IIW Guideline
INTERNATIONAL WELDED STRUCTURES DESIGNER

Minimum Requirements for the Education, Training, Examination and Qualification

IAB-201r1-10

MINIMUM REQUIREMENTS FOR THE EDUCATION, TRAINING, EXAMINATION AND QUALIFICATION

INTERNATIONAL WELDED STRUCTURES DESIGNER

Prepared and issued by the IAB-International Authorisation Board
Under the authority of the IIW-International Institute of Welding

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Av. Prof. Dr. Cavaco Silva, 33
Taguspark – Apartado 012
P-2741-901 Porto Salvo
Portugal

Tel: +351.21 4211351
Fax: +351.21 4228122
E-mail: ewf-iab@isq.pt
www.iiw-iis.org

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1. Introduction

This guideline for the international education, training, examination and qualification has been prepared by Group A "Education, Training and Qualification" of the International Authorisation Board (IAB) of the International Institute of Welding (IIW).

1.1 Guideline Structure

Chapter 2 provides an overview of the guideline content.

Chapter 3 of the guideline covers the minimum requirements for education and training. Students having successfully completed this course of education and the appropriate examinations (minimum 182 hours) will be expected to be capable of applying the technology required in Welded Structures Designer at the "Comprehensive" level (IWSD-C) as covered by this guideline. Students having successfully completed modules 1, 2, 3, and 7 of this course and the appropriate examinations (minimum 104 hours) will be expected to be capable of applying the technology required in Welded Structures Designer at the "Standard" level (IWSD-S) as covered by this guideline.

The contents are given in the following structure:	Hours in comprehensive level	Hours in standard level
Module 1: Welding technology	25	25
Module 2: Strength of materials	25	25
Module 3: Design of welded structures	25	25
Module 4: Design of welded joints	25	
Module 5: Design of welded plate structures	25	
Module 6: Design for purpose of welded structures	25	
Module 7: Fabrication, costs, quality and inspection	25	25
Examinations	7	4
Total	182	104

A "teaching hour" shall contain at least 50 minutes of direct teaching. It is not obligatory to follow exactly the order of the topics given in this guideline and choice in the arrangement of the syllabus is permitted. The dept to which each topic is dealt with is indicated by the number of hours allocated to it in the guideline.

It is to be noted that the overall structure of the syllabus for comprehensive and standard levels is similar, however some items are not considered appropriate in the education of the IWSD-S candidate. This will be reflected in the scope and depth of the examination.

Chapter 4 of the guideline covers the rules for examination and qualification.

1.2 General Access Conditions

In a separate document (Directory of Access Conditions, Doc. IAB-020-2000) the national definitions are given in detail.

Applicants entering for Welded Structures Designer at comprehensive level shall fulfil at least the National Access Conditions at the IWT level.

Applicants not fulfilling the entry access conditions at comprehensive level may follow the course, but are not allowed entry to the IIW examination at comprehensive level.

Applicants entering for Welded Structures Designer at the Standard level shall fulfil at least the National Access Conditions at the IWS level.

Note: While the minimum entrance requirements for the Standard level are equivalent to those for the IWS and for the comprehensive level are equal to those of IWT, some of the mathematical concepts presented in modules 3-6 will be very difficult for individuals with limited or no post-secondary mathematics training. It is therefore recommended that individuals entering the Standard level course should have mathematics background equivalent to those for the IWT. Similarly, individuals entering the Comprehensive level course should have entrance requirements equivalent to IWE. Alternatively, the individual should have at least one year of polytechnic level mathematics.

Applicants not fulfilling the entry access conditions at standard level may follow the course, but are not allowed entry to the IIW examination at Standard level.

In the case that a participant has an IWE, IWT or IWS diploma, the participant can get a release of attendance in modules 1 and 7, however she/he must complete the examinations (refer to diagram 1).

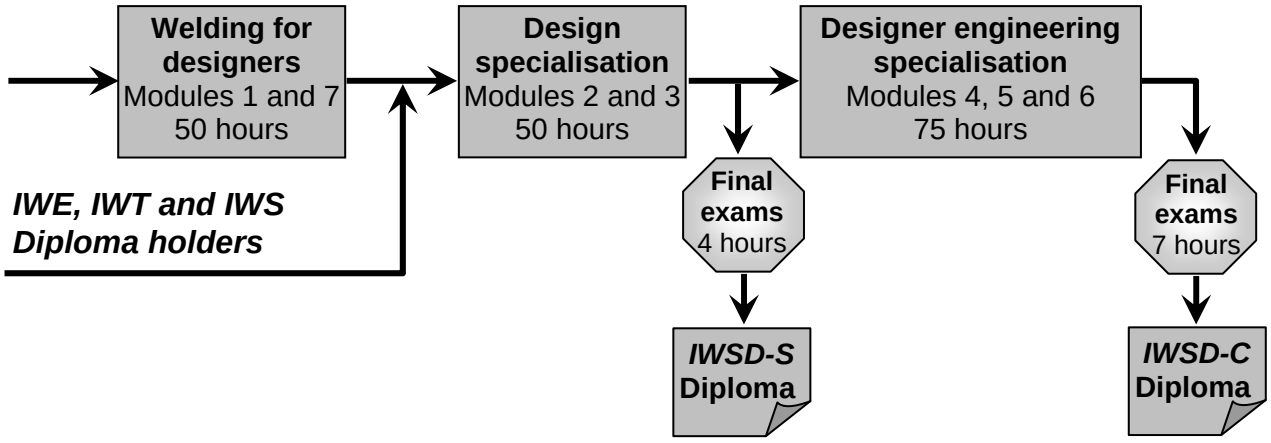

Diagram 1

2 Course content overview: Theoretical and Practical Education

	Hours
Module 1: WELDING TECHNOLOGY	**25**
M1.1 Welding terminology	**3**
M1.2 Welding symbols and design drawings	**3**
M1.3 Overview of welding processes	**9**
M1.4 Materials and weld metallurgy	**10**
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M6.4 Post- weld treatment methods for welded structures	**4**
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M6.6 Numerical methods and fatigue design	**4**
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M7.1 Fabrication costs and cost reduction	**8**
M7.2 Fabrication friendly design	**10**
M7.3 Quality assurance in welding fabrication	**4**
M7.4 Inspection methods and criteria	**3**
Examinations: standard level	**4**
Examinations: comprehensive level	**7**
Total hours standard level	**104**
Total hours comprehensive level	**182**

3. Course Syllabus

Module 1: Welding Technology (25 hrs; for both comprehensive and standard levels)

M1.1 Welding terminology (3 hrs)

Objective: The student will understand key terms and abbreviations and be acquainted with basic standards pertaining to welding and welded joints.

Scope:

Definitions and terminology related to:

- basic types of welded joints;
- joint preparation;
- fusion joints

Expected result at Comprehensive and Standard levels:

1. Review standard terminology in EN ISO 17659 “Welding. Multilingual terms for welded joints with illustrations”.
2. Review standard terminology in EN ISO 4063:2000 “Welding and allied processes – Nomenclature of processes and reference numbers”.
3. Present proper terms when discussing with welding engineers and welding technicians.
4. Illustrate how to locate information from relevant standards.
5. Classify various types of fusion joints based on proper terminology.
6. Classify various weld joint types based on proper terminology.
7. Classify weld preparations based on proper terminology.

M1.2 Welding symbols and design drawings (3 hrs)

Objective: The student will be acquainted with welding symbols and characters used in design drawings and how to produce engineering drawings for production.

Scope:

- ✓ Welding symbols
- ✓ Weld drawing characters
- ✓ Weld process abbreviations

Expected result at comprehensive and standard levels:

1. Review standard ISO 2553:1992 “Welded, brazed and soldered joints – Symbolic representation on drawings”.
2. Interpretation of correct welding process based on standard representations.
3. Illustrate correct markings or engineering drawings for a weld process.
4. Explain specifications for weld quality for design and inspection.
5. Explain the procedure for edge preparation and the common symbols used.

M1.3 Overview of welding processes (9 hrs)

Objective: The student will become acquainted with the most common welding processes designated and designations for welding processes.

Scope:

For mechanical and process engineering the following welding processes are recommended. The specific processes included in this section may vary depending on the target industry of the audience.

- ✓ Manual metal arc
- ✓ MIG/MAG
- ✓ TIG
- ✓ Submerged arc
- ✓ Electron beam
- ✓ Laser welding
- ✓ Resistance welding
- ✓ Friction stir welding

Expected result at Comprehensive and Standard levels:

1. Explain the working principals of the most common welding processes.
2. Explain the goals for selecting a suitable welding process for an application.
3. Review nomenclature in EN ISO 4063:2000 “Welding and allied processes – Nomenclature of processes and reference numbers”.
4. Explain the range of applications for the methods being presented.
5. Explain constructional and material requirements for the welding processes.
6. Illustrate proper welding parameters for an application.
7. Explain the selection of welding consumables.
8. Formulation and interpretation of a welding procedure specification (WPS).

M1.4 Materials and weld metallurgy (10 hrs)

Objective: The student will understand effects of welding on the material metallurgy. This includes effect on material microstructure, hardness, hot cracking, ductility, etc.

Scope:

- ✓ Welding of constructional materials and their properties in the as-welded condition
- ✓ Basics of welding metallurgy
- ✓ Effect of heat input
- ✓ Fe-C equilibrium and TTT diagrams
- ✓ Microstructures and the effect on the mechanical properties of weld
- ✓ Typical imperfections and errors

Expected result at Comprehensive and Standard levels:

1. Explain aspects of welded joint design to ensure ductility.
2. Illustrate the control of heat input for weld processes.
3. Explain basic aspects of control the microstructures by heat input.
4. Explain proper selection of filler materials for common applications.
5. Review common weld imperfections and their sources.
6. Explain methods to avoid common weld imperfections.

Module 2: Strength of Materials (25 hrs; for both Comprehensive and Standard levels)

M2.1 Static equilibrium (3 hrs)

Objective: To be acquainted with basic concepts of static equilibrium from simple structures and how these are applied in the analysis of simple structural elements.

Scope:
- ✓ Equilibrium of forces
- ✓ Equilibrium of moments
- ✓ Action and reaction forces
- ✓ Free body diagram
- ✓ Shear and moment diagrams
- ✓ Tension, compression, shear, bending and torsion force components

Expected result at comprehensive and standard levels:
1. Review basic principals of statics and dynamics that are relevant to understanding the behaviour of structures.
2. Explain different forces components that can act on a structure and how these are defined.
3. Calculation of statically determinate beams or other simple solids.
4. Identify statically determinate and statically indeterminate structures.
5. Present shear moment diagrams for beams and frame type structures.

M2.2 Stress, strain and deformation (3 hrs)

Objective: To understand the basic concepts of stress, strain, strength and deformation of solids.

Scope:
- ✓ Normal stresses and strains
- ✓ Shear stresses and strains
- ✓ Elastic deformation of solids
- ✓ Static and dynamic forces
- ✓ Plastic deformation of solids
- ✓ Stress strain curves for materials
- ✓ Yield strength
- ✓ Mohr's circle

Expected result at Comprehensive and Standard levels:
1. Present basic definitions of normal and shear stresses.
2. Illustrate the relationship between stresses and strains for common structural materials.
3. Illustrate importance of yield strength and ultimate strength for simple structural elements.
4. Calculation of stresses and strains for simple statically loaded structural elements.
5. Illustrate yielding for combined loading.

M2.3 Failure criteria for structures and structural materials (4 hrs)

Objective: The student will be introduced to potential common failure modes for structures and structural materials.

Scope:
- ✓ Yielding
- ✓ Multiaxial stresses
- ✓ Plastic collapse

- ✓ Ultimate strength
- ✓ Fatigue and fracture
- ✓ Global buckling
- ✓ Local buckling
- ✓ Lateral buckling
- ✓ Slenderness

Expected result at comprehensive and standard levels:

1. Illustrate common modes of failure for structural elements.
2. Compute ultimate load-carrying capacity for typical structural members based of strength of materials.
3. Explain features of real structures that differ from the theoretical solutions and how these affect strength.
4. Explain the basic principles of elastic and plastic design.
5. Illustrate selection process for simple structural elements based on strength of materials analysis.
6. Calculate strength of a simple element based on both elastic and plastic strength.

M2.4 Introduction to fatigue (6 hrs)

Objective: The student will understand the key concepts related to fatigue of materials and structures.

Scope:

- ✓ Definition of a fatigue load cycle
- ✓ Variable amplitude loading
- ✓ Cumulative damage
- ✓ Crack growth
- ✓ Mean stress
- ✓ Stress range
- ✓ Stress concentrations
- ✓ S-N curve
- ✓ Fatigue limit

Expected result at Comprehensive and Standard levels:

1. Illustrate basic features of cyclic loading including stress range, stress amplitude, mean stress.
2. Illustrate variable amplitude loading and cumulative damage.
3. Explain importance of mean stresses, stress concentration and surface finish on fatigue life.
4. Illustrate concepts of fatigue strength, fatigue life and fatigue limit.
5. Compute design life for a simple structural element using S-N –curve.
6. Illustrate how relevant information can be obtained from design guidance documents, e.g., IIW Doc. XIII-1965-03/XV-1127-03 “Recommendations for fatigue design of welded joints and components”.

M2.5 Introduction to fracture mechanics (5 hrs)

Objective: The student will be introduced to fracture modes and how the stress intensity factor can be used in modelling fatigue crack growth and brittle fracture.

Scope:

- ✓ Stress intensity factor
- ✓ Brittle fracture

- ✓ Ductile fracture
- ✓ Fatigue crack growth
- ✓ Paris equation
- ✓ Plastic zone
- ✓ Critical stress intensity factor

Expected result at Comprehensive and Standard levels:

1. Explain mechanism and common features of ductile fracture of structures.
2. Explain mechanism and common features of brittle fracture of materials and structures.
3. Explain fatigue crack growth based on linear elastic fracture mechanics.
4. Illustrate relationship between fracture type and surface appearance.
5. Review an industrial failure case involving fracture.
6. Explain the stress intensity factor, stress intensity factor range and critical stress intensity factor.
7. Compute stress intensity factors for a simple geometry using geometry factors.
8. Review experimental method related to fracture.

M2.6 Material properties (4 hrs)

Objective: The student will understand several of the critical material parameters used to assess to suitability of a structure or structural material.

Scope:

- ✓ Yield and ultimate strength
- ✓ Elongation
- ✓ Fracture toughness
- ✓ Elastic modulus
- ✓ Poisson ratio
- ✓ Fatigue limit

Expected result at Comprehensive and Standard levels:

1. Explain the stress strain behaviour on common structural materials.
2. Demonstrate how material properties are derived from a tension test.
3. Compute the elastic and plastic limit load of a simple structural member.
4. Illustrate the importance and limitation of the fatigue limit in design.
5. Explain the importance of elongation /ductility for ultimate load design.

Module 3: Design of Welded Structures (25 hrs; for both comprehensive and standard levels)

M3.1 Basic theory of structural systems (4 hrs)

Objective: The student should understand the basic classes of structural elements and how these elements are combined in a simple structure.

Scope:
- ✓ Tension elements
- ✓ Compression elements
- ✓ Beam elements
- ✓ Truss and frame structures
- ✓ Plate elements
- ✓ Joining and connections
- ✓ As appropriate a suitable design guidance document, e.g., EN 1993 Eurocode 3: Design of Steel Structures, may be used

Expected result at Comprehensive and Standard levels:
1. Explain the basic features of different structural elements and how these are used in design.
2. Explain the structural differences between moment bearing and non-moment bearing connections.
3. Explain the potential failure modes associated with the different structural elements.
4. Compute ultimate strength of tension members.
5. Compute shape factor, plastic limit load and elastic limit load for beam element.
6. Understand the basic difference in load transfer mechanism for a beam element constructed of plates and one constructed of tension/compression truss elements.

M3.2 Loads on structures (4 hrs)

Objective: The student will understand the important distinction between different classes of loads acting on a structure and be aware of how to compute loads for design.

Scope:
- ✓ Dead loads
- ✓ Live loads
- ✓ Distributed and concentrated loads
- ✓ Partial safety factors for loads
- ✓ Design loads
- ✓ Statistical load variation
- ✓ As appropriate a suitable design guidance document, e.g., EN 1991 Eurocode 1: Actions on structures, may be used

Expected result at Comprehensive and Standard levels:
1. Explain possible sources for dead loads and live loads that can act on a structure.
2. Understand how static and moving loads affect a structure.
3. Compute the design load for a structure based on partial safety factors and load class.
4. Explain some of the sources for variation of loads.
5. Explain the concept of partial safety factor and how these are used in the design of structures.
6. Interpret appropriate standards with respect to computation of design loads.
7. Interpret appropriate standards with respect to load classification and partial safety factors for loads.

M3.3 Introduction to the design of structures (8 hrs)

Objective: The objective is to provide an introduction to the philosophy and process of design for welded structures.

Scope:
- ✓ Design goals and constraints
- ✓ Safety, economy, durability and serviceability
- ✓ Proportioning of members
- ✓ Analysis and evaluation
- ✓ Partial safety factors
- ✓ Sources of variation in design loads and strength of structural components
- ✓ Ultimate and serviceability limit states

Expected result at Comprehensive and Standard levels:
1. Clarify the set of design objectives that are placed on a structure.
2. Illustrate the design process first concept to detail design and final evaluation.
3. Introduce the concepts of optimization with respect to performance, manufacturability, life cycle cost, etc.
4. Demonstrate the set of limit states that are placed on a structural system.
5. Illustrate the possible influences of manufacturing tolerances on the final design of a structure.
6. Explain the basic aspects of limit state design.
7. Illustrate the use of partial safety factors in calculations.
8. Compute loading combinations required in limit state design method.
9. Explain sources of load variation for welded structures.

M3.4 Analysis methods for structures (5 hrs)

Objective: The student will be introduced to the use of simple and more sophisticated analytical tools in the design of structures.

Scope:
- ✓ Spreadsheet tools
- ✓ Finite Element Analysis
- ✓ Design guideline formulas

Expected result at Comprehensive and Standard levels:
1. Demonstrate use of a spreadsheet based calculation system in the design of a structural system.
2. Explain the basis for selecting an appropriate analysis method for a design situation.
3. Explain the advantages, disadvantages and uses of different analysis methods.
4. Explain the use and interpretation of finite element results for steel structures design.
5. Correctly interpret and understand the use of design guideline formulas for calculation of design strength and design load.

M3.5 Design guidance documents, codes and standards (4 hrs)

Objective: The student will become familiar with the appropriate use of design guidance documents in the design of fabricated structures.

Scope:

- ✓ Dimensioning
- ✓ Partial safety factors
- ✓ Design load
- ✓ Design strength
- ✓ Limit state design / allowable stress design

As appropriate, a suitable design guidance document, e.g., EN 1993 Eurocode 3-part 6: Design of Steel Structures: Crane supporting structures, EN 1993 Eurocode 3-part 2: Design of Steel Structures: Steel bridges, EN 13445: Unfired pressure vessels, etc., may be used.

Expected result at Comprehensive and Standard levels:

1. Understand the procedures recommended in one design guidance document for fabricated structures.
2. Compute design strength of a simple structural component using procedures outlined in one design guidance document.
3. Compute the needed design load for a structure considering both static and variable loads.
4. Identify from the design guidance document other related codes and standards related to materials, manufacturing, and calculation methods, etc.
5. Explain the basic features of the design guidance document being used.
6. Explain possible sources of exceptional / accidental loads on the structure being considered.
7. Understand the relationship between design strength and design load for a structure and failure probability.

Module 4: Design of Welded Joints (25 hrs; for comprehensive level only)

M4.1 Categories of welded joints (4 hrs)

Objective: The student will understand the differences between functional weld categories and how the design requirements will depend on the categories

Scope:

Weld categories:

- primary load carrying joints;
- connecting joints;
- binding joints;
- accessory joints.

Expected result at Comprehensive level:

1. Identify various classes of welded joints based on their function.
2. Explain the load-bearing requirement of various weld categories.
3. Explain the need to avoid the under and oversize of the throat thickness.
4. Illustrate the role of joint preparation and weld penetration for load-carrying joints.
5. Identify joint categories from an engineering structure.

M4.2 Design of welded joints with predominantly static loading (8 hrs)

Objective: The student will understand how the throat thickness of weld will be defined in predominantly static loaded joints.

Scope:

- ✓ Throat thickness
- ✓ Elastic and plastic design
- ✓ Deformation capacity
- ✓ Stress components in a fillet weld
- ✓ Correlation factor for weld strength
- ✓ Design strength

As appropriate, a suitable design guidance document, e.g., EN 1993 Eurocode 3-part 1-8: Design of Steel Structures: Design of Joints, may be used.

Expected result at comprehensive level:

1. Explain the assumptions involved in the design of predominantly static loaded joints.
2. Identify relevant stress values from a type stress-time history for a structural component.
3. Calculate the design strength of end welds based on weld stress components.
4. Calculate the design strength of side welds based on weld stress components.
5. Calculate the strength reduction factor for long side welds or transverse stiffeners.
6. Calculate the needed throat thickness for a full strength primary load carrying weld.
7. Calculate the throat thickness for a binding welded joint.

M4.3 Design of welded joints with predominantly dynamic/cyclic loading (10 hrs)

Objective: The student will understand the fatigue behaviour of welded joints and be able to perform relevant fatigue life calculations.

Scope:

- ✓ Fatigue of welded joints:
  - stress concentrations
  - residual stresses
  - initial defects
- ✓ Constant and variable amplitude loading
- ✓ Cumulative damage
- ✓ FAT class
- ✓ Overview of fatigue calculation methods in a relevant design guidance document, e.g., IIW Doc. XIII-1965-03/XV-1127-03 “Recommendations for fatigue design of welded joints and components”

Expected result at Comprehensive level:

1. Explain the assumptions involved in the design of predominantly static loaded joints.
2. Identify relevant stress values from a type stress-time history for a structural component.
3. Calculate the design strength of end welds based on weld stress components.
4. Calculate the design strength of side welds based on weld stress components.
5. Calculate the strength reduction factor for long side welds or transverse stiffeners.
6. Calculate the needed throat thickness for a full strength primary load carrying weld.
7. Calculate the throat thickness for a binding welded joint.

M4.4 Design against brittle fracture (3 hrs)

Objective: The student will be acquainted with brittle fracture analysis based on linear elastic fracture mechanics.

Scope:

- ✓ Fracture toughness
- ✓ Critical stress intensity
- ✓ Critical crack size
- ✓ Temperature and material toughness
- ✓ Overview of calculation methods in a relevant design guidance document, e.g., EN 1993 Eurocode 3-part 1-10: Design of Steel Structures: Selection of materials for fracture toughness and through thickness properties

Expected result at Comprehensive level:

1. Review theory of fracture mechanics and brittle fracture.
2. Explain relationship between material fracture toughness and temperature.
3. Review calculation procedures in a relevant design guidance document.
4. Compute critical crack size for structural element with typical material properties.
5. Compute stress intensity factor for a welded connection.

Module 5: Design of Welded Plate Structures (25 hrs; for comprehensive level only)

M5.1 Plates and shells (8 hrs)

Objective: The student will have a basic understanding of plate buckling and design requirements to avoid buckling.

Scope:
- ✓ Plate buckling
- ✓ Modified slenderness
- ✓ Effective width
- ✓ Stiffeners
- ✓ Buckling coefficient

Expected result at Comprehensive level:
1. Explain the buckling of plate type structures and the buckling coefficient.
2. Illustrate the critical buckling stress vs. slenderness for plates.
3. Review the concept of cross section class and its relationship with relative slenderness.
4. Compute effective width for a slender flange under compression.
5. Illustrate an example of stiffener design based on standard equations.

As appropriate, a suitable design guidance document, e.g., EN 1993 Eurocode 3-part 1-5: Design of Steel Structures: Supplementary rules for planar plated structures without transverse loading, may be used.

M5.2 Beam and column structures (8 hrs)

Objective: The students will have a basic understanding of design methods for beam structures and beam / column structures to avoid buckling.

Scope:
- ✓ Beam and column profiles
- ✓ Cross section classes
- ✓ Local and global stability
- ✓ Plastic design
- ✓ Torsion (warping) of open thin-walled cross sections
- ✓ Longitudinal stiffeners
- ✓ Design of slender webs
- ✓ Shape factors for beam profiles

Expected result at comprehensive level:
1. Explain the combined effect of axial / bending loads.
2. Illustrate proper placement of longitudinal stiffeners for beams subject to bending.
3. Illustrate proper design methods for stiffening of wide flanges.
4. Review buckling of beam webs subject to shear loads.
5. Illustrate optimal design of beam elements for stiffness / bending resistance.
6. Compute bending resistance of a beam with slender or semi-compact webs.

As appropriate, a suitable design guidance document, e.g., EN 1993 Eurocode 3-part 1-5: Design of Steel Structures: Supplementary rules for planar plated structures without transverse loading, may be used.

M5.3 Design considerations for welding residual stresses and distortion (9 hrs)

Objective: The student will understand the theoretical background of residual stresses and distortion and can use simplified estimation methods.

Scope:

- ✓ Welding induced residual stresses
- ✓ Welding induced distortion
- ✓ Classification of distortions
- ✓ Weld sequence effects and residual stresses
- ✓ Effect of residual stress on structural behaviour
- ✓ Lamellar tearing

Expected result at comprehensive level:

1. Illustrate the formation of longitudinal and transverse welding residual stresses.
2. Explain the influence of constraint on residual stress formation.
3. Illustrate the difference between single and multi-pass welding on residual stress formation.
4. Compute approximate residual deformation due to welding.
5. Illustrate the influence of residual stresses on the ultimate strength of a structural member.
6. Explain possible influences of residual stress on lamellar tearing and fatigue.
7. Illustrate proper selection of weld order to minimise residual stresses.

Module 6: Design for Purpose of Welded Structures (25 hrs; for comprehensive level only)

M6.1 Introduction to design for purpose concepts for welded structures (3 hrs)

Objective: The students will be introduced to the basics of the "design for purpose" strategy for welded structures

Scope:
- ✓ Alternate structure solutions
- ✓ Assessment of weld importance in terms of loading
- ✓ Definition of weld quality for different purposes

Expected result at comprehensive level:
1. Explain the roles and priority of welds within a structure.
2. Explain the importance of various structural solutions for fatigue and static strength of a welded joint.
3. Review of possible weld defect types and identify significance or lack of significance for strength.
4. Review alternatives for improving the fatigue strength of a structural detail.
5. Illustrate good and bad examples of weld specification.

M6.2 Improved design of statically loaded joints (2 hrs)

Objective: The student will understand what are essential items concerning improved design of statically loaded joints

Scope:
- ✓ Flow of forces in welded joints
- ✓ Weld start / stop positions
- ✓ Slot and plug welds
- ✓ Deformation capacity of a weld

Expected result at Comprehensive level:
1. Illustrate the effect of statically loaded welds on a flexible foundation.
2. Review deformation capacity for statically loaded welds and illustrate good and bad design examples.
3. Compute optimal geometry for a welded attachment.

M6.3 Improved design of dynamically/cycllic loaded joints (8 hrs)

Objective: The students will understand how the fatigue life will depend on the different parameters and how these parameters can be control in design and manufacturing phases of production

Scope:
- ✓ Nominal stress
- ✓ Structural stress
- ✓ Weld defects
- ✓ Notch stress
- ✓ Welds starts / stops
- ✓ Root defects

Expected result at Comprehensive level:

1. Review principals for weld location for improved fatigue strength.
2. Illustrate importance of reducing the structural stress concentration.
3. Explain the importance of weld misalignment in fatigue design.
4. Explain the importance of weld toe shape for fatigue.
5. Review importance of weld start / stop positions.
6. Compute fatigue strength of cruciform joint based on IIW recommendations.

M6.4 Post- weld treatment methods for welded structures (4 hrs)

Objective: The students will understand the theoretical background, advantages and disadvantages of post-weld treatment methods. They will be acquainted with the practical aspects for executing the methods and inspection requirements. Reference document should be IIW publication XIII-1815-00 “IIW recommendations on post-weld improvement of steel and aluminium structures”.

Scope:

- ✓ TIG dressing
- ✓ Grinding
- ✓ Needle peening
- ✓ Hammer peening
- ✓ Quality control
- ✓ Fatigue strength improvement

Expected result at Comprehensive level:

1. Review common methods for post-weld treatment for welded joints.
2. Explain procedures and quality control procedure associated with common treatment methods.
3. Explain benefits and limitations of the various methods in terms of fatigue strength.

M6.5 Design considerations for manual and automated welding processes (2,5 hrs)

Objective: The student will understand the design requirements and challenges involved in automated welding processes

Scope:

- ✓ Weld angle and position
- ✓ Interference
- ✓ Seam tracking
- ✓ Joint selection

Expected result at Comprehensive level:

1. Review examples of both good and bad design with respect to manufacturability.
2. Explain sources of interference during welding and how these can be avoided in design.
3. Explain design alternatives that are better suited for automated weld processes.

M6.6 Numerical methods and fatigue design (4 hrs)

Objective: The students will be introduced to the use of numerical analyses methods in the fatigue design of welded structures

Scope:

- ✓ Finite element analysis
- ✓ Nominal stress approach
- ✓ Structural stress approach
- ✓ Notch stress approach
- ✓ Linear elastic fracture mechanics
- ✓ Overview of fatigue numerical methods in a relevant design guidance document, e.g., IIW Doc. XIII-1965-03/XV-1127-03 “Recommendations for fatigue design of welded joints and components”

Expected result at Comprehensive level:

1. Explain principals of proper FE meshing for fatigue analysis based on structural stresses.
2. Explain principals of proper FE meshing for fatigue analysis based on local notch stresses.
3. Review simple tools for fracture mechanics crack growth simulations.

M6.7 Laboratory testing (1,5 hrs)

Objective: The students will have a general background on the role of laboratory testing and its role in research, development and design

Scope:

- ✓ Fatigue testing methods
- ✓ Quasi-static testing methods
- ✓ Evaluation of laboratory failures
- ✓ Methods for data analysis

Expected result at comprehensive level:

1. Explain the background of design curves based on fatigue testing.
2. Review of relevant documents and standards for laboratory testing and data analysis. For example:
   - IIW XIII-1516-93 Fatigue testing of welded components;
   - IIW XIII-1871-01 Large scale testing of welded components;
   - XIII-WG1-114-03 Best practice guide on statistical analysis of fatigue data.

Module 7: Fabrication, Costs, Quality and Inspection (25 hrs; for both comprehensive and standard levels)

M7.1 Fabrication costs and cost reduction (8 hrs)

Objective: The student will understand the average cost levels of various fabrication processes and how they affect the total cost of a product

Scope:
- ✓ Joint preparation costs
- ✓ Filler material cost
- ✓ Welding speed and machine costs
- ✓ Fixed and marginal costs
- ✓ Semi finished components

Expected result at Comprehensive and Standard levels:
1. Compute example on the influence of weld throat thickness on weld cost.
2. Illustrate typical division of welding costs for different types of welding operations.
3. Review typical production process and their relationship between cost and productivity.
4. Comparison of cost levels for manual welding, mechanized welding and robot welding.
5. Review of case studies in fabrication cost reduction.

M7.2 Fabrication friendly design (10 hrs)

Objective: The students will be acquainted with the costs of common fabrication processes of a welded structure and how these costs can be minimized during the design process. The student should know how to communicate these “fabrication friendly” concepts in a design drawing.

Scope:
- ✓ Production costs
- ✓ Manufacture friendly design
- ✓ Automated and robotized production
- ✓ LCC
- ✓ Production measures

Expected result at Comprehensive and Standard levels:
1. Explain the influence of design in the total cost of a finished product.
2. Explain the principals of life cycle costs.
3. Review industrial case studies on product cost reduction.
4. Present limitations and advantages of various automated and robotized processes and how these influence design.
5. Explain general steps to reduce the overall costs of a structure.
6. Review different and often conflicting measures of fabrication productivity.
7. Illustrate good and bad examples of design drawings for efficient fabrication costs.

M7.3 Quality assurance in welding fabrication (4 hrs)

Objective: The students will be acquainted with the role, methods and requirements for quality assurance in welding fabrication

Scope:

- ✓ Quality standards involved
- ✓ Weld imperfections
- ✓ Acceptance of imperfections
- ✓ Quality systems for production

Expected result at Comprehensive and Standard levels:

1. Review fundamental aspects of a quality system for fabricated structures.
2. Explain and identify typical defect types in welded joints.
3. Review typical corrective actions for reducing weld flaws.
4. Review of relevant standards for quality control, e.g., ISO 9001 “Quality management systems”, EN ISO 3834-series “Quality requirements for welding technology”, ISO 6520-1:1998 “Welding and allied processes. Classification of geometrical imperfections in metallic materials- Part 1 fusion welding”, ISO 5817:2003 “Welding – Fusion welded joints in steel, nickel titanium and their alloys – Quality level for imperfections” and ISO 10042:2006 “Arc Welding Joints in Aluminium and its Weldable Alloys - Guidance on Quality Levels for Imperfections”.

M7.4 Inspection methods and criteria (3 hrs)

Objective: The students will be acquainted with the common inspection methods of welded structures and their applicability

Scope:

- ✓ Inspection methods
- ✓ Destructive testing:
  - Charpy;
  - Tensile;
  - Bending;
  - Etc.
- ✓ Non-destructive testing:
  - Magnetic particle;
  - Ultrasonic;
  - Etc.

Expected result at Comprehensive and Standard levels:

1. Explain the technical limitations of common non-destructive inspection methods.
2. Explain the function of common destructive test procedure.
3. Introduce documentation relevant to the inspection of welded joints.
4. Review of relevant standards for quality control, e.g., (ISO 5817:2003) “Arc-welded joints in steel – Guidance on quality levels for imperfections”, ISO 15614-1 “Welding Procedure Tests for The Arc Welding of Steel”, EN 571-1 “Non destructive testing. Penetrating testing. Part 1: General principles”, EN 583-1 “Non-destructive testing. Ultrasonic examination. Part 1: General principles”, etc.

4. Examinations

4.1 Examination procedures and administration

Procedures and administration are covered by Document IAB-001-2000/EWF416.

4.2 Approval of the training course

Any training course leading to the IIW examination shall be approved by the Authorised National Body. The number of teachers required to give the course shall be sufficient to ensure that the essential specialist knowledge and industrial experience to cover the syllabus are adequately represented in the team of teachers and visiting lecturers.

4.3 Examination procedures for Comprehensive level

The examination procedures described below are designed to test the candidate's knowledge and understanding of different situations in weld design active in industry. There will be written examinations in each following modules:

Module 1: Welding technology
Module 2: Strength of materials
Module 3: Design of welded structures
Module 4: Design of welded joints
Module 5: Design of welded plate structures
Module 6: Design for purpose of welded structures
Module 7: Fabrication, costs, quality and inspection

The questions are to reflect the course topics. The time devoted to the written examination shall be a minimum of 0,5 hours per module. However, the total examination time for all seven modules shall be a minimum of 7 hours.

4.4 Examination procedures for standard level

The examination procedures described below are designed to test the candidate's knowledge and understanding of different situations in weld design active in industry. There will be written examinations in each following modules:

Module 1: Welding technology
Module 2: Strength of materials
Module 3: Design of welded structures
Module 7: Fabrication, costs, quality and inspection

The questions are to reflect the course topics. The time devoted to the written examination shall be a minimum of 0,5 hours per module. However, the total examination time for all four modules shall be a minimum of 4 hours.

4.5 Evaluation of performance

Comprehensive level

In order to pass the examination the candidates shall achieve

a) at least 50% of the maximum possible score in each module
b) the final weighted score based on the above mentioned percentages should be at least 60 % of the maximum possible score

Successfully completed individual parts of the examination remain valid for a period of 3 years. The examination for all seven modules shall be completed within a period of 3 years from the start of the course.

Standard level

In order to pass the examination the candidates shall achieve at least 60 % of the maximum possible score

The examination for all four modules shall be completed within a period of 3 years from the start of the course.

4.6 Re-examination and appeals procedure

Failure in any individual module of the examination shall require re-examination only in the module failed. Examinations shall be retaken within 2 weeks to 15 months of the initial examination and, in the case of a second failure, one further attempt is permitted within 1 to 15 months from the date of the second examination. Failure of this third attempt will result in the candidate being treated as an initial candidate and a retake of the whole course will be required.

Candidates who feel they have been unfairly treated during the examination procedure have the right to appeal to the Authorized National Body.

The remaining procedures are covered in Document IAB-001-2000/EWF416.