

Unit 31: Highway Construction and Maintenance in Civil Engineering

Unit code:	J/600/0384
QCF Level 3:	BTEC Nationals
Credit value:	10
Guided learning hours:	60

● Aim and purpose

This unit provides learners with knowledge of highway planning, the processes involved in the construction of earthworks for new highways and highway maintenance, an understanding of methods used to drain highways and subsoils, and skills to specify highway pavement construction.

● Unit introduction

The civil engineering industry requires a workforce that is flexible, creative, highly skilled and technically competent. These skills are extremely important to civil engineers involved in the planning, building and maintaining of roads and highways. Road building is at the centre of the civil engineering profession and has a long history in Britain, dating back through the industrial revolution to the road builders of Roman Britain. The unit content has been designed specifically to focus on road and highway technology that is of clear and immediate use to learners. This will enable them to understand and apply technology and processes in a broader vocational context.

The first part of the unit explores how new roads are planned and looks at factors influencing route location and construction methods. In particular, learners will have the opportunity to investigate earthworks, pavement construction and drainage methods. The final part of the unit introduces maintenance processes and includes structural and environmental factors. On completion of the unit, learners will understand road planning procedures and apply construction and maintenance techniques to well-defined complex and non-routine projects.

● Learning outcomes

On completion of this unit a learner should:

- 1 Know how a new highway is planned
- 2 Know the processes involved in the construction of earthworks for new highways
- 3 Be able to specify different forms of highway pavement construction
- 4 Understand the methods used to drain highways and subsoils
- 5 Know highway maintenance processes.

Unit content

1 Know how a new highway is planned

Planning a new highway: land acquisition; route location; public consultation; allocation of resources; design of line and level

Land acquisition: procedures to acquire land; potential problems

Route location: assessment of traffic volumes; environmental impact; potential earthwork problems; choice of alignment; procedures to consult public; public enquiries

Allocation of resources: funding of new highways (design, build, finance, operate – DBFO); private and/or public funding

Design of line and level: factors that affect vertical and horizontal alignment

2 Know the processes involved in the construction of earthworks for new highways

Earthworks: site clearance; cut and fill; embankment construction; control of line and level; treatment of weak areas

Site clearance: advance fencing contracts; grubbing out; stripping topsoil

Cut and fill: setting out embankments and cuttings; plant used; mass haul curves; computer applications

Embankment construction: end product or method specification; control of line and level; suitable and unsuitable materials for fill; procedures and testing as work proceeds

Treatment of weak areas: replacement; stabilisation; drainage techniques

3 Be able to specify different forms of highway pavement construction

Highway pavement construction: different forms of construction; methods of construction; material specification; quality control

Different forms of construction: flexible; rigid composites; flexible composites; continuously reinforced concrete roadbase (CRCR)

Methods of construction: paving machines; slip form and fixed form pavers; manual and semi-manual methods of constructing elements; use of site profiles and automatic paver guidance techniques; compaction procedures

Quality control: sampling of materials; temperature checks; analysis and testing of materials; checks on the finished road surface

Material specification: bituminous materials; concrete and cement bound materials (CBM)

4 Understand the methods used to drain highways and subsoils

Highway drainage: surface water drains; collection of run-off from paved surfaces; land and subsoil water drains; pipework; manholes; disposal of collected water

Surface water drains: conventional kerb and gully; side filter drains; grips and ditches; combined kerb/main drain; gully spacing and construction

Collection of run-off from paved surfaces: camber; crossfall; longitudinal fall; crowned channels

Land and sub-soil drains: arrangement of patterns; types of pipe; typical cross-sections

Pipework: connections to main drain; laying methods; support and protection; backfill

Manholes: purposes; forms of construction; materials used; typical cross-sections

Disposal of collected water: soakaways; water courses; catchpits; associated calculations

5 Know highway maintenance processes

Highway maintenance: different types of maintenance; defects in highways; maintenance processes

Different types of maintenance: structural; routine; winter

Defects in highways: structural defects; identification by inspection and testing; typical results; application of maintenance standards; selection of remedial treatments from examination and collected and established data

Maintenance processes: patching; resurfacing; reconstruction; surface dressing; use of sealants; resetting kerbs and flags; slurry sealing and retreading

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:
<p>P1 identify the procedures used to plan a new highway [IE1, IE2, IE4, IE6, RL4, RL5, TW1, TW2]</p>	<p>M1 analyse methods of strengthening weak areas of earthworks before construction of the highway pavement</p>	<p>D1 evaluate the testing requirements for materials used in pavement construction</p>
<p>P2 describe the constraints that public consultation, land acquisition and funding methodologies may impose on the planning of a new highway [IE1, IE2, IE4, IE6, RL4, RL5, TW1, TW2]</p>		
<p>P3 describe site clearance and earthwork processes [IE1, IE2, IE4, IE6, RL4, RL5, TW1, TW2]</p>		
<p>P4 describe how the line and level of earthworks is controlled [IE1, IE2, IE4, IE6, CT1, RL2, RL3, RL4, RL5]</p>		
<p>P5 produce details of commonly used forms of highway pavement construction [IE1, IE2, IE4, IE6, CT1, RL2, RL3, RL4, RL5]</p>		
<p>P6 produce material specifications for highway pavement construction [IE1, IE2, IE4, IE6, CT1, RL2, RL3, RL4, RL5]</p>		

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:
<p>P7 explain how surface water is collected from the paved surface of highways [IE1, IE2, IE4, IE6, CT1, RL2, RL3, RL4, RL5, SM3]</p>	<p>M2 produce details, supported by calculations, of the spacing of road gullies and the sizing of soakaways</p>	<p>D2 evaluate data from a structural survey of a pavement construction and associated drainage in terms of warning levels of intervention and possible remedial methods.</p>
<p>P8 explain the methods used for land and subsoil drainage [IE1, IE2, IE4, IE6, RL4, RL5, TW1, TW2]</p>		
<p>P9 describe structural, routine and winter maintenance of highways. [IE1, IE2, IE4, IE6, RL4, RL5, TW1, TW2]</p>	<p>M3 analyse the methods used to rectify typical defects in pavements.</p>	

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 CT – creative thinkers	RL – reflective learners TW – team workers	SM – self-managers EP – effective participators
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Essential guidance for tutors

Delivery

The unit content is broad covering highway construction and maintenance in civil engineering and follows a logical sequence. Tutors should use the unit content headings as a guide to delivery. Knowledge of how a highway is planned, constructed and maintained should be developed sequentially. An awareness and understanding of hazards and risks arising from highway construction and maintenance activities, including relevant legislation, should be embedded into the delivery throughout the unit.

Delivery must include development of learner knowledge and understanding of road and route planning, together with the ability to produce sketches and drawings and carry out non-complex calculations for earth moving and surface water drainage. Learners should be made aware of the various processes involved in performing earthwork activities, including soil stabilisation and appropriate treatments for weak areas. The emphasis should be on the recognition and application of highway construction techniques, with learners being able to produce standard pavement details and specify appropriate materials and details of construction methods for use with highway construction. The upkeep and maintenance process associated with highways is a key element and links should be formed with industry, in particular the local highways authority. Visits to road construction and renewal projects should be arranged. Input from current practitioners is an essential element of unit delivery.

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

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

Outline learning plan

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

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

Topic and suggested assignments/activities and/assessment
Introduction to unit content
Tutor input: development of UK road network, including motorways
Independent learner research: highway classification
Tutor input: road usage, level of use, effect on road integrity, legislation, planning
Small group activity: new road planning, route location
Tutor input: public consultations, public enquiries and land acquisition including compulsory purchase legislation
Independent learner research on finance initiatives including public private partnerships
Tutor input: local and regional responsibilities for road maintenance

Topic and suggested assignments/activities and/assessment

Tutor input: site investigation techniques including borehole log data analysis

Individual learner exercise: substrate investigation including soil bearing capacities and soil stabilisation consolidation techniques

Tutor input: site clearance including selection of heavy plant and equipment, setting out including line, level and curve techniques

Individual learner exercise: calculation of spoil and overburden quantities

Tutor input: forms and methods of road construction including flexible, rigid, composites and continuously reinforced concrete road bases

Individual learner exercise: sketching, drawing and illustration of methods of construction including cross-section details

Small group work: web search for specialised plant including paving machines, slip forming, fixed forming, automatic paving and compaction procedures

Tutor input: development and application of bituminous materials, concrete and cement bound materials including temperature checks, testing and quality control

Assignment 1: New Highway Proposal

Tutor input: management and disposal of surface water including runoff mechanisms, camber, cross-fall, longitudinal fall, crowned channels, kerbs and gullies, side filter drains, grips and ditches

Small group work: gully spacing calculation and sizing of soakaways

Individual learner exercise: drawing and sketching, pipe laying techniques, subsoil drainage arrangements, inspection chamber positions and discharge sources

Tutor input: road defects and warning levels of intervention

Small group work: maintenance processes, re-surfacing, patching, sealants and surface dressing

Independent learner research into maintenance routines including effects of winter

Assignment 2: Highway Drainage, Maintenance and Renewal

Review of unit and assignment feedback

Assessment

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

The structure of the unit content is such that two assignments could be used to provide learners with an opportunity to produce the evidence required to achieve all the grading criteria. For example, the first could cover P1, P2, P3, P4, P5, P6, M1 and D1 and the second P7, P8, P9, M2, M3 and D2.

For P1, the learner must identify the procedures carried out when planning a new road including route location considerations, methods of assessing traffic volumes and environmental concerns.

For P2, the learner must describe the potential constraints public consultations, land acquisition and funding methodologies will impose on a planned new road. For example, opposition and pressure group impact, land acquisition including the right to compulsory purchase and finance arrangements and funding sources.

For P3, the learner must describe site clearance and earthwork processes. At this level it is sufficient to describe the plant and equipment used and the processes involved in cutting, filling and forming embankments

For P4, the learner must describe how line and level are controlled. Complex calculations are not necessary, but learners should produce sketches or referenced diagrams to illustrate their descriptions.

For P5, the learner must produce details of commonly used forms of highway pavement construction. The illustrations should include current surface treatments and at least one form of rigid, flexible and tactile pavement construction. The use of sketches and referenced diagrams is appropriate.

For P6, the learner must produce material specifications for highway pavement construction. This should build on the evidence produced for P5.

For P7, the learner must explain how surface water is collected from the paved surface of highways. Evidence must include descriptions of surface camber run-off mechanisms and associated side filter drains, kerbs and gullies. Sketches and referenced diagrams are suitable forms of evidence.

For P8, the learner must explain the methods used for land and subsoil drainage. Evidence could be in the form of descriptions of pipe systems, patterns used and disposal methods including soakaways, watercourses and catch pits serviced by drains. The use of sketches and referenced diagrams is appropriate.

For P9, the learner must describe structural, routine and winter maintenance of highways. Evidence will include structural defects caused by wear and weather degradation, remedial work including patching and re-surfacing and routine road re-marking and sweeping.

For M1, the learner must analyse methods of strengthening weak areas of the earthworks before construction of the highway pavement. Learners should include the plant, materials and techniques used to strengthen weak areas. Examples of suitable evidence approaches could be as for P2 but with the inclusion of appropriate drawings and other images.

For M2, the learner must produce details, supported by calculations, of the spacing of road gullies and the sizing of soakaways. Calculations should be substantially correct, clearly set out and the correct units stated.

For M3, the learner must analyse the methods used to rectify typical defects in pavements. This should build on the evidence for P9.

For D1, the learner must evaluate the testing requirements for materials used in pavement construction including test data. The evaluation can be evidenced in the form of specifications supported by testing data and graphs.

For D2, the learner must evaluate given data from a structural survey of a pavement construction, compare wearing levels and recommend appropriate remedial measures. Evidence should include traffic volumes, levels of wearing and resistance to abrasion and rutting. Weather degradation and the effects of extended maintenance cycles should also form part of the evidence.

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, P4, P5, P6, M1, D1	New Highway Proposal	A major section of a dual carriageway is to be widened and redirected to relieve heavy traffic congestion in a medium-sized market town of historic importance. The planned route cuts through green belt land which contains farm land and existing domestic properties. Cut-and-fill is to be used in formation of the embankments required to maintain the line and level of the existing road. As a trainee highway engineer, you are asked to produce a report on this project.	<p>A report detailing traffic assessment methods, public consultation procedures, land acquisition procedures (including right of appeal procedures and compulsory purchase legislation), key features of the environmental impact assessment and finance options.</p> <p>A project profile to include cut-and-fill methods (including detailed illustrations), embankment construction techniques and cross-sectional details of existing and new highway pavements, together with materials specifications as appropriate.</p>
P7, P8, P9, M2, M3, D2	Highway Drainage, Maintenance and Renewal	As a trainee highway engineer, you are asked to produce a 'best practice' guide for drainage and highway maintenance for new apprentices.	Best practice guide to include methods used to dispose of both surface water and land and subsoil water, an interpretation of structural survey data, warning levels of intervention and typical structural defects caused by wear, overloading and weather degradation, together with methods and materials for rectification of these defects.

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
		Construction in Civil Engineering

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

- BE Design
- Construction Contracting Operations
- Construction Plant and Equipment Supervision
- Construction Site Supervision
- Transportation.

Essential resources

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

Employer engagement and vocational contexts

Tutor engagement with the local highways authority would greatly benefit the learning experience giving learners a real context within which to visualise the techniques of highway construction and maintenance. The use of old contract documents, including drawings and method statements, would be beneficial.

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

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

Indicative reading for learners

Textbooks

Chudley and Greeno – *Advanced Construction Technology, 4th Edition* (Pearson, 2006) ISBN 9780132019859

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

Manley S, Charters M, Francis C, Topliss S, Doyle M – *Construction and the Built Environment* (Pearson, 2008) ISBN 9780435499914

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

Journals

Building Magazine – CMP

Construction News – Emap

Websites

www.ciob.org.uk

Chartered Institute of Building

www.ice.org.uk

Institution of Civil Engineers

www.thomastelford.com

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Delivery of personal, learning and thinking skills (PLTS)

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

Skill	When learners are ...
Independent enquirers	exploring the types of work that define highway construction and maintenance
Creative thinkers	trying out alternative solutions for highway construction
Reflective learners	giving a presentation on the activities of highway engineers to their peers
Team workers	collaborating with others in group work to produce a presentation on an aspect of highway planning
Effective participators	presenting a case for the compulsory purchase of land in the way of a highway development.

Although PLTS 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 ...
Self-managers	producing a milestone chart to demonstrate assignment progress, including tutorial review dates.

● Functional Skills – Level 2

Skill	When learners are ...
ICT – Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	researching and sourcing website details in order to provide research material for use in compiling unit assignments
Manage information storage to enable efficient retrieval	setting up an electronic filing system to store assignment data and research material
ICT – Find and select information	
Select and use a variety of sources of information independently for a complex task	using search engine refinements to obtain research information and supporting information for assignment compilation
ICT – Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: <ul style="list-style-type: none"> • text and tables • images • numbers • records 	producing the final assignment submission for assessment
Present information in ways that are fit for purpose and audience	processing documents and producing a back-up CD
Evaluate the selection and use of ICT tools and facilities used to present information	producing a group multimedia presentation on a civil engineering topic
English	
Speaking and listening – make a range of contributions to discussions and make effective presentations in a wide range of contexts	taking part in active teaching sessions and presenting ideas in a group situation
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	reading textbooks and journals and browsing civil engineering websites
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	producing written assignments for assessment purposes.