} = specific quantities. of saturated, surface dry.

Mix proportion calculation:

The mix proportions have been Calculated based on the assumption that the aggregates are saturated and surface dry.

Lecture No. 28 [Unit-IV - Fresh And Hardened Properties of Concrete]

Topic(s) to be covered	Workability, Test for Workability.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Workability of fresh concrete	Remembering

Teaching Learning Material	Student Activity
Chalk & Talk	Listen

Lecture Notes

1. Workability :⇒ Introduction :-

Fresh concrete is the one which is a freshly mixed materials, viz, cement, Sand, Coarse aggregate and Water which can be moulded into any shape. This is called as plastic concrete and the state of concrete is said to be in wet State.

Hardened Concrete is the One which has passed wet state and the hydration is complete. The hardness can be measured through its strength after using for three days, 7 days or 28 days.

Workability:

1. Mixability 2. Stability 3. flowability (or) mobility 4. Compactability 5. Finishability.

The above requirements for fresh concrete are collectively reffered to as workability of concrete. Thus workability of a concrete is that property of a freshly mixed concrete. which has the qualities with which it can be easily mixed, placed, compacted and finished so as to get a homogeneous material.

Workability of a fresh concrete depends on the following factors:

1. Water Content
2. Mix proportions
3. Size of Aggregate
4. Shape of Aggregates
5. Surface texture
6. Grading
7. Use of admixture.

1. Water Content :

→ Water Content highly influence the workability. Higher the water content per cubic meter of concrete, the higher the fludity of the concrete.

→ Ading more water should be the last resort as it affects the workability.

→ In case of controlled concrete one cannot arbitary increase the water content.

→ However, more water may be added provided more Cement is added which keeps the water cement ratio Same and at the same time the final Strength remains Same

2. Mix proportions :

→ Workability is also very much affected by aggregate cement ratio. In lean concrete, less quantity of paste is available for the given Surface area of aggregate. which restrains the → mobility of concrete.

→ In case of rich Concrete with low aggregate cement ratio, more paste is available to form faty and cohesive mix which provided high workability

3. Size of Aggregates :-

Rounded or Cubical shaped aggregates make the concrete workable compared to angular, flaky aggregate. Reasons for high workability of rounded aggregates may be attributed to the fact that for the given volume or weight it will have less surface area and less voids.

High strength and high performance concrete have high signicance with the shape of aggregate.

4. Surface Texture :

Rough texture aggregates have more Surface area than Smooth texture aggregates. Thus, the workability is less in rough textured aggregates. Further the reduction of inter particle frictional resistance offered by smooth aggregates gives high workability.

5. Grading Aggregates :

Grading of aggregates plays the highest influence on the workability. A well graded aggregates has less void volume contributing for more availability of paste in concrete and

- hence high workability.

6. Used of Admixtures:

Admixtures like plasticizers and super plasticizers greatly improve the workability significantly. Use of air - entraining agent reduces the internal friction between the particles and also act as artificial fine aggregate and thereby improve workability.

Lecture No. 29

Topic(s) to be covered	Test for Workability of Concrete, Segregation and Bleeding.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	various test conducted for determination of workability	Understanding

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

Segregation and Bleeding of Concrete:

Segregation is defined as the separation of the constituent materials of concrete. If all the ingredient of concrete are properly distributed to make a homogeneous mixture then the concrete is said to be good. on the other hand, if a simple of concrete exhibits a tendency for seperation, for example coarse aggregate for

Segregation.

Segregation may be of three types

i) The Coarse aggregate seperating out or settling down from the rest of the matrix

ii) the paste or matrix separating away from Coarse aggregate.

iii) Water seperating out from the rest of the material being a material of lowest specific gravity.

Bleeding :-

Bleeding is also reffered to as Water gain. Some of the water which has the lowest speific gravity in a concrete comes out to the surface of the concrete.

This is a sort of segregation. Bleeding is observed in a highly wet mix, badly proportioned and insufficiently mixed concrete, Bleeding rate increase with time up to about one hour or so and thereafter the rate decrease but continus more or less till the final setting time of cement.

Bleeding is an inherent phenomenon in Concrete. However, it can be reduced by proper proportioning and uniform and complete mixing. Further, use of fine pozzolanic materials reduces bleeding by creating a longer path for the water to transverse. It is also reported that the bleeding can be reduced by the use of air entraining agent, finer cement or cement with low alkali content.

Testing of fresh Concrete:

Following test are commonly employed to measure workability of fresh concrete.

1. Slump Test
2. Compaction factor Test
3. Flow Test
4. Kelly Ball Test
5. Vee-Bee Consistometer Test
6. Seggregation and Bleeding of Concrete Test
7. Setting Time Test.

1. Standard slump Test

The apparatus for conducting the slump test consists of metallic mould in the form of a frustum of a cone with 20cm bottom diameter

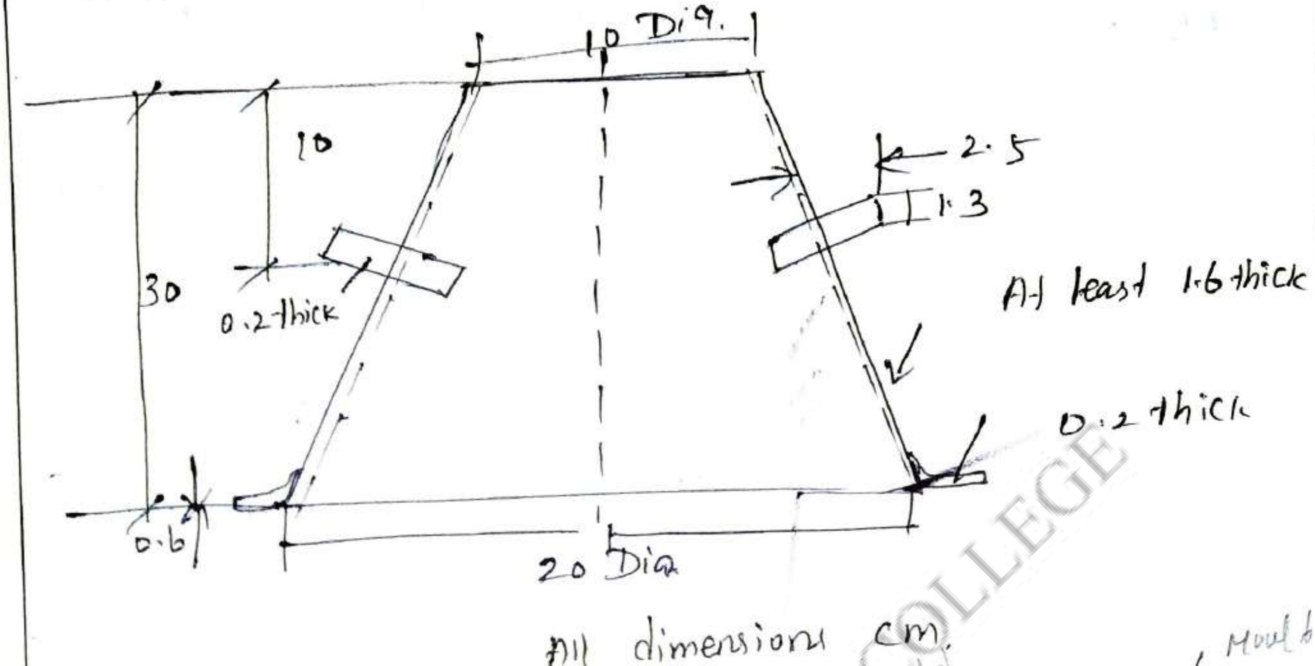
10cm top diameter and 30cm height. A steel tamping rod of 16mm dia, 0.6m long with a bullet end is used for tamping.

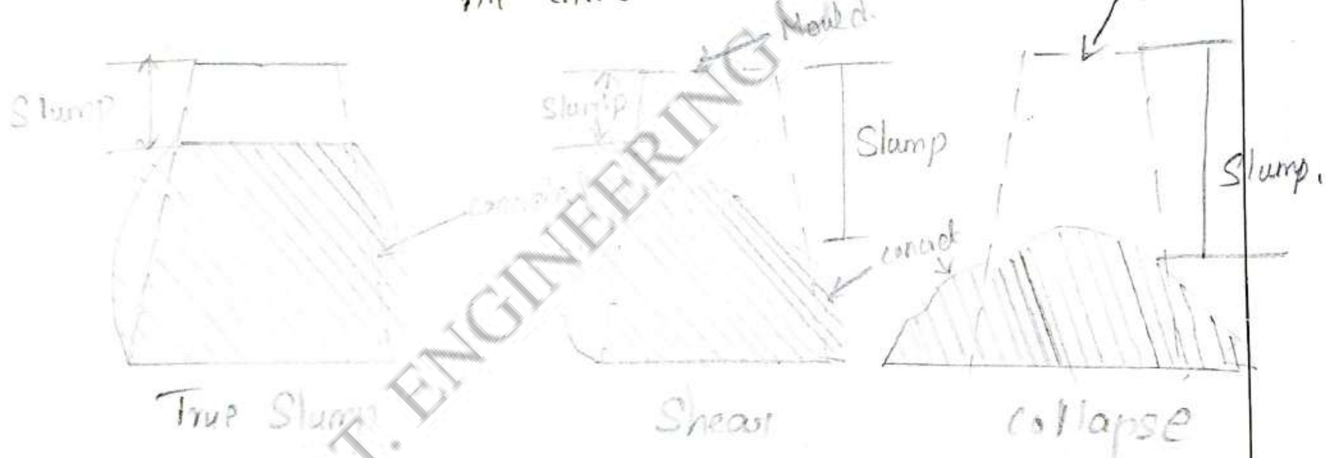
⇒ The internal surface of the mould is throughly cleaned and placed on a smooth non absorbant horizontal surface.

⇒ The mould is filled in four layers of equal height. Each layer is compacted by giving 25 belows with the tamping rod uniformly. After filling the mould and roding, the excess concrete is stuck off and levelled.

⇒ The mould is lifted upwards from the conirete immediately by raising it slowly. This allows the concrete to subside. This subsidence is reffered to as slump of concrete.

⇒ The pattern of slump also represents the characteristics of concrete. If slump of the concrete is even it is called true slump. If one - half of the cone slides down is called as shear slump.

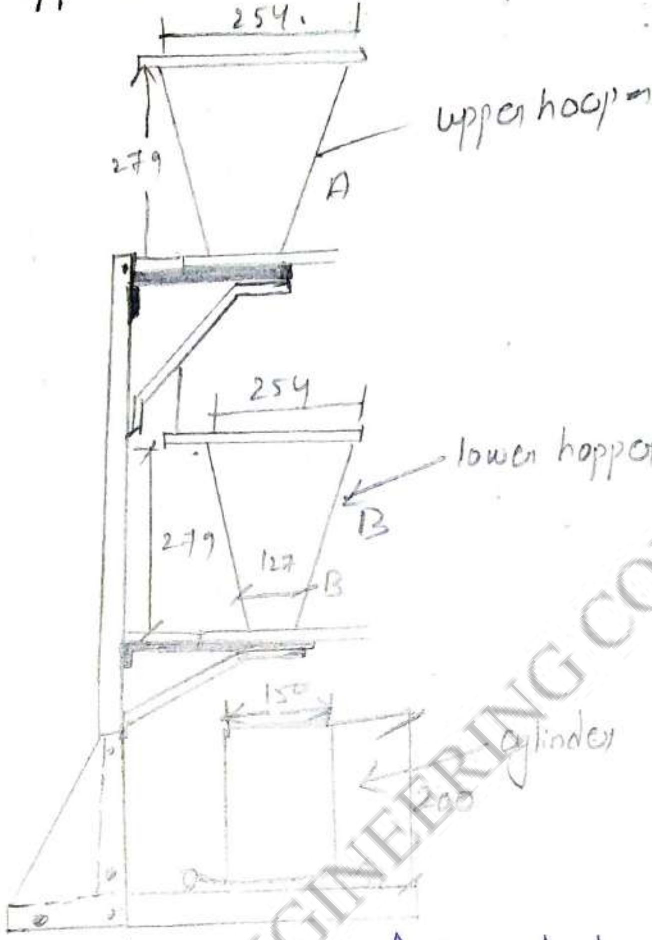




Compaction factor Test :-

This is a more refined test than the slump test. This test measures the degree of compaction obtained by using a certain energy in overcoming the internal friction of the concrete.

The test apparatus consists of two conical hopers with bottom doors and a seperate cylinder kept at the bottom. The concrete is filled in the top hoppers and into the bottom cylinder.



Compacting factor test apparatus.

After striking off the level in the cylinder the weight of the concrete (W_1) in the cylinder is determined. The same cylinder is filled with the same batch of concrete and compacted to get the maximum weight (W_2). The ratio of the observed weight (W_1) to the theoretical weight (W_2) ... W_1/W_2 is the compacting factor.

Lecture No. 30

Topic(s) to be covered	Test for Workability of concrete.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1.	Various test conducted on determination of Workability	Understanding

Teaching Learning Material	Student Activity
Chalk & Talk	Listen

Lecture Notes

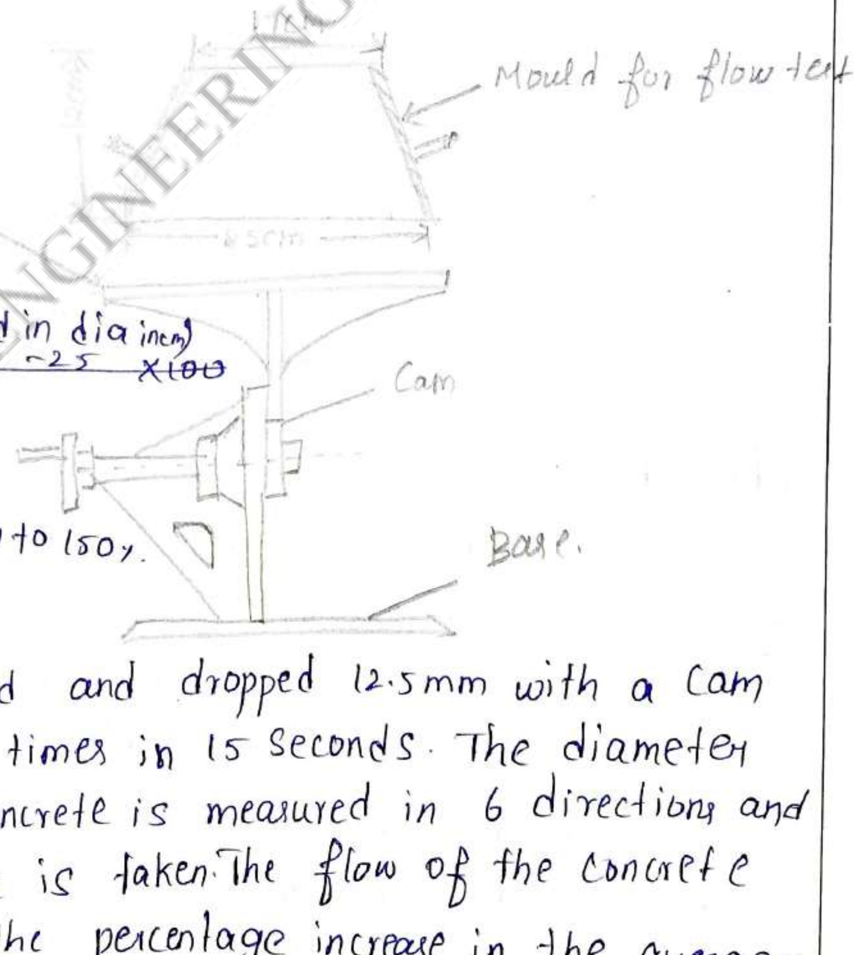
Flow Test :-

This test gives an indication of the quality of concrete with respect to consistency, cohesiveness and non-segregation. In this test a mass of concrete is subjected to jolting and the flow or spread of the concrete is measured. The flow is related to workability.

The test apparatus consists of a flow table of 76mm dia on which concentric circles are marked. A mould similar to the one used in slump test with base diameter as 25cm and upper dia 17cm with a height of 12cm is used.

The mould is kept on the clean table and concrete is filled in two layers with each layer being rodded 25 times with a tamping rod of 1.6cm diameter and 61cm long with rounded ends.

The excess concrete on the top of the mould is levelled. The mould is lifted vertically upwards completely. The concrete stands on its own without support.



$$\text{Flow\%} = \frac{(\text{Average spread in dia in cm}) - 25}{25} \times 100$$

The value varies from 0 to 150%.

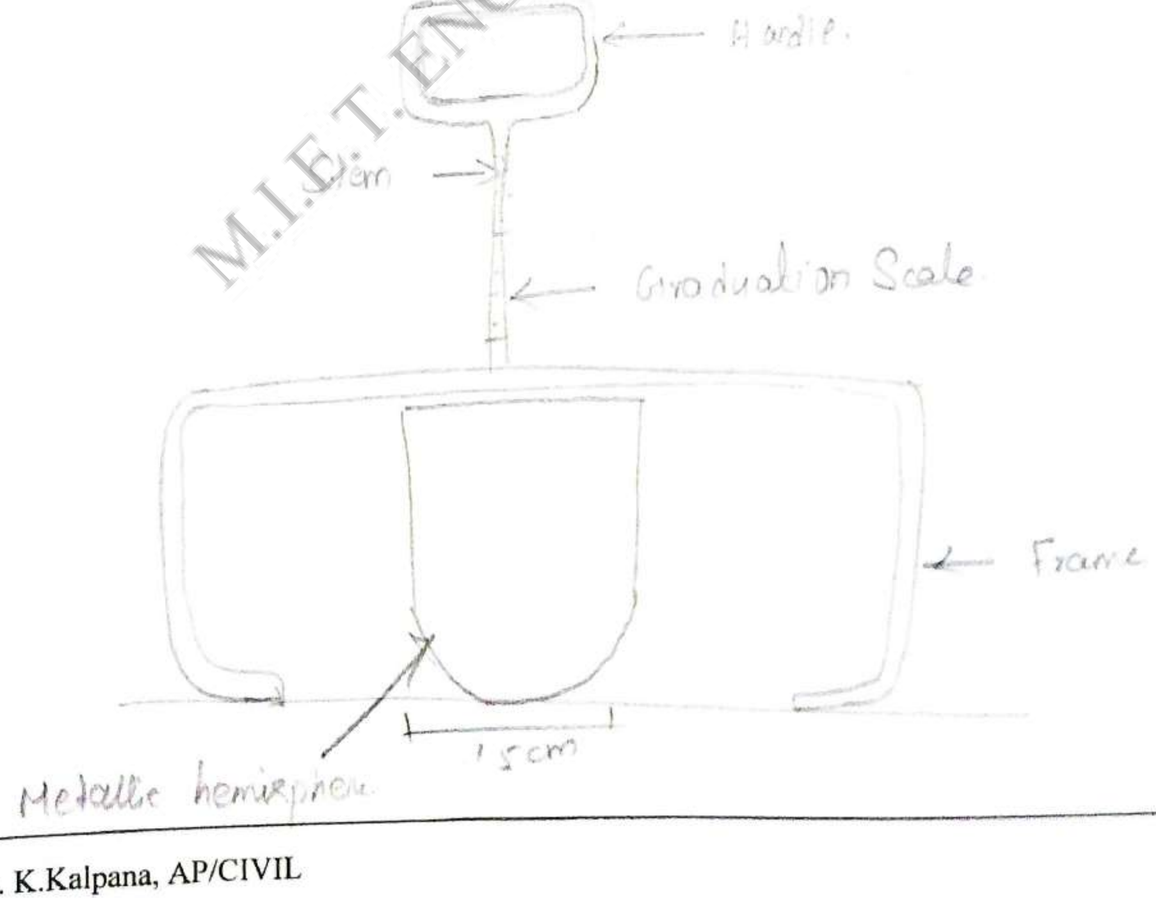
The table is raised and dropped 12.5mm with a cam arrangements, 15 times in 15 seconds. The diameter of the spread concrete is measured in 6 directions and the average value is taken. The flow of the concrete is defined as the percentage increase in the average diameter of the spread concrete to the base diameter of the mould.

Kelly - Ball Test:

It consists of a metal hemisphere of 15cm diameter weighing 13.6 kg. The Concrete base should be 20 cm depth and the minimum distance from the centre of the ball nearest edge of the concrete is 23cm.

The ball is lowered gradually on the surface of the Concrete. The depth of penetration is read immediately on the stem to the nearest 5mm. The test can be done in a shorter period of about 15 sec. This test gives more consistant results than slump test.

The test can be performed in the field and it can be performed on the concrete placed on site.



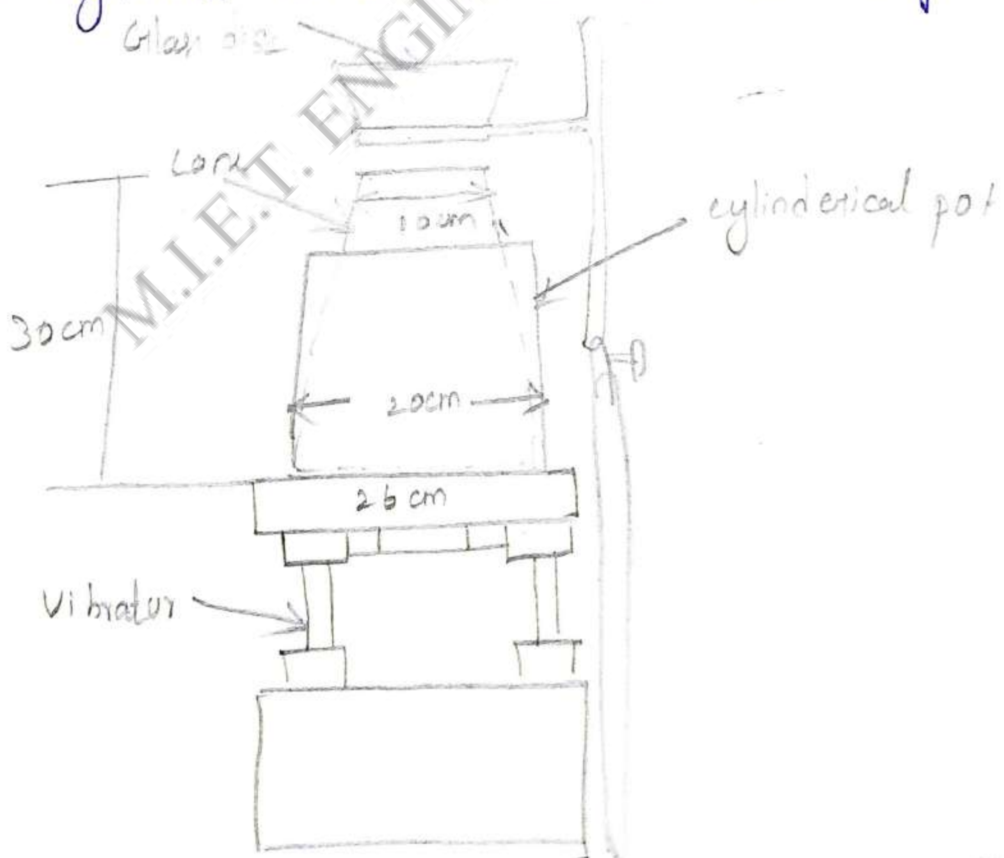
Vee-Bee Consistometer Test:

This test consists of a vibrating table, a metal Pot, a sheet metal cone and a standard iron rod.

A Slump cone with Concrete is placed inside the sheet meet cylinderical pot of the consistometer. The glass disc is turned and placed on the top of the concrete in the pot. The vibrator is switched on and the stop watch is started simultaneously.

The vibrator is switched on and stop watch is started simultaneously.

The vibrator is kept on till the concrete in the cone assumes a cylindrical shape. The time is noted. The time required in seconds for the concrete to change from the shape of cone to the shape of a cylinder is known as vee Bee Degree



The cylindrical Contained is kept on a level surface free from vibration at a temperature of 27°c ± 2°c and is covered with a lid. Water accumulated at the top is drawn by means of a pipette at 10 minutes interval for the first 40 minutes and at 30 minutes interval subsequently till bleeding stops.

In Order to faciliate collections of bleeding water the contained may be slightly tilled and all the bleeding water is collected in a jar.

$$\text{Bleeding water percentage} = \frac{(\text{Total quantity of bleeding water})}{\text{Total quantity of water in the sample of Concrete}} \times 100$$

Setting Time Test on Concrete:-

Setting time of concrete differs widely from setting time of cement for various resons. The setting time of concrete depends on various factor, water cement ratio, temperature conditions type of cement, use of mineral admixtures and use of plasticiers.

Bleeding of Concrete Test :

Bleeding is an inherent phenomenon in Concrete. It Can be reduced by proper proportioning and uniform complete mixing. This test method covers the determination of relative quantity of mixing water that will bleed from a sample of freshly mixed concrete.

Apparatus Required are :

1. A cylindrical Container with inside diameter of 250mm and inside hight of 280mm of approximately $0.01 m^3$ capacity.
2. A tamping rod similar to the one used in slump test.
3. A pipette for drawing off free water from the surface.
4. A graduated jar of $100 cm^3$ Capacity.

Freshly mixed concrete is filled in the cylinder in 50mm layer for a depth of 250 ± 3mm (5 layers). Each layer is tamped by giving strokes and the top surface is made smooth by trowelling.

The cylindrical Container is weighed and the weight of the concrete is noted. Knowing the total water Content in $1m^3$ of concrete, quantity of water in the cylindrical contained is also Calculate.

Lecture No. 31

Topic(s) to be covered	Determination of strength properties of Hardened Concrete.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Various properties of Hardened Concrete	Remembering

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

Properties of Hardened Concrete:

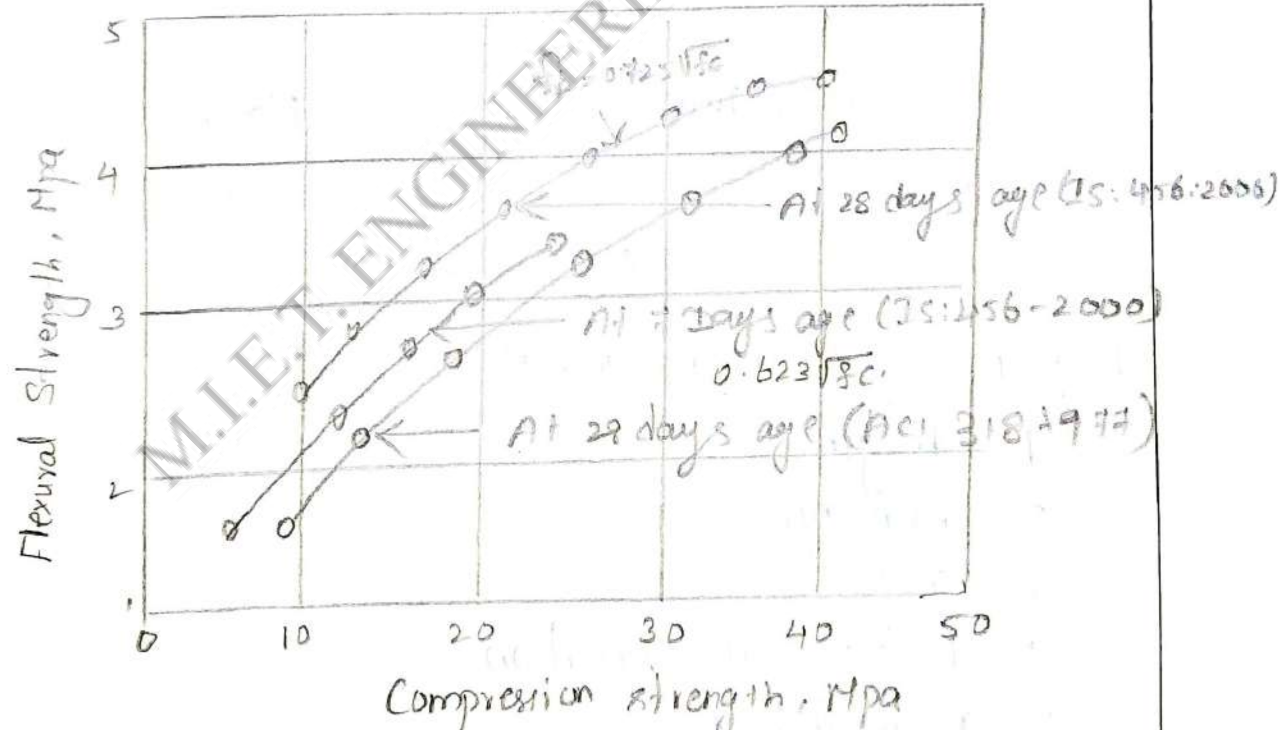
1. Strength
2. Shrinkage
3. Creep
4. Temperature Variation
5. Permeability
6. Durability.

1. Strength:

⇒ Compressive Strength:

In a simple definition Strength of Concrete is its resistance to rupture. Strength of concrete are Compressive strength, flexural strength and tensile strength. Of these strength, compressive strength gains importance as concrete is primarly meant to withstand compressive stresses. Different types of specimens, cubes cylinder and prisms are use to determine the compressive strength.

2.



Tensile Strength.

The tensile stress at which failure occurs in a specimen is the tensile strength of concrete.

Flexural strength:

Flexural tensile strength or modulus of rupture is the load at which the concrete members crack. Flexural strength of concrete is usually found by testing plain concrete beams.

Bond strength:

Bond strength may be visualised in two forms
1. hard strength b/w paste and Steel Reinforcement paste and aggregate.

Shrinkage

long-term strength and durability very much affected by volume chang. volume change or deformation occurs due to load primarily. Apart from this deformation is caused also due to shrinkage and creep. shrinkage is the volume change caused due to the inherent properties of concrete while creep is due to sustained load.

→ plastic Shrinkage

→ Drying shrinkage.

Plastic shrinkge:

About 1% of the volume of cement is the reduction occurs during hydration. This reduction in plastic strain which is magnified further due to loss of water by evaporation, by absorption or by aggregates. This particularly occurs under hot climates and high winds. These are the Reasons for plastic shrinkage.

Drying shrinkage:

Drying shrinkage is the one that takes place after the concrete has completely set and hardened. In general most of shrinkage takes place in the first few months after setting. The change in volume is primarily due to the loss of water held in gel pores.

Dry shrinkage is more in cement paste than in cement mortar and it is more in cement concrete than in cement mortar. Concrete made out of smaller size aggregates shrink more that made out of bigger sizes. Further finer the gel the more is the shrinkage.

Creep:

Creep is the deformation when the concrete is subjected to a sustained load.

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Creep:
creep is the deformation when the concrete is subjected to a sustained load.

It is a time-dependent part of strain resulting from stress. Shrinkage and creep take place simultaneously.

Temperature Variation:

Variation in temperation also cause deformation. Effects of temperature variation in concrete is almost, similar to those of shrinkge. A rise in temperature cause expansion of concrete whiche a decrease leads to contraction. The amount of expansion or contraction depends on the co-efficient of thermal expansion of concrete and it is of the order of the $10 \times 10^{-6}/C^{0}$.

Permeability:

Rapid and excess water evaporation from concrete leaves voids inside the concrete. This leads to porosity in concrete and forms continuous path which makes the concrete permeable. As permeability is governed by porosity, it has a direct consequence of the water-cement Ratio.

Durability:

Durability of concrete is its satisfactory performance during its working time and through its entire life span. Although Concrete is a durable material, it may get deteriorated under highly aggresive or hostile environment.

Lecture No. 32

Topic(s) to be covered	Compressive Strength test, split tensile strength, Flexural strength

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Testing of Hardened concrete	Understanding.

Teaching Learning Material	Student Activity
chalk & Talk	Listen

Lecture Notes

Testing of Hardened Concrete :

⇒ Destructive Testing of Concrete.

1. Compressive Strength Test
2. Flexural Strength Test
3. Split - tension Test.

⇒ Non Destructive Testing of Concrete

1. Rebound Hammer Test
2. pulse velocity Method.

3. pull - Out Test
4. Frequency Method
5. Nuclear Method
6. Radioactive Method.
7. Electrical Methods.
8. Break - off Method.
9. Maturity Method.

⟹ Compressive Strength Test :

The tests are conducted on cubical or cylindrical specimens.

The cube specimen is of size 15x15x15cm. If the largest nominal size of the aggregate does not exceed 20mm, 10cm size cubes may also be used.

Cylindrical specimens have a length equal to twice the diameter. They are 15cm in dia and 30cm long.

A steel bar 16mm dia and 0.6m long with bullet pointed at the lower end serves as a tamping bar.

A Strain controlled testing machine is used for conducting the compression test. The test cube specimens are made as soon as practicable after mixing. The concrete is filled into the mould approximately in 5cm deep. Each layer is compacted by tamping rod or by vibration. After the top layer has been compacted the top of the mould is levelled using a trowel. The top is covered with a glass or metal plate to prevent evaporation.

The specimens are demoulded after 24 hours and submerged in fresh clean water or Saturated lime solution and kept there until taken out just prior to test.

The water should be maintained at 27°C ± 2°c and on no account the specimens are allowed to become dry.

$$\text{Compressive Strength} = \frac{\text{load at failure}}{\text{Area of cross Sectional specimen}}.$$

Flexural strength test:

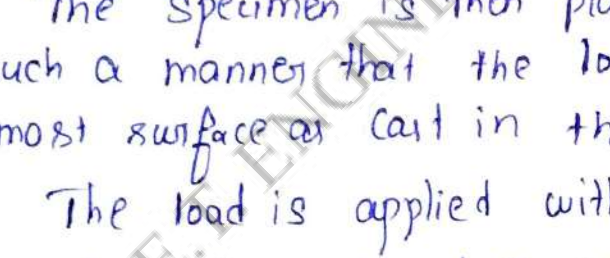
In Order to prepare the beams, metallic mould should be used which should be preferably of steel or Cast iron and the metal should be of sufficient thickness to prevent spreading or warping. The standard size of specimens are 15x15x70cm, The tamping bar should be a steel bar weighing 2 kg, 40cm long and should have a ramming face of 25mm square.

The testing maching may be a Strain controlled one with sufficient capacity for the tests. The bed of testing machine should be provided with steel rollers 38mm in diameter on which the specimen is to be supported. These Rollers should be mounted such that the distance from centre to centre of 60 cm for 15cm specimens or 40cm 10 cm specimens.

The specimen is then placed in the machine in such a manner that the load is applied to the uppermost surface as cast in the mould.

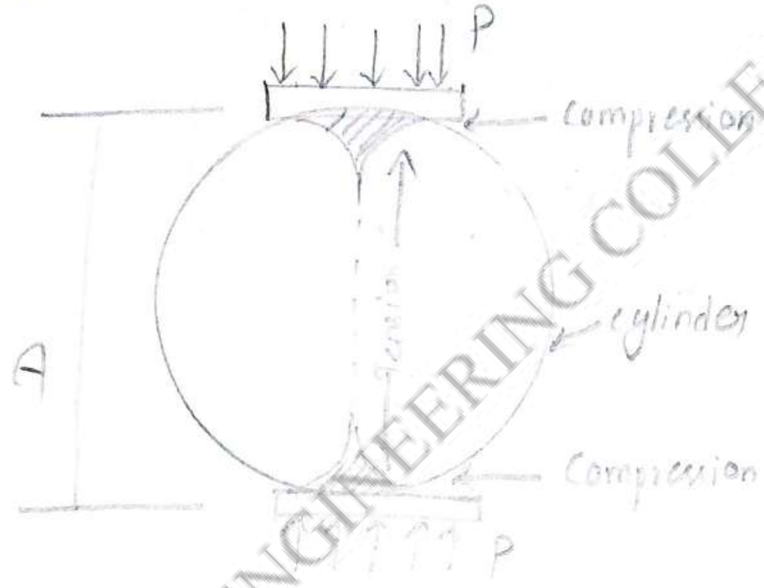
The load is applied without shock and increased continuously at a rate such that the rate of loading is 400 kg/min for 15cm specimens and at a rate of 180kg/min for 10cm specimens. The load is increased untill the specimen fails, and the specimen during the test Recorded

$$f_b = \frac{3p \times a}{b \times d^2} = \text{Modulus of Rupture}$$



Split - tension test :-

In this test a cylinderical specimen is placed horizontally between the loading surface of a compression testing machine. The load is applied until failure of the cylinder along the vertical diameter.



The cylinderical specimen is kept horizontally on the loading platform. The loading condition produces a high compressive stress immediately below the two generators to which the load is applied. But a larger portion, about 5/6 th of the depth, is subjected to tensile stress.

The load is applied gradually and the maximum compressive load is noted.

$$\frac{2P}{\pi LD}\left[\frac{D^2}{r(D-r)}-1\right]$$

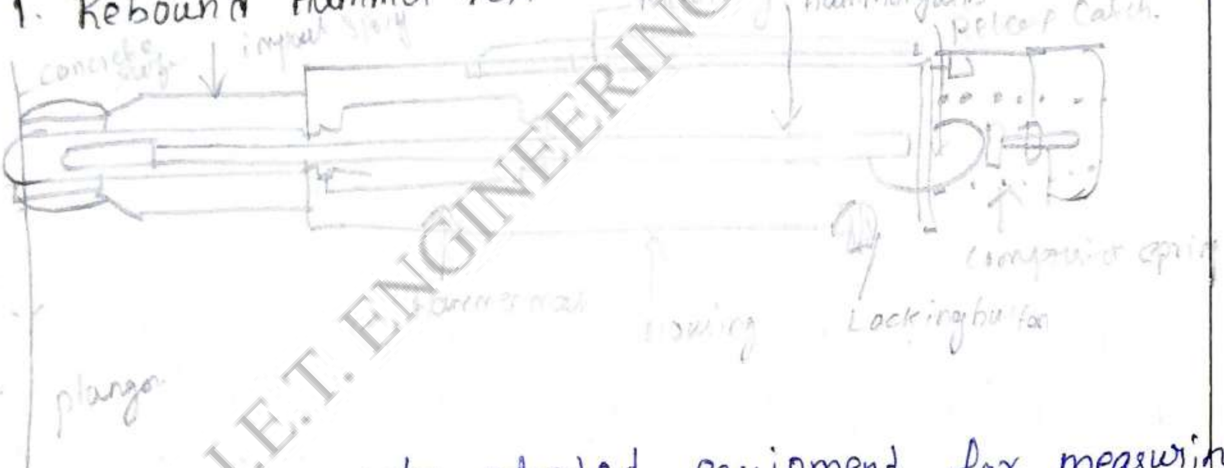
and horizontal stress of split - tensile strength

$$f_{ct} = \frac{2P}{\pi L D}.$$

P — Compressive load on the cylinder
L - Length of the cylinder
D - Diameter of the cylinder

Non Destructive Testing of Concrete:

1. Rebound Hammer test.



This is commonly adopted equipment for measuring the surface hardness.

When the plunger at the tip of the hammer mass is pressed against the surface of concrete. it retracts against the force of the spring. when completely retracted the spring controlled mass Rebounds, taking a rider with it along the guide By pushing a button. the rider can be held in position to allow reading to be taken

Lecture No. 33

Topic(s) to be covered	Compresive strength, split tensile strength flexural strength.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Non destructive Methods for testing of Hardened Concrete	Understanding.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen

Lecture Notes

pulse velocity Method :-

It Consists of two methods 1. Mechanical Sonic pulse velocity method 2. Ultrasonic pulse velocity method.

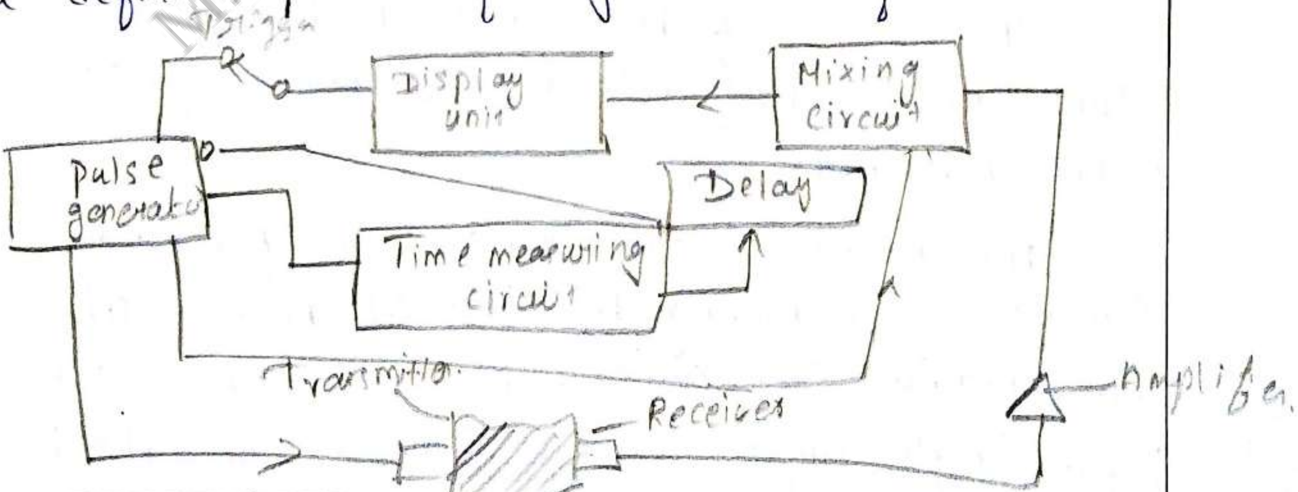
The mechanical sonic pulse velocity method consists of measuring the time of travel of longitudinal (or) compresion waves generated by a single impact hammer blow or repeated blows.

The Ultrasonic pulse velocity method consists of measuring the time of travel electronically generated mechanical pulse through the concrete.

The pulse velocity methods have been used to evaluate the quality of concrete, concrete strength, durability, modulus of elasticity, direction of water.

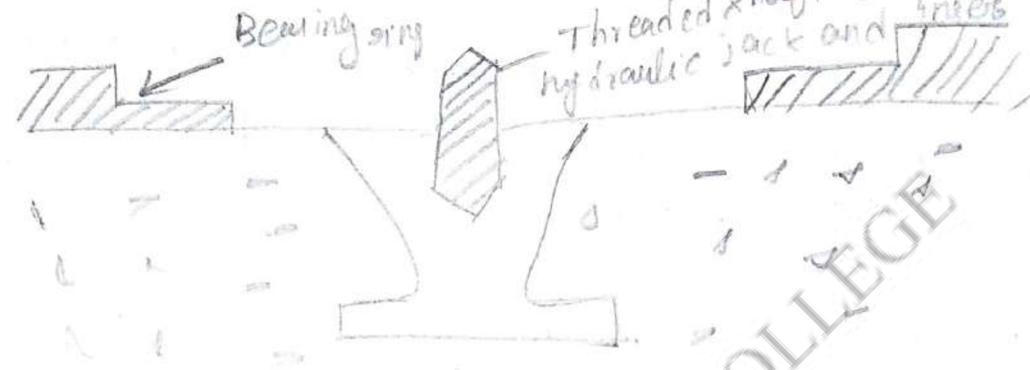
The ultrasonic pulse velocity method consists of measuring the time of travel of an ultrasonic pulse wave passing through the concrete to be tested. The time of travel b/w initial onset and reception of the pulse is measured eletronically by the tester. The path length between the transducers divided by the time of trave gives the average wave propagation.

The method provides an excellent means of establishing uniformity of concrete and deserves a definite place in quality control operations.



Pull-out Test:

The pull-out test Consists of pulling out from Concrete a specially shaped steel insert whose enlarged end has been cast into Concrete.



The pull-out force Required is measured using a dynamometer. Because of its shape, the steel insert is pulled out along with a cone of Concrete. The concrete in the pulled out region will be in shear / tension with generating lines of the Cone running at approximately 45^{0} to the direction of pull.

The equipement is Simple to assemble and operate. It is Safe and testing can be carried out in the field in a matter of minutes. The tests are reproduceable with an exceptional degree of accuracy and co-relation with Compressive strength of Concrete is good.

The major drawback in this method is that the concrete surface gets damaged and needs to be Repaired after the tests. The test does not measure the strength in the interior of concrete because the pull out assembly has to be inserted into Concrete at the time of concreting itself.

Following non-destructive methods are also used to find the strength and other Properties of concrete using non-destructive techniques.

1. Frequency method
2. Nuclear method
3. Radioactive method
4. Electrical method.
5. Break-off method.
6. Maturity method
7. Windsor probe Test.

Lecture No. 34

Topic(s) to be covered	Stress strain curve for Concrete, Modulus of Elasticity

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Stress, strain Curve for concrete	Understanding

Teaching Learning Material	Student Activity
Chalk & Talk	Listen

Lecture Notes

Stress strain curve for Concret :

Stress strain curve of Concrete is obtained by conducting a compression test, the test being conducted at uniform rate of strain on cubical or cylindrical specimen.

The stress-strain relation is fairly linear in the initial stages but subsequently becomes non-linear Reaching a maximum value and

Unloaded after being stressed to 0.5 fo or less, a permanent set is noticed.

Further, the magnitude of the permanent set gradully decreases with more cycles of loading and Unloading as long as the strees is within 0.5 fo and the stress - strain curve tends to be a straight line.

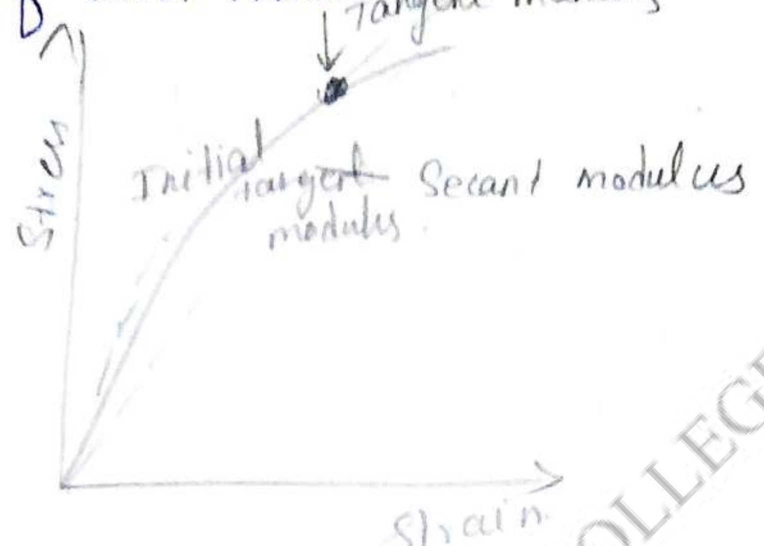
Modulus of elasticity:

Modulus of elasticity of concrete is determined by subjecting a cubical or cylinderical specimen to Uniaxial compression and measuring deformations by means of dial gauges fixed reading between certain gauge length. Dial gauge reading divided by the gauge length gives the strain and load applied divided by area of cross section gives the strees.

A series of Reading are taken and the strees - strain Relationship is established modulus of elasticity is obtained by diving the strees by the strain

The term young's modulus of elascity can strictly be applied only to the strength

Part of stress strain curve



→ The moudulus found from this tangent is Reffered to as initial tangent modulus.

→ Tanget drawn at any other point othe stress-strain curve and modulus calculated with Reference to this tangent is called tangent moudulus.

Lecture No. 35

Topic(s) to be covered	Durability of concrete, water absoiption, permeability.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Durability of concrete	Remembering
LO2	Water absorption for concrete	Remembering
LO3	permeability of concrete	Remembering

Teaching Learning Material	Student Activity
Chalk & Talk	Listen

Lecture Notes

Durability of Concrete:

⇒ Factors influencing durability of concrete.

1. The environment
2. The type and quality of constituent materials
3. The Cement Content and Water Content Ratio of the Concrete
4. The Cover to the embeded steel.

5. Workmanship, to obtain full compaction and efficient cutting.
6. The shape and size of the member.
7. permeability of the finished concrete.

Degree of Exposure:

The degree of exposure anticipated for the concrete during its service life together with other Relevant factors are relating to mix composition, workmanship, design and detailling should be considered.

Water Absorption:

Water in excess of the mix design amount can have a direct, negative input on the strength, quality and durability of concrete.

As better quality control and performance of concrete are specified for construction projects, it has become critical that accurate control of the water content of a concrete mix is enforced

$$\text{Total Water Content} = \frac{(\text{Wet Sample mass} - \text{Dry Sample mass})}{\text{Wet Sample mass}} \times 100.$$

The total Water Content has to be monitored and used as a Relative indicator of potential variability in concrete strength. The water absorbed in the aggregate is substracted from the total water and the Remainder is used to calculate the free water Content.

Permeability :

The permeability of concrete at the surface has been Recognized as a major factor determining the durability of concrete structures. This important Property Can be measured Reliably at the building site or at Component.

	At the end of this lecture, students will be able to	Bloom's Level
101	Corrosion test for concred	Remembering

Teaching Learning Material	Student Activity
Chalk & Talk	Listen

Lecture Notes

Corrosion of concrete:

The gradual deterioration of concrete by chemically aggressive agents is called concrete corrosion.

Basically corrosion of concrete is a physico - chemical process and the extent of deterioration caused to it by the aggresive agents is dependent upon the properties of the consitituents of concrete and the corrosive media.

The two main factors Responsible for the loss of durability of concrete.

1. Deterioration of concrete
2. Corrosion of steel Reinforcement.

⇒ Deterioration of concrete is caused mainly by acids in the form of water solution or acidic gases which form acids on dissolving in water. Deterioration is also caused due to salt solution, alkalies and by various aggresive chemicals.

1) Decomposition
2) chemical Reaction
3) Crystallization.

⇒ In general, concrete provides a high degree of protection agains corrosion to embedded steel Reinforcement.

⇒ Corrosion inducing agents are oxygen

chloride Iron, carbondioxide and Water.

⇒ concrete provide high alkaline environment for the steel and concrete with low water cement Ratio Protects and passivates the steel against Corrosion.

Acid Resistance:

In general, concrete is not fully Resistant to acids Depending on the type and Concentration of acid, most acid solutions will slowly or rapidly disintegrate portland cement Concrete.

oxalic acid and phosphoric acid are harmless. The most vulnerable part of the cement hydrate in $Ca(OH)_2$ but C-S-H gel can also be attacked Silicious agg. are most Resistant to acid attack then calcareous agg.

Concrete can also subjected to deterioration by liquids with pH value less than 6.5 and the attack by acid will be very severe with a pH value less than 4.5. As the attact proceeds all the cement compounds are eventually broken down and leached away, together with any carbonate agg. materials.

In the case of sulphuric acid attach calcium sulphate formed can proved to react with calcium aluminate phase in cement to form calcium sulphoalu-minate, which on crystallization can cause expansion and disruption of concrete. Further, if acids are able to reach the Reinforcing steel through cracks or porosity of concrete corrosion can occur which wil cause cracking.

Lecture No. 37

Topic(s) to be covered	Light Weight Concrete.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	preparation of light weight Concrete and strength of light weight concrete	Understanding.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

Special Concrete :-

The modification are aimed at to get a better concrete material for this the following aspects need Consideration.

⇒ Bettar mechanical properties than that of conventional Concrete. Mechanical properties are improved by the Undermentioned approaches.

1. Modifications in microstructure of the cement paste.
2. Reduction in overall porosity.
3. Improvements in the strength of aggregate matrix interface
4. Control of extent and propagation of cracks.

2 Better durability attained by means of increased chemical and freeze - thaw Resistance

3. Improvements ~~on the~~ in selected properties of interest, such as impermeability, adhesion, thermal insulation, lightness, abrasion and skid Resistance. etc...

The above improvements on the conventional concrete lead to special concretes which are discussed below.

light Weight Concrete:-

light weight cement concrete has less density compared to the conventional concrete. light-weight concrete may be made by

→ Omitting the fine Aggregate
→ Using light-Weight aggregate
→ Aerating concrete.

The Concrete Prepared by omitting the fine aggregate is called no-fine concrete. This has low drying shrinkage. This is used for cast in-situ external load bearing walls, small Retaining Wall, where Respective loads are expected. This has better insulating properties.

The light-weight aggregate used are pumice, expanded slates, furnace clinker etc., and the fine aggregate used are crushed light weight aggregate or natural sand. This type of light weight concrete has better insulating and fire resistance properties, highly water absorptive and economical. This can be used for all the works stated above.

The light weight concrete obtained by aeration is also called as gas, porous or foamed concrete.

Out of the three main groups of light-weight concretes, the light weight aggregates concrete and aerated concrete are more often used than the no-fines concrete. light weight Concrete also classified based on the purpose for which it is Used.

i) Structural light weight concrete.
2) Non-load bearing Concrete.

3) Insulating concrete.

light-weight concrete has become more popular in Recent years because it offers large advantages over the conventional concrete. Based on the advancement and better understanding of the concrete has helped much in the promotion and use of light-weight concrete.

Groups of light weight concrete.

No fines concrete.	light weight Aggregate concrete	Aerated concrete.	
		chemical aerating	foaming mixture.
a) Gravel	a) clinker	a) Aluminium powder method	a) performed foam.
b) Crushed stone.	b) Foamed slag	b) Hydrogen peroxide and bleaching powder method	b) Air-entrained foam.
c) Coarse clinker	c) Expanded clay.		

d) Sintered pulverised fuel Ash	Expanded shale.
e) Expanded Clay (or) Slate	e) Expanded slate
f) Expanded slate	f) Sintered pulverished fuel Ash.
g) Foamed slag	g) Exfoliated vermiculite h) Expanded Perlite. i) pumice j) Organic Aggregate.

—x—

Lecture No. 38

Topic(s) to be covered	Foam Concrete.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Several Methods by which foam (or) areated concrete can be manufactured.	Understanding

Teaching Learning Material	Student Activity
Chalk & Talk	listen.

Lecture Notes

FOAM CONCRETE:

Foam Concrete is generally called as aerated concrete and also as gas Concrete or Cellular Concrete. In simple terms foam or areated concrete is made by introducing air or gas into a slurry composed of Portland cement or lime and finely Crushed Siliceous filler so that when the mix set and hardens, a uniformly cellular structure is formed.

They are several methods by which foam or aerated concrete can be manufactured which are given below.

1. By the formation of gas by chemical Reaction with in the mass ~~of~~ during liquid or plastic state.

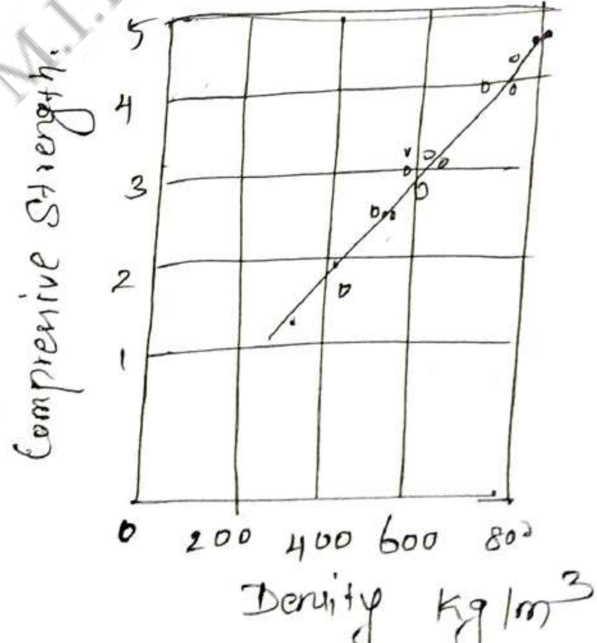
2. By mixing performed stake foam with the slurry.

3. By using finely powdered metal with the slurry and made to react with the calcium hydroxide liberated during the hydration process. to give out large quantity of hydrogen gas. This hydrogen gas when contained in the slurry mix, gives the cellular structure.

In the place of aluminium powder powdered zins may also be used. Instead of metal power, hydrogen peroxide and bleaching powder have also been Used.

Classification method is of the most widely adopted method using aluminium powder or such other similar material. This method has been adopted in large scale manufacture of aerated concrete in the factory.

In the factory the whole process is mechanised and the product is subjected to high pressure steam curing. The products so formed will neither retrogression of strength non dimensional instability.



This type of concrete is of low density and hence gained popularity because of this and other thermal insulation properties. Foam Concrete is made in the density range of 20 kg/m³ to about 800 kg/m³.

High density grades of this concrete are used in the manufacture of prefabri-cated structural members in conjuction with steel Reinforcement.

Medium density grades are used for the manufacture of building blocks or load bearing walls.

Of course, lower density grades of this concrete are used used for insulation purposes.

The above Relation between strength and density of hig pressure steam cured foam concrete.

Lecture No. 39.

Topic(s) to be covered	Self compacting concrete, vaccum concrete

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Behaviour of self compacting concrete and Vaccum Concrete.	Understanding.

Teaching Learning Material	Student Activity
chalk & Talk	listen.

Lecture Notes

Self compacting concrete :

Self compacting concrete is also called as self-consolidating super workable concrete or self-consolidating concrete.

This type of high performance concrete has been developed for the use in situations where vibration is difficult and Reinforcing steel.

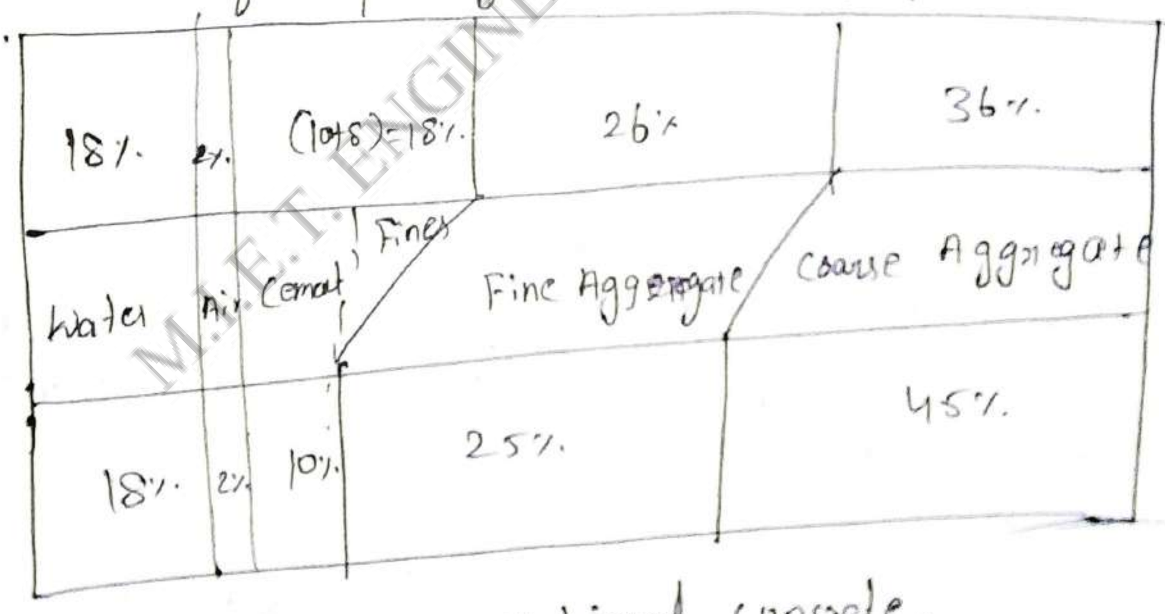
→ Self compacting concrete technology is based on increasing the amount of fine materials like fly ash, lime stone filler.

→ Without changing the water content compared to the conventional concrete.

→ Proportions used in self-compacting concrete as compared to conventional concrete mix

→ Rheological behaviour of concrete is changed because of the variations in proportions

Self compacting concrete + Superplasticizer.



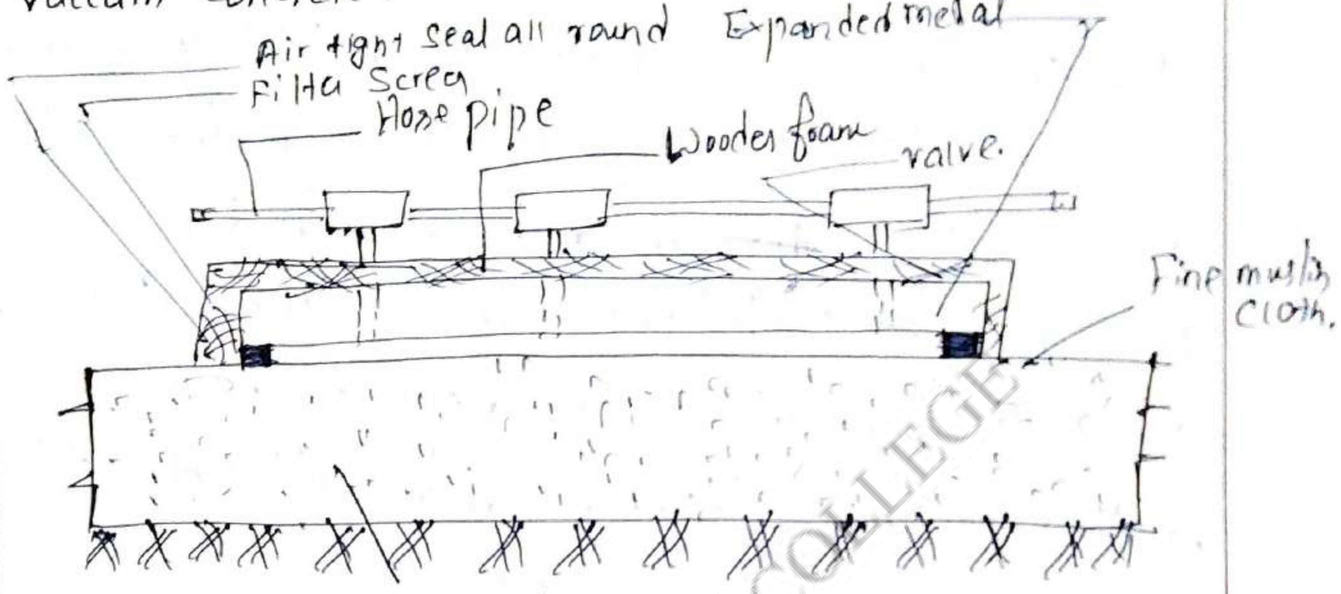
Conventional concrete.

Self compacting concrete, also called as self levelling cohesive Concrete, is a highly flowable concrete which can spread readily into place (low velocity) through and around dense Reinforcement under its own weight. Further it fills formwork adequately without segregation or bleeding and without the need of significant vibration.

It has an low yield stress and an increased plastic viscosity. Although the Concrete requires minimal force to initiate flow, it has Adequate cohesion to Resist aggregate segregation and excessive bleeding, excess aggreate can float in the morter without segregating.

Modern application of self compacting concrete is centered on high performance better and more realiable quality, dense and Uniform surface texture, improved durability, higher strength and faster construction.

Vaccum Concrete :



Incase of concreting thin sections like slabs and walls, a fluid mix with water cement ratio of 0.50 to 0.65 is required so as to faciliate the placing and compaction.

Invariably such a mix will show poor abrasive resistance and Relatively less strength. In situation the vaccum treatment of concrete, involving the Remove of excess water and air by using suction can be helpful.

The concrete made by use of such vacum treatment is called the Vaccum Concrete using suction through a surface mat connected to a vaccum pump.

Duration of vaccum dewatering depends on the water cement ratio and the quantity of water to be Removed. For a slab of thickness from 25mm to 12.5mm the time ranges from 1 to 15 minutes. Initially the treatment is more pronounced in the beginning and falls off rapidly. Hence it is of no advantage to prolong the periods of treatment beyond these valves.

The enhancement properties of concrete by vaccum treatment are..

1. Compressive strength of floor increases by up to 60%.
2. Tensile strength increase approximately by 70%.
3. Cement Consumption is reduced to the extent of 40% no cement is Required seperately for finishing the surface

4. Abrasion Resistance of the floor increase neatly by 60%.

5. shrinkage of concrete and wrapping of floor are Reduced.

Vaccum concrete is mainly useful for factory production of precast plain and reinforced concrete units. It is very much useful for sloping concrete slabs and thin load-bearing and partition walls.

Vaccum treatment can also be effective used in the resurfacing repair of Road pavements.

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Lecture No. 40

Topic(s) to be covered	High strength Concrete.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Various Methods for adopting High Strength concrete: preparation.	Understanding

Teaching Learning Material	Student Activity
chalk & Talk	Listen.

Lecture Notes

HIGH STRENGTH CONCRETE:

Concrete is generally classified as Normal Strength Concrete (NSC), High strength Concrete (HSC) and Ultra high strength concrete (UHSC) However, there is no clear cut boundary amoung the above Concretes. But indian standard denotes the boundary between the NSC and HSC and 35 Mpa.

As per ACI committee Report, the Compressive strength for high strength concrete ranges between 40 Mpa to 80 Mpa. But as per IS: 456 (2000), for high strength concrete, compressive strength ranges from 60 Mpa to 80 Mpa.

High strength Concrete can be made by adopting any one of the following methods

- → Seeding
- → Revibration
- → High speed slurry mixing.
- → Use of admixtures
- → inhibition of cracks
- → Sulphur impregation
- → Use of cementitious Aggregate.

→ Seeding:

By this approach a small percentage of finely ground, fully hydrated portland

Cement is added to the fresh concrete mix. This approach is supposed to add to the strength development but is difficult to explain the Reasons. This method may not hold much Promise.

2. Revibration:

In long run Concrete Undergoes plastic shrinkage. Mixing water creates certain continuous capillary path, bleeding and stagnation of water at some places. All these factors lead to the Reduction of Concrete.

High speed slurry mixing:

This Process involves the adverse preparation of cement - water mixture which is then blended with aggregate to produce Concrete. By this process high Compressive strength is attained. The reason for this high strength is attributed to more efficient hydrated of cement particles and water achieved in the vigorous blending of cement Paste.

4. Use of Admixture.

Addition of admixturee like reducers produce increased Compressive strength. That is high range water reduced, super plasticizers can be used up to 1% by weight of cement

5. Inhibition of cracks:

Formation and propagation of cracks lead to failure of ~~failu~~ concrete. If the propagation of cracks is inhibited, the strength will be higher.

6. Sulphur Impregnation:

High strength Concrete has been produced by impregnating sulphur into low strength porous concrete.

7. Use of Cementitious Aggregate:

Use of cementitious aggregate has been reported to have yielded high strength. Cement fondes is a type of clinker which where finely ground results in a kind of cement. when coarsely crushed, it makes a kind of aggregate known as Alag.

Lecture No. 41

Topic(s) to be covered	Fiber Reinforced Concrete.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Various factors influencing the Properties of fiber Reinforced Concrete	Understanding

Teaching Learning Material	Student Activity
Chalk & Talk	listen.

Lecture Notes

FIBRE - REINFORCED CONCRETE:

plain Concrete has several setbacks, very low tensile strength, limited ductility and a little resistance to cracking. The inherent weakness of plain concrete, is the presence of microcracks at the mortar - aggregate interface. Such weakness can be removed by inclusion of fibers in the mix. The fibres help to transfer loads at the internal microcracks. Such a concrete is called fibre reinforced concrete.

Types of fibers :-

The types of fibers which are generally used in FRC are steel fibres, poly propylene, nylons, asbestos, coir, glass and Carbon.

Factors influencing the properties of FRC :

→ Relative fibre matrix stiffness.
→ Volume of fibre.
→ Aspect Ratio of the fibres
→ Orientation of fibres
→ workability and Compaction of Concrete
→ Size of Coarse Aggregate
→ Mixing.

1. Relative fibre matrix stiffness :

For efficient stress transfer, the modulus of elasticity of matrix must be much lower than that of fibre. low modulus of fibres are Unlikely to give strength improvement.

But they help in the absorption of large energy and therefore impart greater degree of toughness and Resistance to impact. Such fibres are nylon and polypropeline

2. Volume of fibres:

Strength of concrete largely depend on the quantity of fibres used in it. Increase in the volume of fibres causes a linear increase in the tensile strength and toughness of fibre is likely to cause segregation and harshness of concrete and mortar.

3. Aspect Ratio of fibres:

Aspect ratio influences greately the properties of fibre Reinforced concrete upto an aspect ratio of 75, the Ultimate strength of the concrete increases linearly. Beyond 75, relative strength and toughness are reduced.

4. Orientation of fibres:

In conventional concrete the Reinforcement oriented in the Required direction whereas fibres are randomly oriented. It has been observed that in fibre Reinforced Concrete the fibres align parallel to applied load thereby offer more tensile strength and toughness than randomly distributed or perpendicular fibers.

Workability and Compaction of Concrete:

In the Conventional concrete incorporation of steel fiber decrease the workability considerably.

6. Size of Aggregate:

It has been recommended that the max. size of coarse aggregate should be restricted to 10mm. In order to prevent the Reduction in strength of the concrete.

7. Mixing.

Mixing of fibre reinforced concrete has to be done carefully to avoid falling of fibers, segregation and dificulty of mixing the material uniformly.

Lecture No. 12

Topic(s) to be covered	Ferro Cement

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Various Types of ferro cement	Understanding.
LO2	Various Methods of Casting Techniques for ferro cement.	Understanding

Teaching Learning Material	Student Activity
Chalk & Talk	Listen

Lecture Notes

FERROCEMENT

Ferrow cement is a type of thin reinforced Concrete construction where usually a hydraulic cement is reinforced with layers of continuous and relatively small diameter wire meshes. It can be considered as a modified form of reinforced concrete.

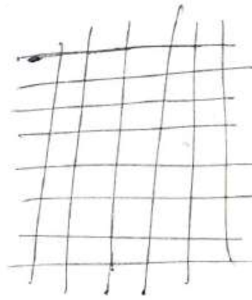
Type of Reinforcement:

→ **Wire Mesh:**

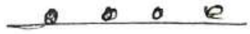
The wire mesh consists of galvanished wire of diameter 0.5 to 1.5mm spaced at 6 to 20mm center to centre, is formed by welding, twisting or weaving. specific mesh types include woven or interlocking mesh, woven cloth and welded mesh. The welded wire meshes may have openings of hexagonal square Rectangular diamond shapes.

Plan

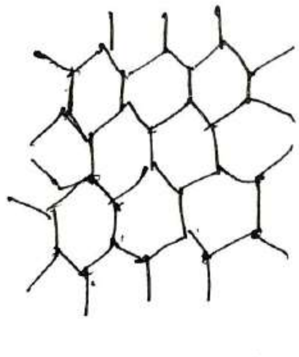
Section



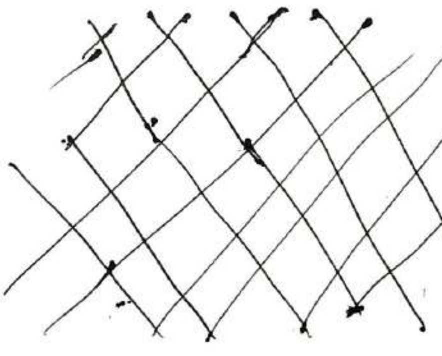
plan



section.



(c) Hexagonal wire mesh.



Expanded metal lath

2. Skeleton steel:

Skeleton steel comprises of large diameter (about 3 to 8mm) steel rods typically spaced at 70 to 100mm. This may by tied - reinforcement or welded wire fabric, welded wire fabrics normally contain large diameter wires spaced at 25mm or more.

3. Expanded metal lath:

This is formed by slitting thin gage sheets and expanding them in the direction perpendicular to the slits. They offer strength approximately equal to that offered by welded wire mesh.

Casting Techniques:

1. Hand plastering
2. Semi - mechinical process
3. Centrifuging and
4. Guniting.

1. Hand plastering :-

This techniques does not use any form - work. In this techniques, a reinforcement

Cage is made using small diameter steel rod reinforcement bent to the required shape. This forms the basic frame which provides the rigidly for the whole structure before plastering.

2. Semi-mechanical process:

In this technique hand plastering is made over formwork. In this system an inner cylindrical mould is provided over which one layer of wire mesh is wound. over this layer 4mm dia wire is tied in both the directions at a spacing of 15cm.

3. Centrifuging:

This technique is specially used for the fabrication of concrete cylindrical units. Because of high first crack strength, the pipe thickness can be Reduced thus Resulting in less dead weight.

4. Guniting:

Guniting is the method of applying mortar to the wire mesh using suitable system. experienced gunmen can give good compact and uniform surface through guniting.

Lecture No. 43

Topic(s) to be covered	Readymix Concrete

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO)	Advantages and Disadvantages for Redymix concrete.	Remembering.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

READY MIX CONCRETE (RMC)

Redy-mix Concrete (RMC) is the concrete which is made at a plant away from the construction site and conveyed in special vehicles.

Redy-mix concrete plant use transit mixers. This is a popular equipment for transporting concrete over a long distance. Transit mixers are truck mounted having a capacity of 4 to

7 m^3. There are two Variations in the ready mix concrete. In one type the mixed concrete is transported to the site by keeping it agitated all along at a speed varying b/w 2 and 6 revolutions per minute

In the other type the concrete is batched at the central batching plant and mixing is done in the truck mixer. either in trasit or imme dialely prior to discharging the Concrete at site.

Transit mixing permits largor hand and is less velnerable in case of delay. The speed of the rotating drums in the truck mixer is between 4 and 16 Revolutions per minute.

Here, the water neded not to be added till the mixing is commenced. with the developement of twin fin process mixer, the transis mixer have become very efficiency in mixing.

Advantages of Redymix Concrete:

→ As the RMC companies have laboratory facility with sufficient equipement, only quality raw materials are used to produced concrete.

→ Uniform and consistent quality of concrete is assumed as it is produced by automated batching plant

→ Control on water - cement ratio is maintained as it is monitored and operated by automated batching plant.

→ Due to high workable and cohesive - mix less chance of segregation, lumping and consequent absence of honey-comb in the concrete.

→ Better finishing is feasible due to pumpable concrete mix.

→ less construction time because of continous mechanical operation.

→ Greately eliminates need of ordering, storing and wastage of row materials.

Disadvantages of Redy-mix Concrete:

→ Time and rate of pouring of concrete depends on the traffic condition at the site.

→ Requirement of proper approach road in sites is essential to transport the huge weight carrying transit mixers.

→ Concrete produced for a stipulated work can not be used during unexpected situation like traffic, rain, machine problem.

→ Better planning is Required as the concrete can not be taken as and when required.

→ There is a possibility of change of water - cement ratio by the workmen

→ Quite expensive.

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Lecture No. 44

Topic(s) to be covered	SIFCON-Shotcrete. polymer Concrete.

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	preparation of shotcrete and the uses of shotcrete.	Remembering
LO2	polymer Concrete and the uses of polymer Concrete.	Remembering.

Teaching Learning Material	Student Activity
chalk & talk	listen.

Lecture Notes

SLURRY INFILTRATED FIBRE CONCRETE (SIFCON)

Slurry infiltrated fibre Concrete (SIFCON) is a high performance material which combines simultaneously a number of outstanding properties such as strength (compression, tension, bending, and shear), ductility. toughness, durability, stiffness and energy absorption capacity under monotonic and cyclic loads.

SHOTCRETE

Shotcreate is primarily a mortar deposited by jetting it with velocity on to a prepared surface. This technique is also called as guniting which has been further developed by the introduction of small sized coarse aggregate. By this process greater thickness of mix is deposited in one operation and also to make the process economical by reducing the cement content.

Uses of shotcrete

- Thin over-head vertical or horizontal surfaces particularly on the curved or folded sections
- Canal, reservoir and tunnel lining.
- Swimming pools and other retaining structures and prestressed tanks.
- Restoration and Repair of concrete structure

→ Fire damaged structures.
→ Water proofing of walls
→ Stabilization of rock slopes and temporary protection of freshly excavated rock surfaces.
→ Protection against long term corrosion of pilling, coal bunkers, oil tanks steel building frames and other structures.
→ Encasing structural steel for fire proofing.
→ Refractory lining of kilns, chimneys, furnaces, ladles.

Types of shotcreting :-

→ Dry mix Process :-

The dry mix process consists of a number of stages and calls for some specialised plant. A small plant set up.

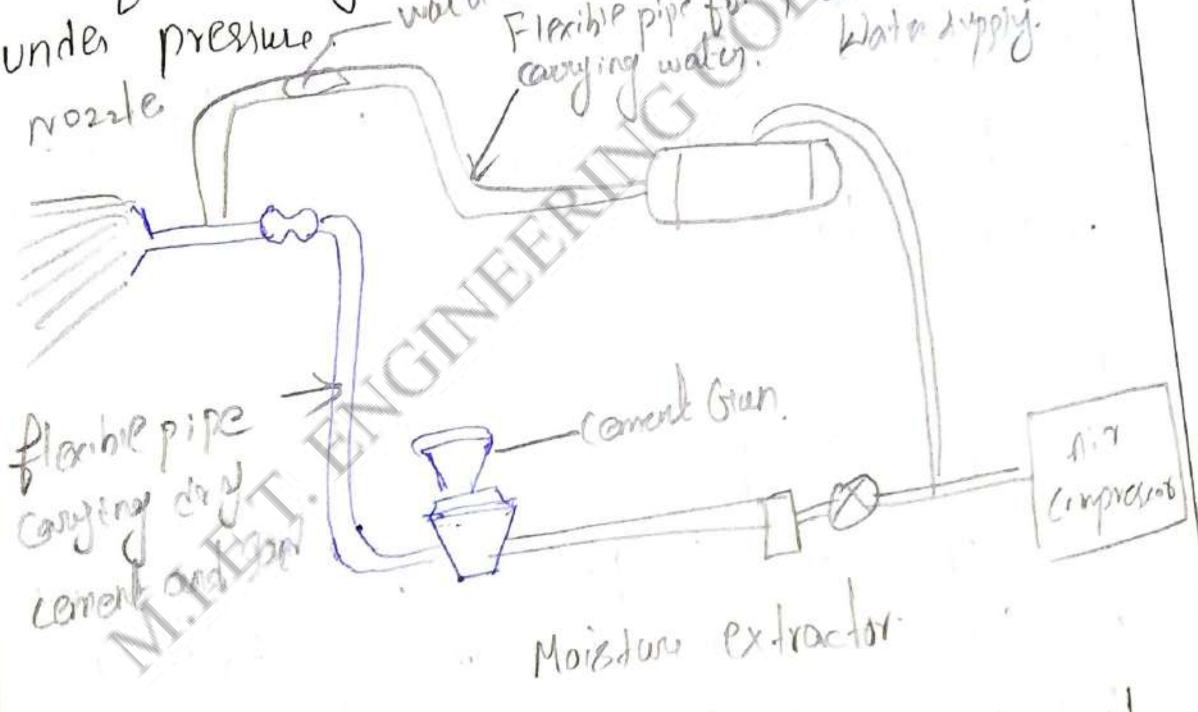
Operation stages:

→ Cement and Sand are thoroughly mixed first
→ the cement / sand mixture is fed into

a special air - pressurised mechanical feeder termed as gun.

→ The mixer is metered into the delivery hose by a feed wheel or distributor within the gun.

→ This material is carried by compressed air through the delivery house to a special nozzle. The nozzle is fitted with a perforated manifold through which water is sprayed under pressure.



Wet mix process :

As done in ordinary concreting, in the wet mix process, all the ingredients, cement, sand small sized coarse aggregate and water are mixed before entering the chamber of delivery equipment

At the delivery point it is jetted by compressed air, on to the work in the same way as that of dry mix process

The ready mix Concrete is metered into the feeding chamber and conveyed by compressed air at pressure of 5.5 to 7 atmosphere to a nozzle. Additional air is injected at the nozzle to increase the velocity and improve the gunning pattern. Equipement capable of placing concrete at the rate of 3 to 9 Cubic meters per hour is available.

Polymer Concrete:

polymer Concrete is a Composite wherein the polymer replaces the cement - water matrix in the cement concrete. It is manufactured in a manner Similar to that of cement concrete. polymer concrete is also called as Resin Concrete.

polymer concrete is prepared as detailed below. Pre polymer also called as monomers are added to the graded aggregate and the mixture is throughly mixed by hand or machine.

Uses of polymer Concrete:

1 Have a good potential as Repair material and for overlays

2. For rapid repair of damaged airfield pavements and industrial structures.

3. For treating the sluiceways and stilling basin of dams

4. For rock bolts

5. For providing necessary corrosion protection to ground anchors

6. For high voltage insulation application

7. For electrical poles

8 For transporting a variety of chemicals through polymer concrete pipes.

Lecture No. 25

Topic(s) to be covered	High Performance Concrete, Geopolymer Concrete

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
LO1	Classification of High performance concrete	Remembering

Teaching Learning Material	Student Activity
Chalk & Talk	listen

Lecture Notes

HIGH PERFORMANCE CONCRETE :

High performance Concrete is a Concrete in which Certain characteristics are developed for a particular application and environment, so that it will give excellent performance in the structure in which it will be placed, in the environment to which it will be exposed, and with the loads to which it will be subjected to during its design life.

In simple terms high performance Concrete can be defined as a Concrete mixture which processes high workability, high strength, high modulus of elasticity, high density, high dimensional stability, low permeability and Resistance to chemical attack.

Classification of High performance Concrete

→ Based on characteristic strength

→ Based on durability and Target Strength

Geopolymer Concrete:

Among the green house gases, CO_2 Contributes about 65% global warming, it is reported that the amount of CO_2 released during the manufacture of OPC due to the calcination of limestone and Combustion of fossil fuel is in the Order of one ton for every ton of OPC produced

On the other hand the supplementary cementing materials such as fly ash, silica fume, granulated blast furnace slag, rice-husk ash and metakaolin may be used for the developement of alternate binders to portland cement.

Such a thought lead to the birth of new product called geopolymer concrete.

Making of Geopolymer Concrete:

→ The fly ash and the aggregates are first mixed together dry for about three minutes. The aggregates are prepared in saturated surface - dry condition.

→ The alkaline liquid is mixed with the superplasticizer and the extra water if any.

→ The liquid component of the mixture is then added to the dry materials and the mixing continued for another four minutes.

→ The fresh concrete can be handled up to 120 minutes without any sign of setting and without any degradation to the compressive strength.

→ The fresh concrete in cast and compacted by the usual methods adopted for conventional concrete.

→ The workability of fresh concrete is measured by means of conventionally concrete slump test

→ Heat - curing substantially assists the chemical reaction the occurs in the geo polymer paste. Both curing time and curing temperature influences the compressive strength of geopolymer concrete.

Properties of geopolymer concrete:

→ Short term properties of Geopolymer concrete

→ long term properties of Geopolymer concrete.