Unit 19: Principles of Structural Design

Level: **4**

Credits: **15**

Ofqual Code: **D/618/8099**

Introduction

Buildings, bridges, roads and many other types of man-made structures are critical to the economic and social wellbeing of our society. We rely on these structures to provide us with suitable spaces and infrastructure to support our daily lives. In this unit, students will explore the fundamental principles of structural design, codes of practice and standards required to construct safe, effective static structures commonly used in today's building and infrastructure projects.

Topics included in this unit are: methods and techniques used to determine bending moments and shear forces in simply supported steel and reinforced concrete beams; deflection in simply supported steel beams; axial load carrying capacity of steel and reinforced concrete columns.

On successful completion of this, unit students will be able to determine and analyse forces within fixed structures and understand the fundamental concepts of structural design.

Learning Outcomes

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

LO1 Calculate bending moments and shear forces for simply supported steel and concrete beams

LO2 Determine deflection for different types of beams and loading conditions

LO3 Calculate the axial load carrying capacity of steel and reinforced concrete columns

LO4 Explore design methods for steel, reinforced concrete beams and columns.

Essential Content

LO1 **Calculate bending moments and shear forces for simply supported steel and concrete beams**

Loading

Dead loads

Live loads

Wind loads

Point loads

Uniformly distributed loads

Elasticity and plasticity of common construction materials

Factors of safety

Building regulations

Health and safety regulations

Bending moments

Bending moment diagrams

Shear forces

Shear force diagrams

LO2 **Determine deflection for different types of beams and loading conditions**

Types of beam

Simply supported

Cantilevered

Continuous

Fixed

Loading conditions

Uniformly distributed loads

Point loads

Deflection

Unit of deflection

Cantilever deflection

Simply supported deflection

LO3 **Calculate the axial load carrying capacity of steel and reinforced concrete columns**

Axial loading

Steel columns

Reinforced concrete columns

Foundations

Slenderness ratio

Effective length

Material properties

Corrosion resistance

Weathering

LO4 **Explore design methods for steel, reinforced concrete beams and columns**

Limit state design

Steel

Beam design and selection

Column design and selection

Reinforced concrete

Beam design and selection

Column design and selection

Building Information Modelling (BIM) for structures

Collaboration (e.g., roles, workflows, professional relationships)

Coordination (e.g., information coordination, information sharing, clash detection)

Common Data Environment

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Calculate bending moments and shear forces for simply supported steel and concrete beams		
P1 Determine the following by calculations and diagrams: bending moments and shear force in simply supported steel beams with point loads and uniformly distributed loads. **P2** Discuss the statutory requirements to ensure safety in structural designs.	**M1** Produce valid factors of safety for live loads, dead loads and imposed loads, using current codes of practice and building regulations.	**D1** Evaluate how maximum bending moments determine steel beam selection, using current codes of practice and approved documents in terms of economics and safety.
LO2 Determine deflection for different types of beams and loading conditions		
P3 Calculate the deflection for different types of beam under different loading conditions. **P4** Explain how deflection in beams affects structural stability.	**M2** Analyse different support methods and their effect on deflection in fixed structures.	**D2** Assess the most effective support method for a given scenario, in terms of ease and speed of construction, economics, safety and environmental factors.
LO3 Calculate the axial load carrying capacity of steel and reinforced concrete columns		
P5 Describe the concepts of slenderness ratio and effective length. **P6** Determine the axial load-carrying capacity of steel columns and reinforced concrete columns.	**M3** Analyse the load-carrying capacity, size, weight and corrosion resistance properties of different materials used for beams and columns in fixed structures.	
LO4 Explore design methods for steel, reinforced concrete beams and columns		
P7 Develop a design solution, including beam design and column design, for a given scenario. **P8** Produce drawings and specifications in support of a structural design solution.	**M4** Evaluate the use of an alternative material in achieving a design solution, discussing the benefits or challenges associated with it.	**D3** Assess the use of Building Information Modelling in the production of accurate structural design information and the collaborative environment of structural design.

Recommended Resources

Print resources

ARYA, C. (2009), *Design of Structural Elements*, CRC Press

BHATT, P., MACGINLEY, T., CHOO, B. (2014), *Reinforced Concrete Design to Eurocodes*, CRC Press

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

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 Structur*es, Macmillan International Higher Education

SMITH, P. (2001), *An Introduction to Structural Mechanics*, Macmillan International Higher Education

SOMAYAJI, S. (2001), *Civil Engineering Materials*, Pearson College Division

Web resources

https://bit.ly/3BVZZ7y	**Chartered Institution of Civil Engineering Surveyors** (Professional Body)
https://bit.ly/3fsrTP1	**Institution of Civil Engineers** (Professional Body)
https://bit.ly/3rI3WrR	**International Association for Bridge and Structural Engineering** (Professional Body)
https://bit.ly/3fbUjwj	**The Institution of Structural Engineers** (Professional Body)