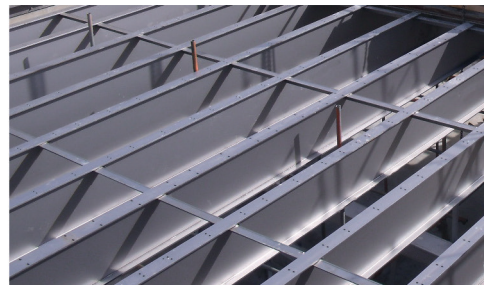




27

Steel Design Guide

Structural Stainless Steel





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NANCY BADDOO

The Steel Construction Institute
Silwood Park, Ascot, UK

AMERICAN INSTITUTE OF STEEL CONSTRUCTION

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Author

Nancy Baddoo is an associate director at The Steel Construction Institute (SCI) and a Fellow of the Institution of Civil Engineers. She has worked on many research projects studying the structural performance of stainless steel as well as being active in disseminating design guidance through publications, seminars, and online design tools. She chairs the European technical committee responsible for the stainless steel Eurocode, EN 1993-1-4.

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TABLE OF CONTENTS

CHAPTER 1 INTRODUCTION 1

- 1.1 WHAT IS STAINLESS STEEL?1
- 1.2 APPLICATIONS OF STAINLESS STEELS IN THE CONSTRUCTION INDUSTRY2
- 1.3 SCOPE OF THIS DESIGN GUIDE7

CHAPTER 2 MATERIALS: PROPERTIES, SELECTION AND DURABILITY 9

- 2.1 BASIC STRESS-STRAIN BEHAVIOR9
- 2.2 SUITABLE STAINLESS STEELS FOR STRUCTURAL APPLICATIONS9
- 2.3 MECHANICAL PROPERTIES11
 - 2.3.1 Standards for Flat and Long Products . . .11
 - 2.3.2 Standards for Bolts11
 - 2.3.3 Mechanical Properties Used in Design . .14
- 2.4 PHYSICAL PROPERTIES17
- 2.5 SELECTION OF MATERIALS18
 - 2.5.1 Stainless Steel Selection18
 - 2.5.2 Availability of Product Forms19
 - 2.5.3 Life Cycle Costing and Environmental Impact21
- 2.6 DURABILITY21
 - 2.6.1 Introduction21
 - 2.6.2 Types of Corrosion and Performance of Steel Types22
 - 2.6.3 Corrosion in Selected Environments . . .24
 - 2.6.4 Design for Corrosion Control25

CHAPTER 3 DESIGN REQUIREMENTS 29

- 3.1 LOADS AND LOAD COMBINATIONS29
- 3.2 DESIGN BASIS29
 - 3.2.1 Required Strength29
 - 3.2.2 Limit States29
 - 3.2.3 Design for Stability29
 - 3.2.4 Design for Serviceability and Ponding . .30
- 3.3 MEMBER PROPERTIES30
 - 3.3.1 Classification of Sections for Local Buckling30
 - 3.3.2 Gross and Net Area Determination . . .31
 - 3.3.3 Compact Sections in Flexure32

CHAPTER 4 DESIGN OF MEMBERS FOR TENSION 33

- 4.1 AUSTENITIC AND DUPLEX STAINLESS STEEL TENSION MEMBERS33
- 4.2 PRECIPITATION HARDENING STAINLESS STEEL TENSION RODS33

CHAPTER 5 DESIGN OF MEMBERS FOR COMPRESSION 35

- 5.1 GENERAL PROVISIONS35
- 5.2 EFFECTIVE LENGTH35
- 5.3 FLEXURAL BUCKLING OF MEMBERS WITHOUT SLENDER ELEMENTS35
- 5.4 TORSIONAL AND FLEXURAL-TORSIONAL BUCKLING OF MEMBERS WITHOUT SLENDER ELEMENTS35
- 5.5 SINGLE ANGLE COMPRESSION MEMBERS AND BUILT-UP MEMBERS36
- 5.6 MEMBERS WITH SLENDER ELEMENTS . . .36
 - 5.6.1 Slender Unstiffened Elements, Q_s 36
 - 5.6.2 Slender Stiffened Elements, Q_a 36

CHAPTER 6 DESIGN OF MEMBERS FOR FLEXURE 39

- 6.1 GENERAL PROVISIONS39
- 6.2 I-SHAPED MEMBERS AND CHANNELS BENT ABOUT THEIR MAJOR OR MINOR AXIS . . .39
- 6.3 SQUARE AND RECTANGULAR HSS AND BOX-SHAPED MEMBERS40
 - 6.3.1 Yielding40
 - 6.3.2 Flange Local Buckling40
 - 6.3.3 Web Local Buckling40
- 6.4 ROUND HSS40
- 6.5 RECTANGULAR BARS AND ROUNDS . . .40
- 6.6 UNSYMMETRICAL SHAPES, EXCLUDING SINGLE ANGLES40
- 6.7 DETERMINATION OF DEFLECTION40

CHAPTER 7 DESIGN OF MEMBERS FOR SHEAR 43

CHAPTER 8 DESIGN OF MEMBERS FOR COMBINED FORCES 45

- 8.1 DOUBLY AND SINGLY SYMMETRIC MEMBERS SUBJECT TO FLEXURE AND AXIAL FORCE45
 - 8.1.1 Doubly and Singly Symmetric Members Subject to Flexure and Compression . . .45
 - 8.1.2 Doubly and Singly Symmetric Members Subject to Flexure and Tension45
- 8.2 UNSYMMETRIC AND OTHER MEMBERS SUBJECT TO FLEXURE AND AXIAL FORCE45

CHAPTER 9 DESIGN OF CONNECTIONS..... 47

9.1	DURABILITY.....	47
9.2	DESIGN OF WELDED CONNECTIONS.....	48
9.3	DESIGN OF BOLTED CONNECTIONS.....	49
9.3.1	General.....	49
9.3.2	Pretensioned Bolts.....	49
9.3.3	Size and Use of Holes, Spacing and Edge Distance.....	49
9.3.4	Tension and Shear Strength of Bolts and Threaded Parts.....	49
9.3.5	Combined Tension and Shear in Bearing-Type Connections.....	50
9.3.6	Bearing Strengths at Bolt Holes.....	50
9.3.7	Special Fasteners.....	51
9.4	AFFECTED ELEMENTS OF MEMBERS AND CONNECTING ELEMENTS.....	51
9.5	BEARING STRENGTH.....	51
9.6	FLANGES AND WEBS WITH CONCENTRATED FORCES.....	51

CHAPTER 10 FIRE RESISTANCE..... 53

10.1	GENERAL PROVISIONS.....	53
10.2	STRUCTURAL DESIGN FOR FIRE CONDITIONS BY ANALYSIS.....	53
10.2.1	Thermal Elongation.....	53
10.2.2	Mechanical Properties at Elevated Temperature.....	53
10.2.3	Specific Heat.....	53
10.2.4	Emissivity.....	53
10.3	STRUCTURAL DESIGN REQUIREMENTS.....	53
10.3.1	Simple Methods of Analysis.....	53

CHAPTER 11 FATIGUE..... 57**CHAPTER 12 FABRICATION AND ERECTION .. 59**

12.1	INTRODUCTION.....	59
12.2	SAFETY AND HEALTH.....	59
12.3	STORAGE AND HANDLING.....	59
12.4	SHAPING OPERATIONS.....	60
12.4.1	Cutting.....	60
12.4.2	Holes.....	60
12.5	WELDING.....	60
12.5.1	Introduction.....	60
12.5.2	Processes.....	61
12.5.3	Filler Metals.....	61
12.5.4	Welding Distortion.....	61
12.5.5	Metallurgical Considerations.....	62
12.5.6	Post Weld Treatment.....	63
12.5.7	Inspection of Welds.....	63
12.6	INSTALLING STAINLESS STEEL BOLTS.....	64
12.7	GALLING AND SEIZURE.....	64
12.8	FINISHING.....	64

CHAPTER 13 TESTING..... 67

13.1	GENERAL.....	67
13.2	STRESS-STRAIN CURVE DETERMINATION.....	67
13.3	TESTS ON MEMBERS.....	67

APPENDIX A. THE CONTINUOUS STRENGTH METHOD..... 69

A.1	GENERAL.....	69
A.2	MATERIAL MODELLING.....	69
A.3	DEFORMATION CAPACITY.....	69
A.4	COMPRESSIVE STRENGTH.....	70
A.5	FLEXURAL STRENGTH.....	70

APPENDIX B. COMMENTARY TO THE DESIGN RULES..... 71

B.1	INTRODUCTION.....	71
B.1.1	Purpose of the Commentary.....	71
B.1.2	How Does the Structural Performance of Stainless Steel Differ from Carbon Steel?.....	71
B.1.3	Design Specifications for Structural Stainless Steel.....	71
B.1.4	Scope of the Design Guide.....	71
B.2	DETERMINATION OF STAINLESS STEEL RESISTANCE FACTORS.....	72
B.2.1	Probabilistic Basis and Reliability Index.....	72
B.2.2	Load and Load Effects.....	72
B.2.3	Resistance.....	73
B.2.4	Determination of Resistance Factor.....	74
B.2.5	Precipitation Hardening Stainless Steels.....	75
B.3	SECTION CLASSIFICATION.....	75
B.3.1	Eurocode 3 Methodology for Carbon Steel and Stainless Steel.....	75
B.3.2	The AISC <i>Specification</i> Methodology for Carbon Steel.....	75
B.3.3	Recommendations for the AISC Design Guide.....	75
B.3.4	Determination of Resistance Factor.....	75
B.4	DESIGN OF MEMBERS FOR TENSION.....	77
B.4.1	Determination of Resistance Factor.....	77
B.5	DESIGN OF MEMBERS FOR COMPRESSION.....	77
B.5.1	Flexural Buckling of Members Without Slender Elements.....	77
B.5.2	Torsional and Flexural-Torsional Buckling of Members Without Slender Elements.....	82
B.5.3	Single Angle Compression Members and Built-Up Members.....	82
B.5.4	Members with Slender Elements.....	83

B.6	DESIGN OF MEMBERS FOR FLEXURE	88		
B.6.1	Laterally Restrained Members	88		
B.6.2	Laterally Unrestrained Members (Lateral Torsional Buckling).	91		
B.6.3	Determination of Deflection	93		
B.7	DESIGN OF MEMBERS FOR SHEAR	94		
B.7.1	Eurocode 3 Methodology for Carbon Steel and Stainless Steel.	94		
B.7.2	The AISC <i>Specification</i> Methodology for Carbon Steel	95		
B.7.3	Recommendations for the AISC Design Guide	96		
B.7.4	Determination of Resistance Factor	97		
B.8	DESIGN OF MEMBERS FOR COMBINED FORCES.	97		
B.8.1	Eurocode 3 Methodology for Carbon Steel and Stainless Steel.	97		
B.8.2	The AISC <i>Specification</i> Methodology for Carbon Steel	98		
B.8.3	Recommendations for the AISC Design Guide	98		
B.8.4	Determination of Resistance Factor	99		
B.9	DESIGN OF CONNECTIONS	99		
B.9.1	Design of Welded Connections	99		
B.9.2	Design of Bolted Connections	99		
B.9.3	Affected Elements of Members and Connecting Elements.	102		
B.9.4	Bearing Strength.	102		
B.9.5	Flanges and Webs with Concentrated Forces	102		
B.10	STRUCTURAL DESIGN FOR FIRE CONDITIONS.	103		
B.10.1	Mechanical and Thermal Properties at Elevated Temperatures	103		
B.10.2	Compression Members.	103		
B.10.3	Flexural Members.	106		
B.11	CONTINUOUS STRENGTH METHOD.	112		
B.11.1	Determination of Resistance Factors for Continuous Strength Method (Compression Members)	112		
B.11.2	Determination of Resistance Factors for Continuous Strength Method (Flexural Members)	112		
	DESIGN EXAMPLES.	117		
	SYMBOLS	139		
	REFERENCES.	143		
	SOURCES OF ADDITIONAL INFORMATION. . .	149		

Chapter 1

Introduction

1.1 WHAT IS STAINLESS STEEL?

Stainless steel is the name given to a family of corrosion and heat resistant steels containing a minimum of 10.5% chromium. Just as there are various structural and engineering carbon steels meeting different strength, weldability and toughness requirements, there is also a wide range of stainless steels with varying levels of corrosion resistance and strength. This array of stainless steel properties is the result of controlled alloying element additions, each affecting specific attributes of strength and ability to resist different corrosive environments. To achieve the optimal economic benefit, it is important to select a stainless steel which is adequate for the application without being unnecessarily highly alloyed and costly.

With a combination of the chromium content above 10.5%, a clean surface and exposure to air or any other oxidizing environment, a transparent and tightly adherent layer of chromium-rich oxide forms spontaneously on the surface of stainless steel. If scratching or cutting damages the film, it reforms immediately in the presence of oxygen. Although the film is very thin, about 0.2×10^{-6} in. (5×10^{-6} mm), it is both stable and nonporous and, as long as the type of stainless steel is corrosion resistant enough for the service environment, it will not react further with the atmosphere. For this reason, it is called a passive film. The stability of this passive layer depends on the composition of the stainless steel, its surface treatment, and the corrosiveness of its environment. Its stability increases as the chromium content increases and is further enhanced by alloying additions of molybdenum and nitrogen.

Stainless steels can be classified into the following five basic groups, with each group providing unique properties and a range of different corrosion resistance levels.

Austenitic stainless steels

The most widely used types of austenitic stainless steel are based on 17 to 18% chromium and 8 to 11% nickel additions. In comparison to structural carbon steels, which have a body-centered cubic atomic (crystal) structure, austenitic stainless steels have a different, face-centered cubic atomic structure. As a result, austenitic stainless steels, in addition to their corrosion resistance, have high ductility, are easily cold-formed, and are readily weldable. Relative to structural carbon steels, they also have significantly better toughness over a wide range of temperatures. They can be strengthened by cold working, but not by heat treatment. Their corrosion

performance can be further enhanced by higher levels of chromium and additions of molybdenum and nitrogen.

Ferritic stainless steels

The chromium content of the most popular ferritic stainless steels is between 10.5% and 18%. Ferritic stainless steels contain either no or very small nickel additions and their body-centered atomic structure is the same as that of structural carbon steels. They are generally less ductile, less formable and less weldable than austenitic stainless steels. They can be strengthened by cold working, but to a more limited degree than the austenitic stainless steels. Like the austenitics, they cannot be strengthened by heat treatment and can be used in a broad range of corrosive environments. They have good resistance to stress corrosion cracking and their corrosion performance can be further enhanced by additions of molybdenum.

Duplex stainless steels

Duplex stainless steels have a mixed microstructure of austenite and ferrite, and so are sometimes called austenitic-ferritic steels. They typically contain 20 to 26% chromium, 1 to 8% nickel, 0.05 to 5% molybdenum, and 0.05 to 0.3% nitrogen. They provide higher strength levels than austenitic steels and are suitable for a broad range of corrosive environments. Although duplex stainless steels have good ductility, their higher strength results in more restricted formability compared to the austenitics. They can also be strengthened by cold working, but not by heat treatment. They have good weldability and good resistance to stress corrosion cracking.

Martensitic stainless steels

Martensitic stainless steels have a similar body-centered cubic structure as ferritic stainless steel and structural carbon steels, but due to their higher carbon content, they can be strengthened by heat treatment. Martensitic stainless steels are generally used in a hardened and tempered condition, which gives them high strength and provides moderate corrosion resistance. They are used for applications that take advantage of their wear and abrasion resistance and hardness, like cutlery, surgical instruments, industrial knives, wear plates and turbine blades. They are less ductile and more notch sensitive than the ferritic, austenitic and duplex stainless steels. Although most martensitic stainless steels can be welded, this may require preheat and postweld heat treatment, which can limit their use in welded components.