UNIT 521: DESIGN OF STRUCTURAL ELEMENTS

Lesson 1: Identify the materials used for structural elements **Suggested Teaching Time:** 4 hours

Learning Outcome: Know the factors that affect the design of structural elements

Topic	Suggested Teaching	Suggested Resources
Identify the materials used for structural elements (AC1.1)	• A whole-class discussion should be used to identify the materials that are used for structural purposes in civil engineering. This could be done using photographs and other images, specifications, the internet and site visits. • The class should be split into four small groups, with each group researching one of the four main classes of material used in structural elements (steel, reinforced concrete, masonry and timber). The groups should focus on where each is used, the properties that make each material useful in a given situation and the limitations on the use of each. Each group should make a short presentation of their findings and be prepared to answer questions. • The tutor should build upon the above presentations to demonstrate the advantages and disadvantages of the use of each material for a range of structural elements including beams (including cantilevers), columns, frames, slabs and walls (including retaining walls). • Learners should compile a table showing the outcomes of the above discussion. This table should show materials horizontally and structural elements vertically, with a cross to indicate where each material can be used.	**Books:** *Design of Structural Elements: Concrete, Steelwork, Masonry & Timber Designs to British Standards and EU Codes*, 3rd edition (CRC Press, 2009) ISBN: 0415467209 **Software:** Goya Siemens PLM RISA Technology ANSYS **Website:** www.istructe.org

UNIT 521: DESIGN OF STRUCTURAL ELEMENTS

Lesson 2: Guidance on the factors that affect the use of materials **Suggested Teaching Time:** 4 hours

Learning Outcome: Know the factors that affect the design of structural elements

Topic	Suggested Teaching	Suggested Resources
Guidance on the factors that affect the use of materials (AC 1.2)	• Learners must be given access to a wide range of current codes of practice, design guides and software applications. They must discuss the nature of each to determine whether the contents of each are mandatory, advisory or simply of help in the design process. • The class should be split into small groups, with each group researching a different source of the information used in the design process. The groups should focus on where each is used, the nature of the advice given and the limitations on the use of each. Each group should make a short presentation of their findings and be prepared to answer questions. • The above discussion should be supported by an incomplete hand-out for the learners to complete during the discussion. This should relate the sources of information that have been researched to the various factors used in design. These should include loadings (dead, imposed, wind), pressures (earth, water), limit states, load factors, materials factors, design strengths, sectional properties, stability, durability and fire protection issues. • The tutor should lead the learners to an understanding of where to go for the information they will need, and the importance of using the information as indicated. The tutor should collect the hand-outs and amend each as appropriate in order to embed the concepts in the learners' understanding.	**Books:** *Design of Structural Elements: Concrete, Steelwork, Masonry & Timber Designs to British Standards and EU Codes*, 3rd edition (CRC Press, 2009) ISBN: 0415467209 **Software:** Goya Siemens PLM RISA Technology ANSYS **Website:** www.istructe.org

UNIT 521: DESIGN OF STRUCTURAL ELEMENTS

Lesson 3: Factors that affect the design of steel beams, steel columns and slabs and built up bases **Suggested Teaching Time:** 8 hours

Learning Outcome: Understand how the factors affect the design of structural elements

Topic	Suggested Teaching	Suggested Resources
Factors that affect the design of steel beams, steel columns and slabs and built up bases (AC 2.1)	• The tutor should now build upon the learning contained in Lesson 2, and differentiate between the factors that affect the design of structural elements in general and those that affect specific forms of structural element. • This may involve reference to concepts already covered in Unit 441: Structural Mechanics, and may require a certain degree of revision of these concepts. An incomplete hand-out should be used to save time and to maximise the learners' involvement. It may be necessary to devote some time to reinforcing the concepts and linking formulae with their purpose and the order in which they are to be used in the design of structural elements. • The general factors are indicated above. These must be linked to the following, as and where necessary, and be supported by suitable diagrams. • Steel beams: loadings, steel grades, ultimate bending stresses for degree of restraint, bending shear, deflection, bearing, web buckling. • Steel columns: end fixity, effective length, radius of gyration, slenderness ratio, steel grades, ultimate load capacity. • Slabs and built up bases: ground loadings, base size, base plates (thickness, holding down bolts, shaft end specification, fire protection). • Exemplar material should be used to embed the factors that must be either known, or available from tables, or calculated, in order to do design.	**Books:** *Design of Structural Elements: Concrete, Steelwork, Masonry & Timber Designs to British Standards and EU Codes*, 3rd edition (CRC Press, 2009) ISBN: 0415467209 **Software:** Goya Siemens PLM RISA Technology ANSYS **Website:** www.istructe.org

UNIT 521: DESIGN OF STRUCTURAL ELEMENTS

Lesson 4: Factors that affect the design of reinforced concrete slabs, beams and columns

Suggested Teaching Time: 8 hours

Learning Outcome: Understand how the factors affect the design of structural elements

Topic	Suggested Teaching	Suggested Resources
Factors that affect the design of reinforced concrete slabs, beams and columns (AC 2.2)	• The tutor should now build upon the learning contained in Lesson 2, and differentiate between the factors that affect the design of structural elements in general and those that affect specific forms of structural element. • This may involve reference to concepts already covered in Unit 441: Structural Mechanics, and may require a certain degree of revision of these concepts. An incomplete hand-out should be used to save time and to maximise learners' involvement. Relevant formulae and diagrams needed. • The general factors are indicated earlier. These must be linked to the following, as and where necessary, and be supported by suitable diagrams. • Reinforced concrete slabs: loadings, concrete (mixes, strength) steel (types, strength), bending, shear, deflection, curtailment, bond, steel area (max and min), slab details. • Beams: reinforced concrete loadings, concrete (mixes, strength) steel (types, strength), bending, shear, deflection, bond, curtailment, steel areas (max and min), links, built up shear reinforcement. • Columns: reinforced concrete braced members, influence of end condition, slenderness ratio limits (short columns), minimum eccentricity, steel reinforcement, steel areas (max and min), linker enforcement, column details • Exemplar material should be used to embed the factors that must be either known, or available from tables, or calculated, in order to do design.	**Books:** *Design of Structural Elements: Concrete, Steelwork, Masonry & Timber Designs to British Standards and EU Codes*, 3rd edition (CRC Press, 2009) ISBN: 0415467209 **Software:** Goya Siemens PLM RISA Technology ANSYS **Website:** www.istructe.org

UNIT 521: DESIGN OF STRUCTURAL ELEMENTS

Lesson 5: Factors that affect the design of masonry walls **Suggested Teaching Time:** 6 hours

Learning Outcome: Understand how the factors affect the design of structural elements

Topic	Suggested Teaching	Suggested Resources
Factors that affect the design of masonry walls (AC 2.3)	• The tutor should now build upon the learning contained in Lesson 2, and differentiate between the factors that affect the design of structural elements in general and those that affect specific forms of structural element. • This may involve reference to concepts already covered in Unit 441: Structural Mechanics, and may require a certain degree of revision of these concepts. An incomplete hand-out should be used to save time and to maximise learners' involvement. Relevant formulae and diagrams needed. • The general factors are indicated earlier. These must be linked to the following, as and where necessary, and be supported by suitable diagrams. • Solid masonry walls: mortar strengths, restraints, effective length, effective height, effective width, slenderness ratio, capacity reduction factor, ultimate load capacity/metre. • Cavity masonry walls: ultimate loadings, effective height, effective length, effective thickness, lateral support, slenderness ratio, capacity reduction factor, eccentricity ratio, ultimate load capacity/metre. • Exemplar material should be used to embed the factors that must be either known, or available from tables, or calculated, in order to do design.	**Books:** *Design of Structural Elements: Concrete, Steelwork, Masonry & Timber Designs to British Standards and EU Codes*, 3rd edition (CRC Press, 2009) ISBN: 0415467209 **Software:** Goya Siemens PLM RISA Technology ANSYS **Website:** www.istructe.org

UNIT 521: DESIGN OF STRUCTURAL ELEMENTS

Lesson 6: Factors that affect the design of timber beams and columns **Suggested Teaching Time:** 6 hours

Learning Outcome: Understand how the factors affect the design of structural elements

Topic	Suggested Teaching	Suggested Resources
Factors that affect the design of timber beams and columns (AC 2.4)	• The tutor should now build upon the learning contained in Lesson 2, and differentiate between the factors that affect the design of structural elements in general and those that affect specific forms of structural element. • This may involve reference to concepts already covered in Unit 441: Structural Mechanics, and may require a certain degree of revision of these concepts. An incomplete hand-out should be used to save time and to maximise learners' involvement. Relevant formulae and diagrams needed. • The general factors are indicated earlier. These must be linked to the following, as and where necessary, and be supported by suitable diagrams. • Timber beams: joists as beams - material (type, size, grading, associated strength), influence of 'K' factors, bending, shear, deflection, bearing. • Timber columns: struts in roofs and stud walls - timber grade, permissible compressive strength, end conditions, effective length, slenderness ratio, modification factor for compression, ratio of modulus of elasticity to compressive stress. • Exemplar material should be used to embed the factors that must be either known, or available from tables, or calculated, in order to do design.	**Books:** *Design of Structural Elements: Concrete, Steelwork, Masonry & Timber Designs to British Standards and EU Codes*, 3rd edition (CRC Press, 2009) ISBN: 0415467209 **Software:** Goya Siemens PLM RISA Technology ANSYS **Website:** www.istructe.org

UNIT 521: DESIGN OF STRUCTURAL ELEMENTS

Lesson 7: Designing structural elements

Suggested Teaching Time: 18 hours

Learning Outcome: Be able to design structural elements to agreed specifications

Topic	Suggested Teaching	Suggested Resources
Designing structural elements (AC 3.1, 3.2, 3.3, 3.4, 3.5)	• In a sense, the learning has been done in earlier lessons. The materials, general design factors, specific design factors and properties of sections should be generally understood. • The learners should have access to a wide range of current codes of practice and design guides, and know how and when to use each of these. • Exemplar design calculations should be made available for all of the tasks indicated below, with all relevant diagrams clearly linked to the designs. • The learners must attempt to complete the design calculations for all of the structural elements listed below. These should be checked and amended by the tutor as appropriate, and where there are substantial errors the learners must repeat the calculations for a different specification. This iterative process should only end when each learner achieves a correct design. • The tutor should demonstrate the use of software applications designed to solve the problems that the students have been addressing. The learners may use these when they are competent to do so. The software programmes should only be sued to check the learners' design calculation, which must have been done without recourse to such applications. • Where there are clear differences between a learner's answers and that provided by the software, this should be used as a basis for discussion and improvement.	**Books:** *Design of Structural Elements: Concrete, Steelwork, Masonry & Timber Designs to British Standards and EU Codes*, 3rd edition (CRC Press, 2009) ISBN: 0415467209 **Software:** Goya Siemens PLM RISA Technology ANSYS **Website:** www.istructe.org

UNIT 521: DESIGN OF STRUCTURAL ELEMENTS

Lesson 7: Designing structural elements (continued)

Suggested Teaching Time: (included in 18 hours for Lesson 7)

Learning Outcome: Be able to design structural elements to agreed specifications

Topic	Suggested Teaching	Suggested Resources
Designing structural elements (continued) (AC 3.1, 3.2, 3.3, 3.4, 3.5)	• The tutor must produce realistic specifications to allow the learners to design the following structural elements. • All relevant drawings, tables, codes of practice and formulae to be provided. • Steel beams (restrained, unrestrained). • Steel columns (universal columns, both axial loads and eccentric loads). • Slabs and built-up bases for axially loaded columns. • Reinforced concrete slabs (solid), singly reinforced beams, short columns, both axial and eccentric loads). • Solid walls, axially loaded. • Cavity walls, eccentrically loaded. • Timber joists, given loadings and span conditions. • Timber struts, axially loaded, acting in typical roof truss or vertically in a stud wall, given length and end conditions.	**Books:** *Design of Structural Elements: Concrete, Steelwork, Masonry & Timber Designs to British Standards and EU Codes*, 3rd edition (CRC Press, 2009) ISBN: 0415467209 **Software:** Goya Siemens PLM RISA Technology ANSYS