



INSTITUTE OF CONCRETE TECHNOLOGY
CONCRETE TECHNOLOGY & CONSTRUCTION
Stage 2: GENERAL PRINCIPLES
Learning objectives

2.00 Introduction to the course

- 2.00.01 Outline the aims, objectives and content of the course.
- 2.00.02 State methods of teaching and learning to be used on the course.
- 2.00.03 Plan for career progression and further training following successful completion of the course.

2.01 Health and safety

- 2.01.01 Identify the risks to health and safety within the concrete construction industry.
- 2.01.02 Identify and state sources of danger in the operation of concreting plant and equipment and list precautions to be taken to ensure safe working.

2.02 Sustainability (with acknowledgement to BRE Global Ltd)

- 2.02.01 Define embodied energy and embodied carbon dioxide associated with concrete supply.
- 2.02.02 State the positive and negative environmental contributions of cement manufacture.
- 2.02.03 List alternative fuels that may be used in cement manufacture.
- 2.02.04 Explain sustainability and quality issues of using recycled aggregates.
- 2.02.05 Explain how concrete admixtures contribute to sustainability.

2.03 Portland cements and additions

- 2.03.01 List the common types of cements and combinations, describe their manufacture and state typical applications for each.
- 2.03.02 Name the four main chemical compounds in Portland cement and compare their effects on concrete properties.
- 2.03.03 Define how standards identify different types of common cement in respect of their compositions and strength classifications.
- 2.03.04 Define the terms 'hydraulic binder', 'minor additional constituents', 'additives', 'filler' and 'auto control' in relation to Portland cements.
- 2.03.05 Describe the production, properties and use of pulverized-fuel ash (fly ash), ground granulated blastfurnace slag, silica fume, metakaolin and natural pozzolanas in concrete.
- 2.03.06 For each of the materials listed in 2.03.05 describe the effects on the properties of concrete in the fresh and hardened states.
- 2.03.07 Name the main standard tests for cement, typical limiting values and the significance of the test result for concrete.

2.04 Non-Portland cements

- 2.04.01 Name the principal raw materials of non-Portland cements and outline the normal manufacturing processes.
- 2.04.02 Name the main chemical compounds in calcium aluminate cement and explain conversion and precautions necessary to minimise its effect.
- 2.04.03 Compare and contrast the properties of Portland and non-Portland cements.
- 2.04.04 Describe suitable applications for non-Portland cements.

2.05 Natural aggregates

- 2.05.01 Define and describe the formation of igneous, metamorphic and sedimentary rocks, and list common types of each.
- 2.05.02 List the main operations in the extraction and processing of natural aggregates.
- 2.05.03 Explain how the source and processing of an aggregate influence its physical properties.
- 2.05.04 State important requirements for an aggregate which is to be used in concrete having an exposed aggregate finish.
- 2.05.05 List and explain requirements for satisfactory storage of aggregates.
- 2.05.06 List and describe standard tests for aggregates, and state their limiting values.

- 2.05.07 List the main impurities associated with aggregates for concrete, describe their likely effects on concrete and state their limiting values.
- 2.05.08 Prepare a combined grading curve from two or more aggregate gradings.
- 2.05.09 Explain how changes in aggregate properties can influence the properties of fresh and hardened concrete.
- 2.05.10 Identify magnitude of changes in aggregate quantities likely to cause significant changes in concrete.

2.06 Light-weight and heavy-weight aggregates and concrete

- 2.06.01 Name and recognise types of light-weight and heavy-weight aggregate.
- 2.06.02 State origins of light-weight and heavy-weight aggregate.
- 2.06.03 State reasons for using light-weight and heavy-weight aggregates in concrete and describe typical applications.
- 2.06.04 Compare characteristics of light-weight and heavy-weight aggregates affecting storage, batching and mixing.
- 2.06.05 List and describe the properties of light-weight aggregates and outline their production methods.
- 2.06.06 List the main types of heavy-weight aggregates and state the approximate relative density of each type.

2.07 Admixtures

- 2.07.01 Define and classify types of admixture.
- 2.07.02 Identify safe limiting quantities for dosage of admixtures in common use.
- 2.07.03 Describe the effects on fresh and hardened concrete of the correct use of admixtures and the effects that overdosing would have on these properties.

2.08 Mixing water

- 2.08.01 Describe chemical and physical tests for mixing water for concrete.
- 2.08.02 State why sea water is unsuitable as mixing water for reinforced concrete.

2.09 Steel for reinforcing and prestressing

- 2.09.01 Identify different types of steel reinforcement by visual inspection or description.
- 2.09.02 Define 'yield stress' of steel.
- 2.09.03 Compare important properties of different types of reinforcement.
- 2.09.04 Describe the uses and appearance of different types of reinforcement.
- 2.09.05 List sizes of reinforcement bars available.
- 2.09.06 Describe suitable methods of storing reinforcement bars on site.
- 2.09.07 Identify the condition of reinforcement by visual inspection or description and decide whether it is fit for use.
- 2.09.08 Determine method of dealing with reinforcement in an unsatisfactory condition.
- 2.09.09 Describe methods of bending bars.
- 2.09.10 Identify shapes of bent bars in common use.
- 2.09.11 Describe the application of steel fabric and typical fixing details.
- 2.09.12 Describe methods of fixing and locating reinforcement and state standard tolerances in cutting, bending and locating reinforcement.
- 2.09.13 Describe methods of protecting starter bars.
- 2.09.14 Describe common items of prestressing equipment and state the purpose of their use.
- 2.09.15 Describe and compare the tensile properties of different types of prestressing tendons, and compare them with reinforcing steel.

2.10 Fibre-reinforced concrete

- 2.10.01 Describe the various types of fibrous reinforcing materials, their application and properties in concrete.

2.11 Fresh concrete

- 2.11.01 Define consistence with respect to cohesion, mobility, compactability and flow characteristics.
- 2.11.02 List major factors that influence consistence and surface finish characteristics and their effects.
- 2.11.03 Describe the causes and effects of segregation, bleeding and plastic cracking, and explain how the effects can be reduced.
- 2.11.04 Define the terms 'false set' and 'flash set' and state possible causes.

2.12 Hardened concrete – behaviour under load

- 2.12.01 Define the terms 'stress', 'strain', 'modulus of elasticity' and 'creep', in relation to hardened concrete.
- 2.12.02 Explain the difference between compressive strength, tensile strength and flexural strength and state the relative performance of concrete in each.

2.13 Hardened concrete – dimensional changes

- 2.13.01 Define the terms 'drying shrinkage', 'moisture movement' and 'thermal movement', in relation to hardened concrete.
- 2.13.02 Identify the main factors affecting dimensional changes and state their effects.

2.14 Hardened concrete – durability

- 2.14.01 Explain durability of concrete and its reinforcement and identify major causes of deterioration.
- 2.14.02 Identify important factors affecting the resistance of concrete to abrasion, fire, frost and chemical attack.
- 2.14.03 Identify sources of chlorides and explain their effect on the durability of reinforced concrete and precautions that should be taken in chloride environments.
- 2.14.04 Describe carbonation and explain its effect on the durability of reinforced concrete.
- 2.14.05 Describe the deleterious effects on concrete that can occur in sulfate-bearing ground.
- 2.14.06 Describe the mechanism of alkali silica reaction and the steps detailed in BRE Digest 330 to minimise this effect in concrete.

2.15 Testing concrete

- 2.15.01 Compare consistence test methods, and state why two concretes of the same slump can have different degrees of compactability.
- 2.15.02 State key mechanical and operational factors of compression testing machines and their effects on performance.
- 2.15.03 Describe procedures for testing cubes, cylinders and cores for saturated density and compressive strength of concrete, make calculations and identify abnormal modes of failure.
- 2.15.04 Describe a method of comparing compression testing machines using cubes or cylinders.
- 2.15.05 Describe the method of preparation of cylinders and drilled cores for compression testing.
- 2.15.06 State the necessary properties of materials for capping of cylinders or cores and list suitable materials.
- 2.15.07 Outline the procedure for determining indirect tensile strength.
- 2.15.08 Describe the equipment and procedure for accelerated testing of specimens.
- 2.15.09 Outline a procedure for the rapid analysis of fresh concrete.
- 2.15.10 Assess results of the rapid analysis of fresh concrete.
- 2.15.11 Outline the methods and purpose of common non-destructive tests for hardened concrete.
- 2.15.12 Describe the testing of a structure using a rebound hammer and interpret the results accounting for the type of structure, the number of readings and their location, surface condition and the angle of test.

2.16 Quality control – statistical methods

- 2.16.01 State the principles of quality control for the production of concrete.
- 2.16.02 Define the terms 'mean', 'standard deviation' and coefficient of variation and, given a number a number of results, calculate each of these values, using formulae and graphical methods.
- 2.16.03 Explain the relevance in mix design of 'normal distribution' of concrete strength.
- 2.16.04 Explain why the mean and standard deviation of a set of results may differ from target or assumed values.

2.17 Specification

- 2.17.01 State the purpose and application of designated, designed, prescribed and standardized prescribed concretes, and list the essential requirements to be specified for each.
- 2.17.02 Identify and interpret specification clauses related to materials and mix design.
- 2.17.03 Define the main parameters used for judging conformity for designated, designed, prescribed and standardized prescribed concretes.
- 2.17.04 Describe and operate the procedure for checking the conformity of a designed concrete and state the range of possible actions in the event of non-conformity.

2.18 Mix design

- 2.18.01 Define the terms 'characteristic strength', 'design margin' and 'target mean strength' and explain how they are related.
- 2.18.02 State the factors affecting mix design and make modifications to a design for particular conditions of construction and use.
- 2.18.03 Design concretes of specified strength, of maximum water/cement ratio, minimum and maximum cement content, for conditions of exposure, air entrainment, sulfates in the ground or minimizing the risk of ASR.
- 2.18.04 Design a concrete for a given strength class of concrete using a recognised method.
- 2.18.05 Design a trial mix of concrete given sufficient data.
- 2.18.06 Calculate batch weights given size of mixer, density of fresh concrete and mix proportions by weight, expressed either as ratios or quantities per unit volume.
- 2.18.07 Describe the preparation of a laboratory trial mix, the assessment of the concrete and any necessary adjustment.
- 2.18.08 Calculate quantities of materials for full-scale mixes from trial mix data, from materials properties and specified proportions or quantities.

2.19 Storage, batching and mixing

- 2.19.01 Compare advantages and disadvantages of the main types of batching and mixing plants.
- 2.19.02 Choose suitable type and size of plant for a particular situation, given type of concrete and rate of production required, for common situations only.

- 2.19.03 Describe and sketch storage and plant layout for batching and mixing, given details of output required, situation, ground conditions, access and facilities available for site-mixed, precast and ready-mixed concrete production.
- 2.19.04 Calculate batch weights for a given mixer capacity and stated mix design details.
- 2.19.05 Calculate quantities of materials, delivery rate and storage capacity given concreting programme, mix design data and materials availability including allowances for loss.
- 2.19.06 State factors affecting uniformity of concrete and describe what action may be taken to minimize any problem.

2.20 Concrete production and supply

- 2.20.01 State procedure for dealing with concrete in the event of a change being observed in properties during handling.

2.21 Ready-mixed concrete

- 2.21.01 Compare the basic advantages and economics of site-mixed and ready-mixed concrete.
- 2.21.02 Describe the various methods normally used for producing and supplying ready-mixed concrete and state their relative advantages and applications.
- 2.21.03 State the capacities, total laden weights and dimensions of typical ready-mixed concrete trucks.
- 2.21.04 Describe the normal contractual basis of supply of concrete and the method by which the quantity may be checked.
- 2.21.05 State the procedures to be agreed between purchaser and supplier in the provision of ready-mixed concrete.
- 2.21.06 List essential items of information to be given in an order for ready-mixed concrete.
- 2.21.07 State procedures for the preparation of a site for the receipt of ready-mixed concrete
- 2.21.08 State the intentions and main requirements of a third-party accreditation quality assurance scheme.

2.22 Operation and maintenance of plant

- 2.22.01 Describe the various types of plant available for the production of concrete.
- 2.22.02 State main requirements for setting up and operation of mobile or portable concreting plant and equipment in common use.
- 2.22.03 State procedures for cleaning concreting plant and equipment after use.
- 2.22.04 State procedures for routine maintenance of concreting plant and equipment by the operator.

2.23 Management

- 2.23.01 Name the key management and supervisory positions on a construction contract, in a precast concrete works and in a ready-mixed concrete plant and explain the roles of these personnel.
- 2.23.02 Describe the roles of client, architect, consulting engineer, contractor, specialist sub-contractor, ready-mixed concrete suppliers, precast concrete manufacturer and materials supplier in the performance of a construction contract.
- 2.23.03 Outline a training programme for a testing technician to the level of Paper 1 Concrete Practice.

2.24 Formwork and falsework

- 2.24.01 List and describe the types of materials commonly used in construction of formwork.
- 2.24.02 State the factors that affect the pressure of concrete on formwork and show how the pressures are distributed.
- 2.24.03 State reasons for using each type of material listed in 2.24.01.
- 2.24.04 Describe satisfactory arrangements of formwork for columns, suspended slabs, walls and beams, giving sizes, spacing and disposition of supports.
- 2.24.05 Describe and explain the use of proprietary systems in formwork.
- 2.24.06 Sketch arrangements of formwork to kickers, box-outs and stop ends.
- 2.24.07 Compose pre-pour checklists for columns, slabs, walls and beams.
- 2.24.08 Describe inaccuracy of line and verticality of formwork in relation to specification.
- 2.24.09 Describe types of release agent and their effects on striking and concrete finish.
- 2.24.10 List and explain the factors which govern the minimum striking times for formwork and state minimum striking times for columns, suspended slabs, walls and beam
- 2.24.11 Describe satisfactory condition of formwork for re-use and state procedures for preparing and storing forms for re-use.
- 2.24.12 Describe procedures for handling, storage, maintenance and repair of formwork.

2.25 Reinforced concrete

- 2.25.01 Define and describe compression, tension, shear and bending as applied to beams, slabs and columns under load.
- 2.25.02 Describe and compare the behaviour of plain, reinforced and prestressed concrete beams under load.
- 2.25.03 Make appropriate comparisons between strengths of reinforcement and concrete, and compare the thermal expansions of steel and concrete.
- 2.25.04 State typical strength classes of concrete for reinforced concrete.

- 2.25.05 State the factors that govern the cross-sectional areas of steel and concrete required in a reinforced concrete structural member.
- 2.25.06 Describe and explain reasons for the disposition of reinforcement in beams, slabs, cantilevers, columns and walls, its action in controlling cracking and how bond is developed with concrete.
- 2.25.07 Describe and explain the causes and effects on the durability of concrete of changes in the thickness of concrete cover, the quality of concrete and variation in exposure.
- 2.25.08 Describe the effects of surface geometry (i.e. plain or deformed bars) and the surface condition of steel on its performance as reinforcement.
- 2.25.09 Describe how the position of reinforcement is maintained during concreting.

2.26 Prestressed concrete

- 2.26.01 Distinguish between pre-tensioned and post-tensioned concrete and describe applications of each.
- 2.26.02 Describe the principles of prestressed concrete construction, both pre-tensioned and post-tensioned.
- 2.26.03 State typical strength classes of concrete for prestressing.
- 2.26.04 Outline main methods of prestressing for both pre-tensioned and post-tensioned.
- 2.26.05 Describe common items of prestressing equipment and state the purpose of their use.
- 2.26.06 List precautions to be taken to ensure safe working during stressing operations.
- 2.26.07 State reasons for grouting prestressing ducts and outline method of grouting.

2.27 Precast concrete

- 2.27.01 List and explain the factors affecting the choice between precast and in situ concrete construction.
- 2.27.02 Describe the principal methods and main operations used in precast concrete manufacture and state the applications and advantages of each method.
- 2.27.03 Identify the special requirements for aggregate storage, batching, mixing and handling equipment used in precast concrete production.
- 2.27.04 Describe the methods of mould making and list factors affecting dimensional accuracy
- 2.27.05 Name, list and recognise materials commonly used for moulds for standard precast concrete products. Describe common forms of moulds for standard precast concrete products and state the correct mould from a product specification, selecting the material bearing in mind the number of casts, degree of accuracy required and the production technique.
- 2.27.06 List main methods of compaction used for standard precast concrete products and state reasons for using each method.
- 2.27.07 List main operations in manufacturing and curing processes for standard precast concrete products
- 2.27.08 Describe satisfactory procedures for handling and stacking standard precast concrete products at the works
- 2.27.09 Describe satisfactory procedures for receiving, unloading and storing standard precast concrete products on site.
- 2.27.10 State precautions to be taken to ensure safe working during the handling of precast concrete
- 2.27.11 Outline procedures for receiving, unloading and storing structural precast concrete components on site.
- 2.27.12 Describe methods of erection for columns, beams, slabs, cladding and other units in precast concrete.
- 2.27.13 Describe the materials and components used for fixing, fastening and lifting units.
- 2.27.14 Describe methods of fixing and making connections between precast units and in situ concrete and between precast concrete components
- 2.27.15 Describe the forms of testing carried out on the main types of precast concrete units.

2.28 Transporting and placing

- 2.28.01 Describe principal means of transporting and placing fresh concrete.
- 2.28.02 Compare advantages and disadvantages of each type of equipment in 2.25.01
- 2.28.03 Recognise range of handling capacity for each type of equipment in 2.25.01.
- 2.28.04 Choose suitable type of equipment and method of placing fresh concrete for a particular situation given details of concrete, construction and access, for common situations only.
- 2.28.05 Describe and explain how properties of concrete can be affected during handling, transporting and placing and described and justify suitable methods for typical and special situations.

2.29 Compaction and finishing

- 2.29.01 List and describe principal types of compaction equipment and recognise from visual inspection or description.
- 2.29.02 Compare advantages and disadvantages of each type of equipment listed in 2.25.01.
- 2.29.03 Select the correct vibrating equipment in a given situation and describe its care and maintenance.
- 2.29.04 Describe correct use of immersion, beam and clamp-on vibrators.
- 2.29.05 Describe correct use of pneumatic or electric hammer for vibration of concrete.
- 2.29.06 State the effects of various types of vibration on the design and construction of formwork.
- 2.29.07 State and explain problems likely to be experienced in compacting and finishing special concretes.

2.30 Curing

- 2.30.01 State special requirements which should be taken when concreting in hot or cold weather, including requirements for concrete temperatures.
- 2.30.02 State the main requirements for the protection of concrete during extreme hot or cold conditions.
- 2.30.03 Explain how a delay in curing may cause plastic cracking and state remedies.
- 2.30.04 List and explain the factors which govern the minimum striking times for formwork and state minimum striking times for columns, suspended slabs, walls and beams
- 2.30.05 State the purpose of accelerated curing and describe established methods.

2.31 Joints

- 2.31.01 Describe and sketch details of joints in a concrete structure and state the applications of each type of joint.
- 2.31.02 List items requiring special care and attention in the formation of joints and state likely effects of not taking care.
- 2.31.03 Determine the locations and methods of forming construction joints for a given structure.
- 2.31.04 Describe the satisfactory location of construction joints in walls, slabs, beams and columns.
- 2.31.05 Describe and explain the use of compressible joint fillers, water stops and joint sealing compounds.

2.32 Concrete finishes

- 2.32.01 List the factors to be considered in the production of a concrete required for a given type of finish
- 2.32.02 Recognise the factors necessary to produce direct and indirect surface finishes.
- 2.32.03 Name and describe common types of integral decorative finish to concrete and their method of production.
- 2.32.04 Identify condition of moulds and erected formwork as suitable for achievement of high quality finish.
- 2.32.05 Explain the significance of release agents, striking times and curing on the appearance of concrete finishes.
- 2.32.06 List factors affecting quality of finished surface of concrete and state effects of each.
- 2.32.07 Be familiar with concreting procedures as satisfactory for achievement of high quality finish.
- 2.32.08 Name, identify and explain the occurrence of common defects in concrete surfaces, and describe how to minimise them.

2.33 Concrete roads

- 2.33.01 List the main operations in the construction and curing of concrete pavements.
- 2.33.02 Describe materials used for and compositions of pavement quality concretes.
- 2.33.03 Name the main items of construction equipment for concrete pavements and state their purpose.
- 2.33.04 Distinguish between contraction joints, expansion joints and warping joints and explain their purpose.
- 2.33.05 Identify road forms and joint assemblies
- 2.33.06 State normal thickness of pavement concrete for major and minor roads.
- 2.33.07 Distinguish between different classes of cement-bound materials (CBM) and their possible use in road construction.
- 2.33.08 State the importance of optimum moisture content of CBM.
- 2.33.09 Describe how the density of CBM could be checked on site.
- 2.33.10 State type of reinforcement and its normal position when used in a concrete pavement and state reason for using reinforcement.
- 2.33.11 Name common finishes used for concrete roads and state methods of producing them.

2.34 Ground slabs

- 2.34.01 List main operations in the construction of concrete ground slabs.
- 2.34.02 Describe the main methods of construction for concrete floor slabs and their finishes.
- 2.34.03 State the requirements for suitable materials for sub-grades and sub-bases.
- 2.34.04 State reasons for providing underlay to ground slabs.
- 2.34.05 State the main factors to be considered in determining bay layout.
- 2.34.06 Sketch and explain the standard joints used in floor slabs.
- 2.34.07 Describe construction details for ground slabs at edges and joints.
- 2.34.08 Describe main methods of finishing ground floor slabs.
- 2.34.09 Describe methods of curing floor slabs and concrete finishes and treatment to combat dusting on a concrete floor.
- 2.34.10 Distinguish between levelling screeds and wearing screeds.
- 2.34.11 Describe methods of construction of screed finishes and state application of each.
- 2.34.12 State the mix proportions and uses of floor screeds, the possible causes of failure of screeds and the precautions that can be taken to minimise risk of failure.
- 2.34.13 Name suitable materials and state mix proportions for a wearing screed finish.
- 2.34.14 Outline procedure for applying and finishing wearing screeds.