

UNIT I

Chapter 1 : Introduction to Concrete & Ingredients of Concrete 1-1 to 1-44

a) Cement and Aggregate : Manufacture, chemical composition, hydration, physical and mechanical properties, classification, types and application of cement, tests on cement, Classification of aggregate, physical and mechanical properties of aggregate, deleterious materials in aggregate, alkali-aggregate reaction, Fineness and gradation of aggregates using sieve analysis, tests on aggregates.

b) Water and Admixtures : Quality of water for use in concrete, role of admixture, classification and types of admixtures like accelerators, retarders, plasticizers, super plasticizers, mineral admixtures-fly ash, silica fume, ground granulated blast furnace slag.

1.1 Introduction..... 1-1

1.2 History of Cement..... 1-1

1.3 Manufacture of Portland Cement 1-2

1.3.1 The Basic Raw Materials..... 1-2

1.3.2 Manufacturing Process of Portland Cement 1-2

1.3.3 The Common Two Processes Used for Manufacturing of Cement..... 1-3

1.4 Chemical composition and basic Chemistry of Cement 1-4

1.4.1 Bogue’s Compound..... 1-5

1.4.2 Properties of Bogue’s Compound..... 1-5

1.5 Hydration of cement..... 1-6

1.5.1 Heat of Hydration..... 1-7

1.6 Classification of Cement 1-8

1.6.1 ASTM Standards Classify Cement into Five Different Types..... 1-8

1.6.2 BIS Classification 1-8

1.7 Types and Applications of Cement..... 1-8

1.7.1 Ordinary Portland Cement (IS : 269, 8112 and 12269) 1-9

1.7.2 Rapid Hardening Portland Cement (IS : 8041)..... 1-9

1.7.3 Low Heat Portland Cement (IS : 12600)..... 1-9

1.7.4 Sulphate Resisting Cement (IS : 12330)1-10

1.7.5 Quick Set Cement1-10

1.7.6 Pozzolana Portland Cement (IS : 1489)1-10

1.7.7 Blast Furnace Slag Cement (IS : 445)1-11

1.7.8 White and Colour Cement (IS : 8042)1-11

1.7.9 Air Entraining Cement.....1-12

1.7.10 Hydrophobic Cement (IS : 8043).....1-12

1.8 Tests on Cement.....1-12

1.8.1 Field tests on Cement.....1-12

1.8.2 Laboratory Tests on Cement1-12

1.8.3 Compressive Strength Test (IS : 4031 Part 6)1-17

1.8.4 Physical and Mechanical Properties of cement.....1-17

1.9 Aggregates.....1-18

1.9.1 Introduction.....1-18

1.9.2 Classification of Aggregates1-19

1.9.3 Fine Aggregate and its properties.....1-20

1.9.4 Bulking of sand1-21

1.9.5 Impurities in Sand1-22

1.9.6 Coarse Aggregate1-22

1.9.7 Physical Properties of Aggregates1-23

1.9.8 Mechanical Properties of Aggregates.....1-25

1.9.9 Shape Test on Aggregate1-27

1.9.10 Deleterious Materials1-28

1.9.11 Soundness test on Aggregate1-29

1.9.12 Porosity of Aggregate.....1-29

1.9.13 Alkali Aggregate Reaction (AAR)1-29

1.9.14 Fineness and Gradation of Aggregates using Sieve Analysis.....1-30

1.10 Water.....1-34

1.10.1 Quality of Water for Concrete1-34

1.10.2 Test on water1-35

1.11 Concrete Admixtures1-36

1.11.1 Role or Functions of Admixtures.....1-36

1.11.2 Classification and Types of Admixtures.....1-36

1.11.3 Mineral Admixture1-37

1.11.4 Chemical Admixture1-39

UNIT II**Chapter 2 : Production, Properties & Testing of Fresh Concrete 2-1 to 2-18**

- a) Production and Properties of Fresh Concrete :** Nominal mixes, Water-cement ratio, Process of manufacturing fresh concrete-batching, mixing, transportation, compaction, curing of concrete, curing methods, influence of temperature, maturity rule, workability and factors affecting workability, cohesion and segregation.
- b) Tests on Fresh Concrete :** Workability by slump cone, compaction factor, Vee-Bee consistometer and flow table apparatus, Effect of admixture on workability of concrete and optimum dosage of admixture by Marsh cone test.

| | | |
|------------|--|-------------|
| 2.1 | Nominal Mixes..... | 2-1 |
| 2.2 | Water-cement ratio..... | 2-1 |
| 2.3 | Process of Manufacturing of Fresh Concrete..... | 2-2 |
| 2.3.1 | Batching..... | 2-2 |
| 2.3.2 | Mixing of Concrete..... | 2-3 |
| 2.3.3 | Transportation of Concrete..... | 2-3 |
| 2.3.4 | Placing of Concrete..... | 2-3 |
| 2.3.5 | Compaction of Concrete..... | 2-4 |
| 2.3.6 | Curing of Concrete..... | 2-4 |
| 2.3.7 | Curing Methods..... | 2-5 |
| 2.4 | Influence of Temperature..... | 2-6 |
| 2.5 | Maturity Rule..... | 2-6 |
| 2.6 | Properties of Fresh Concrete..... | 2-7 |
| 2.6.1 | Workability..... | 2-7 |
| 2.6.2 | Factors Affecting Workability..... | 2-8 |
| 2.6.3 | Cohesion..... | 2-10 |
| 2.6.4 | Segregation..... | 2-10 |
| 2.6.5 | Bleeding..... | 2-11 |
| 2.6.6 | Laitance..... | 2-12 |
| 2.7 | Tests on Fresh Concrete..... | 2-12 |
| 2.7.1 | Slump Cone Test..... | 2-13 |
| 2.7.2 | Compaction Factor Test..... | 2-14 |
| 2.7.3 | Vee-Bee Compaction Test..... | 2-15 |
| 2.7.4 | Flow Table Test..... | 2-16 |
| 2.8 | Effect of Admixture on Workability of Concrete..... | 2-17 |

| | | |
|------------|---|----------------|
| 2.9 | Marsh Cone Test for optimum dosage of admixture..... | 2-18 |
| ➤ | Modern Question Papers | (M - 1) |

UNIT III**Chapter 3 : Properties and Testing of Hardened Concrete 3-1 to 3-28**

- a) Hardened concrete :** Strength of concrete, factors affecting strength, micro-cracking and stress-strain relationship, relation between tensile and compression strength, impact strength, abrasion resistance, creep and shrinkage.
- b) Testing of hardened concrete :** Destructive tests - compression strength, flexural strength, indirect tensile strength, core test. Nondestructive tests: rebound hammer, ultrasonic pulse velocity, pullout test and impact echo test.

| | | |
|-------------|---|-------------|
| 3.1 | Strength of concrete..... | 3-1 |
| 3.2 | Factors Affecting Strength of Concrete..... | 3-1 |
| 3.2.1 | Water-Cement Ratio..... | 3-2 |
| 3.2.2 | Gel Space Ratio..... | 3-4 |
| 3.2.3 | Aggregate - Cement Ratio and Bond Strength..... | 3-6 |
| 3.2.4 | Aggregate Size, Shape and Grading..... | 3-6 |
| 3.2.5 | Combine effect of Age, Curing and Temperature of Concrete..... | 3-7 |
| 3.3 | Micro-cracking of Concrete and Stress-strain Relationship..... | 3-8 |
| 3.4 | Relation between Tensile and Compressive Strength..... | 3-9 |
| 3.5 | Impact Strength of Concrete..... | 3-10 |
| 3.6 | Abrasion Resistance of Concrete..... | 3-10 |
| 3.7 | Modulus of Elasticity of Concrete..... | 3-11 |
| 3.8 | Creep in Concrete..... | 3-12 |
| 3.9 | Shrinkage in Concrete..... | 3-13 |
| 3.9.1 | Types of Shrinkage..... | 3-14 |
| 3.10 | Testing of Harden Concrete..... | 3-15 |
| 3.10.1 | Compressive Test..... | 3-16 |
| 3.10.2 | Tensile Strength..... | 3-18 |
| 3.10.3 | Flexural Tensile Test Procedure..... | 3-18 |
| 3.10.4 | Important Facts about Flexural Tensile Test..... | 3-19 |
| 3.10.5 | Indirect Tensile Test or Split Tensile Test..... | 3-19 |
| 3.11 | Core Test..... | 3-20 |
| 3.12 | Non Destructive Testing..... | 3-21 |

| | | |
|--------|--|------|
| 3.12.1 | Objectives of NDT..... | 3-21 |
| 3.12.2 | Advantages and Disadvantages of NDT..... | 3-21 |
| 3.12.3 | Various Types of Non-Destructive Test (NDT)..... | 3-22 |
| 3.12.4 | Rebound Hammer Test..... | 3-22 |
| 3.12.5 | Ultrasonic Pulse Velocity Test..... | 3-24 |
| 3.12.6 | Pullout Test | 3-25 |
| 3.12.7 | Impact Echo Test | 3-27 |
| 3.12.8 | Rebar Locator..... | 3-28 |

UNIT IV

Chapter 4 : Concrete Mix Design & Methods of Mix Design 4-1 to 4-31

(a) Concrete Mix Design : Concept and objectives of concrete mix design, factors affecting the mix design, quality control, variability of laboratory test result, acceptance criteria, Grade designation and IS requirements as per IS 456 (Exposure conditions, minimum & maximum cement content and maximum W/C ratio)

(b) Methods of Mix Design : IS code method and DOE method (with and without mineral admixture), Use of spreadsheet t/programming/ software for concrete mix design.

| | | |
|------------|---|-------------|
| 4.1 | Concept of Mix design | 4-1 |
| 4.2 | Objectives of Mix design..... | 4-1 |
| 4.3 | Types of Mixes..... | 4-2 |
| 4.3.1 | Nominal Mix..... | 4-2 |
| 4.3.2 | Standard Mix..... | 4-3 |
| 4.3.3 | Design Mix | 4-4 |
| 4.4 | Factors affecting the Mix Design | 4-4 |
| 4.5 | Statistical Quality Control..... | 4-5 |
| 4.5.1 | Variability of Laboratory Test Result | 4-6 |
| 4.5.2 | Mean Strength..... | 4-7 |
| 4.5.3 | Variance | 4-7 |
| 4.5.4 | Standard Deviation (SD)..... | 4-7 |
| 4.5.5 | Coefficient of Variation..... | 4-8 |
| 4.5.6 | Quality Control and Variability..... | 4-8 |
| 4.5.7 | Characteristics Compressive Strength | 4-9 |
| 4.5.8 | Example of Standard Deviation..... | 4-9 |
| 4.6 | Acceptance Criteria..... | 4-10 |

| | | |
|------------|---|-------------|
| 4.7 | Laboratory Trial Mixes and Guideline to Improve | 4-11 |
| 4.8 | Methods of Concrete Mix Design | 4-15 |
| 4.8.1 | IS Code Method of Mix Design | 4-15 |
| 4.8.2 | Step by Step Procedure for Concrete Mix by IS : 10262 - 2019..... | 4-15 |
| 4.9 | Department of Environment Method (DOE) ... | 4-27 |

UNIT V

Chapter 5 : Concreting Equipments, Techniques & Special Concrete 5-1 to 5-34

(a) Concreting Equipment's and Techniques :

Batching plants, concrete mixers, hauling, pumps, concrete vibrators and compaction equipment's. Special concreting techniques- ready mix concrete, under water concreting, roller compacted concrete, cold and hot weather concreting.

(b) Special concretes :

Lightweight concrete and its types, foam concrete, no fines concrete, self-compacting concrete, high density concrete, fiber reinforced concrete, geo-polymer concrete and Ferrocement technique.

| | | |
|------------|--|-------------|
| 5.1 | Concrete Equipment's..... | 5-1 |
| 5.1.1 | Batching Plants..... | 5-1 |
| 5.1.2 | Concrete Mixers for Mixing..... | 5-3 |
| 5.1.3 | Hauling Equipment's and Concrete Pumps..... | 5-6 |
| 5.1.4 | Concrete Vibrators and Compaction Equipments | 5-8 |
| 5.2 | Special Concreting Techniques | 5-10 |
| 5.2.1 | Pumped Concrete..... | 5-10 |
| 5.2.2 | Ready Mix Concrete (RMC) | 5-11 |
| 5.2.3 | Underwater Concreting | 5-13 |
| 5.2.4 | Tremie Concrete Method..... | 5-13 |
| 5.2.5 | Roller Compacted Concrete | 5-14 |
| 5.2.6 | Cold Weather Concreting | 5-15 |
| 5.2.7 | Hot Weather Concreting | 5-16 |
| 5.3 | Special Concretes..... | 5-17 |
| 5.3.1 | Light Weight Concrete | 5-18 |
| 5.3.2 | Self Compacting Concrete (SCC) | 5-21 |
| 5.3.3 | High Density Concrete | 5-23 |
| 5.3.4 | Fibre Reinforced Concrete (FRC) | 5-24 |

| | | | | | |
|---|--|-------------|-------------|---|---------------------------|
| 5.3.5 | Types of Fibres | 5-25 | 6.7 | Carbonation of concrete | 6-9 |
| 5.3.6 | Factors Affecting Fibres Reinforce Concrete | 5-26 | 6.8 | Introduction to Repair of Concrete | 6-9 |
| 5.3.7 | Geo Polymer Concrete | 5-28 | 6.8.1 | Symptoms and Diagnosis of Distress | 6-10 |
| 5.4 | Ferrocement Technique..... | 5-29 | 6.8.2 | Causes of Cracks in Harden Concrete..... | 6-10 |
| 5.4.1 | Specifications of Ferrocement | 5-30 | 6.8.3 | Factors Contributing Cracking of Harden Concrete | 6-11 |
| 5.4.2 | Properties of Ferrocement | 5-30 | 6.9 | Evaluation of Cracks..... | 6-16 |
| 5.4.3 | Advantages of Ferrocement..... | 5-31 | 6.10 | Necessity of Evaluation of Crack..... | 6-16 |
| 5.4.4 | Disadvantages of Ferrocement..... | 5-31 | 6.11 | Selection of Repair Procedure..... | 6-17 |
| 5.4.5 | Uses of Ferrocement..... | 5-31 | 6.12 | Repair of Defects using Different Techniques | 6-18 |
| 5.5 | Ferrocement Technique..... | 5-31 | 6.12.1 | Preparation of Surface..... | 6-18 |
| UNIT VI | | | 6.12.2 | Selection of Proper Repairing Material..... | 6-18 |
| Chapter 6 : Deterioration and Repairs in Concrete | | | 6.13 | Common Types of Repairs | 6-21 |
| 6-1 to 6-31 | | | 6.14 | Shotcrete..... | 6-26 |
| <p>a) Deterioration – Durability, factors affecting the durability of concrete, Permeability, sulphate attack, acid attack, chloride attack, corrosion of reinforcement, carbonation of concrete</p> <p>b) Repairs – Symptoms and diagnosis of distress, evaluation of cracks, selection of repair procedure, repair of defects using various types and techniques – shotcrete and grouting. Introduction to retrofitting of concrete structures by fibre reinforced polymer (FRP), polymer impregnated concrete. Corrosion monitoring and preventive measures.</p> | | | 6.14.1 | Properties of Shotcrete | 6-27 |
| 6.1 | Durability of Concrete..... | 6-1 | 6.14.2 | Types of Shotcreting Method | 6-27 |
| 6.1.1 | Factors Affecting Durability of Concrete | 6-2 | 6.15 | Introduction to Retrofitting of concrete by using Fibre Reinforce Polymer (FRP)..... | 6-28 |
| 6.2 | Permeability of Concrete..... | 6-3 | 6.15.1 | Properties of FRP | 6-29 |
| 6.2.1 | Importance of Permeability Study of Concrete | 6-3 | 6.15.2 | Advantages of FRP | 6-29 |
| 6.2.2 | Factors Affecting Permeability of Concrete..... | 6-4 | 6.16 | Polymer Impregnated Concrete | 6-30 |
| 6.2.3 | Control Measures to Reduce Permeability | 6-5 | 6.17 | Corrosion Monitoring..... | 6-30 |
| 6.3 | Sulphate Attack on Concrete | 6-5 | 6.17.1 | Different Methods to assessed Corrosion of Steel | 6-30 |
| 6.4 | Acid Attack on Concrete | 6-6 | 6.17.2 | Preventive Techniques to Control Corrosion..... | 6-31 |
| 6.5 | Chloride Attack on Concrete..... | 6-6 | ➤ | Appendix - A : Solved University Question Paper of Dec.-2019 | A-1 to A-18 |
| 6.6 | Corrosion of Reinforcement..... | 6-7 | ➤ | Modern Question Paper (End Sem) | (M - 1) to (M - 2) |

