



Unit 13: Site Engineering for Construction

Delivery guidance

In this unit, learners will investigate and develop the essential skills required for setting-out construction and civil engineering projects, exploring a range of approaches that can be used to make sure that construction projects meet their specified tolerances.

Approaching the unit

Through investigative and problem-solving activities, learners will appreciate the importance of ensuring specifications are met. For example, learners will understand the reasons for ensuring that roads are set out to the correct level.

Learners will explore the techniques involved with surveying, including how they are used to ensure both sub-structures and superstructures meet specifications and drawn information.

Using surveying equipment, and suppliers as guest speakers, will provide ideal opportunities for learners to see the range of modern surveying equipment available in their country.

This unit will also develop learners' understanding of methods of controlling the horizontal and vertical aspects of structures and excavations and how they can gather and interpret data for these control purposes.

The knowledge and skills developed throughout this unit are highly valued within the international construction industry. Many international learners attend college on a part-time basis, and are already employed in a construction or civil engineering context. This unit will reinforce the learning from site and grow confidence in accuracy in setting-out so the level of responsibility can be achieved on site with associated promotional prospects.

Delivering the learning aims

Learning aim A

For learning aim A, you could begin with a site visit to observe setting-out taking place. Developing a relationship with a local contractor is a great way of getting a site visit agreed. This would be an interesting way to introduce learners to the local country terminology that is used for setting-out. Learners should be encouraged to produce a glossary of local surveying terms commonly used on a construction site in your country. Tutor-led demonstrations and practical tasks could be used to develop an understanding of the equipment and methods used in the setting-out of a grid line for structural steelwork and the external and internal wall positions. You could follow this with practical activities for learners to apply techniques for setting-out right angles and transferring benchmarks in a site-based environment. Learners need to be encouraged to justify the selection of equipment for setting-out activities.

You could then examine methods of interpreting drawing information and how these are used to set out excavations and external walls. This could be achieved through fieldwork tasks where drawings are provided and learners complete the setting-out



appropriately. Throughout the activities, learners should become familiar with the traditional and digital tools that are used in setting-out. Resources in terms of drawings, pegs, string lines, nails and profile boards need to be provided for setting-out activities, along with hammers to drive pegs and profile boards.

Learning aim B

With learners now confident in their understanding of how the equipment and techniques are used for setting-out on-site, you can begin to introduce them to the practical application of these methods through learning aim B. You could begin by considering the methods used to set out drainage, such as locating key design features, and carrying out related calculations. This offers learners the opportunity to apply the theory discussed in learning aim A and should be complemented by the use of site visits as appropriate. This is very practical learning aim. Suitable locations will need to be sourced to set out the drainage run, embankment and complex road curve.

Learning aim C

This learning aim explores the vertical and horizontal control with regard to excavation control, volumes to be moved and accuracy in setting-out such elements. Aspects of mathematics with regard to ground levels and formation levels will enable calculations of excavation volumes to be undertaken. This unit links to *Unit 10: Surveying in Construction*, where data obtained from a grid of levels can be reused for a volume calculation.



Assessment model

Learning aim	Key content areas	Recommended assessment approach
A Undertake the setting out of construction work on plan	A1 Setting-out terminology A2 Basic setting-out processes A3 Interpreting drawn information to set out construction work A4 Site engineering equipment	A case study scenario where learners have to acquire all the information, equipment and data for a setting-out project. They will produce a method statement detailing all requirements, then set out a building on plan.
B Undertake the setting out of infrastructure works	B1 Setting out drainage B2 Setting out embankment and cutting profiles B3 Interpreting drawn information to set out roads	Fieldwork practical tasks to defined levels of accuracy. Learners will evaluate methodologies used in undertaking a series of practical setting-out tasks.
C Explore how to maintain horizontal and vertical control in setting out	C1 Vertical and horizontal control of structures C2 Vertical and horizontal control of excavation	



Assessment guidance

The assessment of this unit is most likely to be in the form of two assignments, one for learning aim A and a second for learning aims B and C.

For Assignment 1, learner evidence would normally be presented as a method statement for a setting-out task that communicates all technical considerations required before starting the practical exercise. Learners need to explain the setting-out procedures that they will use to achieve a given level of accuracy. They will also need to evidence their justifications of the selection of tools, equipment and processes for the stated purpose and the accuracy of setting-out required. For example, excavation work followed by finished concrete levels will have different tolerances.

Learners need to demonstrate that they can set out, from plan, a building for initial excavation. It should use corner pegs, contain a void for differentiation and have an agreed tolerance specified by a known standard. The setting-out then must be extended for the construction of the building walls, with central, internal and external grid lines established by the use of profile rails.

In Assignment 2, learners need to demonstrate their analytical skills with a pre-excavation survey for the setting-out of infrastructure works. If they have undertaken *Unit 10: Surveying in Construction*, the data from this unit can be used for this purpose. Learners will need to clearly present a range of evidence collated from fieldwork activities, including an evaluation of the methodologies used in completing a range of practical setting-out tasks for a drainage run, an embankment or cutting and a complex road curve. Each will be supported by calculations and appropriate diagrams.



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 13: Site Engineering for Construction

Introduction

This unit enables learners to gain practical experience of setting-out methods used for a range of applications in the construction and civil engineering sector. There are opportunities for visiting speakers to explain the techniques that can be used, along with site visits to gain first-hand experience of the processes involved in setting-out within your country.

Learners will need to be confident in the interpretation and communication of setting-out data and plans being considered. You should give learners real-world scenarios and tasks to allow them to practice and develop the skills needed to set out a range of construction features in a fieldwork setting. Learners should also gain experience of the control methods used on site to ensure that horizontal and vertical tolerances are met.

Learning aim A

The purpose of learning aim A is to give learners the background knowledge and understanding of setting-out that will prepare them for carrying out setting-out tasks using a range of techniques and equipment. Part of this learning aim is theoretical and part is practical setting-out.

Learning aim A1

- Introduce learners to terminology that relates to setting-out on construction sites. You may like to refer to *Unit 10: Surveying in Construction*, which covers such terminology applied to surveying and setting-out. This could be achieved through site visits, demonstrations and visiting speakers.
- Learning could be further supported through class discussions to confirm the meaning of terms and the applications of key pieces of equipment. These should be localized to your country and native language.
- Learners should carry out research activities within small groups to produce information sheets that explain the application of equipment and how it is used.
- Introduce the use of coordinates and related measuring methods. Initially, this could be explored through case studies and classroom-based exercises for learners to plot coordinates using a range of techniques. Coordinates are used for setting-out using designer's drawings that are uploaded into a total station, and from this, known points can be set out.

Learning aim A2

- Introduce learners to the techniques used to establish basic setting-out points. This could be achieved through paired practical activities to apply a variety of methods to construct right angles. Videos could be used to demonstrate techniques using theodolites and total stations.
- Set learners tasks to construct a range of right angles in the field. A right angle is the basic requirement for many structures and learners must be able to attain this simple knowledge using 3,4,5 trigonometry.



- Follow this with a tutor-led group discussion on benchmarks, including how to source them, and the methods used to establish temporary benchmarks on site.
- Learners to carry out activities to establish a temporary benchmark from a given point.
- Run a class discussion on the reasons for taking recordings on site and the importance of protecting a temporary benchmark.
- The practical element of this learning aim can now be commenced. Learners need to set out a building, suggest a rectangle with a void. The outside, centre line and inside external walls need to be indicated on profile boards. Start with a simple rectangle and a centre line as practice for the observed assessment of P2.

Learning aim A3

- Demonstrate to learners how to interpret drawings to obtain setting-out information and dimensions for use on site.
- Carry out fieldwork in setting-out buildings on plan for initial excavation and for external wall positions. This could be developed into a formal assessment of P2 using a given drawing with a void in part of the building. Observation records and photographs could record the evidence for this AC P2

Learning aim A4

- A tutor-led presentation can introduce learners to the use of traditional setting-out tools and equipment.
- Learners create a document identifying and explaining how, why and when the different tools and equipment may be used.
- Introduce learners to digital technologies, using a tutor-led class discussion to consider the benefits of using this equipment, including total stations, laser levelling and laser measuring. The discussion should lead to the justification of equipment selection in supporting the distinction grading criterion one.

Learning aim B

The range of surveying techniques introduced in learning aim A are further explored through practical application in learning aim B, as the learners progress through a range of setting-out activities for a given situation.

Learning aim B1

- To introduce learning aim B, lead a discussion with learners to examine their understanding of the purpose for setting-out on site. This could reflect on an earlier site visit from this unit, or be discussed as part of a further site visit where setting-out is to be carried out.
- In a class-based session, introduce learners to the approaches that need to be considered when setting-out drainage. You could demonstrate how to calculate gradients from design drawings and then assess learner understanding through the use of case study-based questions.
- The mathematics behind the setting-out of profile boards to a gradient for drainage needs to be practiced in the classroom so learners grasp what a gradient is. Learners must also understand the local building regulations that state what gradient must be adhered to in drainage installations. Explain how the length of a traveller is established from the invert level of a drain and the height of the profile boards above ground level.



As with previous calculations, learners could complete task sheets to assess their understanding of the processes.

- Further tutor-led demonstrations could be used to show learners how to transfer temporary benchmarks to on-site drainage positions before dividing the class into smaller groups to complete the activity themselves on a suitable work site.

Learning aim B2

- Once learners are competent with the techniques required for setting-out drainage, introduce them to the methods used for setting-out embankments and cutting profiles.
- You could demonstrate the calculations that they need to be able to carry out before assessing their understanding.
- Follow this with demonstrations of the activities that need to be completed that link to assessment criteria, with learners then carrying them out in small groups.
- Discuss with learners the methods used for setting-out roads, including the need to ensure that road curve points are correct in accordance with road design drawings.

Learning aim B3

- With an understanding of how to interpret road design drawings, introduce learners to the chord point method of setting-out curves using demonstrations of calculations and the physical setting-out road curbs using pins.
- Learners to work in teams to set out a road curve from a given drawing.
- Introduce learners to the deflection angle method, demonstrating the methods of establishing the deflection and tangent angles and chord lengths. Then, show learners how to use a theodolite to establish each tangential point from the data produced.
- Learners to work in teams to set out a further road curve.
- Tutor-led discussion to evaluate the relative benefits of each method of setting-out roads. Learners should consider which is more appropriate for given situations.
- There should also be an opportunity for fieldwork or site visits during this learning aim (along with learning aim C), as this will give learners the opportunity to observe and perhaps even undertake measurements in a real environment.

Learning aim C

Learning aim C will introduce learners to the techniques used for the vertical and horizontal control of structures and excavations. As with learning aims A and B, there are opportunities for site visits and visiting speakers to contextualise theory and practice in a site-based environment.

Learning aim C1

- Introduce learners to the topic by leading a discussion on the reasons for horizontal and vertical control of structures. This could be expanded on by using case studies where control has not been effective, and discussions to explain the effects of not using control methods. It is good to reference this at this stage in the installation of structural steelwork frames and the need for horizontal and vertical control.
- Use practical demonstrations to introduce learners to the methods of positioning kickers for *in situ* concrete columns; this could be supported through the use of videos. Demonstrate the methods used to confirm verticality of column shuttering and check tolerances, and ask learners to work in small teams to carry out similar checks on shuttering.



- Introduce learners to methods of checking squareness and diagonals of shuttering profile on plan, and visual checks of the cover of reinforcement.
- Discuss the similarities between concrete works and structural steel works, and the approaches that need to be taken when checking profile lines and the position of holding down bolts.
- Learners to complete a range of practical exercises that involve inspection and checks to ensure that both concrete and steel structures are within tolerances.
- Many of the activities above will rely on the services of a main contractor who could make available a local site for learners to carry out their practical checks.

Learning aim C2

- A visiting speaker who specialises in setting-out excavations could discuss how data is collected and used prior to excavation, e.g. to establish and record ground levels.
- Use group activities to set out a grid over an excavation area and plot a grid of levels to reduced levels. If learners have completed *Unit 10: Surveying in Construction* then the grid of levels can be reused for this task.
- Demonstrate to learners the techniques used to produce an interim and final grid of levels from reduced excavations. You could also demonstrate the methods of establishing volumes, including calculating the formation level achieved and confirmation of depth.



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

This unit links to:

- Unit 1: Construction Technology
- Unit 6: Construction Mathematics
- Unit 10: Surveying in Construction
- Unit 12: Building Surveying 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 Internationals in Construction. Check the Pearson website (<http://qualifications.pearson.com/endorsed-resources>) for more information as titles achieve endorsement.

Textbooks

Topliss, S. et al., *BTEC Nationals Construction Student Book + Activebook: For the 2017 specifications (BTEC Nationals Construction 2016)*, Pearson, 2017, ISBN 9781292184043 (please note that this book was written specifically for the UK market but it may be useful)

Greeno, R. and Osbourn, D. *Mitchell's Introduction to Building* (5th Edition), Routledge, 2012, ISBN 9780273738046

Smith, J. (ed), *The Management of Setting out in Construction: Ice Design and Practice Guide*, Thomas Telford Ltd, 1997, ISBN 9780727726148 – Includes techniques for setting-out a range of features

Journals

Building Magazine (Building) – has case studies of a range of commercial, industrial and domestic construction projects

Construction News (EMAP Publishing Ltd.) – includes information about health and safety, current practice and projects

Videos

Go to the 'YouTube' website and search for the following videos:

"Setting Out" – CITB training video for health and safety on site when setting-out

"Malcolm Oaten's Tack-On Profile Board System" – Examples of setting profile rails and travellers

"Adjustable Kicker - Formwork Brace" – One method of using kickers

"CTV 10 Setting out a building" – Setting-out processes for buildings

"How to use a digital theodolite" – Use of a digital theodolite

"Surveying 1 - Introduction to Levelling" – Use of a level



Websites

Institution of Civil Engineers (the professional body for Civil Engineers in the UK) for resources, standards, career advice and CPD, providing useful context on the role of a civil engineer.

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 students to access them through the school/college intranet.