The CARES Guide
to Product Certification

**Part 9**
*2025*

# Stainless reinforcing **steels**

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# Introduction

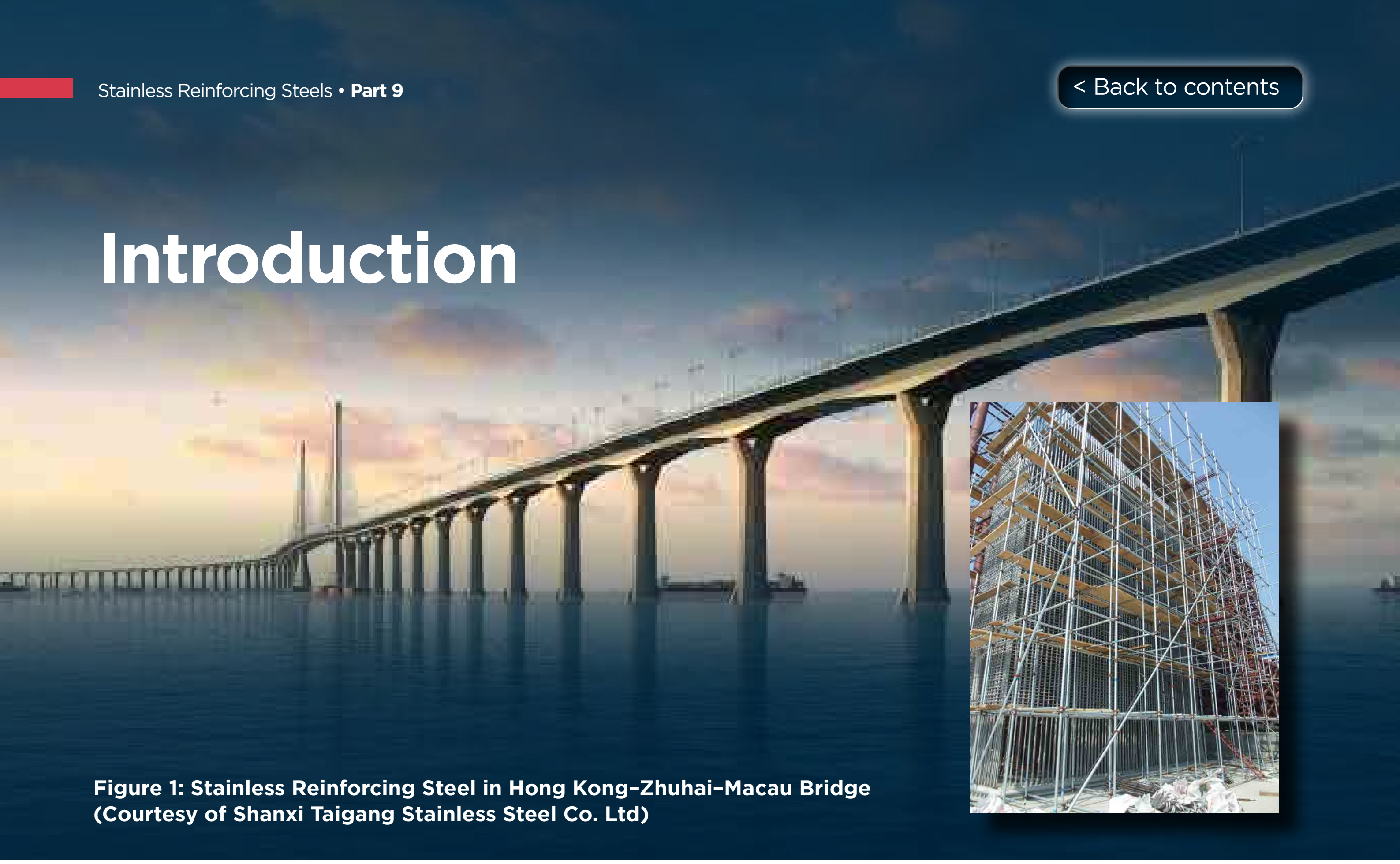

**Figure 1: Stainless Reinforcing Steel in Hong Kong–Zhuhai–Macau Bridge (Courtesy of Shanxi Taigang Stainless Steel Co. Ltd)**

**In normal atmospheric exposure conditions, with adequate concrete cover and appropriate detailing, corrosion of reinforcing steel in concrete is not a problem; the concrete provides a protective environment for the reinforcing steel. In certain aggressive environments, however, corrosion of reinforcing steels can occur and quite rapidly reducing the service life of the structure. The effects of this and other poor installation practises such as insufficient concrete cover have been well documented. The problems of maintenance and replacement of corrosion-affected structures continue to be disruptive and ongoing repair costs continue to escalate more than multi-billion dollars worldwide.**

In response, clients are increasingly requesting a Design, Build and Maintain Project Specification before the structures are handed over to the local authorities after a prescribed number of years.

One solution is the selective use of stainless reinforcing steels, which are inherently resistant to corrosion. Stainless reinforcing steels have the potential to:

- Allow relaxation in design for durability criteria normally used for carbon steel reinforced structures.
- Significantly decrease the inspection and maintenance cost of structures at risk of reinforcement corrosion.
- Extend the design life of structures at risk of reinforcement corrosion.
- Allow for the unique mechanical properties of stainless reinforcing steels to ensure improved life cycle assessment and potential reduction in carbon footprint compared to traditional carbon steels

When considering the whole-life cost of a structure there is a definite advantage, despite the initial cost of stainless compared to carbon steel reinforcement. It is important to note that carbon steel and stainless steel reinforcement may be used together when embedded in concrete without fear of galvanic corrosion, hence selective use of stainless rebar in “corrosion prone” areas can be employed.

There are numerous prestigious and critical repair projects which have employed the use of stainless-steel reinforcing bars, several examples are detailed within this report.

CARES first introduced their Stainless Construction Product Approval Scheme in 2001 in response to the growing market requirement for stainless reinforcing steel. The British Standard for reinforcing steels, BS 6744:2023 has developed significantly since the 2001 version ensuring more guidance for the use of stainless steels in place of carbon steel in construction projects. CARES were actively involved in the BS 6744 standard working group for the interim updates in 2009 and 2016 and more recently the 2023 version.

The fully developed 2023 version builds on the previous 2016 version allowing for more flexibility and maintains the previous requirement for assessment of Critical Chloride Threshold level (CCTL). This is a key advancement on previous versions allowing specifiers greater confidence in use of various stainless alloys at varying CCTL.

The aim of the CARES Assessment Scheme is to provide purchasers of CARES approved stainless reinforcing steels with the same level of confidence in specification and purchasing, as has become the established norm in the UK for carbon steel reinforcement.

# Corrosion of reinforcing steel in concrete

**Figure 2: Buddhist temple, Chounbri province, Thailand (Courtesy of Marcegaglia Stainless Sheffield Ltd)**

Carbon reinforcing steel is generally passive in terms of corrosion behaviour at the pH levels normally found within concrete (pH = 13). However, corrosion can be accelerated by a number of different chemical processes in certain environmental conditions. The most commonly cited causes of corrosion of reinforcing steel in concrete are:

a) Carbonation of the concrete due to atmospheric attack. The absorption of water and carbon dioxide from the atmosphere into concrete, can cause a lowering of the pH, due to the formation of carbonic acid. Once the pH is sufficiently reduced, corrosion of the reinforcement can occur with inevitable spalling of the concrete and potential reduction in load capability of the structure

b) The pH of concrete is similarly affected by the ingress of chloride ions into the concrete. When chloride ions reach a certain threshold level at the steel surface, passivity is broken down, and corrosion of the reinforcing steel proceeds.

Carbonation is normally controlled by the correct provision of concrete cover.

Structures most at risk of chloride attack are those exposed to marine environments or de-icing salts, particularly those parts of the structure experiencing wetting and drying cycles. These may be marine structures exposed to wetting and drying (for example in the inter-tidal or splash zones), or in highway structures or car parks exposed to road de-icing salts.

Stainless steels are generally defined as those having a minimum of 12% chromium present as an alloying constituent. The presence of chromium results in a thin layer of stable chromium oxide forming on the surface of the steel. The oxide layer is passive, and highly resistant to atmospheric corrosion. Moreover, the oxide layer is instantaneously self-healing in oxidising conditions, so that cracks, defects or surface damage do not affect corrosion resistance. Stainless steels retain passivity in concrete at low pH levels, and high chloride concentrations, hence their use in structures at risk of chloride induced corrosion.

**Figure 2: Great Belt Link, Denmark (Courtesy of Arminox, Denmark)**

# Stainless reinforcing steels

**Figure 3: Allt Chonoglais Bridge, A82, Scotland (Courtesy of Marcegaglia Stainless Sheffield Ltd)**

Within the broad definition of stainless steels, there are many different types available. BS EN 10088-3 lists more than 60 different available alloy compositions. The different steels are grouped by type, according to their metallurgical structure; austenitic, ferritic, martensitic or duplex.

In recent years duplex steels have become more prominent in their use due to the previous volatility of the Nickel market and the effect on the higher Nickel containing austenitic alloys, these developments are recognised in the more recent versions of BS 6744.

BS 6744:2023 includes ten stainless steel designations from BS EN 10088-3, of varying chemical analysis, and corrosion resistance characteristics. Table 5 of the standard details those alloys used for corrosion resistance to chloride ingress in concrete, including those with a low magnetic permeability.

Where enhanced corrosion resistance is required or where the steel may be exposed then Stainless alloys 1.4501 and 1.4529 are specified.

In certain special applications, the non-magnetic nature of austenitic stainless can also be advantageous, such as for the reinforcement of structures housing magnetic resonance equipment. Where low magnetic permeability is required (e.g. in buildings with sensitive electronic equipment) then the higher nitrogen bearing austenitic alloys 1.4311 and 1.4429 may be used.

It is, however, worthy to note that reinforcing steel produced by the cold ribbing process may increase the magnetic permeability due to the cold working process. Guidance on magnetic properties is given in Annex C of BS 6744:2023.

**Table 1. List of alloys detailed in BS 6744:2023 – austenitic stainless steel**

| Stainless Designation | C max | Si max | Mn max/ range | S max | Cr range | Ni range | Mo range | Cu range | P max | N max/ range | Other elements |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.4311 | 0.03 | 1.0 | 2.0 | 0.030 | 17.5– 19.5 | 8.5– 11.5 | — | — | 0.045 | 0.12– 0.22 | — |
| 1.4429 | 0.03 | 1.0 | 2.0 | 0.015 | 16.5– 18.5 | 10.5– 13.0 | 2.5– 3.0 | — | 0.045 | ≤0.12– 0.22 | — |
| 1.4301 | 0.07 | 1.00 | 2.00 | 0.030 | 17.5– 19.5 | 8.0– 10.5 | — | — | 0.045 | 0.10 | — |
| 1.4404 | 0.03 | 1.0 | 2.0 | 0.030 | 16.5– 18.5 | 10.0–13.0 | 2.0– 2.5 | — | 0.045 | ≤0.11 | — |
| 1.4436 | 0.05 | 1.0 | 2.0 | 0.030 | 16.5– 18.5 | 10.5– 13.0 | 2.5– 3.0 | — | 0.045 | ≤0.11 | — |
| 1.4529 | 0.02 | 0.50 | 1.0 | 0.010 | 19.0– 21.0 | 24.0– 26.0 | 6.0– 7.0 | 0.50– 1.50 | 0.030 | 0.15– 0.25 | W 0.50/1.00 |

**Figure 4: Quarta Ponte Maritima Macau-Taipa, Courtesy of Zhejiang Fugang, China**

**Table 2. List of alloys detailed in BS 6744:2023 – duplex stainless steel**

| Stainless Designation | C max | Si max | Mn max/ range | S max | Cr range | Ni range | Mo range | Cu range | P max | N max/ range | Other elements |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.4501 | 0.03 | 1.0 | 1.0 | 0.015 | 24.0- 26.0 | 6.0- 8.0 | 3.0- 4.0 | 0.50- 1.00 | 0.035 | | – |
| 1.4162 | 0.04 | 1.0 | 4.0- 6.0 | 0.015 | 21.0- 22.0 | 1.35- 1.70 | 0.10- 0.80 | 0.10- 0.80 | 0.040 | 0.20- 0.25 | – |
| 1.4362 | 0.03 | 1.0 | 2.0 | 0.015 | 22.0- 24.5 | 3.5- 5.5 | 0.10- 0.60 | 0.10- 0.60 | 0.035 | 0.05- 0.20 | – |
| 1.4462 | 0.03 | 1.0 | 2.0 | 0.015 | 21.0- 23.0 | 4.5- 6.5 | 2.5- 3.5 | – | 0.035 | 0.10- 0.22 | – |

BS 6744:2023 indicates that the above alloys are those more widely used and for which the most academic research on chloride resistance is available. Other stainless alloys may be used, and their analysis may be obtained from EN10088-1.

It is recommended that advice on use be obtained from the manufacturer and to check the manufacturer's certification for CCTL value for each alloy.

Annex B of BS 6744:2023 provides guidance on the durability of stainless steels

**Manufacturing Process routes for stainless reinforcing steels**

Most stainless steels are made by the electric arc process. This is followed by a secondary refining process, either AOD (Argon Oxygen Decarburising) or VOD (Vacuum Oxygen Decarburising). Steels are continuously cast into blooms or billets, prior to hot rolling.

Stainless reinforcing steels may be hot rolled to achieve their final mechanical properties. This normally requires close control of rolling temperatures and / or alloying elements. Alternatively, they may be hot rolled into coil, followed by a cold ribbing operation to achieve the final profile and properties. The latter may increase the alloy's normal magnetic permeability due to the cold working of the surface.

Stainless steels are supplied in the surface cleaned condition, with rolling scale removed. The testing for Critical Chloride Threshold level as detailed in Anne A of the standard is heavily dependent on consistent control of this process.

Stainless reinforcing steels can be cut, bent and processed in the same way as carbon steel, according to BS 8666.

**Mechanical properties of stainless reinforcing steels**

BS 6744:2023 specifies one grade, B500B, similar to carbon steels as detailed in BS4449:2005 + A3:2016. These grades can therefore be substituted for normal carbon steel, without significant design modification.

The term "grade" is often confused with alloy type. In BS 6744, "grade" refers only to the mechanical properties, and not to the chemical composition, which is determined by the steel type (designation).

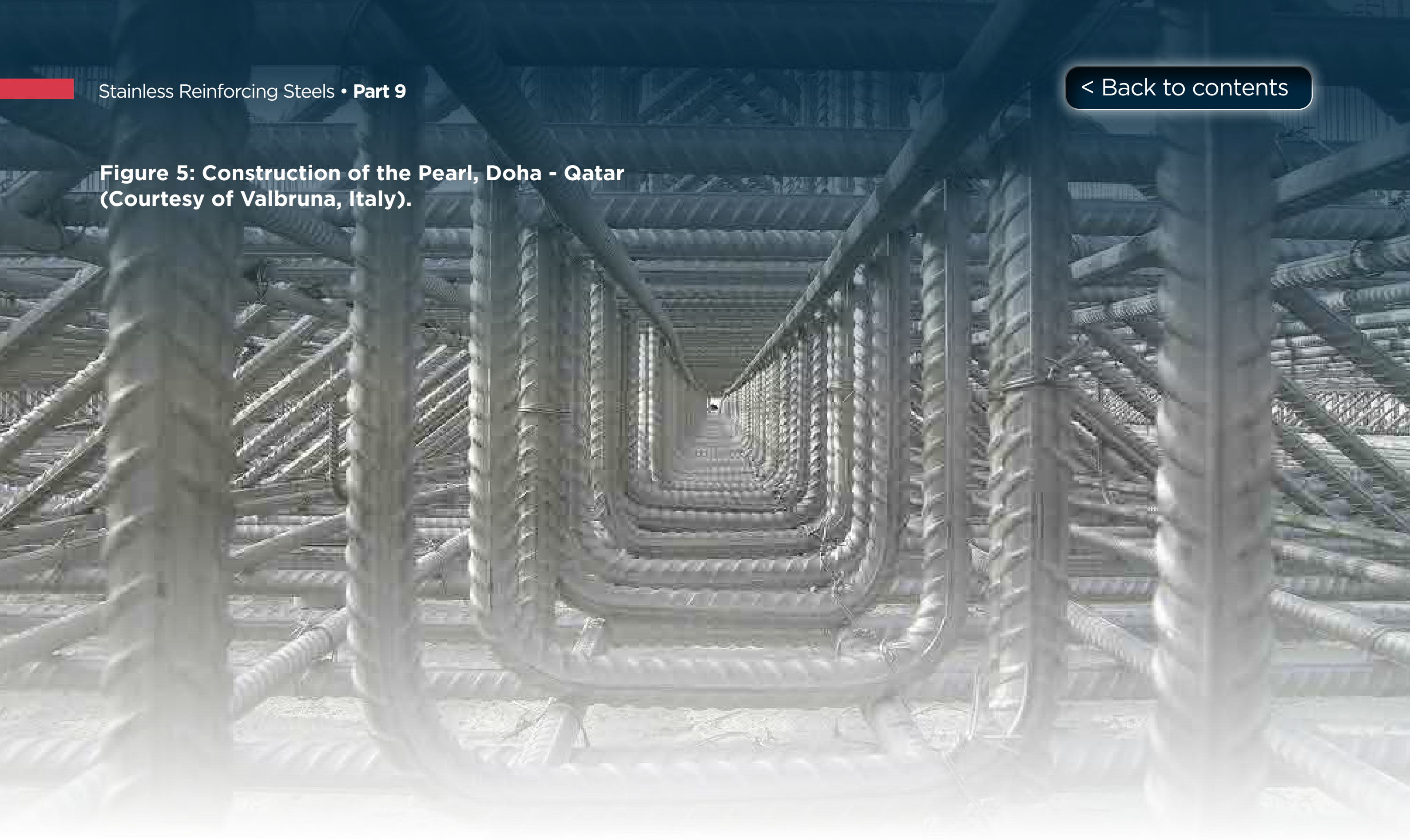

**Figure 5: Construction of the Pearl, Doha - Qatar (Courtesy of Valbruna, Italy).**

**Table 3. Typical properties of stainless reinforcing steel**

| Mechanical property | Strength grade – B500 |
|---|---|
| Characteristic yield strength Cy (MPa) - min | 500 |
| 0.2% proof strength Rp0.2 MPa - min | 500 |
| | **Ductility Class – B** |
| Minimum value of stress ratio | ≥1.08 |
| Percentage total elongation at maximum force, Agt | ≥5.0 |
| Percentage elongation after fracture, A5 | ≥14% |

Higher tensile stainless reinforcement properties may be available due to the use of duplex stainless steels, advice should be obtained from the manufacturer in their use.

Annexes I and E of BS 6744:2023 provides guidance on using the enhanced strength and ductility of stainless reinforcing steel.

Stainless reinforcing steels are “non-ageing”, because of their austenitic structure, and hence there is no requirement to perform a re-bend test. However, a bend test is included in BS 6744:2023.

The fatigue performance specified for the stainless steels in BS 6744:2023 is the same as for carbon steels in BS 4449:2015+A3:2016. This also supports that stainless steels can easily be substituted into fatigue designs based on carbon steel.

Duplex stainless-steel designations are required to undertake additional testing to check the absence of detrimental metallurgical phases in the finished condition. This test is in the form of a Charpy impact test to ensure it complies with the requirements of EN 10088 (all parts).

Apart from its corrosion resistant applications, austenitic stainless reinforcing steel can also be used in cryogenic applications, where its toughness at low temperatures is required.

**Use of stainless steels in place of carbon steel**

The most significant barrier to the use of stainless reinforcing steel is the cost. For this reason, stainless steel is normally used selectively in those parts of the structure most at risk of chloride ingress.

There are many examples and references where carbon steel reinforcing steel has been successfully and selectively replaced with stainless reinforcing steel to extend the life of the construction project. Please refer to the references as detailed at the back of this guide.

The concrete society Technical Report TR51 gives guidance on the use of stainless steel reinforcement.

# The CARES Scheme for manufacturers of stainless reinforcing steel

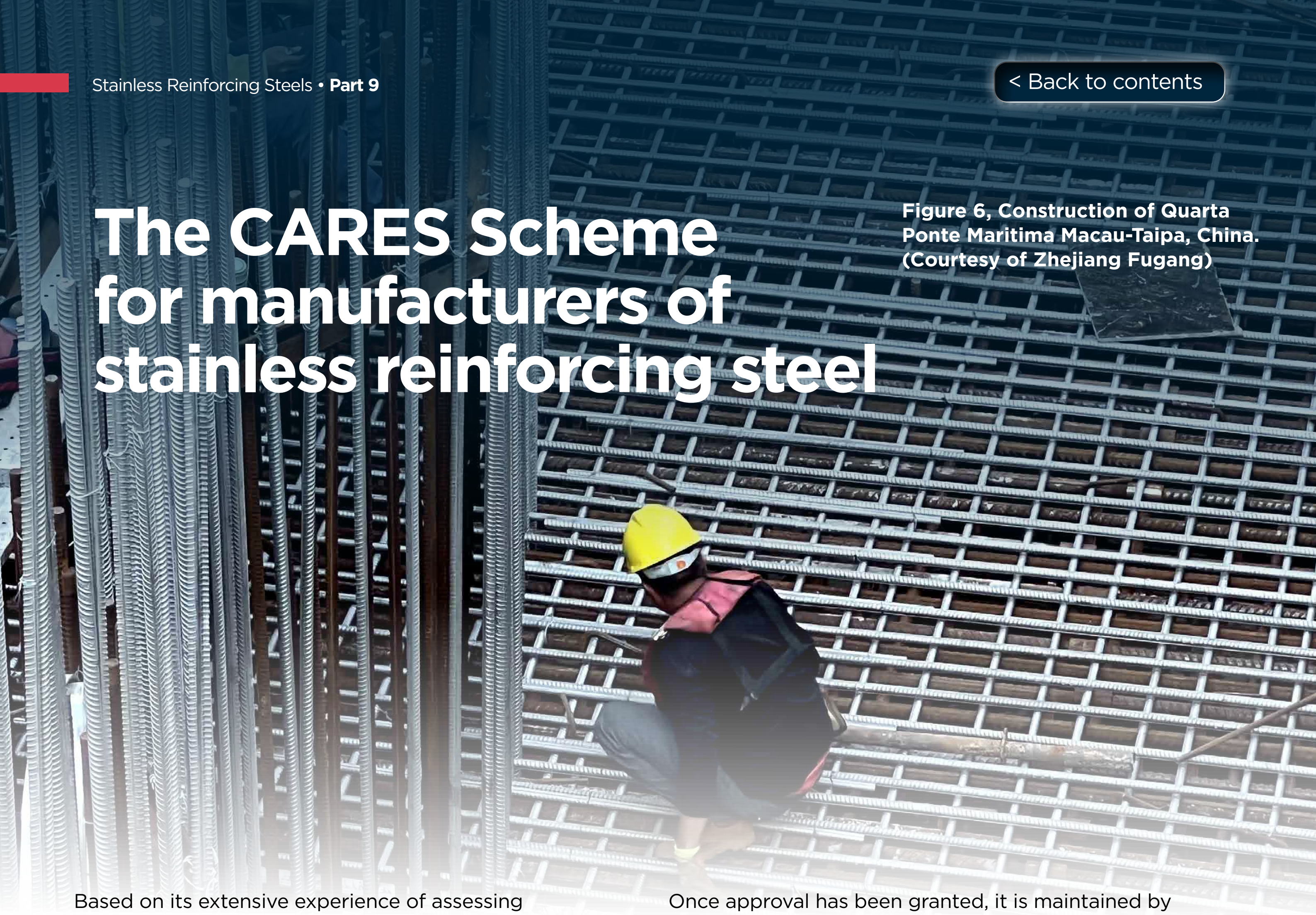

**Figure 6, Construction of Quarta Ponte Maritima Macau-Taipa, China. (Courtesy of Zhejiang Fugang)**

Based on its extensive experience of assessing manufacturing and fabricating operations for carbon steel reinforcement, CARES introduced a similar scheme for the stainless reinforcing steel sector. Two Quality and Operations Schedules are available, one for manufacturers of stainless reinforcement (CP&AS16), and one for processing and supply (CP&AS06).

The schemes provide for:

- Independently verified compliance with the specified standards (BS 6744:2023 and BS 8666:2020).
- Quality management system approval to ISO 9001:2015+A1:2024.
- Approval for the whole process route, from steelmaking, rolling, processing, fabricating to delivery to site.
- Full traceability throughout the supply chain.
- Removing the need for purchasers to have their own testing and inspection regime on site, saving time and cost.

Approval is gained by a manufacturer only after demonstrating that their quality systems meet the requirements of ISO 9001:2015+A1:2024, and the additional product-specific CARES requirements. An extensive programme of witness and independent testing also has to be passed, with independent testing being conducted by UKAS accredited laboratories to ensure integrity and competence.

Once approval has been granted, it is maintained by regular surveillance audits conducted by CARES specialist assessors. At these inspections, the system is audited, and random checks are made on product quality, by both witness and independent testing.

Approval is gained by a processor after demonstrating that their quality management system meets the requirements of ISO 9001:2015+A1:2024 and the product-specific CARES requirements. Regular surveillance visits include both quality system audits and verification of cutting and bending capability.

**The CARES Scheme- verified compliance**

The CARES scheme for stainless reinforcing steel, through its combination of auditing and independent testing throughout the supply chain, ensures compliance of stainless reinforcing steels with the specified requirements.

When using CARES approved fabricators, specifiers can be confident that all steel supplied will be from CARES approved manufacturers. The product can be used without the need for further product testing. Where CARES approved fabricators are not specified, the onus is on the purchaser to verify compliance, which may require inspection and testing involving both significant cost and potential site delays.

Stainless reinforcing steel offers designers the possibility of producing durable structures with inherent resistance to reinforcement corrosion. The CARES scheme for stainless reinforcing steels offers purchasers the confidence that the product has been produced and tested in accordance with the specification.

specification guide

# Your guide to specifying Learn how to procure CARES certified steel products

**To specify CARES certification that meets government and private sector quality assurance and responsible sourcing requirements use the text from the guide in your project specifications.**

# References


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4) "The use of stainless steel reinforcement in bridges" Report and Cost Analysis Tool British Stainless Steel Association CD ROM, 2003

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6) "Welsh engineers design durable bridges" Concrete, June 2003, Edward James

7) ISO 9001:2015+A1:2024 "Quality management systems - Requirements"

8) BRITISH STANDARDS INSTITUTION. BS 6744:2023 "Stainless steel bars for the reinforcement of and use in concrete-Requirements and test methods"

9) BRITISH STANDARDS INSTITUTION. BS 4449:2005+A3:2016 "Carbon steel bars for the reinforcement of concrete"

10) CARES "Construction Products and Associated Services Scheme - Appendix 16 - Quality and operations assessment schedule for stainless steel bar and coil for the reinforcement of concrete including inspection and testing"

11) "Behaviour of stainless steels in concrete" Pedeferri P et al in "Repair and rehabilitation of reinforced structures: the state of the art." Ed Selva Araya, W F et al American Society of Civil Engineers 1998 pp 192-206

12) BRITISH STANDARDS INSTITUTION. BS EN 10088-3:2023 "Stainless Steels-Part 3; Technical delivery conditions for semi-finished products, bars, rods and sections for general purposes.

13) BRITISH STANDARDS INSTITUTION. BS 8666:2000 "Specification for scheduling, dimensioning, bending and cutting of steel reinforcement for concrete

14) CARES "Construction Products and Associated Services Scheme - Appendix 6 - Quality and operations assessment schedule for the processing and/or supply of stainless steel products for the reinforcement and use in concrete"

15) NATIONAL HIGHWAYS Manual of contract documents for Highways Works Volume 1: SPECIFICATION FOR HIGHWAY WORKS (Series 1700, clause 1713)


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