British Standard

BRITISH STANDARD

BS 4486:1980

Incorporating
Amendment No. 1

Specification for

Hot rolled and hot rolled and processed high tensile alloy steel bars for the prestressing of concrete

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Cooperating organizations

The Iron and Steel Standards Committee, under whose direction this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

British Cast Iron Research Association
British Constructional Steelwork Association
British Internal Combustion Engine Manufacturers' Association
British Ironfounders' Association
British Railways Board
British Shipbuilders
British Steel Industry*
British Steel Industry — Wire Section*
Concrete Society Limited*
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Steel Casting Research and Trade Association
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The organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

British Steel Corporation
British Precast Concrete Federation Ltd.
Cement and Concrete Association
Concrete Pipe Association
Department of the Environment (PSA)
Prestressing Equipment Manufacturing Association
Individual expert

This British Standard, having been prepared under the direction of the Iron and Steel Standards Committee, was published under the authority of the Executive Board and comes into effect on 31 March 1980

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The following BSI references relate to the work on this standard:
Committee reference ISM/9 (formerly ISE/9)
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Contents

Foreword

This British Standard, prepared under the direction of the Iron and Steel Standards Committee, was first published in 1969, and specifies requirements for cold worked high tensile alloy steel bars used in prestressed concrete. During the period since 1969, the European Coal and Steel Community in Project Group 101 generated Euronorm 138 "Prestressing steels".

This revision of BS 4486:1969 for hot rolled and hot rolled and processed high tensile steel bars for the prestressing of concrete supersedes the 1969 issue and it closely follows the appropriate parts of Euronorm 138, but some minor changes have been made in order to make it applicable to the requirements of the United Kingdom. Requirements for high tensile steel wire and strand for the prestressing of concrete are specified in BS 5896.

Product certification. Users of this British Standard are advised to consider the desirability of third party certification of product conformity with this British Standard based on testing and continuing surveillance, which may be coupled with assessment of a supplier's quality system against the appropriate Part of BS 5750.

Enquiries as to the availability of third party certification schemes will be forwarded by BSI to the Association of Certification Bodies. If a third party certification scheme does not already exist, users should consider approaching an appropriate body from the list of association members.

NOTE Attention is drawn to the requirements in **9.2** for material covered by a certification scheme.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 6, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This British Standard specifies requirements for preferred sizes of smooth or deformed alloy steel bars in straight lengths supplied in the hot rolled or hot rolled and processed conditions. Two nominal strength levels of steel are specified. This standard does not specify fatigue testing, this subject being included in BS 4447. Stress-corrosion testing is not specified.

2 References

The titles of the publications referred to in this standard are listed on the inside back cover.

3 Definitions

For the purposes of this British Standard, the following definitions apply.

3.1
cast

usually the product of a single furnace charge. Where the furnace contents are tapped into two or more ladles, the product of each ladle may be called a separate cast

3.2
bar

a steel product produced in straight lengths by hot rolling of steel and which may be smooth or deformed. Processed bars are bars subsequently processed by stretching or other forms of cold working, and which also may have an additional tempering treatment to give the required properties

3.3
bar tendon

a bar used in prestressed concrete

3.4
nominal size

the diameter of a nominally round bar. For deformed bar the nominal size is the diameter of a round bar of the same cross-sectional area

3.5
length

a piece of straight bar, without joint, cut to a specified length

3.6
batch

a number of lengths of one nominal size from one cast

3.7
consignment

any quantity of material prepared at any one time for delivery to one location

4 Designation for enquiry and order purposes

4.1 When ordering material to this standard, the purchaser shall state:

a) the number of this British Standard, i.e. BS 4486;

b) type of surface, i.e. smooth or deformed;

c) nominal size;

d) nominal tensile strength;

e) packing and protection requirements.

4.2 The bars shall be designated as follows:

a) BS 4486;

b) RE = smooth, RR = deformed;

c) nominal diameter;

d) nominal tensile strength.

Example. A round smooth bar of 32 mm nominal diameter and 1 030 N/mm^2 nominal tensile strength is designated BS 4486-RE-32-1030.

5 Manufacture

5.1 Unless the process is specified by the purchaser in his order, the steel may be made by any process except that the air, and mixed air/oxygen bottom blown basic converter processes shall not be used.

5.2 The steel shall be hot rolled into bars. Subsequent processing may be required to achieve the specified mechanical properties. Such processing may take the form of cold working by stretching and additional tempering treatment may follow such cold working.

5.3 The cast analysis shall not show more than 0.040 % sulphur or more than 0.040 % phosphorus.

5.4 If required by the purchaser, a chemical analysis of the steel shall be provided by the supplier.

5.5 When deformed bars are supplied, the deformation shall be transversed with a substantially uniform spacing not greater than 0.8 nominal size; this applies to continuous or discontinuous helical deformations, where present. The deformation shall be in the form of ribs or of a thread. The mean area of ribs or thread per unit length above the core of the bar, projected on a plane normal to the axis of the bar, shall not be less than (0.15 nominal size) mm^2 per mm of bar length.

5.6 Where bars are threaded after processing, the thread shall be cold rolled. When used with suitably designed components, threads shall be capable of compliance with the requirements of BS 4447 and note 4 of Table 1.

5.7 The finished material shall be free from defects, which may have occurred at any stage during manufacture, to a degree that would impair the performance as a prestressing bar. Longitudinal cracks that do not impair the specified properties of the bar shall not be considered as a defect.

5.8 Production lengths shall contain no welds. All bars shall be protected at all stages of manufacture from the effects of local heat, whether by weld splash or other accidental means.

The manufacturer shall give adequate protection to prevent corrosion and damage to bars before delivery to the purchaser. In particular, threaded ends shall be treated to retain a film of lubricating oil on threads.

NOTE Coatings for specific purposes are to be applied to the surface of the steel only if previously agreed between the manufacturer and the purchaser. Such coatings are not specified in this standard.

6 Mass of processed bar tendons

6.1 The mass of bar tendons shall be calculated on the basis that the density of steel is 7 850 kg/m^3.

6.2 Where bars are ordered and supplied by mass, the mass of finished bar tendons shall not differ from the mass calculated on the nominal diameter by more than the tolerances shown in Table 1.

7 Dimensions and properties

7.1 Dimensions. The dimensions of bars shall be in accordance with Table 1.

7.2 Properties

7.2.1 *General*. Bar design data, tolerances and specified properties of bars shall be in accordance with Table 1 and their mechanical properties shall be in accordance with **7.2.2**, **7.2.3** and **7.2.4**.

7.2.2 *Specified characteristic value*. In this standard specified characteristic values are shown as specified characteristic breaking loads and specified characteristic 0.1 % proof loads.

For prestressing steel the specified characteristic value is the lower limit of the one sided statistical tolerance interval for which there is a 95 % probability that at least 95 % of the values will be equal to or greater than this lower limit. For the practical application of this criterion it is arbitrarily assumed that the distribution is normal (BS 2846-3 refers).

In manufacturer's inspection the criterion may be considered to be met if, in each homogenous production lot, not more than 5 % of the test results are less than the specified characteristic value and no test result is less than 95 % of this value.

7.2.3 *Maximum standard deviation*. For the statistical interpretation of data (see **9.3.4**) a maximum standard deviation is given for breaking load and 0.1 % proof load.

The maximum standard deviation is the maximum value of the standard deviation based on the entire production of one manufacturer for a sufficiently long period using the same process and technique.

Specified characteristic values associated with maximum standard deviations indicate the desired level and degree of consistency of the property under consideration.

The maximum standard deviations specified are intended for application in:

a) manufacturer's inspection for the verification of the degree of consistency of the production; and

b) acceptance tests of material not covered by a certification scheme, for comparison with the standard deviation of the sample in accordance with **9.3.4**.

7.2.4 *Elongation*. The percentage elongation after fracture shall be determined on a gauge length of $5.65\sqrt{S_o}$, where S_o is the original cross-sectional area of the gauge length.

8 Periodic tests

8.1 Relaxation at constant strain. Curves for relaxation of load shall be established at a temperature of 20 ± 2 °C for a period of 1 000 h from initial loads of 60 %, 70 % and 80 % of the breaking load determined on an adjacent test piece. The initial load shall be applied uniformly over a period of not more than 5 min. Thereafter the gauge length shall be maintained constant and load relaxation readings shall commence 1 min after the application of the total load.

NOTE Where stress-corrosion testing is required, this should be agreed between the manufacturer and the purchaser, and is not specified in this standard.

9 Routine testing and inspection

Procedures for the following are specified in this clause:

Manufacturer's inspection.

Material covered by a certification scheme.

Material not covered by a certification scheme.

9.1 Manufacturer's inspection

9.1.1 The manufacturer shall carry out an inspection for the properties listed in **9.1.3**. The unit of production from which test pieces are selected shall be the cast and tests shall be carried out on 20 test pieces from every unit.

9.1.2 The test pieces shall be taken from the ends of processed bars or from cut-off lengths produced during processing and they shall be suitably identified with the batch from which they were taken. The length of any test piece shall be sufficient to provide a distance between grips of 20 times the nominal size of the bar.

9.1.3 The following properties shall be determined for each test piece.

a) Geometrical properties.

b) Breaking load.

c) Proof load.

d) Elongation at fracture.

e) Modulus of elasticity over the appropriate stress range.

9.1.4 Tensile tests shall be carried out on the full section of the bar without machining. The breaking load, 0.1 % proof load and percentage elongation of the steel shall be determined in accordance with BS 18-2. The rate of loading when approaching the proof load shall not exceed 10 N/mm^2 per second. For the routine testing, the 0.1 % proof load may be taken as the load at 0.6 % total strain.

9.1.5 Tests on stress relaxation shall be carried out periodically on the minimum number of samples and the values shall be in accordance with Table 1.

9.1.6 Products with test results in accordance with the values specified in Table 1 shall be considered to comply with the requirements of this standard.

9.2 Material covered by a certification scheme

9.2.1 *Certification*. Where the manufacturer and his products are required to be approved under a certification scheme acceptable to the purchaser, control procedures shall be carried out to the satisfaction of the certifying authority.

9.2.2 *Test certificates*. Each consignment shall be accompanied by a test certificate containing:

a) all the information necessary to identify the consignment;

b) a summary of the relevant test results from the manufacturer's records;

c) the modulus of elasticity at 70 % of the specified characteristic strength.

9.2.3 *Compliance*. The consignment shall be deemed to comply with the requirements of this standard on the basis of the manufacturer's test certificate, normally without the need for further testing. This does not preclude the purchaser's option to carry out further tests to verify that the specified properties have been obtained.

9.3 Material not covered by a certification scheme

9.3.1 *Documentation*. Documentary evidence of manufacturer's ability to comply with the requirements of this standard is required as follows.

The manufacturer shall provide a survey of his recent inspection tests for all the properties appropriate to the product specified in this standard. If the manufacturer has not previously or recently supplied material to this standard, by agreement with the purchaser recent data on material to a similar specification may be submitted.

Data on long-term behaviour normally covered by periodical testing may be taken from manufacturer's records of tests on recent productions of similar material.

9.3.2 *Inspection of consignments*. Each separate consignment shall be subject to inspection by the manufacturer in accordance with **9.1** with the exception of the tests for long-term behaviour.

9.3.3 *Test certificates*. Each consignment shall be accompanied by a test certificate containing:

a) all the information necessary to identify the consignment;

b) all the test results obtained in testing the consignment;

c) load-extension diagrams covering the testing of materials used to make up the consignment;

d) cast analysis of the steel.

9.3.4 *Acceptance*. If the purchaser is satisfied with the manufacturer's ability to supply material that complies with the requirements of this standard, but wishes to have further or independent inspection in addition to that given by the manufacturer's test certificate, the details shall be agreed at the time of ordering the material.

Such purchasers' acceptance tests for the properties listed in **9.1** shall be made on a sample selected as follows. The unit of production from which a test piece is selected shall be 5 t. The consignment shall be divided into inspection lots of 100 t and a test piece shall be selected from each unit in a random selection of 15 units of production in the inspection lot. If there are less than 15 units in the lot, then additional test pieces shall be taken from separate bars sufficient to make up the required number.

Analysis of the results of the breaking load and proof load tests made on the sample shall show compliance with the specified characteristic values and maximum standard deviation specified in this standard. Statistical interpretation of data shall be in accordance with Table 3 of BS 2846-3:1975 and Table E of BS 2846-4:1976 both for one-sided tolerance interval of 0.95 and for confidence level 0.95.

For all other properties, all test results shall show compliance with the requirements of this standard.

9.4 Retests

9.4.1 *Tests for compliance with specified characteristic values*. No retests are allowed, except where there has been a malfunction in the test procedure.

9.4.2 *Tests for compliance with all other mechanical properties*

a) *Manufacturer's inspection*. If any test piece fails any of the other specified mechanical tests, two additional test pieces shall be taken from the same unit of production. These test pieces shall be subjected to the same test or tests that the original test piece failed. If both test pieces pass the tests then that unit of production shall be deemed to comply with the requirements of this standard. If one of the retest pieces fails then the unit of production shall be deemed not to comply with this standard.

b) *Purchaser's testing of non-certified material*. For material inspected according to **9.3.4**, if any test piece fails, the purchaser's inspection lot shall be deemed not to comply with the requirements of this standard until the same test or tests have been satisfactorily completed on a further random selection of 15 units of production in the inspection lot.

Table 1 — Dimensions and properties of hot rolled and hot rolled and processed high tensile alloy steel bars

Type of bar	Nominal size (see note 1)	Nominal tensile strength (see note 1)	Surface	Nominal 0.1 % proof stress	Nominal cross-sectional area (see note 2)	Nominal mass (see note 2)	Tolerance		Specified properties			Maximum relaxation as 1 000 h	
							On smooth bar dia. (see note 3)	On section and mass	Characteristic breaking load (see note 4)	Characteristic 0.1 % proof load	Minimum elongation at fracture (see note 6)	Initial load as % of actual breaking load	Value
	mm	N/mm^2		N/mm^2	mm^2	kg/m		%	kN	kN		%	%
Hot rolled or hot rolled and processed	26.5 32 36 40	1 030	Smooth or deformed	835	522 804 1 018 1 257	4.33 6.31 7.99 9.86	Range 0.6 mm for all sizes	Batch + 4 % – 2 % Individual bar + 6 % – 2 %	568 830 1 048 1 300	460 670 850 1 050	6	For all bars 60 70 80	For all bars 1.5 3.5 6.0

NOTE 1 The nominal size of bar and nominal tensile strength data are given for designation purposes only.

NOTE 2 The nominal cross-sectional area and nominal mass data are given for information only.

NOTE 3 The diameter tolerance does not apply to deformed bars.

NOTE 4 The load carried by the threaded portion of smooth bars is not to be less than the specified characteristic load.

NOTE 5 The modulus of elasticity may be taken as:
205 ± 10 kN/mm^2 for as rolled and as rolled stretched and tempered bars,
165 ± 12 kN/mm^2 for as rolled and stretched bars.

The value for a particular consignment is to be provided on request.

NOTE 6 The minimum elongation at fracture is measured on gauge length of $5.65\sqrt{S_0}$ where S_0 is the original cross-sectional area of the gauge length. If measurement of extension under load is possible, the minimum elongation at maximum load is to be 3.5 %. The actual elongation at maximum load need not be measured.

NOTE 7 The maximum standard deviations (see **7.2.3**) expressed as equivalent stress values of load for the various bar sizes are as follows:
Nominal tensile strength: 55 N/mm^2;
Nominal 0.1 % proof stress: 60 N/mm^2.

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Publications referred to

BS 18, *Methods for tensile testing of metals.*
BS 18-2, *Steel (general).*
BS 2846, *Guide to statistical interpretation of data.*
BS 2846-3, *Determination of a statistical tolerance interval.*
BS 2846-4, *Techniques of estimation and tests relating to means and variances.*
BS 4447, *The performance of prestressing anchorages for post-tensioned construction.*
BS 5896, *Specification for high tensile steel wire and strand for the prestressing of concrete.*
Euronorm 138, *Prestressing steels.*

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