Unit 28: Topographic Surveying in Construction and Civil Engineering

Unit code: K/600/0426

QCF Level 3: BTEC Nationals

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit gives learners the opportunity to develop the skills needed to carry out surveys to establish the levels of points, determine coordinates of stations, and survey land and buildings. Learners will also develop a knowledge of emerging technologies in control and topographic surveys.

Unit introduction

Topographic surveying is the measurement of existing features of the earth's surface and the presentation of the results. Knowledge of the size, shape and position of natural and manmade features is an essential element in the planning of a wide variety of projects.

Surveyors use a variety of instruments to carry out measurements, which are normally recorded electronically. Measurement data is transferred from the instrument to suitable software for processing and the production of the required drawings. Drawings in digital format can be sent to the client electronically, and are often input directly into their own software for analysis, planning or design of the project.

Surveying is a technologically-advanced discipline and is changing rapidly in terms of instrumentation and the presentation of results.

The professional surveyor must be confident with the underlying mathematics involved in the processing of data, and calculations are therefore an important part of the unit. Learners should have an understanding of trigonometry and basic mathematical principles before starting this unit. The use of spreadsheets for calculations and software for producing drawings is also an important aspect of this unit.

Learning outcomes

On completion of this unit a learner should:

1 Be able to carry out control surveys to establish the levels of points

2 Be able to carry out control surveys to determine coordinates of stations

3 Be able to carry out surveying of land and buildings

4 Know about emerging technologies in control and topographic surveys.

Unit content

1 Be able to carry out control surveys to establish the levels of points

Control surveys: procedures to establish vertical control; calculations

Procedures: fly levelling to establish levels of points

Calculations: adjustment of simple levelling networks

2 Be able to carry out control surveys to determine coordinates of stations

Control surveys: procedures; calculations

Procedures: to determine coordinates and stations; traversing; free station

Calculations: polar and rectangular coordinates; adjustment of simple traverses

3 Be able to carry out surveying of land and buildings

Surveying of land: topographic surveys (hard detail, soft detail and contours); use of total stations and standard software; production of plans

Surveying of buildings: measured building surveys (internal and external); use of standard software; production of plans

4 Know about emerging technologies in control and topographic surveys

Emerging technologies: Global Positioning Systems (GPS); automated total stations; laser scanning

Advantages: in terms of accuracy; reliability; ease of use; site conditions; cost

Assessment and grading criteria

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

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 carry out levelling surveys to establish vertical control [IE1, IE2, IE4, IE6, TW1, SM2, SM3, EP3]	**M1** adjust a simple levelling network using a standard method of calculation.	**D1** compare the suitability of standard adjustment methods in terms of their accuracy
P2 carry out control surveys to determine coordinates [IE1, IE2, IE4, IE6, TW1, SM2, SM3, EP3]	**M2** adjust a simple traverse network using a standard method of calculation	
P3 calculate coordinates of stations from data collected [IE1, IE2, IE4, IE6, TW1, SM2, SM3, EP3]		
P4 carry out surveys of land and buildings [IE1, IE2, IE4, IE6, TW1, SM2, SM3, EP3]	**M3** specify appropriate instruments and techniques for topographic surveying tasks.	**D2** assess the accuracy and effectiveness of new technologies against current methods used in control and topographic surveying.
P5 produce plans of land and buildings using standard software [IE1, IE2, IE4, IE6, TW1, SM2, SM3, EP3]		
P6 describe the uses and advantages of emerging technologies in control and topographic surveying. [IE1, IE2, IE4, IE6, TW1, SM2, SM3, EP3]		

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

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

Essential guidance for tutors

Delivery

Tutors delivering this unit have opportunities to use a wide range of techniques. Lectures, discussions, seminar presentations, site visits, supervised practicals, research using the internet and/or library resources and use of personal and/or industrial experience are all suitable. Delivery should stimulate, motivate, educate and enthuse learners. Visiting expert speakers could add to the relevance of the subject but, as this is essentially a practical unit, learners will learn more quickly by doing, rather than by listening.

The four learning outcomes are not linked to each other but there is a natural progression through plan control, levelling and topographic surveys. Learning outcomes 1 to 3 are essentially practical. Learning outcome 4 is less in practical nature but it gives learners the opportunity to investigate new technologies and relate their use to the practical work they have already carried out.

The unit requires learners to carry out standard surveying calculations using non-programmable calculators. However, once learners have demonstrated this ability, the use of spreadsheets to carry out repetitive calculations should be encouraged.

The unit gives learners opportunities to carry out realistic surveying tasks and produce high quality results. This unit is likely to be delivered later in the programme, since a familiarity with the use of surveying equipment, and an understanding of basic levelling and angle calculations, is assumed. Learners should therefore have studied a mathematical unit prior to starting this unit.

Group activities are permissible, but tutors will need to ensure that individual learners are provided with equal experiential and assessment opportunities.

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

Outline learning plan

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

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

Topic and suggested assignments/activities and/assessment
Tutor explanation: Introduction to the unit
Levelling
Tutor explanation: surveying principles and terminology, introduction to levelling and the automatic level, levelling techniques, 2 peg test
Learner exercise: 2 peg test
Learner exercise: practical levelling exercise
Learner exercise: calculate reduced levels using 'rise and fall' and 'HOC' methods
Learner exercise: adjust/check calculations using standard methods
Didactic input: explanation of contour surveys, techniques to compute areas and volumes from contours, spot heights, ground sections.
Learner exercise: formative assessment exercise
Learner exercise: computation of areas and volumes from contours
Traversing
Tutor explanation: introduction to traversing, open and closed loop traverse
Learner exercise: calculations of traverse angles
Tutor explanation: sources of errors in a closed traverse
Learner exercise: worked example of closed traverse calculations
Tutor explanation: Bowditch Method of Traverse Correction
Class discussion: factors affecting choice of stations
Learner exercise: correction of reduced angles using (2n-4)x90
Learner exercise: calculation of WCB from angles
Tutor explanation: introduction to polar and rectangular coordinates
Learner exercise: calculation and conversion of coordinates using manual methods
Tutor explanation: introduction to the optical theodolite
Learner exercise: formative assessment exercise
Assignment 1: Contour Surveys and Determining Coordinates
Topographic survey
Tutor explanation: introduction to total station and familiarisation equipment
Didactic input: data capture and use, download survey data, manipulation of data
Learner exercise: full total station survey including GPS (formative assessment exercise)

Topic and suggested assignments/activities and/assessment
Emerging technologies
Tutor explanation: history of surveying
Class discussion: processes involved, time needed, accuracy and cost (manual and with automated instruments)
Independent investigation: available technologies and their uses
Industrial visit to local, regional or national company to gain an understanding of data capturing techniques and use of software aids
Assignment 2: Surveying Land and Buildings and Emerging Technologies
Review of unit and assignment feedback

Assessment

Evidence for this unit can be gathered from a variety of sources, including well-planned investigative assignments, case studies or reports of practical assignments.

There are many suitable forms of assessment that could be used. Some example assessment approaches are suggested below. However, these are not intended to be prescriptive or restrictive, and are provided as an illustration of the alternative forms of assessment evidence that would be acceptable.

Some criteria can be assessed directly by the tutor during practical activities. If this approach is used, suitable evidence would be observation records or witness statements. Guidance on the use of these is provided on the Edexcel website.

The structure of the unit suggests that the grading criteria could be addressed fully by using two assignments. The first of these would cover P1, P2, P3, M1, M2 and D1 and the second P4, P5, P6, M3 and D2. Learners may work in groups of three to four when carrying out practical work.

To achieve a pass grade learners must meet the six pass criteria listed in the grading criteria grid.

For P1, learners must undertake levelling surveys to establish vertical control. They must actively participate in fieldwork, be able to carry out calculations of levels of stations and produce a contour plan drawn to scale along with a written description of the processes involved.

For P2, learners must carry out control surveys to determine coordinates. They must actively participate in fieldwork for a traverse survey, collect all the required data and provide a written description of the processes involved in carrying out the survey.

For P3, learners must calculate coordinates of stations from the data collected for P2. They must calculate angles and distances from the basic observations and, carry out calculations of eastings and northings and produce a plan drawn to scale.

For P4, learners must undertake surveys of land and buildings using standard survey instruments and produce plans using standard software. They must actively participate in fieldwork for a topographic survey, carry out calculations of eastings, northings and levels of observed points and provide a description of the processes involved in carrying out the survey.

For P5, learners must produce plans from the data collected in P4, using standard software. They must produce a plan using survey software and/or computer-aided drawing along with a description of the processes involved in using the software

For P6, learners must describe the uses and advantages of emerging technologies in control and topographic surveying. They must be able to demonstrate, at the very least, a knowledge of all the instruments mentioned in the unit content for learning outcome 4. Evidence should be in the form of a presentation, a report or oral answers to questions posed by the tutor.

To achieve a merit grade learners must meet all the pass grade criteria and the three merit grade criteria.

For M1, learners must be able to adjust a simple levelling network using a standard method of calculation.

For M2, learners must be able to adjust a simple traverse network using a standard method of calculation.

For M3, learners must specify appropriate instruments and techniques for topographic surveying tasks. They must be able to discuss the application of these instruments to typical topographic surveying tasks including an explanation of how they are used on modern projects. Evidence should be in the form of a presentation, a report or oral answers to questions posed by the tutor.

To achieve a distinction grade learners must meet all of the pass and merit grade criteria and the two distinction grade criteria.

For D1, learners must compare the suitability of standard adjustment methods in terms of their accuracy when used in simple control networks.

For D2, learners must assess the accuracy and effectiveness of new technologies compared to current methods for control and topographic surveying. They must be able to make reasoned judgements about their appropriateness in terms of cost and site conditions, and demonstrate their understanding of the digital data flow from observation to final product. Evidence should be in the form of a presentation, a report or oral answers to questions posed by the tutor.

Programme of suggested assignments

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

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3, M1, M2, D1	Contour Surveys and Determining Coordinates	You are working as a trainee surveyor and have been asked by your senior surveyor to carry out a contour survey. The client is a housing contractor who will use your survey results to ascertain cut-and-fill quantities. You have also been asked to carry out a traverse survey for a housing contractor.	A report containing both raw and processed data as well as written descriptions of the processes involved.
P4, P5, P6, M3, D2	Surveying Land and Buildings and Emerging Technologies	You are working as a junior surveyor. Your client is a housing contractor. Your senior engineer has asked you to carry out a topographic survey using a total station and standard software. You have also been asked to carry out an investigation into how emerging technology can be applied to surveying tasks.	A report containing both raw and processed data as well as written descriptions of the processes and emerging technology involved.

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

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

Level 1	Level 2	Level 3
		Surveying in Construction and Civil Engineering
		Setting Out Processes in Construction and Civil Engineering
		Spatial Data Techniques in Construction and Civil Engineering
		Surveying Technology in Construction and Civil Engineering
		Construction in Civil Engineering

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

- BE Design
- Construction Contracting Operations
- Spatial Data Management
- Surveying, Property and Maintenance.
- Transportation.

Essential resources

Since this unit is practical in nature, centres will need a suitable range and quantity of equipment and suitable areas for carrying out realistic tasks in safety.

As a minimum, the instruments required include tape measures, automatic optical levels and total stations (preferably with on board data storage) but learners should be made aware of the other instruments mentioned in the unit content and, wherever possible, should have the opportunity to use them. Suitable ancillary equipment, such as staffs, tripods and ranging poles, will also be required. There should be sufficient instruments available so that during fieldwork teams are small in number.

To meet the requirements of learning outcome 3, learners will need to have access to industry-standard surveying software or, alternatively, they could use spreadsheets and a CAD package to produce the required drawings. Centres will require access to areas of land with topographic and built features where practical surveying work can be carried out safely. Health, safety and welfare issues must be considered at all times and risk assessments undertaken where necessary.

Employer engagement and vocational contexts

The use of vocational contexts is essential in the delivery and assessment of this unit. Much of the work can be set in a real world context. Learning outcome 4 lends itself well to investigating what goes on in the real world of surveying. Visits to companies/shows/exhibitions will enhance this particular part of the unit. Companies with a surveying section are likely to be able to show how field data is manipulated and adjusted, especially with the use of new technologies and software packages.

Support to enable centres to initiate and establish links to industry, and to networks arranging visits to industry and from property practitioners is given below:

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

Indicative reading for learners

Textbooks

Bannister A and Baker R – *Solving Problems in Surveying, 2nd Edition* (Pearson Higher Education, 1994) ISBN 0582236444

Bannister A and Raymond S and Baker R – *Surveying, 7th Edition* (Pearson Higher Education, 1998) ISBN 0582302498

Irvine W and Maclennan F – *Surveying for Construction, 5th Edition* (McGraw-Hill, 2005) ISBN 007711141

Johnson A – *Plane and Geodetic Surveying, 1st Edition* (Spon Press, 2004) ISBN 0415320046

Muskett J – *Site Surveying, 2nd Edition* (Blackwell Science, 1995) ISBN 0632038489

Uren J and Price W F – *Surveying for Engineers, 4th Edition* (Palgrave Macmillan, 2005) ISBN 1403920540

Journals

Civil Engineering Surveyor – Institution of Civil Engineering Surveyors

Geomatics World – PV Publications

New Civil Engineer – Emap

RICS Business – RICS

RICS Construction Journal – RICS

RICS Land Journal – RICS

Websites

www.bconstructive.co.uk	BConstructive
www.ciob.org.uk	Chartered Institute of Building
www.cskills.org	ConstructionSkills
www.cstt.org.uk	Chartered Surveyors Training Trust
www.ice.org.uk	Institution of Civil Engineers
www.ices.org.uk	Institution of Civil Engineering Surveyors
www.rics.org	Royal Institution of Chartered Surveyors

Delivery of personal, learning and thinking skills (PLTS)

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

Skill	When learners are ...
Independent enquirers	planning and carrying out research to develop an awareness of emerging technologies in surveying and judging its appropriateness assessing accuracy of control networks using mathematical evidence
Self-managers	organising time and resources and prioritising actions while carrying out a topographic survey using a total station and producing plans using standard software
Team workers	carrying out practical field exercises in level and traverse surveys
Effective participators	proposing practical ways to adjust levelling or traverse networks.

Although PLTS opportunities are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are ...
Creative thinkers	asking questions during field/class work to extend their thinking
Reflective learners	assessing the accuracy of their own work and identifying areas of improvement
Self-managers	building and maintaining relationships by managing their emotions in fieldwork situations.

Functional Skills – Level 2

Skill	When learners are ...
ICT – Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	using total station and standard software for topographic surveys
Manage information storage to enable efficient retrieval	storing and retrieving both field and processed data
ICT – Find and select information	
Select and use a variety of sources of information independently for a complex task	using internet and other online sources to investigate use and applications of emerging technologies
ICT – Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: • text and tables • images • numbers • records	preparing reports and presenting results of their fieldwork
Bring together information to suit content and purpose	processing field data to produce a number of products
Present information in ways that are fit for purpose and audience	presenting evidence of data capture and data processing as well as the end product
Mathematics	
Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations	calculating areas and volumes in a contour survey
Identify the situation or problem and the mathematical methods needed to tackle it	adjusting levelling and traverse networks
Select and apply a range of skills to find solutions	carrying out a topographic survey and using a standard software and/or CAD to produce a suitable plan
Use appropriate checking procedures and evaluate their effectiveness at each stage	assessing the accuracy of levelling and traverse networks
Draw conclusions and provide mathematical justifications	adjusting closing errors in levelling and traverse networks

Skill	When learners are ...
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	discussing choice of stations and accuracy issues in surveying
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	assessing the appropriateness of emerging technologies
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	explaining use and advantages of emerging technologies in surveying.