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Website: www.bca.gov.sg/academy

ISBN : 978-981-05-9754-2

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BC 1: 2008

Design Guide on Use of Alternative Steel Materials to BS 5950

BCA Sustainable Construction Series – 3

The education and research arm of the Building and Construction Authority

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Design Guide on Use of Alternative Steel Materials to BS 5950

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ISBN 978-981-05-9754-2

Preface

This design guide serves as Singapore's national code of practice for the use of alternative steel materials in design to the British Standard "BS 5950 Structural use of steelwork in building", including those manufactured to British Standards. Steel materials not covered in BS 5950 by default shall be allowed with or without restrictions if they are in compliance with the provisions of this design guide.

The objective of this design guide is to ensure that only adequate (in terms of material performance) and reliable (in terms of quality assurance) steel materials, regardless of material standards to which the materials are manufactured to, are used in the design of structural steelworks to ensure public safety.

This design guide only gives provisions for structural design based on BS 5950, and therefore only serves as guidance at the design stage. It has been assumed in the drafting of this design guide that the execution of its provisions is entrusted to appropriately qualified persons, in compliance with appropriate execution standards to control materials, fabrication and erection of steelwork.

As a code of practice, this design guide takes the form of guidance and recommendations. It should not be quoted as if it was a specification and particular care should be taken to ensure that claims of compliance are not misleading. Reference for additional design recommendations other than those given in this design guide shall be made to various parts of BS 5950.

This design guide does not purport to include all the necessary provisions of a contract. Users of this design guide are responsible for their correct application.

Compliance with this design guide does not of itself confer immunity from legal obligations.

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List of Symbols

For the purposes of this design guide, the following symbols apply.

f_u Tensile strength of stud shear connector, in N/mm^2

L_o Proportional gauge length used to compute elongation in tensile test, in mm

p_{bb} Bearing strength of bolts, in N/mm^2

p_s Shear strength of bolts, in N/mm^2

p_t Tension strength of bolts, in N/mm^2

p_w Design strength of fillet welds, in N/mm^2

p_y Design strength of structural steels, in N/mm^2

p_{yo} Basic design strength of structural steels with thickness not greater than 16 mm, in N/mm^2

S_o Original cross-sectional area of specimen in tensile test, in mm^2

t Thickness of steel materials, in mm

U_b Minimum tensile strength of bolts, in N/mm^2

U_e Minimum tensile strength of welding consumables, in N/mm^2

U_s Minimum tensile strength of structural steels, in N/mm^2

Y_b Minimum yield strength of bolts, in N/mm^2

Y_s Minimum yield strength of structural steels, in N/mm^2; which is taken as the stress at either the initiation of yielding for steel materials with clearly defined yield point; and as the lesser of 0.2% proof stress, or the stress at 0.5% total elongation, for steel materials with no clearly defined yield point

Section 1
Introduction

Section 1 Introduction

1.1 Scope

Under the provisions of this design guide, alternative steel materials not manufactured to British Standards may be allowed in structural design based on BS 5950. To be consistent, this design guide outlines the material performance requirements and quality assurance requirements to be imposed on all steel materials, including those manufactured to British Standards, intended for use in accordance with BS 5950, in the context of Singapore.

1.2 Acronyms

Unless otherwise stated, the following acronyms apply throughout this design guide.

1.2.1 Acronyms for standards and organizations

AS	- Australian Standard(s)
AISC	- American Institute of Steel Construction
ANSI	- American National Standards Institute
API	- American Petroleum Institute
ASTM	- American Society for Testing and Materials
AWS	- American Welding Society
BCA	- Building and Construction Authority of Singapore
BS	- British Standard(s)
EN	- European Standard(s)
GB	- National Standard(s) of the People's Republic of China
ISO	- International Organization for Standardization
JIS	- Japanese Industrial Standard(s)
NZS	- New Zealand Standard(s)
SINGLAS	- The Singapore Laboratory Accreditation Scheme

1.2.2 Acronyms for technical terms

CEV	- Carbon equivalent value
FPC	- Factory production control
NDT	- Non-destructive testing

1.3 Terms and definitions

For the purposes of this design guide, the following terms and definitions apply.

1.3.1 Alternative steel materials

Alternative steel materials are steel materials not manufactured in accordance with British Standards, and therefore not covered in BS 5950 by default. The use of alternative steel materials in BS 5950 shall be allowed with or without recommendations and/or restrictions according to the classification defined in **1.3.2**.

1.3.2 Classification of alternative steel materials

Classification of alternative steel materials is carried out based on the assessments of both material performance requirements defined in **1.3.3** and quality assurance requirements defined in **1.3.4** to categorise alternative steel materials into three classes – Class 1, Class 2 and Class 3 for the purpose of design to BS 5950 defined in **Section 4**.

NOTE See Section 4 for more details on the classification procedure and the description for each class.

1.3.3 Material performance requirements

Material performance requirements are the essential requirements for the mechanical, physical, dimensional and/or other relevant properties of alternative steel materials to ensure their adequacy to be used in the structural design based on BS 5950.

NOTE See Section 2 for more details on structural performance requirements.

1.3.4 Quality assurance requirements

Quality assurance requirements are the requirements for the manufacturers of alternative steel materials to provide adequate assurance on the nominal specifications of the materials, and are acceptable to BCA, to ensure their reliability to be used in the structural design based on BS 5950.

NOTE See Section 3 for more details on quality assurance requirements.

1.3.5 Certified steel materials

Certified steel materials are alternative steel materials which can be found in Singapore and manufactured to one of the five international standards, which are British/European (BS EN), American (API, ASTM and AWS), Japanese (JIS), Australian/New Zealand (AS/NZS and AS) and Chinese (GB) standards, with their nominal specifications already certified to be complying with the essential material performance requirements through rigorous evaluation.

Not all materials manufactured to the abovementioned five international standards are in the lists of certified steel materials (see **Appendix A**), but only those which meet the essential material performance requirements.

NOTE Certified steel materials still need to be classified accordingly (see Section 4).

1.3.6 Manufacturer

The term 'manufacturer' in this design guide shall refer to the manufacturer of steel materials.

1.3.7 Stockist

The term 'stockist' in this design guide shall refer to the supplier of steel materials who does not manufacture the steel materials, but only stocks and supplies the steel materials to the market.

1.3.8 Trader

The term 'trader' in this design guide shall refer to the supplier of steel materials who does not manufacture the steel materials, but only supplies the steel materials to the market.

1.3.9 Purchaser

The term 'purchaser' in this design guide shall refer to the purchaser of steel materials for design, fabrication and erection of steelwork.

1.3.10 Product

The term 'product' in this design guide shall refer to the steel material produced or manufactured by the 'manufacturer' defined in **1.3.6**.

1.3.11 Certification agency

The term 'certification agency' in this design guide shall refer to the independent third-party agency which carries out the duty of auditing the production control system of a manufacturer through necessary inspection, assessment and surveillance.

NOTE Attestation by a certification agency, acceptable to or recognised by BCA, is part of the quality assurance requirements (see Section 3).

1.4 Technical equations

Unless otherwise stated, the following technical equations apply throughout this design guide.

1.4.1 Carbon equivalent value

Carbon equivalent value as a measure of the weldability of steel materials shall be computed using the following equation.

$$\text{CEV}\ (\%) = \%\,\text{C} + \frac{\%\,\text{Mn}}{6} + \frac{\%\,\text{Cr} + \%\,\text{Mo} + \%\,\text{V}}{5} + \frac{\%\,\text{Cu} + \%\,\text{Ni}}{15}$$

1.4.2 Proportional gauge length

Proportional gauge length used in computing the elongation as a measure of the ductility of steel materials shall be computed using the following equation.

$$L_o = 5.65\sqrt{S_o}$$

Section 2
Material Performance Requirements

Alternative steel materials shall be manufactured to a national standard in the first place and they shall, at the same time, meet the relevant material performance requirements. The essential material performance requirements for various types of commonly available alternative steel materials are as given in **2.1**, **2.2**, **2.3**, **2.4**, **2.5**, **2.6**, **2.7**, **2.8** and **2.9**.

Project-specific (internal soundness and through thickness deformation properties, for examples) or other requirements given in BS 5950 but not covered by this design guide (surface and physical conditions, for examples) shall also be complied with.

2.1 Steel plates

This section covers hot-rolled uncoated steel plates with a minimum thickness of 3 mm, supplied flat or pre-curved in any shape as required. Steel for cold forming (see **2.4**) is not within the scope of this section.

NOTE References for material performance requirements in this section include, in alphanumerical order, BS 5950-1, BS 5950-2, BS EN 1993-1-12, BS EN 10025-1, BS EN 10025-2, BS EN 10025-3, BS EN 10025-4, BS EN 10025-5, BS EN 10025-6, BS EN 10029 and BS EN 10051.

2.1.1 Manufacturing process

Rimming steel shall not be allowed and the steel shall be at least semi-killed in the deoxidation process. The plates may be produced directly on reversing mill, by cutting from parent plates rolled on reversing mill or hot rolled wide strips. The plate edges may be as rolled or sheared, flame cut or chamfered.

The products may be supplied in as-rolled, normalized or quenched and tempered condition, or with controlled rolling (normalized rolling or thermo-mechanical rolling).

2.1.2 Mechanical properties

2.1.2.1 Strength

The nominal yield strength shall be in the range of 235 N/mm^2 to 690 N/mm^2. The nominal tensile strength shall be in the range of 300 N/mm^2 to 1000 N/mm^2.

2.1.2.2 Ductility

The elongation after fracture on proportional gauge length shall be at least 15 %, for nominal yield strength not greater than 460 N/mm^2; and shall be at least 10 % for nominal yield strength greater than 460 N/mm^2. The tensile strength to yield strength ratio shall be at least 1.2 based on nominal values, or at least 1.1 based on actual values, for nominal yield strength not greater than 460 N/mm^2.

NOTE Conversion of elongation values measured not based on proportional gauge length is necessary and shall be performed according to BS EN ISO 2566-1.

2.1.2.3 Impact toughness

As a minimum, the product shall be able to absorb at least 27 J of impact energy at 20 °C.

NOTE Depending on other factors including the thickness and minimum service temperature, the impact toughness should also conform to the appropriate requirements as given in BS 5950-1.

2.1.2.4 Through thickness deformation properties

Where appropriate, through thickness deformation properties shall be specified to guarantee adequate deformation capacity perpendicular to the surface to provide ductility and toughness against lamellar tearing.

NOTE Specification of through thickness deformation properties can be referred to BS EN 10164.

2.1.3 Chemical composition

In general, based on ladle analysis, carbon content shall not exceed 0.26 %; maximum CEV and content of impurities shall be in accordance with the requirements given in Table 1.

NOTE 1 Interpolation for maximum content shall be allowed for design strength not given in Table 1.

NOTE 2 Depending on the product thickness or variation in metallurgical process and intended use, the requirements for chemical composition might vary and shall be referred to BS EN 10025-1, BS EN 10025-2, BS EN 10025-3, BS EN 10025-4, BS EN 10025-5 and BS EN 10025-6.

Table 1 — Chemical composition requirements for steel plates based on ladle analysis

p_y (N/mm², based on t ≤ 16 mm)	Maximum content (% by mass)		
	CEV	P[a]	S
235	0.40	0.045	0.050
275	0.44	0.045	0.050
355	0.49	0.045	0.050
420	0.52	0.040	0.050
460	0.55	0.040	0.050
460[b]	0.50	0.040	0.040
550[b]	0.83	0.030	0.020
690[b]	0.83	0.030	0.020

a) For certain weathering steel, maximum phosphorous content shall be allowed up to 0.15 %.
b) For quenched and tempered steel only.

2.1.4 Dimensional and mass tolerances

2.1.4.1 Dimensions

In general, the deviation in actual thickness from nominal plate thickness shall not exceed the larger of ± 2 mm and ± 10 %.

2.1.4.2 Mass

In general, the deviation in actual mass from mass computed using a density of 7850 kg/m^3 shall be limited by the dimensional tolerances.

2.2 Hot rolled sections

This section covers hot rolled structural open sections including universal beams and columns, joists, channels, angles and T sections.

NOTE References for material performance requirements in this section include, in alphanumerical order, BS 5950-1, BS 5950-2, BS EN 10024, BS EN 10025-1, BS EN 10025-2, BS EN 10025-3, BS EN 10025-4, BS EN 10025-5, BS EN 10034, BS EN 10055, BS EN 10056-2, BS EN 10164 and BS EN 10279.

2.2.1 Manufacturing process

Rimming steel shall not be allowed and the steel shall be at least semi-killed in the deoxidation process.

T sections may be produced directly through hot rolling or by splitting the universal beams or columns.

The products may be supplied in as-rolled, normalized or quenched and tempered condition, or with controlled rolling (normalized rolling or thermo-mechanical rolling).

2.2.2 Mechanical properties

2.2.2.1 Strength

The nominal yield strength shall be in the range of 235 N/mm^2 to 460 N/mm^2. The nominal tensile strength shall be in the range of 300 N/mm^2 to 750 N/mm^2.

2.2.2.2 Ductility

The elongation after fracture on proportional gauge length shall be at least 15 %. The tensile strength to yield strength ratio shall be at least 1.2 based on nominal values, or at least 1.1 based on actual values.

NOTE Conversion of elongation values measured not based on proportional gauge length is necessary and shall be performed according to BS EN ISO 2566-1.

2.2.2.3 Impact toughness

As a minimum, the product shall be able to absorb at least 27 J of impact energy at 20 °C.

NOTE Depending on other factors including the thickness and minimum service temperature, the impact toughness should also conform to the appropriate requirements as given in BS 5950-1.

2.2.3 Chemical composition

In general, based on ladle analysis, carbon content shall not exceed 0.26 %; maximum CEV and content of impurities shall be in accordance with the requirements given in Table 2.

NOTE 1 Interpolation for maximum content shall be allowed for design strength not given in Table 2.

NOTE 2 Depending on the product thickness or variation in metallurgical process and intended use, the requirements for chemical composition might vary and shall be referred to BS EN 10025-1, BS EN 10025-2, BS EN 10025-3, BS EN 10025-4 and BS EN 10025-5.

Table 2 — Chemical composition requirements for hot rolled sections based on ladle analysis

p_y (N/mm^2, based on t ≤ 16 mm)	Maximum content (% by mass)		
	CEV	P[a]	S
235	0.40	0.045	0.045
275	0.44	0.045	0.045
355	0.49	0.045	0.045
420	0.52	0.040	0.040
460	0.55	0.040	0.040
a) For certain weathering steel, maximum phosphorous content shall be allowed up to 0.15 %.			

2.2.4 Dimensional and mass tolerances

2.2.4.1 Dimensions

In general, the deviation in the actual overall dimensions like section height, width and leg length shall not exceed the larger of ± 4 mm and ± 3 %; the deviation in the thicknesses of flange, web and leg shall not exceed the larger of ± 2 mm and ± 10 %.

2.2.4.2 Mass

In general, the deviation in actual mass from mass computed using a density of 7850 kg/m^3 shall not exceed ± 6 %, except for T sections where the deviation shall not exceed ± 8 %.

2.3 Hollow sections

This section covers both hot finished and cold-formed structural hollow sections of circular, square or rectangular forms. Hot finished elliptical hollow sections are also within the scope of this section.

NOTE References for material performance requirements in this section include, in alphanumerical order, BS 5950-1, BS 5950-2, BS 7668, BS EN 10210-1, BS EN 10210-2, BS EN 10219-1 and BS EN 10219-2.

2.3.1 Manufacturing process

Rimming steel shall not be allowed and the steel shall be at least semi-killed in the deoxidation process.

Quenched and tempered steel shall not be allowed.

Hollow sections shall be manufactured by a seamless or by a welding process.

Hot finished hollow sections may be formed hot, with or without subsequent heat treatment, or formed cold with subsequent heat treatment to attain the metallurgical conditions equivalent to those formed hot. Hot finished hollow sections may also be supplied in normalized condition or with normalized rolling.

Cold-formed hollow sections shall be formed cold without subsequent heat treatment except the weld seam may be in the as welded or heat treated condition. Cold-formed hollow sections may also be supplied in normalized condition or with controlled rolling (normalized rolling or thermo-mechanical rolling).

2.3.2 Mechanical properties

2.3.2.1 Strength

The nominal yield strength shall be in the range of 235 N/mm^2 to 460 N/mm^2. The nominal tensile strength shall be in the range of 300 N/mm^2 to 750 N/mm^2.

2.3.2.2 Ductility

The elongation after fracture on proportional gauge length shall be at least 15 %.

NOTE Conversion of elongation values measured not based on proportional gauge length is necessary and shall be performed according to BS EN ISO 2566-1.

2.3.2.3 Impact toughness

As a minimum, the product shall be able to absorb at least 27 J of impact energy at 20 °C.

NOTE Depending on other factors including the thickness and minimum service temperature, the impact toughness should also conform to the appropriate requirements as given in BS 5950-1.

2.3.3 Chemical composition

In general, based on ladle analysis, carbon content shall not exceed 0.24 %; maximum CEV and content of impurities shall be in accordance with the requirements given in Table 3 and Table 4.

NOTE 1 Interpolation for maximum content shall be allowed for design strength not given in Table 3 and Table 4.

NOTE 2 Depending on the product thickness or variation in metallurgical process and intended use, the requirements for chemical composition might vary and shall be referred to BS EN 10210-1 and BS EN 10219-1.

Table 3 — Chemical composition requirements for hot finished hollow sections based on ladle analysis

p_y (N/mm², based on t ≤ 16 mm)	Maximum content (% by mass)		
	CEV	P[a]	S
235	0.41	0.040	0.040
275	0.45	0.040	0.040
355	0.50	0.035	0.035
420	0.52	0.035	0.035
460	0.55	0.035	0.035
a) For certain weathering steel, maximum phosphorous content shall be allowed up to 0.15 %.			

Table 4 — Chemical composition requirements for cold-formed hollow sections based on ladle analysis

p_y (N/mm², based on t ≤ 16 mm)	Maximum content (% by mass)		
	CEV	P[a]	S
235	0.37	0.040	0.040
275	0.40	0.040	0.040
355	0.48[b]	0.035	0.035
420	0.50[b]	0.035	0.035
460	0.53[b]	0.035	0.035
a) For certain weathering steel, maximum phosphorous content shall be allowed up to 0.15 %. b) If thermo-mechanical rolling, which is recommended to lower the CEV, is introduced, the corresponding maximum CEV allowed shall be reduced by 10 %.			

2.3.4 Dimensional and mass tolerances

2.3.4.1 Dimensions

In general, the deviation in the actual overall dimensions like section height, width and diameter shall not exceed ± 2 %; the deviation in the wall thicknesses shall not exceed the larger of ± 2 mm and ± 10 %.

2.3.4.2 Mass

In general, the deviation in actual mass from mass computed using a density of 7850 kg/m^3 shall not exceed ± 6 %.

2.4 Steel for cold forming

This section covers steel flat products used for the manufacture of cold-formed open sections such as light-gauge lipped or plain channels and high strength galvanized purlins with a thickness, exclusive of coatings, of not more than 8 mm for use as structural members, and supplied in sheet, strip or coil. Cold-formed structural hollow sections (see **2.3**) and profiled steel sheets for composite slabs (see **2.8**) are not within the scope of this section.

NOTE References for material performance requirements in this section include, in alphanumerical order, BS 5950-5, BS 5950-7, BS EN 10025-2 and BS EN 10051.

2.4.1 Manufacturing process

The steel flat products for cold forming might be hot rolled, cold rolled or continuously hot-dip coated.

For hot rolled steel sheets, strips or coils, rimming steel shall not be allowed and the steel shall be at least semi-killed in the deoxidation process; the products may be supplied in as-rolled, normalized or with controlled rolling (normalized rolling or thermo-mechanical rolling).

For cold rolled steel sheets, strips or coils, low carbon steel shall not be allowed.

For coated steel sheets, strips or coils, low carbon steel shall not be allowed; the coatings might be zinc, zinc-iron alloy, zinc-aluminium alloy, aluminium-zinc alloy or aluminium-silicon alloy.

2.4.2 Mechanical properties

2.4.2.1 Strength

The nominal yield strength shall be in the range of 200 N/mm^2 to 550 N/mm^2. The nominal tensile strength shall be in the range of 250 N/mm^2 to 750 N/mm^2.

2.4.2.2 Ductility

The elongation after fracture on proportional gauge length shall be at least 15 %, for nominal yield strength not greater than 460 N/mm^2; and shall be at least 10 % for nominal yield strength greater than 460 N/mm^2.

NOTE Conversion of elongation values measured not based on proportional gauge length is necessary and shall be performed according to BS EN ISO 2566-1.

2.4.3 Chemical composition

In general, based on ladle analysis, carbon content shall not exceed 0.25 %, CEV shall not exceed 0.48 % and content of each phosphorous and sulphur shall not exceed 0.05 %. For special steel with high mechanical and/or plastic strain resistances, maximum phosphorous content shall be allowed up to 0.12 %.

NOTE Depending on the product thickness or variation in metallurgical process and intended use, the requirements for chemical composition might vary and shall be referred to BS EN 10025-2, BS EN 10149-2, BS EN 10149-3, BS EN 10268 and BS EN 10326.

2.4.4 Dimensional and mass tolerances

2.4.4.1 Dimensions

In general, the deviation in actual thickness from nominal plate thickness shall not exceed the larger of ± 0.3 mm and ± 10 %.

2.4.4.2 Mass

In general, the deviation in actual mass from mass computed using a density of 7850 kg/m^3 shall be limited by the dimensional tolerances.

2.5 Non-preloaded bolting assemblies

This section covers structural bolting assemblies, which include the ISO metric hexagon bolts with the matching nuts and washers, used for non-preloaded or bearing type bolted connections. Bolts with thread size in the range of 5 mm to 68 mm; plain washers with or without chamfer, are covered in this section.

NOTE References for material performance requirements in this section include, in alphanumerical order, BS 4190, BS 4320, BS 5950-1, BS 5950-2, BS EN 20898-2 (ISO 898-2), BS EN ISO 898-1, BS EN ISO 4014, BS EN ISO 4016, BS EN ISO 4017, BS EN ISO 4018, BS EN ISO 4032, BS EN ISO 4033, BS EN ISO 4034 and BS EN ISO 7091.

2.5.1 Manufacturing process

The bolts may be produced by cold forging or hot forging; alloying or quenching and tempering shall be allowed to achieve higher strength; free cutting steel may be allowed for lower grades of bolts.

The nuts may be produced by cold forging, hot forging or by turning from bar; alloying or quenching and tempering shall be allowed to achieve higher strength; free cutting steel may be allowed for lower grades of nuts.

The washers shall be made from mild steel.

2.5.2 Mechanical properties

2.5.2.1 Strength

For bolts, the nominal tensile strength shall be in the range of 300 N/mm^2 to 1200 N/mm^2; the recommended grades of non-preloaded bolts, and the corresponding nominal tensile and yield strengths, in accordance with the property class designation system of ISO 898-1 are given in Table 5.

NOTE The nominal strengths given in Table 5 shall not be used as the tension strength for design (see BS 5950-1).

Table 5 — Recommended grades of non-preloaded bolts

Grade of bolts	Nominal tensile strength (N/mm^2)	Nominal yield strength (N/mm^2)
4.6	400	240
8.8	800	640
10.9	1000	900

For nuts, the proof load stress shall be in the range of 400 N/mm^2 to 1200 N/mm^2; the recommended grades of nuts, and the corresponding proof load stress and the compatible grades of bolts, in accordance with the property class designation system of ISO 898-2 are given in Table 6.

NOTE Nuts of one class higher shall be used when overtapping of nut thread occurs due to the thick coating of bolts.

Table 6 — Recommended grades of nuts in non-preloaded assemblies

Grade of nuts	Proof load stress (N/mm^2)	Compatible bolt grades
4	400	≤ 4.8
8	800	≤ 8.8
10	1000	≤ 10.9

2.5.2.2 Ductility

For bolts, the elongation after fracture on proportional gauge length shall be at least 8 %; the reduction in area after fracture shall be at least 35 %.

2.5.2.3 Hardness

The bolts and nuts of recommended grades shall be able to meet the one of the three hardness ranges given in Table 7 and Table 8, respectively; whereas the Vickers hardness of the washers shall be in between 100 HV to 200 HV.

Table 7 — Hardness requirements for non-preloaded bolts

Grade of bolts	Range of hardness		
	Vickers hardness (HV)	Brinell hardness (HB)	Rockwell hardness (HRB or HRC)
4.6	120 – 220	114 – 209	67 – 95 (HRB)
8.8	250 – 335	238 – 318	22 – 34 (HRC)
10.9	320 – 380	304 – 361	32 – 39 (HRC)

Table 8 — Hardness requirements for nuts in non-preloaded assembly

Grade of nuts	Range of hardness		
	Vickers hardness (HV)	Brinell hardness (HB)	Rockwell hardness (HRC)
≤ 8	≤ 310	≤ 302	≤ 30
10	≤ 370	≤ 353	≤ 36
12	≤ 395	≤ 375	≤ 39

2.5.3 Chemical composition

For bolts, based on product analysis, carbon content shall not exceed 0.55 %; maximum content of impurities shall be in accordance with the requirements given in Table 9.

Table 9 — Chemical composition requirements for non-preloaded bolts based on product analysis

Grade of bolts	Maximum content (% by mass)	
	P	S
≤ 6.8[a]	0.050	0.060
≥ 8.8	0.050	0.060
a) Free cutting steel may be allowed for these grades with the following maximum contents – sulphur 0.34 %, phosphorous 0.11 % and lead 0.35 %.		

For nuts, based on product analysis, maximum content of carbon and impurities shall be in accordance with the requirements given in Table 9.

Table 10 — Chemical composition requirements for nuts in non-preloaded assemblies based on product analysis

Grade of nuts	Maximum content (% by mass)		
	C	P	S
≤ 6[a]	0.50	0.110	0.150
8	0.58	0.060	0.150
10 and 12	0.58	0.048	0.058
a) Free cutting steel may be allowed for these grades with the following maximum contents – sulphur 0.34 % and lead 0.35 %.			

2.5.4 Dimensional tolerances

As a minimum, dimensional tolerances shall be in accordance with the corresponding standards which the bolts, nuts and washers are manufactured to.

2.6 Preloaded bolting assemblies

This section covers structural bolting assemblies, which include the ISO metric hexagon bolts with the matching nuts and washers, used for preloaded or non-slip bolted connections. Bolts with thread size in the range of 12 mm to 36 mm; plain washers with or without chamfer and tension indicating washers, are covered in this section.

NOTE References for material performance requirements in this section include, in alphanumerical order, BS 4395-1, BS 4395-2, BS 4604-1, BS 4604-2, BS 5950-1, BS 5950-2, BS 7644-1, BS 7644-2, BS EN 14399-1, BS EN 14399-2, BS EN 14399-3, BS EN 14399-4, BS EN 14399-5, BS EN 14399-6, BS EN 20898-2 (ISO 898-2) and BS EN ISO 898-1.

2.6.1 Manufacturing process

The bolts shall be heat-treated under uniform conditions, and hardened by quenching and tempering.

The nuts shall be heat-treated under uniform conditions, and hardened by quenching and tempering; free cutting steel shall not be allowed.

The washers shall be hardened by quenching and tempering.

2.6.2 Mechanical properties

2.6.2.1 Strength

For bolts, the nominal tensile strength shall be in the range of 800 N/mm^2 to 1200 N/mm^2; the recommended grades of preloaded bolts, and the corresponding nominal tensile and yield strengths, in accordance with the property class designation system of ISO 898-1 are given in Table 11.

NOTE The nominal strengths given in Table 5 shall not be used as the tension strength for design (see BS 5950-1).

Table 11 — Recommended grades of preloaded bolts

Grade of bolts	Nominal tensile strength (N/mm^2)	Nominal yield strength (N/mm^2)
8.8	800	640
10.9	1000	900

For nuts, the proof load stress shall be in the range of 800 N/mm^2 to 1200 N/mm^2; the recommended grades of nuts, and the corresponding proof load stress and the compatible grades of bolts, in accordance with the property class designation system of ISO 898-2 are given in Table 12.

NOTE Nuts of one class higher shall be used when overtapping of nut thread occurs due to the thick coating of bolts.

Table 12 — Recommended grades of nuts in preloaded assemblies

Grade of nuts	Proof load stress (N/mm^2)	Compatible bolt grades
8	800	8.8 or lower
10	1000	10.9 or lower

2.6.2.2 Ductility

For bolts, the elongation after fracture on proportional gauge length shall be at least 8 %.

2.6.2.3 Hardness

The bolts and nuts of recommended grades shall be able to meet the one of the three hardness ranges given in Table 13 and Table 14, respectively; whereas for the washers, either the Vickers hardness shall be in between 300 HV to 370 HV or the Rockwell hardness shall be in between 38 HRC to 45 HRC.

Table 13 — Hardness requirements for preloaded bolts

Grade of bolts	Range of hardness		
	Vickers hardness (HV)	Brinell hardness (HB)	Rockwell hardness (HRC)
8.8	250 – 335	238 – 318	22 – 34
10.9	320 – 380	304 – 361	32 – 39

Table 14 — Hardness requirements for nuts in preloaded assemblies

Grade of nuts	Range of hardness		
	Vickers hardness (HV)	Brinell hardness (HB)	Rockwell hardness
8	175 – 310	166 – 302	88 HRB – 30 HRC
10	258 – 370	248 – 353	24 HRC – 36 HRC
12	≤ 395	≤ 375	≤ 39 HRC

2.6.3 Chemical composition

For bolts, based on product analysis, carbon content shall not exceed 0.55 %; the maximum content of sulphur and phosphorus shall not exceed 0.06 % each.

For nuts, based on product analysis, maximum content of carbon and impurities shall be in accordance with the requirements given in Table 15.

Table 15 — Chemical composition requirements for nuts in preloaded assemblies based on product analysis

Grade of nuts	Maximum content (% by mass)		
	C	P	S
8	0.58	0.060	0.150
10 and 12	0.58	0.050	0.060

2.6.4 Dimensional tolerances

As a minimum, dimensional tolerances shall be in accordance with the corresponding standards which the bolts, nuts and washers are manufactured to.

2.7 Welding consumables

This section covers welding consumables, including electrodes, wires, rods and fluxes, used in arc welding.

NOTE References for material performance requirements in this section include, in alphanumerical order, BS 5950-1, BS 5950-2, BS EN 440, BS EN 756, BS EN 758, BS EN 1597-1, BS EN 1668 and BS EN ISO 2560.

2.7.1 Mechanical properties

The mechanical properties of the all-weld metal shall be obtained through multi run technique.

NOTE Multi run technique shall be referred to BS EN 1597-1 or equivalent.

2.7.1.1 Strength

The nominal yield strength of the all-weld metal shall be in the range of 355 N/mm^2 to 690 N/mm^2.

2.7.1.2 Ductility

The elongation after fracture of the all-weld metal on proportional gauge length of 5 times the specimen diameter shall be at least 15 %.

NOTE Conversion of elongation values measured not based on proportional gauge length is necessary and shall be performed according to BS EN ISO 2566-1.

2.7.1.3 Impact toughness

As a minimum, the all-weld metal shall be able to absorb at least 27 J of impact energy at 20 °C.

NOTE Depending on other factors including the thickness and minimum service temperature, the impact toughness should also conform to the appropriate requirements as given in BS 5950-1.

2.8 Profiled steel sheets

This section covers profiled steel sheets with a thickness, exclusive of coatings, in the range of 0.7 mm to 5.0 mm for use in composite slabs through composite action.

NOTE References for material performance requirements in this section include, in alphanumerical order, BS 5950-4, BS 5950-6, BS 5950-7, BS EN 10143 and BS EN 10326.

2.8.1 Manufacturing process

The profiled steel sheets shall be continuously hot-dip zinc-coated with structural quality.

2.8.2 Mechanical properties

2.8.2.1 Strength

The nominal yield strength shall be in the range of 220 N/mm^2 to 550 N/mm^2. The nominal tensile strength shall be in the range of 275 N/mm^2 to 600 N/mm^2.

2.8.3 Chemical composition

In general, based on ladle analysis, carbon content shall not exceed 0.25 % and content of each phosphorous and sulphur shall not exceed 0.12 % and 0.05 %, respectively.

2.8.4 Dimensional and mass tolerances

2.8.4.1 Dimensions

In general, the deviation in actual thickness from nominal plate thickness shall not exceed the larger of ± 0.1 mm and ± 10 %.

2.8.4.2 Mass

In general, the deviation in actual mass from mass computed using a density of 7850 kg/m^3 shall be limited by the dimensional tolerances.

2.9 Stud shear connectors

This section covers headed stud shear connectors used in transmitting the longitudinal shear between concrete and steel in composite beams and slabs. The shank diameter shall be in the range of 10 mm to 25 mm. The head diameter shall be at least 1.5 times the shank diameter; whereas the head depth shall be at least 0.4 times the shank diameter.

NOTE References for material performance requirements in this section include, in alphanumerical order, BS 5950-3.1 and BS EN ISO 13918.

2.9.1 Manufacturing process

The stud shear connectors shall be made from mild steel or stainless steel.

2.9.2 Mechanical properties

2.9.2.1 Strength

The nominal tensile strength shall be at least 400 N/mm^2.

2.9.2.2 Ductility

The elongation after fracture on proportional gauge length shall be at least 14 %.

NOTE Conversion of elongation values measured not based on proportional gauge length is necessary and shall be performed according to BS EN ISO 2566-1.

2.9.3 Dimensional tolerances

As a minimum, dimensional tolerances shall be in accordance with the corresponding standards which the shear connectors are manufactured to.

Section 3
Quality Assurance requirements

The actual performance and compliance of the alternative steel materials with the nominal specifications stipulated in their respective national standards and material performance requirements from **Section 2** shall be substantiated by a quality assurance system acceptable to BCA.

A manufacturer with an acceptable quality assurance system shall establish a production control system attested with a certificate issued by a certification agency (see **3.1**) and shall provide sufficient guarantee to the purchasers with appropriate test certificates (see **3.2**).

3.1 Factory production control

The manufacturer shall establish, document and maintain a factory production control (FPC) system to ensure the conformity of the products to the nominal specifications.

Such system shall consist of written procedures, regular inspections and tests and/or assessments and the use of the results to control feedstock materials, equipment, personnel, the production process and the products, in accordance with the relevant performance requirements (see **Section 2**).

As a minimum, the production control system shall meet the requirements in **3.1.1**, **3.1.2**, **3.1.3**, **3.1.4**, **3.1.5** and **3.1.6** through attestation by an independent third-party certification agency acceptable to or recognised by BCA on the basis of; first, initial inspection on the system after receiving and analyzing the complete set of manuals of production control system submitted by the manufacturers; second, continuous surveillance and assessment of the production control system through inspection carried out at least once a year.

Certificates of factory production control system, issued by the independent third-party certification agencies acceptable to or recognised by BCA, shall form the acceptable indicator for an attested factory production control system.

3.1.1 Feedstock materials

The source of feedstock and/or raw materials shall be well-documented for a period of at least 7 years to ensure the full traceability of the products.

The specifications of all incoming feedstock and/or raw materials and the relevant inspection scheme to ensure their conformity shall be documented in accordance with the manufacturer's written procedures.

3.1.2 Equipment

All equipment used in the manufacturing process shall be regularly inspected and maintained to ensure consistency in the manufacturing process and the product quality; all weighing, measuring and testing equipment for quality control shall be in accordance with the standards listed in **Appendix B** or the equivalent standards, regularly inspected and calibrated to ensure the reliability and accuracy of results.

Such inspections, maintenances and calibrations shall be carried out and documented in accordance with the manufacturer's written procedures.

3.1.3 Personnel

Qualifications of personnel involved in NDT, process affecting product quality and conformity, based on relevant education, training, skills and experience, shall be assessed and documented in the manufacturer's written procedures.

The responsibilities of personnel managing, performing or verifying work affecting product quality and conformity, and their inter-relationship, shall be clearly defined.

3.1.4 Product testing

The manufacturer shall establish testing procedures to ensure conformity of the products to the nominal specifications. The testing shall be performed in accordance with the standards listed in **Appendix B** or the equivalent standards.

3.1.4.1 Initial type testing

Initial type testing shall be carried out under the sole responsibility of the manufacturer before the products are made available in the market and upon the introduction of changes to the manufacturing process which may affect the product characteristics. As a minimum, the initial type testing shall include the experimental and/or theoretical evaluation of the product characteristics corresponding to the relevant performance requirements (see **Section 2**).

3.1.4.2 Routine testing

Routine testing shall be carried out by the manufacturer in accordance with the manufacturer's written procedures.

3.1.4.3 Specific testing

Specific testing, upon request at the time of order, shall be carried out by authorised inspection representative independent of the manufacturing department prior to delivery to ensure the products to be supplied conform to the nominal specifications and additional requirements made at the time of order.

3.1.5 Product marking

The products shall be properly marked using methods like painting, stamping, laser marking, bar coding, durable adhesive labels or attached tags with the product specifications, particulars of manufacturer and any other essential information. Information corresponding to the relevant material performance requirements given in **Section 2** and **Appendix B** shall be attached in the form of test certificates (see **3.2**).

For bolts to be used for structural purpose, every individual bolt must be properly marked to clearly indicate the grade.

3.1.6 Non-conforming products

The manufacturer shall establish appropriate actions to be taken against products not conforming to the nominal specifications. Occurrence of such non-conformity shall be documented in accordance with the manufacturer's written procedures.

3.2 Manufacturer test certificates

Testing, including inspections, conducted by the manufacturers shall be substantiated by test certificates. As a minimum, a department independent from the production department, within the manufacturer's organization, shall conduct the testing. Upon the request of the purchasers or BCA, certificates issued by an independent third party inspection agency shall also be produced. As a minimum, the manufacturers shall provide quality assurance with manufacturer test certificates containing information given in **3.2.1**, **3.2.2**, **3.2.3**, **3.2.4**, **3.2.5** and **3.2.6**.

3.2.1 Information of manufacturer

The manufacturer's name, contact information and company registration number shall be indicated clearly in the test certificate.

3.2.2 Reference details

The number of purchase order, reference number and date of issue shall be indicated clearly in the test certificate.

3.2.3 Material specifications

The number of material standard including the standard for dimension and tolerance, and the grade, name or code of material supplied, and/or other useful information about the material supplied, shall be indicated clearly in the test certificate.

3.2.4 Information for traceability

The heat number, batch number of the feedstock materials and the quantity of the steel materials actually supplied to the purchaser shall be indicated clearly in the test certificate.

3.2.5 Test results

The test results, which are corresponding and conforming to the relevant material performance requirements (see **Section 2** and **Appendix B**), shall be indicated clearly in the test certificate. Use of the test results of feedstock materials shall be clearly indicated, if any.

3.2.6 Authentication

The test certificate shall be authenticated with the manufacturer's company stamp, and by the stockist or trader, if appropriate.

Section 4

Classification of Alternative Steel Materials

Section 4 Classification of alternative steel materials

Classification of alternative steel materials is necessary to determine whether these materials shall be allowed in the structural design based on BS 5950 with or without any restriction. The adequacy and reliability of alternative steel materials shall be verified against the material performance requirements (see **Section 2**) as well as the quality assurance requirements (see **Section 3**), respectively, in the entire process of classification.

4.1 Adequacy assessment

The adequacy of alternative steel materials shall be verified against the material performance requirements. Certification and material testing are the two possible methods to verify the adequacy of alternative steel materials.

4.1.1 Certification

Certification is the process of rigorous evaluation of the specifications given in the British/European, American, Japanese, Australian/New Zealand and Chinese material standards, against the essential material performance requirements. The purpose of certification is to derive lists of certified steel materials as defined in **1.3.5**. Only those materials with their specifications complying with the relevant material performance requirements are included in the lists.

4.1.2 Material testing

Material testing is the process of demonstrating the adequacy of non-certified steel materials, during the design stage prior to material procurement, through appropriate material sampling and test methods as given in **Appendix B**.

NOTE Material testing for the purpose of adequacy assessment during the design stage shall not exempt the end purchasers from performing the obligatory inspection and testing in accordance with appropriate regulations during procurement and execution.

4.2 Reliability assessment

The reliability of alternative steel materials shall be verified against the quality assurance requirements. Two types of certificates are required to verify the reliability of alternative steel materials. Failure of the manufacturer to produce either one of the certificates given in **4.2.1** or **4.2.2** is considered not meeting the quality assurance requirements.

4.2.1 Factory production control certificates

The manufacturer shall produce a factory production control (FPC) certificate issued by an independent third-party certification agency acceptable to or recognised by BCA as an attestation of the factory production control system in meeting the requirements given in **3.1**.

The purchaser shall obtain a validated copy of such certificate directly from the manufacturer or through the stockist or trader.

4.2.2 Manufacturer test certificates

The manufacturer shall produce an authenticated test certificate (see **3.2**) as an additional layer of quality assurance on the alternative steel materials delivered.

The purchaser shall obtain such certificate directly from the manufacturer or a validated copy of such certificate through the stockist or trader. In both cases, the quantity of steel materials actually supplied to the purchaser shall be clearly indicated.

4.3 Classification procedure

The complete classification procedure of alternative steel materials shall follow the flow represented by the overall framework shown in Figure 1.

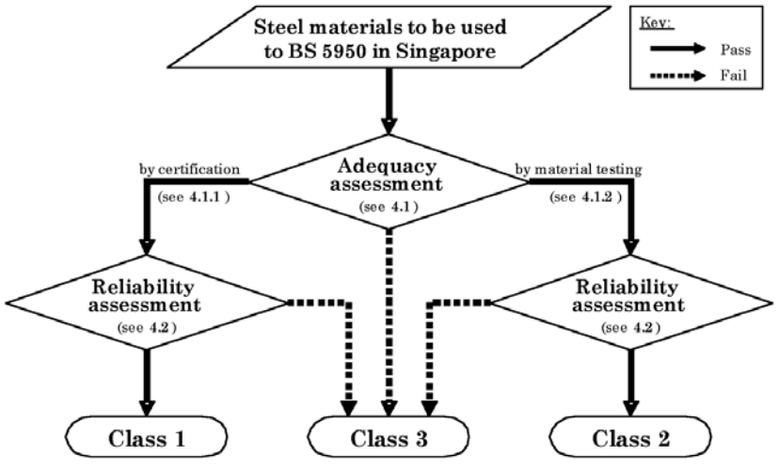

Figure 1 — Overall framework for classification of alternative steel materials

Alternative steel materials shall be classified based on the verification against material performance requirements and quality assurance requirements, see Figure 1, into three classes – Class 1, Class 2 and Class 3, as defined in **4.3.1**, **4.3.2** and **4.3.3**.

4.3.1 Class 1 alternative steel materials

Class 1 alternative steel materials are certified steel materials manufactured with approved quality assurance.

NOTE Only materials in the list of certified materials can be qualified as Class 1 alternative steel materials, depending on the quality assurance provided by the manufacturers.

4.3.2 Class 2 alternative steel materials

Class 2 alternative steel materials are non-certified steel materials which meet the material performance requirements through material testing, and are manufactured with approved quality assurance.

NOTE Materials not in the list of certified materials can only be qualified as Class 2 alternative steel materials, depending on the quality assurance provided by the manufacturers.

4.3.3 Class 3 alternative steel materials

Class 3 alternative steel materials are steel materials which do not meet at least one of the two requirements – material performance requirements and quality assurance requirements.

4.4 Special case

As an alternative to **4.3** and on a case-by-case basis subject to approval by BCA, the steel material may be treated as Class 2 status if its adequacy and reliability can be guaranteed through rigorous material control and testing plans on site. As a minimum, such written plan should comprise at least 100% visual inspection and non-destructive testing for delivery conditions and dimensional control, 100% material testing for all batches and/or heat numbers (see **Appendix B**) by a SINGLAS accredited laboratory or other laboratory accredited under a mutual recognition agreement with SINGLAS and a material compliance report from an independent expert consultant.

Section 5
Design recommendations

Section 5 Design recommendations

This section covers the design recommendations on the use of three different classes of alternative steel materials, as defined in **4.3.1**, **4.3.2** and **4.3.3**, to BS 5950. The major design parameters and equations are given in **5.1**, **5.2** and **5.3** whereas other properties which are common to all three classes of alternative steel materials are given in **5.4**.

5.1 Design recommendations on Class 1 alternative steel materials

This section covers the design guide on Class 1 alternative steel materials, which are in the lists of certified steel materials in **Appendix A** and are in compliance with the quality assurance requirements (see **Section 3**).

5.1.1 Class 1 structural steel

This section covers the design strength of Class 1 steel plates, hot rolled sections, hollow sections and steel for cold forming.

The design strength p_y of Class 1 structural steel shall be computed using the following equation.

Design strength:

$$p_y = \frac{Y_s}{1.0} \leq \frac{U_s}{1.2} \text{ or } 460\,\text{N/mm}^2;$$

or $p_y = \frac{Y_s}{1.0} \leq 690\,\text{N/mm}^2$ for steel plates with nominal yield strength of at least 460 N/mm^2, where plastic design shall not be allowed.

The design strengths corresponding to different steel grades are given in Table 16, Table 17, Table 18, Table 19 and Table 20.

NOTE For rolled sections, the specified thickness of the thickest element of the cross-section shall be used.

Table 16 — Design strengths of British/European (BS EN) structural steels

Grade	Design strength p_y (N/mm^2), for thickness (mm) less than or equal to					
	16	**40**	**63**	**80**	**100**	**150**
S235	235	225	215	215	215	195
S275	275	265	255	245	235	225
S355	355	345	335	325	315	295
S420	420	400	390	370	360	340
S460	460	440	430	410	400	380
S460[a]	460	460	440	440	440	400
S500[a]	500	500	480	480	480	440
S550[a]	550	550	530	530	530	490
S620[a]	620	620	580	580	580	560
S690[a]	690	690	650	650	650	630
a) Quenched and tempered steel only, plastic design shall not be allowed.						

Table 17 — Design strengths of American (ASTM and API) structural steels

Designation	Grade in metric [imperial]	Design strength p_y (N/mm²), for thickness (mm) less than or equal to						
		20	32	40	50	65	80	100
ASTM structural steels								
A 36	250 [36]	250	250	240	240	230	220	210
A 242	345 [50]	345	345	335	335	325	315	305
A 501	345 [50]	345	345	335	335	325	315	-
A 572	290 [42]	290	290	280	280	270	260	250
	345 [50]	345	345	335	335	325	315	305
	380 [55]	380	380	370	370	-	-	-
	415 [60]	415	415	-	-	-	-	-
	450 [65]	450	450	-	-	-	-	-
A 588	345 [50]	345	345	335	335	325	315	305
A 709	250 [36]	250	250	240	240	230	220	210
	345 [50]	345	345	335	335	325	315	305
	485 [70][a]	485	485	475	475	465	455	455
	690 [100][a]	690	690	680	680	670	660	650
A 792	230 [33]	230	-	-	-	-	-	-
A 852	485 [70][a]	485	485	475	475	465	455	445
A 875	230 [33]	230	-	-	-	-	-	-
	255 [37]	255	-	-	-	-	-	-
	275 [40]	275	-	-	-	-	-	-
	345 [50]	345	-	-	-	-	-	-
	410 [60]	410	-	-	-	-	-	-
A 913	345 [50]	345	345	335	335	325	315	305
	415 [60]	415	415	405	405	395	385	375
	450 [65]	450	450	440	440	430	420	410
A 945	345 [50]	345	345	335	335	-	-	-
	450 [65]	450	450	440	440	430	-	-
A 992	345 [50]	345	345	335	335	325	315	305

Designation	Grade in metric [imperial]	Design strength p_y (N/mm²), for thickness (mm) less than or equal to						
		20	32	40	50	65	80	100
A 1008	205 [30]	205	-	-	-	-	-	-
	210 [31]	210	-	-	-	-	-	-
	230 [33]	230	-	-	-	-	-	-
	240 [35]	240	-	-	-	-	-	-
	310 [45]	310	-	-	-	-	-	-
	340 [50]	340	-	-	-	-	-	-
	410 [60]	410	-	-	-	-	-	-
A 1011	205 [30]	205	-	-	-	-	-	-
	230 [33]	230	-	-	-	-	-	-
	250 [36]	250	-	-	-	-	-	-
	310 [45]	310	-	-	-	-	-	-
	340 [50]	340	-	-	-	-	-	-
API line pipes								
API 5L (PSL 2)	Grade B	241	241	231	-	-	-	-
	Grade X42	290	290	280	-	-	-	-
	Grade X46	317	317	307	-	-	-	-
	Grade X52	359	359	349	-	-	-	-
	Grade X56	386	386	376	-	-	-	-
	Grade X60	414	414	404	-	-	-	-
	Grade X65	448	448	438	-	-	-	-
a) For steel plates only, plastic design shall not be allowed.								

Table 18 — Design strengths of Japanese (JIS) structural steels

Grade	Design strength p_y (N/mm²), for thickness (mm) less than or equal to					
	16	40	75	100	160	200
SM 490A, B	325	315	295	295	285	275
SM 490C	325	315	295	295	-	-
SM 490YA,YB	365	355	335	325	-	-
SM 520B, C	365	355	335	325	-	-
SM 570	460	450	430	420	-	-
SMA 490BW,BP	365	355	335	325	305	295

Grade	Design strength p_y (N/mm²), for thickness (mm) less than or equal to					
	16	40	75	100	160	200
SMA 490CW, CP	365	355	335	325	-	-
SMA 570W	460	450	430	420	-	-
SN 400 B, C	235	235	215	215	-	-
SN 490 B, C	325	325	295	295	-	-
SSC 400	245	-	-	-	-	-

Table 19 — Design strengths of Australian/New Zealand (AS/NZS) structural steels

Grade	Design strength p_y (N/mm²), for thickness (mm) less than or equal to						
	8	12	20	32	50	80	150
3678-250-L15	250	250	250	250	250	240	240
3678-300-L15	300	300	300	280	280	280	280
3678-350-L15	350	350	350	340	340	340	330
3678-400-L15	400	400	380	360	360	360	-
3678-450-L15	450	450	450	420	400	-	-
3679-250	250	250	250	250	230	-	-
3679-350	350	340	340	340	330	-	-
3679-400	400	400	380	380	-	-	-
1163-C250	250	250	-	-	-	-	-
1163-C275	275	275	-	-	-	-	-
1163-C300	300	300	-	-	-	-	-
1163-C350	350	350	-	-	-	-	-
1163-C400	400	400	-	-	-	-	-
1163-C450	450	450	-	-	-	-	-
1397-G250	250	-	-	-	-	-	-
1397-G300	300	-	-	-	-	-	-
1397-G350	350	-	-	-	-	-	-
1397-G450	450	-	-	-	-	-	-
1397-G500	500	-	-	-	-	-	-
1397-G550	550	-	-	-	-	-	-
1595-C220	210	-	-	-	-	-	-
1595-C260	250	-	-	-	-	-	-
1595-C350	350	-	-	-	-	-	-

Table 20 — Design strengths of Chinese (GB) structural steels

Grade	Design strength p_y (N/mm²), for thickness (mm) less than or equal to				
	16	35	50	100	150
Q235	235	225	215	215	195
Q275	275	265	255	245	225
Q295	295	275	255	235	-
Q345[a]	345	325	295	275	-
Q345[b]	325	315	305	-	-
Q355[c]	355	345	335	325	-
Q390	390	370	350	330	-
Q420	420	400	380	360	-
Q460	460	440	420	400	-

a) Not applicable to Q345 for seamless hollow sections manufactured to GB/T 8162.

b) Only applicable to Q345 for seamless hollow sections manufactured to GB/T 8162.

c) Only applicable to weathering steel Q355NH manufactured to GB/T 4172.

5.1.2 Class 1 non-preloaded bolted connections

This section covers the design strengths of Class 1 non-preloaded bolts and the recommended combinations of matching components in non-preloaded bolting assemblies.

The design strengths corresponding to different bolt grades are given in Table 21, Table 22, Table 23, Table 24 and Table 25.

Table 21 — Design strengths of British/European (BS EN) non-preloaded bolts

Grade	Shear strength p_s (N/mm²)	Bearing strength p_{bb} (N/mm²)	Tension strength p_t (N/mm²)
4.6	160	460	240
8.8	375	1000	560
10.9	400	1300	700

NOTE The design shear strength p_s, bearing strength p_{bb} and tension strength p_t is taken as $0.4U_b$, $0.7(U_b + Y_b)$ and $0.7U_b$ respectively, where U_b and Y_b are the minimum tensile and yield strength of the bolt material.

Table 22 — Design strengths of American (ASTM) non-preloaded bolts

Grade	Shear strength p_s (N/mm²)	Bearing strength p_{bb} (N/mm²)	Tension strength p_t (N/mm²)
ASTM A 307 Grade B	165	289	289
ASTM A 325	290	899	507
ASTM A 449	248	714	434
ASTM A 490	416	1386	728

Table 23 — Design strengths of Japanese (JIS) non-preloaded bolts

Grade	Shear strength p_s (N/mm²)	Bearing strength p_{bb} (N/mm²)	Tension strength p_t (N/mm²)
3.6	120	336	210
4.6, 4.8	160	448	280
5.6, 5.8	200	560	350
6.8	240	756	420
8.8	320	1008	560
9.8	360	1134	630
10.9	400	1330	700
12.9	480	1596	840

Table 24 — Design strengths of Australian/New Zealand (AS) non-preloaded bolts

Grade	Shear strength p_s (N/mm²)	Bearing strength p_{bb} (N/mm²)	Tension strength p_t (N/mm²)
3.6	120	336	210
4.8	160	504	280
5.8	200	630	350
6.8	240	756	420
8.8	320	1008	560
10.8	400	1260	700

Table 25 — Design strengths of Chinese (GB) non-preloaded bolts

Grade	Shear strength p_s (N/mm²)	Bearing strength p_{bb} (N/mm²)	Tension strength p_t (N/mm²)
4.6	125	320	200
8.8	250	720	400
10.9	310	930	500

The recommended combinations of matching components in non-preloaded bolting assemblies are given in Table 26, Table 27, Table 28, Table 29 and Table 30.

Table 26 — Recommended combinations of British/European (BS EN) non-preloaded bolting assemblies

Grade of bolt	Grade of nut	Grade of washer
4.6	4 for $d >$ M16; 5 for $d \leq$ M16	100 HV
8.8	8; 10 for overtapped nut thread	
10.9	10; 12 for overtapped nut thread	

Table 27 — Recommended combinations of American (ASTM) non-preloaded bolting assemblies

Grade of bolt	Class of nut	Grade of washer
ASTM A 307 Grade B	4 to 10, 12, 16	Type 1 and Type 3
ASTM A 325	8S, 8S3, 10S (ASTM A 563)	
ASTM A 449	8S, 9 to 12 (ASTM A 563)	
ASTM A 490	8S, 10 to 12 (ASTM A 563)	

Table 28 — Recommended combinations of Japanese (JIS) non-preloaded bolting assemblies

Grade of bolt	Class of nut		Grade of washer
	Style 1	Style 2	
3.6, 4.6, 4.8 for $d >$ M16	1 for $d >$ M16	-	Product Grade A and C
3.6, 4.6, 4.8 for $d \leq$ M16	5 for $d \leq$ M39	-	
5.6, 5.8 for $d \leq$ M39	5 for $d \leq$ M39	-	
6.8 for $d \leq$ M39	6 for $d \leq$ M39	-	
8.8 for $d \leq$ M39	8 for $d \leq$ M39	8 for $d >$ M16; 8 for $d \leq$ M39	
9.8 for $d \leq$ M16	-	9 for $d \leq$ M16	
10.9 for $d \leq$ M39	10 for $d \leq$ M39	-	
12.9 for $d \leq$ M39	12 for $d \leq$ M16	12 for $d \leq$ M39	

Table 29 — Recommended combinations of Australian/New Zealand (AS/NZS) non-preloaded bolting assemblies

Grade of bolt	Class of nut	Grade of washer
3.6	4	AS/NZS 1252
4.8	4	
5.8	5	
6.8	6	
8.8	8	
10.8	10	

Table 30 — Recommended combinations of Chinese (GB) non-preloaded bolting assemblies

Grade of bolt	Grade of nut	Grade of washer
4.6	4 for $d >$ M16; 5 for $d \leq$ M16	100 HV
8.8	8; 10 for overtapped nut thread	
10.9	10; 12 for overtapped nut thread	

5.1.3 Class 1 preloaded bolted connections

This section covers the design strengths of Class 1 preloaded bolts and the recommended combinations of matching components in preloaded bolting assemblies.

The design strengths corresponding to different bolt grades are given in Table 31, Table 32, Table 33, Table 34 and Table 35.

Table 31 — Design strengths of British/European (BS EN) preloaded bolts

Grade	Shear strength p_s (N/mm²)	Tension strength p_t (N/mm²)
8.8	375	560
10.9	400	700

NOTE The design shear strength p_s and tension strength p_t is taken as $0.4U_b$ and $0.7U_b$ respectively, where U_b and Y_b are the minimum tensile and yield strength of the bolt material.

Table 32 — Design strengths of American (ASTM) preloaded bolts

Grade	Shear strength p_s (N/mm²)	Tension strength p_t (N/mm²)
ASTM A 354 Grade BC	344 for $d \leq 62.5$ mm; 316 for $d > 62.5$ mm	603 for $d \leq 62.5$ mm; 555 for $d > 62.5$ mm
ASTM A 354 Grade BD	413 for $d \leq 62.5$ mm; 386 for $d > 62.5$ mm	723 for $d \leq 62.5$ mm; 675 for $d > 62.5$ mm
ASTM A 325 Type 1	290	507
ASTM A 490	416	728

Table 33 — Design strengths of Japanese (JIS) preloaded bolts

Grade	Shear strength p_s (N/mm²)	Tension strength p_t (N/mm²)
F8T	387	571
F10T	484	713
F11T	532	785

Table 34 — Design strengths of Australian/New Zealand (AS) preloaded bolts

Grade	Shear strength p_s (N/mm²)	Tension strength p_t (N/mm²)
8.8	320	560
10.9	400	700
12.9	480	840

Table 35 — Design strengths of Chinese (GB) preloaded bolts

Grade	Shear strength p_s (N/mm²)	Tension strength p_t (N/mm²)
8.8	250	400
10.9	310	500

The recommended combinations of matching components in preloaded bolting assemblies are given in Table 36, Table 37, Table 38, Table 39 and Table 40.

Table 36 — Recommended combinations of British/European (BS EN) preloaded bolting assemblies

Grade of bolt	Grade of nut	Grade of washer
8.8	8	300 – 370 HV
10.9	10	

Table 37 — Recommended combinations of American (ASTM) preloaded bolting assemblies

Grade of bolt	Grade of nut	Grade of washer
All	Class 8S3-C or 8S3-D	(F436) Type 1 or Type 3

Table 38 — Recommended combinations of Japanese (JIS) preloaded bolting assemblies

Grade of bolt	Grade of nut	Grade of washer
F8T (Class 1 set)	F10	F35
F10T (Class 2 set)		
F11T (Class 3 set)		

Table 39 — Recommended combinations of Australian/New Zealand (AS/NZS) preloaded bolting assemblies

Grade of bolt	Grade of nut	Grade of washer
8.8	8	AS/NZS 1252
10.9	10	
12.9	12	

Table 40 — Recommended combinations of Chinese (GB) preloaded bolting assemblies

Grade of bolt	Grade of nut	Grade of washer
8.8S[a]	8H	35 – 45 HRC
10.9S[a]	10H	
a) Equivalent to grades 8.8 and 10.9 in Table 31.		

5.1.4 Class 1 fillet welds

This section covers the design strength fillet welds made of Class 1 welding consumables.

The design strengths of fillet welds corresponding to different welding consumable grades are given in Table 41, Table 42, Table 43, Table 44 and Table 45.

Table 41 — Design strengths of fillet weld made of British/European (BS EN) welding consumables

Grade	Tensile strength U_e (N/mm²)	Design strength p_w (N/mm²)
35	440	$0.50U_e \leq 0.55U_s$ U_s = tensile strength of parent metal
38	470	
42	500	
46	530	
50	560	

Table 42 — Design strengths of fillet weld made of American (AWS) welding consumables

Grade	Tensile strength U_e (N/mm²)	Design strength p_w (N/mm²)
E49xx	490	245

Table 43 — Design strengths of fillet weld made of Japanese (JIS) welding consumables

Grade	Tensile strength U_e (N/mm²)	Design strength p_w (N/mm²)
D43xx	450	225
D50xx	510	255
D53xx	600	300

Table 44 — Design strengths of fillet weld made of Australian/New Zealand (AS) welding consumables

Grade	Tensile strength U_e (N/mm²)	Design strength p_w (N/mm²)
E43xx	430	215
E49xx	490	245
E55xx	550	275
E57xx	570	285

Table 45 — Design strengths of fillet weld made of Chinese (GB) welding consumables

Grade	Tensile strength U_e (N/mm²)	Design strength p_w (N/mm²)
43	420	210
50	490	245
55	540	270

5.1.5 Class 1 profiled steel sheets

This section covers the design strength of Class 1 profiled steel sheets.

The design strengths corresponding to different steel grades are given in Table 46, Table 47, Table 48, Table 49 and Table 50.

Table 46 — Design strengths of British/European (BS EN) profiled steel sheets

Grade	Yield strength Y_s (N/mm²)	Tensile strength U_s (N/mm²)	Design strength p_y (N/mm²)	
			BS 5950-4	BS 5950-6
S220GD	220	300	$0.93U_s$	$Y_s \leq 0.84U_s$
S250GD	250	330		
S280GD	280	360		
S320GD	320	390		
S350GD	350	420		
S550GD	550	560		

Table 47 — Design strengths of American (ASTM) profiled steel sheets

Grade	Yield strength Y_s (N/mm²)	Tensile strength U_s (N/mm²)	Design strength p_y (N/mm²)	
			BS 5950-4	BS 5950-6
210	210	320	$0.93U_s$	$Y_s \leq 0.84U_s$
240	240	340		
275	275	380		
280	280	370		
300	300	390		
340	340	450		
410	410	480		

Table 48 — Design strengths of Japanese (JIS) profiled steel sheets

Grade	Yield strength Y_s (N/mm²)	Tensile strength U_s (N/mm²)	Design strength p_y (N/mm²)	
			BS 5950-4	BS 5950-6
SGH340, SGC340	245	340	$0.93U_s$	$Y_s \leq 0.84U_s$
SGH400, SGC400	295	400		
SGH440, SGC440	335	440		
SGH490, SGC490	365	490		
SGH540	400	540		

Table 49 — Design strengths of Australian/New Zealand (AS/NZS) profiled steel sheets

Grade	Yield strength Y_s (N/mm²)	Tensile strength U_s (N/mm²)	Design strength p_y (N/mm²)	
			BS 5950-4	BS 5950-6
250	250	320	$0.93U_s$	$Y_s \leq 0.84U_s$
300	300	340		
350	350	420		
450	450	480		
500	500	520		
550	550	550		

Table 50 — Design strengths of Chinese (GB) profiled steel sheets

Grade	Yield strength Y_s (N/mm²)	Tensile strength U_s (N/mm²)	Design strength p_y (N/mm²)	
			BS 5950-4	BS 5950-6
220	220	300	$0.93U_s$	$Y_s \leq 0.84U_s$
250	250	330		
280	280	360		
320	320	390		
350	350	420		
400	400	470		
500	500	530		
550	550	560		

5.1.6 Class 1 stud shear connectors

This section covers the characteristic resistance of Class 1 stud shear connectors.

The characteristic resistance of stud shear connectors shall be computed using the following equation.

Characteristic resistance: $Q_k = 0.29\alpha d^2 \cdot \sqrt{0.8 f_{cu} E_c} \quad \leq 0.8 f_u \cdot \frac{\pi d^2}{4}$

where $\alpha = 0.2\left(\frac{h}{d} + 1\right) \leq 1$ for ; $\frac{h}{d} \geq 3$;

h = overall as-welded height of stud shear connector;
d = shank diameter of stud shear connector;
f_{cu} = cube compressive strength of concrete;
E_c = modulus of elasticity of concrete;
f_u = tensile strength of stud shear connector, but not greater than 450 N/mm².

The tensile strengths of stud shear connectors manufactured to EN, ASTM, JIS, AS/NZS and GB are given in Table 51.

Table 51 — Tensile strengths of British/European (BS EN), American (AWS), Japanese (JIS), Australian/New Zealand (AS/NZS) and Chinese (GB) stud shear connectors

Material standards	Tensile strength f_u (N/mm²)
BS EN ISO 13918	450
AWS D 1.1 (Type B)	450
JIS B 1198	400
AS/NZS 1554.2	410
GB/T 10433	400

5.2 Design recommendations on Class 2 alternative steel materials

This section covers the design guide on Class 2 alternative steel materials, which are not in the lists of certified steel materials (see **Appendix A**) but are in compliance with both the material performance requirements (see **Section 2**) through material testing and quality assurance requirements (see **Section 3**).

5.2.1 Class 2 structural steel

This section covers the design strength of Class 2 steel plates, hot rolled sections, hollow sections and steel for cold forming.

The basic design strength p_{yo} corresponding to the thickness not greater than 16 mm shall be computed using the following equation.

Basic design strength: $$p_{yo} = \frac{Y_s}{1.1} \leq \frac{U_s}{1.3} \text{ or } 460\ \text{N/mm}^2$$

The design strengths corresponding to different thickness are given in Table 52.

Table 52 — Design strengths of Class 2 structural steels

Design strength p_y, for thickness[a] (mm) less than or equal to					
16	**40**	**63**	**80**	**100**	**150**
$p_{yo} = \frac{Y_s}{1.1}$ $\leq \frac{U_s}{1.3}$ or 460 N/mm²	$0.95p_{yo}$	$0.92p_{yo}$	$0.90p_{yo}$	$0.85p_{yo}$	$0.80p_{yo}$
a) For rolled sections, used the specified thickness of the thickest element of the cross-section.					

5.2.2 Class 2 non-preloaded bolted connections

This section covers the design strengths of Class 2 non-preloaded bolts and the recommended combinations of matching components in non-preloaded bolting assemblies.

The design strengths corresponding to different bolt grades are given in Table 53.

Table 53 — Design strengths of Class 2 non-preloaded bolts

Tensile strength	Yield strength	Shear strength p_s	Bearing strength p_{bb}	Tension strength p_t
$U_b \leq 1000$ N/mm^2	Y_b	$0.3U_b$	$0.5(U_b + Y_b)$	$0.5U_b \leq Y_b$

The recommended combinations of matching components in non-preloaded bolting assemblies are given in Table 54.

Table 54 — Recommended combinations of Class 2 non-preloaded bolting assemblies

Tensile strength of bolt	Proof load of nut	Hardness of washer
$U_b \leq 1000$ N/mm^2	$\geq U_b$	≥ 100 HV (or equivalent hardness)

5.2.3 Class 2 preloaded bolted connections

This section covers the design strengths of Class 2 preloaded bolts and the recommended combinations of matching components in preloaded bolting assemblies.

The design strengths corresponding to different bolt grades are given in Table 55.

Table 55 — Design strengths of Class 2 preloaded bolts

Tensile strength	Yield strength	Shear strength p_s	Tension strength p_t
$U_b \leq 1000$ N/mm^2	Y_b	$0.3U_b$	$0.5U_b \leq Y_b$

The recommended combinations of matching components in preloaded bolting assemblies are given in Table 56.

Table 56 — Recommended combinations of Class 2 preloaded bolting assemblies

Tensile strength of bolt	Proof load of nut	Hardness of washer
$U_b \leq 1000$ N/mm^2	$\geq U_b$	≥ 300 HV (or equivalent hardness)

5.2.4 Class 2 fillet welds

This section covers the design strength fillet welds made of Class 2 welding consumables.

The design strength of fillet weld shall be computed using the following equation.

Design strength of fillet weld: $p_w = 0.4U_e \leq 0.45U_s$

where U_e = tensile strength of all-weld metal, but not greater than 550 N/mm^2
U_s = tensile strength of parent metal

5.2.5 Class 2 profiled steel sheets

This section covers the design strength of Class 2 profiled steel sheets.

The design strength of profiled steel sheets shall be computed using the following equations.

Design strength: $p_y = 0.85Y_s$ in design to BS 5950-4

$p_y = 0.9Y_s \leq 0.75\ U_s$ in design to BS 5950-6

where Y_s = yield strength of profiled steel sheets, and
U_s = tensile strength of profiled steel sheets, but not greater than 450 N/mm^2

5.2.6 Class 2 stud shear connectors

This section covers the characteristic resistance of Class 2 stud shear connectors.

The characteristic resistance of stud shear connectors shall be computed using the following equation.

Characteristic resistance: $Q_k = 0.25\alpha d^2 \cdot \sqrt{0.8 f_{cu} E_c} \leq 0.6 f_u \cdot \frac{\pi d^2}{4}$

where $\alpha = 0.2\left(\frac{h}{d} + 1\right) \leq 1$ for $\frac{h}{d} \geq 3$;

h = overall as-welded height of stud shear connector;
d = shank diameter of stud shear connector;
f_{cu} = cube compressive strength of concrete;
E_c = modulus of elasticity of concrete;
f_u = tensile strength of stud shear connector, but not greater than 450 N/mm^2.

5.3 Design recommendations on Class 3 alternative steel materials

This section covers the design guide on Class 3 alternative steel materials, which are not in compliance with at least one of the material performance requirements (see **Section 2**) or quality assurance requirements (see **Section 3**).

5.3.1 Class 3 structural steel

This section covers the design strength of Class 3 steel plates, hot rolled sections, hollow sections and steel for cold forming.

The use of Class 3 structural steel is to be restricted to non-structural purpose. The basic design strength p_{y0} corresponding to the thickness not greater than 16 mm shall be taken as 170 N/mm^2.

The design strengths corresponding to different thickness are given in Table 57.

Table 57 — Design strengths of Class 3 structural steels

Design strength p_y (N/mm^2), for thickness[a] (mm) less than or equal to					
16	**40**	**63**	**80**	**100**	**150**
170	160	155	150	145	135
a) For rolled sections, used the specified thickness of the thickest element of the cross-section.					

5.3.2 Class 3 non-preloaded bolted connections

Structural connections shall not be made of Class 3 steel materials.

5.3.3 Class 3 preloaded bolted connections

Structural connections shall not be made of Class 3 steel materials.

5.3.4 Class 3 fillet welds

Structural connections shall not be made of Class 3 steel materials.

5.3.5 Class 3 profiled steel sheets

This section covers the design strength of Class 3 profiled steel sheets.

The design strength of profiled steel sheets shall be taken as 150 N/mm^2.

5.3.6 Class 3 stud shear connectors

Structural connections shall not be made of Class 3 steel materials.

5.4 Other properties

Unless otherwise stated, the following design values shall be used for steel materials wherever applicable.

- Modulus of elasticity: $E = 205\ 000\ \text{N/mm}^2$
- Shear modulus: $G = \dfrac{E}{2(1+\nu)}$
- Poisson's ratio: $\nu = 0.30$
- Coefficient of linear thermal expansion (in the ambient temperature range): $\alpha = 12 \times 10^{-6}\ \text{per °C}$
- Density: $\rho = 7\,850\ \text{kg/m}^3$

Appendix A Lists of Certified Steel Materials
Appendix B Testing of Steel Materials
Appendix C Standards for Reference

Appendix A Lists of certified steel materials

This appendix only covers certified steel materials manufactured to certain British/European standards (BS EN), American standards (API, ASTM and AWS), Japanese standards (JIS), Australian/New Zealand standards (AS/NZS and AS) and Chinese standards (GB), and shall be updated in accordance with the latest version of the respective standards.

NOTE Depending on the quality assurance provided by the manufacturer, materials in this appendix can be either Class 1 or Class 3.

A.1 Certified British/European steel materials

A.1.1 Certified British/European steel plates

Any combination of steel grades manufactured to:-

BS EN 10025-2: 2004
- S235JR
- S235J0
- S235J2
- S275JR
- S275J0
- S275J2
- S355JR
- S355J0
- S355J2
- S355K2

or

BS EN 10025-3: 2004
- S275N
- S275NL
- S355N
- S355NL
- S420N
- S420NL
- S460N
- S460NL

or

BS EN 10025-4: 2004
- S275M
- S275ML
- S355M
- S355ML
- S420M
- S420ML
- S460M
- S460ML

or

BS EN 10025-5: 2004
- S235J0W
- S235J2W
- S355J0WP
- S355J2WP
- S355J0W
- S355J2W
- S355K2W

or

BS EN 10025-6: 2004
- S460Q
- S460QL
- S460QL1
- S500Q
- S500QL
- S500QL1
- S550Q
- S550QL
- S550QL1
- S620Q
- S620QL
- S620QL1
- S690Q
- S690QL
- S690QL1

with dimensional and/or mass tolerances in accordance with:-

BS EN 10029:1991
- Class A
- Class B
- Class C
- Class D

or

BS EN 10051:1992
- Category A
- Category B

A.1.2 Certified British/European hot rolled sections

Any combination of steel grades manufactured to:-

BS EN 10025-2: 2004
- S235JR
- S235J0
- S235J2
- S275JR
- S275J0
- S275J2
- S355JR
- S355J0
- S355J2
- S355K2

or

BS EN 10025-3: 2004
- S275N
- S275NL
- S355N
- S355NL
- S420N
- S420NL
- S460N
- S460NL

or

BS EN 10025-4: 2004
- S275M
- S275ML
- S355M
- S355ML
- S420M
- S420ML
- S460M
- S460ML

or

BS EN 10025-5: 2004
- S235J0W
- S235J2W
- S355J0WP
- S355J2WP
- S355J0W
- S355J2W
- S355K2W

or

BS EN 10025-6: 2004
- S460Q
- S460QL
- S460QL1

with dimensional and/or mass tolerances in accordance with:-

BS EN 10024:1995, BS EN 10034:1993, BS EN 10055:1996, BS EN 10056-1:1999 or BS EN 10279:2000

A.1.3 Certified British/European hollow sections

Either any combination of steel grades manufactured to:-

BS EN 10210-1:2006

- S235JRH
- S275J0H
- S275J2H
- S275NH
- S275NLH
- S355J0H
- S355J2H
- S355K2H
- S355NH
- S355NLH
- S420NH
- S420NLH
- S460NH
- S460NLH

with dimensional and/or mass tolerances in accordance with:-

BS EN 10210-2:2006

Or any combination of steel grades manufactured to:-

BS EN 10219-1:2006

- S235JRH
- S275J0H
- S275J2H
- S275MH
- S275MLH
- S275NH
- S275NLH
- S355J0H
- S355J2H
- S355K2H
- S355MH
- S355MLH
- S355NH
- S355NLH
- S420MH
- S420MLH
- S460MH
- S460MLH
- S460NH
- S460NLH

with dimensional and/or mass tolerances in accordance with:-

BS EN 10219-2:2006

A.1.4 Certified British/European steel for cold forming

Either any combination of steel grades manufactured to:-

BS EN 10025-2:2004

- S235JR
- S235J0
- S235J2
- S275JR
- S275J0
- S275J2
- S355JR
- S355J0
- S355J2
- S355K2

BS EN 10149-2:1996

- S315MC
- S355MC
- S420MC
- S460MC
- S500MC
- S550MC

or

BS EN 10149-3:1996

- S260NC
- S315NC
- S355NC
- S420NC

or

with dimensional and/or mass tolerances in accordance with:-

BS EN 10143:2006

A.1.5 Certified British/European non-preloaded bolting assemblies

Bolts manufactured to:-

- BS 4190:2001
- BS 7419:1991
- BS EN ISO 4014:2001
- BS EN ISO 4016:2001
- BS EN ISO 4017:2001
- BS EN ISO 4018:2001

Nuts manufactured to:-
- BS 4190:2001
- BS EN ISO 4032:2001
- BS EN ISO 4033:2001
- BS EN ISO 4034:2001

Washers manufactured to:-
- BS 4320:1968
- BS EN ISO 7091:2000

A.1.6 Certified British/European preloaded bolting assemblies

Bolts manufactured to:-
- BS 4395-1:1969
- BS 4395-2:1969
- BS EN 14399-3:2005
- BS EN 14399-4:2005

Nuts manufactured to:-
- BS 4395-1:1969
- BS 4395-2:1969
- BS EN 14399-3:2005
- BS EN 14399-4:2005

Washers manufactured to:-
- BS 4395-1:1969
- BS 4395-2:1969
- BS EN 14399-5:2005
- BS EN 14399-6:2005

A.1.7 Certified British/European welding consumables

Welding consumables, which result in all-weld metals meeting material performance requirements in **2.7**, and manufactured to:-

- BS EN 440:1995
- BS EN 756:2004
- BS EN 758:1997
- BS EN 1668:1997
- BS EN ISO 2560:2005

A.1.8 Certified British/European profiled steel sheets

Any combination of steel grades manufactured to:-

BS EN 10326:2004
- S220GD
- S250GD
- S280GD
- S320GD
- S350GD
- S550GD

with dimensional and/or mass tolerances in accordance with:-

BS EN 10143:2006

A.1.9 Certified British/European stud shear connectors

Stud shear connectors manufactured to:-

BS EN ISO 13918:1998

A.2 Certified American steel materials

A.2.1 Certified American steel plates

Any combination of steel grades manufactured to:-

ASTM A 36–2005*

or

ASTM A 242–2004*

or

ASTM A 572–2007*
- Grade 290
- Grade 345
- Grade 380
- Grade 415
- Grade 450

or

ASTM A 588–2005*
- Grade A
- Grade B
- Grade C
- Grade K

or

ASTM A 709–2007
- Grade 250F*
- Grade 345F*
- Grade 485F
- Grade 690F

or

ASTM A 852–2003(07)

or

ASTM A 945–2006
- Grade 345
- Grade 450

NOTE *Copper content should not exceed 0.6 %, based on ladle analysis.

with dimensional and/or mass tolerances in accordance with:-

ASTM A 6–2007**

NOTE **Thickness of plate is less than 101 mm.

A.2.2 Certified American hot rolled sections

Any combination of steel grades manufactured to

ASTM A 36–2005*

or

ASTM A 572–2007*
- Grade 290
- Grade 345
- Grade 380
- Grade 415
- Grade 450

or

ASTM A 588–2005*
- Grade A
- Grade B
- Grade C
- Grade K

or

ASTM A 709–2007*
- Grade 250F
- Grade 345F

or

ASTM A 992–2006

or

ASTM A 913–2007
- Grade 345
- Grade 415
- Grade 450

NOTE *Copper content should not exceed 0.6 % and sulphur content should not exceed 0.045 %, based on ladle analysis.

with dimensional and/or mass tolerances in accordance with:-

ASTM A 6–2007**

NOTE **At least one dimension should be higher than 75 mm.

A.2.3 Certified American hollow sections

Any combination of steel grades manufactured to:-

API 5L–2004
- Grade B-PSL 2
- Grade X42-PSL 2
- Grade X46-PSL 2
- Grade X52-PSL 2
- Grade X56-PSL 2
- Grade X60-PSL 2
- Grade X65-PSL 2

with dimensional and/or mass tolerances in accordance with:-

API 5L–2004

A.2.4 Certified American steel for cold forming

Any combination of steel grades manufactured to:-

ASTM A 1011–2004
- Grade SS 205
- Grade SS 230
- Grade SS 250
- Grade HSLAS 310 Cl1, Cl2
- Grade HSLAS 340 Cl2
- Grade HSLAS-F 310
- Grade HSLAS-F 340

or

ASTM A 1008–2006
- Grade SS 205
- Grade SS 230
- Grade HSLAS 310
- Grade HSLAS 340 Cl2
- Grade HSLAS-F 340
- Grade HSLAS-F 410
- Grade SHS 210
- Grade SHS 240
- Grade BHS 210
- Grade BHS 240

or

ASTM A 792–2005
- Grade SS 230

or

ASTM A 875–2002a
- Grade SS 230
- Grade SS 255
- Grade SS 275
- Grade HSLAS 340
- Grade HSLAS 410

with dimensional and/or mass tolerances in accordance with:-

ASTM A 924–2007* or ASTM A 568–2007

NOTE *ASTM A 924–2007, Table 3: Thickness Tolerances for Hot-Dip Metallic-Coated Sheet—1-in. [25–mm] Minimum Edge Distance

A.2.5 Certified American non-preloaded bolting assemblies

Bolts manufactured to:-
- ASTM A 307–2007b (Grade B)
- ASTM A 325–2007a
- ASTM A 449–2007b
- ASTM A 490–2006

Nuts manufactured to:-
- ASTM A 563–2007a (Class 5, Class 9, Class 8S, Class 8S3-A, C, D, E, F, Class 10, Class 10S, Class 10S3 and Class 12)
- ASTM A 194–2007b (Grade 4, Grade 6, Grade 7, 7M, Grade 8, 8A, 8C, 8CA, 8M, 8MA, 8T, 8TA, 8P, 8PA, 8N, 8NA, 8LN, 8LNA, 8MN, 8MNA, 8MLN, 8MLNA, 8R, 8RA, 8S, 8SA, 8MLCuN, 8MLCuNA, Grade 9C, 9CA and Grade 16)

Washers manufactured to:-
- ASTM F 436–2007a (Type 1 and Type 3)

A.2.6 Certified American preloaded bolting assemblies

Bolts manufactured to:-
- ASTM A 325–2007a
- ASTM A 354–2007a (Grade BC and Grade BD)
- ASTM A 490–2006

Nuts manufactured to:-
- ASTM F 1852–2007
- ASTM A 563–2007a (Class 8S3-C and Class 8S3-D or Class 10S zinc-coated for zinc-coated bolts)

Washers manufactured to:-
- ASTM F 959–2007a
- ASTM F 436–2007a (Type 1 and Type 3)

A.2.7 Certified American welding consumables

Welding consumables, which result in all-weld metals meeting material performance requirements in **2.7**, and manufactured to:-

AWS A 5.1–2004
- E4915
- E4916
- E4918
- E4927
- E4928
- E4948

A.2.8 Certified American profiled steel sheets

ASTM A 653–2007*
- Grade HSLAS 275
- Grade HSLAS 340
- Grade HSLAS 410
- Grade HSLAS-F 275
- Grade HSLAS-F 340
- Grade HSLAS-F 410
- Grade SHS 210
- Grade SHS 240
- Grade SHS 280
- Grade SHS 300
- Grade BHS 210
- Grade BHS 240
- Grade BHS 280
- Grade BHS 300

NOTE *Phosphorous content should not exceed 0.05 %.

with dimensional and/or mass tolerances in accordance with:-

ASTM A 924–2007**

NOTE **ASTM A 924–2007, Table 3: Thickness Tolerances for Hot-Dip Metallic-Coated Sheet—1-in. [25–mm] Minimum Edge Distance

A.2.9 Certified American shear stud connectors

Stud shear connectors manufactured to:-

AWS D 1.1–2007
- Type B

A.3 Certified Japanese steel materials

A.3.1 Certified Japanese steel plates

Steel grades manufactured to:-

JIS G 3106:2004
- SM490A**
- SM490B**
- SM490C*
- SM490YA*
- SM490YB*
- SM520B*
- SM520C*
- SM570*

or

JIS G 3114:2004
- SMA490BW**
- SMA490BP**
- SMA490CW*
- SMA490CP*
- SMA570W*

or

JIS G 3136:2000
- SN400B***
- SN400C****
- SN490B***
- SN490C****

NOTE *Thickness of plate should not be greater than 100 mm.

NOTE **Thickness of plate should not be greater than 200 mm.

NOTE ***Thickness of plate should be in the range of 6 mm to 100 mm.

NOTE ****Thickness of plate should be in the range of 16 mm to 100 mm.

A.3.2 Certified Japanese hot rolled sections

Steel grades manufactured to:-

JIS G 3106:2004
- SM490A**
- SM490B**
- SM490C*
- SM490YA*
- SM490YB*
- SM520B*
- SM520C*
- SM570*

or

JIS G 3114:2004
- SMA490BW**
- SMA490BP**
- SMA490CW*
- SMA490CP*
- SMA570W*

or

JIS G 3136:2000
- SN400B***
- SN400C****
- SN490B***
- SN490C****

NOTE *Thickness of section should not be greater than 100 mm.

NOTE **Thickness of section should not be greater than 200 mm.

NOTE ***Thickness of section should be in the range of 6 mm to 100 mm.

NOTE ****Thickness of section should be in the range of 16 mm to 100 mm.

A.3.3 Certified Japanese hollow sections

Any combination of steel grades manufactured to:-

JIS G 3475: 1996*
- STKN490B

with dimensional and/or mass tolerances in accordance with:-

JIS G 3475: 1996*

NOTE *Only hot-finished non-seamless hollow sections with outside diameter not greater than 100 mm are certified.

A.3.4 Certified Japanese steel for cold forming

Steel grades manufactured to:-

JIS G 3106:2004
- SM490A
- SM490B
- SM490C
- SM490YA
- SM490YB
- SM520B
- SM520C
- SM570

or

JIS G 3114:2004
- SMA490BW
- SMA490BP
- SMA490CW
- SMA490CP
- SMA570W

or

JIS G 3136:2000
- SN400B
- SN490B

or

JIS G 3350:2005
- SSC400

A.3.5 Certified Japanese non-preloaded bolting assemblies

Bolts manufactured to:-
- JIS B 1051: 2000
- JIS B 1180: 2004

Nuts manufactured to:-
- JIS B 1052: 1998
- JIS B 1181: 2004

Washers manufactured to:-
- JIS B 1256: 1998

A.3.6 Certified Japanese preloaded bolting assemblies

Bolts manufactured to:-
- JIS B 1186: 1995

Nuts manufactured to:-
- JIS B 1186: 1995

Washers manufactured to:-
- JIS B 1186: 1995

A.3.7 Certified Japanese welding consumables

Welding consumables, which result in all-weld metals meeting material performance requirements in **2.7**, and manufactured to:-

- JIS Z 3211: 2000
- JIS Z 3212: 2000
- JIS Z 3313: 1999

A.3.8 Certified Japanese profiled steel sheets

Any combination of steel grades manufactured to:-

JIS G 3302: 2005
- SGH340
- SGH400
- SGH440
- SGH490
- SGH540
- SGC340
- SGC400
- SGC440
- SGC490

with dimensional and/or mass tolerances in accordance with:-

JIS G 3302: 2005

A.3.9 Certified Japanese stud shear connectors

Stud shear connectors manufactured to:-

JIS B 1198: 1995

A.4 Certified Australian/New Zealand steel materials

A.4.1 Certified Australian/New Zealand steel plates

Either any combination of steel grades manufactured to:-

AS/NZS 3678-1996
- Grade 250 L15
- Grade 300 L15
- Grade 350 L15
- Grade 400 L15
- Grade 450 L15

with dimensional and/or mass tolerances in accordance with:-

AS/NZS 1365-1996*

NOTE *Plates are rolled on continuous mills. If plates are rolled on reversing mills, width of plate should be less than 2.7 m.

Or any combination of steel grades manufactured to:-

AS 1548-1995
- Grade 5-490 N or A
- Grade 7-430 R, N, T, or A
- Grade 7-460 R, N, T, or A
- Grade 7-490 R, N, T, or A

with dimensional and/or mass tolerances in accordance with:-

AS/NZS 1548-1995*

NOTE *Plates are rolled on continuous mills. If plates are rolled on reversing mills, width of plate should be less than 2.7 m.

A.4.2 Certified Australian/New Zealand hot rolled sections

Any combination of steel grades manufactured to:-

AS/NZS 3679.1-1996
- Grade 250 (L0, L15)
- Grade 350 (L0, L15)
- Grade 400 (L0, L15)

with dimensional and/or mass tolerances in accordance with:-

AS/NZS 3679.1-1996*

NOTE *Basis for acceptance is stringent mass tolerance requirement.

A.4.3 Certified Australian/New Zealand hollow sections

Any combination of steel grades manufactured to:-

AS 1163-2007
- C250 (L0, L15)
- C275 (L0, L15)
- C300 (L0, L15)
- C350 (L0, L15)
- C400 (L0, L15)
- C450 (L0, L15)

with dimensional and/or mass tolerances in accordance with:-

AS 1163-2007*

NOTE * Basis for acceptance is stringent mass tolerance requirement.

A.4.4 Certified Australian/New Zealand steel for cold forming

Any combination of steel grades manufactured to:-

AS/NZS 1595-1998
- CA 220
- CA 260
- CA 350

with dimensional and/or mass tolerances in accordance with:-

AS/NZS 1365-1996*

Or any combination of steel grades manufactured to:-

AS/NZS 1397-2001
- Grade 250
- Grade 300
- Grade 350
- Grade 400
- Grade 450

with dimensional and/or mass tolerances in accordance with:-

AS/NZS 1365-1996*

NOTE *Basis for acceptance is stringent thickness tolerance requirement.

A.4.5 Certified Australian/New Zealand non-preloaded bolting assemblies

Bolts manufactured to:-
- AS/NZS 1252-1996
- AS 4291.1-2000*
- AS/NZS 1559-1997

NOTE *Grade 12.9 is non-certified.

Nuts manufactured to:-
- AS/NZS 1252-1996
- AS/NZS 4291.2-1995

Washers manufactured to:-
- AS/NZS 1252-1996

A.4.6 Certified Australian/New Zealand preloaded bolting assemblies

Bolts manufactured to:-
- AS/NZS 1252-1996
- AS 4291.1-2000

Nuts manufactured to:-
- AS/NZS 1252-1996
- AS/NZS 4291.2:1995

Washers manufactured to:-
- AS/NZS 1252-1996

A.4.7 Certified Australian/New Zealand welding consumables

Welding consumables, which result in all-weld metals meeting material performance requirements in **2.7**, and manufactured to:-

- AS/NZS 1554.1-2004
- AS/NZS 4855-2007
- AS/NZS 4857-2006*
- AS 1858.1-2003**
- AS/NZS 2717.1-1996

NOTE *Only grades 55, 62 and 69 are certified.

NOTE **Z is non-certified.

NOTE ***Only grades W5xxx to W6xxx are certified; grade W5ZXH is non-certified.

A.4.8 Certified Australian/New Zealand profiled steel sheets

Any combination of steel grades manufactured to:-

AS/NZS 1397-2001
- Grade 250
- Grade 300
- Grade 350
- Grade 400
- Grade 450
- Grade 500
- Grade 550

with dimensional and/or mass tolerances in accordance with:-

AS/NZS 1365-1996*

NOTE *Tolerances for cold-rolled sheet/strip.

A.4.9 Certified Australian/New Zealand shear stud connectors

Stud shear connectors manufactured to:-

AS/NZS 1554.2-2003*

NOTE *Stud diameter should be at least 15.9 mm.

A.5 Certified Chinese steel materials

A.5.1 Certified Chinese steel plates

Any combination of steel grades manufactured to:-

GB/T 700-2006*
- Q235BZ
- Q235CZ
- Q235DTZ
- Q275BZ
- Q275CZ
- Q275DTZ

or

GB/T 1591-1994*
- Q295B
- Q345B
- Q345C
- Q345D
- Q345E
- Q390B
- Q390C
- Q390D
- Q390E
- Q420B
- Q420C
- Q420D
- Q420E
- Q460C
- Q460D
- Q460E

or

GB/T 4171-2000
- Q295GNH
- Q295GNHL
- Q345GNH
- Q345GNHL
- Q390GNH

or

GB/T 4172-2000
- Q235NHC
- Q235NHD
- Q235NHE
- Q295NHC
- Q295NHD
- Q295NHE
- Q355NHC
- Q355NHD
- Q355NHE
- Q460NHD
- Q460NHE

or

YB 4104-2000
- Q235GJC
- Q235GJD
- Q235GJE
- Q235GJZxxC**
- Q235GJZxxD**
- Q235GJZxxE**
- Q345GJC
- Q345GJD
- Q345GJE
- Q345GJZxxC**
- Q345GJZxxD**
- Q345GJZxxE**

with dimensional and/or mass tolerances in accordance with:-

GB/T 709-2006*
- Class A
- Class B
- Class C
- Class N
- PT.A
- PT.B

NOTE *Steel plates manufactured to GB/T 912-1989 and GB/T 3274-1988, which make reference to GB/T 700-2006, GB/T 1591-1994 and GB/T 709-2006, shall be considered certified.

NOTE **Zxx shall be Z15, Z25 and Z35, in accordance with GB/T 5313-1985.

A.5.2 Certified Chinese hot rolled sections

Any combination of steel grades manufactured to:-

GB/T 700-2006
- Q235BZ
- Q235CZ
- Q235DTZ
- Q275BZ
- Q275CZ
- Q275DTZ

or

GB/T 1591-1994
- Q295B
- Q345B
- Q345C
- Q345D
- Q345E
- Q390B
- Q390C
- Q390D
- Q390E
- Q420B
- Q420C
- Q420D
- Q420E
- Q460C
- Q460D
- Q460E

or

GB/T 4171-2000
- Q295GNH
- Q295GNHL
- Q345GNH
- Q345GNHL
- Q390GNH

or

GB/T 4172-2000
- Q235NHC
- Q235NHD
- Q235NHE
- Q295NHC
- Q295NHD
- Q295NHE
- Q355NHC
- Q355NHD
- Q355NHE
- Q460NHD
- Q460NHE

with dimensional and/or mass tolerances in accordance with:-

GB/T 706-1988, GB/T 707-1988, GB/T 9787-1988, GB/T 9946-1988 or GB/T 11263-2005

A.5.3 Certified Chinese hollow sections

Either any combination of steel grades manufactured to:-

GB/T 700-2006
- Q235CZ
- Q235DTZ
- Q275CZ
- Q275DTZ

or

GB/T 1591-1994
- Q345C
- Q345D
- Q345E
- Q390C
- Q390D
- Q390E
- Q420C*
- Q420D*
- Q420E*
- Q460C*
- Q460D*
- Q460E*

or

GB/T 4171-2000
- Q295GNH
- Q295GNHL
- Q345GNH
- Q345GNHL
- Q390GNH

NOTE *Quenched and tempered steels are non-certified.

with dimensional and/or mass tolerances in accordance with:-

GB/T 6728-2002

Or any combination of steel grades manufactured to:-

GB/T 8162-1999
- Q345

with dimensional and/or mass tolerances in accordance with:-

GB/T 8162-1999 and GB/T 17395-1998

A.5.4 Certified Chinese steel for cold forming

Any combination of steel grades manufactured to:-

GB/T 700-2006
- Q215AZ
- Q215BZ
- Q235AZ
- Q235BZ
- Q235CZ
- Q235DTZ
- Q275AZ
- Q275BZ
- Q275CZ
- Q275DTZ

or

GB/T 1591-1994
- Q295A
- Q295B
- Q345A
- Q345B
- Q345C
- Q345D
- Q345E
- Q390A
- Q390B
- Q390C
- Q390D
- Q390E
- Q420A
- Q420B
- Q420C*
- Q420D*
- Q420E*

NOTE *Quenched and tempered steels are non-certified.

with dimensional and/or mass tolerances in accordance with:-

GB/T 709-2006

A.5.5 Certified Chinese non-preloaded bolting assemblies

Bolts manufactured to:-
- GB/T 5780-2000
- GB/T 5781-2000
- GB/T 5782-2000
- GB/T 5783-2000

Nuts manufactured to:-
- GB/T 41-2000
- GB/T 6170-2000
- GB/T 6175-2000

Washers manufactured to:-
- GB/T 95-2002

A.5.6 Certified Chinese preloaded bolting assemblies

Bolts manufactured to:-
- GB/T 1228-2006
- GB/T 3632-1995

Nuts manufactured to:-
- GB/T 1229-2006
- GB/T 3632-1995

Washers manufactured to:-
- GB/T 1230-2006
- GB/T 3632-1995

A.5.7 Certified Chinese welding consumables

Welding consumables, which result in all-weld metals meeting material performance requirements in **2.7**, and manufactured to:-

- GB/T 5117-1995
- GB/T 5118-1995
- GB/T 5293-1999
- GB/T 8110-1995
- GB/T 10045-2001
- GB/T 12470-2003
- GB/T 17493-1998

A.5.8 Certified Chinese profiled steel sheets

Any combination of steel grades manufactured to:-
GB/T 2518-2004

- 220 (structural grade)
- 250 (structural grade)
- 280 (structural grade)
- 320 (structural grade)
- 350 (structural grade)
- 400 (structural grade)
- 500 (structural grade)
- 550 (structural grade)

with dimensional and/or mass tolerances in accordance with:-

GB/T 2518-2004

A.5.9 Certified Chinese stud shear connectors

Stud shear connectors manufactured to:-

GB/T 10433-2002

Appendix B Testing of steel materials

Testing of steel materials shall be in accordance with the standards given in Table B.1.

Table B.1 — Material testing required for steel materials

Tests	Materials	Parameters tested[a]	Standards for reference
Tensile test	Steel plates Hot rolled sections Hollow sections Steel for cold forming Bolts Profiled steel sheets Stud shear connectors	Yield strength Tensile strength Elongation after fracture	BS EN 10002-1:2001
Charpy impact test	Steel plates Hot rolled sections Hollow sections Steel for cold forming	Impact energy	BS EN 10045-1:1990
Hardness test	Bolts Nuts Washers	Brinell hardness Vickers hardness Rockwell hardness	BS EN ISO 6506-1:2005 BS EN ISO 6507-1:2005 BS EN ISO 6508-1:2005
Proof load test	Nuts	Proof load stress	BS EN 20898-2:1994
All-weld metal tests	Welding consumables	Yield strength Tensile strength Elongation after fracture Impact energy	BS EN 1597-1:1997
Chemical analysis	Steel plates Hot rolled sections Hollow sections Steel for cold forming Bolts Profiled steel sheets	Carbon content[b] Carbon equivalent value[b] Sulphur content[b] Phosphorous content[b] Others[c]	BS EN ISO 14284:2002

a) To ensure the adequacy of non-certified steel materials, parameters tested shall be in compliance with the relevant material performance requirements given in **Section 2**.
b) Compared to the limits specified for ladle analysis in **Section 2**, limits for product analysis shall be:-
0.03 % higher for carbon content;
0.04 % higher for carbon equivalent value;
0.01 % higher for each sulphur and phosphorous content.
c) The content of the following elements shall also be determined and recorded:- silicon, manganese, copper, chromium, molybdenum, nickel, aluminium, niobium, titanium, vanadium, nitrogen and any other element intentionally added.

Appendix C Standards for reference

This appendix covers British/European, American, Japanese, Australian/New Zealand and Chinese standards used as reference materials for this design guide. The standards listed in this appendix are only current and confirmed at the time of drafting of this design guide and shall be updated in accordance with the latest version of the respective standards.

C.1 British/European standards for reference

The following British/European standards are published by the British Standards Institution, London, United Kingdom.

C.1.1 British/European standards on design of steel structures

BS 5950-1:2000	Structural use of steelwork in building — Part 1: Code of practice for design — Rolled and welded sections
BS 5950-2:2001	Structural use of steelwork in building — Part 2: Specification for materials, fabrication and erection — Rolled and welded sections
BS 5950-3.1:1990	Structural use of steelwork in building — Part 3: Design in composite construction — Section 3.1 Code of practice for design of simple and continuous composite beams
BS 5950-4:1994	Structural use of steelwork in building — Part 4: Code of practice for design of composite slabs with profiled steel sheeting
BS 5950-5:1998	Structural use of steelwork in building — Part 5: Code of practice for design of cold-formed thin gauge sections
BS 5950-6:1995	Structural use of steelwork in building — Part 6. Code of practice for design of light gauge profiled steel sheeting
BS 5950-7:1992	Structural use of steelwork in building — Part 7: Specification for materials and workmanship: cold formed sections
BS EN 1993-1-1:2005	Eurocode 3: Design of steel structures — Part 1-1: General rules and rules for buildings
BS EN 1993-1-3:2006	Eurocode 3: Design of steel structures — Part 1-3: General rules — Supplementary rules for cold-formed members and sheeting
BS EN 1993-1-8:2005	Eurocode 3: Design of steel structures — Part 1-8: Design of joints
BS EN 1993-1-12:2007	Eurocode 3: Design of steel structures — Part 1-12: Additional rules for the extension of EN 1993 up to steel grades S 700

C.1.2 British/European standards on steel materials

BS 7668:2004	Weldable structural steels — Hot finished structural hollow sections in weather resistant steels — Specification
BS EN 10020:2000	Definition and classification of grades of steel
BS EN 10021:1993	General technical delivery requirements for steel and iron products
BS EN 10025-1:2004	Hot rolled products of structural steels — Part 1: General technical delivery conditions
BS EN 10025-2:2004	Hot rolled products of structural steels — Part 2: Technical delivery conditions for non-alloy structural steels
BS EN 10025-3:2004	Hot rolled products of structural steels — Part 3: Technical delivery conditions for normalized/normalized rolled weldable fine grain structural steels
BS EN 10025-4:2004	Hot rolled products of structural steels — Part 4: Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels

BS EN 10025-5:2004	Hot rolled products of structural steels — Part 5: Technical delivery conditions for structural steels with improved atmospheric corrosion resistance
BS EN 10025-6:2004	Hot rolled products of structural steels — Part 6: Technical delivery conditions for flat products of high yield strength structural steels in the quenched and tempered condition
BS EN 10027-1:2005	Designation systems for steels — Part 1: Steel names
BS EN 10079:2007	Definition of steel products
BS EN 10149-1:1996	Specification for hot-rolled flat products made of high yield strength steels for cold forming — Part 1: General delivery conditions
BS EN 10149-2:1996	Specification for hot-rolled flat products made of high yield strength steels for cold forming — Part 2: Delivery conditions for thermomechanically rolled steels
BS EN 10149-3:1996	Specification for hot-rolled flat products made of high yield strength steels for cold forming — Part 3. Delivery conditions for normalized or normalized rolled steels
BS EN 10164:2004	Steel products with improved deformation properties perpendicular to the surface of the product — Technical delivery conditions
BS EN 10210-1:2006	Hot finished structural hollow sections of non-alloy and fine grain steels — Part 1: Technical delivery conditions
BS EN 10219-1:2006	Cold formed welded structural hollow sections of non-alloy and fine grain steels — Part 1: Technical delivery conditions
BS EN 10326:2004	Continuously hot-dip coated strip and sheet of structural steels — Technical delivery conditions

C.1.3 British/European standards on manufacturing tolerances

BS EN 10024:1995	Hot rolled taper flange I sections — Tolerances on shape and dimensions
BS EN 10029:1991	Specification for tolerances on dimensions, shape and mass for hot rolled steel plates 3 mm thick or above
BS EN 10034:1993	Structural steel I and H sections — Tolerances on shape and dimensions
BS EN 10051:1992	Continuously hot-rolled uncoated plate, sheet and strip of non-alloy and alloy steels — Tolerances on dimensions and shape
BS EN 10055:1996	Hot rolled steel equal flange tees with radiused root and toes — Dimensions and tolerances on shape and dimensions
BS EN 10056-2:1993	Specification for structural steel equal and unequal leg angles — Part 2: Tolerances on shape and dimensions
BS EN 10210-2:2006	Hot finished structural hollow sections of non-alloy and fine grain steels — Part 2: Tolerances, dimensions and sectional properties
BS EN 10219-2:2006	Cold formed welded structural hollow sections of non-alloy and fine grain steels — Part 2: Tolerances, dimensions and sectional properties
BS EN 10279:2000	Hot rolled steel channels — Tolerances on shape, dimension and mass

C.1.4 British/European standards on bolting assemblies

General information

BS EN 20898-2:1994	Mechanical properties of fasteners — Part 2: Nuts with specified proof load values — Coarse thread
BS EN ISO 898-1:1999	Mechanical properties of fasteners made of carbon steel and alloy steel — Part 1: Bolts, screws and studs
BS EN ISO 16426:2002	Fasteners — Quality assurance system

Non-preloaded assemblies

BS 4190:2001	ISO metric black hexagon bolts, screws and nuts — Specification
BS 4320:1968	Specification for metal washers for general engineering purposes metric series
BS 7419:1991	Specification for holding down bolts
BS EN ISO 4014:2001	Hexagon head bolts — Product grades A and B
BS EN ISO 4016:2001	Hexagon head bolts — Product grade C
BS EN ISO 4017:2001	Hexagon head screws — Product grades A and B
BS EN ISO 4018:2001	Hexagon head screws — Product grade C
BS EN ISO 4032:2001	Hexagon nuts, style 1 — Product grades A and B
BS EN ISO 4033:2001	Hexagon nuts, style 2 — Product grades A and B
BS EN ISO 4034:2001	Hexagon nuts — Product grade C
BS EN ISO 7091:2000	Plain washers — Normal series — Product Grade C

Preloaded assemblies

BS 4395-1:1969	Specification for high strength friction grip bolts and associated nuts and washers for structural engineering metric series — Part 1: General grade
BS 4395-2:1969	Specification for high strength friction grip bolts and associated nuts and washers for structural engineering metric series — Part 2: Higher grade bolts and nuts and general grade washers
BS 4604-1:1970	Specification for the use of high strength friction grip bolts in structural steelwork metric series — Part 1: General grade
BS 4604-2:1970	Specification for the use of high strength friction grip bolts in structural steelwork metric series — Part 2: Higher grade (parallel shank)
BS 7644-1:1993	Direct tension indicators — Part 1: Specification for compressible washers
BS 7644-2:1993	Direct tension indicators — Part 2: Specification for nut face and bolt face washers
BS EN 14399-1:2005	High-strength structural bolting assemblies for preloading — Part 1: General requirements
BS EN 14399-2:2005	High-strength structural bolting assemblies for preloading — Part 2: Suitability test for preloading
BS EN 14399-3:2005	High-strength structural bolting assemblies for preloading — Part 3: System HR — Hexagon bolt and nut assemblies
BS EN 14399-4:2005	High-strength structural bolting assemblies for preloading — Part 4: System HV — Hexagon bolt and nut assemblies

BS EN 14399-5:2005	High-strength structural bolting assemblies for preloading — Part 5: Plain washers
BS EN 14399-6:2005	High-strength structural bolting assemblies for preloading — Part 6: Plain chamfered washers

C.1.5 British/European standards on welding consumables

BS EN 440:1995	Welding consumables — Wire electrodes and deposits for gas shielded metal arc welding of non alloy and fine grain steels — Classification
BS EN 756:2004	Welding consumables — Solid wires, solid wire-flux and tubular cored electrode-flux combinations for submerged arc welding of non alloy and fine grain steels — Classification
BS EN 758:1997	Welding consumables — Tubular cored electrodes for metal arc welding with and without a gas shield of non-alloy and fine grain steels — Classification
BS EN 1668:1997	Welding consumables — Rods, wires and deposits for tungsten inert gas welding of non alloy and fine grain steels — Classification
BS EN ISO 2560:2005	Welding consumables — Covered electrodes for manual metal arc welding of non-alloy and fine grain steels — Classification

C.1.6 British/European standards on profiled steel sheets

BS EN 10326:2004	Continuously hot-dip coated strip and sheet of structural steels — Technical delivery conditions
BS EN 10143:2006	Continuously hot-dip coated steel sheet and strip — Tolerances on dimensions and shape

C.1.7 British/European standards on stud shear connectors

BS EN ISO 13918:1998	Welding — Studs and ceramic ferrules for arc stud welding

C.1.8 British/European standards on material testing

BS EN 1597-1:1997	Welding consumables — Test methods — Part 1. Test piece for all-weld metal test specimens in steel, nickel and nickel alloys
BS EN 10002-1:2001	Metallic materials — Tensile testing — Part 1: Method of test at ambient temperature
BS EN 10045-1:1990	Charpy impact test on metallic materials — Part 1: Test method (V-and U-notches)
BS EN 20898-2:1994	Mechanical properties of fasteners — Part 2: Nuts with specified proof load values — Coarse thread
BS EN ISO 2566-1:1999	Steel — Conversion of elongation values — Part 1: Carbon and low alloy steels
BS EN ISO 6506-1:2005	Metallic materials — Brinell hardness test — Part 1: Test method
BS EN ISO 6507-1:2005	Metallic materials — Vickers hardness test — Part 1: Test method
BS EN ISO 6508-1:2005	Metallic materials — Rockwell hardness test — Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)
BS EN ISO 14284:2002	Steel and iron — Sampling and preparation of samples for the determination of chemical composition

C.1.9 British/European standards on inspection documents

BS EN 10168:2004	Steel products — Inspection documents — List of information and description
BS EN 10204:2004	Metallic products — Types of inspection documents

C.2 American standards for reference

The following American standards are published by the American Institute of Steel Construction, Chicago, Illinois; the American Petroleum Institute, Washington, D.C.; the American Society for Testing and Materials, West Conshohocken, Pennsylvania; the American Welding Society, Miami, Florida, United States of America.

C.2.1 American standards on design of steel structures

AISC 305-2005	Code of Standard Practice for Steel Buildings and Bridges
ANSI/AISC 360-2005	Specification for Structural Steel Buildings

C.2.2 American standards on steel materials

API 5L–2004	Specification for line pipe
ASTM A 36–2005	Standard Specification for Carbon Structural Steel
ASTM A 53–2007	Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 109–2003	Standard Specification for Steel, Strip, Carbon (0.25 Maximum Percent), Cold-Rolled
ASTM A 242–2004	Standard Specification for High-Strength Low-Alloy Structural Steel
ASTM A 268–2005a	Standard Specification for Seamless and Welded Ferritic and Martensitic Stainless Steel Tubing for General Service
ASTM A 283–2003(07)	Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
ASTM A 308–2006	Standard Specification for Steel Sheet, Terne (Lead-Tin Alloy) Coated by the Hot-Dip Process
ASTM A 333–2005	Standard Specification for Seamless and Welded Steel Pipe for Low-Temperature Service
ASTM A 423–1995(04)	Standard Specification for Seamless and Electric-Welded Low-Alloy Steel Tubes
ASTM A 500–2007	Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A 501–2007	Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
ASTM A 514–2005	Standard Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding
ASTM A 529–2005	Standard Specification for High-Strength Carbon-Manganese Steel of Structural Quality
ASTM A 572–2007	Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
ASTM A 573–2005	Standard Specification for Structural Carbon Steel Plates of Improved Toughness
ASTM A 588–2005	Standard Specification for High-Strength Low-Alloy Structural Steel with 50 ksi [345 MPa] Minimum Yield Point to 4–in. [100–mm] Thick
ASTM A 595–2006	Standard Specification for Steel Tubes, Low-Carbon or High-Strength Low-Alloy, Tapered for Structural Use
ASTM A 606–2004	Standard Specification for Steel, Sheet and Strip, High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, with Improved Atmospheric Corrosion Resistance
ASTM A 618–2004	Standard Specification for Hot-Formed Welded and Seamless High-Strength Low-Alloy Structural Tubing

ASTM A 653–2007	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A 673–2007	Standard Specification for Sampling Procedure for Impact Testing of Structural Steel
ASTM A 709–2007	Standard Specification for Structural Steel for Bridges
ASTM A 792–2006a	Standard Specification for Steel Sheet, 55 % Aluminum-Zinc Alloy-Coated by the Hot-Dip Process
ASTM A 847–2005	Standard Specification for Cold-Formed Welded and Seamless High-Strength, Low- Alloy Structural Tubing with Improved Atmospheric Corrosion Resistance
ASTM A 852–2003(07)	Standard Specification for Quenched and Tempered Low-Alloy Structural Steel Plate with 70 ksi [485 MPa] Minimum Yield Strength to 4 in. [100 mm] Thick
ASTM A 871–2001	Standard Specification for High-Strength Low-Alloy Structural Steel Plate With Atmospheric Corrosion Resistance
ASTM A 875–2006	Standard Specification for Steel Sheet, Zinc-5 % Aluminum Alloy-Coated by the Hot-Dip Process
ASTM A 913–2007	Standard Specification for High-Strength Low-Alloy Steel Shapes of Structural Quality, Produced by Quenching and Self-Tempering Process (QST)
ASTM A 945–2006	Standard Specification for High-Strength Low-Alloy Structural Steel Plate with Low Carbon and Restricted Sulfur for Improved Weldability, Formability, and Toughness
ASTM A 992–2006	Standard Specification for Structural Steel Shapes
ASTM A 1003–2005	Standard Specification for Steel Sheet, Carbon, Metallic- and Nonmetallic-Coated for Cold-Formed Framing Members
ASTM A 1008–2007	Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
ASTM A 1011–2007	Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability

C.2.3 American standards on manufacturing tolerances

ASTM A 6–2007	Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
ASTM A 450–2007	Standard Specification for General Requirements for Carbon, Ferritic Alloy, and Austenitic Alloy Steel Tubes
ASTM A 568–2007	Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low- Alloy, Hot-Rolled and Cold-Rolled, General Requirements for
ASTM A 924–2007	Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM A 999–2004	Standard Specification for General Requirements for Alloy and Stainless Steel Pipe

C.2.4 American standards on bolting assemblies

Non-preloaded assemblies

ASTM A 193–2007	Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
ASTM A 194–2007b	Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A 307–2007b	Standard Specification for Carbon Steel Bolts and Studs, 60 000 psi Tensile Strength

ASTM A 325–2007a	Standard Specification for Structural Bolts, Steel, Heat Treated 830 MPa Minimum Tensile Strength [Metric]
ASTM A 354–2007a	Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners
ASTM A 449–2007b	Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use
ASTM A 490–2006	Standard Specification for High-Strength Steel Bolts, Classes 10.9 and 10.9.3, for Structural Steel Joints [Metric]
ASTM A 563–2007a	Standard Specification for Carbon and Alloy Steel Nuts [Metric]
ASTM F 436–2007a	Standard Specification for Hardened Steel Washers

Preloaded assemblies

ASTM A 193–2007	Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
ASTM A 194–2007b	Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A 354–2007a	Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners
ASTM A 563–2007a	Standard Specification for Carbon and Alloy Steel Nuts [Metric]
ASTM F 436–2007a	Standard Specification for Hardened Steel Washers
ASTM F 959–2007a	Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners [Metric]
ASTM F 1852–2007	Standard Specification for "Twist Off" Type Tension Control Structural Bolt/Nut/ Washer Assemblies, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength

C.2.5 American standards on welding consumables

AWS D1.3–1998	Structural welding code – Sheet steel
AWS A5.1–2004	Specifications for carbon steel electrodes for shielded metal arc-welding

C.2.6 American standards on profiled steel sheets

ASTM A 606–2004	Standard Specification for Steel, Sheet and Strip, High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, with Improved Atmospheric Corrosion Resistance
ASTM A 653–2007	Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

C.2.7 American standards on shear stud connectors

ASTM A 29–2005	Standard Specification for Steel Bars, Carbon and Alloy, Hot-Wrought, General Requirements for
AWS D 1.1–2004	Structural Welding Code – Steel

C.3 Japanese standards for reference

The following Japanese standards are published by the Japanese Industrial Standards Committee, Tokyo, Japan.

C.3.1 Japanese standards on design of steel structures

JSCE: 1997	Design Code for Steel Structures – Part A: Structures in General
JSCE: 1997	Design Code for Steel Structures – Part B: Composite Structures

C.3.2 Japanese standards on steel materials

JIS G 3101:2004	Rolled steels for general structure
JIS G 3106:2004	Rolled steels for welded structure
JIS G 3114:2004	Hot-rolled atmospheric corrosion resisting steels for welded structure
JIS G 3128:1999	High yield strength steel plates for welded structure
JIS G 3131:2005	Hot-rolled mild steel plates, sheets and strip
JIS G 3132:2005	Hot-rolled carbon steel strip for pipes and tubes
JIS G 3136:2005	Rolled steels for building structure
JIS G 3302:2005	Hot-dip zinc coated steel sheets and coils
JIS G 3312:2005	Prepainted hot-dip zinc-coated steel sheets and coils
JIS G 3321:2005	Hot-dip 55 % aluminium-zinc alloy-coated steel sheets and coils
JIS G 3322:2005	Prepainted hot-dip 55 % aluminium-zinc alloy-coated steel sheets and coils
JIS G 3350:2005	Light gauge sections for general structure
JIS G 3352:2003	Steel decks
JIS G 3444:2006	Carbon steel tubes for general structural purposes
JIS G 3466:2006	Carbon steel square pipes for general structural purposes
JIS G 3475:1996	Carbon steel tubes for building structure

C.3.3 Japanese standards on manufacturing tolerances

JIS G 3191:2002	Dimensions, mass and permissible variations of hot rolled steel bars in coil
JIS G 3192:2005	Dimensions, mass and permissible variations of hot rolled steel sections
JIS G 3193:2005	Dimensions, mass and permissible variations of hot rolled steel plates, sheets and strip
JIS G 3194:1998	Dimensions, mass and permissible variations of hot rolled flat steel

C.3.4 Japanese standards on bolting assemblies

Non-preloaded assemblies

JIS B 1051:2000	Mechanical properties of fasteners made of carbon steel and alloy steel
JIS B 1052:1998	Mechanical properties of nuts
JIS B 1180:2004	Hexagon head bolts and hexagon head screws
JIS B 1181:2004	Hexagon nuts and hexagon thin nuts
JIS B 1256:1998	Plain washers

Preloaded assemblies

JIS B 1186:1995	Sets of high strength hexagon bolt, hexagon nut and plain washers for friction grip joints

C.3.5 Japanese standards on welding consumables

JIS Z 3200:1995	Welding consumables – Technical delivery conditions for welding filler materials – Type of product, dimensions, tolerances and markings
JIS Z 3211:2000	Covered electrodes for mild steel
JIS Z 3212:2000	Covered electrodes for high tensile strength steel
JIS Z 3313:1999	Flux cored wires for gas shielded and self-shielded metal arc welding of mild steel, high strength steel and low temperature service steel

C.3.6 Japanese standards on profiled steel sheets

JIS G 3302:2005	Hot-dip zinc coated steel sheets and coils
JIS G 3321:2005	Hot-dip 55 % aluminium-zinc alloy-coated steel sheets and coils

C.3.7 Japanese standards on stud shear connectors

JIS B 1198:1995	Headed studs

C.4 Australian/New Zealand standards for reference

The following Australian/New Zealand standards are published by Standards Australia, Sydney, Australia.

C.4.1 Australian/New Zealand standards on design of steel structures

AS 4100-1998	Steel structures

C.4.2 Australian/New Zealand standards on steel materials

AS 1163-2007	Structural steel hollow sections (cold-formed)
AS 1397-2001	Steel sheet and strip – Hot-dipped zinc-coated or aluminium/zinc-coated
AS 1548-1995	Steel plate for pressure equipment
AS/NZS 1594-2002	Hot-rolled steel flat products
AS/NZS 1595-1998	Cold-rolled, unalloyed, steel sheet and strip
AS/NZS 3678-1996	Structural steel – hot-rolled plates, floor plates and slabs
AS/NZS 3679.1-1996	Structural steel – Part 1: Hot-rolled bars and sections

C.4.3 Australian/New Zealand standards on manufacturing tolerances

AS/NZS 1365-1996	Tolerances for flat rolled steel products
AS 1548-1995	Steel plate for pressure equipment
AS/NZS 3679.1-1996	Structural steel – Part 1: Hot-rolled bars and sections

C.4.4 Australian/New Zealand standards on bolting assemblies

AS 1112.3-2000	ISO metric hexagon nuts – Part 3: Product grade C
AS 1112.4-2000	ISO metric hexagon nuts – Part 4: Chamfered thin nuts. Product grades A and B
AS 4291.1-2000	Mechanical properties of fasteners made of carbon steel and alloy steel – Bolts, screws and studs
AS/NZS 1252-1996	High strength steel bolts with associated nuts and washers for structural engineering
AS/NZS 1559-1997	Hot-dip galvanized steel bolts with associated nuts and washers for tower construction.
AS/NZS 4291.2-1995	Mechanical properties of fasteners – Nuts with specified proof load values – Coarse thread

C.4.5 Australian/New Zealand standards on welding consumables

AS 1554.1-2004	Structural Steel Welding – Welding of steel structures
AS/NZS 4855-2007	Manual arc weld
AS/NZS 4857-2006	Manual arc weld high strength steel
AS/NZS 1167.2-1999	Welding and brazing – Filler metals
AS/NZS 2717.1-1996	Welding – Electrodes – Gas metal arc
AS 1858.1-2003	Electrodes and fluxes for submerged-arc welding – Carbon steels and carbon-manganese steels

AS 1858.1-2003	Electrodes and fluxes for submerged-arc welding – Carbon steels and carbon-manganese steels

C.4.6 Australian/New Zealand standards on profiled steel sheets

AS 1397-2001	Steel sheet and strip – Hot-dipped zinc-coated or aluminium/zinc-coated

C.4.7 Australian/New Zealand standards on shear stud connectors

AS/NZS 1554.2-2003	Structural steel welding – Stud welding

C.5 Chinese standards for reference

The following Chinese standards are published by the Standardization Administration of China, Beijing, People's Republic of China.

C.5.1 Chinese standards on design of steel structures

GB 50017-2003	Code for design of steel structures
GB 50018-2002	Technical code of cold-formed thin-wall steel structures
JGJ 81-2002	Technical specification for welding of steel structure of building
JGJ 82-1991	Code for design, construction and acceptance of high strength bolt connection of steel structures

C.5.2 Chinese standards on steel materials

GB/T 700-2006	Carbon structural steels
GB/T 912-1989	Hot-rolled plain carbon and low alloy structural steel sheets and strips
GB/T 1591-1994	High strength low alloy structural steels
GB/T 3274-1988	Carbon structural and low alloy steel rolled plates and strips
GB/T 4171-2000	Superior atmospheric corrosion resisting structural steel
GB/T 4172-2000	Atmospheric corrosion resisting steel for welded structures
GBT 5313-1985	Steel plate with through-thickness characteristics
GB/T 8162-1999	Seamless steel tubes for structural purposes
GB/T 13304-1991	Steels – Classification
GB/T 15574-1995	Steel products classification and definitions
YB 4104-2000	Steel plates for high rise building structure

C.5.3 Chinese standards on manufacturing tolerances

GB/T 706-1988	Hot-rolled beam steel – Dimensions, shape, weight and tolerances
GB/T 707-1988	Hot-rolled channel steel – Dimensions, shape, weight and tolerances
GB/T 709-2006	Dimension, shape, weight and tolerances for hot-rolled steel plates and sheets
GB/T 6728-2002	Cold formed steel hollow sections for general structure – Dimensions, shapes, weight and permissible deviations
GB/T 9787-1988	Hot-rolled equal-leg angle steel – Dimensions, shape, weight and tolerances
GB/T 9946-1988	Dimensions, shape, weight and tolerances for hot-rolled L-sectional steel
GB/T 11263-2005	The hot-rolled H and cut T section
GBT 17395-1998	Dimensions, shapes, masses and tolerances of seamless steel tubes

C.5.4 Chinese standards on bolting assemblies

General information	
GB/T 3098.1-2000	Mechanical properties of fasteners – Bolts, screws and studs
GB/T 3098.2-2000	Mechanical properties of fasteners – Nuts – Coarse thread
Materials	
GB/T 699-1999	Quality carbon structural steels

GB/T 3077-1999	Alloy structure steels
GB/T 6478-2001	Steels for cold heading and cold extruding

Non-preloaded assemblies

GB/T 41-2000	Hexagon nuts – Product grade C
GB/T 95-2002	Plain washers – Product grade C
GB/T 5780-2000	Hexagon head bolts – Product grade C
GB/T 5781-2000	Hexagon head bolts – Full thread – Product grade C
GB/T 5782-2000	Hexagon head bolts
GB/T 5783-2000	Hexagon head bolts – Full thread
GB/T 6170-2000	Hexagon nuts, style 1
GB/T 6175-2000	Hexagon nuts, style 2

Preloaded assemblies

GB/T 1228-2006	High strength bolts with large hexagon head for steel structures
GB/T 1229-2006	High strength large hexagon nuts for steel structures
GB/T 1230-2006	High strength plain washers for steel structures
GB/T 1231-2006	Specifications of high strength bolts with large hexagon nuts, plain washers for steel structures
GB/T 3632-1995	Sets of torshear type high strength bolt hexagon nut and plain washer for steel structures
GB/T 3633-1995	Technical requirement for sets of torshear type high strength bolt hexagon nut and plain washer for steel structures

C.5.5 Chinese standards on welding consumables

GB/T 3429-2002	Wire rod for electrode
GB/T 5117-1995	Carbon steel covered electrodes
GB/T 5118-1995	Low alloy steel covered electrodes
GB/T 5293-1999	Carbon steel electrodes and fluxes for submerged arc welding
GB/T 8110-1995	Welding wires for gas shielding arc welding of carbon and low alloy steels
GB/T 10045-2001	Carbon steel flux cored electrodes for arc welding
GB/T 12470-2003	Low alloy steel electrodes and fluxes for submerged arc welding
GB/T 14957-1994	Steel wires for melt welding
GB/T 14981-2004	Dimensions, shape, mass and tolerances for hot-rolled wire rods
GB/T 17493-1998	Low alloy steel flux cored electrodes for arc welding

C.5.6 Chinese standards on profiled steel sheets

GB/T 2518-2004	Continuous hot-dip zinc-coated steel sheets and strips
GB/T 12755-1991	Roll-profiled steel sheet for building

C.5.7 Chinese standards on stud shear connectors

GB/T 10433-2002	Cheese head studs for arc stud welding