Pearson BTEC Nationals in Civil Engineering

Delivery Guide

Pearson BTEC Level 3 National Diploma in Civil Engineering

Pearson BTEC Level 3 National Extended Diploma in Civil Engineering

Pearson BTEC Level 3 National Extended Certificate in Construction and the Built Environment (360 GLH)

Pearson BTEC Level 3 National Foundation Diploma in Construction and the Built Environment (540 GLH)

First teaching September 2017

Edexcel, BTEC and LCCI qualifications

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All information in this specification is correct at time of publication.

Welcome to your BTEC National delivery guide

This delivery guide is a companion to your BTEC Level 3 National specifications, Authorised Assignment Briefs (AABs) and Sample Assessment Materials (SAMs). It contains ideas for teaching and learning, including practical activities, realistic scenarios, ways of involving employers in delivery, ways of managing independent learning and how to approach assessments. The aim of this guide is to show how the specification content might work in practice and to inspire you to start thinking about different ways to deliver your course.

The guidance has been put together by tutors who have been close to the development of the qualifications and so understand the challenges of finding new and engaging ways to deliver a BTEC programme in the context of the new qualifications from 2017.

Guidance around what you will need to consider as you plan the delivery of the qualification(s) has been provided. You will find information around the structure of your course, how you may wish to build the course for your learners, suggestions for how you could make contact with employers and information around the other support and resources available to you.

Unit-by-unit guidance has been provided, which includes suggestions on how to approach the learning aims and unit content, as well as ideas for interesting and varied activities. You will also find coverage of assessments, including useful advice about external assessment, as well as tips and ideas around how to plan for and deliver your assignments.

You will also find a list of carefully selected resources for each unit. The lists include suggestions for books, websites and videos that you can either direct your learners to use or that you can use as a way to complement your delivery.

We hope you will find this guidance relevant and useful.

Enjoy your course!

What's new

The BTEC Level 3 Nationals 2017 are the result of more than three years' consultation with employers, higher education institutions, and many thousands of tutors and managers in colleges and schools. Our aim has been to ensure that the BTEC Level 3 Nationals continue to allow a recognised and well-respected route into employment or higher education by meeting the needs of these key stakeholders and that learners continue to enjoy a stimulating course of study and develop the skills and attributes that will enable them to progress.

As a result of this consultation and on the advice of employers, higher education institutions and most importantly of those of you who teach BTEC, some key changes have been made to the BTEC Level 3 Nationals. These are described throughout this delivery guide and include the following.

- **Updated content and a larger proportion of mandatory content** – both employers and universities said they wanted a greater consistency in coverage of the subject for BTEC learners. Employers wanted to see systematic coverage of core knowledge and skills for their sector, and for the Nationals to reflect up-to-date industry practice.
- **The reintroduction of external assessment** – employers were keen to see an element of rigour and consistency across the country in terms of assessment, while higher education institutions wanted learners to be better prepared for meeting deadlines and preparing for formal exams, where appropriate. Both were keen to see learners applying their knowledge and skills to new contexts through synoptic projects and assessments.

- **A focus on employability skills** – the BTEC approach to learning, through projects, practical assignments, group work and through simulating the world of work, has always supported the development of employability skills, e.g. self-management. In the new Nationals, the balance of cognitive and skills work has been carefully calibrated to ensure that learners get a range of different opportunities across their course.
- **Broader assessment in internal units** – the assessment criteria for each unit are carefully structured to set a clear level of demand. Distinction criteria encourage and require depth of study, including demonstration of the application of knowledge and understanding as well as a synoptic element for the learning aim or unit.
- **Alignment with DfE criteria for performance measures for 16–19 year olds in England** – all new BTECs are designed as either Applied General qualifications or Tech Levels to fulfil criteria for inclusion in 2018 performance tables and funding for 16–19 year olds and 19+ learners.

To support transition to the BTEC Level 3 Nationals 2017, we are providing a support programme with exemplar and practice materials, and training is available. Please see the *Support and resources* section for details of the support and the link to sign up to training, which will be available from 2017 and throughout the lifetime of the qualification.

Notes:

The specification tells you what **must** be taught and what **must** be assessed. This delivery guide provides suggestions and ideas on how you could do this.

The suggestions given in this delivery guide link with the Authorised Assignment Briefs provided by Pearson, but they are not compulsory. They are designed to get you started and to spark your imagination.

Contents

OVERVIEW

Delivery Guides as support

In the specification, the 'Unit content' tells you what must be taught and the 'Assessment criteria' what must be assessed. The 'Essential information for assessment decisions' explains what the assessment criteria mean.

This delivery guide provides suggestions and ideas on how to plan and deliver the qualification, and includes a summary of recent changes.

Unit-by-unit guidance has been provided that includes suggestions on how to approach the learning aims and unit content. Teaching, learning and formative assessment activities are also suggested. You will also find delivery plans to help you timetable your course and ensure your learners are well prepared for internal and external assessments.

Links to carefully selected resources are provided for each unit. The lists include suggestions for books, websites and videos that will help you plan and deliver your course. Alternatively, you may wish to direct your learners to these resources.

Use the delivery guides as model templates or an interpretation on which you can base your own plan. Every delivery guide presents each unit as an exemplar, highlighting Civil Engineering links to motivate tutors and learners.

Significant changes for those teaching to the new 2017 specification

The BTEC Level 3 Nationals 2017 contain significant changes to the previous 2010 version. These changes reflect the views and demands of civil engineering teaching practitioners, those working in the construction sector and government bodies with oversight of the qualifications.

For those familiar with the older 2010 specification, these changes are summarised in the table below:

Change	**New 2017**		**Old 2010**	
Programme Name	Civil Engineering		Construction and the Built Environment (Civil Engineering)	
Qualification Names/GLH	No equivalent		Certificate	180 GLH
	Extended Certificate (Construction & the Built Environment only)	360 GLH	Subsidiary Diploma	360 GLH
	Foundation Diploma (Construction & the Built Environment only)	540 GLH	90 – credit Diploma	540 GLH
	National Diploma in Civil engineering	720 GLH	Diploma	720 GLH
	Extended Diploma in Civil Engineering	1080 GLH	Extended Diploma	1080 GLH
Mandatory Units	Between 4 and 9. All qualifications		1	
Optional Units	Choose from up to 33 dependent on qualification		Choose from up to 30 dependent on qualification	
Assessment	Internal through assignment and up to 3 External depending on qualification		Internal only through assignments	

Structure

The table below shows the structure of the qualifications in the Civil Engineering suite of qualifications.

By a clear understanding of the units and careful selection, centres can tailor the qualification to suit the needs of their learners and the resources of the centre.

Unit (number and title)	Unit size (GLH)	Extended Certificate (360 GLH)	Foundation Diploma (540 GLH)	Diploma (720 GLH)			Extended Diploma (1080 GLH)		
				CBE	C	BS	CBE	C	BS
1 Construction Principles	120	M	M	M	M	M	M	M	M
2 Construction Design	120	M	M	M	M	M	M	M	M
3 Tendering and Estimating	120						M	M	M
4 Construction Technology	60	M	M	M	M	M	M	M	M
5 Health and Safety in Construction	60	M	M	M	M	M	M	M	M
6 Surveying in Construction	60		O	M	O		M	O	
7 Graphical Detailing in Construction	60		O	M	O	O	M	O	O
8 Building Regulations and Control in Construction	60		O	M			M	O	
9 Management of a Construction Project	60			O	O	O	M	O	O
10 Building Surveying in Construction	60		O	O			O	O	
11 Site Engineering for Construction	60		O	O	M		O	M	
12 Low Temperature Hot Water Systems in Building Services	60			O		O	O		O
13 Measurement Techniques in Construction	60		O	O	O		O	O	
14 Provision of Primary Services in Buildings	60		O	O		M	O		M
15 Further Mathematics for Construction	60				M	O	O	M	O
16 Work Experience in the Construction Sector	60						O	O	O
17 Projects in Construction	60			O	O	O	O	O	O
18 Building Information Modelling	60			O	O	O	O	O	O
19 Quantity Surveying	60		O	O		O	O		O
20 Quality Control Management in Construction	60			O			O	O	O
21 Building Services Science	60					M	O		M
22 Economics and Finance in Construction	60						O		
23 Construction in Civil Engineering	60				M		O	M	
24 Planning Application Procedures in Construction	60						O		
25 Property Law	60						O		
26 Conversion, Adaptation and Maintenance of Buildings	60						O		
27 Building Services Control Systems	60					O			O
28 Ventilation and Air Conditioning Design	60					O			O
29 Use of Static and Dynamic Fluids in Building Services	60					O			O
30 Plumbing Technology in Building Services	60					O			O
31 Electrical Principles in Building Services	60					O			O
32 Electrical Installation Standards, Components and Design	60					O			O
33 Measurement Techniques in Building Services	60					O			O
34 Building Regulations and Control in Building Services	60					O			O
35 Principles and Applications of Structural Mechanics	60				O			O	
36 Public Health Engineering	60				O			O	
37 Specialist Civil Engineering Techniques	60				O			O	
38 Highway Construction and Maintenance in Civil Engineering	60				O			O	

Overview of the Civil Engineering qualification suite

The level 3 Nationals in Civil Engineering are a suite of qualifications that focus on different progression routes, allowing learners to choose the one best suited to their aspirations. Pearson has developed the content of the new BTEC Nationals in collaboration with employers and representatives from higher education and relevant professional bodies. This ensures that the content is up-to-date and includes the knowledge, understanding, skills and attributes required in the sector.

Whereas the previous Nationals were internally assessed only, this new suite of qualifications has three different types of assessment: internal, external and synoptic. There is also more of an emphasis on developing and utilising links with employers. This may require a review of how the units are delivered and assessed, providing a unique opportunity to create project-based assessments that map across more than one unit, and to embrace employer engagement when developing realistic briefs and case studies.

These qualifications are aimed at supporting post-16 learners to help them choose specialist pathways within civil engineering-related industries, by giving them the technical skills and knowledge required. This will enable learners to pursue their desired career goals either through employment or suitable higher education courses. As previously outlined, employers must have significant involvement in these programmes.

In the Civil Engineering sector, these are:

- Pearson BTEC Level 3 National Extended Certificate in Construction and the Built Environment (360 GLH)
- Pearson BTEC Level 3 National Foundation Diploma in Construction and the Built Environment (540 GLH)
- Pearson BTEC Level 3 National Diploma in Civil Engineering (720 GLH)
- Pearson BTEC Level 3 National Extended Diploma in Civil Engineering (1080 GLH)

All qualifications in the suite share some common units and assessments, allowing learners some flexibility in moving between qualifications where they wish to select a more specific progression route. The published programme specification provides an overview of various qualification sizes clearly highlighting both mandatory (M) and optional (O) units. Some units are mandatory across all qualification sizes, while some units are mandatory only for larger size of the qualification. While choosing the optional units, consideration must be given to possible coordinated delivery across units, as well as to the efficient use of resources.

Making the right choice for your learners

You should support learners to help them make the right choice that aligns well with their future career aspirations, such as starting a degree or a specific job role in the industry.

For example, the **Extended Diploma** is largest size of qualification within the suite:

- It is equivalent in size to 3 A levels and allows learners to develop a substantial common core of knowledge.
- Learners have the choice to study topics in depth across a full range of optional units.
- Learners will develop the broader skills highly valued by higher education institutions, such as critical thinking.
- It covers a wide range of written and verbal communication skills that are required in the construction sector.

This qualification would suit learners if they are studying full time over a period of two years and wish to pursue a career in civil engineering. It may be the case that they wish to proceed directly into employment as, for example, a technician (as this qualification is intended to meet the requirements of registering as a technician). Alternatively, this qualification will also allow learners to progress into higher education.

For each qualification, no prior study of the sector is needed, but learners should normally have a range of achievement at level 2 in GCSEs or equivalent qualifications, including English, Mathematics and Science.

The smaller size qualifications, such as the **Foundation Diploma**, cater for learners who wish to learn about construction alongside other areas of study (such as an A level), and as a support in their progression to higher education.

Making contact with employers

The employers in the construction industry range from small design consultancies to large national and international construction companies. Depending on the size of the qualification, business models of varying sizes will benefit learners, as well as the optional units that you have chosen.

If the centre has well established construction programmes, you could start by contacting employers who are already on the customer database. If this is not possible, developing a list of local companies using internet-based searches is a good start. You could also develop a list of relevant staff within, for example, the local council, Highway Agency and Environment Agency. You should also look to build links with professional bodies such as the Chartered Institute of Building (CIOB), Chartered Institute of Building Services Engineers (CIBSE) and Institution of Civil Engineers (ICE).

Making contact with employers via email or phone is a good start, but ensure that you are clear regarding the unit content in advance. You should also be flexible with the timing of any site visits or guest speakers. While talking to employers, it is always worthwhile to articulate the mutual benefits of developing a positive relationship between the centre and the employers. For example, one of the benefits that they are likely to receive from this relationship could be by offering work placements, which will give them opportunities for low-risk employee recruitment, while also contributing towards the local and national skills agenda.

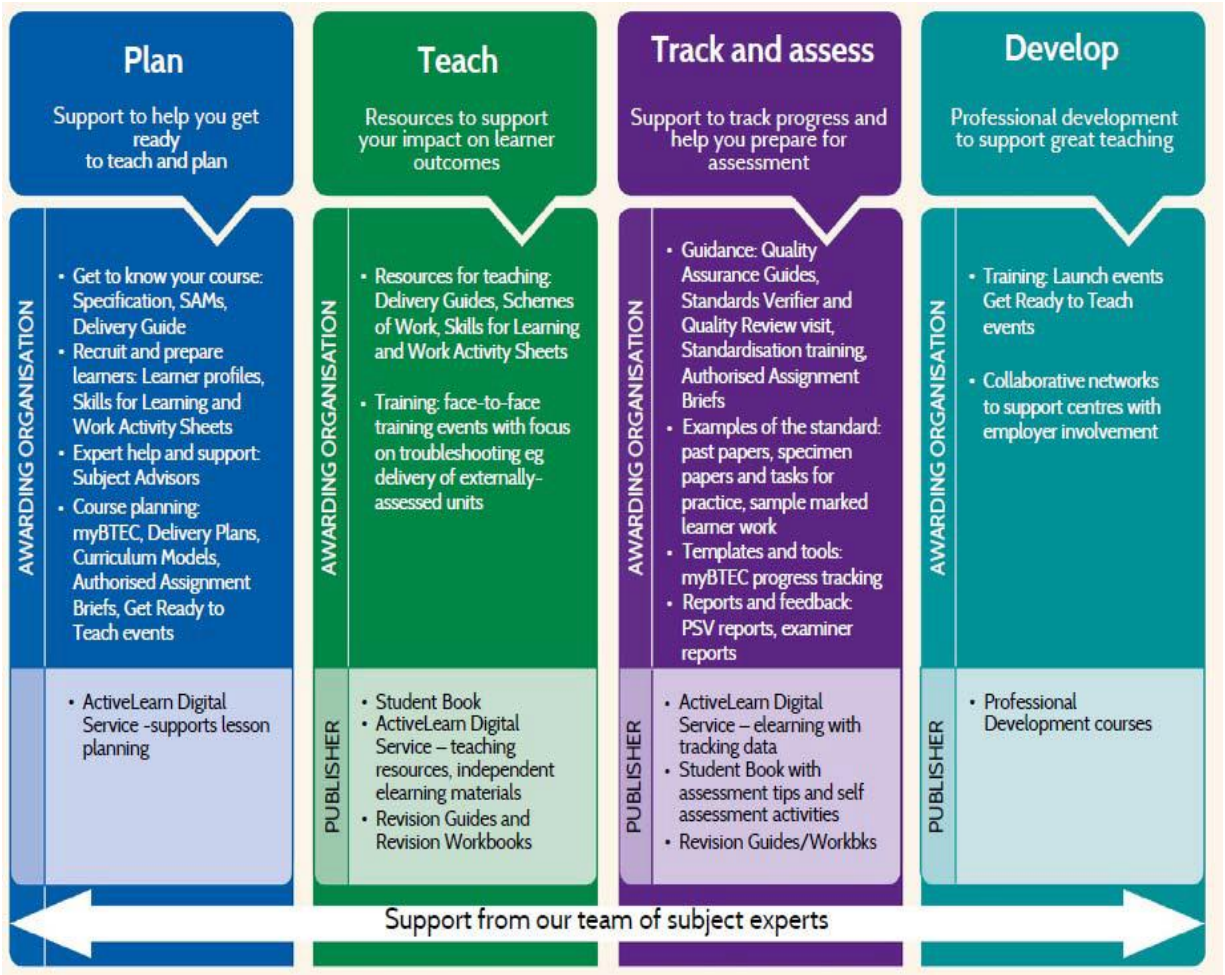
SUPPORT AND RESOURCES

There are a wealth of resources available to ensure that you feel confident delivering your BTEC National qualification throughout your entire course.

All the 'Awarding Organisation' resources can be found on the Pearson Qualifications website here:
http://qualifications.pearson.com/en/qualifications/btec-nationals/construction-and-the-built-environment-2017.html

As well as the free resources supporting the qualification, provided by Pearson as an Awarding Organisation, Pearson Learning Services ('Publisher' in the tables below) provides a range of engaging resources to support BTEC Level 3 Nationals, including:

- Student books in e-book and print formats
- Revision guides and revision workbooks in e-book and print formats
- Teaching and assessment packs, including e-learning materials via the ActiveLearn Digital Service



In addition to the 'publisher' resources listed above, publishers other than Pearson may produce textbooks that are endorsed for BTEC. Check the Pearson website (http://qualifications.pearson.com/en/support/published-resources.html) for more information as titles achieve endorsement.

There are also a number of people who are available for you to speak to:

- **Standards Verifiers** – they are subject specialists who can support you with ensuring that your assessment plan is fit for purpose and whose role is to confirm that you are assessing your learners to national standards as outlined in the specification by providing quality assurance through sampling.
- **Curriculum Development Managers (CDMs)** – they are regionally based and have a full overview of the BTEC qualifications and of the support and resources that Pearson provides. CDMs often run network events.
- **Customer Services** – the 'Support for You' section of our website gives the different ways in which you can contact us for general queries. For specific queries, our service operators can direct you to the relevant person or department.

Subject Advice
TeachingConstruction@pearson.com

Training for the new BTEC Level 3 Nationals can be found on the Pearson website here: http://qualifications.pearson.com/en/support/training-from-pearson-uk.html

Unit 35: Principles and Applications of Structural Mechanics

Delivery guidance

Approaching the unit

The focus during the delivery of 'Unit 35: Principles and Applications of Structural Mechanics' should be on developing the knowledge and skills that will enable learners to understand how structures behave under load and to solve relevant structural mechanics problems.

This is an optional unit for learners taking the BTEC Level 3 National Diploma and Extended Diploma in Civil Engineering, and throughout delivery, tutors can engage learners by relating the content of this unit to industry projects or work undertaken in other units of the qualification. When starting teaching, the emphasis should be on how the skills developed in this unit are transferable across a variety of engineering sectors, and how will they support learners during higher education, as well as in various job roles.

Illustrations, images, animations and video clips are all useful resources to explain how loads are carried and transmitted through various structural elements. Such resources are freely available online and can be easily incorporated into any tutor presentation.

Invite guest speakers from structural design, geotechnics and environmental engineering, or experts from higher education institutions, who could help learners understand the importance of skills learned in this unit for further study and the satisfactory performance in various job roles.

Delivering the learning aims

Throughout the delivery, the content of this unit should relate to a number of units in this qualification, which will help to motivate learners.

Learning aim A

Learning aim A is about understanding the types of structural members and how these behave under various loading conditions. This learning aim provides the underpinning knowledge required to develop skills in structural mechanics.

The sessions could start by introducing how several types of loads act on structures. Make full use of animations, DVDs, pictures, illustrations or web-based videos. Then, introduce concepts such as compression, tension, deflection, stress and strain, as well as any structural material used (e.g. steel, timber and reinforced concrete) by touring the campus building and asking learners to identify the structural materials that they can see.

Once learners have grasped the concepts, introduce how the behaviour of structural members could be shown graphically and explain their impact on structural design. Engage learners by demonstrating examples, such as loading types, types of forces and loading configurations, and then give learners activity sheets where they can practise developing these skills.

Introduce calculations related to section properties, such as stress, strain, modulus of elasticity and the factor of safety.

Learners can be supported and challenged during unit delivery through a variety of means, such as knowledge quizzes, paired or small group activities and class discussions, which will give learners opportunities for peer learning.

Learning aims B and C

Learning aim B is concerned with the analysis of beams, columns and frames. It should be emphasised that this analysis provides an essential base for the design, which is covered in learning aim C.

A holistic project-based approach could be adopted, where the delivery of learning aims B and C could be combined, as these have a significant overlap in terms of their content. Learners could complete a project, which will give them an opportunity to demonstrate the skills to analyse beams, columns and frames and to design beams, columns and mass retaining wall. Structural engineering consultancies can be contacted in order to obtain analysis and design examples.

Introduce the learning aims by solving examples in a step-by-step manner. Develop worksheets covering beams, columns, frames and retaining walls so that learners can practise the analysis techniques. The example project can be used, which learners could then analyse and design.

Learning aim D

Learning aim D could be delivered through a tutor-led research activity. Explore opportunities where learners could visit a technology exhibition and use this for both delivery and assessment of this learning aim.

It is important to have access to relevant project information, such as drawings, especially those related to layout, material specifications and loading conditions.

Finally, where possible, invite a guest speaker from design background. The guest speaker should be able to share with learners the current approaches and design practices in the industry.

Assessment model (in internally assessed units)

Learning aim	Key content areas	Recommended assessment approach
A Understand the principles of structural behaviour under load	**A1** Concepts **A2** Simple structural behaviour from given data	A presentation or written report to clearly explain, with the aid of diagrams and supporting calculations, the underpinning concepts relating to how structural elements behave under loads A report containing calculations and interpretation of results for contextualised structural element tasks subject to loading conditions A report containing written responses on design methods and their suitability, and production of design solutions for a given design brief
B Carry out calculations to solve structural mechanics problems	**B1** Beams **B2** Columns **B3** Frames	
C Undertake the design of structural elements	**C1** Beam design **C2** Column design **C3** Retaining wall design	A report or presentation for a given project scenario that evaluates the measures used to protect and enhance land and buildings
D Examine the use of computers in structural analysis and design	**D1** Computer software packages for design calculations **D2** Benefits and drawbacks of using computing software	A written review for a journal on structural design, read by structural and civil engineers, of the impact of computer software on computer structural analysis and design

Assessment guidance

There are maximum three summative assignments for this unit. The assignment briefs should be set within the context of a small design project.

For assignment 1, which will cover learning aim A, adequate details should be provided in order to interpret the behaviour of structural elements under load, such as the size of members and loading conditions. Tutors should ensure that learners are sufficiently supported. Part of the assessment could be completed under laboratory conditions, where learners could interpret the behaviour of structural elements under load.

For assignment 2, which will cover learning aims B and C, a design brief should be included with drawings and material specifications, so that the learners can carry out their own analysis and undertake design. Learners should refer to credible sources of information while evaluating alternative design approaches.

Assignment 3 is essentially a research exercise that uses web-based resources or requires attending an event, where learners can carry out an evaluation of the structural software available. Assessment evidence may take the form of a project report and a portfolio, containing learner analysis and design calculations, as well as evidence of research. Ask learners, as part of the instructions, to include sketches, illustrations and a list of information sources used.

Getting started

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

Unit 35: Principles and Applications of Structural Mechanics

Introduction

Introduce learners to the unit using animations, DVDs, pictures, illustrations or web-based videos relating to structural mechanics and structural engineering.

Engage learners during the delivery of this unit through knowledge quizzes, paired or small group activities, class discussions and research work, as well as through guest speakers and visits to technology exhibitions.

Learning aim A – Understand the principles of structural behaviour under load

- For the delivery of topic A1, tutors could deliver a presentation to introduce the topic by showing animations or short video clips. Use plain English to explain how structural elements behave under different loading conditions, and the resulting stress within the element.
- Tutors could continue the presentation by using animations, DVDs, pictures, illustrations or web-based videos to introduce concepts such as structural members, tension, compression, stress, strain and deflection.
- Ask learners to form into groups of two for a practical activity. Take learners on a campus tour and give them a checklist where they can identify every type of structural member they see in a particular location, as well as the material used. Learners are to complete the list in their group and then present to the rest of the group during a class discussion. Tutors to give support, drawing upon common judgement errors and summarise learner findings.
- Carry out a learning check using a knowledge quiz and assess learning through peer assessment. Ask learners to reach the correct answers through a class discussion, providing support where necessary.
- For the delivery of A2, facilitate a tutor-led class discussion to introduce how the behaviour of structural members could be shown graphically. Include deflected shapes of beams and columns, and engage learners through a Q&A session.
- Ask the learners to form into small groups, and give each group one example of a beam and a column. Ask each group to discuss, research and draw the deflected shape. Learners are then to justify their findings as a group to their peers. Drawing upon key points, tutors should provide support, where appropriate, and summarise learner findings.
- Through tutor demonstration, introduce calculations related to section properties, stress, strain, modulus of elasticity and factor of safety. Engage learners through a Q&A session. Use a knowledge quiz to check learning before asking learners to start calculations.
- Ask learners to form into groups of two and complete a number of activity sheets for the calculations as mentioned previously. Provide model answers, asking learners to complete a self-assessment, and give constructive and developmental feedback.
- To review learning across this topic, facilitate a class discussion, interpreting the behaviour of structural members under load. Tutors are to summarise learner feedback and expand upon key points as necessary.

Learning aim B – Carry out calculations to solve structural mechanics problems

Learning aim C – Undertake the design of structural elements

- Tutors to develop a project brief or obtain one from a design consultancy. There must be adequate details for learners to analyse and design the required structural members such as structural drawings, layout and material specifications.
- The sequence of delivery would be such that the delivery of topic B1 could be followed by topic C1, so that both the analysis and design of beams are covered.
- For the delivery of topic B1, introduce the different types of support and the way the beams are classified. Use illustrations, animations and pictures of projects showing the ways in which beams could be supported. Engage learners through a Q&A session.
- Introduce the concept of point loads and distributed loads by making a reference to the self-weight of beams. It is important at this stage to introduce the sign conventions in order to show loading on the beams, as well the way that the beam is supported.
- Through a tutor demonstration (and starting an example of a beam with point load), show how support reactions are calculated. Follow the same example to plot the shear force and bending moment diagram for this beam. Engage learners by asking them to do calculations, thereby 'helping' to solve the example.
- Facilitate a class discussion about the relationship between shear force and bending moment. Introduce the concept of 'contraflexure' and the relationship between the point of zero shear and maximum bending moment. Give learners an example of beams with overhangs, as well as cantilever beams under various load configurations. Ask them to work in small groups to estimate the deflected shape of these beams. Provide support, drawing upon key points and summarise learner findings.
- Through a tutor demonstration, show how beams with overhangs and cantilever beams could be analysed. Engage learners in calculations and through a Q&A session.
- Ask learners to form into groups of two to complete a number of activity sheets, analysing them to produce shear force and bending moment diagrams. Include simple to complex load configurations for differentiation purposes in order to cater for the varying ability among learners. Provide support and draw upon common learner errors, such as value of shear and bending at free ends. Tutors should provide model answer sheets so that learners are able to develop a clear understanding of how structural calculations are to be presented.
- For the delivery of topic C1, demonstrate to learners some examples of a steel beam design (as it is generally straightforward to deal with), which will instil confidence in learners as they develop their design skills. Give learners extracts from relevant parts of the steel manual, so that they could find out the dimensions themselves. Emphasise the relationship between analysis and design by highlighting how the maximum bending moment, as well as section properties, have been used in design.
- Tutors could deliver a presentation, introducing the concept of limit states in design. The focus should be on the ultimate limit state at this level. Follow this by the design of the same beam in timber, as well as in reinforced concrete. Throughout the presentation, refer to relevant British and/or European codes.
- Using the example design project and tutor-led group activity, ask learners to carry out the design of beams. Different beams, in terms of their position within the structure, could be assigned to learners in small groups and/or based on the structural materials. For example, one group could design the same beam in steel, while the other could do this in reinforced concrete. Give support to calculate loads on the beams. Learners should then present their designs to the rest of the class in their groups, justifying the design recommendations made.

- Introduce the delivery of topic B2, followed by topic C2. For topic B2, introduce the concept of axial and eccentric loading using a tutor-led class discussion. Draw upon learners' existing knowledge gained through their experience of designing beams.
- Tutors could then deliver a presentation about the effective length and slenderness ratio, and the relationship between the two elements. Using illustrations, highlight the

difference between a long and a short column.

- Give learners a knowledge quiz to assess their understanding of key terminology, drawing upon the key points and summarise.
- Develop a number of task sheets covering design exercises for columns that are related to the example project. Tutors could demonstrate some example calculations before handing these to the learners, and support learners while they are working on solving the tasks. This activity could also be conducted in small groups.
- Use a knowledge quiz to start the delivery of topic B3. The quiz should recap the concepts related to loads and structural member types.
- Tutors could show examples of how to determine determinacy of a frame while highlighting the difference between statically determinate and indeterminate structures. Follow this by a tutor demonstration to work through three methods to analyse a frame, including graphical method. Engage learners by involving them in calculations as well as through a Q&A session.
- Using the example design project and tutor-led group activity, assign each group with a typical frame. For example, groups could be allocated a roof truss, a structural frame or a truss bridge. Give support to steer the group initially. Learners to present their work to the rest of the class in their groups, justifying the design recommendations made.
- Use a tutor presentation to introduce the delivery of C3. This part of the unit draws upon knowledge across the unit, and hence should be delivered after other analysis and design work has been undertaken.
- Using illustrations and pictures, show learners various types of retaining walls and the purpose of each type. Demonstrate to learners the factors required to design a mass retaining wall, with example calculations to check a wall against sliding, overturning and overstressing. Engage learners by involving them in calculations, as well as through a Q&A session.
- Using the example design project and tutor-led group activity, ask learners to design and apply checks for a given retaining wall. Ensure that learners are given all the data such as loads, materials and surcharge values. Provide support to determine the section size and to calculate loads. Once complete, learners to present to the rest of the class in their groups, justifying the design recommendations made. Tutors to give learners constructive and developmental feedback.
- To review learner knowledge across these learning aims, facilitate a class discussion to evaluate the alternative design methods, the approaches to calculate loads and to determine section sizes. Provide support, drawing upon the key points and summarise.

Learning aim D – Examine the use of computers in structural analysis and design

- To introduce topic D1, tutors to deliver a presentation by showing a variety of easy-to-use free software packages available on the web. Demonstrate the use of one of these to the class and engage learners through a Q&A session.
- Learners to form into small groups to complete a research activity, where they must find some suitable software relevant to the calculations that they have carried out so far. Ask each group to use the solutions to any of their questions as test data, such as those relating to calculation of reactions. Each group to then discuss their findings with their peers, and tutors should facilitate a discussion where they can provide developmental and constructive feedback.
- For the delivery of topic D2, ask learners to carry out research into the benefits and drawbacks of computer software. Give learners a checklist of what to include in their responses. Some topical issues could be allocated to specific groups, e.g. cyber security. Learners to present their findings to the rest of the class.
- Invite a guest speaker from a design background to highlight the benefits and limitations of computer software. Support learners before the visit in order to prepare

valid questions to ask from the guest speaker. Follow this by facilitating a class discussion to summarise the learning during the session.

- Organise visits to a relevant exhibition, where learners can see the software in action and may have the opportunity to experience state-of-the art technology. If this could be arranged, this visit could become part of the assessment for this learning aim, where learners could evaluate (with the help of their visit notes) an evaluation of the chosen software.
- Learners could prepare checklists based upon the unit content, so that they can record, and make note of, the relevant details.

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

This unit links to:

- Unit 1: Construction Principles
- Unit 15: Further Mathematics for Construction

Resources

In addition to the resources listed below, publishers are likely to produce Pearson-endorsed textbooks that support this unit of the BTEC Nationals in Civil Engineering. Check the Pearson website (http://qualifications.pearson.com/endorsed-resources) for more information as titles achieve endorsement.

Textbooks

Durka F et al, *Structural Mechanics: Loads, Analysis, Materials and Design of Structural Elements* (7th edition), Prentice Hall, 2010 ISBN 9780132239646 – it is a popular text covering range of important concepts in structural mechanics.

Seward D, *Understanding Structures: Analysis, Materials, Design* (5th edition), Palgrave, 2014 ISBN 9781137376565 – it is a popular text where structural concepts are explained in a fun way.

Journals

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

The Structural Engineer [Institution of Structural Engineers (IStructE)] – this is IStructE journal, which covers a broad range of areas relating to structural engineering.

Videos

Tutors can access '*YouTube*' and search for the following videos:

'How to Design a Retaining Wall' by Allan Block – this video explains the design of a retaining wall.

'Solving Beam Reactions: Point load' by John Tingerthal – this video shows how to determine beam reactions.

'Theory of Columns-1.mpg' by Arnab Dutta – this video can help learners understand theory of columns.

Websites

'iCE.org' – iCE is the professional body for civil engineers. The website contains information about the codes, products and industry updates.

'The Institution of Structural Engineers' – IStructE is the professional body for structural engineers, covering information across all aspects of structural engineering.

'The Structural Engineer: The International Information Center for Structural Engineering' – this website provides an extensive list of software packages used in structural engineering.

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.

Unit 36: Public Health Engineering

Delivery guidance

Approaching the unit

The focus during the delivery of '*Unit 36: Public Health Engineering*' should be on developing the knowledge and skills that will enable learners to understand how the principles, methods and processes relate to public health engineering.

Utility records, drawings, illustrations, images, animations and video clips are useful resources to explain how drinking water is produced and distributed. Such resources are freely available online and can be easily incorporated into any tutor presentations.

In addition to this, site visits would benefit learners, and could possibly include a water treatment plant, landfill sites and sewerage treatment plant. Involving local professionals and experts from the public health engineering organisations (e.g. utilities providers, consultants and suppliers) as guest speakers will be helpful to enthuse learners, as they gain an insight into the current practices within the industry.

Tutors could use simple laboratory experiments to demonstrate, for example, the purification of water. Tutors can also develop a number of activity sheets, including practice questions, to support learners in developing the skills required to carry out design calculations for below ground drainage systems.

Delivering the learning aims

Throughout the delivery, the content of this unit should relate to a number of units in this qualification, which will help to motivate learners.

Learning aim A is about understanding below ground drainage systems and sewerage treatment methods. An important element of this learning aim is for learners to develop an understanding of the sustainable urban drainage system (SUDS). The focus is on the design, installation and testing of drainage systems, as well as the ways to treat sewage.

The session could start by introducing how a below ground drainage system works using animations, DVDs, pictures, illustrations or web-based videos. Then, introduce an example to learners showing the design requirements and associated calculations relating to the systems.

Site visits are key to engaging learners, for example, an early visit to a site where drainage systems are being installed or tested. The site visit will reinforce learning about several types of pipes and their cover and bedding requirements. Learners will experience first-hand knowledge of access points, gradients and the health and safety requirements required in such environments.

Tutors could produce activity sheets where learners are to carry out design calculations for below ground drainage. Learners are required to understand the importance of assessing the practical and functional uses of the system and be able to demonstrate their problem-solving skills.

Learners can be supported and challenged during unit delivery through a variety of means, such as knowledge quizzes, paired or small group activities and class discussions, which will provide learners with opportunities for peer learning.

Learning aim B focuses on the different types of solid waste, disposal methods and the legislation relating to waste disposal. Introduce the different types by using pictures and illustrations on short video clips. Reinforcing this learning

through visits, such as to a landfill site and/or a recycling centre, will be of great benefit for the learners, as they would be able to see how and why solid waste is segregated. On the visit, introduce the relevant legislation as to why it is implemented, which will help learners to appreciate the rationale of the regulations. Alternatively, site waste management plans (SWMP) could be introduced to explain and reinforce learning.

In learning aim C, learners will be developing an understanding of the sources and treatment of drinking water. Variety of animations and videos are available online to explain the different sources of water. Engage learners through knowledge quizzes, group-based research activities and presentations. Basic laboratory and/or field kits could also be used to help learners understand the characteristics of drinking water. Tutors could also arrange for a visit to local water treatment facility.

It is important to have access to drawings and utility records related to drainage systems, as well as water distribution networks. Copies of legislation, standards, design charts and tables will also be required.

Finally, where possible, invite a guest speaker from a utility company, a design consultancy, a supplier or a manufacturer. The guest speaker should be able to share with learners the current approaches and design practices in industry, ensuring efficiency and environmental sustainability.

Assessment model

Learning aim	Key content areas	Recommended assessment approach
A Understand below ground drainage systems and methods for treating sewerage	**A1** Introduction to below ground drainage systems **A2** Installation, testing and maintenance of below ground drainage systems **A3** Methods of treating domestic sewerage	Learners will produce a report that investigates below ground drainage systems and methods of treating domestic sewerage.
B Examine methods for disposing of solid domestic waste	**B1** Types and forms of solid domestic waste **B2** Methods of disposal of solid waste **B3** Requirements and constraints relating to the disposal of solid waste	Learners will produce a report that investigates and evaluates the disposal of solid domestic waste produced within a given domestic development.
C Examine the processes used to produce and distribute drinking water	**C1** Sources of drinking water **C2** Treatment of drinking water **C3** Storage and distribution of drinking water	Learners will produce a report that examines a range of sources of drinking water, methods used to purify water and the subsequent storage and distribution of drinking water.

Assessment guidance

There are maximum three summative assignments for this unit. The assignment briefs should be set within the context of a small development, such as a housing or commercial development. The brief should be developed in way that all three assignments could be set against it.

For assignment 1, which will cover learning aim A, adequate details should be provided about the design requirements, pipe materials and disposal issues in order to allow learners to compare, justify and suggest alternatives to treat sewage and dispose sludge. Learners should include calculations and consider the issues related to cost and health and safety, while justifying the design choices made.

Assignment 2, which will cover learning aim B, could be contextualised for the same development as the first assignment. Learners will evaluate disposal methods with reference to the solid waste materials and legal constraints. The evaluation should include rationale for sorting materials and due consideration of legal, environmental and health and safety issues.

For assignment 3, the development could be in a place where learners should consider storing and distributing water to the consumers. Learners would then be able to evaluate various approaches in their responses. Ensure to investigate client requirements so that learners can carry out suitable evaluation. Assessment evidence may take the form of written reports, which will need to include sketches, illustrations and a list of the information sources used.

Getting started

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

Unit 36: Public Health Engineering

Introduction

Introduce learners to the unit using utility records, animations, DVDs, pictures, illustrations or web-based videos relating to drainage and drinking water for a small development.

Well-organised site visits (where learners can see below ground drainage, waste management and water treatment and/or distribution) are invaluable to the delivery of this unit. Visits will need to be timetabled carefully to ensure that learners have sufficient knowledge of the relevant learning aim to fully benefit from the experience. The site visits for this unit could also be done in conjunction with 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 (i.e. domestic, commercial or industrial)
- construction stage (i.e. what learners could see during the visit)
- extent to which site staff could engage (i.e. project presentation, access to drawings, design and treatment data etc).

Learners could prepare checklists before the visits, so that they can record details of materials, jointing methods and type of system, as well as installation, treatment and disposal processes. If finding appropriate sites proves difficult, DVDs can illustrate project examples to learners (or other project data).

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

Learning aim A – Understand below ground drainage systems and methods for treating sewerage

- For learners to examine both below ground drainage and sewerage treatment, the delivery of this learning aim would benefit from a site visit. If a visit is not possible, targeted use of online resources and videos clips can enhance tutor-led presentations and classroom-based activities.
- For the delivery of topic A1, a tutor presentation could be delivered to show how below ground drainage works using animations, DVDs, pictures, illustrations or web-based videos.
- Tutors could facilitate a class discussion, engaging learners by asking them to consider the principles and applications of combined, totally separate, partially separate and grey water systems. This could be followed by a Q&A session, drawing upon the key points and summarising.
- In the following session, more detail can be presented by explaining the types of systems, design requirements and factors. Introduce SUDS at this point. Use drawings, DVD or web-based video resources as appropriate, as well as informal Q&A sessions to check understanding.
- Learners can then get into small groups to investigate suitable systems for different scenarios. For example, one group could be given the task of investigating systems that could be used for an industrial estate, while another group could consider a small housing development. All groups are to then share their findings. Tutors to observe and give guidance where necessary, collating group notes for the class to

be uploaded into a shared access folder.

- Extend the group activity by including suitable SUDS structures. Each group could be allocated a specific structure, e.g. one group could work on swales, while another could focus on wet ponds. Ask learners to discuss their findings for the given scenario, drawing upon key points, summarise and add their findings to a shared access folder.
- In a tutor presentation, introduce the design requirements for below ground water drainage. Engage learners through a Q&A session.
- Learners to get into small groups and be issued a set of example project documents, including design requirements and the final design. For each group, assign a specific topic out of the unit content for this learning aim, e.g. one group must identify how access requirements have been satisfied. All groups are to share their findings. Tutors to observe and give guidance where necessary, collating group notes for the class to be uploaded into a shared access folder.
- Use a knowledge quiz to check learner knowledge before starting the design calculations. The same example project data from before could be used, and once completed, provide model answers. Ask learners to do a self-assessment, and then give them constructive and developmental feedback.
- Tutors could develop activity sheets for learners to practise questions related to 'Chezy', 'Chezy-Manning' and 'continuity' equations. Demonstrate to learners how to do some example calculations before handing out the activity sheets, and support them as they work towards solving the tasks (this could also be conducted in small groups). Conclude this activity with learner feedback and summarise the key factors for consideration.
- Tutors could develop activity sheets relating to design calculations, including drain size, loadings, depth of flow and self-cleansing velocity. Demonstrate to learners how to do some example calculations before handing out the activity sheets, and support them as they work towards solving the tasks (this could also be conducted in small groups). Conclude this activity with learner feedback and summarise the key factors for consideration.
- Tutors could deliver a presentation containing animations, videos and drawings for the delivery of topic A2. Introduce installation and jointing techniques for a variety of pipes. Engage learners through a Q&A session, drawing upon the key points and summarising.
- Using a tutor-led group activity, ask learners to carry out research into the various testing methods available. Assign each group a specific type, e.g. one group could work on CCTV inspection, while another group could be given air test. All groups are to share their findings, with tutors drawing upon the key points, summarise, and then add their findings to a shared access folder.
- Facilitate a class discussion, by asking learners to form into small groups, and give them an example design project. Ask each group to justify access and maintenance requirements. Allocate each group a specific aspect of this, e.g. one group could justify the access points provided. All groups are to share their findings, with tutors drawing upon the key points, summarise and then add their findings to a shared access folder.
- Tutors could arrange for a guest speaker, from either a utility company or design background, to visit the centre and present to the class. Ideally, they can cover some real-life examples of drainage systems in terms of their design, installation and testing. Prior to the visit by the guest speaker, prepare learners to ask questions to ensure that they take advantage of this opportunity.
- For the delivery of topic A3, consider arranging a visit to a sewerage treatment facility where learners can observe the techniques used for treatment. This would give them the opportunity to experience state-of-the-art equipment first-hand. Learners could prepare checklists based upon the unit content, so that they can

record and note the relevant details. If it can be arranged, this visit could form part of the assessment for this learning aim.

- If a visit cannot be arranged, use animations, videos and class discussions for the delivery of topic A3. Engage learners by providing group-based research activities that must be presented to the rest of the class.
- To review learning across this learning aim, facilitate a class discussion where learners should justify the suitability of approaches while designing below ground drainage systems. Summarise learner feedback and expand on the key points where necessary.

Learning aim B – Examine methods for disposing of solid domestic waste

- The delivery of this learning aim would benefit from a site visit in order for learners to examine how solid waste is segregated and disposed. If a visit is not possible, use of online resources and videos clips can enhance tutor-led presentations and classroom-based activities.
- For the delivery of topics B1 and B2, tutors could deliver a presentation to show how solid waste is disposed. You could use animations, DVDs, pictures, illustrations or web-based videos.
- Using a tutor-led discussion, introduce the characteristics of various solid waste types and how these can help to determine the disposal method. Engage learners through Q&A sessions to draw upon key points and summarising.
- Use a knowledge quiz to check learning, which can be based on the campus waste data, data from local recycling companies or online data. Then give model answers to learners. Ask learners to complete a self-assessment and give them constructive and developmental feedback.
- Tutors can deliver a presentation on disposal methods. Use DVD and/or web-based video resources as appropriate. Further, engage learners throughout with informal Q&A sessions to check their understanding.
- Learners are to get into small groups to investigate suitable systems for different scenarios. For example, one group could be given the task of investigating systems that could be used for an industrial estate, while another group could consider a small housing development. All groups are to share their findings, with tutors drawing upon the key points, summarise and then add their findings to a shared access folder.
- For topic B3, learners are required to know about the regulations relating to solid waste disposal. Tutors could deliver a presentation introducing relevant regulations, including those relating to health, safety and welfare. Use the previous data to give examples of compliance, instead of reviewing extracts from specific regulations. Tutors could also give summary handouts with key features of regulations, which learners could refer to during class discussions.
- Learners are to get into small groups to carry out research into the disposal of solid waste, taking into account regulatory, health and safety, and environmental considerations. All groups are to share their findings, with tutors drawing upon the key points, summarise and then add their findings to a shared access folder.
- Tutors could arrange for a guest speaker with an environmental management background to visit the centre and present to the class. Ideally, they can cover some real-life examples of the types of solid waste; how it is disposed; and what are the regulatory and other challenges, e.g. cost implications. Prior to the visit by the guest speaker, ask learners to prepare questions to ensure that they take advantage of this opportunity.
- To review learning across this learning aim, tutors could facilitate a class discussion. Learners are to evaluate the requirements and constraints, and how this could impact on the sorting and disposal of solids.

Learning aim C – Examine the processes used to produce and distribute drinking water

- The delivery of this learning aim would benefit from a site visit, so that learners can examine how water is treated, stored and distributed. If a visit is not possible, use of online resources and videos clips can enhance tutor-led presentations and classroom-based activities.
- For the delivery of topic C1, tutors could deliver a presentation showing the variety of sources of drinking water, e.g. rainfall, rivers, wells and boreholes. Make use of illustrations, animations and video resources, and engage learners through an informal Q&A session.
- Ask learners to form into small groups and to carry out research into the different sources of water and how river management helps to maintain these sources. All groups are to share their findings, with tutors drawing upon the key points, summarise and then add their findings to a shared access folder.
- For the delivery of topic C2, tutors could deliver a presentation to introduce the treatment approaches and processes. Building upon the previous activity, ask learners to relate the characteristics of the water obtained from various resources to the possible treatment processes.
- Consider arranging visit to a water treatment facility where learners can observe the techniques used for water treatment and purification. Learners could prepare checklists based upon the unit content, so that they can record and note the relevant details. If it can be arranged, this visit could form part of the assessment for this learning aim.
- If a visit cannot be arranged, use animations, videos and class discussion for the delivery of topic C2. Engage learners through group-based research activities that are to be presented to the rest of the class. Tutor to draw upon the key points and summarise.
- Tutors could use some basic lab and/or field kits to test the quality of water obtained from various sources. Working in small groups, learners could then use the data obtained to evaluate relevant treatment and purification processes.
- For the delivery of topic C3, tutors could deliver a presentation to introduce how water is stored and distributed. Engage learners through animations, videos and class discussion.
- Follow this by a tutor-led class discussion, and then give learners some utility records, layout drawings or illustrations, showing the storage and distribution arrangements. Learners are to get into small groups and be allocated a specific aspect, e.g. one group could work on isolation arrangements, while another could investigate pumping station arrangements.
- A visit to a reservoir or pumping station could be arranged to reinforce the delivery of topic C3. Learners could then observe first-hand the storage and distribution arrangements. Learners could prepare checklists in advance based upon the unit content, so that they can record and note the relevant details. If it can be arranged, this visit could form part of the assessment for this learning aim.
- Tutors could arrange for a guest speaker either from a utility company, or with an environmental management background, to visit the centre and present to the class. Ideally, they can cover some real-life examples of water treatment, storage and distribution. Prior to the visit by the guest speaker, ask learners to prepare questions to ensure they take advantage of this opportunity.
- To review learning across this topic, facilitate a class discussion, evaluating how water sources, treatment methods, and distribution and storage influence the supply of drinking water for a given scenario.

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

This unit links to:

- Unit 1: Construction Principles
- Unit 4: Construction Technology
- Unit 23: Construction 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 Nationals in Construction and the Built Environment. Check the Pearson website (http://qualifications.pearson.com/endorsed-resources) for more information as titles achieve endorsement.

Textbooks

Afullo A, *Integrated Solid Waste Management Handbook: For Engineers, Planners, Environmentalists, Students and Policy Makers*, WAMRA TECHNOPRISES, 2014 ISBN 9789966720535 – this handbook provides a comprehensive guide to managing solid waste and covers a wide range of perspectives.

Spellman F, *Handbook of Water and Wastewater Treatment Plant Operations* (3rd Edition), CRC Press, 2013 ISBN 9781466553378 – it is a useful text to understand variety of treatment processes.

Journal

SOPHE Journal (Society for Public Health Education) – this is Society of Public Health Engineers (SoPHE) journal containing useful research and industry reports relevant to all aspects of public health engineering.

Videos

Tutors can access 'YouTube' and search for the following videos:

'Drinking Water Treatment Plant' by City of Winnipeg – this video explains the working of a drinking water treatment plant.

'The sewage treatment process' by Unity water – this video shows the sewage treatment process.

'Wastewater Treatment Plant Tour – Flush to Finish' by City of Grand Island – this video shows how wastewater is treated.

Website

'Society of Public Health Engineers (SoPHE)' under the 'Chartered Institute of Building (CIBSE)' – this website gives useful information about various aspects of public health engineering.

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.

Unit 37: Specialist Civil Engineering Techniques

Delivery guidance

Approaching the unit

The focus during the delivery '*Unit 37: Specialist Civil Engineering Techniques*' should be on specialist civil engineering techniques to design and construct bridges, tunnels and marine structures.

Drawings, illustrations, images, animations and video clips are useful resources to explain the principles governing specialist structures and the unique solutions that these provide 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 an under-construction bridge, marine structure or a tunnelling project. 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 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 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 provision of abutments, 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 the opportunities for peer learning.

Tutors 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 bridge, 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 reinforce learning about several types of bridges, design factors and various elements and methods of bridge construction.

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. Tutors could contact the construction companies for such information, which are often more than willing to help.

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

A well-planned site visit will provide 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 especially 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, tutors could task learners with exploring the challenges and impacts of using sprayed concrete in a tunnel lining. To give access to more case studies, tutors 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	Learners will produce a proposal for a type of bridge that will meet design criteria for a given scenario, including alternatives.
B Examine the principles of tunnelling	**B1** Design considerations for tunnels **B2** Construction methods for tunnels	Learners will produce 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	Learners will conduct 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 are maximum three summative assignments for this unit. The assignment briefs should be set within the context of a large civil engineering construction project, such as section of a motorway 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 suitable evaluation. The evaluation must relate to the project scenario provided 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 their choices made. The lining methods, as well as the methods for 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 defences, so that a range of factors could 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. Tutors could ask learners to include sketches, illustrations and a list of information sources used.

Getting started

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

Unit 37: 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 motorway 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, coffer dams 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.
- For the delivery of topic A1, a tutor presentation could be delivered 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 the class discussions.
- To introduce learners to the terminology used to identify elements of a bridge, ask them to form into small groups and give illustrations and drawings of bridges to each group. Each group to identify and annotate the given illustrations and drawings to name all the elements. Learners to share their answers with their peers.
- Tutors could deliver a presentation and, building upon the learning so far, introduce

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 vehicular traffic or pedestrians.

- Learners are 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, with tutors drawing upon the key points, and add this information to a shared access folder.
- For the delivery of topic A2, tutors could deliver a presentation to introduce the materials that could be used for construction of bridges, e.g. reinforced concrete, steel, brick and stone. Tutors could then facilitate a class discussion, asking learners to consider the reasons certain types of material are used.
- Tutors could give case studies to learners for the delivery of topic A3, for example, the construction of a railway bridge. Facilitate a class discussion about the application of bridges in highways, railways, pedestrian and cycle. Explain a case study in respect of design requirements, traffic levels, loadings, benefits and drawbacks, and engage learners through a Q&A session.
- Tutors could arrange for a guest speaker (such as a site manager, design engineer, structural engineer or technical staff working at the local council) 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. Tutors could 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 of online resources and videos clips can enhance tutor-led presentations and classroom-based activities.
- For the delivery of topic B1, tutors could 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 into small groups and give each group illustrations and drawings of tunnels. Each group to identify and annotate the given illustrations and drawings to name all the elements. Learners to share their answers with their peers.
- For the delivery of topic B2, tutors could deliver a presentation to introduce the methods used 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 against given ground conditions. Tutors can draw upon the key points and add this information to a shared access folder.
- Introduce the lining methods used for tunnels using a tutor presentation. Then

engage learners with a Q&A session.

- Learners to get into small groups and tutors to allocate a shaft construction approach to each group, e.g. secant piling, sheet piling and diaphragm walls. All groups to present their findings. Learners can share their findings with the rest of the class, with tutors drawing upon the key points, and add this information to a shared access folder.
- To review learning across this topic, use the same project brief developed as a learning tool. Ask learners to form 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

- Introduce the delivery of topic 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 the same project brief developed as a learning tool. Learners are 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.
- For the delivery of topic C2, use project videos relating to the construction of cofferdams and caissons. Facilitate a class discussion about the approaches to construct these, drawing upon the key points and summarise.
- Learners are 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 topic C2, consider arranging visit to a project site where learners can observe the techniques used for construction of these works. Learners could prepare checklists based upon the unit content so that they can record and note the relevant details. If this could be arranged, this visit can form part of the assessment for this learning aim.
- For the delivery of topic C3, tutors could arrange for a visit to a site where learners can observe harbour works and breakwaters. Learners could prepare checklists based upon the unit content, so that they can record and note the relevant details. If this could be arranged, this visit can form part of the assessment for this learning aim.
- Use the project brief developed as a learning tool. 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 upon 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 Principles
- Unit 2: Construction Design
- Unit 4: Construction Technology
- Unit 5: Health and Safety in Construction
- Unit 6: Surveying in Construction
- Unit 13: Measurement Techniques in Construction
- Unit 16: Work Experience in the Construction Sector
- Unit 23: Construction in Civil Engineering
- Unit 36: Public Health Engineering
- Unit 38: 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 Nationals in Construction and the Built Environment. Check the Pearson website (http://qualifications.pearson.com/endorsed-resources) for more information as titles achieve endorsement.

Textbooks

Hemphill G, *Practical Tunnel Construction*, John Wiley and Son, 2012 ISBN 9780470641972 – it is a useful text to understand variety of tunnelling techniques.

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

Rosignoli M, *Bridge Construction Equipment*, ICE Publishing, 2013 ISBN 9780727758088 – it is a credible text explaining the equipment required in bridge construction and covers a wide range of scenarios.

Journals

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

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

The Structural Engineer [Institution of Structural Engineers (IStructE)] – this is *IStructE* journal, which covers a broad range of areas relating to structural engineering.

Videos

Tutors can access 'YouTube' and search for the following videos:

'Construction of bridge' by Bindas Ajit – it is an excellent animated clip explaining construction of a bridge.

'How are bridges built underwater' by iGYANKOSH

'Tunnel Construction Video' by Luz Lazo – this video explains tunnel construction.

'What is coastal erosion?' by Environment Agency TV – this videos provides useful information about coastal erosion.

Websites

'British Tunnelling Society (BTS)' – it is the website of British Tunnelling Society and contains a wealth of information about all aspects of tunnelling.

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

'iCE.org' – it 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 – it gives information about coastal defences, which is an excellent overview of the topic.

'Steel Construction.info' – it is a credible source providing 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.

Unit 38: Highway Construction and Maintenance in Civil Engineering

Delivery guidance

Approaching the unit

This unit is applicable to the 'Civil Engineering' pathway of the BTEC Level 3 National Diploma and Extended Diploma in Civil Engineering, as it covers large concrete and earthwork structures, as well as infrastructure projects. This unit ultimately focuses on highway construction and maintenance, with three distinct learning aims covering planning and preparation, design and maintenance. Methodology for the planning and delivery of this unit could include:

- engaging the local authority 'Highways Engineering Department' into the development of assignments for the design elements of the assessment
- arranging a site visit for learners to view highway maintenance techniques
- engaging with a property developer to design the road infrastructure for the initial planning stages of the development, along with associated highway drainage
- arranging for a guest speaker, such as a civil engineer who specialises in highway design, to visit the centre and give a talk for learners.

The focus of this unit is on highway planning, design and maintenance. The UK highway infrastructure covers a wide range of road classifications, from motorways that are smart interactively controlled to minor B roads that are single-track access. Learners are to look at the processes that are involved in planning, preparing and designing a road; at earthworks and how these are developed and the ways highways can be drained; and different forms of construction e.g. a concrete road or an asphalt/tarmacadam road construction. Linking this design element to a construction development would give an engaging method of integrating civil engineering into construction activities. Working across two pathways would give some integration for those learners studying both construction and civil engineering.

The planning and design of the road should be from the basis of a new construction, so that all aspects of the planning within the unit content can be considered. Delivery methods can include guest speakers from the highways department and the planning authority. This would give a 'hands-on' approach for learners, including detailed and informative discussions with highway and planning professionals. Tutors may wish to engage with the local authority when delivering this unit, and this relationship may give the centre with good resources on highway design; how planning of such highways is undertaken; and how the local authority maintains its infrastructure.

Gaining access to the standard design details for road construction is essential, in order to demonstrate the national standards that operate in the UK. There are links that have been given in the 'Resources' section of this guide, so that tutors can gain access to the relevant downloadable materials. It is critical to be selective and use those that suitably match the unit content.

Delivery of learning aims

Learning aim A1

It covers the planning and preparation stages of a highway design. Placing this into the context of a new housing estate would give a useful Greenfield approach to the planning of such an infrastructure that will service the new homes. Aspects such as the acquisition of land; the route that the new highway will take; how it will be funded; and its design in terms of line and level all need to be considered. Learning aim A2 examines earthwork construction for new highways, including site clearance, cut and fill, embankment construction and the control of line and level. Reference to any local planning issues or concerns raised by a community for a highway development should be used as engaging resources for the land e.g. compulsory purchase orders.

Tutors could invite a civil engineering contractor who specialises in road construction to visit the centre, as they would help to support learner understanding of learning aim A2, especially regarding the earthwork associated with the construction of a new road, the balance of cut and fill, and how efficiencies are driven through good design.

Learning aim B1

It covers the actual construction of a highway and the different methods of construction. There are two methods of pavement construction that must be covered: flexible and rigid. Small group work with two opposing teams producing a design for the construction of a new road, reinforced with a presentation to a client, would give an ideal opportunity to engage and share learner knowledge. This could be achieved as a micro project with learners conducting research into their method, the machines and equipment required, and the specifications of materials used for each type of construction.

Learning aim B2

It focuses on the drainage installation that is required to ensure that surface water is removed effectively from roads and highways. The standard highway design details (listed in the 'Resources' section) give clear illustrations of the installation of road drainage. It also gives detailed cross-sections of road pavements, so falls can be demonstrated to learners. The connection of road drainage to the associated discharge points needs to be explored in learning aim B3. Local roads workings could be used to demonstrate this, along with earth mapping software programmes. The latter would give aerial views of highway drainage and associated water discharge areas e.g. ponds, dykes, soakaways, SUDS and mains drainage.

Learning aim B4 covers quality control, which focuses on the testing of materials as they are laid *in situ*. It is important to highlight that tests differ between flexible and rigid pavement constructions.

Learning aim C

It covers the maintenance of our highways. The local authority 'Highways Engineers Department' would give a useful resource in the form of a guest speaker, such as an engineer. Tutors could prepare a set of questions based around the assessment criteria for this unit, that focuses on the different methods of repair and what maintenance is required. Similarly, gaining access to a highway maintenance contractor would also give not only employer engagement, but useful resources in terms of visual materials of the methods of repair. These are listed in learning aim C2 and cover a range of repair methods.

Assessment model (in internally assessed units)

Learning aim	Key content areas	Recommended assessment approach
A Undertake the planning and preparation works required for highway construction	**A1** Introduction to planning a new highway **A2** Earthwork construction for new highways	A set of proposals for a new highway, based on a given scenario, including information about preparatory activities, design of earthworks, pavement details and drainage.
B Undertake the production of plans for highway construction	**B1** Forms and methods of highway construction **B2** Drainage of highways **B3** Drainage of land and sub-soils **B4** Quality control	
C Examine maintenance procedures for highways	**C1** Introduction to highway maintenance **C2** Highway maintenance processes	A report that investigates and evaluates the need for highway maintenance and approaches that can be taken to rectify defects.

Assessment guidance

There are two distinct areas of assessment, including a written report and a set of highway design proposals. To set up the assessment for the highway proposal for learning aims A and B, learners will need to be given a design scenario that covers the following criteria:

- an area of land that the proposed road will route through, along with a location map
- the topographical survey of the route
- aerial access to the proposed site in order to view features that will need to be considered
- drainage discharge details
- environmental concerns voiced by the community
- client's proposed specification.

This scenario can be amended and extended as soon as learners begin their design route and specification for the proposed highway. Learners need to produce a full set of proposals that cover the aspects of each of the following:

- earthworks
- line and level
- land acquisition
- funding
- planned route.

Learners will need to produce drawings for the scenario in support of their proposals. Here, links to other units may prove useful, such as *Unit 7: Graphical Detailing in Construction* and any surveying and setting out units in the specification.

The second suggested assessment method for learning aim C is a formal report. This should introduce the types of highway maintenance used to repair defects in flexible and rigid pavements. Tutors could give a series of images with defects and ask learners to propose solutions for each repair. Learners can achieve a distinction grade by evaluating the repair in terms of quality and its life span.

Getting started

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

Unit 38: Highway Construction and Maintenance in Civil Engineering

Introduction

This unit is a very specialised unit dealing with the highway infrastructure and its installation and maintenance in the UK. Engaging employers in terms of local authorities and highway contractors is essential in supporting you with the delivery not only in terms of resources but also first-hand experience.

The key to the learner's proposals is the setting up of the scenario. This should contain sufficient detail so that learners can cover all aspects of the assessment criteria and contain some drawings of the location. Learners can present their evidence using a verbal and slide presentation, which could be recorded and used as the evidence for the comprehensive verb used in the distinction criteria. Since learners have to explain, this is an ideal method of gathering evidence for the assessment criteria.

Learning aim A – Undertake the planning and preparation works required for highway construction

Learners to be issued with a detailed scenario. The suggested delivery for learning aim A is as follows:

- Learners are to get into small groups and open a large-scale location map. They then have to plan their route. Tutor to act as the voice of the surrounding community, and give comments when appropriate.
- Learners to use tracing paper to plan the route of the highway against the criteria within the scenario
- At the end of the period of planning, learners are to present their route with a justification as to why its direction is appropriate by stating valid reasons.

Once the route is established (as a collective decision), the next stage involves some resource planning. The second part of this mini-task is to make decisions with justification regarding the following questions:

- 'How will the new road be funded: public or private?'
- 'What traffic volumes will it be able to carry?'
- 'How can the environmental impact be reduced?'
- 'How will the public be consulted about the changes?'
- 'What type of highway should be constructed?'

Tutors to ensure that learners debate among themselves, so that they outline all of the considerations that need to be met as part of the assessment evidence.

The next stage is to move onto the construction planning. Learners to obtain a longitudinal profile of the road design against the existing levels so that they can plan to balance the cut and fill volumes. This will need the tutor's intervention regarding design levels and ground levels. A link to a resource has been provided (see 'Resources' section) that details mass haul cut and fill planning. This needs to be applied to the topography of the location and the design levels of the roadway.

Tutors could introduce a variable to make the task more challenging, e.g. weak ground that needs to be stabilised and drained before highway construction works can commence.

Learning aim B – Undertake the production of plans for highway construction

Learning aim B is concerned with the production of plans for highway construction. It includes the design of drainage for land and sub-soils, which needs to be indicated on plans, so this part of the sub-structure can be accommodated in the construction of the highway. A variety of engaging delivery methods can be used to cover this unit content, such as:

- Learners to get into small groups, with the tutor allocating half of the groups with 'rigid' pavements and the other half of the groups with 'flexible' pavements. Learners to then research the construction methods that are suitable and materials specifications for highways with a range of traffic requirements.
- Tutor to culminate the learners' research work and facilitate a debate, getting learners to justify which one to use for the given scenario.
- Learners to produce a cross-section detail with a specification for their justified choice, along with the associated drainage requirements at road kerb positions. This can include road gullies and associated drainage and discharge ditches and outfalls.
- Tutors to use videos to demonstrate the two different methods of construction (links to suitable videos have been provided in the 'Resources' section).
- Investigation of published standard details for highway design of drainage which is covered under learning aim B2. A number of these are available to download on local authority highways websites to assist with this method.
- Learners to investigate land drainage types for the disposal of collected water, methods and procedures (to include soakaways sustainable urban drainage systems, watercourses, catch pits and associated calculations).
- Tutors to show learners the 'Standards for Highways: Volume 4', which details typical drainage arrangements for highways (including manholes) and soakaway designs and provides typical cross-section details.
- Tutors to arrange for a guest speaker from the 'Highways Department' to visit the centre and provide advice about the construction details for flexible and rigid pavement, including a class discussion of the typical details. These could include the build-up of the different layers in a flexible pavement, from the sub-base, base layer and wearing course. Examples of how they instigate repairs would also engage the aspect of highway maintenance.
- Tutors could also arrange for a highways contractor to visit the centre and provide a case study for a design and build highway project, e.g. a toll road.

Presentation of the learner's proposals is a matter of choice. Learners could use small group work activities to deliver an aspect against their design proposals. However, care should be taken with any observation records for the presentation so that all individuals meet the assessment criteria for the unit.

For learning aim B4, use and application of quality control methods could be evidenced by asking learners to create a leaflet about onsite testing, to ensure that flexible and rigid pavements are constructed in accordance with the British Standards and Highways design standards. Images can be included in the leaflet to illustrate the different types of testing that needs to be undertaken.

Learning aim C – Examine maintenance procedures for highways

Learning aim C focuses on the use and application of maintenance to ensure defects in highways are resolved, and the benefits and drawbacks of alternative approaches. The suggested assessment for this learning aim takes the form of a written report. There are several different engaging methods of delivery that could be used to deliver this content, including:

- Tutors can ask the guest speaker from the previous learning aim (the highways contractor) to provide learners with a demonstration of the methods that can be used to repair and maintain both flexible and rigid pavements.
- Tutors can also invite a guest speaker from the local authority to talk about the differences between seasonal maintenance of roads, e.g. summer versus winter, through routine and structural repairs. This should include how roads are surveyed for defects and the recording and commissioning processes involved.
- Tutors can provide learners with a series of visual images of defects. Then learners have to identify the defects and write a repair method statement, justifying their chosen repair method. Tutors can use videos to demonstrate the repair methods that are employed in the UK.
- Tutors can arrange for a site visit for learners to observe road planning work in the field and maintenance processes such as laying a new surface. They can observe a top dressing being applied to maintain the road surfaces and white lining in operation.

This is a very short section within learning aim C, so a holistic approach to the maintenance of a highway should be adopted. This will allow the evidence to be based on a repair with learners demonstrating a recommended technique, then justifying and evaluating that technique.

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

This unit has link to the following unit within the suite of qualifications:

- Unit 7: Graphical Detailing in Construction

Resources

In addition to the resources listed below, publishers are likely to produce Pearson-endorsed textbooks that support this unit of the BTEC Nationals in Civil Engineering. Check the Pearson website (http://qualifications.pearson.com/endorsed-resources) for more information as titles achieve endorsement.

Textbooks

Hughes D, *Highways* (5th Edition), ICE, 2015 ISBN 9780727759931 – It is a detailed textbook covering all aspects of highway engineering.

Pitman P, *External Works, Roads and Drainage (A Practical Guide)*, Taylor and Francis, 2001 ISBN 9780419257608 – It is an excellent 'hands-on' approach textbook.

Videos

Access 'YouTube' website and search for the following videos:

'Highway Concrete Machines At Work' by groutaone – It shows a rigid concrete paving being laid.

'World Amazing Modern Road Construction Asphalting Vogele Dynapac Truck Mega Machines Europe' by Epic Machines – It shows asphalt road construction machinery laying down a new surface.

'Repairing Potholes Process – Velocity Patching' by New Vision Media – It shows pavement repair using a unique spray method on a tarmacked road.

Websites

'Ice.org.uk' – It is a professional body for civil engineering with information on professional development, career pathways, standards and other resources.

For information on planning:

'Gov.uk' – Search the website for 'Planning and the Major Road Network in England' for Highways England planning guidance.

'Norfolk County Council' – Click on 'Rubbish, recycling and planning', 'Planning applications', 'Design of developments' and then search for 'Highway advice for developers' – It is a useful local authority website covering all aspects of highways development.

'theihe.org' – The relevant professional body for Highway Engineering including standards, professional development and other resources.

Tutor to access a search engine and look for 'UGPTI Earthwork and Mass Diagrams PDF', which provides an example of mass haul calculations for cut and fill.

For information on design:

'Gov.uk' – Search the website for 'Standards for Highways Online Resources the Design Manual for Roads and Bridges'.

'Williams Lea Tag' – Search for 'Standards for Highways in the UK'.

For information on construction:

'Pavement Interactive' and 'The Constructor.org' – These websites give information on pavement types.

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