Unit 31: Advanced Structural Design

Level: **5**

Credits: **15**

Ofqual Code: **M/618/8107**

Introduction

With the development of new materials and processes, along with technologies that allow us to design and model more complex structures, the influence on structural design has become increasingly challenging. The ability to conceive and accurately model complex buildings, bridges, roads and other types of structure, pushes both the aesthetic and technical envelope in which structural and civil engineers now operate.

In managing the design and construction of modern structures, the civil or structural engineer must be able to carry out increasingly complex calculations, dealing with dynamic conditions, while maintaining an awareness of the overall design intention.

Extending areas of study from *Unit 19: Principles of Structural Design*, this unit will support students to extend their ability to design, test and quantify more complex structural conditions.

Learning Outcomes

By the end of this unit, students will be able to:

LO1 Explain strategies to resist deflection due to wind loadings on fixed structures

LO2 Determine bending, shear and deflection for complex support conditions

LO3 Design complex columns and piled foundations based on calculation

LO4 Explore the design of tensile structures.

Essential Content

LO1 **Explain strategies to resist deflection due to wind loadings on fixed structures**

Wind loading

Calculating wind loading

Wind loading on tall buildings

Shear forces

Lateral load

Uplift load

Torsional load

Managing wind loading

Building form

Stiffening

LO2 **Determine bending, shear and deflection for complex support conditions**

Bending

Supported timber beams

Steel cantilever beams

Reinforced concrete cantilevers

Steel three-pin frames

Shear

Supported timber beams

Steel three-pin frames

Deflection

Supported timber beams with point loads and uniformly distributed loading

Steel cantilever beams with point loads and uniformly distributed loading

Reinforced concrete cantilever beams with point loads and uniformly distributed loading

Structural connections

Beam-to-beam connections

Beam-to-column connections

Types of connection

Bolt fixings

Welded connections

Fin plates

Splices

Bracing connections

LO3 **Design complex columns and piled foundations based on calculation**

Axial loading

Carrying capacity of timber columns

Carrying capacity of reinforced concrete piled foundations

Carrying capacity of steel piled foundations

Eccentric loading

Buckling

Stress

Piled foundations

End bearing piles

Friction piles

Sheet piles

Micropiling

Helical piles

Structural design information

CAD drawings

Building Information Modelling (BIM)

Calculations

LO4 **Explore the design of tensile structures**

Linear structures

Suspension bridges

Cable-stayed beams/trusses

Three-dimensional structures

Tensegrity structures

Tensairity structures

Surface-stressed structures

Pre-stressed membranes

Gridshell

Fabric structure

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explain strategies to resist deflection due to wind loadings on fixed structures		
P1 Calculate wind loads on fixed structures. **P2** Discuss methods to resist or manage wind loading.	**M1** Analyse the relationship between building form and wind loading.	**D1** Calculate and size the type of lateral stiffening required to resist wind loading for a given structure.
LO2 Determine bending, shear and deflection for complex support conditions		
P3 Calculate bending and shear in complex support conditions. **P4** Determine deflection in complex support conditions.	**M2** Evaluate structural connections in relation to complex support conditions.	**D2** Critically analyse the use of different materials to determine their structural efficiency in managing bending, shear and deflection.
LO3 Design complex columns and piled foundations based on calculation		
P5 Calculate the axial load-carrying capacity of complex columns, with eccentric loading and reinforced concrete piled foundations. **P6** Prepare design information for a structure utilising piled foundations and steel columns.	**M3** Discuss the benefits of using Building Information Modelling (BIM) in the structural design workflow.	**D3** Assess the most effective foundation type for a given scenario in terms of ease and speed of construction, economics, safety and environmental factors.
LO4 Explore the design of tensile structures		
P7 Discuss the differences between types of tensile structures. **P8** Design a simple tensile structure for a given scenario.	**M4** Compare tensile structural solutions to a given scenario.	**D4** Using research and calculations, justify the choice of a tensile structure solution for a given scenario.

Recommended Resources

Print resources

COBB, F. (2020), *Structural Engineer's Pocket Book British Standards Edition,* CRC Press

HULSE, R., CAIN, J. (2009), *Structural Mechanics: Worked Example*s, Macmillan International Higher Education

MCKENZIE, W. (2015), *Design of Structural Elements,* Macmillan International Higher Education

MOSLEY, W., HULSE, R., BUNGEY, J. (2012), *Reinforced Concrete Design*, Macmillan International Higher Education

NAGEIM, H., DURKA, F. (2003), *Structural Mechanics*, Pearson Education

OZELTON, E., BAIRD, J. (2008), *Timber Designers' Manual*, John Wiley & Sons

REYNOLDS, C., STEEDMAN, J., THRELFALL, A. (2007), *Reinforced Concrete Designer's Handbook*, Eleventh Edition, CRC Press

SEWARD, D. (2014), *Understanding Structures*, Macmillan International Higher Education

Links

This unit links to the following related units:

- Unit 2: Construction Technology
- Unit 3: Science & Materials
- Unit 7: Surveying, Measuring & Setting-out
- Unit 8: Mathematics for Construction
- Unit 13: Building Information Modelling
- Unit 19: Principles of Structural Design
- Unit 21: Geotechnics & Soil Mechanics
- Unit 26: Digital Applications for Building Information Modelling
- Unit 29: Contracts & Management
- Unit 30: Project Management
- Unit 33: Construction Technology for Complex Buildings Projects
- Unit 34: Further Mathematics for Construction
- Unit 41: Highway Engineering
- Unit 42: Hydraulics
- Unit 45: Advanced Materials
- Unit 47: Advanced Building Information Modelling.