MUTHAYAMMAL ENGINEERING COLLEGE

(An Autonomous Institution)

(Approved by AICTE, New Delhi, Accredited by NAAC & Affiliated to Anna University)
Rasipuram - 637 408, Namakkal Dist., Tamil Nadu

L - 01

LECTURE HANDOUTS

CIVIL

III/V

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **I - CONSTITUENT MATERIALS**

Date of Lecture:

Topic of Lecture: Cement-Different types

Introduction :

- Cement in dry state has no bonding property.
- When mixed with water react chemically and becomes a bonding agent.
- A substance used for construction that sets, hardens, and adheres to other materials to bind them together.
- Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Non-hydraulic cement
- Hydraulic cements

Detailed content of the Lecture:

Types of cement:

- Ordinary Portland cement
- Rapid hardening cement
- Low heat cement
- Sulphate resistant cement
- Air entraining cement
- White and coloured cement
- High alumina cement
- Pozzolanic cement
- Super sulphate cement
- Expansive cement
- Quick setting cement

Ordinary Portland cement:

The OPC was classified into three grades, namely 33 grade, 43 grade and 53 grade depending upon the strength of the cement at 28 days when tested as per IS 4031-1988

Rapid hardening cement:

Rapid hardening cement develops strength at the age of three days, the same strength as that is expected of ordinary portland cement at seven days.

Low heat cement:

A reduction of temperature will retard the chemical action of hardening and so further restrict the rate of evolution of heat.

Sulphate resistant cement:

Sulphates in solution permeate into hardened concrete and attack calcium hydroxide, hydrated calcium aluminate and even hydrated silicates.

Air entraining cement:

This cement is made by mixing a small amount of an air-entraining agent with OPC clinker at the time of grinding.

White and coloured cement:

For manufacturing various coloured cements either white cement or grey Portland cement is used as a base.

High alumina cement:

High alumina cement is obtained by fusing or sintering a mixture, in suitable proportions, of alumina and calcareous materials and grinding the resultant product to a fine powder.

Quick setting cement:

The early setting property is brought out by reducing the gypsum content at the time of clinker grinding.

Video Content / Details of website for further learning (if any):

https://www.youtube.com/watch?v=bPe0Vt09TGg

Important Books/Journals for further learning including the page nos.:

Shetty,M.S, “Concrete Technology”, S.Chand and Company Ltd, New Delhi, 2003 – Page No (28 TO 30)

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LECTURE HANDOUTS

CIVIL **III/V**

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **I - CONSTITUENT MATERIALS**

Date of Lecture:

Topic of Lecture: Chemical composition and Properties

Introduction :

- The durability of concrete ascertains the test reports. So the test on hardened concrete plays a vital role for the quality control of the concrete.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Non-hydraulic cement
- Hydraulic cements

Detailed content of the Lecture:
Chemical Properties:

- The raw materials used for the manufacture of cement consist mainly of lime, silica, alumina and iron oxide.

Oxide	Percent content
CaO	60-67
SiO_2	17-25
Al_2O_3	3.0-8.0
Fe_2O_3	0.5-6.0
MgO	0.1-4.0
Alkalies (k_2O, Na_2O)	0.4-1.3
SO_3	1.3-3.0

- These oxides interact with one another in the kiln at high temperature to form more complex compounds.

- The relative proportions of these oxide compositions are responsible for influencing the various properties of cement, in addition to rate of cooling and fineness of grinding.

Functions of cement ingredients:

Lime:

Controls strength and soundness. Its deficiency reduces strength and setting time.

Silica:

Gives strength due to the formation of dicalcium and tricalcium silicates. Excess of it causes slow setting.

Alumina:

Responsible for quick setting. It acts as a flux and lowers the clinkering temperature. If in excess it lowers the strength.

Calcium Sulphate:

Present in the form of gypsum and its function is to increase the initial setting time of cement.

Iron Oxide:

Imparts color and help in fusion of different ingredients of cement.

Magnesia:

Imparts color and hardness. If in excess causes cracks and makes cement unsound.

Physical Properties of Cement:

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

- Fineness of cement
- Soundness
- Consistency
- Strength
- Setting time
- Heat of hydration
- Loss of ignition
- Bulk density
- Specific gravity (Relative density)
- These physical properties are discussed in details in the following segment. Also, you will find the test names associated with these physical properties

Tests:

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

- **Le Chatelier Test**

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

- **Autoclave Test**

  Cement paste (of normal consistency) is placed in an autoclave (high-pressure steam vessel) and slowly brought to 2.03 MPa, and then kept there for 3 hours. The change in length of the specimen (after gradually bringing the autoclave to room temperature and pressure) is measured and expressed in percentage. The requirement for good quality cement is a maximum of 0.80% autoclave expansion

Video Content / Details of website for further learning (if any):

https://www.youtube.com/watch?v=bPe0Vt09TGg

Important Books/Journals for further learning including the page nos.:

Shetty,M.S, "Concrete Technology", S.Chand and Company Ltd, New Delhi, 2003 – Page No (28 TO 30)

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LECTURE HANDOUTS

CIVIL

III/V

Course Name with Code : 19CEE08 & CONCRETE TECHNOLOGY

Course Teacher : M.GOPINATH

Unit : I - CONSTITUENT MATERIALS

Date of Lecture:

Topic of Lecture: : IS Specifications

Introduction :

- Indian standard codes are list of codes used for civil engineers in India for the purpose of design and analysis of civil engineering structures like buildings, dams, roads, railways, airports and many more

Prerequisite knowledge for Complete understanding and learning of Topic:

- IS Specifications
- Hydraulic cements

Detailed content of the Lecture:

IS Specifications

- Super Sulphated Cement - IS 6909 :1990
- Low Heat Cement – IS 12600: 1989
- Portland Pozzolana Cement –IS 1489(Part I) 1991 (Flyash based)IS 1489(PartII) 1991 (Calcined based)
- Coloured Cement : White Cement – IS 8042:1989
- Ordinary Portland Cement
- Ordinary Portland Cement 33 Grade – IS 269:1989
- Ordinary Portland Cement 43 Grade – IS 8112: 1989
- Ordinary Portland Cement 53 Grade – IS 12269:1987
- Rapid hardening cement – IS 8041: 1990
- Extra Rapid Hardening Cement
- Sulphate Resisting Cement – IS 12330:1998
- Portland Slag Cement – IS 455: 1989
- Super Sulphated Cement - IS 6909 :1990
- Low Heat Cement – IS 12600: 1989
- Portland Pozzolana Cement –

- IS 1489(Part I) 1991 (Flyash based)
- IS 1489(PartII) 1991 (Calcined based)
- Air Entraining Cement
- Coloured Cement : White Cement – IS 8042:1989
- Hydrophobic Cement – IS 8043 : 1991
- Masonry Cement – IS 3466: 1988
- Expansive Cement
- Oil Well Cement – IS 8229:1986
- Concrete Sleeper grade Cement – IRS-T 40: 1985
- High Alumina Cement – IS 6452:1989
- Fineness of cement is tested in two ways:
- By sieving – IS 4031(Part I) : 1996
- By determination of specific surface (total surface area of all the particles in one gram of cement) by air-permeability apparatus. Expressed as cm^2/gm or m^2/gm. Generally Blaine Air Permeability apparatus is used - IS 4031(Part 2) : 1999
- IS 269:1989 – Specification for ordinary Portland cement, 33 grade
- IS 383:1970 – Specification for coarse and fine aggregates from natural sources for concrete
- IS 455:1989 Specification for Portland slag cement
- IS 456:2000 Code of practice for plain and reinforced concrete
- IS 457:1957 Code of practice for general construction of plain and reinforced concrete for dams and other massive structures
- IS 516:1959 Method of test for strength of concrete
- IS 650:1991 Specification for standard sand for testing of cement
- IS 1199:1959 Methods of sampling and analysis of concrete
- IS 1343:1980 Code of practice for prestressed concrete
- IS 1344:1981 Specification for calcined clay pozzolana

IS 1489(Part 1):1991 Specification for Portland pozzolana cement Part 1 Flyash based

- IS 1489(Part 2):1991 Specification for Portland-pozzolana cement: Part 2 Calcined clay based
- IS 1727:1967 Methods of test for pozzolanic materials
- IS 2386(Part 1):1963 Methods of test for aggregates for concrete: Part 1 Particle size and shape
- IS 2386(Part 2):1963 Methods of test for aggreegates for concrete: Part 2 Estimation of deleterious materials and organic impurities
- IS 2386(Part 3):1963 Methods of test for aggregates for concrete: Part 3 Specific gravity, density, voids, absorption and bulking
- IS 2386(Part 4):1963 Methods of test for aggregates for concrete: Part 4 Mechanical

properties

- IS 2386(Part 5):1963 Methods of test for aggregates for concrete : Part 5 Soundness
- IS 2386(Part 6):1963 Methods of test for aggregates for concrete : Part 6 Measuring mortar making properties of fine aggregates
- IS 2386(Part 7):1963 Methods of test for aggregates for concrete : Part 7 Alkali aggregate reactivity
- IS 2386(Part 8):1963 Methods of test for aggregates for concrete: Part 8 Petrographic examination
- IS 2430:1986 Methods for sampling of aggregates for concrete
- IS 2502:1963 Code of practice for bending and fixing of bars for concrete reinforcement
- IS 2645:2003 Integral waterproofing compounds for cement mortar and concrete – Specification
- IS 2770(Part 1):1967 Methods of testing bond in reinforced concrete: Part 1 Pull-out test
- IS 3085:1965 Method of test for permeability of cement mortar and concrete
- IS 3370(Part 1):2009 Code of practice for concrete structures for storage of liquids: Part 1 General requirements
- IS 3370(Part 2):2009 Code of practice for concrete structures for storage of liquids: Part 2 Reinforced concrete structures
- IS 3370(Part 3):1967 Code of practice for concrete structures for the storage of liquids: Part 3 Prestressed concrete
- IS 3370(Part 4):1967 Code of practice for concrete structures for the storage of liquids: Part 4 Design tables
- IS 3466:1988 Specification for masonry cement
- IS 3535:1986 Methods of sampling hydraulic cement
- IS 3558:1983 Code of practice for use of immersion vibrators
- IS 3812(Part 1):2003 Specification for pulverized fuel ash Part 1 For use as pozzolana in cement, cement
  mortar and concrete
- IS 3812(Part 2):2003 Specification for pulverized fuel ash Part 2 For use as admixture in cement mortar and concrete
- IS 4031(Part 1):1996 Methods of physical tests for hydraulic cement: Part 1 Determination of fineness by dry sieving
- IS 4031(Part 2):1999 Methods of physical tests for hydraulic cement: Part 2 Determination of fineness by specific surface by Blaine air permeability method
- IS 4031(Part 3):1988 Methods of physical tests for hydraulic cement: Part 3 Determination of soundness
- IS 4031(Part 4):1988 Methods of physical tests for hydraulic cement: Part 4 Determination of consistency of standard cement paste
- IS 4031(Part 5):1988 Methods of physical tests for hydraulic cement: Part 5 Determination of initial and final setting times
- IS 4031(Part 6):1988 Methods of physical tests for hydraulic cement: Part 6 Determination of compressive strength of hydraulic cement (other than masonry cement)
- IS 4031(Part 7):1988 Methods of physical tests for hydraulic cement: Part 7 Determination

of compressive strength of masonry cement

- IS 4031(Part 8):1988 Methods of physical tests for hydraulic cement: Part 8 Determination of transverse and compressive strength of plastic mortar using prism
- IS 4031(Part 9):1988 Methods of physical tests for hydraulic cement: Part 9 Determination of heat of hydration
- IS 4031(Part 10):1988 Methods of physical tests for hydraulic cement: Part 10 Determination of drying shrinkage
- IS 4031(Part 11):1988 Methods of physical tests for hydraulic cement: Part 11 Determination of density
- IS 4031(Part 12):1988 Methods of physical tests for hydraulic cement: Part 12 Determination of air content of hydraulic cement mortar
- IS 4031(Part 13):1988 Methods of physical tests for hydraulic cement: Part 13 Measurement of water retentivity of masonry cement
- IS 4031(Part 14):1989 Methods of physical tests for hydraulic cement: Part 14 Determination of false set
- IS 4031(Part 15):1991 Methods of physical test for hydraulic cement: Part 15 Determination of fineness by wet sieving
- IS 4032:1985 Method of chemical analysis of hydraulic cement
- IS 4305:1967 Glossary of terms relating to pozzolana
- IS 4634:1991 Methods for testing performance of batch-type concrete mixers
- IS 4845:1968 Definitions and terminology relating to hydraulic
- IS 4926:2003 Ready mixed concrete – Code of practice

Video Content / Details of website for further learning (if any):

https://www.youtube.com/watch?v=bPe0Vt09TGg

Important Books/Journals for further learning including the page nos.:

Shetty,M.S, "Concrete Technology", S.Chand and Company Ltd, New Delhi, 2003 – Page No (28 TO 30)

Course Teacher

Verified by HOD

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **I - CONSTITUENT MATERIALS**

Date of Lecture:

Topic of Lecture: : Aggregates -Classification

Introduction :

- The aggregate is a relatively inert material and it imparts volume stability.
- The aggregate provide about 75% of the body of the concrete and hence its influence is extremely important.

Prerequisite knowledge for Complete understanding and learning of Topic:

- The natural source of aggregate is obtained from Igneous rocks (Granite, Basalt).

Detailed content of the Lecture:

IS Specifications

Aggregate:

- Construction aggregate, or simply "aggregate", is a broad category of coarse to medium grained particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates.
- Aggregates are the most mined materials in the world. Aggregates are a component of composite materials such as concrete and asphalt concrete; the aggregate serves as reinforcement to add strength to the overall composite material.
- Due to the relatively high hydraulic conductivity value as compared to most soils, aggregates are widely used in drainage applications such as foundation and French drains, septic drain fields, retaining wall drains, and roadside edge drains.
- Aggregates are also used as base material under foundations, roads, and railroads. In other words, aggregates are used as a stable foundation or road/rail base with predictable, uniform properties (e.g. to help prevent differential settling under the road or building), or as a low-cost extender that binds with more expensive cement or asphalt to form concrete.

Classification of Aggregate Based on Size

1.Fine Aggregate

2.Coarse Aggregate

1.Fine Aggregate

- It is the aggregate, most of which passes through a 4.75mm IS sieve.
- The lowest size of sand is about 0.07 mm.
- The fine aggregate may be natural sand, crushed stone sand or crushed gravel sand.
- According to IS 383-1970, there are 4 grading zones of the fine sand, grade 1, grade 2, grade3 and grade 4.

2.Coarse Aggregate

- The aggregates, most of which are retained on 4.75mm IS sieve are termed as coarse aggregates.

The coarse aggregates may be

- Crushed stone
- Uncrushed gravel
- Partially crushed stone or gravel.

Irregular aggregates

- The aggregate having partly round particles (pit sand and gravel) has higher percentage of voids ranging from 35 to 38 %.
- It requires more paste for a given workability.
- The interlocking between particles, though better than that obtained with the rounded aggregate, is inadequate for high strength concrete.

Angular aggregates

- The aggregate with sharp angular and rough particles (crushed rock) has a maximum percentage of voids ranging from 38 to 40%.
- The interlocking between particles is good, providing a good bond.
- The aggregate requires more paste to make workable concrete of high strength.
- The angular aggregate is suitable for high strength concrete and pavements subjected to tension.
- inadequate for high strength concrete.

Video Content / Details of website for further learning (if any):
https://www.youtube.com/watch?v=bPe0Vt09TGg

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L - 06

LECTURE HANDOUTS

CIVIL **III/V**

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **I - CONSTITUENT MATERIALS**

Date of Lecture:

Topic of Lecture: : Mechanical properties and tests

Introduction :

- The strength of concrete can be determined by using the destructive type and non0-destructive type. The durability of concrete ascertains the test reports. So the test on hardened concrete plays a vital role for the quality control of the concrete.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Compression Testing on Hardened Concrete

Detailed content of the Lecture:

1. Representative samples of concrete shall be taken and used for casting cubes 15 cm x 15 cm x 15 cm or cylindrical specimens of 15 cm dia x 30 cm long.
2. The concrete shall be filled into the moulds in layers approximately 5 cm deep. It would be distributed evenly and compacted either by vibration or by hand tamping. After the top layer has been compacted, the surface of concrete shall be finished level with the top of the mould using a trowel; and covered with a glass plate to prevent evaporation.
3. The specimen shall be stored at site for 24+ ½ h under damp matting or sack. After that, the samples shall be stored in clean water at 27+2^{0}C; until the time of test. The ends of all cylindrical specimens that are not plane within 0.05 mm shall be capped.
4. Just prior to testing, the cylindrical specimen shall be capped with sulphur mixture comprising 3 parts sulphur to 1 part of inert filler such as fire clay.
5. Specimen shall be tested immediately on removal from water and while they are still in wet condition.

6. The bearing surface of the testing specimen shall be wiped clean and any loose material removed from the surface. In the case of cubes, the specimen shall be placed in the machine in such a manner that the load cube as cast, that is, not to the top and bottom.
7. Align the axis of the specimen with the steel platen, do not use any packing.

- The load shall be applied slowly without shock and increased continuously at a rate of approximately 140 kg/sq.cm/min until the resistance of the specimen to the increased load breaks down and no greater load can be sustained. The maximum load applied to the specimen shall then be recorded and any unusual features noted at the time of failure brought out in the report.

- Compressive strength is calculate using the following formula

Compressive strength (kg/cm²) = W_f / A_p

Where

W_f = Maximum applied load just before load, (kg)

A_p = Plan area of cube mould, (mm^2)

- Hardness Testing
  - Vickers hardness test (HV), which has one of the widest scales
  - Brinell hardness test (HB)
  - Knoop hardness test (HK), for measurement over small areas
  - Janka hardness test, for wood
  - Meyer hardness test

- Rockwell hardness test (HR), principally used in the USA
- Shore durometer hardness, used for polymers
- Barcol hardness test, for composite materials
- Tensile testing, used to obtain the stress-strain curve for a material, and from there, properties such as Young modulus, yield (or proof) stress, tensile stress and % elongation to failure.

- Impact testing
  - Izod test
  - Charpy test

- Fracture toughness testing
  - Linear-elastic (KIc)
  - K–R curve
  - Elastic plastic (JIc, CTOD)

- Creep Testing, for the mechanical behaviour of materials at high temperatures (relative to their melting point)
- Fatigue Testing, for the behaviour of materials under cyclic loading
  - Load-controlled smooth specimen tests
  - Strain-controlled smooth specimen tests
  - Fatigue crack growth testing

- Non-Destructive Testing

Video Content / Details of website for further learning (if any):
https://www.youtube.com/watch?v=bPe0Vt09TGg

Important Books/Journals for further learning including the page nos.:

Shetty,M.S, "Concrete Technology", S.Chand and Company Ltd, New Delhi, 2003 – Page No (28 TO 30)

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Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **I - CONSTITUENT MATERIALS**

Date of Lecture:

Topic of Lecture: : Tests As Per BIS Grading Requirements

Introduction :

- The strength of concrete can be determined by using the destructive type and non0-destructive type. The durability of concrete ascertains the test reports. So the test on hardened concrete plays a vital role for the quality control of the concrete.

Prerequisite knowledge for Complete understanding and learning of Topic:

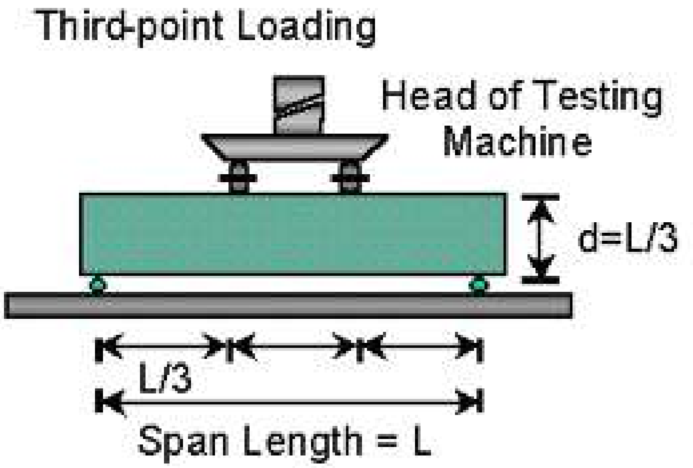
- **Flexural Strength on Concrete**

Detailed content of the Lecture:

1. Prepare the test specimen by filling the concrete into the mould in 3 layers of approximately equal thickness. Tamp each layer 35 times using the tamping bar as specified above. Tamping should be distributed uniformly over the entire crossection of the beam mould and throughout the depth of each layer.
2. Clean the bearing surfaces of the supporting and loading rollers , and remove any loose sand or other material from the surfaces of the specimen where they are to make contact with the rollers.
3. Circular rollers manufactured out of steel having cross section with diameter 38 mm will be used for providing support and loading points to the specimens. The length of the rollers shall be at least 10 mm more than the width of the test specimen. A total of four rollers shall be used, three out of which shall be capable of rotating along their own axes.

The distance between the outer rollers (i.e. span) shall be **3d** and the distance between the inner rollers shall be **d**. The inner rollers shall be equally spaced between the outer rollers, such that the entire system is systematic.

4. The specimen stored in water shall be tested immediately on removal from water; whilst they are still wet. The test specimen shall be placed in the machine correctly centered with the longitudinal axis of the specimen at right angles to the rollers. For moulded specimens, the mould filling direction shall be normal to the direction of loading.



5. The load shall be applied at a rate of loading of 400 kg/min for the 15.0 cm specimens and at a rate of 180 kg/min for the 10.0 cm specimens.

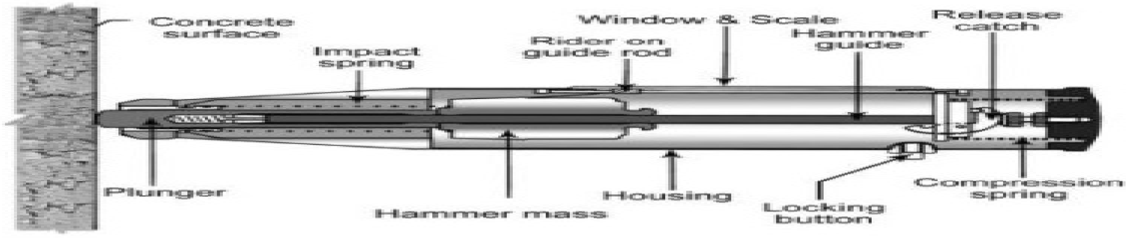
Rebound Hammer Test

Rebound hammer test is done to find out the compressive strength of concrete by using rebound hammer as per IS: 13311 (Part 2) – 1992. The underlying principle of the rebound hammer test is

- ❖ The rebound of an elastic mass depends on the hardness of the surface against which its mass strikes.
- ❖ When the plunger of the rebound hammer is pressed against the surface of the concrete, the pring-controlled mass rebounds and the extent of such a rebound depends upon the surface hardness of the concrete.
- ❖ The surface hardness and therefore the rebound is taken to be related to the compressive strength of the concrete.
- ❖ The rebound value is read from a graduated scale and is designated as the rebound

number or rebound index.

- ❖ The compressive strength can be read directly from the graph provided on the body of the hammer.



Video Content / Details of website for further learning (if any):

http://www.alphace.ac.in/downloads/notes/cv/10cv81.pdf
http://www.engineeringcivil.com/rebound-hammer-test.html
http://www.engineersdaily.com/2011/05/pull-out-test- concrete.html

Important Books/Journals for further learning including the page nos.:

Shetty, M.S, "Concrete Technology, Theory and Practice", S. Chand and Company Ltd, New Delhi, 2008 Pg.no: 148 to 158

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L - 08

LECTURE HANDOUTS

CIVIL **III/V**

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **I - CONSTITUENT MATERIALS**

Date of Lecture:

Topic of Lecture: : Quality of water for use in concrete

Introduction :

- Concrete is a chemically combined mass which is manufactured from binding materials and inert materials with water.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Function
- Potable water as mixing water
- Determination of Suitability of Mixing Water

Detailed content of the Lecture:

Function of Water in Concrete:

The application of condensed silica fume as a mineral admixture in concrete is almost a routine one nowadays for the production of tailor-made high-performance concretes. Abrams' Law, which was originally formulated for conventional concrete containing cement as the only cementitious material, is not directly applicable to these new-generation concretes. In the present paper, modified relationships have been proposed to evaluate the strength of silica fume concrete. An extensive experimentation was carried out to determine the isolated effect of silica fume on concrete, and, analyzing the 28-day strength results of 32 concrete mixes performed over a wide range of water–binder ratios and silica fume replacement percentages, simplified relationships have been proposed. These simplified models might serve as useful guides for proportioning concrete mixes incorporating silica fume.

Three water serves the following purpose:

1. To wet the surface of aggregates to develop adhesion because the cement pastes adheres quickly and satisfactory to the wet surface of the aggregates than to a dry surface.

2. To prepare a plastic mixture of the various ingredients and to impart workability to concrete to facilitate placing in the desired position and
3. Water is also needed for the hydration of the cementing materials to set and harden during the period of curing.

The quantity of water in the mix plays a vital role on the strength of the concrete. Some water which have adverse effect on hardened concrete. Sometimes may not be harmless or even beneficial during mixing. So clear distinction should be made between the effect on hardened concrete and the quality of mixing water.

Potable water as mixing water:

- The common specifications regarding quality of mixing water is water should be fit for drinking. Such water should have inorganic solid less than 1000 ppm. This content lead to a solid quantity 0.05% of mass of cement when w/c ratio is provided 0.5 resulting small effect on strength.
- But some water which are not potable may be used in making concrete with any significant effect. Dark color or bad smell water may be used if they do not posses deleterious substances.
- P^H of water to even 9 is allowed if it not tastes brackish. In coastal areas where local water is saline and have no alternate sources, the chloride concentration up to 1000 ppm is even allowed for drinking.

Determination of Suitability of Mixing Water:

- A simple way of determining the suitability of such water is to compare the setting time of cement and the strength of mortar cubes using the water in question with the corresponding results obtained using known suitable or distilled water.
- About 10% tolerance is generally allowed. Such tests are recommended when water for which no service record is available containing dissolved solids in excess of 2000 ppm or, in excess of 1000 ppm. When unusual solids are present a test is also advisable.

Video Content / Details of website for further learning (if any):
https://civil-engg-world.blogspot.in/2009/09/quality-of-water-in-concrete-mix.html
http://www.engineeringcivil.com/rebound-hammer-test.html
http://www.engineersdaily.com/2011/05/pull-out-test- concrete.html

Important Books/Journals for further learning including the page nos.:
Shetty, M.S, "Concrete Technology, Theory and Practice", S. Chand and Company Ltd, New Delhi, 2008 Pg.no: 119

Course Teacher

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LECTURE HANDOUTS

CIVIL | **III/V**

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **I - CONSTITUENT MATERIALS**

Date of Lecture:

Topic of Lecture: : Sea water and their effects

Introduction :

- Concrete exposed to marine environment may deteriorate as a result of combined effects of chemical action of seawater constituents on cement hydration products, alkali-aggregate expansion

Prerequisite knowledge for Complete understanding and learning of Topic:

- General, Theoretical Aspects, Permeability is the key to durability

Detailed content of the Lecture:

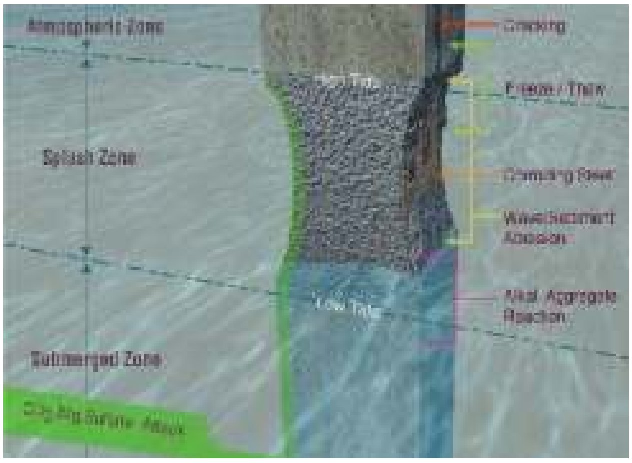
Sea water and their effects

- seawater has a salinity of between 31 g/kg and 38 g/kg, that is 3.1–3.8%, seawater is not uniformly saline throughout the world.
- Where mixing occurs with fresh water runoff from river mouths, near melting glaciers or vast amounts of precipitation (e.g. Monsoon), seawater can be substantially less saline.
- The most saline open sea is the Red Sea, where high rates of evaporation, low precipitation and low river run-off, and confined circulation result in unusually salty water.
- The salinity in isolated bodies of water can be considerably greater still - about ten times higher in the case of the Dead Sea.

- Most seawater is fairly uniform in chemical composition, which is characterized by the presence of about 3.5 percent soluble salts by weight.
- The ionic concentrations of Na+ and Cl are the highest, typically 11,000 and 20,000 mg/liter, respectively.
- However, from the standpoint of aggressive action to cement hydration products, sufficient amounts of Mg2+ and SO2? 4 are present, typically 1400 and 2700 mg/liter, respectively.

Theoretical Aspects

- From the standpoint of chemical attack on hydrated Portland cement in unreinforced concrete, when alkali reactive aggregates are not present, one might anticipate that sulfate and magnesium are the harmful constituents in seawater.
- It may be recalled that with groundwater, sulfate attack is classified as severe when the sulfate ion concentration is higher than 1500 mg/liter; similarly,
- Portland cement paste can deteriorate by cat–ion-exchange reactions when magnesium ion concentration exceeds, for instance, 500 mg/liter.



Permeability is the key to durability.

- Deleterious interactions of serious consequence between constituents of hydrated Portland cement and seawater take place when seawater is not prevented from penetrating into the interior of a concrete.
- Typical causes of insufficient water tightness are poorly proportioned concrete mixtures, absence of properly entrained air if the structure is located in a cold climate, inadequate consolidation and curing, insufficient concrete cover on embedded steel, badly designed or constructed joints, and micro cracking in hardened concrete attributable to lack of control of loading conditions and other factors, such as thermal shrinkage, drying shrinkage, and alkali aggregate expansion

Video Content / Details of website for further learning (if any):
https://civil-engg-world.blogspot.in/2009/09/quality-of-water-in-concrete-mix.html
http://www.engineeringcivil.com/rebound-hammer-test.html
http://www.engineersdaily.com/2011/05/pull-out-test- concrete.html

Important Books/Journals for further learning including the page nos.:
Shetty, M.S, "Concrete Technology, Theory and Practice", S. Chand and Company Ltd, New Delhi, 2008 Pg.no: 119

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LECTURE HANDOUTS

CIVIL | **III/V**

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **II- ADMIXTURES AND THEIR EFFECTS**

Date of Lecture:

Topic of Lecture: : Chemical admixtures

Introduction :

- Admixtures vary in composition from surfactants and soluble salts and polymers to insoluble minerals. The purposes for which they are generally used in concrete include improvement of workability, acceleration or retardation of setting time, control of strength development, and enhancement of resistance to frost action, thermal cracking, alkali-aggregate expansion, and acidic and sulfate solutions

Prerequisite knowledge for Complete understanding and learning of Topic:

- Properties of Admixtures, Chemical Admixtures, Mineral Admixtures.

Detailed content of the Lecture:

ADMIXTURES

- An admixture is defined as a material other than water, aggregate, hydraulic cements and fiber reinforcement, used as an ingredient of concrete or mortar and added to the batch immediately before or during mixing.

PROPERTIES OF ADMIXTURES:

- IS9103:1999 Specification for admixtures for concrete
- Admixtures should not impair durability of concrete nor combine with the constituent to form harmful compounds nor increase the risk of corrosion of reinforcement.
- The workability, compressive strength and the slump loss of concrete with and without the use of admixtures shall be established during the trial mixes before use of admixtures.
- The relative density of liquid admixtures shall be checked for each drum containing admixtures and compared with the specified value before acceptance.
- The chloride content of admixtures shall be independently tested for each batch before acceptance.

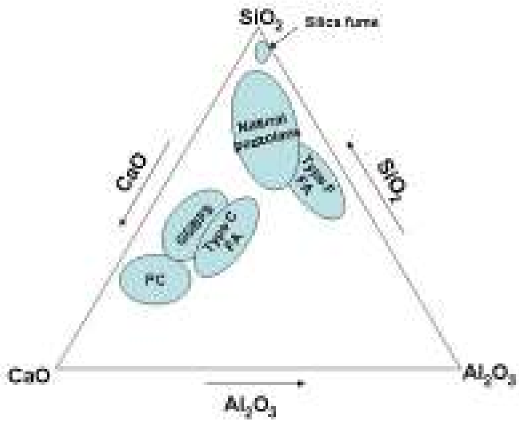
- If two or more admixtures are used simultaneously in the same concrete mix, data should be obtained to assess their interaction and to ensure their compatibility.

CLASSIFICATION OF ADMIXTURES:

Admixtures are commonly classified by their function in concrete but often they exhibit some additional action.

Chemical Admixtures: The purposes for which they are generally used in concrete include improvement of workability, acceleration or retardation of setting time, control of strength development, and enhancement of resistance to frost action, thermal cracking, alkali-aggregate expansion, and acidic and sulfate solutions

Mineral Admixtures: The use of pozzolanic materials is as old as that of the art of concrete construction. It was recognized long time ago, that the suitable pozzolans used in appropriate amount, modify certain properties of fresh and hardened mortars and concretes.



Video Content / Details of website for further learning (if any):
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LECTURE HANDOUTS

CIVIL **III/V**

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **II- ADMIXTURES AND THEIR EFFECTS**

Date of Lecture:

Topic of Lecture: Accelerators - Retarders

Introduction :

- Admixtures vary in composition from surfactants and soluble salts and polymers to insoluble minerals. The purposes for which they are generally used in concrete include improvement of workability, acceleration or retardation of setting time, control of strength development, and enhancement of resistance to frost action, thermal cracking, alkali-aggregate expansion, and acidic and sulfate solutions

Prerequisite knowledge for Complete understanding and learning of Topic:

- Properties of Admixtures, Chemical Admixtures, Mineral Admixtures.

Detailed content of the Lecture:

RETARDERS

- A retarder is an admixture that slows down the chemical process of hydration so that concrete remains plastic and workable for a longer time than concrete without the retarder.
- Retarders are used to overcome the accelerating effect of high temperature on setting properties of concrete on hot weather concreting.
- Sometimes concrete may have to be placed in difficult conditions and delay may occur in transporting and placing. In ready mixed concrete practices, concrete is manufactured in central batching plant and transported over a long distance to the job sites.

RETARDING ADMIXTURES

- It is mentioned earlier that all the plasticizers and super plasticizers by themselves show certain extent of retardation.
- Many a time this extent of retardation of setting time offered by admixtures will not be

sufficient. Instead of adding retarders separately, retarders are mixed with plasticizers or super plasticizers at the time of commercial production. Such commercial brand is known as retarding plasticizers

ACCELERATORS

Accelerating admixtures are added to concrete to increase the rate of early strength development in concrete to

- Permit earlier removal of formwork;
- Reduce the required period of curing;
- Advance the time that a structure can be placed in service;
- Partially compensate for the retarding effect of low temperature during cold Weather concreting;
- In the emergency repair work.

ACCELERATING PLASTICIZERS

- ❖ Certain ingredients are added to accelerate the strength development of concrete to plasticizers or super plasticizers.
- ❖ Such accelerating super plasticizers, when added to concrete result in faster development of strength.
- ❖ The accelerating materials added to plasticizers or super plasticizers are triethenolamine chlorides, calcium nitrite, nitrates and fluosilicates etc.
- ❖ The accelerating plasticizers or accelerating super plasticizers manufactured by well known companies are chloride free

Video Content / Details of website for further learning (if any):
http://www.alphace.ac.in/downloads/notes/cv/10cv81.pdf
http://www.engineeringcivil.com/rebound-hammer-test.html
http://www.engineersdaily.com/2011/05/pull-out-test- concrete.html

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LECTURE HANDOUTS

CIVIL | **III/V**

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **II- ADMIXTURES AND THEIR EFFECTS**

Date of Lecture:

Topic of Lecture: Plasticizers- Super plasticizers

Introduction :

- Admixtures vary in composition from surfactants and soluble salts and polymers to insoluble minerals. The purposes for which they are generally used in concrete include improvement of workability, acceleration or retardation of setting time, control of strength development, and enhancement of resistance to frost action, thermal cracking, alkali-aggregate expansion, and acidic and sulfate solutions

Prerequisite knowledge for Complete understanding and learning of Topic:

- Plasticizers, Super Plasticizers

Detailed content of the Lecture:

PLASTICIZERS (Water Reducers)

- Requirement of right workability is the essence of good Concrete. Concrete in different situations require different degree of workability.
- A high degree of workability is required in situations like deep beams, thin walls of water retaining structures with a high percentage of steel reinforcement, column and beam junctions, pumping of Concrete, hot weather Concreting.
- Plasticizers which can help in difficult conditions for obtaining higher workability without using excess of water.
- The organic substances or the combinations of organic and inorganic substances, which allow a high reduction in water content for the given workability or give a higher workability at the same water content, are termed as Plasticizing Admixtures.

The basic products constituting plasticizers are:

- ❖ Anionic surfactants such as lignosulphonates and their modifications and derivatives, salts of sulphonates hydrocarbons.
- ❖ Nonionic surfactants such as polyglycol esters, acid of hydroxylated carboxyl acids and their modifications and derivatives.

SUPERPLASTICIZERS (HIGH RANGE WATER REDUCERS)

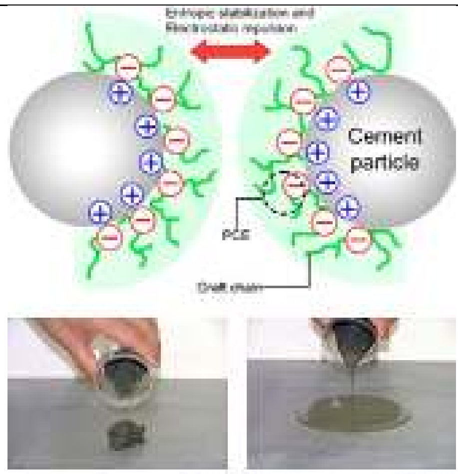
- ❖ Superplasticers constitute a relatively new category and improved version of plasticizer, the use of which was developed in Japan and Germany during 1960 and 1970 respectively.
- ❖ They are chemically different from normal plasticizers.
- ❖ Use of superplasticizer permits the reduction of water to the extent upto 30 per cent without reducing workability in contrast to the possible reduction up to 15 per cent in case of plasticizers.
- ❖ It is the use of superplasticizer which has made it possible to use w/c as low as 0.25 or even lower and yet to make flowing concrete to obtain strength of the order 120 Mpa or more. It is the use of superplasticizer which has made it possible

Concrete industry. Common builders and Government departments are yet to take up the use of this useful material. Super plasticizers can produce:

- ➢ At the same w/c ratio much more workable concrete than the plain ones,
- ➢ For the same workability, it permits the use of lower w/c ratio,
- ➢ As a consequence of increased strength with lower w/c ratio, it also permits a reduction of cement content.

Classification of Super plasticizer: Following are a few polymers which are commonly used as base for super plasticizers.

- ❖ Sulphonated melamine-formaldehyde condensates (SMF)
- ❖ Sulphonated naphthalene-formaldehyde condensates (SNF)
- ❖ Modified lignosulphonates (MLS)



Plasticizer Superplasticizer

EFFECTS OF SUPERPLASTICIZERS ON FRESH CONCRETE

- It is to be noted that dramatic improvement in workability is not showing up when plasticizers or super plasticizers are added to very stiff or what is called zero slump concrete at nominal dosages.
- A mix with an initial slump of about 2 to 3 cm can only be fluidized by plasticizers or super plasticizers at nominal dosages. high dosage is required to fluidify no slump concrete.
- An improvement in slump value can be obtained to the extent of 25 cm or more depending upon the initial slump of the mix, the dosage and cement content.
- It is often noticed that slump increases with increase in dosage. But there is no appreciable increase in slump beyond certain limit of dosage.

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http://www.engineeringcivil.com/rebound-hammer-test.html
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LECTURE HANDOUTS

CIVIL **III/V**

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **II- ADMIXTURES AND THEIR EFFECTS**

Date of Lecture:

Topic of Lecture: Water proofers

Introduction :

- Admixtures vary in composition from surfactants and soluble salts and polymers to insoluble minerals. The purposes for which they are generally used in concrete include improvement of workability, acceleration or retardation of setting time, control of strength development, and enhancement of resistance to frost action, thermal cracking, alkali-aggregate expansion, and acidic and sulfate solutions

Prerequisite knowledge for Complete understanding and learning of Topic:

- Water-Reducing Admixtures

Detailed content of the Lecture:

Water-Reducing Admixtures:

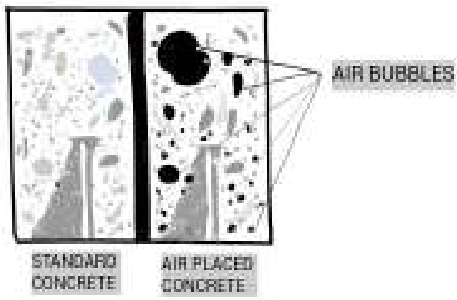
- Used to reduce the quantity of mixing water required to produce concrete of a certain slump, reduce water-cementing materials ratio, reduce cement content, or increase slump.
- Typical water reducers reduce the water content by approximately 5% to 10%.

Water-Reducing Admixtures Materials:

- Lignosulfonates.
- Carbohydrates.
- Hydroxylated carboxylic acids
- Perhaps one of the important advancements made in concrete technology was the discovery of air entrained concrete.
- Air entrained concrete is made by mixing a small quantity of air entraining agent or by using air entraining cement.
- These air entraining agents incorporate millions of no coalescing air bubbles, which will

act as flexible ball bearings and will modify the properties of plastic concrete regarding workability, segregation, bleeding and finishing quality of concrete.

- It also modifies the properties of hardened concrete regarding its resistance to frost action and permeability.



The air voids present in concrete can be brought under two groups:

(a) Entrained air (b) Entrapped air.

- Entrained air is intentionally incorporated, minute spherical bubbles of size ranging from 5 microns to 80 microns distributed evenly in the entire mass of concrete.
- The entrapped air is the void present in the concrete due to insufficient compaction.
- These entrapped air voids may be of any shape and size normally embracing the contour of aggregate surfaces.
- Their size may range from 10 to 1000 microns or more and they are not uniformly distributed throughout the concrete mass.

AIR ENTRAINING AGENTS

The following types of air entraining agents are used for making air entrained concrete.

(a) Natural wood resins

(b) Animal and vegetable fats and oils, such as tallow, olive oil and their fatty acids such as stearic and oleic acids.

(c) Various wetting agents such as alkali salts or sulphated and sulphonated organic compounds.

(d) Water soluble soaps of resin acids, and animal and vegetable fatty acids.

(e) Miscellaneous materials such as the sodium salts of petroleum sulphonic acids, hydrogen peroxide and aluminium powder

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LECTURE HANDOUTS

CIVIL

III/V

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **II- ADMIXTURES AND THEIR EFFECTS**

Date of Lecture:

Topic of Lecture: Mineral Admixtures

Introduction :

- Admixtures vary in composition from surfactants and soluble salts and polymers to insoluble minerals. The purposes for which they are generally used in concrete include improvement of workability, acceleration or retardation of setting time, control of strength development, and enhancement of resistance to frost action, thermal cracking, alkali-aggregate expansion, and acidic and sulfate solutions

Prerequisite knowledge for Complete understanding and learning of Topic:

- Pozzolanic

Detailed content of the Lecture:

Mineral Admixtures:

- Also called 'Supplementary Cementing Materials'
- Used when special performance is needed: Increase in strength, reduction in water demand, impermeability, low heat of hydration, improved durability, correcting deficiencies in aggregate gradation (as fillers), etc.
- Result in cost and energy savings: Replacement of cement leads to cost savings; energy required to process these materials is also much lower than cement
- Environmental damage and pollution is minimized by the use of these by-products – about 6 – 7% of total CO_2 emission occurs from the production of cement
- Usage depends on supply and demand forces, as well as the market potential and attitudes

TYPE OF ADMIXURES

- Fly ash

- Silica fume
- Rise husk ash
- Metakaoline
- Ground Granulated Blast furnace Slag (GGBS)

Typical compositions

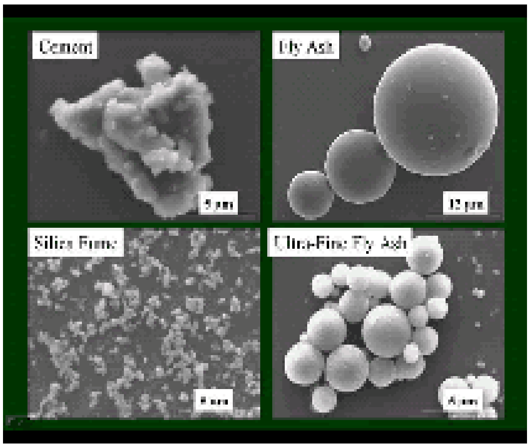
PC: Portland cement

BY MASS	PC	GGBS	F-FA	C-FA	SF
SiO_2	21	35	50	35	90
Al_2O_3	5	8	25	20	2
Fe_2O_3	2	3	10	5	2

GGBFS: Ground granulated blast furnace slag

F-FA: Type F fly ash

MINERAL ADMIXTURES:



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MUTHAYAMMAL ENGINEERING COLLEGE

(An Autonomous Institution)

(Approved by AICTE, New Delhi, Accredited by NAAC & Affiliated to Anna University)
Rasipuram - 637 408, Namakkal Dist., Tamil Nadu

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LECTURE HANDOUTS

CIVIL | **III/V**

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **II- ADMIXTURES AND THEIR EFFECTS**

Date of Lecture:

Topic of Lecture: Fly Ash, Silica Fume, Ground Granulated Blast Furnace Slag

Introduction :

- Admixtures vary in composition from surfactants and soluble salts and polymers to insoluble minerals. The purposes for which they are generally used in concrete include improvement of workability, acceleration or retardation of setting time, control of strength development, and enhancement of resistance to frost action, thermal cracking, alkali-aggregate expansion, and acidic and sulfate solutions

Prerequisite knowledge for Complete understanding and learning of Topic:

- **Pozzolanic Or Mineral Admixtures**

Detailed content of the Lecture:

- The use of pozzolanic materials is as old as that of the art of concrete construction.
- It was recognized long time ago, that the suitable pozzolans used in appropriate amount, modify certain properties of fresh and hardened mortars and concretes.
- Pozzolans have been extensively used in Europe, USA and Japan, as an ingredient of Portland cement concrete particularly for marine and hydraulic structures.
- It has been amply demonstrated that the best pozzolans in optimum proportions mixed with Portland cement improves many qualities of concrete, such as:

(a) Lower the heat of hydration and thermal shrinkage

(b) Increase the water tightness

(c) Reduce the alkali-aggregate reaction

(d) Improve resistance to attack by sulphonate soils and sea water

(e) Improve extensibility

(f) Lower susceptibility to dissolution and leaching

(g) Improve workability

(h) Lower costs.

FLY ASH:

- Fly ash is finely divided residue resulting from the combustion of powdered coal and transported by the flue gases and collected by electrostatic precipitator.
- In U.K. it is referred as pulverized fuel ash (PFA). Fly ash is the most widely used pozzolanic material all over the world.

SILICA FUME

- Silica fume, also referred to as micro silica or condensed silica fume, is another material that is used as an artificial pozzolanic admixture.
- 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.

GROUND GRANULATED BLAST FURNCE SLAG (GGBS)

- Ground granulated blast-furnace slag is a non metallic product consisting essentially of silicates and aluminates of calcium and other bases.
- The molten slag is rapidly chilled by quenching in water ton form a glassy sand like granulated material

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LECTURE HANDOUTS

CIVIL

III/V

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **II- ADMIXTURES AND THEIR EFFECTS**

Date of Lecture:

Topic of Lecture: Metakaoline

Introduction :

- Metakaolin is the anhydrous calcined form of the clay mineral kaolinite. Minerals that are rich in kaolinite are known as china clay or kaolin, traditionally used in the manufacture of porcelain. The particle size of metakaolin is smaller than cement particles, but not as fine as silica fume.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Mineral Admixtures

Detailed content of the Lecture:

- This is obtained from calcination of kaolinite clay in the range of 740 – 840 ^{o}C. The crystalline clay loses its structure at this temperature by the loss of bound water. Burning should strictly be done in this range, since beyond 1000 oC, recrystallization of the clay occurs.
- A general formula of metakaolin can be written as AS_2. This aluminosilicate compound reacts with CH produced during cement hydration in the following form (suggested by Murat – in Cement and Concrete Research, Vol. 13, 1983):

  $AS_2 + 6CH + 9H \rightarrow C_4AH_{13} + 2C\text{-}S\text{-}H$

  C-S-H formed in this reaction is aluminous, with a C/S ranging from 0.83 (for crystalline forms of C-S-H) to > 1.5 (for amorphous and semi-crystalline forms of C-S-H).
- The content of C-S-H and its formation rate depends on the mineralogical characteristics of the kaolin precursor. Metakaolin has a performance comparable to silica fume as a mineral admixture in concrete. Since MK is not a by-product, its processing is an expensive affair. Thus the marketability of MK is not as good as silica fume, which is a

proven by-product.

Advantages

- Increased compressive and flexural strengths
- Reduced permeability (including chloride permeability)
- Reduced potential for efflorescence, which occurs when calcium is transported by water to the surface where it combines with carbon dioxide from the atmosphere to make calcium carbonate, which precipitates on the surface as a white residue.
- Increased resistance to chemical attack
- Increased durability
- Reduced effects of Alkali-Silica Reactivity (ASR)
- Enhanced workability and finishing of concrete
- Reduced shrinkage, due to "particle packing" making concrete denser
- Improved color by lightening the color of concrete making it possible to tint lighter integral color

USES

- High performance, high strength, and lightweight concrete
- Precast and poured-mold concrete
- Fibercement and ferrocement products
- Glass fiber reinforced concrete
- Countertops, art sculptures
- Mortar

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LECTURE HANDOUTS

CIVIL | **III/V**

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **II- ADMIXTURES AND THEIR EFFECTS**

Date of Lecture:

Topic of Lecture: Their effects on concrete properties

Introduction :

- Metakaolin is the anhydrous calcined form of the clay mineral kaolinite. Minerals that are rich in kaolinite are known as china clay or kaolin, traditionally used in the manufacture of porcelain. The particle size of metakaolin is smaller than cement particles, but not as fine as silica fume.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Mineral Admixtures

Effect on fresh concrete properties

- The setting time is increased when fly ash is used.
- Workability and flow of concrete are increased due to the spherical shape of the fly ash particles, which lends a ball-bearing type effect on the concrete mixture.
- Bleeding and segregation are usually reduced for well-proportioned fly ash concrete.
- The paste volume is increased when mass replacement of cement by fly ash is done.
- Because of its high fineness, the use of silica fume causes an increase in the water demand of concrete. Typically it is always used in conjunction with a superplasticizer.
- Silica fume causes the mix to be sticky and cohesive. Also, concrete mixes with silica fume are prone to slump loss problems. Because of its cohesiveness, a higher slump is needed to place silica fume concrete.
- Bleeding is reduced drastically. In fact, most silica fume mixes do not show any bleeding. In dry areas, if the evaporation rate exceeds the rate at which concrete sets, plastic shrinkage may occur.

- Apart from delaying the initial set, slag does not significantly alter the fresh concrete properties. The workability of slag concrete is similar to an equivalent PC concrete, primarily because slag possesses the same level of fineness as PC.
- The rate of strength gain is slowed down considerably when cement is replaced by slag. The delay increases with increasing replacement. 100% slag concrete is also possible, although the curing duration to produce the required strengths would need to be substantially increased
- Shrinkage cracks occur when concrete members undergo restrained volumetric changes (shrinkage) as a result of either drying, autogenous shrinkage or thermal effects. Restraint is provided either externally (i.e. supports, walls, and other boundary conditions) or internally (differential drying shrinkage, reinforcement).
- Once tensile strength of the concrete is exceeded, a crack will develop. The number and width of shrinkage cracks that develop are influenced by the amount of shrinkage that occurs, the amount of restraint present and the amount and spacing of reinforcement provided.
- These are minor indications and have no real structural impact on the concrete member.

Plastic-shrinkage cracks are immediately apparent, visible within 0 to 2 days of placement, while drying-shrinkage cracks develop over time.

- Autogenous shrinkage also occurs when the concrete is quite young and results from the volume reduction resulting from the chemical reaction of the Portland cement Concrete members may be put into tension by applied loads. This is most common in concrete beams where a transversely applied load will put one surface into compression and the opposite surface into tension due to induced bending.
- The portion of the beam that is in tension may crack. The size and length of cracks is dependent on the magnitude of the bending moment and the design of the reinforcing in the beam at the point under consideration.

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CIVIL **III/V**

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **II- ADMIXTURES AND THEIR EFFECTS**

Date of Lecture:

Topic of Lecture: Effect on hardened concrete properties

Introduction :

- Metakaolin is the anhydrous calcined form of the clay mineral kaolinite. Minerals that are rich in kaolinite are known as china clay or kaolin, traditionally used in the manufacture of porcelain. The particle size of metakaolin is smaller than cement particles, but not as fine as silica fume.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Concrete properties

Effect on hardened concrete properties

- Strength gain of fly ash concrete is slower than normal concrete, as stated in the previous sections. The potential for thermal cracking is much reduced compared to ordinary PC concrete. Ultimate strengths are usually improved when fly ash is used.
- Pozzolanic activity is proportional to the amount of particles under 10 μm in diameter.
- Creep and shrinkage of fly ash concrete are typically higher than normal concrete, because of the increased amount of paste in the concrete (when mass replacement is done).
- More air-entraining admixture is needed to entrain air in fly-ash concrete.
- The results on the effects of fly ash on sulphate resistance are inconclusive.
- Expansions during alkali aggregate reaction are reduced by the use of fly ash, because of the dilution of Portland cement (implying there are lesser alkalis available).
- For properly cured fly ash concrete, the rate of chloride diffusion is reduced compared to ordinary PC concrete.
- Pore size refinement and reduction in permeability occurs when silica fume is used. Due to a combined effect of silica fume as a highly reactive pozzolan and filler, the transition

zone between aggregate and paste is strengthened.

- Compressive and flexural strengths are increased, while the chloride permeability and diffusion are reduced significantly compared to ordinary PC concrete.
- Elastic modulus is increased ($E_{SFC} \sim 1.15\ E_{PCC}$), or, in other words, concrete becomes stiffer with the use of silica fume.
- Creep and shrinkage are increased at high replacement levels (10 – 15%) because of an increase in the volume of the paste. However, due to the higher stiffness, the resistance to creep and shrinkage deformation is higher.
- Expansions due to ASR are reduced in silica fume concrete.
- Corrosion rate is reduced with the use of silica fume. This is because of two reasons: the low permeability of SFC causes a lower availability of moisture and oxygen at the cathodic sites, and the high resistivity of SFC makes the flow of electrons difficult.
- Carbonation depth is generally lowered.
- SFC has very good abrasion and erosion resistance. This makes it an ideal choice for industrial flooring.
- The ultimate strengths with slag are generally improved; the durability is also improved with the replacement of cement by slag.
- Slag is the ideal admixture for marine concrete, as slag concrete shows excellent resistance to chemical attack and corrosion
- Slag concrete is reported to have higher carbonation rates compared to ordinary PC concrete
- Compressive strength tests are conducted by certified technicians using an instrumented, hydraulic ram which has been annually calibrated with instruments traceable to the Cement and Concrete Reference Laboratory (CCRL) of the National Institute of Standards and Technology (NIST) in the U.S., or regional equivalents internationally. Standardized form factors are 6" by 12" or 4" by 8" cylindrical samples, with some laboratories opting to utilize cubic samples

Details of website for further learning :
http://www.alphace.ac.in/downloads/notes/cv/10cv81.pdf

Important Books/Journals for further learning including the page nos.:
Shetty, M.S, "Concrete Technology, Theory and Practice", S. Chand and Company Ltd, New Delhi, 2008 Pg.no: 148 to 158

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LECTURE HANDOUTS

CIVIL

III/V

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **III- PROPORTIONING OF CONCRETE MIX**

Date of Lecture:

Topic of Lecture: Principles Of Mix Proportiong

Introduction :

- Mixture proportioning refers to selection of the proper amount of ingredients to make a batch of concrete. Selecting concrete proportions involves a balance between economy and requirements for placeability, strength, durability, density, and appearance.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Concrete properties

Principles of concrete mix design:

- There have been many methods developed from the simple volumetric batching to prescribed rules to the highly complicated using computer simulations.
- In all cases, some or all of the following parameters need to be specified from the outset to enable a concrete to be designed for a particular purpose; maximum water-cement (w/c) ratio, minimum cement content, air content, slump, maximum size of aggregate, and strength requirement.
- Estimating the required batch weights for the concrete involves a sequence of logical straightforward steps whether based on a series of trial mixes, computer simulations, sound rule of thumb advice or a combination of all three.
- An essential part of mix design is to minimise voids in order to produce a closed structure. It is assumed that any voids (micro- not entrapped air) within the concrete will be filled with water.
- The pore structure resulting determines the concrete’s resilience to carbonation, chloride ingress etc. Inadequate fines will lead to harsh concrete that has a tendency to entrap air. In comparison, high levels of fines can lead to cohesive mixes which can entrap air.

- The volume of fines needed for a closed structure increases with the size of the coarse aggregate. Fines are derived from the cements and additions, the smaller sand fraction and crushed rocks etc.

Various Methods of Proportioning

- Arbitrary proportion
- Indian Road Congress,
- IRC 44 method
- High strength concrete mix design
- Mix design based on flexural strength
- Road note No. 4 (Grading Curve method)
- ACI Committee 211 method
- DOE method
- Mix design for pumpable concrete
- Indian standard Recommended method IS 10262-82

Factors to be considered for mix design

- The grade designation giving the characteristic strength requirement of concrete.
- The type of cement influences the rate of development of compressive strength of concrete.
- Maximum nominal size of aggregates to be used in concrete may be as large as possible within
- the limits prescribed by IS 456:2000.
- The cement content is to be limited from shrinkage, cracking and creep.
- The workability of concrete for satisfactory placing and compaction is related to the size and shape of section, quantity and spacing of reinforcement and technique used for transportation, placing and compaction.
- Requirements of concrete mix design should be known before calculations for concrete mix. Mix design is done in the laboratory and samples from each mix designed is tested for confirmation of result.
- But before the mix design process is started, the information about available materials, strength of concrete required, workability, site conditions etc. are required to be known.

Details of website for further learning :
http://www.alphace.ac.in/downloads/notes/cv/10cv81.pdf

Important Books/Journals for further learning including the page nos.:
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LECTURE HANDOUTS

CIVIL **III/V**

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **III- PROPORTIONING OF CONCRETE MIX**

Date of Lecture:

Topic of Lecture: Properties of Concrete Related to Mix Design

Introduction :

- Mixture proportioning refers to selection of the proper amount of ingredients to make a batch of concrete. Selecting concrete proportions involves a balance between economy and requirements for placeability, strength, durability, density, and appearance.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Concrete Related to Mix Design

PROPERTIES OF CONCRETE

Inspectors should familiarize themselves with the most important properties of concrete: •

- **Workability**
- **Durability**
- **Strength**
- **Volume change**
- **Air Entrainment**
- **Density**

Workability

- Workability is one of the most important of these properties. The degree of workability necessary in a concrete mix depends entirely upon the purpose for which it is used and the methods and equipment used in handling and placing it in the work.
- Inspectors must use their best judgement in determining the workability of the concrete and must make any adjustments to the mix that is necessary to improve the workability in accordance with instructions in this Manual and the Specifications

Durability

- The ultimate durability is the most important property of concrete. To ensure a high degree of durability, it is essential that clean, sound materials and the lowest possible water content are used in the concrete, together with thorough mixing.
- Good consolidation during placement of the concrete is important, as are proper curing and protection of the concrete during the early hardening period, which assure favorable conditions of temperature and moisture.
- Cure concrete properly for a minimum of three days in order to develop good durability.

Strength

- The strength of concrete is the next important property to consider. With a fixed amount of cement in a unit volume of concrete, the strongest and most impermeable concrete is one that has the greatest density, i.e., which in a given unit volume has the largest percentage of solid materials.
- The use of the absolute minimum quantity of water required for proper placement ensures the greatest strength from the concrete.

Air Entrainment

- All concrete contains some entrapped air bubbles. Large entrapped air bubbles are undesirable. Air-entrained concrete has air, in a finely divided and dispersed form, purposely induced at the time of mixing.
- The air is produced in the concrete by the addition of an approved air-entraining admixture. The entrained air in the concrete, in the form of a large number of very small air bubbles in the mortar portion of the mix, is the result of the foaming action of the admixture.

Density

- The value of high density was addressed indirectly in connection with other related properties in concrete.
- The factors that contribute to high density for all types of concrete are:
  - ✓ Use of well-graded aggregate of the largest possible maximum size. • Minimum water content consistent with good workability.
  - ✓ Minimum air content consistent with adequate durability.
  - ✓ Thorough consolidation during placement.

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LECTURE HANDOUTS

CIVIL

III/V

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **III- PROPORTIONING OF CONCRETE MIX**

Date of Lecture:

Topic of Lecture: Physical Properties of Materials Required for Mix Design

Introduction :

- Mixture proportioning refers to selection of the proper amount of ingredients to make a batch of concrete. Selecting concrete proportions involves a balance between economy and requirements for placeability, strength, durability, density, and appearance.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Concrete Related to Mix Design

PROPERTIES OF CONCRETE

Requirements of concrete mix design should be known before calculations for concrete mix. Mix design is done in the laboratory and samples from each mix designed is tested for confirmation of result. But before the mix design process is started, the information about available materials, strength of concrete required, workability, site conditions etc. are required to be known.

Following are the information Required for concrete mix design:

1. **Characteristic strength of concrete required:** Characteristic strength is the strength of concrete below which not more than 5% of test results of samples are expected to fall. This can also be called as the grade of concrete required for mix design. For example, for M30 grade concrete, the required concrete compressive strength is 30 N/mm^2 and characteristic strength is also the same.
2. **Workability requirement of concrete:** The workability of concrete is commonly measured by slump test. The slump value or workability requirement of concrete is based on the type of concrete construction.
3. **Quality control at site:** The strength and durability of concrete depends on the degree of quality control during construction operation at site. Nominal mixes of concrete assumes the worst quality control at site based on past experiences. Thus, for design mix concrete, it is essential to

understand the quality control capability of contractor and workmen at construction site in mixing, transporting, placing, compacting and curing of concrete. Each step in concrete construction process affects the strength and durability of concrete.

4. **Weather conditions:** Weather impacts the setting time of concrete. In hot climate, the concrete tends to set early due to loss in moisture, and in this case, the concrete need to have higher water cement ratio or special admixtures to delay initial setting of concrete. Recommendations for concrete cooling agents also required to be mentioned in the mix design for very hot weather conditions. In cold climates, the initial setting time of concrete increases as the moisture loss rate is very low. Due to this, water cement ratio is considered appropriately. Admixtures should also be recommended to prevent freezing of concrete in case of very cold climate.
5. **Exposure conditions of concrete:** Exposure conditions play an important role in the mix design of concrete. The exposure conditions such as chemical actions, coastal areas etc. needs to be considered for the given site. Generally exposure conditions as per code of practices are mild, moderate, severe, very severe and extreme exposure conditions for concrete constructions. The grade of concrete and durability requirements of concrete changes with exposure conditions. For extreme exposure conditions some standard codes mention minimum strength of concrete as M35.
6. **Batching and mixing methods:** There are two types of batching method, i.e. volumetric batching and batching by weight. These two conditions should be known for concrete mix design calculations. Mixing methods include manual mixing, machine mixing, ready mix concrete etc. The quality control of concrete varies with each type of mixing method.
7. **Quality of materials:** Each construction material should have been tested in laboratory before it is considered for mix design calculations. The type of material, their moisture content, suitability for construction, and their chemical and physical properties affects the mix design of concrete. Type of cement to be used for construction, coarse and fine aggregates sources, their size and shape should be considered.
8. **Special Requirements of concrete:** Special requirement of concrete such as setting times, early strength, flexural strength,

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LECTURE HANDOUTS

CIVIL

III/V

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **III- PROPORTIONING OF CONCRETE MIX**

Date of Lecture:

Topic of Lecture: Design Mix And Nominal Mix

Introduction :

- Mixture proportioning refers to selection of the proper amount of ingredients to make a batch of concrete. Selecting concrete proportions involves a balance between economy and requirements for placeability, strength, durability, density, and appearance.

Prerequisite knowledge for Complete understanding and learning of Topic:

- **Nominal Mix and Design Mix of Concrete:**

Nominal Mix and Design Mix of Concrete:

Concrete is a commonly used construction material, which is the mixture of cement, sand, aggregate, and admixtures blended with water. Concrete gets hardened with time and gains the strength, and for the best results in a construction of your dream home, mixing of concrete is said to be the most important process.

Normally two methods are used for proportioning different ingredients, i.e. nominal mix and design mix of concrete. Selection of types of concrete mix depends on the requirement of strength and nature of work.

Nominal Mix:

- In the nominal mix concrete, all the ingredients and their proportions are prescribed in the standard specifications. These proportions are specified in the ratio of cement to aggregates for certain strength achievement.
- The mix proportions like 1:1.5:3, 1:2:4, 1:3:6 etc. are adopted in nominal mix of concrete without any scientific base, only on the basis on past empirical studies. Thus, it is adopted for ordinary concrete or you can say, the nominal mix is preferred for simpler, relatively unimportant and small concrete works.

Proportions for Nominal Mix Concrete as per Indian Standard (IS 456: 2000)				
Grade of concrete	Total quantity of dry aggregate by mass per 50 kg of cement to be taken as the sum of the individual masses of fine and coarse aggregates	Proportion of fine aggregate to coarse aggregate (by mass)	Maximum quantity of water per 50 kg of cement	Proportion
M5	800	Generally, 1:2 but subject to an upper limit 1:1½ and a lower limit of 1: 2½	60	1:5:10
M7.5	625		45	1:4:8
M10	480		34	1:3:6
M15	330		32	1:2:4
M20	250		30	1:1.5:3

Advantages of Nominal Mix Concrete:

- The nominal mix is the prescriptive type concrete because a proportion is pre-decided.
- It is easy to make at the construction site.
- It doesn't take much time to decide the proportion because proportions are already given by standard code.
- No need to get skilled persons for making the nominal mix concrete.

Disadvantages of Nominal Mix Concrete:

- The major drawback of nominal mix is, it's based on the experience and past empirical studies, and it lacks a proven scientific approach.
- It may or may not create exactly designed strength unless all the other factors like compaction, w/c ratio, curing of concrete are strictly followed.
- The water-cement ratio is considered by assumption so, if we don't take care of it, sometimes it leads to bleeding and segregation of concrete resulting in poor strength and accordingly it hampers the durability of concrete.
- There is no consideration for properties of aggregates such as grading and density of aggregate etc.

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MUTHAYAMMAL ENGINEERING COLLEGE

(An Autonomous Institution)

(Approved by AICTE, New Delhi, Accredited by NAAC & Affiliated to Anna University)
Rasipuram - 637 408, Namakkal Dist., Tamil Nadu

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LECTURE HANDOUTS

CIVIL **III/V**

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **III- PROPORTIONING OF CONCRETE MIX**

Date of Lecture:

Topic of Lecture: Design Mix And Nominal Mix

Introduction :

- Mixture proportioning refers to selection of the proper amount of ingredients to make a batch of concrete. Selecting concrete proportions involves a balance between economy and requirements for placeability, strength, durability, density, and appearance.

Prerequisite knowledge for Complete understanding and learning of Topic:

- **Nominal Mix and Design Mix of Concrete:**

Nominal Mix and Design Mix of Concrete:

Concrete is a commonly used construction material, which is the mixture of cement, sand, aggregate, and admixtures blended with water. Concrete gets hardened with time and gains the strength, and for the best results in a construction of your dream home, mixing of concrete is said to be the most important process.

Normally two methods are used for proportioning different ingredients, i.e. nominal mix and design mix of concrete. Selection of types of concrete mix depends on the requirement of strength and nature of work.

Design Mix

In design mix concrete, proportions of the ingredients are properly determined with their relative ratio to achieve the concrete of desired strength.

Not only the desired strength but also according to the properties of fresh concrete like workability or performance of concrete with the certain specifications are taken in detail consideration.

All the materials are tested before the use and the entire process is found based on trial and error of various options from available materials designated for the work.

There are various standard guidelines available for making a design mix concrete such as,

- **IS Method –** Concrete mix proportioning guidelines (Bureau of Indian Standards – I.S. 10262-2009) and Recommended Guidelines for Concrete Mix Design- I.S. 10262- 1982,
- **BS Method –** (British Standard – BS EN 206- 1 and its complementary standards BS 8500 parts 1& 2)
- **ACI Method –** (American Standard – ACI 211, 211- 91, reapproved- 2002).

Requirement of Materials Properties for Mix Design

- In the design mix method, you have to check every property of the blended materials and after that, you can start design construction. Followings are the properties of ingredients which you have to check,

1. Cement:

- Grade of the Cement,
- Consistency of the Cement
- Initial Setting Time and Final Setting Time of the Cement
- Specific Gravity of the Cement

2. Aggregate:

- Density of the Aggregates
- Bulking of the Fine Aggregate
- The Specific Gravity of the Fine Aggregate and the Coarse Aggregate
- Grading of the Aggregate
- Fineness Modulus
- Particle Size
- Silt Content
- Specific Gravity and Water Absorption
- Unit Weight etc.

Advantages of Mix Design Concrete:

- Design mix is more scientific than the nominal mix.
- Mix design is widely used for more extensive and important concrete works.
- Mix design is based on the actual available material to be used in construction work.
- If the locally available material can satisfy the standard criteria, it can be used for making mix design concrete so that the mix can reduce the cost of importing material from outside.
- The quantity of the ingredient to be used are rational, i.e. it’s neither overused nor underused.
- It is based on the laboratory trial/error experiment method.
- It gives an assurance of strength.
- Mix design concrete is performance-based concrete.

Disadvantages of Mix Design Concrete:

- Mix Design is more time consuming.
- If the type or quality of desired ingredient gets changed during the progress of work, all the proportion will get changed of mix design concrete. Strict supervision is required as it is important or we may end up making a fresh design which may delay the entire project.
- It is always better to have mix design with 2/3 possible brands of cement and also to have aggregate from different sources.
- Need the involvement of the skilled persons to prepare the mix design.

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Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **III- PROPORTIONING OF CONCRETE MIX**

Date of Lecture:

Topic of Lecture: BIS Method of Mix Design

Introduction :

- Mixture proportioning refers to selection of the proper amount of ingredients to make a batch of concrete. Selecting concrete proportions involves a balance between economy and requirements for placeability, strength, durability, density, and appearance.

Prerequisite knowledge for Complete understanding and learning of Topic:

- BIS Method of Mix Design

Procedure for Concrete Mix Design – IS456:2000

- **Step1**. Determine the mean target strength ft from the specified characteristic compressive strength at 28-day fck and the level of quality control.

$$ft = fck + 1.65\ S$$

  Where, S is the standard deviation obtained from the Table of approximate contents given after the design mix.
- **Step 2.**Obtain the water cement ratio for the desired mean target using the empirical relationship between compressive strength and water cement ratio so chosen is checked against the limiting water cement ratio. The water cement ratio so chosen is checked against the limiting water cement ratio for the requirements of durability given in table and adopts the lower of the two values.
- **Step 3.**Estimate the amount of entrapped air for maximum nominal size of the aggregate from the table.
- **Step 4**. Select the water content, for the required workability and maximum size of aggregates (for aggregates in saturated surface dry condition) from table.
- **Step 5.** Determine the percentage of fine aggregate in total aggregate by absolute volume from

table for the concrete using crushed coarse aggregate.

- **Step 6**.Adjust the values of water content and percentage of sand as provided in the table for any difference in workability, water cement ratio, grading of fine aggregate and for rounded aggregate the values are given in table.
- **Step 7**.Calculate the cement content form the water-cement ratio and the final water content as arrived after adjustment. Check the cement against the minimum cement content from the requirements of the durability, and greater of the two values is adopted.
- **Step 8.**From the quantities of water and cement per unit volume of concrete and the percentage of sand already determined in steps 6 and 7 above, calculate the content of coarse and fine aggregates per unit volume of concrete from the following relations:

  Where,

  V = absolute volume of concrete = gross volume (1m3) minus the volume of entrapped air

  Sc = specific gravity of cement

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

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

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

  Ca = total masses of fine and coarse aggregates, per cubic metre of concrete,respectively, kg, and Sfa, Sca = specific gravities of saturated surface dry fine and coarse aggregates, respectively
- **Step 9.** Determine the concrete mix proportions for the first trial mix.
- **Step 10**. Prepare the concrete using the calculated proportions and cast three cubes of 150 mm size and test them wet after 28-days moist curing and check for the strength.
- **Step 11**. Prepare trial mixes with suitable adjustments till the final mix proportions are arrived at.

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Course Teacher

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Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **III- PROPORTIONING OF CONCRETE MIX**

Date of Lecture:

Topic of Lecture: Mix Design Examples

Introduction :

- Mixture proportioning refers to selection of the proper amount of ingredients to make a batch of concrete. Selecting concrete proportions involves a balance between economy and requirements for placeability, strength, durability, density, and appearance.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Mix Design Examples

MIX DESIGN EXAMPLES:

Example 1

Design a concrete mix to obtain a characteristic compressive strength (fc) = 30 N/mm^2 at 28days, with a 2.5% defective rate (k = 1.96), assume that less than 20 previous results are available for calculating the standard deviation. The design requirements are as follows:

- Slump required = 10–30 mm.
- the Maximum aggregate size, MSA = 20 mm (uncrushed),
- Fine aggregate: Fineness modulus, FM =2.5.
- Portland cement class = 42.5.
- maximum free-w/c ratio = 0.55,
- minimum cement content = 290 kg/m^3,
- maximum cement content = not specified.

Absorption of fine aggregate = 2%; Absorption of coarse aggregate = 1.1%
Total Moisture content of coarse aggregate = 2.5%; Total Moisture content of fine aggregate = 1.5%.What are the proportions to produce trial mix of 0.05 m^3 concrete?What are the proportions to produce 25 m^3 concrete?

Step 1: Find Target Mean Strength

Find the **target mean strength**.

Target mean strength = f_m

Specified characteristic strength = f_c, Margin = $k.s$

From Figure A. the standard deviation is 8 MPa

$$f_m = f_c + k.s$$

$$f_m = 30 + 1.96 \times 8 = 45.7\ MPa$$

Step 2: Calculation of Water/Cement Ratio

From Table 1 the compressive strength for w/c =0.50 is 42MPa. From Figure 1 the w/c for compressive strength of 45.7 MPA is **0.47**.

Step 03: Calculation of free Water Content

From Table 2, for 10-30mm level of workability, uncrushed aggregates and maximum aggregate size of 20mm the water content is **160kg/m^3** concrete.

Step 04: Calculation of cement Content

$$w/_c = \frac{w}{c}\ ,\ cement\ content, c = \frac{160}{0.47} = 340\frac{kg}{m^3}concrete$$

Step 05: Weight of Total Aggregate

From Figure 2 for free water content of **160 kg/m^3**, Specific gravity of Uncrushed aggregates
=2.6 (assumed), the wet density of concrete = **2400 kg/m^3**. Therefore, the total aggregatecontent is

Total aggregate content = Wet density of 1m^3 concrete – water content – cement content

= 2400 – 160 – 340 = **1900 kg/m^3**

Step 06: Weight of Fine Aggregate

From Figure 3. The workability level =10-30mm, FM=2.5, w/c=0.47, MSA=20mm the percentage of fine aggregates = 32%.

Fine aggregate content = 1900×0.32 = **608 kg/m^3 concrete**

Coarse aggregate content = 1900 – 608 = **1292 kg/m^3 concrete**

Step 07. Adjustments for Aggregate Weights and Water Content.

Adjusted Fine Aggregate weight.

Total moisture of fine aggregates = 1.5%, and absorption = 2%,So, the aggregates are in **Air dry condition**,

0.5% = W_w/W_{SSD} , W_w = weight of water to reach SSD = 0.5% * 608 = 3.04 kg.

Adjusted weight of fine aggregates = 608 – 3.04 = **605 kg**

The mixing water should be increased by an amount of 3.04 kg

Adjusted Coarse Aggregates weight

Total moisture content of coarse aggregate = 2.5 %, and absorption of coarse aggregate = 1.1%,so the coarse aggregates are in **Wet condition** and there is moisture on the aggregates surface.

Surface water, SM = (2.5% – 1.1%) = 1.4% = W_w / W_{SSD} = W_w / 1292,SM = 1.4% * 1292/100 = 18.1 kg

Adjusted coarse aggregates, CA = 1292 + 18.1 = 1310.1 kg.

Also, amount of water from CA to be added to the mixing water = 18.1 kg

Adjusted Mixing Water

Adjusted mixing water = 160 + 3.04 – 18.1 = 145 kg.

8.Final Results

Final Results

	Cement (kg)	Water (kg or litre)	Fine aggregate (kg)	Coarse Aggregates (kg)	
				10 mm	20 mm
Per $1m^3$ (to nearest 5kg)	340	160	605	1310.1	
				436.7	873.4
	1	0.47	1.78	3.85	
				1.28	2.57
Per 0.05 m^3	17	8	30.3	21.8	43.7
Per 25 m^3	8500	4000	15125	10918	21835

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Course Teacher

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Course Name with Code : 19CEE08 & CONCRETE TECHNOLOGY

Course Teacher : M.GOPINATH

Unit : III- PROPORTIONING OF CONCRETE MIX

Date of Lecture:

Topic of Lecture: Mix Design Examples

Introduction :

- Mixture proportioning refers to selection of the proper amount of ingredients to make a batch of concrete. Selecting concrete proportions involves a balance between economy and requirements for placeability, strength, durability, density, and appearance.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Mix Design Examples

MIX DESIGN EXAMPLES:

M-25 CONCRETE MIX DESIGN		
As per IS 10262-2009		
A-1	**Stipulations for Proportioning**	
1	**Grade Designation**	**M25**
2	Type of Cement	OPC 53 grade confirming to IS-12269-1987
3	Maximum Nominal Aggregate Size	20 mm
4	Minimum Cement Content (MORT&H1700-3 A)	310 kg/m^3
5	Maximum Water Cement Ratio (MORT&H 1700-3 A)	0.45
6	Workability (MORT&H 1700-4)	50-75 mm (Slump)
7	Exposure Condition	Normal

8	Degree of Supervision	Good
9	Type of Aggregate	Crushed Angular Aggregate
10	Maximum Cement Content (MORT&HCl. 1703.2)	540 kg/m^3
11	Chemical Admixture Type	Superplasticiser Confirming to IS-9103
A-2	**Test Data for Materials**	
1	Cement Used	Coromandal King OPC 53 grade
2	Sp. Gravity of Cement	3.15
3	Sp. Gravity of Water	1.00
4	Chemical Admixture	BASF Chemicals Company
5	Sp. Gravity of 20 mm Aggregate	2.884
6	Sp. Gravity of 10 mm Aggregate	2.878
7	Sp. Gravity of Sand	2.605
8	Water Absorption of 20 mm Aggregate	0.97%
9	Water Absorption of 10 mm Aggregate	0.83%
10	Water Absorption of Sand	1.23%
11	Free (Surface) Moisture of 20 mm Aggregate	nil
12	Free (Surface) Moisture of 10 mm Aggregate	nil
13	Free (Surface) Moisture of Sand	nil
14	Sieve Analysis of Individual Coarse Aggregates	Separate Analysis Done
15	Sieve Analysis of Combined Coarse Aggregates	Separate Analysis Done
15	Sp. Gravity of Combined Coarse Aggregates	2.882
16	Sieve Analysis of Fine Aggregates	Separate Analysis Done
A-3	**Target Strength for Mix Proportioning**	
1	Target Mean Strength (MORT&H 1700-5)	36N/mm^2

2	Characteristic Strength @ 28 days	25N/mm^2
A-4	**Selection of Water Cement Ratio**	
1	Maximum Water Cement Ratio (MORT&H 1700-3 A)	0.45
2	Adopted Water Cement Ratio	0.43
A-5	**Selection of Water Content**	
1	Maximum Water content (10262-table-2)	186 Lit.
2	Estimated Water content for 50-75 mm Slump	138 Lit.
3	Superplasticiser used	0.5 % by wt. of cement
A-6	**Calculation of Cement Content**	
1	Water Cement Ratio	0.43
2	Cement Content (138/0.43)	320 kg/m^3
		Which is greater then 310 kg/m^3
A-7	**Proportion of Volume of Coarse Aggregate & Fine Aggregate Content**	
1	Vol. of C.A. as per table 3 of IS 10262	62.00%
2	Adopted Vol. of Coarse Aggregate	62.00%
	Adopted Vol. of Fine Aggregate (1-0.62)	38.00%
A-8	**Mix Calculations**	
1	Volume of Concrete in m^3	1.00
2	Volume of Cement in m^3	0.10
	(Mass of Cement) / (Sp. Gravity of Cement)x1000	
3	Volume of Water in m^3	0.138
	(Mass of Water) / (Sp. Gravity of Water)x1000	
4	Volume of Admixture @ 0.5% in m^3	0.00134
	(Mass of Admixture)/(Sp. Gravity of Admixture)x1000	

5	Volume of All in Aggregate in m^3	0.759
	Sr. no. 1 – (Sr. no. 2+3+4)	
6	Volume of Coarse Aggregate in m^3	0.471
	Sr. no. 5 x 0.62	
7	Volume of Fine Aggregate in m^3	0.288
	Sr. no. 5 x 0.38	
A-9	**Mix Proportions for One Cum of Concrete (SSD Condition)**	
1	Mass of Cement in kg/m^3	**320**
2	Mass of Water in kg/m^3	**138**
3	Mass of Fine Aggregate in kg/m^3	**751**
4	Mass of Coarse Aggregate in kg/m^3	1356
	Mass of 20 mm in kg/m^3	**977**
	Mass of 10 mm in kg/m^3	**380**
5	Mass of Admixture in kg/m^3	**1.60**
6	Water Cement Ratio	0.43

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Important Books/Journals for further learning including the page nos.:
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Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **III- PROPORTIONING OF CONCRETE MIX**

Date of Lecture:

Topic of Lecture: Mix Design Examples (Procedures)

Introduction :

- Mixture proportioning refers to selection of the proper amount of ingredients to make a batch of concrete. Selecting concrete proportions involves a balance between economy and requirements for placeability, strength, durability, density, and appearance.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Mix Design Examples

MIX DESIGN EXAMPLES:

(Procedures)

ACI Mix Design Method

The ACI Standard 211.1 is a "*Recommended Practice for Selecting Proportions for Concrete*".The procedure is as follows:

Step 1. Choice of slump
Step 2. Choice of maximum size of aggregate
Step 3. Estimation of mixing water and air content
Step 4. Selection of water/cement ratio
Step 5. Calculation of cement content
Step 6. Estimation of coarse aggregate content
Step 7. Estimation of Fine Aggregate Content
Step 8. Adjustments for Aggregate Moisture
Step 9. Trial Batch Adjustments

Step 1. Choice of slump

If slump is not specified, a value appropriate for the work can be selected from the

Tablebelow, or from any other references.

Type of Construction	Slump	
	(mm)	(inches)
Reinforced foundation walls and footings	25 - 75	1 - 3
Plain footings, caissons and substructure walls	25 - 75	1 - 3
Beams and reinforced walls	25 - 100	1 - 4
Building columns	25 - 100	1 - 4
Pavements and slabs	25 - 75	1 - 3
Mass concrete	25 - 50	1 - 2

Step 2. Choice of maximum size of aggregate.

Concretes with the larger-sized aggregates require less mortar per unit volume of concrete, and of coarse it is the mortar which contains the most expensive ingredient, cement. Thus the ACI method is based on the principle that the **maximum size of aggregate should be the largest available so long it is consistent with the dimensions of the structure.**

Step 3. Estimation of mixing water and air content.

The ACI Method uses past experience to give a first estimate for the quantity of water per unit volume of concrete required to produce a given slump. The approximate amount of water required for average aggregates is given in Table 1.

Table 1. Approximate Mixing Water and Air Content Requirements for Different Slumps and Maximum Aggregate Sizes.

	Mixing Water Quantity in kg/m³ (lb/yd³) for the listed Nominal Maximum Aggregate Size							
Slump	9.5 mm(0.375 in.)	12.5 mm (0.5 in.)	19 mm(0.75 in.)	25 mm(1 in.)	37.5 mm (1.5 in.)	50 mm(2 in.)	75 mm(3 in.)	100 mm(4 in.)
Non-Air-Entrained								
25 - 50 (1 - 2)	207 (350)	199 (335)	190 (315)	179 (300)	166 (275)	154 (260)	130 (220)	113 (190)
75 - 100 (3 - 4)	228 (385)	216 (365)	205 (340)	193 (325)	181 (300)	169 (285)	145 (245)	124 (210)
150 - 175 (6 - 7)	243 (410)	228 (385)	216 (360)	202 (340)	190 (315)	178 (300)	160 (270)	-

Typical entrappedair (percent)	3	2.5	2	1.5	1	0.5	0.3	0.2
Air-Entrained								
25 - 50 (1 - 2)	**181 (305)**	**175 (295)**	**168 (280)**	**160 (270)**	**148 (250)**	**142 (240)**	**122 (205)**	**107 (180)**
75 - 100 (3 - 4)	**202 (340)**	**193 (325)**	**184 (305)**	**175 (295)**	**165 (275)**	**157 (265)**	**133 (225)**	**119 (200)**
150 - 175 (6 - 7)	**216 (365)**	**205 (345)**	**197 (325)**	**184 (310)**	**174 (290)**	**166 (280)**	**154 (260)**	**-**
Recommended Air Content (percent)								
Mild Exposure	**4.5**	**4.0**	**3.5**	**3.0**	**2.5**	**2.0**	**1.5**	**1.0**
Moderate Exposure	**6.0**	**5.5**	**5.0**	**4.5**	**4.5**	**4.0**	**3.5**	**3.0**
Severe Exposure	**7.5**	**7.0**	**6.0**	**6.0**	**5.5**	**5.0**	**4.5**	**4.0**

Step 4. Selection of water/cement ratio.

The required water/cement ratio is determined by strength, durability and finishability. The appropriate value is chosen from prior testing of a given system of cement and aggregate or avalue is chosen from Table 2 and/or Table 3.

Table 2: Water-Cement Ratio and Compressive Strength Relationship

28-Day Compressive Strength in MPa (psi)	Water-cement ratio by weight	
	Non-Air-Entrained	Air-Entrained
41.4 (6000)	0.41	-
34.5 (5000)	0.48	0.40
27.6 (4000)	0.57	0.48
20.7 (3000)	0.68	0.59
13.8 (2000)	0.82	0.74

Step 5. Calculation of cement content.

$$weight\ of\ cement = \frac{weight\ of\ water}{w/c}$$

The amount of cement is fixed by the determinations made in Steps 3 and 4 above.

Step 6. Estimation of coarse aggregate content.

The most economical concrete will have as much as possible space occupied by CA since itwill require no cement in the space filled by CA.

Step 7. Estimation of Fine Aggregate Content.

At the completion of Step 6, all ingredients of the concrete have been estimated except the fine aggregate. Its quantity can be determined by difference if the "absolute volume" displaced by the known ingredients-, (i.e., water, air, cement, and coarse aggregate), is subtracted from the unit volume of concrete to obtain the required volume of fine aggregate. Then, once the volumes are known the weights of each ingredient can be calculated from the specific gravities.

Step 8. Adjustments for Aggregate Moisture.

As explained previously

Step 9. Trial Batch Adjustments.

The ACI method is written on the basis that a trial batch of concrete will be prepared in the laboratory, and adjusted to give the desired slump, freedom from segregation, finishability, unit weight, air content and strength

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LECTURE HANDOUTS

CIVIL | **III/V**

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **III- FRESH AND HARDENED PROPERTIES OF CONCRETE**

Date of Lecture:

Topic of Lecture: Workability, Tests For Workability of Concrete

Introduction :

- Concrete is referred to as fresh when the setting and hardening process has not yet started. Fresh concrete can be deformed and poured which means it can be transported or pumped and used to fill moulds and formwork.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Workability, Tests For Workability of Concrete

FRESH CONCRETE

Fresh concrete is that stage of concrete in which concrete can be moulded in its plastic state. This is also called Green Concrete. Another term used to describe the state of fresh concrete is consistence, which is the ease with which concrete will flow. **It is the concrete phase from time of mixing to end of time concrete surface finished in its final location in the structure**

For fresh concrete to be acceptable, it should:

1. Be easily mixed and transported.
2. Be uniform throughout a given batch and between batches.
3. Be of a consistency so that it can fill completely the forms for which it was designed.
4. Have the ability to be compacted without excessive loss of energy.
5. Not segregate during placing and consolidation.
6. Have good finishing characteristics.

PROPERTIES OF FRESH CONCRETE

1. **Workability of Concrete – Consistency and Cohesiveness**

   i. Consistency (Easy flow of concrete) - Slump test, Compacting factor test, Vebe test and Flow table test

ii. Cohesiveness - Segregation and Bleeding

2. **Setting**
3. **Air entrainment**

Workability of Concrete –

The capability of being handled and flows into formwork or around any reinforcement, with assistance of compacting equipment. The higher workability concretes are easier to place and handle but obtaining higher workability by increasing water content decreases strength and durability. Workability is often referred to as the ease with which a concrete can be transported, placed and consolidated without excessive bleeding or segregation.

It is obvious that no single test can evaluate all these factors. In fact, most of these cannot be easily assessed even though some standard tests have been established to evaluate them under specific conditions.

Consistence is sometimes taken to mean the degree of wetness; within limits, wet concretes are more workable than dry concrete, but concrete of same consistence may vary in workability. Because the strength of concrete is adversely and significantly affected by the presence of voids in the compacted mass, it is vital to achieve a maximum possible density. This requires sufficient workability for virtually full compaction to be possible using a reasonable amount of work under the given conditions. Presence of voids in concrete reduces the density and greatly reduces the strength: 5% of voids can lower the strength by as much as 30%.

To determine the consistency in workability four tests are followed;

- Slump test
- Compacting factor test
- Vee Bee test and
- Flow table test

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LECTURE HANDOUTS

CIVIL **III/V**

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **III- FRESH AND HARDENED PROPERTIES OF CONCRETE**

Date of Lecture:

Topic of Lecture: Slump Test and Compaction Factor Test

Introduction :

- Concrete is referred to as fresh when the setting and hardening process has not yet started. Fresh concrete can be deformed and poured which means it can be transported or pumped and used to fill moulds and formwork.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Slump Test and Compaction Factor Test

Slump Test

This test is performed to check the consistency of freshly made concrete. The slump testis done to make sure a concrete mix is workable. The measured slump must be within a set range, or tolerance, from the target slump.

Workability of concrete is mainly affected by consistency i.e. wetter mixes will be more workable than drier mixes, but concrete of the same consistency may vary in workability. It can also be defined as the relative plasticity of freshly mixed concrete as indicative of its workability.

Tools and apparatus used for slump test (equipment):

1. Standard slump cone (100 mm top diameter x 200 mm bottom diameter x 300 mmhigh)
2. Small scoop
    1. Bullet-nosed rod (600 mm long x 16 mm diameter)
3. Rule
    1. Slump plate (500 mm x 500 mm)

Procedure of slump test for concrete:

1. Clean the cone. Dampen with water and place on the slump plate. The slump plate shouldbe clean, firm, level and non-absorbent. Collect a sample of concrete to perform the slum test.
2. Stand firmly on the foot pieces and fill 1/3 the volume of the cone with the sample. Compact the concrete by 'rodding' 25 times. Rodding means to push a steel rod in and out of the concrete to compact it into the cylinder, or slump cone. Always rod in a definite pattern, working from outside into the middle.
3. Now fill to 2/3 and again rod 25 times, just into the top of the first layer.
4. Fill to overflowing, rodding again this time just into the top of the second layer. Top up the cone till it overflows.
5. Level off the surface with the steel rod using a rolling action. Clean any concrete from around the base and top of the cone, push down on the handles and step off the foot pieces.
6. Carefully lift the cone straight up making sure not to move the sample.
7. Turn the cone upside down and place the rod across the up-turned cone.
8. Take several measurements and report the average distance to the top of the sample. If the sample fails by being outside the tolerance (ie the slump is too high or too low), another must be taken. If this also fails the remainder of the batch should be rejected.

Compacting factor test

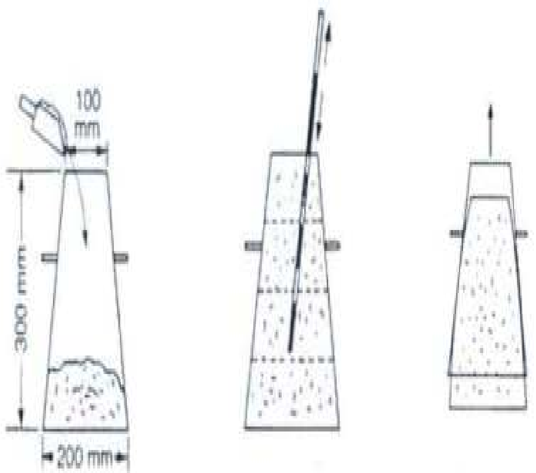
Compacting factor of fresh concrete is done to determine the workability of fresh concrete by compacting factor test as per IS: 1199 – 1959. The apparatus used is Compacting factor apparatus.

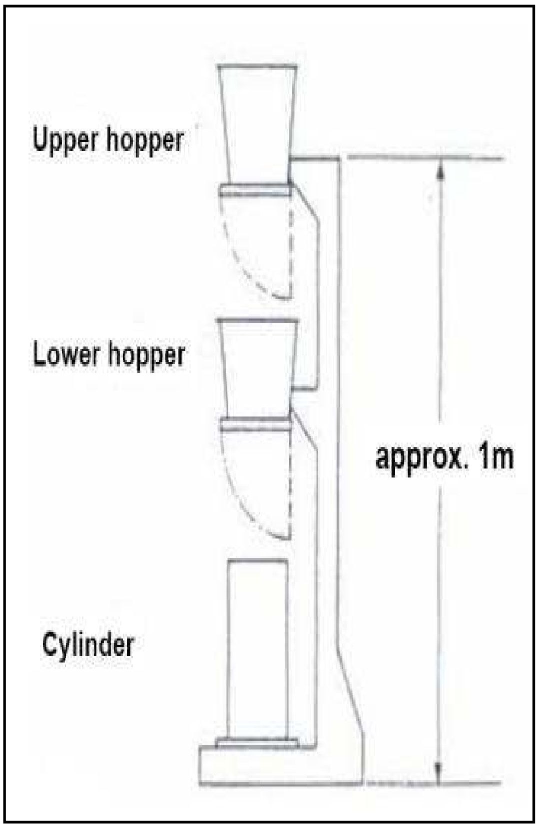
Procedure

- The sample of concrete is placed in the upper hopper up to the brim.
- The trap-door is opened so that the concrete falls into the lower hopper. The trap-door of the lower hopper is opened and the concrete is allowed to fall into the cylinder.
- The excess concrete remaining above the top level of the cylinder is then cut off with the help of plane blades
- The concrete in the cylinder is weighed. This is known as weight of partially compacted concrete.
- The cylinder is filled with a fresh sample of concrete and vibrated to obtain full compaction. The concrete in the cylinder is weighed again. This weight is known as the weight of fully compacted concrete.

Compacting factor = (Weight of partially compacted concrete)/(Weight of fullycompacted concrete)

= (W1-W2 / W2-W)





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Course Name with Code : 19CEE08 & CONCRETE TECHNOLOGY

Course Teacher : M.GOPINATH

Unit : III- FRESH AND HARDENED PROPERTIES OF CONCRETE

Date of Lecture:

Topic of Lecture: Segregation and Bleeding

Introduction :

- Concrete is referred to as fresh when the setting and hardening process has not yet started. Fresh concrete can be deformed and poured which means it can be transported or pumped and used to fill moulds and formwork.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Segregation and Bleeding

Segregation and Bleeding

SEGREGATION – It can be defined as the separation of the constituent materials of concrete. A good concrete is one in which all the ingredients are properly distributed to make a homogeneous mixture. There are considerable differences in the sizes and specific gravities of the constituent ingredients of concrete

Segregation may be of three types:

1. Coarse aggregate separating out or settling down from the rest of the matrix.
2. Paste separating away from coarse aggregate.
3. Water separating out from the rest of the material being a material of lowest specific gravity.

A well made concrete, taking into consideration various parameters such as grading, size, shape and surface texture of aggregate with optimum quantity of waters makes a cohesive mix. Such concrete will not exhibit any tendency for segregation. The cohesive and fatty characteristics of matrix do not allow the aggregate to fall apart, at the same time; the matrix itself is sufficiently contained by the aggregate. Similarly, water also does not find it easy to move out freely from the rest of the ingredients.

The conditions favorable for segregation are

1. Badly proportioned mix where sufficient matrix is not there to bind and contain the aggregates.
2. Insufficiently mixed concrete with excess water content.
3. Dropping of concrete from heights as in the case of placing concrete in column concreting.
4. When concrete is discharged from a badly designed mixer, or from a mixer with worn out blades.
5. Conveyance of concrete by conveyor belts, wheel barrow, long distance haul by dumper, long lift by skip and hoist are the other situations promoting segregation of concrete.

BLEEDING – This in concrete is sometimes referred as water gain. It is a particular form of segregation, in which some of the water from the concrete comes out to the surface of the concrete, being of the lowest specific gravity among all the ingredients of concrete. Bleeding is predominantly observed in a highly wet mix, badly proportioned and insufficiently mixed concrete. In thin members like roof slab or road slabs and when concrete is placed in sunny weather show excessive bleeding.

Due to bleeding, water comes up and accumulates at the surface. Sometimes, along with this water, certain quantity of cement also comes to the surface. When the surface is worked up with the trowel, the aggregate goes down and the cement and water come up to the top surface. This formation of cement paste at the surface is known as **Laitance**. In such a case, the top surface of slabs and pavements will not have good wearing quality. This laitance formed on roads produces dust in summer and mud in rainy season.

Prevention of Bleeding in concrete

- Bleeding can be reduced by proper proportioning and uniform and complete mixing.
- Use of finely divided pozzolanic materials reduces bleeding by creating a longer path for the water to traverse.
- Air-entraining agent is very effective in reducing the bleeding.
- Bleeding can be reduced by the use of finer cement or cement with low alkali content. Rich mixes are less susceptible to bleeding than lean mixes.

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Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **IV- FRESH AND HARDENED PROPERTIES OF CONCRETE**

Date of Lecture:

Topic of Lecture: Determination of Compressive and Flexural Strength as per BIS

Introduction :

- Flexural strength is one measure of the tensile strength of concrete. It is a measure of an un-reinforced concrete beam or slab to resist failure in bending. Flexural MR is **about 10 to 20 percent of compressive strength** depending on the type, size and volume of coarse aggregate used.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Compressive and Flexural Strength

Compressive strength of concrete is the Strength of hardened concrete measured by the compression test. The compression strength of concrete is a measure of the concrete's ability to resist loads which tend to compress it. It is measured by crushing cylindrical concrete specimens in compression testing machine.

Nominal Mix	Minimum cube strength required (in psi)			
	Laboratory Tests		Work Tests	
	7 days	28 days	7 days	28 days
1:1:2	4000	6000	3000	4500
1:1½:3	3350	5000	25000	3750
1:2:4	2700	4000	2000	3000
1:3:6	---	2500	---	2000
1:4:8	---	2000	---	1500

Importance of Determining the Compressive Strength:

Compressive strength results are primarily used to determine that the concrete mixture as delivered on site meets the requirements of the specified strength, fc', in the job specification. Cylinders tested for acceptance and quality control are made and cured in accordance with procedures described for standard-cured specimens in ASTM C-31 (which is the Standard Practice for Making and Curing Concrete Test Specimens in the Field). For estimating the in place concrete strength, ASTM C-31 provides procedures for field-cured specimens. Cylindrical specimens are tested in accordance with ASTM C-39 (which is standard Test Method for Compressive Strength of Cylindrical Concrete Specimens).

A test result is the average of at least two standard-cured strength specimens made from the same concrete batch and tested at the same age. In most cases strength requirements for concrete are at 28 days.

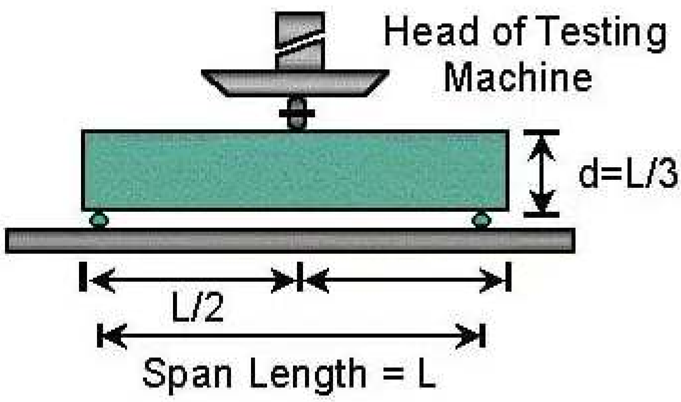
The Applications of Flexural Test on Concrete:

Following are the applications of flexural test:

- Specifying compliance with standards
- It is an essential requirement for concrete mix design
- It is employed in testing concrete for slab and pavement construction

Factors Cause Variability in Flexural Test:

- Concrete specimen preparation
- Specimen size
- Moisture condition of the concrete specimen
- Curing of the concrete specimen
- And whether the specimen is molded or sawed to the required size



It should be noticed that, the modulus of rupture value obtained by center point load test arrangement is smaller than three-point load test configuration by around 15 percent. Moreover, it is observed that low modulus of rupture is achieved when larger size concrete specimen is considered. Furthermore, modulus of rupture is about 10 to 15 percent of compressive strength of concrete. It is influenced by mixture proportions, size and coarse aggregate volume used for specimen construction. Finally, the following equation can be used to compute modulus of rupture,

Flexural Test Machine and Concrete Specimen (ASTM C78)

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LECTURE HANDOUTS

CIVIL

III/V

Course Name with Code : 19CEE08 & CONCRETE TECHNOLOGY

Course Teacher : M.GOPINATH

Unit : IV- FRESH AND HARDENED PROPERTIES OF CONCRETE

Date of Lecture:

Topic of Lecture: Properties of Hardened Concrete

Introduction :

- Hardened concrete is a type of concrete that is strong and have the capacity to bear the structural as well as service loads that are applied to it. Hardened concrete is one of the strongest and durable construction materials. Hardened concrete is concrete that is completely set and able to take the loads.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Compressive and Flexural Strength

Hardened concrete has a number of properties, including:

- Mechanical strength
- Durability.
- Porosity and density.
- Fire resistance.
- Thermal and acoustic insulation properties.
- Impact resistance.

Mechanical strength:

The strength of normal concrete varies between 25 and 40 MPa. Above 50 MPa, the term High Performance Concrete is used (50 MPa corresponds to a force of 50 tonnes acting on a square with sides of ten centimetres).

Durability:

Concrete is extremely resistant to the physico-chemical attack emanating from the environment (frost, rain atmospheric pollution, etc...) It is particularly well-suited for structures exposed to demanding and extreme conditions.

Porosity and density.

These properties are responsible for the first two. The denser (or the less porous) the concrete the better its performance and the greater its durability.

The density of concrete is increased by optimizing the dimensions and packing of the aggregate and reducing the water content.

Fire resistance.

A fire-resistance rating typically means the duration for which a passive fire protection system can withstand a standard fire resistance test. This can be quantified simply as a measure of time, or it may entail a host of other criteria, involving other evidence of functionality or fitness for purpose.

Thermal and acoustic insulation properties.

Thermal insulation **restricts heat transfer**, whereas acoustic insulation restricts sound transfer or sound reverberation. The combined product is thermal acoustic insulation, which is effective in both reducing heat and noise transfer.

Impact resistance.

Impact resistance represents the ability of concrete to withstand repeated blows and absorb energy without adverse effect to cracking and spalling. Impact scenario can also be classified into low velocity impact and high velocity impact.

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CIVIL **III/V**

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **IV- FRESH AND HARDENED PROPERTIES OF CONCRETE**

Date of Lecture:

Topic of Lecture: Determination of Compressive Strength Test

Introduction :

- Hardened concrete is a type of concrete that is strong and have the capacity to bear the structural as well as service loads that are applied to it. Hardened concrete is one of the strongest and durable construction materials. Hardened concrete is concrete that is completely set and able to take the loads.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Compressive and Flexural Strength

DEFINITION

- Compressive strength is defined as the ratio of the load per unit area.

APPARATUS

- Vibrating machine confirming to IS: 10080 – 1982.
- Poking rod confirming to IS: 10080-1982.
- Cube moulds shall be of 70.60mm size confirming to IS: 10080-1982.
- Gauging trowel having steel blade 100 to 150mm in length with straight edge weighing 210 ± 10gms.
- Balance of capacity 10Kg and sensitivity 1gram.

- $$\text{Compressive strength} = \frac{\text{Load}}{\text{Cross sectional area of the specimen}} \; N/mm^2$$

PROCEDURE

- Unless otherwise specified this test shall be conducted at a temperature $27^0 \pm 20$C.
- Weigh the material required for each cube separately.
- Place on a nonporous plate, a mixture cement and standard sand.
- Mix it dry with a trowel for one minute and then with water until the mixture is of uniform colour.
- The time of mixing shall in any event be not less than 3 minutes and should be the time taken to obtain uniform colour exceeds 4 minutes.
- In assembling the moulds ready for use, cover the joints between the halves of the mould with a thin film of petroleum jelly and apply a similar coating of petroleum jelly between the contact surface of the bottom of the mould and base plate in order to ensure that no water escapes during vibration.
- Immediately after fixing the mould in the vibrating machine, place the mortar in the cube mould and prod with the rod.
- Prod the mortar 20 times in about 8 seconds to ensure elimination of entrapped air and honey combing.
- Place the remaining mortar in the cube mould and prod again as specified for the first layer and then compact the mortar by vibration.
- The period of vibration shall be two minutes at the specified speed of 12000 ± 400 vibrations per minute.
- Remove the mould from the vibrating machine and cut of the excess mortar with a straight edge.

Details of website for further learning : http://www.alphace.ac.in/downloads/notes/cv/10cv81.pdf

Important Books/Journals for further learning including the page nos.:
Shetty, M.S, "Concrete Technology, Theory and Practice", S. Chand and Company Ltd, New Delhi, 2008 Pg.no: 148 to 158

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CIVIL **III/V**

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **IV- FRESH AND HARDENED PROPERTIES OF CONCRETE**

Date of Lecture:

Topic of Lecture: Determination of Flexural Strength Test

Introduction :

- Hardened concrete is a type of concrete that is strong and have the capacity to bear the structural as well as service loads that are applied to it. Hardened concrete is one of the strongest and durable construction materials. Hardened concrete is concrete that is completely set and able to take the loads.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Compressive and Flexural Strength

DEFINITION

Flexural strength of Concrete, also known as **Modulus of rupture,** is an indirect measure of the tensile strength of unreinforced concrete. Modulus of rupture can also be defined as the measure of the extreme fibre stresses when a member is subjected to bending. Apart from external loading, tensile stresses can also be caused by warping, corrosion of steel, drying shrinkage and temperature gradient. Concrete is strong in compression but weak in tension because of which the flexural strength accounts for only 10% to 20% of the compressive strength.

PROCEDURE

1. Unreinforced concrete specimens of size 400 mm x 100 mm x 100 mm are casted using the desired concrete grade and cured properly for 28 days.
2. The test specimens are allowed to rest in water for 2 days at a temperature of 24˚C to 30˚C before testing.
3. The testing is done immediately after removal of the specimen from the water and while the specimens are **in wet condition.**
4. Reference lines are drawn using chalks at 5 cm from the edges of the specimen on either side to

indicate the position of the roller supports

5. The prismatic specimens are supported on rollers of the testing machine. These rollers provide a simply supported condition for the test.
6. The load is gradually applied through two symmetrical rollers on the axis of the beam.
7. Further, load is applied without shock and increased continuously at a rate such that the stress in the extreme fibre increases at approximately **7kg/cm²/minute.**
8. Finally, the load is applied until the specimen fails and the maximum load is noted.

Calculation of Flexural Strength from Lab Test

The Flexural Strength or Modulus of Rupture (f_b) is given by

$\mathbf{f_b = Pl/bd^2}$ (when a > 13.3 cm)

$\mathbf{f_b = 3Pa/bd^2}$ (when a < 13.3 cm)

Characteristic compressive strength (MPa)	Flexural Strength (MPa)
20	3.13
25	3.50
30	3.83
35	4.14
40	4.43
45	4.70
50	4.95

Flexural strength of various grades of concrete as per IS code

SIGNIFICANCE OF FLEXURAL STRENGTH

Though the modern construction practice uses reinforcement steel to increase the tensile strength of the concrete, the computation of the flexural strength is significant as the steel reinforcement can only take care of the extreme fibre stresses in the member.

The tensile stress caused by **warping, corrosion of steel, drying shrinkage and temperature gradient** can also cause failure. The determination of flexural strength is an important factor in **the design of pavements** especially when there is inadequate subgrade support.

Details of website for further learning : http://www.alphace.ac.in/downloads/notes/cv/10cv81.pdf

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CIVIL **III/V**

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **IV- FRESH AND HARDENED PROPERTIES OF CONCRETE**

Date of Lecture:

Topic of Lecture: Stress Strain Curve for Concrete

Introduction :

- Stress strain curve of concrete is a graphical representation of concrete behavior under load. It is produced by plotting concrete compress strain at various interval of concrete compressive loading (stress). Concrete is mostly used in compression that is why its compressive stress strain curve is of major interest.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Compressive and Flexural Strength

STRESS-STRAIN CURVE FOR CONCRETE:

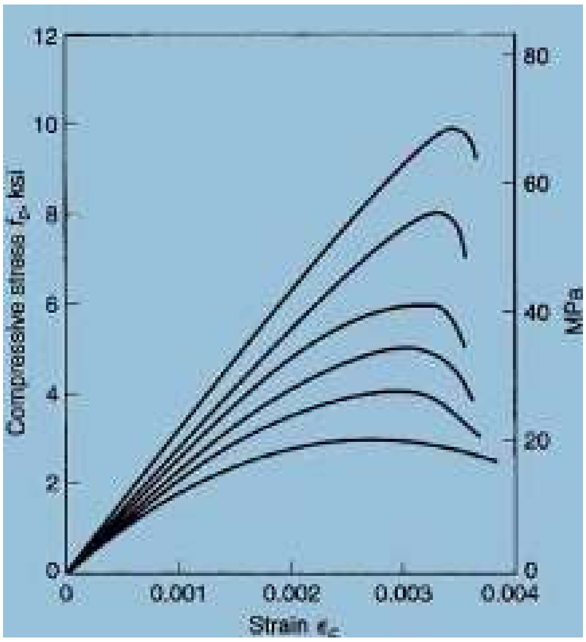
Fig. 1 and Fig. 2 shows strain stress curve for normal weigh and lightweight concrete, respectively. There is a set of curves on each figure which represents the strength of the concrete. So, higher curves show higher concrete strength. Fig. 3 shows how the shape of concrete stress strain curve changes based on the speed of loading. Despite the fact that, speed of testing and concrete density influences the shape of the stress-strain curve, but it can be noticed that, all curves show nearly the same character. i.e. they undergo the same stages under loading. Various portions of concrete stress stain curve are discussed below:

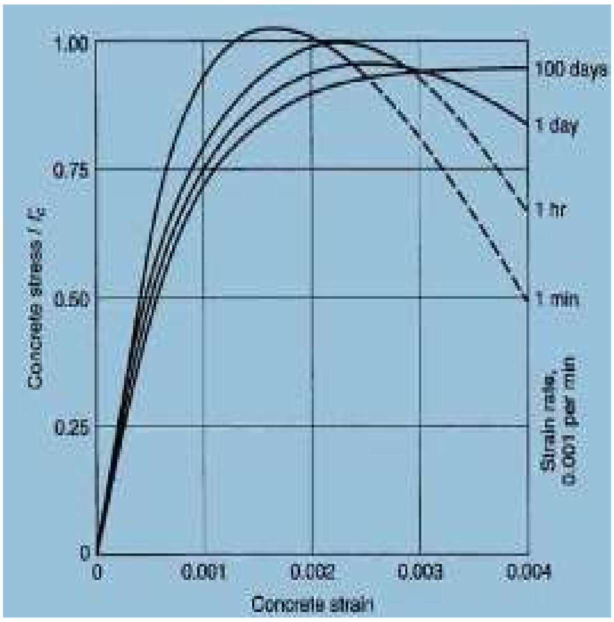
Set of Stress Strain Curve for Normal Density Concrete

1. Straight or Elastic Portion

2. Peak Point or Maximum Compress Stress Point

3. Descending Portion





1. Straight or Elastic Portion

Initially, all stress strain curves (Fig.1 and Fig. 2) are fairly straight; stress and strain are proportional. With this stage, the material should be able to retain its original shape if the load is removed. The elastic range of concrete stress strain curve continues up to 0.45fc' (maximum concrete compressive strength).

2. Peak Point or Maximum Compress Stress Point

The elastic range is exceeded and concrete begin to show plastic behavior (Nonlinear), when a load is further increased. After elastic range, the curve starts to horizontal; reaching maximum compress stress (maximum compressive strength). For normal weight concrete, the maximum stress is realized at compressive strain ranges from 0.002 to 0.003. however, for lightweight concrete, the maximum stress reached at strain ranges from 0.003 to 0. 0035.

3. Descending Portion

After reaching maximum stress, all the curves show descending trend. The characteristics of the stress strain curve in descending part is based on the method of testing.

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Course Name with Code : 19CEE08 & CONCRETE TECHNOLOGY

Course Teacher : M.GOPINATH

Unit : IV- FRESH AND HARDENED PROPERTIES OF CONCRETE

Date of Lecture:

Topic of Lecture: Determination of Youngs Modulus

Introduction :

- Modulus of elasticity of concrete is defined as the ratio of stress applied on the concrete to the respective strain caused. The accurate value of modulus of elasticity of concrete can be determined by **conducting a laboratory test called compression test on** a cylindrical concrete specimen

Prerequisite knowledge for Complete understanding and learning of Topic:

- Determination of Youngs Modulus

Modulus of elasticity of concrete is defined as the ratio of stress applied on the concrete to the respective strain caused. The accurate value of modulus of elasticity of concrete can be determined by conducting a laboratory test called compression test on a cylindrical concrete specimen.

PROCEDURE:

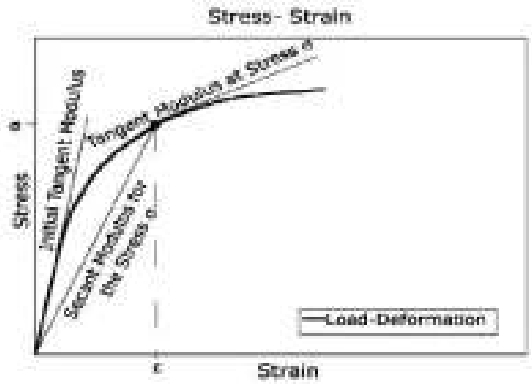
The test procedure involves two stages. Initially, the compressometer is set-up, followed by the application of load and testing.

Setting Up Compressometer

A compressometer is a device used in the compression test of the concrete cylinder to determine its strain and deformation characteristics. The set up involves the following procedures.

1. The compressometer consists of two frames(top and bottom), as shown in figure-1. The frames are initially assembled by the help of spacers. The spacers are held in position during the assembling.
2. The pivot rod is kept on the screws which are then locked in position. The tightening screws of the top and bottom frames are kept in loose condition.

3. Once the compressometer is arranged, it is placed on the concrete specimen kept on a level surface. The compressometer is centrally placed on the specimen.
4. Once the position is set, the screws are tightened and the compressometer is held on the specimen.
5. Once the set up is done, the spacers can be unscrewed and removed.



Precautions

1. Reading must be taken continuously without any delay
2. If the strain readings differ by more than 5% for the different trials, then the test must be repeated.

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CIVIL **III/V**

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **V- SPECIAL CONCRETES**

Date of Lecture:

Topic of Lecture: Light Weight Concrete

Introduction :

- Lightweight concrete is a mixture made with lightweight coarse aggregates such as shale, clay, or slate, which give it its characteristic low density. Structural lightweight concrete has an in-place density of **90 to 115 lb/ft³**, whereas the density of regular weight concrete ranges from 140 to 150 lb/ft³

Prerequisite knowledge for Complete understanding and learning of Topic:

- Determination of Youngs Modulus

Normal weight concrete a density in the range of 140 to 150 lb/ft³ (2240 to 2400 kg/m³). For structural applications the concrete strength should be greater than 2500 psi (17.0 MPa).

Lightweight aggregates used in structural lightweight concrete are typically expanded shale, clay or slate materials that have been fired in a rotary kiln to develop a porous structure. Other products such as air-cooled blast furnace slag are also used.

There are other classes of non-structural LWC with lower density made with other aggregate materials and higher air voids in the cement paste matrix, such as in cellular concrete.

Classification of Lightweight Concrete

It is convenient to classify the various types of lightweight concrete by their method of production. These are:

1. By using porous lightweight aggregate of low apparent specific gravity, i.e. lower than 2.6. This type of concrete is known as ***lightweight aggregate concrete.***

2. By introducing large voids within the concrete or mortar mass; these voids should be clearly distinguished from the extremely fine voids produced by air entrainment. This types of concrete is variously knows **as *aerated, cellular, foamed*** or ***gas concrete.***
3. By omitting the fine aggregate from the mix so that a large number of interstitial voids is present; normal weight coarse aggregate is generally used. This concrete as ***no-fines*** concrete.

Types of Lightweight Concrete

1. Lightweight Aggregate Concrete

In the early 1950s, the use of lightweight concrete blocks was accepted in the UK for load bearing inner leaf of cavity walls. Soon thereafter the development and production of new types of artificial LWA (Lightweight aggregate) made it possible to introduce LWC of high strength, suitable for structural work.

Listed below are several types of lightweight aggregates suitable for structural reinforced concrete:-

1. **Pumice** – is used for reinforced concrete roof slab, mainly for industrial roofs in Germany.
2. **Foamed Slag** – was the first **lightweight aggregate** suitable for reinforced concrete that was produced in large quantity in the UK.
3. **Expanded Clays and Shales** – capable of achieving sufficiently high strength for prestressed concrete. Well established under the trade names of Aglite and Leca (UK), Haydite, Rocklite, Gravelite and Aglite (USA).
4. **Sintered Pulverised** – *fuel ash aggregate* – is being used in the UK for a variety of structural purposes and is being marketed under the trade name Lytag

2. Aerated Concrete

Aerated concrete has the lowest density, thermal conductivity and strength. Like timber it can be sawn, screwed and nailed, but there are non-combustible. For works in-situ the usual methods of aeration are by mixing in stabilized foam or by whipping air in with the aid of an air entraining agent.

3. No Fines Concrete

The term no-fines concrete generally means concrete composed of cement and a coarse (9-19mm) aggregate only (at least 95 percent should pass the 20mm BS sieve, not more than 10 percent should pass the 10mm BS sieve and nothing should pass the 5mm BS sieve), and the product so formed has many uniformly distributed voids throughout its mass.

No-fines concrete is mainly used for load bearing, cast in situ external and internal wall, non load bearing wall and under floor filling for solid ground floors (CP III: 1970, BSI). No-fines concrete was introduced into the UK in 1923, when 50 houses were built in Edinburgh, followed a few years later by 800 in Liverpool, Manchester and London.

Types of Lightweight Concrete Based on Density and Strength

LWC can be classified as :-

1. Low density concrete
2. Moderate strength concrete
3. Structural concrete

Uses of Lightweight Concrete

1. Screeds and thickening for general purposes especially when such screeds or thickening and weight to floors roofs and other structural members.
2. Screeds and walls where timber has to be attached by nailing.
3. Casting structural steel to protect its against fire and corrosion or as a covering for architectural purposes.
4. Heat insulation on roofs.
5. Insulating water pipes.
6. Construction of partition walls and panel walls in frame structures.
7. Fixing bricks to receive nails from joinery, principally in domestic or domestic type construction.

Advantages of Lightweight Concrete

1. Reduced dead load of wet concrete allows longer span to be poured un-propped. This save both labor and circle time for each floor.
2. Reduction of dead load, faster building rates and lower haulage and handling costs. The eight of the building in term of the loads transmitted by the foundations is an important factor in design, particular for the case of tall buildings.

Details of website for further learning : http://www.alphace.ac.in/downloads/notes/cv/10cv81.pdf

Important Books/Journals for further learning including the page nos.:
Shetty, M.S, "Concrete Technology, Theory and Practice", S. Chand and Company Ltd, New Delhi, 2008 Pg.no: 148 to 158

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LECTURE HANDOUTS

CIVIL | **III/V**

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **V- SPECIAL CONCRETES**

Date of Lecture:

Topic of Lecture: High Strength Concrete- Self compacting concrete

Introduction :

- High-strength concrete is typically recognized as concrete with a **28-day cylinder compressive strength greater than 6000 psi or 42 Mpa**. ... Strengths of up to 20,000 psi (140 Mpa) have been used in different applications. Laboratories have produced strengths approaching 60,000 psi (480 Mpa).

Prerequisite knowledge for Complete understanding and learning of Topic:

- High Strength Concrete- Self compacting concrete

HIGH STRENGTH CONCRETE:

High strength concrete (HSC) may be defined as concrete with a specified characteristic cube strength between 60 and 100 N/mm^2, although higher strengths have been achieved and used. Strength levels of 80 to 100 N/mm^2 and even higher are being used for both precast and in-situ work in the USA, France, Norway and some other countries. The main applications for HSC in-situ concrete construction are in offshore structures, columns for tall buildings, long-span bridges and other highway structures. The main advantage is the reduction in size of compression elements and/or the amount of longitudinal reinforcement required.

The methods and technology for producing high strength concrete are not substantially different from those required for normal strength concrete. The target water/cement ratio should be in the range 0.30–0.35 or even lower. HSC can be produced with all of the cements and cement replacements (additions) normally available in the UK. A wide range of aggregates can be used though crushed rock aggregates (of suitably high crushing value) are preferable.

Superplasticisers / high range water reducers should be used to achieve maximum water reduction, although plasticisers may be adequate for lower strength HSC (C60 to C70). Silica fume (microsilica) or metakaoline can be used to enhance the strength at high levels (C80 and above), but is not needed generally at the lower end (C60 to C80).
The terms "High performance concrete" and "High strength concrete" are often taken to mean the same thing. However, as indicated, "High performance" strictly relates to a concrete that has been designed to have good specific characteristics, such as high resistance to chloride ingress or high abrasion resistance. As a result it may also have a high strength, but this is not the main consideration.

SELF COMPACTING CONCRETE

Self compacting concrete (SCC) can be defined as fresh concrete that flows under its own weight and does not require external vibration to undergo compaction. It is used in the construction where it is hard to use vibrators for consolidation of concrete. Filling and passing ability, segregation resistance are the properties of self compacting concrete. SCC possess superior flow ability in its fresh state that performs self compaction and material consolidation without segregation issues. The materials, tests and properties of self compacting concrete are explained in the below sections.

Tests and Properties of Self Compacting Concrete

The requirements of the self compacting concrete are achieved by the properties in its fresh state. The three main properties of SCC are:

1. **Filling Ability:** This property of the concrete is the ability to flow under its own weight without any vibration provided intentionally.
2. **Passing Ability:** This property is the ability of the concrete to maintain its homogeneity.
3. **Segregation resistance:** This is the resistance of the concrete not to undergo segregation when it flows during the self compaction process.

Advantages of Self Compacting Concrete

The main advantages of self compacting concrete are:

1. The permeability of the concrete structure is decreased
2. SCC enables freedom in designing concrete structures
3. The SCC construction is faster
4. The problems associated with vibration is eliminated
5. The concrete is placed with ease, which results in large cost saving
6.

Disadvantages of Self Compacting Concrete

SCC construction face the following limitations:

1. There is no globally accepted test standard to undergo SCC mix design
2. The cost of construction is costlier than the conventional concrete construction
3. The use of designed mix will require more trial batches and lab tests
4. The measurement and monitoring must be more precise.
5. The material selection for SCC is more stringent

Applications of Self Compacting Concrete

The major applications of self compacting concrete are:

1. Construction of structures with complicated reinforcement
2. SCC is used for repairs, restoration and renewal construction
3. Highly stable and durable retaining walls are constructed with the help of SCC
4. SCC is employed in the construction of raft and pile foundations

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LECTURE HANDOUTS

CIVIL | **III/V**

Course Name with Code : 19CEE08 & CONCRETE TECHNOLOGY

Course Teacher : M.GOPINATH

Unit : V- SPECIAL CONCRETES

Date of Lecture:

Topic of Lecture: Fibre Reinforced Concrete

Introduction :

- Fiber-reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity.Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers – each of which lend varying properties to the concrete.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Fibre Reinforced Concrete

FIBRE REINFORCED CONCRETE:

Fiber Reinforced Concrete can be defined as a composite material consisting of mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibers. Fiber reinforced concrete are of different types and properties with many advantages. Continuous meshes, woven fabrics, and long wires or rods are not considered to be discrete fibers. Fiber is a small piece of reinforcing material possessing certain characteristics properties. They can be circular or flat. The fiber is often described by a convenient parameter called "aspect ratio". The aspect ratio of the fiber is the ratio of its length to its diameter.

Effect of Fibers in Concrete:

Fibers are usually used in concrete to control plastic shrinkage cracking and drying shrinkage cracking. They also lower the permeability of concrete and thus reduce the bleeding of water. Some types of fibers produce greater impact, abrasion and shatter resistance in concrete. Generally, fibers do not increase the flexural strength of concrete, so it can not replace moment resisting or structural steel reinforcement.

The necessity of Fiber Reinforced Concrete

1. It increases the tensile strength of the concrete.
2. It reduces the air voids and water voids the inherent porosity of gel.
3. It increases the durability of the concrete.
4. Fibers such as graphite and glass have excellent resistance to creep, while the same is not true for most resins. Therefore, the orientation and volume of fibres have a significant influence on the creep performance of rebars/tendons.

Different Types of Fiber Reinforced Concrete

Following are the different type of fibers generally used in the construction industries.

1. Steel Fiber Reinforced Concrete
2. Polypropylene Fiber Reinforced (PFR) cement mortar & concrete
3. GFRC Glass Fiber Reinforced Concrete
4. Asbestos Fibers
5. Carbon Fibers
6. Organic Fibers

Factors Affecting Properties of Fiber Reinforced Concrete

- Relative Fiber Matrix Stiffness
- Volume of Fibers
- Aspect Ratio of the Fiber
- Orientation of Fibers
- Workability and Compaction of Concrete
- Size of Coarse Aggregate
- Mixing

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LECTURE HANDOUTS

CIVIL **III/V**

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **V- SPECIAL CONCRETES**

Date of Lecture:

Topic of Lecture: Ferrocement

Introduction :

- A composite structural material comprising thin sections consisting of cement mortar reinforced by a number of closely spaced layers of steel wire mesh.- ACI Concrete Terminology.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Fibre Reinforced Concrete

FERROCEMENT

Properties of Ferrocement

- Highly versatile form of reinforced concrete.
- It's a type of thin reinforced concrete construction, in which large amount of small diameter wire meshes uniformly throughout the cross section.
- Mesh may be metal or suitable material.
- Instead of concrete Portland cement mortar is used.
- Strength depends on two factors quality of sand/cement mortar mix and quantity of reinforcing materials used.

Constituent Materials for Ferrocement

1. Cement
2. Fine Aggregate
3. Water
4. Admixture
5. Mortar Mix
6. Reinforcing mesh
7. Skeletal Steel & Coating

Advantages and Disadvantages of Ferrocement

Advantages

- Basic raw materials are readily available in most countries.
- Fabricated into any desired shape.
- Low labour skill required.
- Ease of construction, low weight and long lifetime.
- Low construction material cost.

Disadvantages

- Structures made of it can be punctured by collision with pointed objects.
- Corrosion of the reinforcing materials due to the incomplete coverage of metal by mortar.
- It is difficult to fasten to Ferrocement with bolts, screws, welding and nail etc.

Process of Ferrocement Construction

- Fabricating the skeletal framing system.
- Applying rods and meshes.
- Plastering.
- Curing

Applications of Ferrocements in Construction

- Housing
- Marine
- Agricultural
- Rural Energy
- Anticorrosive Membrane Treatment.
- Miscellaneous.

Cost Effectiveness of Ferrocement Structures

- The type of economic system.
- Type of applications.
- Relative cost of labor.
- Capital and local tradition of construction procedure.
- Low cost of construction materials.

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LECTURE HANDOUTS

CIVIL **III/V**

Course Name with Code : 19CEE08 & CONCRETE TECHNOLOGY

Course Teacher : M.GOPINATH

Unit : V- SPECIAL CONCRETES

Date of Lecture:

Topic of Lecture: Ready Mix Concrete

Introduction :

- Ready mixed refers to concrete that is batched for delivery from a central plant instead of being mixed on the job site.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Ready Mix Concrete

READY MIX CONCRETE:

Ready mixed refers to concrete that is batched for delivery from a central plant instead of being mixed on the job site. Each batch of ready-mixed concrete is tailor-made according to the specifics of the contractor and is delivered to the contractor in a plastic condition, usually in the cylindrical trucks often known as "cement mixers."

Types of Ready Mix Concrete:

- Shrink Mixed Concrete.
- Transit Mixed Concrete.
- Central Mixed Concrete.

Disadvantages of Ready-Mix Concrete

- Requires huge initial investment.
- Not suitable for small projects (less quantity of concrete is required).
- Need an effective transportation system from the batching plant to the job site.

Advantages of Using Ready Mix Concrete (RMC) In Building And Construction Processes

- Quality and Consistency. ...
- Efficiency. ...
- Environment Friendly. ...
- Convenient Delivery. ...
- Versatility. ...
- Reduced Wastage. ...
- Reduced Life-Cycle Cost.

Concrete Grade	Mix Ratio (cement : sand : aggregates)	Compressive Strength
M7.5	1 : 4 : 8	1087 psi
M10	1 : 3 : 6	1450 psi
M15	1 : 2 : 4	2175 psi
M20	1 : 1.5 : 3	2900 psi

Salient features of ready mixed concrete:

- Ready mix concrete has cement, aggregates, sand, water and other chemicals, which are weigh-batched at a centrally located plant for a premium quality. The concrete is then delivered to the construction site in transit mixers and can be used straight away without any further treatment.

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CIVIL **III/V**

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **V- SPECIAL CONCRETES**

Date of Lecture:

Topic of Lecture: SIFCON, Shotcrete

Introduction :

- SIFCON (**Slurry Infiltrated Fiber CONcrete**) is a relatively new composite material utilizing steel fibers in a cement-based matrix.The resulting composite material possesses a very high compressive strength as well as ductility. SIFCON has the potential for many applications in the building industry.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Ready Mix Concrete

Slurry Infiltrated Fiber Concrete (SIFCON) is a high performance cementitious composite that can be classified as a special type of steel fiber reinforced concrete]. In SIFCON production, the fibers are preplaced into the molds, and then infiltrated by cement slurry, which usually have low water/cement ratio.

<u>WHAT IS SIFCON?</u>

SIFCON is unique construction material possessing high strength as well as large ductility and far excellent potential for structural applications when accidental (or) abnormal loads are encountered during services SIFCON also exhibit new behavioral phenomenon, that of ”Fiber lock” which believed to be responsible for its outstanding stress-strain properties. The matrix in SIFCON has no coarse aggregates, but a high cementitious content. However, it may contain fine (or) coarse sand and additives such as fly ash, micro silica and latex emulsions. The matrix fineness must be designed so as to properly infiltrate the fiber network placed in moulds, since otherwise, large pores may form leading to substantial reduction in properties. A controlled quantity of high range water reducing admixtures (super plasticizer) may be used for improving flowing characteristics of SIFCON. All steel fiber types namely straight, hooked and crimped can be used. The fibers are subjected to frictional and mechanical interlock in addition to the bond with the matrix. The matrix plays the role of transferring the forces between fibers by shear, but also acts as bearing to keep fibers interlock.

COMPOSITION OF SIFCON

Proportions of cement and sand generally used for making SIFCON are 1:1, 1:1.5 (or) 1:2 cement slurry alone have some applications. Generally, fly ash (or) silica fume equal to 10 to 15% by weight of cement is used in mix. Water cement ratio varies between 0.3 to 0.4. Percentage of super plasticizers varies from 2 to 5% by weight of cement. The percentage of fibers by volume can be any where from 4 to 20% even though the current practical ranges from 4 to 12%.

Shotcrete use:

- In this context, these terms are not interchangeable. Shotcrete is placed and compacted/consolidated at the same time, due to the force with which it is ejected from the nozzle. It can be sprayed onto any type or shape of surface, including vertical or overhead areas.

Properties of Shotcrete

Properly applied shotcrete is a **structurally sound and durable construction material** which exhibits excellent bonding characteristics to existing concrete, rock, steel, and many other materials. It can have high strength, low absorption, good resistance to weathering, and resistance to some forms of chemical attack.

Applications of SIFCON

- Pavement rehabilitation and precast concrete products.
- Overlays, bridge decks and protective revetments.
- Seismic and explosive-resistant structures.
- Security concrete applications (safety vaults, strong rooms etc)
- Refractory applications (soak-pit covers, furnace lintels, saddle piers)

Advantages of Sifcon:

(1)SIFCON possess excellent durability, energy absorption capacity, impact and abrasion resistance and toughness.
(2)Modulus of elasticity (E) values for SIFCON specimens is more compared with plain concrete.
(3) SIFCON exhibits high ductility.
(4) The limitation in SFRC that is balling problem of steel fibers with increase in fiber volume is overcomes by SIFCON, because of its fiber alignment.
(5) Deflection for SIFCON will be very less compared to conventional and will act as rigid body.

DISADVANTAGES OF SIFCON

Inspite of unique properties of SIFCON it doesn't have much limitations. Uniformity and quality control of fiber distribution in addition to high placement cost associated with manual addition of fibers, restricted wide applications of these composites.

Advantages of shotcrete.

- Shotcrete is used in lieu of conventional concrete, in most instances, for reasons of cost or convenience.
- Shotcrete is advantageous in situations when formwork is cost prohibitive or impractical and where forms can be reduced or eliminated, access to the work area is difficult, thin layers or variable thicknesses are required, or normal casting techniques cannot be employed.
- Additional savings are possible because shotcrete requires only a small, portable plant for manufacture and placement.
- Shotcreting operations can often be accomplished in areas of limited access to make repairs to structures.

Details of website for further learning : http://www.alphace.ac.in/downloads/notes/cv/10cv81.pdf

Important Books/Journals for further learning including the page nos.:
Shetty, M.S, "Concrete Technology, Theory and Practice", S. Chand and Company Ltd, New Delhi, 2008 Pg.no: 148 to 158

Course Teacher

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Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **V- SPECIAL CONCRETES**

Date of Lecture:

Topic of Lecture: Smart concrete - Guniting and shotcreting

Introduction :

- Smart concrete is a very broad category of material that includes **self-sensing concrete**, self-adjusting concrete, self-healing concrete, etc.Self-sensing concrete is a "smart" choice for maintaining sustainable development in concrete materials and structures.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Smart concrete - Guniting and shotcreting

SMART CONCRETE:

- Smart concrete technology offers an alternative method for monitoring the health of reinforced concrete structures. It was developed Dr. Deborah D.L. Chung from State University of New York at Buffalo, U.S. The unique benefit of smart concrete is that it is fortified by carbon fiber, which comprises as much as 0.2% to 0.5% of the volume.
- This can detect stress or strain in concrete structures before they fail. Smart concrete technology has undergone extensive laboratory testing, but is yet to hit the market.
- It works by adding a small quantity of short carbon fiber to concrete with a conventional concrete mixer to modify the electrical resistance of the concrete in response to strain or stress. As a result, the contact between the fiber and cement matrix is impacted when the concrete is deformed or stressed, thereby affecting the volume electrical resistivity of the concrete.
- The strain is then determined by measuring the degree of electrical resistance. Smart concrete is capable of sensing very small structural flaws and hence finds application in checking the internal condition of structures, particularly after an earthquake.
- Smart concrete can also find application in building highways able to detect the position, weight, and speed of vehicles.

GUNITING:

- Guniting is a process used in construction for the application of slope stabilization and certain rehabilitation purpose mainly in the construction of retaining walls, swimming pool construction, tunnel construction, in fluid tank construction and some of the concrete repair works.Clear definition of guniting is understood properly by knowing what is shotcrete.Guniting was a method of early origin in the US, where the method is defined as the process of spraying a mix or mortar or concrete to a surface of application with the help of a spray gun.
- This method makes use of a **spray gun** and hence the process was named as Guniting.Later, in the time of 1930s a method of spraying concrete or mortar mix with the help of a **nozzle spray** under compressed pressure and high velocity was followed by the American Railway Engineers Association(AREA).
- The American concrete Institute too adopted this method in the 1950s and was named as **shotcrete.** These institutes never used the word 'Gunite' or 'guniting'.
- The shotcrete can be carried out with a dry mix or a wet mix.Now later it came to know that the dry Shotcreting process is called as the guniting.
- This is how shotcrete and guniting differs. Gunite is merely a trademark where some countries never use the word Gunite, instead uses dry Shotcreting process.

SHOTCRETING:

Shotcrete is **a method of applying concrete projected at high velocity** primarily on to a vertical or overhead surface. Shotcrete is applied using a wet- or dry-mix process. The wet-mix shotcrete process mixes all ingredients, including water, before introduction into the delivery hose.

DIFFERENCE BETWEEN SHOTCRETE AND GUNITE:

The major difference between the two is that shotcrete is applied pre-mixed with water, so it simply hardens where it falls. On the other hand, gunite is applied as a dry plaster which mixes with water as it leaves the hose. Opting for a gunite pool gives you a few advantages over shotcrete.

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MUTHAYAMMAL ENGINEERING COLLEGE
(An Autonomous Institution)

(Approved by AICTE, New Delhi, Accredited by NAAC & Affiliated to Anna University)
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LECTURE HANDOUTS

CIVIL | **III/V**

Course Name with Code : 19CEE08 & CONCRETE TECHNOLOGY

Course Teacher : M.GOPINATH

Unit : V- SPECIAL CONCRETES

Date of Lecture:

Topic of Lecture: Polymer Concrete- High Performance Concrete

Introduction :

- Polymer concrete is the composite material made by fully replacing the cement hydrate binders of conventional cement concrete with polymer binders or liquid resins, and is a kind of concrete-polymer composite.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Polymer Concrete- High Performance Concrete

POLYMER CEMENT CONCRETE:

Polymer cement concrete is a composite concrete that consist of synthetic polymer within the binding material. Polymer concrete has advantages of higher properties, low energy requirements and low labor costs. It is also called as Polymer Portland cement concrete (PPCC) or latex-modified concrete (LMC).

Composition of Polymer Cement Concrete (PCC)

- To the Portland cement a prepolymer (monomer) of a dispersed polymer is incorporated to make PCC. This combination creates a polymer network in situ during the curing process of the concrete. The use of typical vinyl monomers can interfere with the hydration process or can get degraded.
- So the use of prepolymers are found more effective as perform the function required. In order to improve the mechanical properties of the PCC, these prepolymers can be added in higher proportions.
- As this concrete property is based on the incorporation of a polymer, special care and attention is taken while adding the latex.
- The emulsion employed increases the lubrication properties of the mix. Hence, only less amount of water is required for workability of the mix.

Properties of Polymer Cement Concrete:

- Highly Impermeable
- High Durability
- Resistance to weathering Conditions

Considerations in Polymer Cement Concrete Construction

1. PCC overlays have excellent long-term performance.
2. Mixing of PCC must be done in a concrete mobile mixer.
3. Handling, placing, and finishing of PCC is to be completed in less than 30 min.
4. PCC requires one to two days of moist curing followed by air drying.
5. Styrene-butadine PCC has excellent durability for exterior exposures or environments where moisture is present.
6. Surface discoloration occurs when the concrete is exposed to UV light, except for acrylic polymers.

Applications of Polymer Cement Concrete:

1. Bridge deck coverings
2. Floor construction
3. Precast construction
4. Used as patching compounds

Requirements of Polymers used in PCC

- The latex under ambient conditions must be able to form a film so that it properly coats the cement and the aggregate particles. This helps to create a strong bond between the aggregate and the cement matrix.
- A growing micro rack must be intercepted by the polymer network formed. This is done by dissipating energy through the formation of a micro fibril.

Polymer Latex used in PCC

- Poly (Vinyl esters)
- Poly Epoxies (Vinylidene – chloride)
- Copolymers
- Styrene Utadiene

High performance concrete

- High-performance concrete (HPC) is concrete that has been designed to be more durable and, if necessary, stronger than conventional concrete.
- High-strength concrete is defined as having a specified compressive strength of 8000 psi (55 MPa) or greater.

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LECTURE HANDOUTS

CIVIL **III/V**

Course Name with Code : **19CEE08 & CONCRETE TECHNOLOGY**

Course Teacher : **M.GOPINATH**

Unit : **V- SPECIAL CONCRETES**

Date of Lecture:

Topic of Lecture: Geo Polymer Concrete

Introduction :

- Geopolymer concrete is a type of concrete that is **made by reacting aluminate and silicate bearing materials with** a caustic activator, such as fly ash or slag from iron and metal production.

Prerequisite knowledge for Complete understanding and learning of Topic:

- Geo Polymer Concrete

Constituents of Geo Polymer Concrete:

Two main constituents of geopolymers are: source materials and alkaline liquids. The source materials on alumino-silicate should be rich in silicon (Si) and aluminium (Al). They could be by-product materials such as fly ash, silica fume, slag, rice-husk ash, red mud, etc.

Composition of Geopolymer Concrete

Following materials are required to produce this concrete:

- Fly ash - A byproduct of thermal power plant
- GGBS - A byproduct of steel plant
- Fine aggregates and coarse aggregates as required for normal concrete.
- Alkaline activator solution for GPCC as explained above. Catalytic liquid system is used as alkaline activator solution. It is a combination of solutions of alkali silicates and hydroxides, besides distilled water.

Applications of Geopolymer Concrete

- The applications is same as cement concrete. However, this material has not yet been popularly used for various applications.
- This concrete has been used for construction of pavements, retaining walls, water tanks, precast bridge decks.

Mechanical Properties of Geopolymer Concrete

Compressive strength of geopolymer concrete have been found up to 70 MPa (N/mm^2). The concrete gains its compressive strength rapidly and faster than ordinary Portland cement concrete. The concrete strength after 24 hours have been found to be more than 25 MPa. Compressive strength after 28 days have been found to be 60 to 70 MPa. -Ref. Paper by - James Aldred And John Day and Test results by SERC Chennai.

Other Properties of Geopolymer Concrete:

- The drying shrinkage of is much less compared to cement concrete. This makes it well suited for thick and heavily restrained concrete structural members.
- It has low heat of hydration in comparison with cement concrete.
- The fire resistance is considerably better than OPC based concrete. -Reference - Paper by - James Aldred And John Day.
- This concrete jas chloride permeability rating of 'low' to 'very low' as per ASTM 1202C. It offers better protection to reinforcement steel from corrosion as compared to traditional cement concrete.
- This concrete are found to possess very high acid resistance when tested under exposure to 2% and 10% sulphuric acids.

Use Geopolymer concrete:

Geopolymer concrete has significant advantages over standard concretes. Geopolymer concrete is **more resistant to corrosion and fire**, has high compressive and tensile strengths, and it gains its full strength quickly (cures fully faster). It also shrinks less than standard concrete.

Disadvantages of geopolymer concrete:

GPC needs higher temperature curing. Ambient temperature cured GPC has quite lower strength and durability . The properties of GPC are highly depend on the casting curing condition(it is very sensitive to the moisture, temperature, pressure etc.). Also efflorescence is also a big problem for GPC

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