Unit 31: Specialist Civil Engineering Techniques

Delivery guidance

The focus during the delivery of this unit should be on examining specialist civil engineering techniques, including designing and constructing bridges, tunnels and marine structures.

Approaching the unit

Drawings, illustrations, images, animations and video clips are useful resources to explain the principles governing specialist structures and the unique solutions that these give for a given situation. Such resources are freely available online and can be easily incorporated into tutor presentations.

In addition to this, site visits would benefit learners, and could include trips to ongoing projects where bridges, marine structures or tunnels are under construction. The number and frequency of such site visits would vary according to your delivery schedule and availability of the site(s).

Involving local professionals and experts from the civil engineering design and construction sector as guest speakers will be helpful in order to enthuse learners as they gain an insight into the current local practices within the industry.

Tutors could either develop a mock project brief or adapt an actual case study or design example, which can be used as a learning resource (ideally throughout the delivery of the unit). This would help learners to develop a holistic understanding of the subject.

Delivering the learning aims

Learning aim A

Learning aim A focuses on examining the different types of bridges and construction techniques, for example, cable-stayed, arch, beam and suspension bridges. It will enable learners to develop an understanding of the design principles of bridges, such as the provision of abutments, bearings, footings and foundations. Throughout the delivery of this learning aim, engage learners with knowledge quizzes, paired and/or group activities, class discussions and presentations. These give learners opportunities for peer learning.

You could introduce the various bridge types by using animations, DVDs, pictures, illustrations or web-based videos (some suggested resources have been given in the Resources section). Once the basic principles have been understood, learners can participate in more 'in-depth' group activities and class discussions. For example, learners can supply the rationale behind the given spans and heights for different types of bridges.

Further activities may include conducting independent research and small group

presentations on construction methods and the techniques used for various types of bridges, as well as design considerations.

Site visits are key to engaging learners. For example, an early visit to a site related to the construction of a bridge will help with understanding the content of learning aim A. The visit will also support learning about several types of bridges, design factors and various elements and methods of bridge construction.

Learning aim B

Learning aim B is about examining the principles of tunnelling and the related design considerations, including ground conditions and the ground support available. For the delivery of this learning aim, well-structured research tasks would be beneficial for learners, such as the application of construction techniques. It is important to have access to project drawings, especially related to ground conditions, which can be used as learning resources. You could contact construction companies, who are often more than willing to help, for such information.

You could also arrange for a guest speaker, such as a site manager, design engineer, structural engineer or technical staff working with local authorities or government agencies, to visit the centre. The guest speaker could share with learners some examples of current design and construction principles that are found within the industry.

Learning aim C

A well-planned site visit will give a useful means of delivery for learning aim C, which focuses on the design and construction of marine structures. Ensure that the appropriate safeguards are in place during the site visit, and coordinate with site staff in advance so that all parties are aware of the learning opportunities during the visit. Reinforce this learning in class, using project drawings that are specifically related to component details.

Learners need to consolidate their knowledge through the use of case studies, which can include interesting problem-solving challenges for learners. For example, you could task learners with exploring the challenges and impacts of using sprayed concrete in a tunnel lining. To give access to more case studies, you could either approach companies for relevant information or download examples from the web.

Assessment model

Learning aim	Key content areas	Recommended assessment approach
A Examine different types of bridges and construction techniques	**A1** Bridge design **A2** Materials used in the construction of bridges **A3** Applications of bridges	A proposal for a type of bridge that will meet design criteria for a given scenario, including alternatives.
B Examine the principles of tunneling	**B1** Design considerations for tunnels **B2** Construction methods for tunnels	A report that investigates alternative approaches that could be used to construct a tunnel for a given scenario.
C Examine marine applications of civil engineering	**C1** Coastal protection and sea walls **C2** Cofferdams and caissons **C3** Harbour works and breakwaters	An investigation into the approaches that can be used for coastal defences in a given situation that includes alternative solutions for the scenario.

Assessment guidance

There is a maximum of three summative assignments for this unit. The assignment briefs should be set within the context of a large civil engineering construction project, such as a section of a highway or railway line.

For assignment 1, adequate details should be given about the location, span and expected types of traffic for the proposed bridge, so that learners can carry out a suitable evaluation. The evaluation must relate to the project scenario given and should not be a generic response. Learners should include details about materials and construction approaches in their work.

For assignment 2, you should include (in addition to the above) ground details, so that learners can evaluate suitable tunnelling methods. Learners should include justification of the choices they have made. The lining methods, as well as the methods of shaft construction, should also be included. Learners must ensure that they relate to the given scenario throughout their work.

Tutors should include additional information for assignment 3 about sea conditions and the purpose and application of proposed coastal defenses, so that a range of factors can be evaluated. Learners must consider all possible options in their work, such as sea walls, harbours and breakwaters. The evaluation must relate to the given scenario.

Submitted assessment evidence could be in the form of a project or an investigative report and a proposal. You could ask learners to include sketches, illustrations and a list of information sources used.

Getting started

This gives you a starting place for one way of delivering the unit, based around the recommended assessment approach in the specification.

Unit 31: Specialist Civil Engineering Techniques

Introduction

Introduce learners to the unit using animations, DVDs, pictures, illustrations or web-based videos relating to the specialist civil engineering techniques used within the context of a large construction project.

Engage learners during the delivery of the unit content through knowledge quizzes, paired or group activities, class discussions and presentations, as well as through guest speakers and site visits.

Develop a project brief within the context of a large civil engineering project, such as the construction of a highway in a coastal area, which will give plenty of opportunities for learners to collate evidence across all three learning aims for their assessments.

This could be a case study or project data obtained through any related industry links. After the initial delivery of each learning aim, use this project as a tool for application of the principles learned.

Well-organised site visits (where learners can see bridge construction, tunnelling and marine works) are invaluable for the delivery of this unit. The visits will need to be timetabled carefully to ensure that learners have sufficient knowledge across the learning aims to fully benefit from the experience. The site visits for this unit could also be done in conjunction with the visits from other units. It is critical to coordinate with the site staff in advance to confirm the:

- health and safety requirements
- type of project (e.g. sea walls, cofferdams and harbour works)
- construction stage
- extent to which site staff could engage (project presentation, access to drawings, project data etc.).

Learners could prepare checklists before the visits, so that they can record details of the different elements, components and processes relating to the marine structure being built. If finding appropriate sites proves difficult, tutors could instead use project examples through DVDs or other project data.

Learning aim A – Examine different types of bridges and construction techniques

- The delivery of this learning aim would benefit from a site visit for learners to examine the construction of bridges. If a visit is not possible, use of online resources and videos clips can enhance tutor-led presentations and classroom- based activities.

Learning aim A1

- Deliver a tutor presentation to show the construction of different bridge types (e.g. cable-stayed, suspension, arch, beam and truss), using animations, DVDs, pictures, illustrations or web-based videos. Engage learners through a Q&A session and summarise through a class discussion.
- To introduce learners to the terminology used to identify elements of a bridge, ask them to form small groups and give illustrations or drawings of bridges to each group. Each group should identify and annotate the given illustrations and drawings to name all the elements. Learners share their answers with their peers.
- Deliver a presentation that, building on the learning so far, introduces the design considerations required for bridges. Use a variety of pictures of different bridge types and engage learners through a Q&A session. The focus should be the suitability of each bridge type for various situations, such as motor vehicles or pedestrians.
- Ask learners to carry out independent research for the allocated bridge type and share a real-life example with their peers, evaluating the type used alongside the site conditions. Learners can share their findings with the rest of the class; draw up the key points and add this information to a shared access folder.

Learning aim A2

- For the delivery of learning aim A2, deliver a presentation to introduce the materials that could be used for construction of bridges, e.g. reinforced concrete, steel, brick, stone and timber. Then facilitate a class discussion, asking learners to consider the reasons certain types of material are used.

Learning aim A3

- Give case studies to learners, for example, the construction of a railway bridge. Organise a class discussion about the application of bridges for highways, railways, pedestrians and cyclists. Explain a case study in respect of design requirements, traffic levels, loadings, benefits and drawbacks, and engage learners through a Q&A session.
- Arrange for a guest speaker (such as a site manager, design engineer, structural engineer or technical staff working on a local project) to share with learners some examples of

design principles and construction methods currently in practice. Prior to the visit, ask learners to prepare questions to ensure that they take advantage of this opportunity.

- Ask learners to get into small groups and suggest a suitable bridge type in terms of its application, materials used, design considerations and construction methods. Each group is to create a presentation to deliver to the rest of the class, justifying their proposals. This activity will help to review learning across this topic. End the session by facilitating a class discussion, summarising learner feedback and expanding on key points as necessary.

Learning aim B – Examine the principles of tunnelling

- The delivery of this learning aim would benefit from a site visit for learners to examine the construction of tunnels. If a visit is not possible, use online resources and videos clips to enhance tutor-led presentations and classroom- based activities.

Learning aim B1

- Deliver a presentation to show various ground conditions (e.g. hard rock, soft ground and groundwater), as well as methods to support and improve the ground, using animations, DVDs, pictures, illustrations or web-based videos. Engage learners through a Q&A session and summarise the discussions.
- To introduce learners to the terminology used to identify elements of a tunnel, ask them to form small groups and give each group illustrations and drawings of tunnels. Each group should then identify and annotate the given illustrations and drawings to name all the elements. Learners share their answers with their peers.

Learning aim B2

- Deliver a presentation to introduce the methods used locally to construct tunnels. Use case studies to demonstrate the application of these various construction methods and how these relate to the ground conditions. Engage learners through a Q&A session, focusing on the suitability of particular construction methods for given ground conditions.
- Using a tutor-led group activity, ask learners to carry out research for the allocated construction method and share a real-life example with their peers, evaluating the method used for the given ground conditions. Draw up the key points and add this information to a shared access folder.
- Introduce the lining methods used for tunnels locally and internationally, using a tutor presentation. Then engage learners with a Q&A session.
- Organise learners into small groups and allocate a shaft construction approach to each group, e.g. secant piling, sheet piling and diaphragm walls. All groups should then present their findings. Learners can share their findings with the rest of the class; drawing on the key points, add this information to a shared resource.
- To review learning across this topic, use an appropriate case study for which a tunnel is required. Organise learners into small groups and suggest a suitable tunnelling technique. They are then to evaluate their choice for the given situation. Each group should present

and justify their proposals to the rest of the class. Facilitate a class discussion, summarising learner feedback and expanding on key points as necessary.

Learning aim C – Examine marine applications of civil engineering

Learning aim C1

- Introduce the delivery of learning aim C1 with a tutor presentation, covering the construction of coastal protection and sea walls. Use case studies and project videos relating to the construction of marine structures, and engage learners with a Q&A session.
- Use an appropriate case study where some form of coastal protection is required. Ask learners to get into small groups and suggest a suitable construction method, such as gabions or jetties for coastlines, and bulkheads or revetments for sea walls. They are then to evaluate their choice for the given situation. Each group should present and justify their proposals to the rest of the class.

Learning aim C2

- Use project videos relating to the construction of cofferdams and caissons. Facilitate a class discussion about the approaches to construct these, draw up the key points and summarise.
- Ask learners to get into small groups to carry out research into a specific type of cofferdam or caisson. Ask learners to present their findings in terms of their applications, benefits and drawbacks. Give support and guidance where necessary and upload the work to a shared access folder.
- To reinforce the delivery of learning aim C2, arrange a visit to a local project site where learners can observe the techniques used for construction of these works, or use an appropriate video resource. Learners could prepare checklists, based on the unit content, so that they can record and note the relevant details. If this can be arranged, this visit can form part of the assessment for this learning aim.

Learning aim C3

- Arrange a visit to a site where learners can observe harbour works and breakwaters. Learners could prepare checklists, based on the unit content, so that they can record and note the relevant details. If this can be arranged, this visit can form part of the assessment for this learning aim.
- Use a suitable project brief related to a location where harbour works and/or breakwaters would be required. Ask learners to get into small groups to suggest suitable harbour works and breakwaters in terms of application, benefits and drawbacks. Each group should present and evaluate their proposals to the rest of the class. This activity will help to

review learning across this topic. Facilitate a class discussion, summarising learner feedback and expanding on key points as necessary.

Details of links to other BTEC units and qualifications, and to other relevant units/qualifications

This unit links to:

- Unit 1: Construction Technology
- Unit 2: Construction Design
- Unit 3: Construction Science
- Unit 4: Safe Working Practices
- Unit 10: Surveying in Construction
- Unit 15: Measurement Techniques in Construction
- Unit 18: Work Experience
- Unit 23: Construction in Civil Engineering
- Unit 30: Public Health Engineering
- Unit 32: Highway Construction and Maintenance in Civil Engineering.

Resources

In addition to the resources listed below, publishers are likely to produce Pearson-endorsed textbooks that support this unit of the BTEC International Level 3 Qualifications in Construction and the Built Environment. Check the Pearson website (http://qualifications.pearson.com/endorsed-resources) for more information as titles achieve endorsement.

Textbooks

Chen, W – *Handbook of International Bridge Engineering* (CRC Press, 2013) ISBN 9781439810309. A useful guide to construction methods and materials used in the construction of bridges in different countries and regions of the world.

Hemphill, G – *Practical Tunnel Construction* (Wiley, 2012) ISBN 9780470641972. A useful text to understand a variety of tunneling techniques.

McConnell, K et al. – *Revetment Systems Against Wave Attack: A Design Manual* (ICE, 1998) ISBN 9780727727060. This book contains details of revetment systems and how these could be designed and constructed.

Rosignoli, M – *Bridge Construction Equipment* (ICE, 2013) ISBN 9780727758088. A credible text explaining the equipment required in bridge construction,

covering a wide range of scenarios.

Journals

Journal of Bridge Engineering (American Society of Civil Engineers) – this journal exclusively covers the engineering aspects of bridges.

New Civil Engineer (EMAP Publishing) – this is an Institution of Civil Engineers (ICE) journal containing useful research and industry reports relevant to all aspects of civil engineering.

The Structural Engineer (Institution of Structural Engineers) – this covers a broad range of areas relating to structural engineering.

Videos

Search YouTube for the following videos:

- 'Engineering Connections Earthquake Proof Bridge | Science Documentary | Reel Truth Science' – documentary about the construction of a 3km long bridge in an earthquake zone in Greece
- 'How are Underwater Structures Built?' – an overview of approaches used to construct underwater structures
- 'The Longest Tunnel in The World'
- 'Tunnel Construction Video'
- 'Caisson technology in the construction of port infrastructures' – this video looks at caisson construction for harbours
- 'What is coastal erosion?' by Environment Agency TV – this video gives useful information about coastal erosion.

Websites

British Tunnelling Society (BTS) – the website of the British Tunnelling Society, containing a wealth of information about all aspects of tunnelling.

Designing Buildings Wiki – a credible source covering types of bridges and their construction, including the materials that could be used.

Institution of Civil Engineers – this is the professional body for civil engineers. This website contains information about the codes, products and industry updates.

South East Coastal Group – search for the 'Coastal Defences' PDF, which gives an excellent overview of the topic.

SteelConstruction.info – gives information about construction of steel bridges.

Pearson is not responsible for the content of any external internet sites. It is essential for tutors to preview each website before using it in class so as to ensure that the URL is still accurate, relevant and appropriate. We suggest that tutors bookmark useful websites and consider enabling learners to access them through the school/college intranet.