INSTITUTE OF CONCRETE TECHNOLOGY
CONCRETE TECHNOLOGY & CONSTRUCTION

Stage 2
GENERAL PRINCIPLES

Learning objectives Revision 2 (2015)

2.00.00	**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.
2.01.00	**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.
2.02.00	**Sustainability** 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 Portland cement manufacture. 2.02.03 List alternative fuels that may be used in Portland cement manufacture. 2.02.04 Define 'sustainability' and 'life cycle analysis.' 2.02.05 Explain quality issues of using recycled aggregates. 2.02.06 Explain how concrete admixtures can contribute to sustainability.
2.03.00	**Portland cements and additions** 2.03.01 List the common types of cements and combinations, describe their manufacture and state typical application for each. 2.03.02 Name the four main chemical compounds in Portland cements and compare their effects on the properties of concrete 2.03.03 Define how standards identify the different types of common cement, in respect to 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 fly ash (pulverized-fuel 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.

2.04.00	**Non-Portland cements** 2.04.01 List the common types of non-Portland cements and their principal raw materials. 2.04.02 Explain how these cements work and the precautions to be taken in their use. 2.04.03 Compare the properties of Portland and non-Portland cements. 2.04.04 Describe suitable applications for non-Portland cements.
2.05.00	**Natural, secondary and manufactured aggregates** 2.05.01 Define and describe the formation of igneous, metamorphic and sedimentary rocks, and list common types of each. 2.05.02 Define and describe the sources of secondary and manufactured aggregates and list common types of each. 2.05.03 List the main operations in the extraction and processing of aggregates. 2.05.04 Explain how the source and production of an aggregate influence its physical properties. 2.05.05 State the important requirements for an aggregate which is to be used in concrete having an exposed aggregate finish. 2.05.06 State and explain requirements for satisfactory storage of aggregates. 2.05.07 List and describe standard tests for aggregates and state their limiting values. 2.05.08 List the main impurities associated with aggregates for concrete, describe their likely effects on the concrete and state their limiting values. 2.05.09 Prepare a combined grading curve from two or more aggregate gradings. 2.05.10 Explain how changes in aggregate properties can influence the properties of fresh and hardened concrete. 2.05.11 Identify magnitude of changes in aggregate quantities likely to cause significant changes in the concrete.
2.06.00	**Admixtures** 2.06.01 Define and classify the types of admixtures. 2.06.02 Explain the role of common types of admixtures and when they would be used. 2.06.03 State the requirements for the correct storage and dispensing of admixtures and typical dosage ranges.
2.07.00	**Mixing water** 2.07.01 Describe chemical and physical tests for mixing water for concrete. 2.07.02 State why seawater is unsuitable for mixing water for reinforced concrete.
2.08.00	**Fresh concrete** 2.08.01 Define the rheology of concrete with respect to cohesion, mobility, compactability and flow characteristics. 2.08.02 List the major factors which influence consistence and surface finish characteristics and their effects. 2.08.03 Describe the causes and effects of segregation, bleeding and plastic cracking and explain how the effects can be reduced. 2.08.04 Define the terms ‘false set’ and ‘flash set’ and state possible causes.
2.09.00	**Hardened concrete - behaviour under load** 2.09.01 Define the terms ‘stress’, ‘strain’, ‘modulus of elasticity’ and ‘creep’ in relation to concrete. 2.09.02 Explain the difference between compressive strength, tensile strength and flexural strength and state the relative performance of concrete in each.

2.10.00	**Hardened concrete - dimensional changes** 2.10.01 Define the terms "autogenous shrinkage, drying shrinkage and moisture and thermal movements" in relation to concrete. 2.10.02 Identify the main factors affecting dimensional changes and state their effects and counter measures.
2.11.00	**Hardened concrete - durability** 2.11.01 Explain durability of concrete and its reinforcement and identify the major causes of deterioration. 2.11.02 Identify the important factors affecting the resistance of concrete to abrasion, fire, frost and chemical attack. 2.11.03 Identify sources of chlorides and explain their effect on the durability of reinforced concrete and the precautions that should be taken in chloride environments. 2.11.04 Describe carbonation and explain its effect on the durability of reinforced concrete and the precautions that should be taken to resist this effect and provide good durability. 2.11.05 Describe the deleterious effects on concrete that can occur in sulfate bearing ground and acidic ground, and the precautions which should be taken to resist these effects to ensure good durability. 2.11.06 Describe the mechanism of Alkali Silica Reaction and steps to minimise this effect in concrete.
2.12.00	**Steel for reinforcing and prestressing** 2.12.01 Identify different types of steel reinforcement by visual inspection or description. 2.12.02 Define 'yield stress' of steel 2.12.03 Compare important properties of different types of reinforcement. 2.12.04 Describe the uses and appearance of different types of reinforcement. 2.12.05 List sizes of reinforcement bars available. 2.12.06 Describe suitable methods of storing reinforcement bars on site. 2.12.07 Identify condition of reinforcement by visual inspection or from description and decide whether it is fit for use. 2.12.08 Determine method of dealing with reinforcement in an unsatisfactory condition. 2.12.09 Describe methods of bending bars. 2.12.10 Identify shapes of bent bars in common use. 2.12.11 Describe the application of steel fabric and typical fixing details. 2.12.12 Describe methods of fixing and locating reinforcement and state standard tolerances in cutting, bending and locating reinforcement. 2.12.13 Describe methods of protecting reinforcement and starter bars and discuss the pros and cons of protection. 2.12.14 Describe common items of pre-stressing equipment and state the purpose of their use. 2.12.15 Describe and compare the tensile properties of different types of pre-stressing tendons, and compare them with reinforcing steel. 2.12.16 Indicate special reinforcements such as loops and rings.
2.13.00	**Reinforced concrete** 2.13.01 Define and describe 'compression', 'tension', 'shear' and 'bending' as applied to beams, slabs and columns under load. 2.13.02 Describe and compare the behaviour of plain, reinforced and prestressed concrete beams under load. 2.13.03 Make appropriate comparisons between strengths of reinforcement and concrete, and compare the thermal expansions of steel and concrete. 2.13.04 State typical strength classes of concrete for reinforced concrete.

	2.13.05 State the factors that govern the cross-sectional areas of steel and concrete required in a reinforced concrete structural member. 2.13.06 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 within concrete. 2.13.07 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. 2.13.08 Describe the effects of surface geometry (i.e. plain or deformed bars) and the surface condition of steel on its performance as reinforcement. 2.13.09 Describe how the position of reinforcement is maintained during concreting.
2.14.00	**Prestressed concrete** 2.14.01 Distinguish between pre-tensioned and post-tensioned concrete and describe applications of each. 2.14.02 Describe the principles of prestressed concrete construction, both pre-tensioned and post-tensioned. 2.14.03 State typical strength classes of concrete for prestressing. 2.14.04 Outline main methods of prestressing for both pre-tensioned and post-tensioned. 2.14.05 Describe common items of prestressing equipment and state the purpose of their use. 2.14.06 List precautions to be taken to ensure safe working during stressing operations. 2.14.07 State reasons for grouting prestressing ducts and outline method of grouting.
2.15.00	**Fibre-reinforced concrete** 2.15.01 Describe the various types of fibrous reinforcing materials, their application and properties in concrete.
2.16.00	**Lightweight and heavy-weight aggregates** 2.16.01 Name and recognise types of lightweight and heavy-weight aggregate. 2.16.02 State origins of lightweight and heavy-weight aggregate. 2.16.03 State reasons for using lightweight and heavy-weight aggregates in concrete and describe typical applications. 2.16.04 Compare characteristics of lightweight and heavy-weight aggregates affecting storage, batching and mixing. 2.16.05 List and describe the properties of lightweight aggregates and outline their production methods. 1.16.06 List the main types of heavy-weight aggregates and state the approximate relative density of each type.
2.17.00	**Testing fresh and hardened concrete** 2.17.01 Compare consistence test methods, and state why two concretes of the same slump can have different degrees of compactability. 2.18.02 Describe and compare test methods for the plastic properties of self-compacting concrete. 2.17.03 State key mechanical and operational factors of compression testing machines and their effects on performance. 2.17.04 Describe procedures for testing cubes, cylinders and cores for saturated density and compressive strength of concrete, make calculations and identify abnormal modes of failure. 2.17.05 Describe a method of comparing compression testing machines using cubes or cylinders. 2.17.06 Describe the method of preparation of cylinders and drilled cores for compression testing. 2.17.07 State the necessary properties of materials for capping of cylinders or cores and list suitable materials. 2.17.08 Outline the procedure for determining tensile splitting strength. 2.17.09 Outline the methods and purpose of common non-destructive tests for hardened concrete.

	2.17.10 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.
2.18.00	**Quality control – statistical methods** 2.18.01 State the principles of quality control for the production of concrete. 2.18.02 Define the terms 'mean', 'standard deviation' and 'coefficient of variation' and, given a number of results, calculate each of these values using formulae and graphical methods. 2.18.03 Explain the relevance in mix design of 'normal distribution' of concrete strength. 2.18.04 Explain why the mean and standard deviation of a set of results may differ from target or assumed values.
2.19.00	**Specification** 2.19.01 Explain the role of standards in concrete specification. 2.19.02 Identify and interpret specification clauses related to materials and mix design. 2.19.03 Define the main parameters used for judging conformity for designated, designed, prescribed and standardized prescribed concretes. 2.19.04 Describe proprietary concrete and how it is specified. 2.19.05 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.
2.20.00	**Mix design** 2.20.01 Define the terms 'characteristic strength', 'design margin' and 'target mean strength' and explain how they are related. 2.20.02 State the factors affecting mix design and make modifications to a design for particular conditions of construction and use. 2.20.03 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. 2.20.04 Design a concrete for a given strength class of concrete using a recognised method. 2.20.05 Design a trial mix of concrete given sufficient data. 2.20.06 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. 2.20.07 Describe the preparation of a laboratory trial mix, the assessment of the concrete and any necessary adjustment. 2.20.08 Calculate quantities of materials for full-scale mixes from trial mix data, from materials properties and specified proportions or quantities.
2.21.00	**Storage, batching and mixing** 2.21.01 Compare advantages and disadvantages of the main types of batching and mixing plants. 2.21.02 Choose suitable type and size of plant for a particular situation, given type of concrete and rate of production required, for common situations only. 2.21.03 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. 2.21.04 Calculate batch weights for a given mixer capacity and stated mix design details. 2.21.05 Calculate quantities of constituent materials, delivery rate and storage capacity given concreting programme, mix design data and materials availability including allowances for loss. 2.21.06 State factors affecting uniformity of concrete and describe what action may be taken to minimize any problem.

2.22.00	**Concrete production and supply** 2.22.01 State procedure for dealing with concrete in the event of a change being observed in properties during handling.
2.23.00	**Ready-mixed concrete** 2.23.01 Compare the basic advantages and economics of site-mixed and ready-mixed concrete. 2.23.02 Describe the various methods normally used for producing and supplying ready-mixed concrete and state their relative advantages and applications. 2.23.03 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. 2.23.04 State the procedures to be agreed between purchaser and supplier in the provision of ready-mixed concrete. 2.23.05 List essential items of information to be given in an order for ready-mixed concrete. 2.23.06 State procedures for the preparation of a site for the receipt of ready-mixed concrete 2.23.07 State the intentions and main requirements of a third-party accreditation quality assurance scheme.
2.24.00	**Precast concrete** 2.24.01 List and explain the factors affecting the choice between precast and in situ concrete construction. 2.24.02 Describe the principal methods and main operations used in precast concrete manufacture and state the applications and advantages of each method. 2.24.03 Identify the special requirements for aggregate storage, batching, mixing and handling equipment used in precast concrete production. 2.24.04 Describe the methods of mould making and list factors affecting dimensional accuracy 2.24.05 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. 2.24.06 List main methods of compaction used for standard precast concrete products and state reasons for using each method. 2.24.07 List main operations in manufacturing and curing processes for standard precast concrete products. 2.24.08 Describe satisfactory procedures for handling and stacking standard precast concrete products at the works. 2.24.09 Describe satisfactory procedures for receiving, unloading and storing standard precast concrete products on site. 2.24.10 State precautions to be taken to ensure safe working during the handling of precast concrete 2.24.11 Outline procedures for receiving, unloading and storing structural precast concrete components on site. 2.24.12 Describe methods of erection for columns, beams, slabs, cladding and other units in precast concrete. 2.24.13 Describe the materials and components used for fixing, fastening and lifting units. 2.24.14 Describe methods of fixing and making connections between precast units and in situ concrete and between precast concrete components 2.24.15 Describe the forms of testing carried out on the main types of precast concrete units.
2.25.00	**Operation and maintenance of plant** 2.25.01 Describe the various types of plant available for the production of concrete.

	2.25.02 State main requirements for setting up and operation of mobile or portable concreting plant and equipment in common use. 2.25.03 State procedures for cleaning concreting plant and equipment after use. 2.25.04 State procedures for routine maintenance of concreting plant and equipment by the operator.
2.26.00	**Formwork and falsework** 2.26.01 List and describe the types of materials commonly used in construction of formwork. 2.26.02 State the factors that affect the pressure of concrete on formwork and show how the pressures are distributed. 2.26.03 State reasons for using each type of material listed in 2.26.01. 2.26.04 Describe satisfactory arrangements of formwork for columns, suspended slabs, walls and beams, giving sizes, spacing and disposition of supports. 2.26.05 Describe and explain the use of proprietary systems in formwork. 2.26.06 Sketch arrangements of formwork to kickers, box-outs and stop ends. 2.26.07 Compose pre-pour checklists for columns, slabs, walls and beams. 2.26.08 Describe inaccuracy of line and verticality of formwork in relation to specification. 2.26.09 Describe types of release agent and their effects on striking and concrete finish. 2.26.10 List and explain the factors which govern the minimum striking times for formwork and state minimum striking times for columns, suspended slabs, walls and beams. 2.26.11 Describe satisfactory condition of formwork for re-use and state procedures for preparing and storing forms for re-use. 2.26.12 Describe procedures for handling, storage, maintenance and repair of formwork.
2.27.00	**Transporting and placing** 2.27.01 Describe principal means of transporting and placing fresh concrete. 2.27.02 Compare advantages and disadvantages of each type of equipment in 2.27.01. 2.27.03 Recognise range of handling capacity for each type of equipment in 2.27.01. 2.27.04 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. 2.27.05 Describe and explain how properties of concrete can be affected during handling, transporting and placing and describe and justify suitable methods for typical and special situations, including re-tempering and on-site adjustments.
2.28.00	**Compaction and finishing** 2.28.01 List and describe principal types of compaction equipment and recognise from visual inspection or description. 2.28.02 Compare advantages and disadvantages of each type of equipment listed in 2.28.01. 2.28.03 Select the correct vibrating equipment in a given situation and describe its care and maintenance. 2.28.04 Describe correct use of immersion, beam and clamp-on vibrators. 2.28.05 Describe correct use of pneumatic or electric hammer for vibration of concrete. 2.28.06 State the effects of various types of vibration on the design and construction of formwork. 2.28.07 State and explain problems likely to be experienced in compacting and finishing special concretes.
2.29.00	**Concrete finishes** 2.29.01 List the factors to be considered in the production of a concrete required for a given type of finish. 2.29.02 Recognise the factors necessary to produce direct and indirect surface finishes. 2.29.03 Name and describe common types of integral decorative finish to concrete and methods of production. Cont.

	2.29.04 Identify condition of moulds and erected formwork as suitable for achievement of high quality finish. 2.29.05 Explain the significance of release agents, striking times and curing on the appearance of concrete finishes. 2.29.06 List factors affecting quality of finished surface of concrete and state effects of each. 2.29.07 Be familiar with concreting procedures as satisfactory for achievement of high quality finish. 2.29.08 Name, identify and explain the occurrence of common defects in concrete surfaces, and describe how to minimise them.
2.30.00	**Curing** 2.30.01 List common methods of curing. 2.30.02 State special requirements which should be taken when concreting in hot or cold weather, including requirements for concrete temperatures. 2.30.03 State the main requirements for the protection of concrete during extreme hot or cold conditions. 2.30.04 Explain how a delay in curing may cause plastic cracking and state remedies. 2.30.05 State the purpose of accelerated curing and describe established methods.
2.31.00	**Ground slabs** 2.31.01 List main operations in the construction of concrete ground slabs. 2.31.02 Describe the main methods of construction for concrete floor slabs and their finishes. 2.31.03 State the requirements for suitable materials for sub-grades and sub-bases. 2.31.04 State reasons for providing underlay to ground slabs. 2.31.05 State the main factors to be considered in determining bay layout. 2.31.06 Sketch and explain the standard joints used in floor slabs. 2.31.07 Describe construction details for ground slabs at edges and joints. 2.31.08 Describe main methods of finishing ground floor slabs, including power floating. 2.31.09 Describe methods of curing floor slabs and concrete finishes and treatment to combat dusting on a concrete floor. 2.31.10 Distinguish between a screed and a slab.
2.32.00	**Joints** 2.32.01 Describe and sketch details of joints in a concrete structure and state the applications of each type of joint. 2.32.02 List items requiring special care and attention in the formation of joints and state likely effects of not taking care. 2.32.03 Determine the locations and methods of forming construction joints for a given structure. 2.32.04 Describe the satisfactory location of construction joints in walls, slabs, beams and columns. 2.32.05 Describe and explain the use of compressible joint fillers, water stops and joint sealing compounds.
2.33.00	**Management** 2.33.01 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. 2.33.02 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. 2.33.03 Outline a training programme for a testing technician to such a level as Stage 1 Concrete Practice.

END OF STAGE 2