

CIVIL ENGINEERING
Advanced Higher

Second edition – published April 2000

NOTE OF CHANGES TO ADVANCED HIGHER ARRANGEMENTS SECOND EDITION

COURSE TITLE: Civil Engineering (Advanced Higher)

COURSE NUMBER: C022 13

National Course Specification

Course Content: Original unit *Civil Engineering Specialisms* split into two units, *Civil Engineering Specialisms* and *Introduction to Thermo Fluids*

National Unit Specification:

Changes to outcomes and range reflected in two new units - *Civil Engineering Specialisms* and *Introduction to Fluid Mechanics*.

National Course Specification

CIVIL ENGINEERING (ADVANCED HIGHER)

COURSE NUMBER C022 13

COURSE STRUCTURE

This course has three mandatory units as follows:

<i>D120 13</i>	<i>Structural Analysis and Design (AH)</i>	<i>1.5 credits (60 hours)</i>
<i>D121 13</i>	<i>Civil Engineering Specialisms (AH)</i>	<i>1 credit (40 hours)</i>
<i>D335 13</i>	<i>Civil Engineering: Introduction to Fluid Mechanics (AH)</i>	<i>0.5 credit (20 hours)</i>

In common with all courses, this course includes 40 hours over and above the 120 hours for the component units. This may be used for induction, extending the range of learning and teaching approaches, support, consolidation, integration of learning and preparation for external assessment. This time is an important element of the course and advice on its use is included in the course details.

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following:

- Higher Civil Engineering and Higher Construction
- a Higher Scottish Group Award in Construction
- appropriate units from the Design, Engineering and Technology: Construction framework at Higher level.

Administrative Information

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Additional copies of this course specification (including unit specifications) can be purchased from the Scottish Qualifications Authority for £7.50. **Note:** Unit specifications can be purchased individually for £2.50 (minimum order £5).

National Course Specification: general information (cont)

COURSE Civil Engineering (Advanced Higher)

CORE SKILLS

Core skills for Advanced Higher remain subject to confirmation and details will be available at a later date.

National Course Specification: course details

COURSE Civil Engineering (Advanced Higher)

RATIONALE

The Higher course in Civil Engineering enables candidates to acquire a knowledge and understanding of the structure of the civil engineering industry, the materials used in construction and the construction techniques adopted on site. It also helps candidates to develop skills in the estimation of loading and analysis of forces in structures. The Advanced Higher in Civil Engineering allows candidates to apply previously acquired skills to the solution of a broad range of problems in highway and traffic engineering and water and public health engineering. The course includes the study of geotechnical processes and the impact on the environment of civil engineering activities. It also allows candidates to extend their study of structural mechanics and to investigate the methods used in the design of reinforced concrete, steelwork, masonry and timber structures.

The Advanced Higher course in Civil Engineering will appeal to those with a rewarding and practical creative career in mind. It will be suitable for those who have previously acquired skills in the application of scientific and technological principles and who wish to extend and broaden their study to a range of civil and municipal engineering fields. The award will enable candidates to continue the development of the competencies required of the incorporated engineer. It will provide a sound base for further study at HND and degree levels. The broad nature of the course will provide candidates with increased opportunities for future employment.

The course will enable candidates to:

- apply the principles of structural mechanics to the solution of problems involving plane frames and simple beams
- develop competence in the design of reinforced concrete, steelwork, masonry and timber elements using British Standard Codes of Practice
- acquire an understanding of road, traffic, water supply and public health systems, and to solve problems in traffic engineering
- develop an understanding of geotechnical processes and of the impact of civil engineering projects on the environment
- solve problems in fluid mechanics.

The course will also make a significant contribution to the general education and personal development of the candidate by assisting in the development of core skills in communication, team-work, investigation, analysis, computing and problem-solving. Civil Engineering Advanced Higher should stimulate a desire for involvement in an industry that serves the community. Candidates will learn of the planning, design and construction process and of its application to a broad range of engineering problems. They will be introduced to the exciting challenges facing civil, structural and municipal engineers and learn of the new technologies being developed to protect and shape tomorrow's world.

National Course Specification: course details (cont)

COURSE Civil Engineering (Advanced Higher)

COURSE CONTENT

All of the course content will be subject to sampling in the external assessment.

The unit Structural Analysis and Design stresses the importance of structural engineering in the creative and safe development of the built environment. The unit Civil Engineering Specialisms considers the formation and extraction of rock materials used in civil engineering construction and covers a broad range of civil and municipal engineering activities. The unit Introduction to Fluid Mechanics introduces the basic principles of fluid mechanics and their application in the solution of civil engineering problems. Completion of the Advanced Higher course will provide candidates with a sound knowledge of the range of roles and community responsibilities of civil engineers today and of the inter-relationships of the separate branches of the industry. The additional 40 hours of flexible study assigned to the course will enable candidates to develop a project, carry out further research, practise problem-solving skills and prepare for external assessment.

It is recommended that the three units of the course be offered concurrently rather than sequentially. This will assist candidates in the development of transferable skills and encourage the integration of knowledge and skills required in the civil engineering construction process.

Structural Analysis and Design

This unit is designed to bring together the study of structural mechanics and the processes of structural design. It introduces the candidate to the British Standard Codes of Practice used in the design of reinforced concrete, steelwork, masonry and timber structures. The unit is based on problem-solving activities. Upon completion of the unit the candidates will be able to analyse and design simple structures. The candidate should achieve the level of competence required of a person in a design office who is required to undertake the design of basic structural elements.

The following topics will be included.

Force analysis of pin-jointed frames

This study should provide the candidate with the ability to assess the statical determinacy of frames and to fully analyse frames. The following should be covered: types of frame and support, triangulation, equation of statical determinacy, assumptions in analysis, struts, ties, zero force members, method of joint resolution and method of sections.

Deflection of statically determinate beams

Study of this aspect should enable the candidate to determine deflections of beams under standard and non-standard loading. Deflection formulae for standard loading conditions should include simply supported beams with uniformly distributed loading (udl) over the complete span, central concentrated load, cantilevers with udl over the complete span and free end concentrated load. The use of Macaulay's method should be considered in the derivation of standard deflection formulae and for the determination of deflections under non-standard loading combinations.

National Course Specification: course details (cont)

COURSE Civil Engineering (Advanced Higher)

Singly reinforced concrete beams and slabs

This study introduces the candidate to the principles of limit state design and to the Code of Practice procedures for singly reinforced rectangular beams and slabs. The following principles of limit state design should be covered: definitions of limit states, characteristic loading and material strengths, ultimate and serviceability loadings, and partial factors of safety.

Design considerations covered should include the following: bending tension reinforcement, shear link reinforcement, minimum and maximum areas of reinforcement, deflection, crack control, exposure conditions, fire resistance and concrete placement. Use should be made of the design formulae of BS 8110: Part 1 and, where appropriate, the design charts of BS 8110: Part 2. Designs should be based on characteristic strength of concrete $f_{cu} = 40 \text{ N/mm}^2$ and characteristic strength of reinforcement $f_y = 460 \text{ N/mm}^2$ and $f_{yv} = 250 \text{ N/mm}^2$.

Short, braced, axially loaded reinforced concrete columns

Study of this aspect should provide the candidate with the ability to design axially loaded single-storey columns. The following definitions and design considerations should be covered: braced and unbraced columns, short and slender columns, slenderness limits, types of failure, Code of Practice requirements for maximum and minimum areas of longitudinal steel, links, positioning of steel, equations for ultimate load on columns supporting symmetrical and approximately symmetrical arrangements of beams, exposure conditions and fire resistance. Designs should be based on characteristic strength of concrete $f_{cu} = 40 \text{ N/mm}^2$ and characteristic strength of main reinforcement $f_y = 460 \text{ N/mm}^2$.

Design of structural steel beams

This introduces the candidate to the limit state design of structural steelwork and to the Code of Practice procedures for statically determinate beams having full lateral restraint of the compression flange. The following definitions and limit state design principles should be covered: ultimate and serviceability limit states, grades of steel, material design strength, section classification, partial factors of safety, loading combinations, and design (factored) loading. Designs should be in grade 43 steel and use should be made of flow charts, design formulae and safe load tables. Design considerations covered should be: definition of full lateral restraint provision, local buckling, shear, bending, deflection, web buckling and web crushing.

Axially loaded single-storey steel stanchions

This study will extend the candidate's ability to apply limit state design procedures to the design of simple stanchions. Designs should be in grade 43 steel, use should be made of design formulae and safe load tables, and UB and UC sections should be included. The following design considerations should be covered: design (factored) loading, effective length, slenderness factor, compressive strength and compressive resistance.

National Course Specification: course details (cont)

COURSE Civil Engineering (Advanced Higher)

Structural masonry

This introduces the candidate to the limit state design of structural masonry and to the Code of Practice procedures for the design of stiffened and unstiffened walls. The following definitions and principles of limit state design should be covered: characteristic and design loads, characteristic compressive strengths of units and masonry, design strength and partial factors of safety. Design considerations covered should include the following: slenderness ratio, lateral support, effective height, effective thickness, selection of mortars, piers, load-bearing capacity reduction factor, design compressive strength of wall, eccentricity of load on top of wall, and concentrated load at bearing.

Structural timber

The candidate will acquire an understanding of permissible stress design of structural timber and cover the Code of Practice procedures for the design of floor timbers and axially loaded columns. The following design considerations should be covered: duration of loading, design loading, bending moments and shears, available section sizes, section properties, stress grades, strength classes, bending, shear, deflection, bearing, effective lengths and slenderness ratios of columns, and modification factors.

Civil Engineering Specialisms

This unit is designed to broaden the candidate's knowledge and skills into the fields of highway and traffic engineering, water and public health engineering and geotechnics. It also creates an awareness of the environmental impact of the construction process. On completion of the unit the candidate will understand the fundamental procedures used in a range of civil engineering specialist areas and will be able to solve problems in traffic engineering.

The following topics will be covered.

Road systems and structure

This study should provide the candidate with a knowledge of the road categories, pavement types and materials used in the highway network. The roles of highway engineers and highway technicians in local and central government should be considered. The following should be covered: urban and rural road categories, construction of flexible, rigid, flexible composite and rigid composite pavements, functions of layers in pavements, materials used, including bituminous materials, concrete, sub-base and capping materials, jointing materials, reinforcement and maintenance procedures.

Traffic engineering

This should provide the candidate with a knowledge of traffic engineering terminology, construction features, methods of survey and analysis of data. The following should be covered: speed, flow, concentration, capacity, relationships between variables, traffic control devices such as filter lanes, pedestrian refuges, underpasses, roundabouts, one way streets and car parking facilities. The reasons for and equipment used in traffic surveys should be considered, including the following: speed, volume, parking, accident reports, delays, origin and destination, recorders, stopwatches and data sheets.

The candidate will be required to complete a small traffic survey and analyse the results.

National Course Specification: course details (cont)

COURSE Civil Engineering (Advanced Higher)

Water supply and sewerage systems

Study of this aspect should provide the candidate with a knowledge of water supply and sewerage systems, water pollution problems and treatment processes. The following should be covered: water supply system components (service reservoirs, pipelines, pipeline accessories, dams, storage reservoirs and control mechanisms), sewerage system components (pipelines, storm water drains, sewers and manholes), pollutants (industrial and domestic), water treatment processes (matter removal, solids in solution removal and disinfection), and sewage treatment processes (both effluent and sludge disposal).

Geotechnics

Study of this aspect should provide the candidate with a knowledge of the formation of rocks, rock structures, classification and uses in civil engineering. It should enable the candidate to identify common rock types and to describe their origin. The following should be covered: rock formation (igneous extrusive and intrusive, sedimentary with sub-classification and metamorphic), rock features (bedding, folding, jointing and faulting), landforms and rock properties (strength, fractured state, hardness, durability and skid-resistance). Rocks used in civil engineering should also be covered, ie basalt, dolerite, granite, sandstone, limestone, slate and gravel.

Environmental impact of civil engineering

This study should provide the candidate with a knowledge of the adverse impact of civil engineering projects on the environment. It should consider the ways of reducing such impact and enable the candidate to select methods appropriate to particular civil engineering projects. The following should be covered: natural environment features affected (inland and coastal waters, agricultural land, woodlands, flora, fauna, marine life), impacts (water pollution, land contamination, depletion of natural resources through extraction, waste creation, transport emissions), management methods (impact assessment, audit and site surveys, risk assessment, life-cycle assessment, cost benefit analysis, concept of sustainable development) and impact reduction methods (materials use and recycling, self-regulation controls, waste management, land rehabilitation, clean-up technology, water protection and treatment).

Reference should be made to the Engineering Council *Guidelines on Environmental Issues* and to the *Code of Professional Practice*.

National Course Specification: course details (cont)

COURSE Civil Engineering (Advanced Higher)

Civil Engineering: Introduction to Fluid Mechanics

This unit is designed to introduce the candidate to the principles of fluid mechanics which are applicable to civil engineering. On completion of the unit the candidate will understand the fundamental principles and how they may be applied to the solution of problems in hydrostatics and energy loss in pipework.

The following topics will be covered.

Hydrostatic pressures

This should provide the candidate with an understanding of basic fluid properties and terminology and the ability to determine hydrostatic forces applied to submerged and partly submerged bodies in civil engineering situations. Hydrostatic theory applied to plane surfaces should be covered, including definitions of centre of pressure and centroid of area. Plane surfaces considered should include rectangular, circular and triangular plates. Submerged and partially submerged bodies covered should include retaining structures (dams and walls), and construction systems (cofferdams, sheet piles and formwork).

Equations of continuity and energy

This should provide the candidate with the ability to apply the theorems of continuity and Bernoulli to simple fluid mechanics problems. The sources of energy in fluid systems should be covered, along with the construction of total and pressure head diagrams.

Energy losses in pipework

This should provide the candidate with the ability to calculate energy losses in simple pipe systems and develop an understanding of the different flow conditions which may exist within a system.

ASSESSMENT

To gain the award of the course, the candidate must pass all the unit assessments, as well as the external assessment. External assessment will provide the basis for grading attainment in the course award.

When the units are taken as component parts of a course, candidates will have the opportunity to achieve at levels beyond that required to attain each of the unit outcomes. This attainment may, where appropriate, be recorded and used to contribute towards course estimates and to provide evidence for appeals. Additional details are provided, where appropriate, with the exemplar assessment materials. Further information on the key principles of assessment are provided in the paper *Assessment*, published by HSDU in May 1996.

National Course Specification: course details (cont)

COURSE Civil Engineering (Advanced Higher)

DETAILS OF THE INSTRUMENTS FOR INTERNAL ASSESSMENT

The external assessment will sample across the content of the three units of the course and will consist of a 3 hour question paper, externally devised and assessed. The paper will comprise two sections.

Section A

This will feature five short answer and/or restricted response questions examining candidates' knowledge and understanding of the civil engineering activities and problems covered by the three component units of the course. Candidates will be required to attempt all questions.

Section B

This will feature five extended response and/or structured questions examining candidates' ability to solve analysis and design problems and to effectively communicate solutions. Candidates will be required to attempt three questions.

GRADE DESCRIPTIONS

The descriptions below are of expected performances at Grade C and at Grade A. They are intended to assist candidates, teachers, lecturers and users of the certificate and to help establish standards when question papers are being set. The grade of the award will be based on the total score obtained in the examination.

At C

Candidates can:

- use the appropriate knowledge and understanding acquired through the study of the component units
- demonstrate the ability to integrate skills acquired in component units to solve and manage problems to a suitable conclusion
- apply knowledge and understanding to solve problems set in less familiar contexts.

At A

Candidates can:

- solve problems in which the contexts and given information may not be specified in the content statements but which require the skills, knowledge and understanding developed within the course
- show originality in the approach to analysis and apply knowledge and understanding to solve problems which are less structured or set in more complex contexts
- relate theory to practice
- draw relevant conclusions, summarise results and explain modifications to designs.

National Course Specification: course details (cont)

COURSE Civil Engineering (Advanced Higher)

APPROACHES TO LEARNING AND TEACHING

Where appropriate, arrangements should be made to ensure that there will be no artificial barriers to learning and assessment. The nature of a candidate's special needs should be taken into account when planning learning experiences and selecting assessment instruments. Alternative arrangements can be made as necessary.

Further information for the course is provided in the Subject Guide (published by HSDU/SCCC/SFEU 1997). This gives further advice and information on:

- rationale
- component units
- the relationship of proposed Higher Still courses and units to the existing curriculum
- assessment
- advice on learning and teaching
- management of the course
- support materials.

Delivery of the course material should, as far as is possible, be within the industrial context to ensure that candidates recognise that the knowledge and skills acquired are currently appropriate to civil engineering design. Throughout the course, candidates' contact with industry should be encouraged through site visits, investigations and visiting speakers, etc. It is important that site visits are carefully selected so as to be relevant to the branch of civil engineering being investigated. The support notes to the unit Civil Engineering Specialisms make suggestions for a series of appropriate site visits.

In the study of the unit Structural Analysis and Design it is important that candidates become familiar with particular British Standard Codes of Practice used in industry. Although centres may use the British Standard extract document PD 7312, it is important that candidates are given opportunity to study the actual Codes of Practice. Candidates should become familiar with the range of design guides published by the British Cement Association, the Steel Construction Institute, the Timber Research and Development Association and the Brick Development Association.

It is important that candidates are able to identify individual structural members to be designed within completed structures and that, in order to achieve this, use should be made of structural arrangement drawings.

In the study of the unit Civil Engineering Specialisms, references can be made to such documents as Transport Research Laboratory design publications and guidelines. It is suggested that the environmental impact of civil engineering, included in outcome 5 of the unit, be integrated with other specialisms. Elements of this could be integrated with the unit Structural Analysis and Design in a suitable environmental context. The issues of construction safety, quality and environmental awareness should permeate the learning and teaching process.

In the study of the unit Civil Engineering: Introduction to Fluid Mechanics, candidates should be required to use appropriate design aids, in the form of charts and tables, which will assist in the calculation of energy losses and flow rates in pipes.

National Course Specification: course details (cont)

COURSE Civil Engineering (Advanced Higher)

The use of industrial computer software should be demonstrated to candidates where appropriate. Candidates may be given time to use appropriate software during the additional 40 hours of the course. It is recommended that the three units of the course be delivered concurrently. The additional 40 hours can be used to allow candidates to integrate the knowledge, understanding and skills acquired through study of the three component units, to practise problem-solving skills, carry out research and prepare for external assessment.

SPECIAL NEEDS

This course specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment and Certification Arrangements for Candidates with Special Needs/Candidates whose First Language is not English* (SQA, 1998).

SUBJECT GUIDES

A Subject Guide to accompany the Arrangements documents has been produced by the Higher Still Development Unit (HSDU) in partnership with the Scottish Consultative Council on the Curriculum (SCCC) and Scottish Further Education Unit (SFEU). The Guide provides further advice and information about:

- support materials for each course
- learning and teaching approaches in addition to the information provided in the Arrangements document
- assessment
- ensuring appropriate access for candidates with special educational needs.

The Subject Guide is intended to support the information contained in the Arrangements document. The SQA Arrangements documents contain the standards against which candidates are assessed.

National Unit Specification: general information

UNIT	Structural Analysis and Design (Advanced Higher)
NUMBER	D120 13
COURSE	Civil Engineering (Advanced Higher)

SUMMARY

Successful completion of this unit will demonstrate the ability to apply the principles of structural analysis to determine forces in and the deflections of statically determinate structures and to design structural elements in reinforced concrete, steelwork, masonry and timber.

The unit has been developed so that candidates may acquire experience in using British Standard Codes of Practice in the practical design of structural elements.

The unit is a component of Advanced Higher Civil Engineering.

OUTCOMES

- 1 Analyse, by mathematical means, statically determinate pin-jointed frames.
- 2 Determine the deflections of statically determinate beams using standard formulae and Macaulay's method.
- 3 Design statically determinate singly reinforced beams and slabs in reinforced concrete.
- 4 Design short, braced, axially loaded columns in reinforced concrete.
- 5 Design statically determinate structural steel beams.
- 6 Design axially loaded single-storey steel stanchions.
- 7 Design vertically loaded single-leaf and cavity walls in structural masonry.
- 8 Design flooring, simply supported floor joists and axially loaded columns in structural timber.

Administrative Information

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National Unit Specification: general information (cont)

UNIT Structural Analysis and Design (Advanced Higher)

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following:

- Higher Civil Engineering and Higher Construction
- a Higher Scottish Group Award in Construction
- appropriate units from the Design, Engineering and Technology: Construction framework at Higher level.

CREDIT VALUE

1.5 credits at Higher.

CORE SKILLS

Core skills for Advanced Higher remain subject to confirmation and details will be available at a later date.

National Unit Specification: statement of standards

UNIT Structural Analysis and Design (Advanced Higher)

Acceptable performance in this unit will be the satisfactory achievement of the standards set out in this part of the unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to the Scottish Qualifications Authority.

OUTCOME 1

Analyse, by mathematical means, statically determinate pin-jointed frames.

Performance criteria

- (a) The determinacy of given frames is checked correctly.
- (b) Support reactions for nodally loaded statically determinate frames are calculated correctly.
- (c) The magnitude and nature of the forces in all members of frames are determined accurately using the method of joint resolution.
- (d) The magnitude and nature of the forces in selected members of frames are determined accurately using the method of sections.

Evidence requirements

Written and/or oral evidence indicating an understanding of:

- the distinction between statically determinate and indeterminate frames: this may be evidenced by the candidate applying the appropriate check equation to given frames prior to attempting analysis
- the available mathematical methods of analysis: this may be evidenced by the candidate completing a full analysis of a given frame, by joint resolution, and checking a number of members by the method of sections.

OUTCOME 2

Determine the deflections of statically determinate beams using standard formulae and Macaulay's method.

Performance criteria

- (a) Maximum deflections in beams are evaluated accurately using standard formulae.
- (b) Critical deflections are evaluated accurately using Macaulay's method, in non-standard loading cases.

Note on range for the outcome

Standard cases: simply supported beams with udl over complete span and central concentrated load, cantilevers with udl over complete span and free end concentrated load.

Beam types: simply supported, cantilever, single span with cantilever at one end, constant section over span.

Loading: uniformly distributed, concentrated.

National Unit Specification: statement of standards (cont)

UNIT Structural Analysis and Design (Advanced Higher)

Evidence requirements

Written and/or oral evidence indicating a knowledge and understanding of:

- the use of standard formulae in the determination of deflection: this may be evidenced by the candidate stating and applying the standard formulae for given beams and loadings
- the use of Macaulay's method in deriving the standard deflection formulae: this may be evidenced by the candidate deriving standard formulae using Macaulay's method
- the use of Macaulay's method in the determination of deflection for beams with non-standard combined loading: this may be evidenced by the candidate using Macaulay's method to determine critical deflections for given beams with combination loadings.

OUTCOME 3

Design statically determinate singly reinforced beams and slabs in reinforced concrete.

Performance criteria

- (a) The principles of limit state reinforced concrete design are applied in accordance with the British Standard Code of Practice.
- (b) Ultimate loads on beams and slabs are evaluated accurately.
- (c) Ultimate shear forces and bending moments are evaluated correctly.
- (d) Sectional areas of concrete, main and vertical shear reinforcement are determined correctly for beams using design formulae and design charts.
- (e) Sectional areas of concrete, main and secondary reinforcement are determined correctly for slabs using design formulae and design charts.

Note on range for the outcome

British Standards: BS 8110: Part 1 (or clauses from PD 7312), BS 8110: Part 2 design charts.

Forms of construction: rectangular beams, one-way spanning slabs, statically determinate spans.

Loading: dead, dead plus imposed, uniformly distributed, concentrated.

Materials: concrete grade C40, main reinforcement $f_y = 460 \text{ N/mm}^2$, shear reinforcement $f_{yv} = 250 \text{ N/mm}^2$.

Design considerations: bending, deflection, shear, exposure conditions, fire resistance, cracking, concrete placement.

National Unit Specification: statement of standards (cont)

UNIT Structural Analysis and Design (Advanced Higher)

Evidence requirements

Written and/or oral evidence indicating a knowledge and understanding of:

- the principles of limit state design: this may be evidenced by the candidate interpreting and applying the relevant clauses of the Code of Practice in solving beams and slab design problems
- the evaluation of design bending moments and shear forces: this may be evidenced by the candidate selecting the appropriate combinations of loading critical to particular sections, and evaluating critical bending moments and shear forces
- the design procedure for beams: this may be evidenced by the candidate designing a suitable rectangular section, including main and shear reinforcement, considering bending, exposure conditions, fire resistance, shear, deflection, cracking and concrete placement
- the design procedure for slabs: this may be evidenced by the candidate checking a given slab thickness considering bending, exposure conditions and fire resistance, determining suitable main and secondary reinforcement, and considering shear, deflection, cracking and concrete placement.

OUTCOME 4

Design short, braced, axially loaded columns in reinforced concrete.

Performance criteria

- (a) Ultimate loads on columns are evaluated accurately.
- (b) Sectional areas of concrete, longitudinal and transverse reinforcement are determined correctly using design formulae from the British Standard Code of Practice.

Note on range for the outcome

Design references: BS 8110: Part 1 (or clauses from PD 7312).

Loading: columns supporting a symmetrical or approximately symmetrical arrangement of beams, axial load.

Column sections: rectangular, square.

Evidence requirements

Written and/or oral evidence indicating a knowledge and understanding of:

- the principles of limit state design: this may be evidenced by the candidate interpreting and applying the relevant clauses of the Code of Practice in solving column design problems
- the design procedure for columns: this may be evidenced by the candidate evaluating the design loading for a column, determining a suitable concrete section or checking a given section, and designing suitable reinforcement.

National Unit Specification: statement of standards (cont)

UNIT Structural Analysis and Design (Advanced Higher)

OUTCOME 5

Design statically determinate structural steel beams.

Performance criteria

- (a) The principles of limit state design are applied in accordance with the British Standard Code of Practice.
- (b) Ultimate loads on beams are evaluated accurately.
- (c) Ultimate shear forces and bending moments are evaluated correctly.
- (d) Universal beams are selected and checked correctly using design formulae from the British Standard Code of Practice and safe load tables.

Note on range for the outcome

Design references: BS 5950: Part 1 (or clauses from PD 7312), Steel Construction Institute safe load tables.

Forms of construction: grade 43 beams with full lateral restraint of compression flange, statically determinate spans.

Loading: dead, dead plus imposed.

Design considerations: local buckling, bending, shear, deflection, web buckling, web crushing.

Evidence requirements

Written and/or oral evidence indicating a knowledge and understanding of:

- the principles of limit state design: this may be evidenced by the candidate interpreting and applying the relevant clauses of the Code of Practice in solving beam design problems
- the design procedure for beams: this may be evidenced by the candidate evaluating the design loading for each of two beams, determining the critical bending moments and shear forces and checking the beam sections for bending, shear, deflection, web buckling and web crushing.

National Unit Specification: statement of standards (cont)

UNIT **Structural Analysis and Design (Advanced Higher)**

OUTCOME 6

Design axially loaded, single-storey steel stanchions.

Performance criteria

- (a) Ultimate loads on stanchions are evaluated correctly.
- (b) Universal column and beam sections are selected and checked correctly, using design formulae and safe load tables.

Note on range for the outcome

Design references: BS 5950: Part 1 (or clauses from PD 7312), Steel Construction Institute safe load tables.

Stanchion sections: grade 43 sections, universal beams, universal columns.

Evidence requirements

Written and/or oral evidence indicating a knowledge and understanding of:

- the principles of limit state design: this may be evidenced by the candidate interpreting and applying the relevant clauses of the Code of Practice in solving stanchion design problems
- the design procedure for stanchions: this may be evidenced by the candidate evaluating the design loadings for stanchions, and selecting and checking the suitability of UC and UB sections.

OUTCOME 7

Design vertically loaded single-leaf and cavity walls in structural masonry.

Performance criteria

- (a) The principles of limit state masonry design are applied in accordance with the British Standard Code of Practice.
- (b) Ultimate loads on masonry walls are evaluated accurately.
- (c) Design procedures for masonry walls are used correctly.

Note on range for the outcome

Design references: BS 5628: Part 1 (or clauses from PD 7312), table of UK range of mortars.

Elements: unstiffened walls, stiffened walls.

Loading: dead, imposed, eccentricity effects.

Design considerations: slenderness ratio, lateral support, effective height, effective thickness, design compressive strength, eccentricity of load at top of wall.

National Unit Specification: statement of standards (cont)

UNIT **Structural Analysis and Design (Advanced Higher)**

Evidence requirements

Written and/or oral evidence indicating a knowledge and understanding of:

- the principles of limit state design: this may be evidenced by the candidate interpreting and applying the relevant clauses of the Code of Practice in solving structural masonry design problems
- the design procedure for masonry walls: this may be evidenced by the candidate selecting suitable mortar and masonry units for given wall dimensions and loading situations.

OUTCOME 8

Design flooring, simply supported floor joists and axially loaded columns in structural timber.

Performance criteria

- (a) The principles of permissible stress design are applied in accordance with the British Standard Code of Practice.
- (b) Design loadings on timber floors and on columns are evaluated accurately.
- (c) Design bending moments and shear forces on timber floors are determined correctly.
- (d) Flooring and joist sections are designed correctly.
- (e) Column sections are designed correctly.

Note on range for the outcome

Design references: BS 5268: Part 2 (or clauses from PD 7312), table of section properties.

Design considerations: duration of loading, design loading, stress grades, strength classes, beam bending, shear, deflection, bearing, column axial load, slenderness.

Evidence requirements

Written and/or oral evidence indicating a knowledge and understanding of:

- the principles of permissible stress design: this may be evidenced by the candidate interpreting and applying the relevant clauses of the Code of Practice in solving structural timber design problems
- the design procedure for timber flooring and joists: this may be evidenced by the candidate analysing a given loading situation, determining critical stresses in given timber components or selecting suitable timber sections
- the design procedure for timber columns: this may be evidenced by the candidate checking a given solid column section under axial load.

National Unit Specification: support notes

UNIT Structural Analysis and Design (Advanced Higher)

This part of the unit specification is offered as guidance. The support notes are not mandatory.

While the time allocated to this unit is at the discretion of the centre, the notional design length is 60 hours.

GUIDANCE ON CONTENT AND CONTEXT FOR THIS UNIT

When delivering the unit as a free-standing unit, refer to the Advanced Higher Civil Engineering course details for further information on the content of the unit.

The candidate should achieve the level of competence required of a person in a design office who is required to undertake the design of basic structural elements.

Corresponding to Outcomes 1 to 8

- 1 This outcome should provide the candidate with the ability to distinguish between statically determinate and indeterminate pin-jointed frames and to fully analyse statically determinate frames.
- 2 This outcome should enable the candidate to determine deflections of statically determinate beams under standard and non-standard loading.
- 3 This outcome introduces the candidate to the limit state design of reinforced concrete and to the Code of Practice procedure for the design of singly reinforced beams and slabs.
- 4 This outcome covers the design procedure for short, braced, axially loaded reinforced concrete columns.
- 5 This outcome introduces the candidate to the limit state design of structural steelwork and to the Code of Practice procedure for the design of beams having full lateral restraint of the compression flange.
- 6 This outcome covers the design procedures for axially loaded single-storey steel stanchions.
- 7 This outcome introduces the candidate to the limit state design of structural masonry and to the Code of Practice procedures for the design of stiffened and unstiffened walls.
- 8 This outcome should provide the candidate with an understanding of permissible stress design of structural timber and covers the Code of Practice procedures for the design of floor timbers and axially loaded columns.

For full details of the unit content, refer to the course details for Advanced Higher Civil Engineering.

National Unit Specification: support notes (cont)

UNIT Structural Analysis and Design (Advanced Higher)

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

Although the unit outcomes cover the design of individual structural elements in four materials, it is important that candidates acquire an appreciation of structural form, the interconnections of structural members and the loading paths through structures from roof to foundation level. To achieve this, candidates should be presented with structural arrangements drawings and helped to identify the members for which simple design procedures may be adopted. The British Standard Code of Practice relevant to each type of element and each material should be considered at an early stage of the unit. Rather than completing the design procedures of each outcome in isolation, reference should be made to the positions of the elements to be designed within completed structures and the sources of loading identified.

Delivery of the unit should be in an industrial context and should encourage candidates to view the work of each outcome as a single stage of an overall design process, the objective of which is to ensure structural integrity. Tutorial work should play an important role in consolidation and will allow candidates time to become familiar with the complexities of the Codes of Practice.

For further information about learning and teaching, refer to the course details and the Subject Guide for Advanced Higher Civil Engineering (published by HSDU/SCCC/SFEU 1997).

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Centres may use the instruments of assessment which they consider to be most appropriate. Examples of suitable instruments of assessment for each outcome are provided below, along with a suggestion on the use of a composite project which may form the basis of assessment of Outcomes 3 to 8 inclusive.

Outcome 1

Candidates could be set an assignment based on a non-symmetrically loaded frame for which full force analysis is to be completed. Satisfactory achievement would be based on correct identification of the frame as statically determinate and on the correct use of the method of joint resolution and method of sections.

Outcome 2

Candidates could be set a series of questions as follows:

- (i) Four questions on the use of the four standard deflection formulae referred to in the note on the range for the outcome.
- (ii) One question requiring candidates to derive a standard deflection formula using Macaulay's method.
- (iii) One structured question, based on a single span with a one-end cantilever, requiring candidates to determine deflections at given points, using Macaulay's method.

Satisfactory achievement would be based on three correct answers to (i) and responses of reasonable accuracy to (ii) and (iii).

National Unit Specification: support notes (cont)

UNIT Structural Analysis and Design (Advanced Higher)

Outcome 3

Candidates could be set an extended assignment based on a single span one-way spanning slab with a cantilever overhang beyond a supporting beam. The assignment would require candidates to consider loading and all essential design factors, and to design suitable sections for the beam and slab.

Satisfactory achievement would be based on the production of a competent and practical solution.

Outcome 4

Candidates could be provided with a plan and elevation of a column supporting a symmetrical arrangement of beams, with beam and slab sizes and loading, and be required to carry out a full design of the column.

Satisfactory achievement would be based on the production of a competent and practical solution.

Outcome 5

Candidates could be set a structured question requiring the design of a steel beam, consideration being given to bending, shear, deflection, web buckling and web crushing. The question should require the use of design formulae and safe load tables.

Satisfactory achievement would be based on production of a satisfactory solution.

Outcome 6

Candidates could be set a structured question requiring the design of a single-storey steel stanchion carrying axial load. The question would require determination of ultimate load, investigation of suitable UC and UB sections and the use of design formulae and safe load tables.

Satisfactory achievement would be based on production of a satisfactory solution.

Outcome 7

Candidates could be set an assignment requiring the design of four masonry walls. These would consist of stiffened, unstiffened, single leaf and cavity walls, and loading would be given.

Satisfactory achievement would be based on the production of three suitable designs.

Outcome 8

Candidates could be set an assignment requiring the determination of loading, design of timber flooring and joists, and checking of a given solid section for a column. All relevant design factors should be considered.

Satisfactory achievement would be based on the production of substantially correct solutions.

It is suggested that the evidence required for assessment of Outcomes 3 to 8 inclusive could be generated through use of an extended assignment based on three simple structures. Candidates could be presented with drawings of:

- 1 a simple symmetrical reinforced concrete structure composed of slabs, beams and columns
- 2 a simple steelwork structure consisting of precast floor units, steel beams and steel columns
- 3 a load-bearing brickwork building with timber flooring and joists.

National Unit Specification: support notes (cont)

UNIT Structural Analysis and Design (Advanced Higher)

Loading information could be provided or extracted by candidates from the relevant British Standard.

A total of ten structural elements would require to be designed: three in reinforced concrete, two in steelwork (with one alternative design), two in masonry (with alternative designs in each case) and three in timber.

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment and Certification Arrangements for Candidates with Special Needs/Candidates whose First Language is not English* (SQA, 1998).

National Unit Specification: general information

UNIT	Civil Engineering Specialisms (Advanced Higher)
NUMBER	D121 13
COURSE	Civil Engineering (Advanced Higher)

SUMMARY

Successful completion of this unit will demonstrate the ability to describe the fundamentals of highway and traffic engineering, water and public health engineering, geotechnics and the environmental effects of civil engineering projects. It will also demonstrate the ability to solve mathematical problems in traffic engineering.

The unit has been developed in order to broaden the candidate's knowledge of a wide range of civil engineering specialist areas.

The unit is a component of Advanced Higher Civil Engineering.

OUTCOMES

- 1 Describe road systems and their structure.
- 2 Describe, carry out and analyse traffic surveys.
- 3 Describe water supply and sewerage disposal systems.
- 4 Explain the formation, classification, structure and erosion of common rock types, and their uses as civil engineering materials.
- 5 Describe the effects of civil engineering projects on the environment.

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National Unit Specification: general information (cont)

UNIT Civil Engineering Specialisms (Advanced Higher)

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following:

- Higher Civil Engineering and Higher Construction
- a Higher Scottish Group Award in Construction
- appropriate units from the Design, Engineering and Technology: Construction framework at Higher level.

CREDIT VALUE

1 credit at Higher.

CORE SKILLS

Core skills for Advanced Higher remain subject to confirmation and details will be available at a later date.

Additional information about core skills is published in *Automatic Certification of Core Skills in National Qualifications* (SQA, 1999).

National Unit Specification: statement of standards

UNIT Civil Engineering Specialisms (Advanced Higher)

Acceptable performance in this unit will be the satisfactory achievement of the standards set out in this part of the unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to the Scottish Qualifications Authority.

OUTCOME 1

Describe road systems and their structure.

Performance criteria

- (a) The description of the different categories of roads making up the highway network is correct.
- (b) The description of the different structural types of road pavement is correct.
- (c) The functions of the layers making up a road structure are described correctly.
- (d) The description of road construction materials is correct.

Note on range for the outcome

Road categories: urban, rural.

Structural pavement types: flexible, rigid, composite.

Construction materials: bituminous materials, concrete, jointing materials, reinforcement.

Evidence requirements

Written and/or oral evidence indicating a knowledge and understanding of:

- the characteristics that define the road categories in the UK highway network: this may be evidenced by the candidate listing the categories and the guidelines for inclusion in particular categories
- the different types of pavement used: this may be evidenced by the candidate listing the types of pavement, sketching the make up of each and describing the materials used in their construction.

OUTCOME 2

Describe, carry out and analyse traffic surveys.

Performance criteria

- (a) The use of traffic engineering terminology is correct.
- (b) The relationship between speed, flow and concentration is described correctly.
- (c) The reasons for carrying out traffic surveys are described correctly.
- (d) The equipment used and the procedures laid down for carrying out traffic surveys are described correctly.
- (e) A small traffic survey is carried out and analysed correctly.

Note on range for the outcome

Terminology: speed, flow, concentration, capacity.

Reasons for surveys: speed, volume, parking, accident reports, delays, origin and destination.

Equipment for surveys: recorders, stopwatches, data sheets.

National Unit Specification: statement of standards (cont)

UNIT Civil Engineering Specialisms (Advanced Higher)

Evidence requirements

Written and/or oral evidence indicating a knowledge and understanding of:

- the terminology used in traffic engineering: this may be evidenced by the candidate defining the most common terms used in traffic engineering and any relationships between them
- the reasons for and methods of carrying out traffic surveys: this may be evidenced by the candidate identifying when and where a meaningful traffic survey should be carried out, listing the equipment required for particular surveys and the relevant procedures to be used
- the analysis of traffic survey results: this may be evidenced by the candidate carrying out a small survey and producing a report from the analysed results.

OUTCOME 3

Describe water supply and sewerage disposal systems.

Performance criteria

- (a) The description of water supply and sewerage system components is correct.
- (b) The problems associated with water pollution are described correctly.
- (c) The treatment processes of water and sewerage are outlined correctly.
- (d) The equipment used in treatment of water and sewerage is outlined correctly.

Note on range for the outcome

Water supply systems components: service reservoirs, pipelines, pipeline accessories, dams, storage reservoirs, control mechanisms.

Sewerage systems components: pipelines, storm water drains, sewers, manholes.

Pollutants: industrial, domestic.

Water treatment processes: solids removal, disinfection, pH adjustment.

Sewage treatment processes: primary and secondary treatment processes, sludge treatment and disposal.

Evidence requirements

Written and/or oral evidence indicating a knowledge and understanding of:

- the layout of a typical water supply system and a typical sewerage system: this may be evidenced by the candidate sketching suitable systems and defining the function of each component in a system
- the common forms of pollutant found and the methods used in their control: this may be evidenced by the candidate listing the main pollutants found and the methods of their control
- the main methods of water and sewage treatment: this may be evidenced by the candidate describing a typical water treatment process and a typical sewage treatment process, outlining, in each case, the equipment used.

National Unit Specification: statement of standards (cont)

UNIT Civil Engineering Specialisms (Advanced Higher)

OUTCOME 4

Explain the formation, classification, structure and erosion of common rock types, and their uses as civil engineering materials.

Performance criteria

- (a) The description of the formation of rocks is correct.
- (b) The identification of rock samples is correct.
- (c) Features of rock formations are sketched and explained correctly.
- (d) Landforms resulting from the erosion and deposition of rocks are sketched and explained accurately.
- (e) The uses and behaviour of rocks as civil engineering materials are explained correctly.

Note on range for the outcome

Rock formation: sedimentary, igneous, metamorphic.

Rock features: bedding, folding, jointing, faulting.

Rock types: granite, sandstone, limestone, slate.

Rock properties: strength, fracture state, hardness, skid-resistance.

Evidence requirements

Written and/or oral evidence indicating a knowledge and understanding of:

- the ways in which rocks were formed: this may be evidenced by the candidate describing the formation of the more common sedimentary, igneous and metamorphic rocks, one from each category
- the identification of hand samples of rocks: this may be evidenced by the candidate listing the main visual characteristics of the more common rocks met within civil engineering and hence identifying samples of these rocks, one from each category
- the importance of certain rock features to civil engineering: this may be evidenced by the candidate sketching the rock features in the range statement, describing how they were formed and their significance to civil engineering
- the formation of landforms by erosion of rocks and deposition of the material: this may be evidenced by the candidate describing and sketching two such landforms and explaining their significance to civil engineering.
- the properties and uses of the more common rocks in civil engineering: this may be evidenced by the candidate listing the properties of rock for two civil engineering uses and hence matching these requirements to the properties of the rock.

National Unit Specification: statement of standards (cont)

UNIT Civil Engineering Specialisms (Advanced Higher)

OUTCOME 5

Describe the effects of civil engineering projects on the environment.

Performance criteria

- (a) Features in the natural environment which may be affected are described accurately.
- (b) The principal impacts on, and interactions with, natural environmental systems are described correctly.
- (c) Appropriate ways of reducing the unwanted effects of projects are described.

Note on range for the outcome

Natural environment features affected: inland and coastal waters, agricultural land and woodlands, flora, fauna, marine life.

Impacts: water pollution, land contamination, effect on natural resources, waste, transport emissions.

Civil engineering projects: storage, distribution, construction.

Effective reduction methods: materials usage, recycling, equilibrium, self-regulation controls, land rehabilitation, clean up.

Evidence requirements

Written and/or oral evidence indicating a knowledge and understanding of:

- the aspects of natural environment at risk: this may be evidenced by the candidate listing the appropriate areas which could be affected by two projects and by identifying the methods of assessing the extent of potential effects
- ways of reducing environmental effects: this may be evidenced by the candidate, for one project, describing which of the possible methods, commonly employed to reduce the effects of civil engineering projects on the environment, are the most relevant.

National Unit Specification: support notes

UNIT Civil Engineering Specialisms (Advanced Higher)

This part of the unit specification is offered as guidance. The support notes are not mandatory.

While the time allocated to this unit is at the discretion of the centre, the notional design length is 40 hours.

GUIDANCE ON CONTENT AND CONTEXT FOR THIS UNIT

When delivering the unit as a free-standing unit, refer to the Advanced Higher Civil Engineering course details for further information on the content of the unit.

The candidate should acquire an understanding of the fundamental procedures used in a range of civil engineering specialist areas and develop skills in the solution of problems in traffic engineering.

Corresponding to Outcomes 1 to 5

- 1 This outcome should introduce the candidate to the categories of road in the UK and the different types of road construction and materials.
- 2 This outcome should introduce the candidate to traffic engineering terminology and the methods and reasons for traffic surveys.
- 3 This outcome should introduce the candidate to the reasons for water and sewage treatment and to the most commonly used methods.
- 4 This outcome should introduce the candidate to basic geology, ie types, classification and formation of rocks, and the more common geological structures that may be useful later when involved with design and/or interpretation of site investigation reports. The candidate should also become familiar with some of the rock types used in civil engineering.
- 5 This outcome should introduce the candidate to the impact of civil engineering projects on the environment, emphasising the ways in which civil engineers can improve the environment or reduce any negative effects resulting from engineering projects.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

Since the unit aims to broaden candidates' knowledge and skills in a number of specialist areas, it is important that the delivery and learning take place within the industrial context. It is recommended that candidate contact with the industry be achieved through a series of carefully selected and relevant site visits. A number of suggestions are provided below.

- 1 A visit to a highway construction project. This will enable candidates to look at road materials during a construction operation and after completion. Problems associated with road maintenance could be observed during such a visit.
- 2 A visit to view traffic engineering features, such as filter lanes, pedestrian refuges, underpasses, roundabouts, one-way streets and car parking facilities. The traffic survey completed by candidates could be a spot speed analysis or small parking survey.
- 3 Visits to sewage treatment and water treatment works.
- 4 A series of short visits to sites and other locations to look at rock types used in construction situations, eg sandstone buildings/bridges, granite kerbs, pre-coated chips, gravel in french drains and crushed rock or gravel used in concrete production.

National Unit Specification: support notes (cont)

UNIT **Civil Engineering Specialisms (Advanced Higher)**

5 A visit to an area or site to observe the impact of previous civil engineering or building activities.

Video presentations of recent civil engineering projects will help candidates relate principles to practical industrial situations. In considering the issue of engineering in the environment, examples of good and bad practice should be discussed, with reference to recent developments in clean-up technology, transportation systems, water and sewage treatment, recycling, etc.

For further information about learning and teaching, refer to the course details and the Subject Guide for Advanced Higher Civil Engineering (published by HSDU/SCCC/SFEU 1997).

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Centres may use instruments of assessment which they consider to be most appropriate. Examples of suitable instruments are provided below.

Outcome 1

Candidates could be set an open book exercise containing four extended response questions to cover performance criteria (a) – (d), to test knowledge and understanding of:

- the different categories of roads making up the highway network
- the different structural types of road pavement
- the layers making up a road structure
- the materials used in road construction.

Satisfactory achievement would be based on the production of three correct responses.

Outcome 2

Candidates could be set an open book exercise containing two restricted response questions for performance criteria (a) and (b) to test knowledge and understanding of traffic engineering terminology and relationships. They could also be set two extended response questions for performance criteria (c) and (d) to test the knowledge and understanding of the reasons for carrying out surveys, and the equipment and procedures used.

Candidates could also be given a practical exercise, with a briefing, for performance criteria (e), to test the skills required to collect, analyse and report survey data.

Satisfactory achievement would be based on the production of three correct responses for performance criteria (a) to (d), and a satisfactory exercise/report for performance criteria (e).

National Unit Specification: support notes (cont)

UNIT Civil Engineering Specialisms (Advanced Higher)

Outcome 3

Candidates could be set an open book exercise containing four extended response questions for performance criteria (a) to (d) to test the knowledge and understanding of:

- water supply and sewerage system components
- problems associated with water pollution
- treatment processes for water and sewage
- the equipment used in the treatment of water and sewage.

Satisfactory achievement would be based on the production of three correct responses.

Outcome 4

Candidates could be set an open book exercise containing four extended response questions designed for performance criteria (a), (c), (d) and (e) to test the knowledge and understanding of:

- the formation and classification of rocks
- the features of rock formations
- landforms resulting from erosion and deposition of rocks
- the uses and behaviour of rocks as civil engineering materials.

An identification exercise could be used for performance criterion (b), in which rock samples are identified. This could be either from hand samples or in the field.

Satisfactory achievement would be based on the production of three correct responses to the extended response questions and correctly identifying five rock samples.

Outcome 5

Candidates could be required to complete an open book assignment, based on clear guidelines, requiring them to describe:

- the possible effects of civil engineering projects on the environment
- the effects of two particular projects on the environment, (with the aid of sketches if required)
- the methods that could be employed to reduce the impact of one of the previously mentioned projects.

All performance criteria and range requirements would be covered in the assignment guidelines and satisfactory achievement would be based on the production of a satisfactory report.

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment and Certification Arrangements for Candidates with Special Needs/Candidates whose First Language is not English* (SQA, 1998).

National Unit Specification: general information

UNIT	Civil Engineering: Introduction to Fluid Mechanics (Advanced Higher)
NUMBER	D335 13
COURSE	Civil Engineering (Advanced Higher)

SUMMARY

Successful completion of this unit will demonstrate an understanding of the basic principles of fluid mechanics and the ability to solve mathematical problems in hydrostatics, in use of the equations of continuity and energy, and in energy losses in pipework.

The unit has been developed in order to introduce candidates to the application of fluid mechanics to the specialist areas of civil engineering.

The unit is a component of Advanced Higher Civil Engineering.

OUTCOMES

- 1 Solve problems relating to hydrostatic pressures on vertical submerged plane surfaces.
- 2 Apply the two fundamental fluid mechanics equations of continuity and energy.
- 3 Apply standard solutions to basic energy losses in pipework.

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National Unit Specification: general information (cont)

UNIT Civil Engineering: Introduction to Fluid Mechanics
(Advanced Higher)

RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following:

- Higher Civil Engineering and Higher Construction
- a Higher Scottish Group Award in Construction
- appropriate units from the Design, Engineering and Technology: Construction framework at Higher level.

CREDIT VALUE

0.5 credit at Higher.

CORE SKILLS

Core skills for Advanced Higher remain subject to confirmation and details will be available at a later date.

National Unit Specification: statement of standards

UNIT Civil Engineering: Introduction to Fluid Mechanics (Advanced Higher)

Acceptable performance in this unit will be the satisfactory achievement of the standards set out in this part of the unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to the Scottish Qualifications Authority.

OUTCOME 1

Solve problems relating to hydrostatic pressures on vertical submerged plane surfaces.

Performance criteria

- (a) Basic properties, flow patterns and definitions used in fluid mechanics are described correctly.
- (b) Pressures due to static fluid heads are calculated correctly.
- (c) The concepts of centre of pressure and centroid are explained correctly.
- (d) The result of pressure on a plane surface is calculated correctly.

Note on range for the outcome

Definitions and terminology: density, viscosity, ideal fluid, compressibility, laminar and turbulent flow.
Pressures: gauge pressure, absolute pressure.

Evidence requirements

Written and/or oral evidence indicating a knowledge and understanding of:

- basic terminology used in fluid mechanics: this may be evidenced by the candidate correctly defining the properties commonly used in solving fluid mechanics problems
- pressures due to static fluid head: this may be evidenced by the correct calculation of pressure in gauge and absolute units
- the result of static pressure; this may be evidenced by the candidate correctly calculating the forces and/or moments for two civil engineering applications of plane surfaces, such as a sluice, a penstock, a dam or a cofferdam.

OUTCOME 2

Apply the two fundamental fluid mechanics equations of continuity and energy.

Performance criteria

- (a) The three components of energy in a fluid system are explained correctly.
- (b) The continuity and Bernoulli equations are applied correctly to the pressure and velocity changes in a pipe system.
- (c) The variation in pressure head and total head along the pipe system is correctly shown.

Note on range for the outcome

Energy: total, potential, pressure, kinetic.

National Unit Specification: statement of standards (cont)

UNIT **Civil Engineering: Introduction to Fluid Mechanics (Advanced Higher)**

Evidence requirements

Written and/or oral evidence indicating a knowledge and understanding of:

- the energy components in a fluid system: this may be evidenced by the candidate correctly explaining the energy components that are used in the Bernoulli Equation
- the pressure and velocity conditions in pipes: this may be evidenced by the candidate correctly predicting the changes in pressure and velocity along a pipe system
- the pressure and total heads in pipes: this may be evidenced by the candidate showing diagrammatically the variation of pressure head and total head for the pipe system and indicating significant values.

OUTCOME 3

Apply standard solutions to basic energy losses in pipework.

Performance criteria

- (a) Pipe flow problems for single pipe systems are solved correctly using the Moody Diagram and the Darcy-Weisbach Equation.
- (b) Pipe flow problems for single pipe systems are solved correctly using the HRS charts/tables.

Note on range for the outcome

Flow: steady/uniform flow, laminar and turbulent flow, Reynolds' number, pipe roughness, energy losses.

Evidence requirements

Written and/or oral evidence indicating a knowledge and understanding of:

- steady/non-steady flow and uniform/non-uniform flow: this may be evidenced by the candidate correctly classifying the flow conditions for a given situation
- pipe friction losses: this may be evidenced by the candidate calculating energy losses using the Moody Diagram
- energy losses and flow rates: this may be evidenced by the candidate correctly answering a pipe flow question using the Moody Diagram and Darcy-Weisbach Equation and a further question using HRS charts/tables.

National Unit Specification: support notes

UNIT Civil Engineering: Introduction to Fluid Mechanics (Advanced Higher)

This part of the unit specification is offered as guidance. The support notes are not mandatory.

While the time allocated to this unit is at the discretion of the centre, the notional design length is 20 hours.

GUIDANCE ON CONTENT AND CONTEXT FOR THIS UNIT

When delivering the unit as a free-standing unit, refer to the Advanced Higher Civil Engineering course details for further information on the content of the unit.

Corresponding to Outcomes 1 to 3

- 1 This outcome should introduce candidates to the basic concepts of fluid mechanics and provide an understanding of and the ability to calculate pressures and forces on plane submerged surfaces.
- 2 This outcome should provide the candidate with the ability to apply the theories of continuity and Bernoulli to simple fluid mechanics problems. It should also introduce the concepts of total and pressure head diagrams.
- 3 This outcome should provide the candidate with the ability to calculate energy losses in simple pipe systems and with an understanding of the different flow conditions that can exist within systems.

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

Candidates will have to spend most of the allocated time in solving fluid mechanics problems. It is therefore very important that the unit be delivered in the civil engineering industrial context. To help candidates apply the principles of fluid mechanics to practical industrial situations, the use of video presentations and practical laboratory demonstrations is encouraged.

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Centres may use instruments of assessment which they consider to be most appropriate. Examples of suitable instruments are provided below.

Outcome 1

- (i) Five restricted response questions to determine a candidate's understanding of the basic terms used in fluid mechanics.
- (ii) Three questions, possibly multiple choice, to determine a candidate's understanding of the difference between force, gauge pressure and absolute pressure.
- (iii) Two structured numerical questions requiring the candidate to calculate the pressures and forces due to liquids on typical civil engineering structures.

Satisfactory achievement would be based on the production of four correct responses to (i), two correct responses to (ii) and two reasonably accurate answers to (iii).

National Unit Specification: support notes (cont)

UNIT Civil Engineering: Introduction to Fluid Mechanics (Advanced Higher)

Outcome 2

- (i) One question requiring the candidate to explain the three constituent parts of the Bernoulli Equation and to indicate the output units.
- (ii) One numerical question requiring the candidate to calculate pressures and/or velocities in a pipe system, using the Bernoulli Equation.
- (iii) One question requiring the candidate to draw the total and pressure head lines for a pipe system.

Satisfactory achievement would be based on the correct definition of two of the terms in (i), and the production of reasonably accurate answers to (ii) and (iii).

Outcome 3

- (i) Six restricted response questions to ascertain if the candidate understands the differences between steady and non-steady, uniform and non-uniform, and laminar and turbulent flows.
- (ii) One structured numerical question requiring the candidate to determine the energy/head loss in a pipe system, using the Moody Diagram and Darcy-Weisbach formula.
- (iii) One structured numerical question requiring the candidate to determine the energy/head loss in a pipe system, using the HRS charts/tables.

Satisfactory achievement would be based on correct responses to four questions in (i) and the production of a reasonably accurate answers to (ii) and (iii).

SPECIAL NEEDS

This unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative outcomes for units. For information on these, please refer to the SQA document *Guidance on Special Assessment and Certification Arrangements for Candidates with Special Needs/Candidates whose First Language is not English* (SQA, 1998).