
**Steel for the prestressing of
concrete —**

**Part 4:
Strand**

*Acier pour armatures de précontrainte —
Partie 4: Torons*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 16, *Steels for the reinforcement and prestressing of concrete*.

This second edition cancels and replaces the first edition (ISO 6934-4:1991), which has been technically revised. It also incorporates the Technical Corrigenda ISO 6934-4:1991/Cor 1:1992 and ISO 6934-4:1991/Cor 1:2000.

The main changes compared to the previous edition are as follows:

- subclause [4.6](#) has been added to introduce finishing and appearance;
- [Figure 1](#) has been updated;
- subclause [6.5](#) and [Annex A](#) have been added to introduce and elaborate on stress corrosion;
- subclause [6.6](#) and [Annex B](#) have been added to introduce and elaborate on deflected tensile test;
- [Table 1](#) has been updated;
- in [Clause 7](#), the terminology "newtons per square millimetre" has been replaced with "MPa";
- in [Clause 8](#), packing and protection requirements has been added.

A list of all parts in the ISO 6934 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Steel for the prestressing of concrete —

Part 4: Strand

1 Scope

This document specifies requirements for steel strand which has been given a stress-relieving heat treatment according to the general requirements specified in ISO 6934-1. This document covers 10 grades of steel strand for use in prestressed concrete construction; each strand can contain either 2, 3, 7 or 19 individual wires. In case of any conflict between the requirements of this document and ISO 6934-1, the requirements of document prevail.

2 Normative reference

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6934-1, *Steel for the prestressing of concrete — Part 1: General requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6934-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1

compacted strand

strand which has been compressed (e.g. by cold working after stranding) and given a stress-relieving heat treatment before winding into reel form

4 Conditions of manufacture

4.1 Steel

The strand shall be manufactured from steel wire in accordance with ISO 6934-1.

4.2 Stress-relieving heat treatment

The strand shall be subjected to a low-temperature heat treatment as a continuous linear process by unreeling and running the strand through a suitable form of heating (see ISO 6934-1).

The strand shall be rewound into reels or onto reels having a core diameter which is sufficiently large to ensure that the strand shall be reasonably straight when unreeled (see 8.3).

4.3 Compacted strand

The 7-wire strand shall conform with [4.2](#) before drawing.

After drawing and stress-relieving heat treatment, the strand shall have a pitch of 14 to 18 times the nominal strand diameter.

4.4 Welds

4.4.1 2-wire and 3-wire strand

The wire from which the strand is manufactured shall not contain welds.

4.4.2 7-wire and 19-wire strand

There shall be no strand joints, or strand splices in any length of the finished strand, unless specifically agreed by the purchaser.

During the process of manufacture of individual wires for stranding, welding is permitted only prior to or at the diameter used during the last thermal treatment. There shall be no welds in the wire after it has been drawn through the first die in the wire drawing. If agreed upon by the purchaser, butt-welded joints may be made in the individual wires during manufacture of the strand, provided there is not more than one such joint in any 45 m section of the finished strand.

4.5 Cracks

Longitudinal cracks with a depth less than 4 % of the diameter of the component wires shall not be considered as defects.

4.6 Finishing and appearance

The finished strand shall be uniform in diameter and shall be free of imperfections not consistent with good commercial strand practices.

The strand shall not be oiled or greased. Slight rusting, provided it is not sufficient to cause pits visible to the unaided eye, shall not be cause for rejection.

When the strand is cut without seizings, the wire shall not fly out of position. If any wire flies out of position and can be replaced by hand, the strand shall be considered satisfactory.

5 Strand configuration

The following requirements apply in addition to those of ISO 6934-1.

In 2-wire and 3-wire strand, the individual wires shall be of the same nominal diameter and the pitch shall be 12 to 22 times the nominal strand diameter.

In 7-wire strand, the diameter of the straight centre-wire shall be at least 2 % greater than the diameter of the outer helical wires. The latter shall be tightly spun around the centre wire, with a pitch between 12 and 18 times the nominal strand diameter.

The direction of lay shall be subject to agreement between the manufacturer and purchaser.

In 19-wire strand, the configuration shall be 9 + 9 + 1 Seale strands or 12(6 + 6) + 6 + 1 Warrington strands, and the pitch shall be 12 to 22 times the nominal strand diameter as shown in [Figure 1](#).

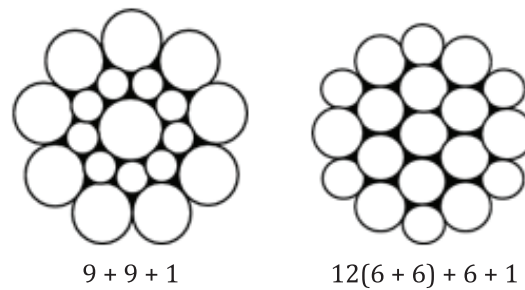


Figure 1 — Typical 19-wire strand configuration

6 Properties

6.1 Dimensions, masses and strength of strand

Dimensions, masses and tensile properties of the strand are given in [Table 1](#).

6.2 Elongation and ductility

The characteristic percentage total elongation at maximum force, A_{gt} , shall be not less than 3,5 %.

6.3 Relaxation

The relaxation at 1 000 h at an initial force of 70 % of the characteristic maximum force specified in [Table 1](#) shall be determined.

If required by the purchaser, the relaxation at 1 000 h shall also be determined at initial forces of 60 % and 80 % of the characteristic maximum forces specified in [Table 1](#).

The maximum relaxation values are specified in [Table 2](#).

6.4 Fatigue

If required by the purchaser, the strands shall withstand 2×10^6 cycles of a stress fluctuating from a maximum stress of 70 % of the characteristic maximum force specified in [Table 1](#) without failure. The stress range shall be 195 MPa for all strands.

6.5 Stress corrosion

If required by purchaser, stress corrosion test results can be provided according to [Annex A](#). The purchaser can also require appropriate corrosion-resistance complementary measure based on usage environments.

6.6 Deflected tensile test

If required by purchaser, deflected tensile test results can be provided according to [Annex B](#).

Table 1 — Dimensions, masses and tensile properties of strand

Type of strand diameters	Nominal strand diameter	Nominal tensile strength ^{a, e}	Nominal cross-sectional area ^a	Mass per length		Characteristic		
				Nominal	Permissible deviation	Maximum force ^{a, b, c}	0,1 % proof force ^{b, c, d}	0,2 % proof force ^{c, d}
mm	mm	MPa	mm ²	g/m	%	kN	kN	kN
2-wire								
2 × 2,90	5,8	1 910	13,2	104		25,2	21,4	22,3
3-wire								
3 × 2,40	5,2	1 770	13,6	107		24,0	20,4	21,1
		1 960				26,7	22,7	23,5
3 × 2,90	6,2	1 910	19,8	155		37,8	32,1	33,2
3 × 3,50	7,5	1 770	29,0	288		51,2	43,5	45,0
		1 860				54,0	45,9	47,0
7-wire ordinary	9,3	1 720	51,6	405	+4	88,8	72,8	75,4
	9,5	1 860	54,8	432	−2	102	83,6	86,6
	10,8	1 720	69,7	546	for all	120	98,4	102
	11,1	1 860	74,2	580	strands	138	113	117
	12,4	1 720	92,9	729		160	131	136
	12,7	1 860	98,7	774		184	151	156
	12,7	2 160	98,7	774		214	175	182
	12,7	2 230	98,7	774		220	180	187
	12,7	2 360	98,7	774		233	191	198
	15,2	1 720	139	1 101		239	196	203
	15,2	1 860	139	1 101		259	212	220
	15,2	2 160	139	1 101		300	246	255
	15,2	2 230	139	1 101		311	254	264
	15,2	2 360	139	1 101		328	269	279
	15,7	1 770	150	1 180		266	218	226
	15,7	1 860	150	1 180		279	229	237
	15,7	2 230	150	1 180		335	275	285
7-wire compacted	12,7	1 860	112	890		209	178	184
	15,2	1 820	165	1 295		300	255	264
	18	1 700	223	1 750		380	323	334
19-wire	17,8	1 860	208	1 652		387	317	329
	19,3	1 860	244	1 931		454	372	386
	20,3	1 810	271	2 149		491	403	417
	21,8	1 810	313	2 482		567	465	482
	28,6	1 780	532	4 229		949	778	807

^a The nominal tensile strength is calculated from the nominal cross-sectional area and the specified characteristic maximum force (see Footnote d).

^b No single test result of a maximum force of 0,1 % proof force and 0,2 % proof force shall not be lower than each specified values in this table.

^c Considering the small tolerance on mass per length, characteristic forces are specified rather than stresses.

^d The 0,1 % proof force is mandatory and the 0,2 % proof force is for information only (see ISO 6934-1), except as otherwise agreed between the manufacturer and purchaser.

^e The nominal modulus of elasticity may be taken to be 195 GPa.

^f Nominal density of strand may be taken to be 7,86 kg/dm³. Mass per length equals nominal cross-sectional area multiplied by nominal density.

Table 2 — Maximum relaxation values

Initial force in percentage of the characteristic maximum force	Relaxation class	
	Relax 1 %	Relax 2 %
70	8,0	2,5
60	4,5	1,0
80	12,0	4,5

7 Designation

The strand shall be ordered in accordance with ISO 6934-1, and be designated as follows:

- ISO 6934-4;
- type of strand (see [Table 1](#));
- nominal diameter, in millimetres;
- nominal tensile strength, in MPa;
- relaxation class (Relax 1 or Relax 2);
- direction of lay.

EXAMPLES

7-wire ordinary strand of nominal diameter 12,7 mm and nominal tensile strength 1 860 MPa with class 2 relaxation and right-hand lay is designated:

ISO 6934-4 - 7-wire ordinary - 12,7 - 1 860 - Relax 2 - right.

3-wire strand of nominal diameter 5,2 mm and nominal tensile strength 1 770 MPa with class 1 relaxation and left-hand lay is designated:

ISO 6934-4 - 3-wire - 5,2 - 1 770 - Relax 1 - left.

8 Delivery conditions

8.1 General

The strand shall be well protected against mechanical injury in shipping as agreed upon at the time of purchase. Delivery conditions shall be in accordance with ISO 6934-1, and the following requirements.

8.2 Reel dimension

The manufacturer shall determine the dimensions of the reels. The preferred reel dimensions are:

Internal diameter: 800 mm ± 60 mm or
950 mm ± 60 mm
Width: 600 mm ± 50 mm or
750 mm ± 50 mm

Where the product is supplied in coil form, the minimum internal diameter of the coil, d_{sw} , shall be such that 90 % of the elastic limit is not exceeded. See [Formula \(1\)](#):

$$\frac{D_i}{d_{sw}} \geq \left(\frac{S_n \times E}{0,9 \times F_{p0,1}} \right) - 1 \quad (1)$$

Where the product is supplied in straight lengths, the maximum mass of the bundle shall be agreed at the time of ordering with the purchaser.

8.3 Curvature of strand

When a length of strand is lying free on a flat surface, the maximum bow height from a base line of length 1 m, measured to the inside of the curve, shall not be greater than 25 mm.

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Annex A

(informative)

Considerations on stress corrosion

A.1 General

High-strength strands have a probability to have vulnerability to stress corrosion and/or hydrogen embrittlement. Stress corrosion cracking (SCC) is the cracking induced from the combined influence of tensile stress and a corrosive environment. The impact of SCC on a material are commonly known to fall between dry cracking and the fatigue threshold of the material. This annex lists examples of standards related to the evaluations. The annex is written for information only. To satisfy the requests of the users, manufacturers may consider user's specifications ahead of other evaluations.

A.2 Reference

See ISO 15630-3^[1].