

Higher National Unit Specification

General information for centres

Unit title: Structural Analysis B: Statically Determinate and Indeterminate Structures

Unit code: DW6Y 35

Unit purpose: This Unit seeks to allow the candidate to apply the principles of structural analysis to solve problems related to forces and stresses in statically determinate and indeterminate structures.

On completion of the Unit the candidate should be able to:

- 1 Determine the plastic modulus and the plastic moment of resistance of structural sections.
- 2 Use the method of plastic analysis to solve problems in structures.
- 3 Analyse statically indeterminate beams using moment distribution.

Credit points and level: 1 HN Credit at SCQF level 8: (8 SCQF credit points at SCQF level 8*).

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from Access 1 to Doctorates.*

Recommended prior knowledge and skills: Access to this Unit is at the discretion of the centre but it would be beneficial if the candidate possesses a basic understanding and knowledge of the analysis of statically determinate beams and the concepts of stress and strain applied to structural elements. This may be evidenced by completion of the Structural Analysis A Unit or equivalent prior knowledge.

Core Skills: There are opportunities to develop the Core Skills of Numeracy and Problem Solving in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Context for delivery: If this Unit is delivered as part of a Group Award, it is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes.

General information for centres (cont)

Assessment: It is possible to assess candidates either on an individual Outcome basis, a combination of Outcomes or by a single holistic assessment combining all Outcomes. The assessment paper/s should be composed of an appropriate balance of short answer, restricted response and structured questions. Assessment should be conducted under supervised, controlled conditions. A single assessment covering all outcomes should not exceed two hours in duration. It should be noted that candidates must achieve all the minimum evidence specified for each Outcome in order to pass this Unit.

Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the knowledge and/or skills section must be taught and available for assessment. Candidates should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

An exemplar instrument of assessment and marking guidelines has been produced to provide examples of the type of evidence required to demonstrate achievement of the aims of this Unit and to indicate the national standard of achievement at SCQF level 8.

Higher National Unit specification: statement of standards

Unit title: Structural Analysis B: Statically Determinate and Indeterminate Structures

Unit code: DW6Y 35

The sections of the Unit stating the Outcomes, knowledge and/or skills, and evidence requirements are mandatory.

Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the knowledge and/or skills section must be taught and available for assessment. Candidates should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

Outcome 1

Determine the plastic modulus and the plastic moment of resistance of structural sections

Knowledge and/or skills

- ◆ The relationship and differences between the elastic and plastic distribution of stress in structural steelwork elements
- ◆ The terminology use in plastic design: plastic hinges; plastic modulus; elastic modulus; shape factor; plastic load factor and moment of resistance
- ◆ The evaluation of the plastic modulus, elastic modulus and shape factor of given section shapes

Evidence Requirements

Candidates will need to provide evidence to demonstrate their knowledge and/or skills by showing that they can:

- ◆ determining the plastic modulus, elastic modulus, shape factors and moment of resistance of given structural steelwork shapes
- ◆ determining the moment of resistance of a section using the structural steelwork section tables

Evidence for the knowledge and/or skills for this Outcome will be provided on a sample basis. In any assessment of this Outcome a minimum of **two out of three** knowledge and/or skills items should be sampled. Candidates must provide a satisfactory response to both items, both by manual calculation exercises and using computer techniques.

Evidence should be generated through assessment undertaken in controlled, supervised conditions. Assessment should be conducted under closed conditions and as such candidates should be not allowed to bring textbooks, handouts or notes to the assessment.

Assessment guidelines

Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and structured questions.

The assessment for this Outcome might be combined with that for Outcome 2 to form a single assessment paper.

Higher National Unit specification: statement of standards (cont)

Unit title: Structural Analysis B: Statically Determinate and Indeterminate Structures

Outcome 2

Use the method of plastic analysis to solve problems in structures

Knowledge and/or skills

- ◆ Continuous beams subject to point load(s), uniformly distributed load(s) or combinations of both
- ◆ Single bay flat roofed portal frames subject to horizontal and vertical load or a combination of both
- ◆ Single bay pitch roofed pin based portal frames subject to vertical uniformly distributed load
- ◆ Bending moment and shear force diagrams for previously analysed beams or portal frames

Evidence Requirements

Candidates will need evidence to demonstrate their knowledge and/or skills by showing that they can:

- ◆ determine the moment of resistance of a continuous beam or portal frame under loading
- ◆ sketch the bending moment and shear force diagrams for a previously analysed beam or frame

Evidence for the knowledge and /or skills for this Outcome will be provided on a sample basis. In any assessment of this Outcome a minimum of **two out of four** knowledge and/or skills items should be sampled. In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of knowledge/skill items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to both items both by manual calculation exercises and using computer techniques.

Evidence should be generated through assessment undertaken in controlled, supervised conditions. Assessment should be conducted under closed conditions and as such candidates should be not allowed to bring textbooks, handouts or notes to the assessment.

Assessment guidelines

Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and structured questions.

The assessment for this Outcome might be combined with that for Outcome 1 to form a single assessment paper.

Higher National Unit specification: statement of standards (cont)

Unit title: Structural Analysis B: Statically Determinate and Indeterminate Structures

Outcome 3

Analyse statically indeterminate beams using moment distribution

Knowledge and/or skills

- ◆ Standard moment distribution procedures to calculate the end bending moments for each member of a continuous beam subject to combinations of point and uniformly distributed loading
- ◆ Bending moment diagram for a previously analysed continuous beam
- ◆ Magnitude and direction of the support reactions for a previously analysed continuous beam
- ◆ Shear force diagram for a continuous beam
- ◆ Moment distribution used in the design codes to elastically analyse continuous beams

Evidence Requirements

Candidates will need evidence to demonstrate their knowledge and/or skills by showing that they can:

- ◆ analyse continuous beams using moment distribution procedures
- ◆ sketch the bending moment and shear force diagrams using the loading diagram and the results from the moment distribution table

Evidence for the knowledge and /or skills for this Outcome will be provided on a sample basis. In any assessment of this Outcome a minimum of **two out of five** knowledge and/or skills items should be sampled. Candidates must provide a satisfactory response to both items, both by manual calculation exercises and using computer techniques.

Evidence should be generated through assessment undertaken in controlled, supervised conditions. Assessment should be conducted under closed conditions and as such candidates should be not allowed to bring textbooks, handouts or notes to the assessment.

Assessment guidelines

Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and structured questions.

Administrative Information

Unit code:	DW6Y 35
Unit title:	Structural Analysis B: Statically Determinate and Indeterminate Structures
Superclass category:	TM
Date of publication:	June 2006
Version:	01
Source:	SQA

© Scottish Qualifications Authority 2006

This publication may be reproduced in whole or in part for educational purposes provided that no profit is derived from reproduction and that, if reproduced in part, the source is acknowledged.

SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of Higher National qualifications.

Additional copies of this Unit specification can be purchased from the Scottish Qualifications Authority. Please contact the Customer Contact Centre for further details, telephone 0845 279 1000.

Higher National Unit specification: support notes

Unit title: Structural Analysis B: Statically Determinate and Indeterminate Structures

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

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

Guidance on the content and context for this Unit

The Unit has been written in order to allow candidates to develop knowledge and understanding skills in the application of the principles of structural analysis in the following areas:-

- 1 Plastic analysis of continuous beams and portal frames formed from structural steelwork sections.
- 2 Elastic analysis of continuous beams.
- 3 Construction of bending moment and shear force for both elastically and plastically analysed continuous beams and portal frames.

This Unit at SCQF level 8 is a mandatory unit within the HND Civil Engineering and an optional unit in the HNC Structural Engineering award

Throughout the Unit emphasis will be placed where appropriate on the application of Health and Safety and Sustainability. Safe working practices should be looked at in accordance with current safety codes of practice and regulations. Sustainability should include reference to criteria affecting sustainability, impact of not implementing sustainability on the environment and the legislation promoting sustainability.

In designing this Unit, the unit writer has identified the range of topics which would be expected to be covered by lecturers. Whilst it is not mandatory for a centre to use this list of topics it is strongly recommended that it does so.

The list of topics is given below. Lecturers are advised to study this list of topics in conjunction with the assessment exemplar pack so that they can get a clear indication of the standard of achievement expected of candidates in this Unit.

1 Determine the plastic modulus and the plastic moment of resistance of structural sections (7 hours)

- ◆ The relationship between stress and strain for structural steel, terms to be included and discussed to include elastic range, plastic range, elastic limit and yield stress.
- ◆ Simple bending equation to be reintroduced, this should include the form of the equation using the elastic modulus.
- ◆ Sketching the distribution of stress in members subject to lateral loading.
- ◆ Development of stress distribution to introduce the concept of: plastic range of stress distribution; plastic modulus and plastic hinges.
- ◆ Given the dimension of a structural section the plastic modulus, elastic modulus, shape factor and moment of resistance are calculated.

Higher National Unit specification: support notes (cont)

Unit title: Structural Analysis B: Statically Determinate and Indeterminate Structures

- ◆ Structural steelwork section tables used to find elastic and plastic modulus and hence shape factor and moment of resistance are determined.
- ◆ Calculation exercises both manually and using computer techniques.

2 Use the method of plastic analysis to solve problems in structures (15 hours)

- ◆ The forms of plastic failure (failure mechanisms) of point loads and uniformly distributed load on simply supported beams are developed.
- ◆ External work done, internal energy and load factor introduced using simply supported beams and developed for continuous beams.
- ◆ Calculations exercises in which one of the following is determined: critical load; plastic moment of resistance, or loading.
- ◆ Sketching of bending moment diagrams indicating significant points.
- ◆ Plastic theory further developed for single bay portal frames.

- ◆ Pitched roof frames with pinned supports subject to vertical uniformly distributed load.
- ◆ Flat roofed frames with pinned or fixed supports subject to horizontal and vertical loads or a combination of both.
- ◆ Calculations exercises, both manually and using computer techniques, for portal frames in which one of the following is determined: critical load; plastic moment of resistance, or loading.
- ◆ Sketching, indicating significant points, of bending moment, shear force and thrust diagrams.

3 Analyse statically indeterminate beams using moment distribution (no sway) (18 hours)

- ◆ Statically determinate and indeterminate beams.
- ◆ Forms of failure of simply supported, built-in and continuous beams.
- ◆ Fixed end moments (FEM) for standard loading conditions.
- ◆ Stiffness coefficient (I/L) and distribution factors applied to continuous beams.
- ◆ Distribution and carry-over of moments.
- ◆ Formation of standard moment distribution table for continuous beams.
- ◆ Calculation exercises on how to use the moment distribution table.
- ◆ Using the moment distribution table and the loading diagram to determine support reactions and hence production of the shear force diagram.
- ◆ Using the moment distribution table and the loading diagram to obtain the bending moment diagram.
- ◆ How continuous beams formed from either reinforced concrete or structural steel are elastically analysed using the design codes.

Higher National Unit specification: support notes (cont)

Unit title: Structural Analysis B: Statically Determinate and Indeterminate Structures

Guidance on the delivery and assessment of this Unit

This Unit has links with the following unit Structural Analysis A: statically determinate structures and it is recommended that it be delivered after this Unit. It should also be linked to the relevant design unit(s).

Where available, evidence from the workplace can also be incorporated to enhance the learning outcomes, provided that this evidence is appropriate and authenticated as the student's own work.

It is recommended that evidence for learning outcomes is achieved through well-planned course work, assignments and projects. Assessment may be formative and summative and both may feature as part of the process. Although assessments must be focused on the individual achievement of each candidate, group work may contribute to the assessment. Integrative assignments and project work will help to link this Unit with other related units.

The volume of evidence required for each assessment should take into account the overall number of assessments being contemplated within this Unit and the design of the overall teaching programme.

In designing the assessment instrument/s, opportunities should be taken to generate appropriate evidence to contribute to the assessment of Core Skills units. Where available, evidence from the workplace can also be incorporated to enhance the learning outcomes, provided that this evidence is appropriate and authenticated as the candidate's own work.

Opportunities for developing Core Skills

Opportunities for the development of Core Skills at the output level are more fully identified in the Core Skills Sign Posting Guide. The grid below is indicative of the opportunities for core skills development within this Unit.

Higher National Unit specification: support notes (cont)

Unit title: Structural Analysis B: Statically Determinate and Indeterminate Structures

Core Skill	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5
1 Communication					
Reading					
Writing					
Oral					
2 Numeracy					
Using Number	✓	✓	✓	✓	
Using Graphical Information					
3 IT					
Using Information Technology					
4 Problem Solving					
Critical Thinking	✓	✓			
Planning and Organising					
Reviewing and Evaluating					
5 Working with Others					

Open learning

This Unit could be delivered by distance learning, which may incorporate some degree of on-line support. However, with regard to assessment, planning would be required by the centre concerned to ensure the sufficiency and authenticity of candidate evidence. Arrangement would be required to be put in place to ensure that the assessment, which is required to be as two events, was conducted under controlled, supervised conditions.

For information on normal open learning arrangements, please refer to SQA guide Assessment and Quality Assurance of Open and Distance Learning (SQA 2000).

Candidates with additional support needs

This Unit specification is intended to ensure that there are no artificial barriers to learning or assessment. The additional support 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 Alternative Assessment Arrangements for Candidates with Disabilities and/or Additional Support Needs*, which is available on SQA's website: www.sqa.org.uk.

General information for candidates

Unit title: Structural Analysis B: Statically Determinate and Indeterminate Structures

The Unit has been written in order to allow candidates to develop knowledge and understanding skills in the application of the principles of structural analysis in the following areas:

- 1 Plastic analysis of continuous beams and portal frames formed from structural steelwork sections.
- 2 Elastic analysis of continuous beams.
- 3 Construction of bending moment and shear force diagrams for both elastically and plastically analysed continuous beams and portal frames.

In order to fully understand the knowledge and skills requirements of this Unit the candidate should have prior knowledge of:

- ◆ the stress and strain relationship of structural steel
- ◆ loading diagrams
- ◆ shear force and bending moment diagrams
- ◆ the structural steelwork section tables

This would normally be evidenced by the candidate having undertaken the Unit “Structural Analysis A: statically determinate structures”.

Assessment will generally involve calculation exercise and the production of bending moment, shear force and thrust diagrams.