

BS 6744:2016



BSI Standards Publication

Stainless steel bars – Reinforcement of concrete – Requirements and test methods



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Contents

Introduction by Lee Brankley, CEO, CARES *iii*

Foreword *iv*

1	Scope	1
2	Normative references	1
3	Terms, definitions and symbols	2
4	Designation	7
5	Standard diameters	7
6	Dimensions, mass and tolerances	8
7	Steelmaking process	9
8	Chemical composition	9
9	Surface quality	9
10	Surface geometry	9
11	Conditions of supply	12
12	Mechanical and physical properties	12
13	Product identification	16

Annexes

Annex A (normative)	Test method for determining the corrosion resistance of stainless reinforcing steel in chloride contaminated concrete	17
Annex B (informative)	Guidance on durability	19
Annex C (informative)	Guidance on magnetic properties	25
Annex D (informative)	Guidance on coefficients of thermal expansion	26
Annex E (normative)	Design guidance: constitutive relationship	26
Annex F (informative)	Guidance on welding	29
Annex G (normative)	Performance at elevated temperatures	30
Annex H (informative)	Quality assurance	30
Annex I (informative)	High-strength bars	33

Bibliography 34

List of figures

Figure 1	– 0.2% proof test	2
Figure 2	– Typical stress-strain curve (relation) for stainless reinforcing	5
Figure A.1	– Geometry of the specimens	18
Figure B.1	– Example predictive model indicating where carbon steel reinforcement can be replaced by stainless steel reinforcement for a given chloride surface content, design life and reinforcement depth	24
Figure E.1	– Idealized design curve from BS EN 1992-1-1:2004+A1:2014	27
Figure E.2	– The constitutive law of stainless reinforcing steel	28
Figure E.3	– Example of design model for stainless reinforcing steel	29

List of tables

Table 1	– Symbols	6
Table 2	– Standard diameters	7
Table 3	– Nominal cross-sectional area of reinforcing steel and nominal mass per metre run	8
Table 4	– Tolerances on mass per metre run	8
Table 5	– Chemical composition (cast analysis)% by mass of typical, commercially available BS EN 10088 stainless reinforcing steel designations	10
Table 6	– Minimum relative rib area, f_{Rmin}	11
Table 7	– Ranges for the rib parameters	11
Table 8	– Strength and ductility properties	14
Table 9	– Bend test formers	14

Table B.1 – Prescriptive guidance advice	22
Table D.1 – Comparative thermal coefficient of expansion data	26
Table E.1 – Young’s modulus for stainless reinforcing steel	27
Table H.1 – Acceptability index, k , as a function of the number of test results, n , for a reliable failure rate of 5% (pass = 0.95) at a probability of 90% ($1 - \alpha = 0.90$)	31

Summary of pages

This document comprises a front cover, an inside front cover, pages i to vi, pages 1 to 36, an inside back cover and a back cover.

Introduction by Lee Brankley, CEO, CARES

BS 6744 is widely specified, both in the UK and internationally. I believe that British Standards remain the choice of informed construction procurement teams because they are performance-based and are developed in partnership with industry.

CARES welcomes the publication by the British Standards Institution of BS 6744:2016, *Stainless steel bars – Reinforcement of concrete – Requirements and test methods*, which was developed by Technical Committee ISE/104 with contributions and support from CARES. Its content forms an essential part of the technical framework used to improve the durability of reinforced concrete structures in chloride containing environments.

I am pleased to introduce BS 6744:2016 and commend its performance-based approach which will make a valuable contribution to the appropriate use of stainless steel reinforcing bar in the UK and internationally.

Developments in the field of the measurement of corrosion resistance and durability guidance have been taken into account during the development of BS 6744:2016. The test method for determining the corrosion resistance of stainless reinforcing steel in chloride contaminated concrete and the guidance on the durability aspects of the corrosion resistance of the reinforcement will be useful tools for engineers.

The 2016 update will help to maintain BS 6744's pre-eminent position in the UK and, more importantly, internationally, as the preferred choice of standard when stainless steel reinforcing is required.

Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 May 2016. It was prepared by Technical Committee ISE/104, *Concrete Reinforcing and Pre-Stressing Steels*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This British Standard supersedes BS 6744:2001+A2:2009, which is withdrawn.

Information about this document

Attention is drawn to the fact that compliance with this document might involve the use of patents applied to steel designation 1.4162 (see 3.1.24). The patent holder agrees to make the material available for production of stainless reinforcing steel bars on reasonable and accessible and non-discriminatory terms. Information on designation 1.4162 may be obtained from: Outokumpu Stainless Ltd, Europa Link, Sheffield, South Yorkshire S9 1TZ.

This standard has been revised so that it can be used in conjunction with BS 8666, *Scheduling, dimensioning, bending and cutting of steel reinforcement for concrete – Specification*, but also to take into account the requirements of Eurocode (EC) 2 (specifically BS EN 1992-1-1 and BS EN 1992-1-2) and the Construction Products Regulations (CPR) [1] with respect to constitutive relationship and durability. It has also been revised to act as the national application standard for BS EN 104031, *Steel for the reinforcement of concrete – Stainless steels* (in preparation).

The decision was taken to remove other uses of steel in concrete, which means that plain bars and grades 200 MPa and ribbed bars above grade 500 MPa are no longer covered by this standard. These products are covered by other standards. This is with the exception of 500 MPa bar and 650 MPa ribbed bar which are now in an informative Annex (Annex I). The standard is open to other strength grades of ribbed bar on the basis that the designers know that these are outside normal UK practice and, once over 600 MPa, outside EC2.

Informative annexes have been prepared to give guidance on durability, magnetic properties, coefficients of thermal expansion, constitutive relationship, welding, performance at elevated temperatures and quality assurance. As far as is possible, the revision has been written to reflect the requirements of BS 4449.

The test method in Annex A is based on the method in BS EN 480-14 adapted by Schönning, Randström and Adair for determining a critical chloride threshold level for stainless steel rebar [2] and that in *Testing for chloride threshold levels of stainless reinforcing bar* [3].

Copyright is claimed on Figure B.1. Copyright holders are Ove Arup & Partners Ltd, 13 Fitzroy Street, London W1T 4BQ.

Product certification/inspection/testing. Users of this British Standard are advised to consider the desirability of third-party certification/inspection/testing of product conformity to this British Standard. Appropriate conformity attestation arrangements are described in BS EN ISO/IEC 17065. Users seeking assistance in identifying appropriate conformity assessment bodies or schemes may ask BSI to forward their enquiries to the relevant association.

Use of this document

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is "shall".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

This British Standard specifies requirements and test methods for solid stainless steel bars used for the reinforcement of concrete. It is applicable to ribbed stainless reinforcing steel bars in grade 500.

It is applicable to bars in which the ribs have been formed by the cold working or hot rolling processes.

NOTE Annex A specifies a test method for determining the corrosion resistance of stainless reinforcing steel in chloride contaminated concrete. Informative annexes give guidance on durability (Annex B), magnetic properties (Annex C), coefficients of thermal expansion (Annex D), constitutive relationship (Annex E), welding (Annex F), performance at elevated temperatures (Annex G) and quality assurance (Annex H).

This British Standard is not applicable to stainless reinforcing steel bars produced from material whose metallurgical history is not known and fully documented.

It is not applicable to other uses of steel in concrete, such as plain bars and grades 200 MPa and ribbed bars above grade 500 MPa, which are covered by other standards. This is with the exception of 500 MPa bar and 650 MPa ribbed bar which are now in an informative annex (Annex I). The standard is open to other strength grades of ribbed bar on the basis that the designers know that these are outside normal UK practice and, once over 600 MPa, outside BS EN 1992 (EC2).

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 8666, *Scheduling, dimensioning, bending and cutting of steel reinforcement for concrete – Specification*

BS EN 196-1, *Methods of testing cement – Part 1: Determination of strength*

BS EN 1993-1-2:2005, *Eurocode 3 – Design of steel structures – Part 1-2: General rules – Structural fire design*

BS EN 10088 (all parts), *Stainless steels*

BS EN ISO 148-1, *Metallic materials – Charpy pendulum impact test – Part 1: Test method*

BS EN ISO 3651-2, *Determination of resistance to intergranular corrosion of stainless steels – Part 2: Ferritic, austenitic and ferritic-austenitic (duplex) stainless steels – Corrosion test in media containing sulfuric acid*

BS EN ISO 6892-2, *Metallic materials – Tensile testing – Part 2: Method of test at elevated temperature*

BS EN ISO 15630-1:2010, *Steel for the reinforcement and prestressing of concrete – Test methods – Part 1: Reinforcing bars, wire rod and wire*

3 Terms, definitions and symbols

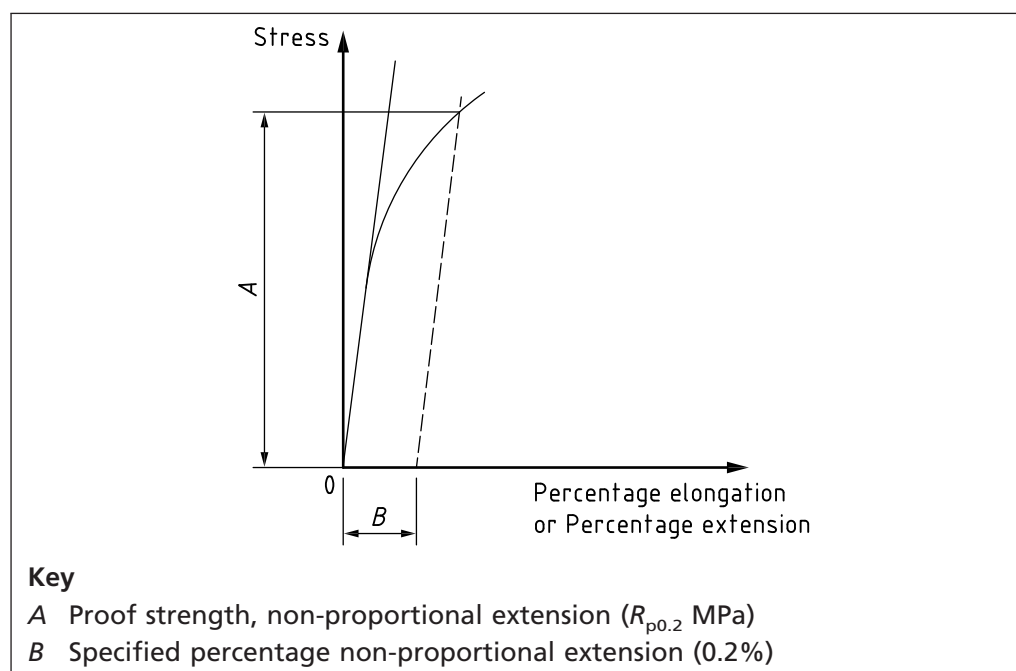
3.1 Terms and definitions

For the purposes of this British Standard, the terms, definitions and symbols given in BS EN 10088 (all parts), BS EN ISO 15630-1 and the following apply.

3.1.1 0.2% proof strength, $R_{p0.2}$

stress at which a non-proportional extension is equal to 0.2% of the extensometer gauge length (see Figure 1)

Figure 1 0.2% proof test



3.1.2 bar

product of ribbed cross section

3.1.3 batch

quantity of reinforcing steel processed from an identical heat or cast, diameter or designation, processed in the same production lot under the same process conditions

3.1.4 bundle

one coil or a number of lengths bound together

3.1.5 cast (heat) analysis

chemical analysis representative of the cast (heat) determined by the steelmaker at their discretion in a manner of their choice

3.1.6 characteristic value, C_v

value of a material or product property having a prescribed probability of not being attained in a hypothetical unlimited test series

NOTE This value generally corresponds to a specific fractile of the assumed statistical distribution of the particular property of the material or product.

- 3.1.7 characteristic yield strength, f_{yk}**
value of the proof stress, having a prescribed probability of not being attained in a hypothetical unlimited test series the characteristic value of which is the lower limit of the one-sided statistical tolerance interval at which there is a 90% probability (i.e. $1 - \alpha = 0.90$) that 95% ($p = 0.95$) of the values are at or above this lower limit

NOTE This definition refers to the long-term quality level of production.

- 3.1.8 coil**
continuous hot rolled or cold worked bar in the form of a coil

NOTE This includes coils welded together to produce a single coiled length.

- 3.1.9 cold worked ribbed stainless reinforcing steel bar**
ribbed bar that has been cold worked

- 3.1.10 critical chloride threshold value**
maximum concentration of chlorides by mass of cement that causes no visible pitting corrosion of reinforcement in the test sample

NOTE Sometimes referred to as "chloride threshold level", "critical chloride content" or "chloride threshold concentration".

- 3.1.11 decoiled product**
reinforcing steel manufactured in coils and subsequently straightened for further processing

- 3.1.12 hot rolled ribbed stainless reinforcing steel bar**
ribbed bar that has been hot worked

- 3.1.13 length**
piece of nominally straight bar cut to a specified length

- 3.1.14 longitudinal rib**
uniform continuous protrusion parallel to the axis of the bar

- 3.1.15 manufacturer**
organization that produces stainless reinforcing steel
NOTE A manufacturer can be a steelmaker, re-roller or a cold worker.

- 3.1.16 maximum value**
value which no test result is permitted to exceed

- 3.1.17 minimum value**
value below which no test result is permitted to fall

- 3.1.18 nominal cross-sectional area, A_n**
cross-sectional area equivalent to the area of a circular plain bar of the same nominal diameter, d , i.e.:

$$\frac{\pi d^2}{4}$$

- 3.1.19 nominal diameter, d**
diameter of a circle with an area equal to the effective cross-sectional area of the bar

NOTE See Clause 5 and Clause 6.

3.1.20 product analysis

chemical analysis carried out on a sample of the product

3.1.21 purchaser

organization that purchases the product for use in reinforced concrete production

3.1.22 reinforcing steel

steel product, in bar or coil form, with a circular or practically circular cross section which is suitable for the reinforcement of concrete

3.1.23 reinforcing steel designation

indication of chemical composition of steel

NOTE See Clause 8.

3.1.24 reinforcing steel grade

steel grade defined by its characteristic proof strength

3.1.25 relative rib area, f_R

area of the projections of all ribs on a plane perpendicular to the longitudinal axis of the wire, bar or rod, divided by the wire length and the nominal circumference

3.1.26 rib height, $\alpha_{\max}$

distance from the highest point of the rib (transverse or longitudinal) to the surface of the core

NOTE See BS EN ISO 15630-1.

3.1.27 rib spacing, c

distance between the centres of two consecutive transverse ribs, measured parallel to the axis of the bar

NOTE See BS EN ISO 15630-1.

3.1.28 stress ratio, σ_f

tensile strength, R_m , divided by 0.2% proof strength, $R_{p0.2}$ (see Figure 2)

3.1.29 supplier

organization supplying reinforcing steel to an end user

NOTE The product may be supplied in straight lengths or fabricated in accordance with BS 8666.

3.1.30 transverse rib

rib on the surface of the bar other than a longitudinal rib

3.1.31 transverse rib flank inclination, α

angle between the rib flank and the longitudinal axis of the bar

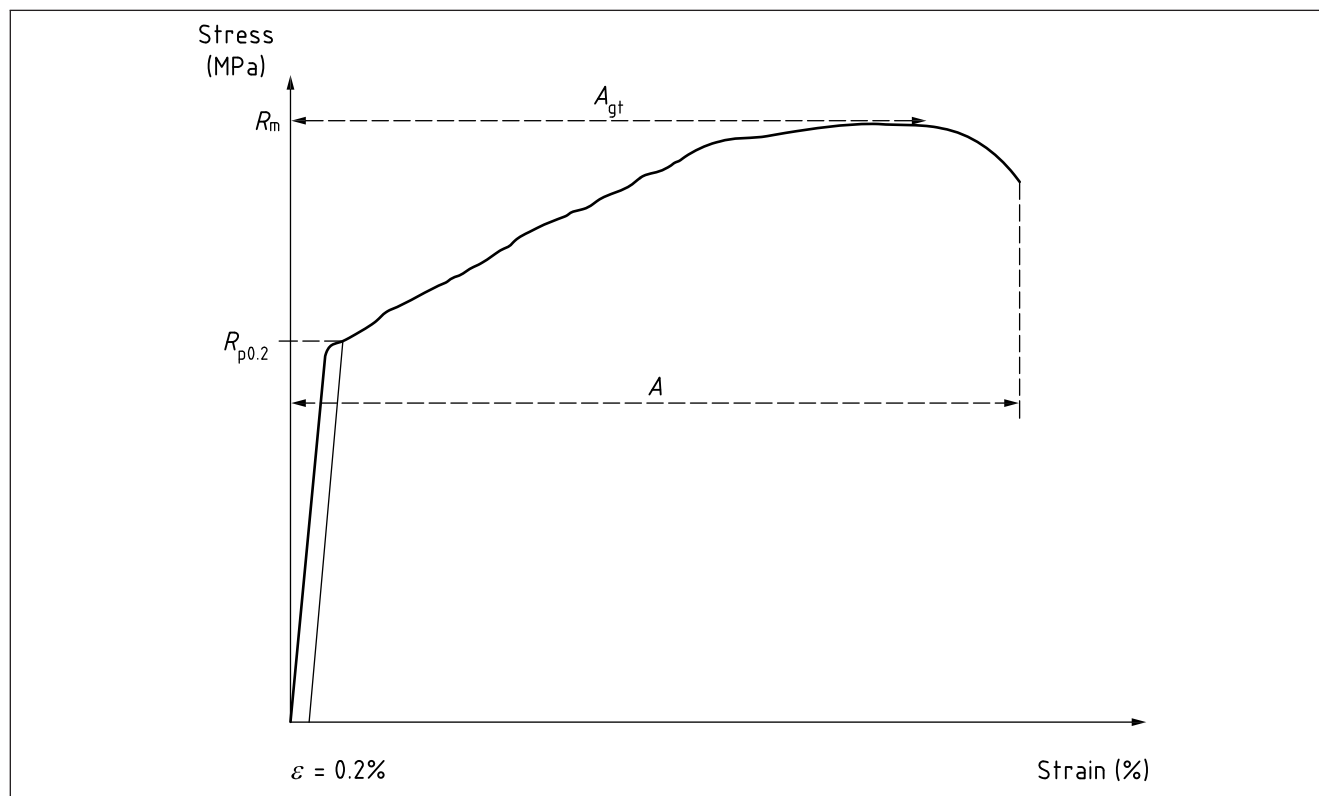
NOTE See BS EN ISO 15630-1.

3.1.32 transverse rib inclination, β

angle between the axis of the transverse rib and the longitudinal axis of the bar

NOTE See BS EN ISO 15630-1.

Figure 2 Typical stress-strain curve (relation) for stainless reinforcing



3.2 Symbols

The symbols used in this British Standard are described in Table 1.

Table 1 Symbols (1 of 2)

Symbol	Unit	Description
A_{gt}	–	Percentage total elongation at maximum force
A_n	mm	Nominal cross-sectional area of the bar
A_5	–	Percentage elongation after fracture using an original gauge length of 5 times the nominal diameter
$CI_{field} \%$	%	Theoretical conversion from laboratory test to actual field performance (not covered in this British Standard)
$CI_{test} \%$	%	Percentage of chlorides added to the test method the stainless steel reinforcement was exposed to
C_v	–	Characteristic value
CCTL%	%	Maximum amount of chlorides by mass of cement to which reinforcement can resist pitting
c	mm	Transverse rib spacing
D	mm	Diameter of cylindrical mortar test block
d	mm	Nominal diameter of the bar
E_o	GPa	Initial modulus of elasticity
E_s	GPa	Modulus of elasticity
E_t	GPa	Tangent modulus of elasticity
E_0	–	A Ramberg-Osgood fitting parameter resembling the elastic modulus
f_p	MPa	Proportional limit
f_R	–	Relative rib area
f_t	MPa	Tensile strength of carbon steel reinforcement
f_y	MPa	Yield strength, 0.2% proof strength
f_{yd}	MPa	Design yield strength of reinforcement
f_{yk}	MPa	Characteristic yield strength of reinforcement
H	mm	Height of cylindrical mortar test block
l	mm	Exposed length of the bar in mortar test block (see Annex B)
k	–	Acceptability index
L	m	Length of bar sample
M_{mR}	kg/m	Mass per metre run of bar
M	kg	Mass of bar sample
m	–	Average of a population of results
N	–	Class N values
n	–	A Ramberg-Osgood fitting parameter related to the strain hardening
R_m	MPa	Tensile strength of stainless steel reinforcement
$R_{p0.2}$	MPa	0.2% proof strength, non-proportional extension
S	–	Standard deviation of a population of results
α	°	Transverse rib flank inclination
$\alpha_{max}^{A)}$	mm	Maximum height of transverse rib
α_{R-O}	–	A Ramberg-Osgood fitting parameter where $\alpha_{R-O} \approx (0.002 \cdot E_0) / \sigma_0$ for stainless reinforcing steel
β	°	Transverse rib inclination: angle between the axis of a transverse rib and the bar axis
ε	%	The Ramberg-Osberg modelled strain
ε_{ud}	%	Design strain of reinforcement
ε_{uk}	%	Characteristic strain of reinforcement at maximum load
γ_s	–	Partial factor for stainless reinforcing steel
μ_r	–	Relative magnetic permeability
σ	–	The Ramberg-Osgood modelled stress
σ_f	–	Stress ratio ($R_m / R_{p0.2}$)