Unit 51: Civil Engineering Construction

Unit code: L/600/0368

QCF Level 3: BTEC Nationals

Credit value: 10

Guided learning hours: 60

Aim and purpose

The aim of this unit is to enable learners to gain a knowledge of earthwork activities and an understanding of methods and techniques used in substructures and superstructures, including the hazards and risks involved in civil engineering construction activities.

Unit introduction

The civil engineering industry requires a highly skilled workforce that is technologically, mathematically and scientifically competent. Civil engineering construction underpins all civil engineering activities. Construction is at the centre of the civil engineering profession and has a long and distinguished history dating from Roman times through to the great engineering feats of Britain's industrial revolution. The content of this unit has been designed specifically to focus on civil engineering construction methods that will be immediately useful to learners. This will enable learners to understand and apply construction methods in a broader vocational context.

The first part of the unit explores how earthworks and excavations are undertaken and looks at the factors influencing construction methods. Specifically, learners will have the opportunity to investigate the substructure construction of foundations, piling and drainage systems. The final part of the unit introduces superstructure construction of commercial and industrial buildings.

Learning outcomes

On completion of this unit a learner should:

1 Know the methods commonly used to perform earthwork activities and control groundwater

2 Understand the methods and techniques used in civil engineering substructures

3 Understand the methods and techniques used in civil engineering superstructures

4 Understand health and safety issues associated with civil engineering construction activities.

Unit content

1 Know the methods commonly used to perform earthwork activities and control groundwater

Earthwork activities: earthmoving equipment; deep excavation; groundwater exclusion

Earthmoving equipment: for basement and trench excavations

Deep excavation: temporary works; trench strutting; trench boxes; false work

Groundwater exclusion: de-watering; sump pumping; permanent exclusion methods

2 Understand the methods and techniques used in civil engineering substructures

Substructure construction: plant and equipment; piling systems; foundations; drainage; utilities

Plant and equipment: excavators; piling rigs; grab buckets; Bentonite plant

Piling systems: sheet steel; contiguous; secant; diaphragm cut-off walls

Foundations: isolated pads; pile caps; ground beams; rafts

Drainage: installation of deep sewers; pipe work; cable trenching; reinforced concrete culverts (stream and river containment and diversion)

Utilities: infrastructure developments; deep sewer installation water discharge pipes; service tunnels; structured cable installation

3 Understand the methods and techniques used in civil engineering superstructures

Plant and equipment: cranes, mobile and static; concrete pumps; all terrain hydraulic access equipment

Steel frames: universal columns; beams; pad and column connections; composite floor decks; concrete frames: columns; beams; floors; formwork

Concrete production: ready mix; placement; pumps; skips

4 Understand health and safety issues associated with civil engineering construction activities

Health and safety: legislative framework; hazards and risks; Construction Design and Management (CDM)

Legislative framework: acts and regulations; duties of employers; duties of employees

Construction hazards: hazard identification; risk assessments; method statements

Construction Design and Management (CDM): duties of main contractor, sub-contractor, health and safety officer; compliance requirements; health and safety file requirements (welfare; site security; site access; training requirements; certification)

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 identify the earthwork activities carried out when performing, deep excavations and cuttings [IE1, IE2, IE4, IE6, RL3, RL4, TW1, TW2]	**M1** explain the effect of a high water table on deep excavations	**D1** evaluate civil engineering methods used to form deep excavations and basements
P2 describe methods of controlling groundwater [IE1, IE2, IE4, IE6, RL3, RL4, TW1, TW2]		
P3 describe the forms of substructure commonly used for commercial and industrial civil engineering projects [IE1, IE2, IE4, CT1, CT5, RL2, RL3, RL5, TW1, TW2]	**M2** assess the merits and de-merits of common forms of construction for substructures	**D2** appraise civil engineering construction methods used for framed structures with deep substructure foundations
P4 explain how drainage is integrated into substructures [IE1, IE2, IE4, IE6, RL3, RL4, TW1, TW2]		
P5 explain how public utilities are integrated into substructures [IE1, IE2, IE4, IE6, RL3, RL4, TW1, TW2]		
P6 describe the construction plant and equipment used to erect steel and concrete frames [IE1, IE2, IE4, IE6, RL3, RL4, TW1, TW2]	**M3** relate the construction plant and equipment used in the construction of frames to the materials used and the site conditions encountered	
P7 explain the use of steel and concrete frames in superstructures [IE1, IE2, IE4, IE6, RL3, RL4, TW1, TW2]		

Assessment and grading criteria			
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P8	describe heath and safety management roles and responsibilities on civil engineering sites [IE1, IE2, IE4, IE6, RL3, RL4, TW1, TW2]		
P9	explain the hazards and risks associated with substructure activities [IE1, IE2, IE4, IE6, RL3, RL4, TW1, TW2]		
P10	explain the hazards and risks associated with superstructure activities. [IE1, IE2, IE4, IE6, RL3, RL4, TW1, TW2]		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

Tutors delivering this unit have opportunities to use a wide range of techniques. Lectures, discussions, seminar presentations, site visits, research using the internet and/or library resources and use of personal and/or industrial experience are all suitable. Delivery should stimulate, motivate and enthuse learners.

The unit has a broad civil engineering construction content and follows a logical build sequence. Tutors should use the unit content headings as a guide to delivery. Learner knowledge of earthwork activities and below and above ground construction techniques should be developed sequentially. An awareness and understanding of hazards and risks arising from civil engineering activities, including relevant legislation, should be embedded into delivery throughout the unit.

A key element must include the development of the ability to produce general and detailed drawings that explain clearly the techniques used in civil engineering construction. Learners should be made aware of the various processes involved in performing earthwork activities, including the range of ground water control techniques available, and should be conversant with the elements that form the substructure and superstructure of a building. Learner understanding of deep excavation processes for sewers, pipe work and culvert construction for water containment is also a central element of this unit. Links should be made with industry and visits to civil engineering projects should be arranged. Input from current practitioners is an essential element of unit delivery.

Teaching and learning strategies must be devised to help learners develop a clear and knowledgeable understanding of how civil engineering work is carried out. This can be through recognising the different learning styles learners prefer and structuring appropriate delivery. Case studies, project profiles and real-life civil engineering project details should be used to support the delivery. Discrete group activities are permissible, but tutors need to ensure that individual learners have equal experiential and assessment opportunities.

Health, safety and welfare issues are paramount and should be reinforced through close supervision of all workshops and activity areas, and risk assessments must be undertaken before practical activities are taken. Centres are advised to read the *Delivery approach* section in the specification, and *Annexe H: Provision and Use of Work Equipment Regulations 1998 (PUWER)*.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Introduction to unit content
Difference between civil engineering construction and building construction
Methods commonly used to perform earthwork activities
Tutor input: ground excavation, temporary works, groundwater control
Independent learner research: earthmoving plant and equipment
Understand civil engineering substructure construction methods
Tutor input: piling systems, pile caps, pads, ground beams, rafts
Independent learner research/web search: piling rigs, grab buckets, bentonite plant
Independent learner research: appropriate construction methods for given scenarios
Tutor input: deep sewers/trenches for utilities
Independent research: public utility provider service trench requirements
Tutor input: culverts (purposes and construction methods)
Assignment 1: Single Storey Below Ground Reservoir Pumping Station
Civil engineering superstructure construction methods
Tutor input: framed construction including the merits/de-merits of steel and concrete
Independent learner research: column, beam and floor construction, including the provision of formwork and concrete placement techniques
Assignment 2: Two Storey Basement Project with Framed Superstructure
Health and safety issues associated with civil engineering construction activities
Tutor input: health and safety legislative framework including Construction Design and Management
Independent learner exercise: method statements, risk assessments
Independent research: headings used to compile the health and safety file and the role of the planning coordinator
Assignment 3: Health and Safety Issues
Review of unit delivery and unit assessments

Assessment

Evidence for this unit may be gathered from a variety of sources but will include two well-planned investigative assignments. Some example assignment approaches are suggested below. However, these are not intended to be prescriptive or restrictive and are provided as an illustration of the forms of assessment evidence suitable for this unit. Tutors may modify the scenarios but must ensure that the grading criteria are fully covered.

The structure of the unit content is such that a minimum of three assignments could be used to give learners the opportunity to produce the evidence required for achievement of all the grading criteria. For example, the first could cover P1, P2, M1 and D1, the second P3, P4, P5, P6, P7, M2, M3 and D2, and the third P8, P9 and P10. They could be broken up into smaller component parts if this helps the assessment process.

For P1, learners must identify the earthworks activities that may be carried out when forming deep excavations and cuttings. This could be, for example, infrastructure works for public utility providers. Learners should identify the plant used, the challenges presented by various sub-soils and the support and falsework required to provide a safe working environment.

For P2, learners must describe the methods of controlling groundwater. Learners must include a range of methods of groundwater control, for example sump pumping, dewatering and land drainage.

For P3, learners must describe the commonly used forms of substructure for commercial and industrial civil engineering projects. For example learners may outline the use of piles and rafts (sheet, contiguous and secant) and deep drainage techniques for use with service ducts and tunnels.

For P4, learners must explain how drainage is integrated into substructures. This should build on the evidence for P3.

For P5, learners must explain how public utilities are integrated into substructures. This should include deep reinforced concrete culverts and plant rooms, service ducting, cable trenching and service ducts. This should build on the evidence for P3 and P4.

For P6, learners must describe the construction plant and equipment used to erect steel and concrete frames. Evidence should include images and/or drawings of the construction plant and equipment and a statement of the advantages and disadvantages of each.

For P7, learners must explain the use of steel and concrete for framed superstructure construction. Learners should include the use of steel and concrete in the context of merits and de-merits including the levels of skilled labour required, lifting and placement requirements and safe working access.

For P8, learners must describe heath and safety management roles and responsibilities on civil engineering sites. In particular, learners must describe the role of the planning coordinator including the main headings contained in the contractors health and safety file. Risks and hazards associated with the project should be described in the form of a risk audit.

For P9, learners must explain the hazards and risks associated with substructure activities. This should build on the evidence for P3, P4 and P5.

For P10, learners must explain the hazards and risks associated with superstructure activities. This should build on the evidence for P6 and P7.

For M1, learners must explain the effect of a high water table on deep excavations and how a high water table, and the presence of groundwater, can affect deep excavations and their support systems. For example learners could explain the effects of water pressure (head pressure) on open excavations and the workspace environment. Learners would be expected to explain the impact groundwater could have on trench support systems and the tanking methods needed to protect against the ingress of water into below ground structures.

For M2 learners must assess the merits and de-merits of common forms of construction for substructures. Their evidence should clearly show that they can distinguish between different forms of construction and make reasoned assessments. Examples include monolithic structures, rafts, in-situ and pre-cast piles (sheet steel, secant, contiguous) and the feasibility of constructing superstructures on chosen substructure systems.

For M3, learners must relate the construction plant and equipment used in the construction of frames to the materials used and the site conditions encountered. Evidence should also refer to speed of erection, and labour requirements.

For D1, learners must evaluate civil engineering methods used to form deep excavations and basements. They should demonstrate critical thinking on a range of methods. Suitable evidence could include the challenges presented by removing vast amounts of overburden (ground boiling), the merits of ramping back as opposed to using cut-off walls or piling. Evidence could be derived from an extension of the activities undertaken for P1 and P2.

For D2, learners must appraise civil engineering construction methods used for framed structure with deep substructure foundations. They should demonstrate critical thinking on the most appropriate type of frame for use with deep substructure foundations. For example, evidence could be derived from an extension of activities undertaken in P3, M3 and P5. Learners who have successfully demonstrated that they can make effective comparisons will be expected to critically appraise and justify a construction method.

Programme of suggested assignments

The following table shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, M1, D1	Single Storey Below Ground Reservoir Pumping Station	You are training to be a civil engineer. You have been asked to compile a project profile for the excavations, earthworks and groundwater control for a greenfield development, with granular sub-soil and a high water table, and an RC pump station with a deep trench RC service duct.	Project profile.
P3, P4, P5, P6, P7, M2, M3, D2	Two Storey Basement Project with Framed Superstructure	Your company has been awarded a contract to construct a two-storey basement with retail and commercial premises above on five floors. You must appraise the methods by which this development could be built and make recommendations on the method to be used for the basement formation and a framed superstructure.	Report to include text, drawings, images, tables, charts and graphs as appropriate.
P8, P9, P10	Health and Safety Issues	You have been asked to compile a booklet explaining the roles and responsibilities of those involved in the construction of either of the two civil engineering projects outlined above. This should refer to CDM throughout.	Report to include text, drawings, images, tables, charts and graphs as appropriate.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Construction and the Built Environment sector suite. This unit has particular links with the following unit titles in the Construction and the Built Environment suite:

Level 1	Level 2	Level 3
		Health, Safety and Welfare in Construction and the Built Environment
		Construction Technology and Design in Construction and Civil Engineering
		Construction in Civil Engineering
		Public Health Engineering in Civil Engineering

This unit links to the Edexcel Level 3 NVQ in Construction, Plant and Equipment Supervision and the Edexcel Level 4 NVQ in Construction, Plant and Equipment Management. It also links to the following National Occupational Standards at Level 3:

- Construction Contracting Operations
- Construction Plant and Equipment Supervision
- Transportation.

Essential resources

Learners should have access to a variety of literature relevant to the civil engineering industry. Centres should be able to provide a wide range of relevant books, journals and periodicals, together with videos and DVD/CD ROMs, British Standards, BRE papers, maps and open access to the internet. Good quality drawings and section details should be available, including real-life project profiles. Site visits and practitioner guest speakers will support the delivery of this unit.

Employer Engagement and Vocational Contexts

Tutor engagement with local civil engineering companies would greatly benefit the learning experience for learners, giving them a real context in which to visualise the techniques and challenges of civil engineering. The donation and use of old contract documents including drawings and method statements would be also beneficial. Support to enable centres to initiate and establish links to industry, and to networks arranging visits to industry and from property practitioners is given below:

- Learning and Skills Network – www.vocationallearning.org.uk
- National Education and Business Partnership Network – www.nebpn.org
- The Royal Institution of Chartered Surveyors – www.rics.org
- Work Experience/Workplace learning frameworks – Centre for Education and Industry (CEI University of Warwick) – www.warwick.ac.uk/wie/cei/

Indicative reading for learners

Textbooks

Chudley and Greeno – *Advanced Construction Technology* (Pearson, 2006) ISBN 9780132019859

Chudley and Greeno – *Building Construction Handbook, 7th Edition* (Butterworth-Heinemann, 2008) ISBN 9780750686228

Manley S, Charters M, Francis C, Topliss S and Doyle M – *Construction and the Built Environment* (Pearson, 2008) ISBN 978043549914

Osbourn D and Greeno R – *Introduction to Building, 3rd Edition* (Pearson, 2002) ISBN 0582473039

Journals

Building Magazine – CMP

Construction News – Emap

Websites

www.ciob.org.uk	Chartered Institute of Building
www.ice.org.uk	Institute of Civil Engineers
www.thomastelford.com	Thomas Telford – the knowledge business of the Institution of Civil Engineers

Delivery of personal, learning and thinking skills (PLTS)

The following table identifies the PLTS opportunities that have been included within the assessment criteria of this unit:

Skill	When learners are ...
Independent enquirers	exploring the types of work that define civil engineering and differentiate it from building construction
Creative thinkers	trying out alternative solutions for civil engineering projects
Reflective learners	carrying out a presentation on the activities of the civil engineering industry to their peers
Team workers	collaborating with others in group work to produce a presentation on an aspect of earthwork activity.

Functional Skills – Level 2

Skill	When learners are ...
ICT – Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	researching and sourcing website details in order to provide research material for use in compiling the unit assignments
Manage information storage to enable efficient retrieval	setting up an electronic filing system to store assignment data and research material
ICT – Find and select information	
Select and use a variety of sources of information independently for a complex task	making search engine refinements to obtain research information and supporting information for assignment compilation
ICT – Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: • text and tables • images • numbers • records	producing the final assignment submission for assessment
Present information in ways that are fit for purpose and audience	processing document including back-up CD
Evaluate the selection and use of ICT tools and facilities used to present information	producing a multimedia presentation on a civil engineering topic
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	taking part in active teaching sessions and presenting ideas in a group situation
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	reading textbooks and journals and browsing civil engineering websites
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	producing three written assignments for assessment purposes.