AS/NZS 4671:2019

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Australian/New Zealand Standard™

Steel for the reinforcement of concrete

STANDARDS Australia

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AS/NZS 4671:2019

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Master Builders Australia
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Australian/New Zealand Standard™

Steel for the reinforcement of concrete

Originated in Australia as part of AS A81—1958, AS A82—1958, AS A83—1958, AS A84—1958, AS A92—1958 and AS A97—1965.
Originated in New Zealand as part of NZS 197:1949, NZS 1255:1956, NZS 1693:1962, NZS 1879:1964 and NZS 3423P:1972.
Previous edition AS/NZS 4671:2001.
Second edition 2019.

Preface

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee BD-084, Steel Reinforcing and Prestressing Materials, to supersede AS/NZS 4671:2001, *Steel reinforcing materials*.

The objective of the Standard is to provide materials specifications for steel bars and welded mesh used to reinforce concrete structures that have been designed in accordance with standards such as AS 3600, *Concrete structures*, or NZS 3101.1, *Concrete structures standard*, *Part 1*. This Standard has also been referenced by other design standards.

Differences between this Standard and the 2001 edition are briefly outlined below.

(a) *General* — The title of the Standard has been changed to harmonize with ISO 6935, *Steel for the reinforcement and prestressing of concrete*. Although closely aligned technically with both ISO 6935, *Steel for the reinforcement and prestressing of concrete — Test methods* (series) and ENV 10080, *Steel for the reinforcement of concrete — Weldable ribbed reinforcing steel B500 — Technical delivery conditions for bars, coils and welded fabric*, this Standard continues to be classed as not equivalent to these documents primarily because —

(i) ISO 15630 does not contain specific requirements appropriate for reinforcement for earthquake-resistant structures; and

(ii) consequential differences in both the text and numerical values, although minor in nature, are too numerous.

Minor technical and editorial errors and omissions have been addressed.

Changes proposed by the New Zealand Ministry of Business, Innovation and Employment (MBIE) in 2016, in relation to Class E mesh, have been incorporated where possible.

(b) *Strength grades* — Additional higher strength grades of reinforcing steel with a lower characteristic yield stress up to 750 MPa have been introduced in consultation with design standard committees.

The chemical, mechanical and identification requirements for each standard strength grade have been specified.

(c) *Product conformity* — Product conformity requirements have been extensively redrafted to introduce requirements for type testing, batch conformance and long-term quality. In particular, batch conformance criteria allows for minor deviations outside specified limits provided the long-term quality levels are achieved. The importance of long-term quality is emphasized.

The Standard requires that testing is conducted by laboratories in accordance with AS ISO 17025, *General requirements for the competence of testing and calibration laboratories*.

An optional manufacturer's certificate has been introduced to replace the test report in the previous Appendix B. Minimum requirements for the certificate include long-term quality statements.

Two new appendices have been added. Appendix E provides an explanation of the concept of long-term quality versus batch testing. Appendix F gives a rationale for product conformity and sampling, and discusses appropriate points for sampling decoiled products.

The terms "normative" and "informative" are used in Standards to define the application of the appendix to which they apply. A "normative" appendix is an integral part of a Standard, whereas an "informative" appendix is only for information and guidance.

Contents

Introduction

The publication of AS/NZS 4671:2001 enabled a number of significant benefits to the concrete construction industry:

(a) More efficient use of materials, and for designers, to detail less congested reinforcing layouts (particularly in columns and walls) with the use of 500 MPa steels.

(b) More reliable member performance as a result of the clarification of minimum ductility levels.

(c) More uniform product as a result of tighter conformance requirements.

(d) Compatibility between “design” and “production” parameters with the introduction of characteristic values based on normative long-term production statistics.

Since 2001 there have been significant changes in areas that needed to be addressed by this new edition of the Standard.

The limit of 500 MPa for reinforcing steel did not allow manufacturers and designers to explore the options of producing higher strength grades, which can carry higher loads and in turn, may reduce costs further or enhance sustainability.

The existing strength grades remain unchanged except for plain grade 300E (R300E), where the A_{gt} has been reduced to 12 %. R300E, produced off coil, is used solely for fitments and stirrups and does not have as high ductility demand. Higher grades of reinforcing steel up to 750 MPa have been included in separate tables. This change will allow designs to standards such as AS 3600, *Concrete structures*, and NZS 3101, *Concrete structures standard*, to utilize the potential benefits offered by higher strength reinforcing steels. High strength reinforcing steels are typically used for fitments in confinement regions to reduce congestion. Research has shown that high strength ligatures offer improved performance at the joints of concrete beams and columns under seismic loading.

Higher strength grades of reinforcing steel have the potential to improve the sustainability outcomes for the Australian and New Zealand community.

The provision of an optional product conformity report and the requirement for testing to be conducted by laboratories conforming with AS ISO 17025 for the specific test required is designed to address the concerns raised in the New Zealand Ministry of Business, Industry and Employment (MBIE) 2016 amendment to the building code.

NOTES

Australian/New Zealand Standard

Steel for the reinforcement of concrete

1 Scope

This Standard specifies requirements for the chemical composition, mechanical properties and geometric properties of steel used for reinforcing concrete, in the form of —

(a) deformed or plain bars and coils;

(b) machine-welded mesh; and

(c) continuously threaded bars.

This Standard does not apply to prestressing steels, stainless steel, epoxy coated and galvanized reinforcing steels.

NOTE 1 Prestressing steels are covered by AS/NZS 4672.1 and AS/NZS 4672.2.

NOTE 2 Information on galvanized reinforcing steels is available in *Galvanized Reinforcement In Concrete—An Introduction For Engineers and Designers* and S.R. Yeomans, *Galvanized Reinforcement In Concrete Structures—Questions and Answers*. Both are available from the Galvanizers Association of Australia.

2 Normative references

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.

NOTE Documents for informative purposes are listed in the Bibliography.

AS 1391, *Metallic materials — Tensile testing at ambient temperature*

AS ISO/IEC 17025, *General requirements for the competence of test and calibration laboratories*

AS/NZS 1554.3, *Structural steel welding, Part 3: Welding of reinforcing steel*

AS/NZS 1050.1, *Methods for the analysis of iron and steel, Part 1: Sampling iron and steel for chemical analysis*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ISO 15630-1, *Steel for the reinforcement and prestressing of concrete — Test methods — Part 1: Reinforcing bars, rods and wire*

ISO 15630-2, *Steel for the reinforcement and prestressing of concrete — Test methods — Part 2: Welded fabric and lattice girders*

ASTM E415, *Test method for analysis of carbon and low-alloy steel by spark atomic emission spectrometry*

3 Terms and definitions

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

3.1
ageing
heating of the test specimen to 100 ± 10 °C, maintaining this temperature for a period of 60 +15, 0 min and then cooling the specimen in still air to room temperature

Note 1 to entry: The method used to determine the temperature can be a calibrated oven (calibrated for both temperature and temperature spatial distribution) or boiling water.

3.2
assigned diameter
diameter of a bar used for designating a product

Note 1 to entry: In some cases the assigned and nominal diameters may be the same.

3.3
bar
straight length of reinforcing steel

3.4
batches
3.4.1
batch [for material covered by long term quality (LTQ)]
quantity of reinforcing steel of the same designation, produced by the same designation(s) of feed material, process, equipment and conditions —

(a) for hot-worked products, from the same cast; or

(b) for cold-worked products, not exceeding 50 t of bars or coils; or

(c) for mesh products not exceeding 1000 sheets.

3.4.2
batch [for material not covered by long term quality (LTQ)]
quantity of reinforcing steel of the same designation produced by the same process with a maximum mass of 100 t for bars or coils and 2000 sheets for mesh

3.5
characteristic values
3.5.1
lower characteristic value
C_{vL}

value of a property having a prescribed (high) probability (p) of being exceeded in a hypothetical unlimited series of standard tests

3.5.2
upper characteristic value
C_{vU}

value of a property having a prescribed (high) probability (p) of not being exceeded in a hypothetical unlimited series of standard tests

3.6
coil
single length of reinforcing steel wound concentrically

3.7
cold-worked products
reinforcing steel produced by any change in cross-sectional geometry or shape (e.g. straight or coil) below the re-crystallization temperature

3.8
decoiled products
reinforcing steel manufactured in coils and subsequently processed

3.9
deformed reinforcement
3.9.1
indented reinforcement
reinforcing steel with at least two rows of transverse indentations, which are distributed uniformly along the entire length

3.9.2
ribbed reinforcement
reinforcing steel with at least two rows of transverse ribs that are distributed uniformly along the entire length

3.10
hot-worked products
reinforcing steel produced by any change in cross-sectional geometry or shape (e.g. straight or coil) above the re-crystallization temperature

3.11
item
single piece of reinforcing steel (e.g. a bar, a coil or a sheet of mesh)

3.12
long-term quality
LTQ
assessment of a mechanical property of a reinforcing steel product by statistical analysis of the test results for the given property

Note 1 to entry: Further information on LTQ is provided in Appendix E.

3.13
mesh
longitudinal and transverse bars of the same or different diameter and length, which are arranged substantially at right angles and factory electrical resistance welded at the points of intersection and rely on the shear strength of the welds for lapping sheets

3.13.1
length of mesh
longest side of the mesh, irrespective of the manufacturing direction

3.13.2
longitudinal bars in mesh
reinforcing steel in the manufacturing direction of the mesh

3.13.3
overhang of mesh
length of longitudinal or transverse bar projecting beyond the outside edge of the outer cross bar in the mesh

3.13.4
pitch of mesh
centre-to-centre distance between bars in the mesh

Note 1 to entry: For twin bar mesh, the pitch is measured between the midpoint of the adjacent bars.

3.13.5
purpose-made mesh
mesh manufactured according to specific requirements

3.13.6
transverse bars in mesh
reinforcing steel perpendicular to the manufacturing direction of the mesh

3.13.7
twin bars in mesh
two bars of the same designation placed adjacent to each other as a pair

3.13.8
width of mesh
the shortest side of the mesh, irrespective of the manufacturing direction

3.14
nominal equivalent diameter
diameter in millimetres of an equivalent circular section of reinforcing steel having the same mass per metre of the deformed or indented bar

3.15
plain reinforcing steel
reinforcing steel without surface deformations excluding identifying marks

3.16
reinforcing steel
steel that is suitable for the reinforcement of concrete

3.17
ribs
3.17.1
longitudinal rib
uniform continuous protrusion parallel to the axis of the reinforcing steel

3.17.2
transverse rib
any protrusion on the surface of the product other than a longitudinal rib or identifying marks as detailed in Clause 10

3.18
steel producer
organization responsible for manufacturing reinforcing steel in bar or coil form from a hot-working or cold-working process

3.19
steel processor
organization responsible for subsequent processing of reinforcing steel supplied by a steel producer, which significantly changes the profile and properties of the reinforcing steel. This may include cold-rolling, cold-drawing, decoiling and straightening, or automatic, electrical-resistance welding

Note 1 to entry: Cutting and bending of bar or mesh is covered by AS 3600 and NZS 3101.

3.20
test piece
portion of an item of the size (length or other measure) specified in the relevant test method, suitable for carrying out the required test and which has not been subjected to any post-production treatment that may affect the test result other than ageing (where ageing is required)

4 Notation

The following symbols are used in this Standard.

A	=	calculated cross-sectional area of a reinforcing steel, in mm^2
A_{gt}	=	elongation at maximum force from a single tensile test as a percentage

$A_{gt.kL}$	=	lower characteristic value of the elongation determined from a series of tensile tests as a percentage
A_s	=	nominal cross-sectional area of a reinforcing steel bar calculated using the nominal diameter, in mm^2
a	=	pitch of bars in a mesh, in mm
C_{vL}	=	specified lower characteristic value of a variable parameter
C_{vU}	=	specified upper characteristic value of a variable parameter
c	=	longitudinal pitch of the transverse deformations measured parallel to the axis of the reinforcing steel, in mm
d	=	nominal diameter of a reinforcing steel, in mm
f_P	=	relative area of indentations
f_R	=	relative area of ribs
g	=	circumferential gap between deformations, in mm
h	=	rib height or indentation depth, in mm
$J_{k.L}$	=	lower characteristic value of a property (R_e, R_m/R_e or A_{gt}) determined from a series of tests
$J_{k.U}$	=	upper characteristic value of a property (R_e, R_m/R_e) determined from a series of tests
K	=	statistical multiplying factor
k	=	acceptability index
k_i	=	coefficient
L_n	=	nominal length of a bar, in mm
n	=	number of tests or specimens in a series of tests
N	=	number of longitudinal bars in a particular trench mesh
n_b	=	number of test values determined in a batch
n_p	=	number of samples in a collection of test results
p	=	proportion of a population
R_e	=	value of the yield stress (or 0.2 % or 0.5 % proof stress as applicable) determined from a single tensile test in accordance with AS 1391 or ISO 6892-1, in MPa
$R_{ek.L}$	=	lower characteristic value of the yield stress determined from a series of tensile tests, in MPa
$R_{ek.U}$	=	upper characteristic value of the yield stress determined from a series of tensile tests, in MPa
R_m	=	value of the tensile stress (expressed as strength) determined at the maximum force from a single tensile test in accordance with AS 1391 or ISO 6892-1, in MPa
s_n	=	standard deviation for n number of specimens

u = edge overhang of a bar in a mesh, in mm

w_c = crest width of ribs, in mm

w_i = indentation width, in mm

$\bar{X}_b$ = mean of individual test values determined in a single batch

$\bar{X}_p$ = mean of individual test values determined in a number of batches for the purpose of an LTQ calculation

x_n = mean value for n number of specimens

x_s = individual test value

α = rib flank inclination, in degrees (see Figure 7.3)

β = angle of inclination between the centre-line of the transverse deformation and the longitudinal axis of the reinforcing steel, in degrees (see Figure 7.2)

5 Classification and designation

5.1 Classification

Reinforcing steel shall be classified by —

(a) profile, as characterized by the presence or absence of ribs or indentations on its surface;

(b) strength grade, denoted by the specified lower characteristic value (C_{vL}) of its yield stress;

(c) ductility, as characterized by the specified lower characteristic (C_{vL}) of its uniform elongation (A_{gt}) and the ratio of the tensile strength to yield stress (R_m/R_e) in accordance with Tables 7.2(A) and 7.2(B);

(d) size, as characterized by its assigned diameter.

5.2 Standard grades

The standard grades of reinforcing steels, characterized by strength grade and relative ductility class shall be as follows:

(a) 250N.

(b) 300E.

(c) 500L.

(d) 500N.

(e) 500E.

(f) 600N.

(g) 750N.

5.3 Designation of bar and coil

Each of the reinforcing steels described in Clause 5.1 shall be designated by distinguishing letters or numbers in the following manner:

(a) *Profile* — By the letters, R, D, or I, representing plain Round, Deformed ribbed, or deformed Indented surfaces respectively.

(b) *Strength grade* — By the numerical value of the specified lower characteristic yield stress, expressed in MPa.

(c) *Ductility class* — By the letters L, N or E, representing Low, Normal or Earthquake (seismic) ductility respectively.

(d) *Size* — By the numerical value of the assigned diameter, expressed in mm.

The designators shall be stated in the order of profile, strength grade, ductility class and size.

Full designators shall be used in all communications unless the use of abbreviated forms causes no ambiguity, and the omitted characteristics can be readily distinguished or deduced.

EXAMPLE A deformed ribbed bar, of grade 500 MPa normal ductility reinforcing steel with an assigned 16 mm diameter, would be designated as "D500N16".

However, if all the reinforcement ordered or required for a particular project was to be deformed ribbed bars of the same strength grade but varied in other characteristics, and there was a general note to this effect in the project plans and specifications, the designation may be abbreviated to 'N16'.

5.4 Designation of welded mesh

Welded mesh shall be designated by distinguishing letters or numbers in the following manner:

(a) *Profile* — By the letters, R, D, or I, representing plain Round, Deformed ribbed, or deformed Indented, surfaces respectively.

(b) *Strength grade* — By the numerical value of the specified lower characteristic yield stress expressed in MPa.

(c) *Configuration of the orthogonal bars* — By the letters S or R, representing Square or Rectangular configurations.

(d) *Ductility Class* — By the letters L, N or E representing Low, Normal or Earthquake (seismic) ductility respectively, in accordance with Table 7.2(A) and Table 7.2(B).

(e) *Size* — By the numerical value of the assigned bar diameter in the longitudinal direction, expressed in mm.

(f) *Transverse spacing of the longitudinal reinforcing steel* — By the numerical value of the transverse spacing, expressed in mm, divided by 100.

(g) *Transverse reinforcement for rectangular configured welded mesh* — By the numerical value of the assigned bar diameter, expressed in mm. Transverse reinforcement shall be of the same shape, strength grade and ductility class as the longitudinal reinforcing steel. Unless noted otherwise, transverse reinforcement is usually spaced at 200 mm centres.

The designators shall be stated in the order shape, strength, configuration, ductility, size, spacing and secondary reinforcement if applicable.

Full designators shall be used in all communications unless the use of abbreviated forms causes no ambiguity, and the omitted characteristics can be readily distinguished or deduced.

EXAMPLE A square mesh with an assigned diameter of 9 mm deformed ribbed bar at 200 mm centres, of grade 500 MPa low ductility reinforcing steel, would be designated as "D500SL92".

However, if all the welded mesh ordered or required for a particular project was to be deformed ribbed bars, of the same strength grade but may vary in other characteristics, and there was a general note to this effect in the project plans and specifications, the designation may be abbreviated to “SL92”.

6 Manufacturing methods

6.1 Production

A report of the production methods shall be made available on request.

6.2 Processing

6.2.1 Bars and coils

Processing of coiled steel shall only be carried out in such a way that ensures the material properties of this Standard are met.

6.2.2 Mesh

All mesh shall be factory made and machine welded. The joints at the intersections of the longitudinal bars and the transverse bars shall be made by electrical resistance welding to provide shear resistant connections in accordance with Clause 7.2.5. Mesh that includes butt welded bars shall be permitted.

6.3 Manufacturing control

Production and processing shall be subject to continual control in accordance with Clause 8 and Appendix B.

7 Chemical, mechanical and geometric requirements

7.1 Chemical composition and weldability

The chemical composition, of reinforcing steels, expressed as percentages by mass of the non-ferrous constituents, shall be determined in accordance with the relevant item of Clause 9. The results, including the calculated carbon equivalent, shall conform to the corresponding values specified in Table 7.1(A) and Table 7.1(B). Non-standard grades shall meet the chemical requirements for the nearest lower grade.

The carbon equivalent value (*CEV*) shall be determined by the following equation:

$$CEV = \mathrm{C} + \frac{\mathrm{Mn}}{6} + \frac{\mathrm{Cr} + \mathrm{Mo} + \mathrm{V}}{5} + \frac{\mathrm{Ni} + \mathrm{Cu}}{15} \qquad 7.1$$

where the symbols of the chemical elements indicate content in percent by mass.

The reinforcing steels conforming to this Standard shall be deemed to be weldable under the conditions specified for each class in AS/NZS 1554.3.

7.2 Mechanical properties

7.2.1 General

Mechanical properties of reinforcing steels shall be determined in accordance with the applicable item of Appendix B and the values obtained for the standard grades shall satisfy the applicable criteria given in Table 7.2(A) and Table 7.2(B).

Non-standard grades shall meet the ratio and uniform elongation requirements of the nearest lower grade for the applicable ductility class.

In all determinations of mechanical properties, the condition of test pieces at the time of testing shall be as given in Table 7.3. Where required, test pieces shall be aged in accordance with ISO 15630-1 and ISO 15630-2.

Table 7.1(A) — Composition of reinforcing steels grades ≤ 500 MPa

Type of analysis	Chemical composition, % max.							
	All grades			Carbon equivalent value (*CEV*) for standard grades				
	C	P	S	250N	500L	500N	300E	500E
Cast analysis	0.22	0.050	0.050	0.43	0.39	0.44	0.43	0.49
Product analysis	0.24	0.055	0.055	0.45	0.41	0.46	0.45	0.51

Table 7.1(B) — Composition of reinforcing steels grades > 500 MPa

Type of analysis	Chemical composition, % max.				
	All grades			Carbon equivalent value (*CEV*)	
	C	P	S	600N	750N
Cast analysis	0.33	0.050	0.050	0.49	0.49
Product analysis	0.35	0.055	0.055	0.51	0.51

Table 7.2(A) — Mechanical properties of reinforcing steel grades ≤ 500 MPa

Characteristic property		Specified value					Type of specified value
		250N[a]	500L[b]	500N	300E (Seismic)	500E (Seismic)	
Yield stress (MPa)	$R_{ek.L}$	≥ 250	≥ 500	≥ 500	≥ 300	≥ 500	C_{vL}: $P = 0.95$
	$R_{ek.U}$	—	≤ 750	≤ 650	≤ 380	≤ 600	C_{vU}: $P = 0.05$
Ratio	$(R_m/R_e)_{k.L}$	≥ 1.08	≥ 1.03	≥ 1.08	≥ 1.15	≥ 1.15	C_{vL}: $P = 0.90$
	$(R_m/R_e)_{k.U}$	—	—	—	≤ 1.50	≤ 1.40	C_{vU}: $P = 0.10$
Uniform elongation (%)	$A_{gt.k.L}$	≥ 5.0	≥ 1.5	≥ 5.0	≥ 15.0[c] ≥ 12.0[d]	≥ 10.0	C_{vL}: $P = 0.90$

a Grade 250N may be supplied as plain reinforcing steel in accordance with AS/NZS 3679.1.

b For 500L mesh (NZ only) and all 500L steels in coil form, the only requirement for d < 5.0 mm shall be $R_{ek.L}$ ≥ 500 MPa, except where smaller diameter bars are substituted as permitted by Table 7.6(A).

c Deformed reinforcing steel only.

d Plain reinforcing steel only.

Table 7.2(B) — Mechanical properties of reinforcing steel grades > 500 MPa

Characteristic property		Specified value		Type of specified value
		600N	750N	
Yield stress (MPa)	$R_{ek.L}$	≥ 600	≥ 750	C_{vL}: P = 0.95
	$R_{ek.U}$	≤ 750	≤ 900	C_{vU}: P = 0.05
Ratio	$(R_m/R_e)_{k.L}$	≥ 1.08	≥ 1.04	C_{vL}: P = 0.90
Uniform elongation (%)	$A_{gtk.L}$	≥ 5.0	≥ 4.0	C_{vL}: P = 0.90

Table 7.3 — Condition of test pieces for mechanical properties

Manufacturing and delivery condition of the reinforcing steel	Condition of testing (test pieces)
Produced in straight lengths or coils by hot working	As produced[a]
Produced in straight lengths by cold working	Aged[b]
Produced as coil and delivered in straight lengths	Aged[b]
Produced by cold working and delivered as coil	Straightened and aged[b]
Welded mesh	Aged[b]

[a] Coiled product shall be straightened before testing and requires aging after straightening.

[b] Except for the rebend test, see Clause 7.2.3.

7.2.2 Tensile properties

The yield stress (R_e), maximum tensile strength (R_m) and uniform elongation (A_{gt}) shall be determined in accordance with Appendix C.

The values for R_e and R_m shall be calculated using the nominal cross-sectional areas of the reinforcing steels.

For R_e, the lower yield stress shall apply. If an observable yield phenomenon is not present then:

(a) 0.2 % proof stress ($R_{P0.2}$) shall apply for ductility class L and ductility class N.

(b) 0.5 % proof stress ($R_{P0.5}$) shall apply for ductility class E.

Test specimens shall have a maximum out-of-straightness of L_n/50.

7.2.3 Bending and rebending properties

This property shall apply to deformed reinforcing steels only excluding mesh. The suitability of bars for bending or rebending shall be determined by bending the bars around the stated mandrel diameters and angles specified in Table 7.4.

For bars subject to the rebend test, after the initial 90° bend, the bars shall be aged and cooled and then bent in the reverse direction through the applicable rebend angle specified in Table 7.4 (see Figure 7.1) applying a constant force. After bending or rebending there shall be no visible evidence of cracking on the surface of the test bar, when inspected with the naked eye or with normal corrected vision.

In case of dispute the rebent bar may be subject to a tensile test and will be deemed to have passed the rebend requirements if $C_{vL} \leq R_e \leq C_{vU}$.

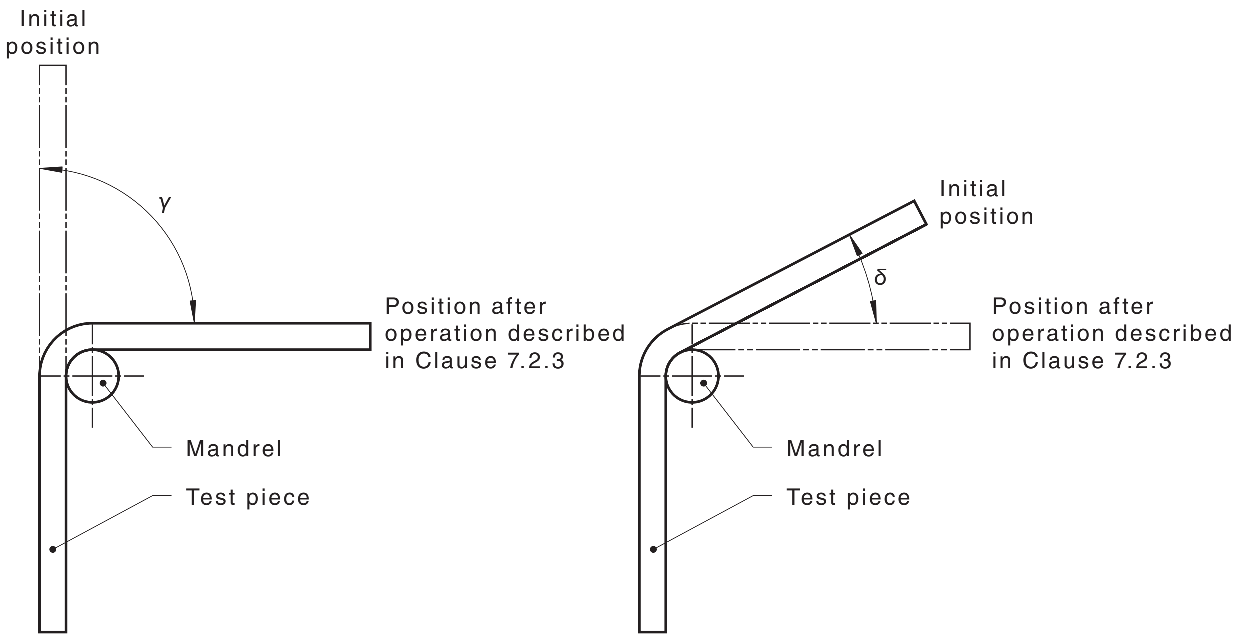


Figure 7.1 — Illustration of the test procedure for rebend tests

Table 7.4 — Mandrel diameter and angle for bend and rebend test

Nominal diameter, mm	Mandrel diameter for ductility class			Bend angle (γ) (under load)	Bend angle after 90° initial bend (δ)
	L	N	E		
$d \leq 16$	3d			90°	20°
		4d	4d		90°
$d > 16$		4d	4d	180°	NA

7.2.4 Fatigue strength

In the case that fatigue testing is requested it shall be conducted in accordance with ISO 15630.

7.2.5 Shear strength of joints in mesh

The shear strength of welded joints in mesh shall be determined in accordance with Clause C.5. The welded connection at the intersection of bars in a mesh shall be capable of resisting a direct shear force of not less than 0.5 × strength grade × A_s: where A_s is the nominal cross-sectional area of the largest bar at the joint, in mm^2, and strength grade is the applicable value of C_{vL}.

Meshes where the bar size differential is equal to or exceeds 3 mm shall not be subject to the tests of shear strength of welded joints in mesh.

7.3 Geometric properties

7.3.1 Diameters, cross-sectional areas and masses

Values for the nominal diameter, cross-sectional area and mass for some commonly available reinforcing bars are given in Tables 7.5(A) and Table 7.5(B). Other nominal diameters are permitted. The cross sectional areas and masses for diameters of products not listed in Table 7.5(A) and Table 7.5(B) shall be provided in the test report/certificate.

Table 7.5(A) — Nominal diameters, cross-sectional areas and masses for commonly available reinforcing steels (Australia only)

Nominal diameter mm	Cross-sectional area mm^2	Mass per metre length kg/m	Strength grade and ductility class
10	78.5	0.617	500N
12	113	0.888	
16	201	1.58	
20	314	2.47	
24	452	3.55	
28	616	4.83	
32	804	6.31	
36	1020	7.99	
40	1260	9.86	
50	1960	15.4	

NOTE 1 The values for the mass per unit length have been calculated from the values for the nominal diameter using a density value of 7850 kg/m^3.

NOTE 2 The equivalent diameter is the same as the nominal diameter for all the bars listed above.

Table 7.5(B) — Nominal diameters, cross-sectional areas and masses for commonly available reinforcing steels (New Zealand only)

Nominal diameter mm	Cross-sectional area mm^2	Mass per metre length kg/m	Strength grade and ductility class	
6	28.3	0.222	300E	500E
8	50.3	0.395		
10	78.5	0.617		
12	113	0.888		
16	201	1.58		
20	314	2.47		
25	491	3.85		
32	804	6.31	—	
40	1260	9.86	—	
50	1960	15.4	—	

NOTE 1 The values for the mass per unit length have been calculated from the values for the nominal diameter area using a density value of 7850 kg/m^3.

NOTE 2 The equivalent diameter is the same as the nominal diameter for all the bars listed above.

When determined in accordance with Clause C.3.3.3, the mass per metre length of any size bar shall have a tolerance of ±4.5 %. For plain round reinforcing steel, the mass per metre may be derived using Clause C.3.3.4. In the case of dispute, the method of Clause C.3.3.3 shall take precedence.

7.3.2 Length of bars

The nominal length of bars (L_n) and the deviation from the nominal length are the subjects of agreement at the time of order.

Unless otherwise specified, the nominal length tolerances shall be as follows:

(a) For $L_n \leq 7.0$ m: 0, −40 mm.

(b) For 7.0 m < L_n ≤ 12.0 m: +40, −40 mm.

(c) For L_n > 12.0 m: +60, −40 mm.

NOTE Bar lengths may use length tolerances as per AS/NZS 3679.1 by agreement.

7.3.3 Straightness tolerance of bars

Unless otherwise specified, the tolerance on straightness of bars shall be as follows:

(a) For d ≤ 16 mm: L_n/50.

(b) For d > 16 mm: L_n/100.

7.3.4 Coil size

The mass and dimensions of the coils are subject to agreement at the time of order.

7.4 Surface geometry

7.4.1 General

The deformed steel bars and coils covered by this Standard shall be characterized by surface geometry. The geometry of ribs or indentations shall conform to Clauses 7.4.2.1, 7.4.2.2 and 7.4.2.3. For deformed reinforcement, achievement of the required bond with concrete shall be demonstrated by conformance to Clause 7.4.2.4 or by a bond test in accordance with Clause C.4.

Reinforcing steel not conforming to this Clause shall be treated as plain round bar.

NOTE Geometry of indented bar in accordance with Clause 7.4.2 does not imply similar high bond performance to ribbed bars in accordance with Clause 7.4.2.

7.4.2 Geometry of ribs and indentations

7.4.2.1 General

The reinforcing steel shall have two or more rows of parallel transverse ribs or indentations equally distributed around the circumference and with a uniform spacing along the entire length excepting identifying markings. For ribbed bars, longitudinal ribs may or may not be present.

Methods for determining the geometry of ribs and indentations are provided in Clause C.3.

7.4.2.2 Transverse ribs or indentations

The projection of the transverse ribs of a bar cross section shall extend over 75 % or more of the circumference, calculated from the nominal diameter.

The angle (β) of rib or indentation inclination to the axis of the bar shall be not less than 45°. Where the angle is greater than 45° and is less than 70°, then longitudinal ribs in accordance with Clause 7.4.2.3, shall be present and/or at least one row of ribs or indentations shall be in the reverse direction to the other rows (see Figure 7.2).

The rib flank inclination (α) shall be not less than 45° and the ribs shall be radiused at the transition to the core of the product (see Figure 7.3).

The longitudinal spacing (c) of the ribs shall be between 0.5d to 1.0d and the rib height (h) shall be 0.05d to 0.10d (see Figures 7.2 and 7.3). The crest width of ribs (w_c) shall be not greater than 0.3c (see Figure 7.3).

The indentation depth (h) shall be between 0.03d and 0.10d, the longitudinal spacing (c) of the indentations shall be between 0.5d and 2.0d and the width of indentations (w_i) shall be no less than 0.5c (see Figure C.2).

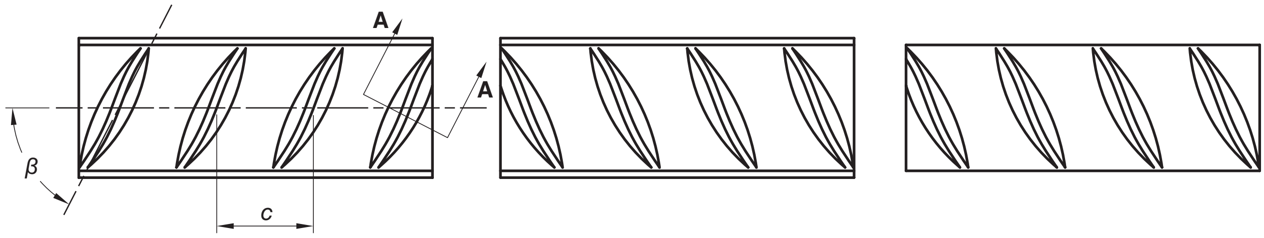


Figure 7.2 — Examples of rib geometry with two rows of transverse ribs

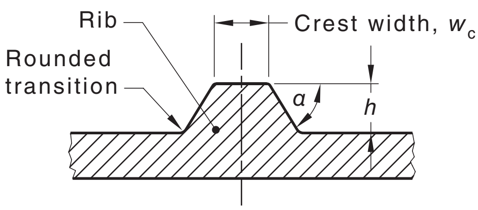


Figure 7.3 — Rib flank inclination (α), crest width (w_c) and rib height (h) — (Section A–A on Figure 7.2)

7.4.2.3 Longitudinal ribs

Where longitudinal ribs are required by Clause 7.4.2.2, the height shall be not less 0.025d and not more than 0.10d.

7.4.2.4 Relative projected area

The relative projected area of ribs (f_R) or indentations (f_P), shall be determined in accordance with Appendix C. When so determined, the minimum value shall be as follows:

(a) For ribs (f_R):

(i) 0.036 for 4.0 mm ≤ d < 5.0 mm.

(ii) 0.039 for 5.0 mm ≤ d ≤ 6.0 mm.

(iii) 0.045 for 6.0 mm < d ≤ 8.0 mm.

(iv) 0.052 for 8.0 mm < d ≤ 10.0 mm.

(v) 0.056 for 10.0 mm < d ≤ 50.0 mm.

(b) For indentations (f_P):

(i) 0.012 for 4.0 mm ≤ d < 5.0 mm.

(ii) 0.015 for 5.0 mm ≤ d ≤ 6.0 mm.

(iii) 0.020 for 6.0 mm < d ≤ 8.0 mm.

(iv) 0.025 for 8.0 mm < d ≤ 10.0 mm.

(v) 0.030 for 10.0 mm < d ≤ 16.0 mm.

7.5 Form and dimensions of mesh

7.5.1 General

Each sheet shall contain not less than the number of bars applicable to its specified length, width, pitch and overhang dimensions.

7.5.2 Commonly available mesh

Commonly available mesh sizes are specified in Table 7.6(A) (Australia only) and Table 7.6(B) (New Zealand only).

7.5.3 Minimum number of bars

The minimum number of bars in any sheet of commonly available mesh shall be as required by Table 7.6(A), or Table 7.6(B) as applicable.

NOTE Where the mesh sizes are not covered by these tables information on the mesh should be ascertained.

7.5.4 Bar arrangement

The bar arrangement shall be single bars, twin bars or a combination of these.

7.5.5 Purpose-made mesh

Purpose-made mesh shall be specified by bar designation and configuration.

NOTE Before detailing purpose-made mesh, any limitations on length, width, configuration, or mass of sheets that may be imposed by the manufacturing plant or equipment should be ascertained.

Table 7.6(A) — Commonly available mesh sizes (Australia only)

Mesh type and reference number	Longitudinal bars		Cross-bars		Mass for 6 m × 2.4 m sheets		Cross-sectional area	
	No. × dia.[a] mm	Pitch mm	No. × dia.[a] mm	Pitch mm	Unit area kg/m²	Sheet kg	Long'l bars mm²/m	Cross bars mm²/m
Rectangular								
RL1218	25 × 11.9	100	30 × 7.6	200	10.5	157	1112	227
RL1018	25 × 9.5	100	30 × 7.6	200	7.3	109	709	227
RL818	25 × 7.6	100	30 × 7.6	200	5.3	79	454	227
Square, with edge side-lapping bars								
SL102	10 × 9.5 + 4 × 6.75	200 100	30 × 9.5	200	5.6	80	354	354
SL92	10 × 8.6 + 4 × 6.0	200 100	30 × 8.6	200	4.6	66	290	290
SL82	10 × 7.6 + 4 × 5.37	200 100	30 × 7.6	200	3.6	52	227	227
SL72	10 × 6.75 + 4 × 4.75	200 100	30 × 6.75	200	2.8	41	179	179
SL62	10 × 6.0 + 4 × 4.24	200 100	30 × 6.0	200	2.2	33	141	141
Square, without edge side-lapping bars								
SL81	25 × 7.6	100	60 × 7.6	100	7.1	105	454	454
Trench meshes								
L12TM	*N* × 11.9	100	N/A	N/A	N/A	N/A	1112	N/A
L11TM	*N* × 10.7	100					899	
L8TM	*N* × 7.6	100					454	

NOTE The number and diameter of cross bars in trench mesh to suit manufacturing requirements.

[a] The diameter shall be the nominal diameter.

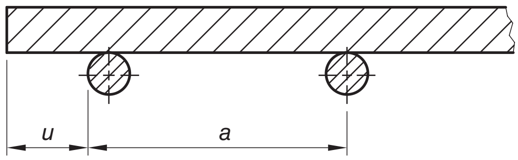
Table 7.6(B) — Commonly available mesh sizes (New Zealand only)

Mesh type and reference number	Longitudinal bars		Cross-bars		Mass for 6 m × 2.4 m sheets		Cross-sectional area	
	No. × dia.[a] mm	Pitch mm	No. × dia.[a] mm	Pitch mm	Unit area kg/m²	Sheet kg	Long'l bars mm²/m	Cross bars mm²/m
Structural								
SE92	13 × 9.0	200	30 × 9.0	200	5.0	75	318	318
SE82	13 × 8.0	200	30 × 8.0	200	3.9	59	251	251
SE72	13 × 7.0	200	30 × 7.0	200	3.0	45	192	192
SE62	13 × 6.1	200	30 × 6.0	200	2.2	33	141	141
Non-structural								
SL51.5	17 × 5.3	150	40 × 5.3	150	2.2	32	147	147
SL41.5	17 × 4.0	150	40 × 4.0	150	1.3	19	84	84

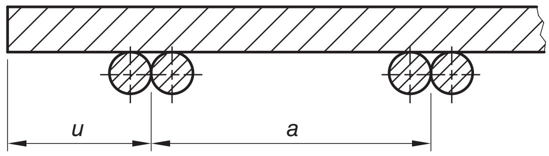
[a] The diameter shall be the nominal diameter.

7.5.6 Pitch

The pitch (*a*) of longitudinal bars and transverse bars shall not be less than 50 mm. The pitch shall be measured as shown in Figure 7.4. The tolerance of the pitch shall not be more than ± 0.075 times the specified value.



(a) Single-bar meshes



(b) Twin-bar meshes

LEGEND:
u = edge overhang of a bar in a mesh (mm)
a = pitch of bars in a mesh (mm)

Figure 7.4 — Pitch of bars and overhang of bars

7.5.7 Sheet size tolerances

The permitted maximum deviations from the specified dimensions of mesh are as follows:

(a) Sheet dimensions ≤ 6 m in length: 0, −40 mm.

(b) Sheet dimensions > 6 m in length: ±0.7 %.

7.5.8 Welds

Welded joints shall withstand normal transport and handling without breaking. The presence of broken welds shall not constitute a cause for rejection unless —

(a) in mesh supplied in sheets, the number of broken welds per sheet exceeds 1 % of the total number of welded joints; or

(b) in mesh supplied in rolls, the number of broken welds in any single continuous area of 15 m^2 measured over the full width of the mesh exceeds 1 % of the total number of welded joints in that area; or

(c) more than 50 % of the permissible maximum number of broken welds in Items (a) and (b) above are located on any one bar.

7.5.9 Deemed-to-satisfy rib or indentation geometry

Where anchorage is to be provided by the cross-weld, the requirements for rib or indentation geometry shall be deemed to be satisfied.

8 Quality of finished bar

Bars shall be free from defects in manufacture revealed during processing of the material and which may be detrimental to their end use as reinforcement for concrete.

The presence of mill scale or rust shall not be cause for rejection of reinforcing steel provided that a cleaned sample meets the minimum requirements of this Standard.

9 Demonstrating product conformity

The minimum requirements for demonstrating product conformity shall be in accordance with Appendix A and Appendix B. Appendix A sets out the type testing requirements, while Appendix B sets out the minimum production testing requirements.

All chemical and tensile tests required for this Standard shall be performed by a laboratory which meets the requirements of AS ISO/IEC 17025.

10 Identification and certificates

10.1 Identification of reinforcing steels

Reinforcing steels shall be identified by either an alphanumeric marking system on the surface of the bar that identifies strength grade and ductility class or by a series of surface features on the product, (see examples in Figure 10.1) at intervals of not greater than 1.5 m, as follows:

NOTE Care should be taken with identifying marks to minimize notching effects.

(a) *Deformed grade 250N* — Crescent-shaped transverse ribs inclined at 90° to the bar axis or two rows of inclined transverse ribs of uniform height reversing in direction on opposite sides of the bar.

(b) *Deformed grade 300E* — Identified by two rows of transverse ribs reversing in direction on opposite sides of the bar and having on one or two sides, two additional longitudinal marks joining two consecutive transverse ribs.

(c) *Deformed grade 500L* — Identified by three rows of transverse ribs or indentations with one row in the reverse direction to the other two.

(d) *Deformed grade 500N* — Identified by two or more continuous and clearly visible longitudinal marks in addition to longitudinal ribs if present, or by a minimum of two short transverse marking that are clearly distinguishable from the transverse ribs.

(e) *Deformed grade 500E (excluding threaded bar)* — Identified by two rows of transverse ribs reversing in direction on opposite sides of the bar and have on one or two sides, two missed deformations adjacent to two additional longitudinal bars joining two consecutive transverse ribs.

(f) *Plain grade 250N and plain grade 500L* — No particular identifying features.

(g) *Plain grade 300E* — Identified by a raised dot.

(h) *Plain grade 500E* — Identified by a raised dot and dash.

(i) *Plain grade 500N* — Identified by a minimum of two short transverse markings.

(j) *Right-hand-threaded grade 500E* — Identified by one short transverse rib on one side of the bar.

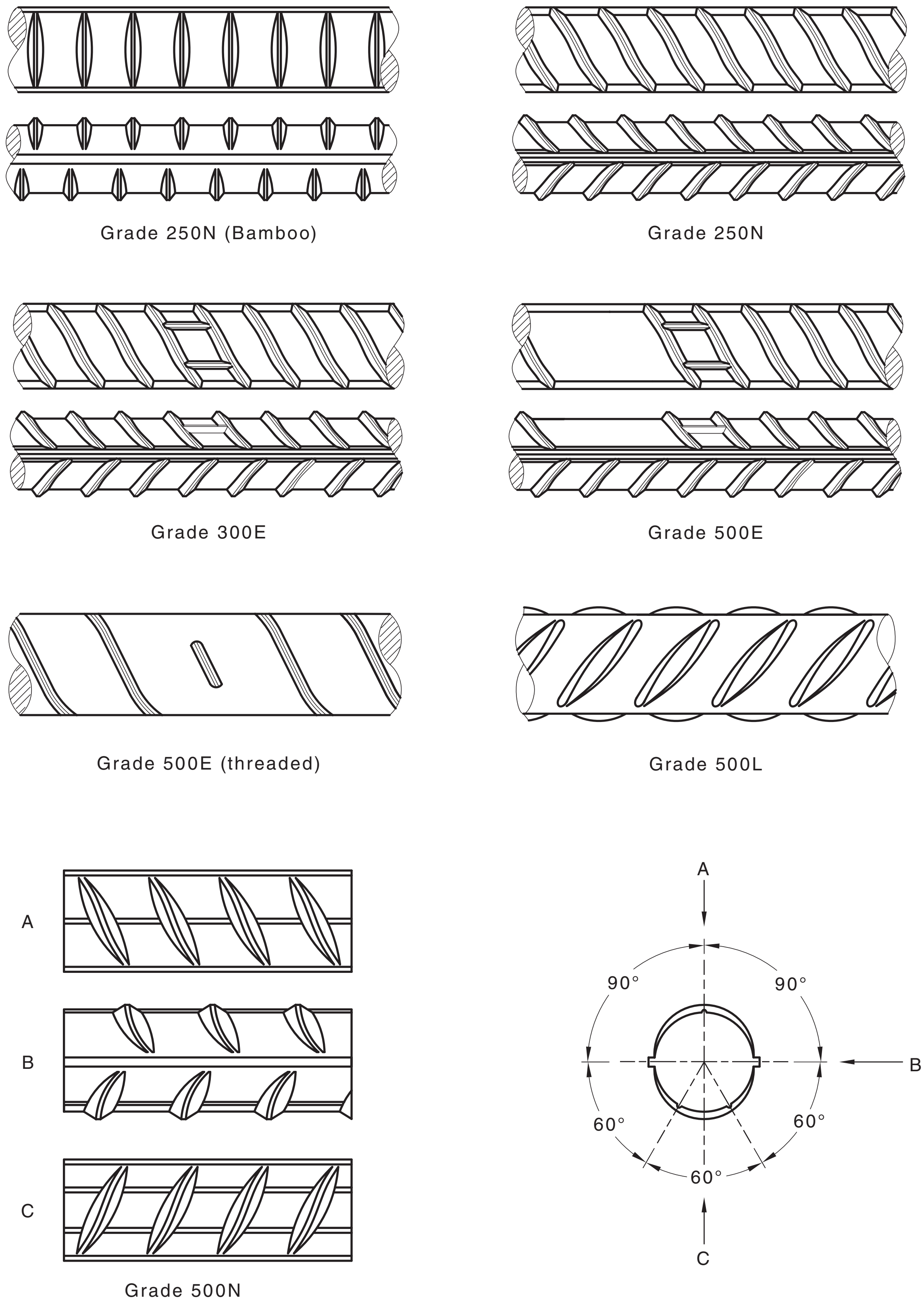


Figure 10.1 — Examples of grade identifiers

10.2 Identification of the steel producer

All reinforcing steel, except for plain grade 250N and plain grade 500L, shall carry unique marks enabling the steel producer to be identified. Details of the steel producer's identification marking shall be made available on request.

10.3 Labelling of reinforcing steel for supply

Each coil or bundle of reinforcing steel for supply, including mesh, shall have a durable label attached on which the following shall be shown:

(a) For steel producers:

  (i) Steel producer's name or trademark.

  (ii) Designation of reinforcing steel.

  (iii) Number of this Standard, i.e. AS/NZS 4671.

  (iv) Heat number or batch number.

  (v) Mass or quantity of the bundle.

  (vi) Unique bundle identification number or mark.

(b) For steel processors:

  (i) Steel processor's name or trademark.

  (ii) Designation of reinforcing steel including mesh.

  (iii) Number of this Standard, i.e. AS/NZS 4671.

  (iv) Unique identification number or code.

  (v) Mass or quantity of the bundle.

Labelling under this Clause is not required for reinforcing steel not for supply.

10.4 Product conformity reports and certificates for reinforcing steels

A report, certificate or a suite of both documents, when supplied, shall provide the following information:

(a) Steel producer or steel processor's name.

(b) The test report/certificate number.

(c) Date of report/certificate.

(d) Mill identification marks when required by this Standard.

(e) Grade identification marks when required by this Standard.

(f) Product classification and designation (refer to Clause 5).

(g) Form of product, i.e. bar, coil, mesh, decoiled.

(h) Carbon equivalent CEV or a statement confirming the CEV meets the requirements of the grade.

(i) Tensile test results shall be reported as long-term quality (LTQ) level. Alternatively batch testing in accordance with Clause B.6 results shall be used where the product is not covered by LTQ. The report shall include the following:

   (i) Start and finish test dates for data set.

   (ii) Total number of tests in data set.

   (iii) Data set (means, characteristic upper and characteristic lower values for the material tensile parameters).

   (iv) Whether the data are LTQ results in accordance with Clause B.5 or batch test results in accordance with Clause B.6.

   NOTE See Appendix E for an explanation of the importance of LTQ. A rationale for the product conformity required by this Standard is given in Appendix F.

(j) For mesh, statement confirming weld shear strength.

(k) Test results shall include details to allow identification of any laboratory accreditation.

(l) The body assessing the product conformity to this Standard. For self-assessment this is the processor or producer.

(m) A declaration that the products supplied conform to the requirements of this Standard (refer to Clause 9).

A report or certificate for reinforcing steel shall only be passed on if the properties of the reinforcing steel are not altered. When producing copies of the original manufacturer's document, it is permissible to replace the original delivered quantity with the subsequent partial quantity.

NOTE 1 For products covered by a manufacturing Standard that utilize AS/NZS 4671 reinforcing steels, and where those products are subsequently load tested in accordance with the relevant standard, it may be more appropriate to provide a certificate for the end product.

NOTE 2 Purchasing guidelines are given in Appendix D (informative).

Appendix A
(normative)

Product conformity

A.1 Scope

This Appendix sets out the following means by which conformance to this Standard can be demonstrated:

(a) Type testing.

(b) Factory production control, which includes the manufacturing control requirements of Appendix B.

The product conformity requirements enable conformity assessment to be made by a manufacturer or supplier (first party), a user or purchaser (second party), or an independent body (third party), and not be dependent on a quality management system standard (e.g. AS/NZS ISO 9001).

Flow charts summarizing the type test and batch test processes outlined in this Appendix are provided in Figure A.1.

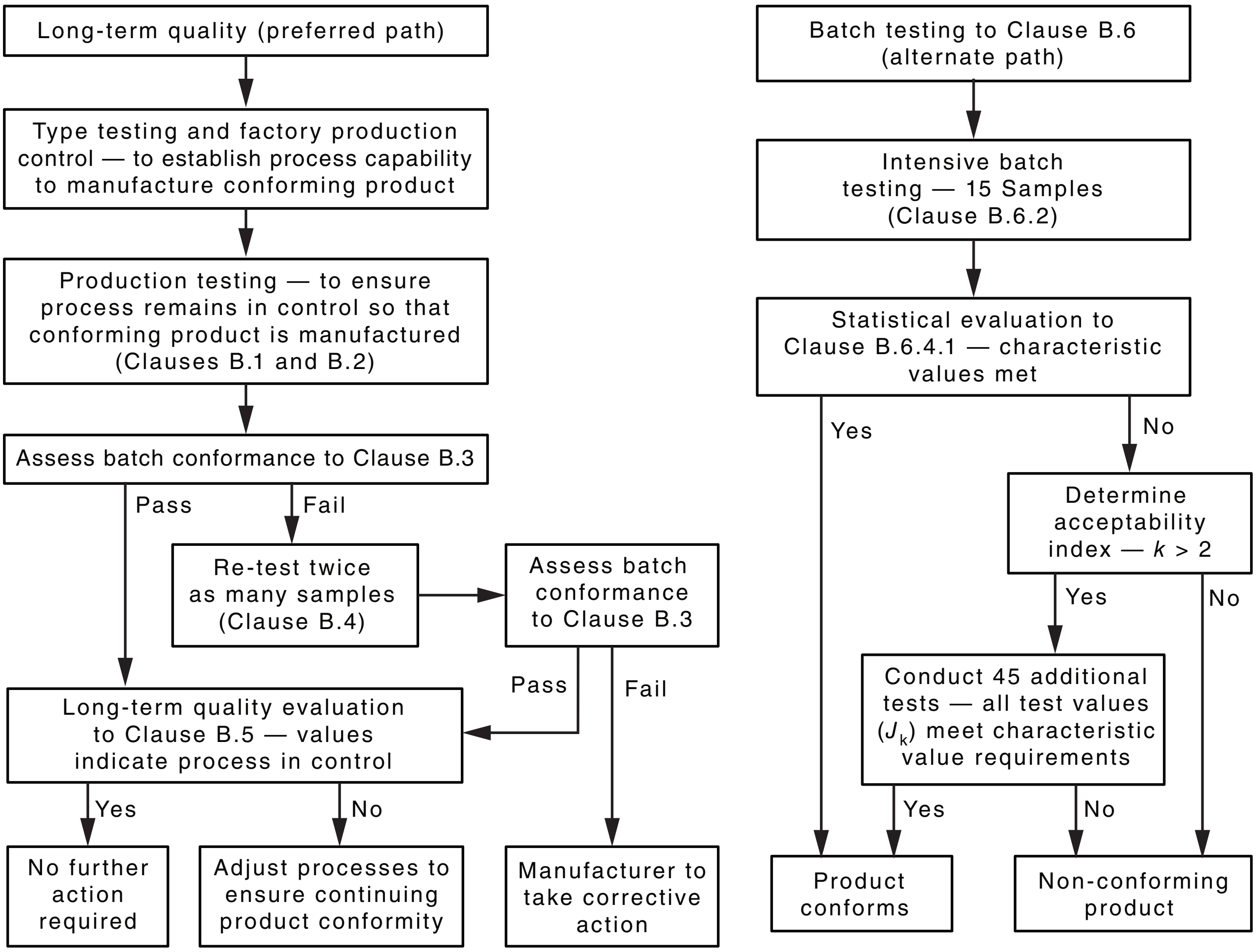


Figure A.1 — Type and batch testing flow charts

A.2 Type testing

A.2.1 General

A type testing program shall be carried out in accordance with Clause A.2.2 for the products from the time they are first placed on the market. Each batch of products manufactured during the initial type testing shall only be released to the market after that batch has been tested in accordance with Clause B.6.

Such a program shall be carried out in each case for all diameters, grade designations and ductility class reinforcing steel (manufactured or processed) that are placed on the market.

Initial type testing shall be performed on first application of this Standard. Tests results older than two years shall not be taken into account for the type test. In addition, the initial type testing shall be performed at the beginning of a new method or process of production, as well as when commencing the use of a new facility or machine.

For decoiled reinforcing steel test samples shall be taken from any straight section after processing. Where manufactured shapes do not include a straight section of reinforcing steel long enough for testing, e.g. spirals or circles, test samples shall be taken from the last practical point after the straightening or drive equipment. Where no straightening or drive equipment is used, the sampling point shall be from the coil.

Chemical composition shall be determined in accordance with AS/NZS 1050.1 and ASTM E415 or other procedures which achieve the same or better degree of accuracy.

Feed material cast/product analysis tests shall be performed by a laboratory which meets the requirements of AS ISO/IEC 17025.

NOTE By way of example, accreditation bodies which are signatories to the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement (MRA) for testing laboratories may be able to offer accreditation against the requirements of AS ISO/IEC 17025. A listing of ILAC signatories is available from the ILAC website (www.ilac.org). In Australia and New Zealand, the National Association of Testing Authorities (NATA) and International Accreditation New Zealand (IANZ) are signatories to the ILAC MRA.

A.2.2 Minimum sampling and testing plan

The initial type testing and inspection plan comprises routine testing and inspection at a sufficiently high frequency to establish the capabilities of the manufacturing process to produce the reinforcing steel product. The minimum testing and inspection frequency plan for initial type testing shall be not less than that specified in Tables A.1, A.2 and A.3. The results of each batch comprising the initial type tests shall conform to the requirements of Clause B.6 or the test results from initial type testing shall satisfy Clause B.5.

The results from type testing shall be included in the LTQ data set for the purposes of Clause B.5.

Table A.1 — Type tests and inspections — Bar and coil products

Minimum sampling and testing frequency plan				
Characteristic	**Clause**	**Requirement**	**Test method**	**Frequency**
Classification and designation	5.1, 5.2 and 5.3	Profile, strength grade, Ductility Class, size	Assign and record	Once
Manufacturing methods	6.1	Production	Method recorded	Once
	6.2	Processing	Method recorded	Once
Chemical composition	7.1	Cast/Product analysis	AS/NZS 1050.1 and ASTM E415 or equivalent method or records inspection	Once
Mechanical properties	7.2.1 and 7.2.2	R_e, R_m/R_e and A_{gt}	AS 1391 or ISO 6892-1, for R_e and R_m/R_e, ISO 15630-1 for A_{gt}	15 tests for each batch for a minimum of 4 batches
	7.2.3	Bending and re-bending properties	Bend test to Table 7.4 requirements	One test for each batch for a minimum of 4 batches
Geometric properties	7.3.1	Diameters cross sectional areas and masses	Gauging equipment, scales and by calculation	One test for each batch for a minimum of 4 batches
Surface geometry	7.4	Geometry of ribs and indentations	Clauses C.3.1 and C.3.2	One test for each batch for a minimum of 4 batches. One set of bond tests if not conforming with 7.4.2.4

Table A.2 — Type tests and inspections — Decoiled products

Minimum sampling and testing frequency plan				
Characteristic	**Clause**	**Requirement**	**Test method**	**Frequency**
Classification and designation	5.1, 5.2 and 5.3	Profile, strength grade, Ductility Class, size	Assign and record	Once
Manufacturing methods	6.1	Production	Method recorded	Once
	6.2	Processing	Method recorded	Once
Chemical composition	7.1	Examine cast/ product analysis records	Records inspection	Each feed coil batch
Mechanical properties	7.2.1 and 7.2.2	R_e, R_m/R_e and A_{gt}	AS 1391 or ISO 6892-1, for R_e and R_m/R_e ISO 15630-1 for A_{gt}	15 tests for each decoiled batch for a minimum of 4 decoiled batches
	7.2.3	Bending and rebending properties	Bend test to Table 7.4 requirements	One test for each decoiled batch for a minimum of 4 decoiled batches
Geometric properties	7.3.1	Diameters cross-sectional areas and masses	Gauging equipment, scales and by calculation	One test for each decoiled batch for a minimum of 4 decoiled batches
Surface geometry	7.4	Rib heights or depth of indentations	Clauses C.3.1 and C.3.2	One test for each decoiled batch for a minimum of 4 decoiled batches. One set of bond tests if not conforming to Clause 7.4.2.4

Table A.3 — Type tests and inspections — Mesh products

Minimum sampling and testing frequency plan				
Characteristic	**Clause**	**Requirement**	**Test method**	**Frequency**
Classification and designation	5.1, 5.2, 5.3 and 5.4	Profile, strength grade, Ductility Class, size configuration and spacing	Assign and record	Once
Manufacturing methods	6.1	Production	Method recorded	Once
	6.2	Processing	Method recorded	Once
Chemical composition	7.1	Examine cast/ product analysis records	Records inspection	Each feed material batch

Table A.3 *(continued)*

Minimum sampling and testing frequency plan				
Characteristic	**Clause**	**Requirement**	**Test method**	**Frequency**
Mechanical properties	7.2.1 and 7.2.2	R_e R_m/R_e and A_{gt}[a]	AS 1391 or ISO 6892-1, for R_e and R_m/R_e ISO 15630-2 for A_{gt}	One test per batch on each of 15 separate longitudinal and 15 separate transverse bars, i.e. 30 tests per batch for a minimum of two batches. An additional 15 tests are required on edge bars if they are of a different diameter for a minimum of two batches
	7.2.5	Shear strength of welds in mesh	Clause C.5	30 tests for each mesh batch for a minimum of two batches. An additional 7 tests are required on the edge bars from each side of the sheet if they are of a different diameter, i.e. 14 additional tests for a minimum of two mesh batches
Geometric properties	7.3.1	Diameters cross sectional areas and masses	Records inspection and/or gauging equipment, scales and by calculation	Each feed material batch
Surface geometry	7.4	Rib heights or depth of indentations		
Form and dimensions	7.5	No. of bars, bar spacing, bar arrangement and sheet size	Visual gauging and measuring equipment	Two tests for each mesh batch for minimum of 2 mesh batches

A.3 Factory production control

A.3.1 General

A factory production control (FPC) system shall be established and documented to ensure that the products placed on the market conform to the stated performance characteristics. The FPC system shall consist of procedures, regular inspections, tests and assessments, and the use of the results to control raw and other incoming material or components, equipment, the production process and the product.

A quality management system covering the requirements of this Standard is a means to satisfy the requirements of FPC.

NOTE An example of a suitable quality management system standard is AS/NZS ISO 9001.

A.3.2 Equipment

A.3.2.1 Weighing and measuring equipment

All weighing and measuring equipment for testing shall be verified to the precision required by this Standard.

A.3.2.2 Maintenance and inspection

All equipment used in the manufacturing process shall be regularly inspected and maintained to ensure use, wear or failure does not cause inconsistency in the manufacturing process. Inspections and maintenance shall be carried out and recorded in accordance with the manufacturer's written procedures.

A.3.3 Raw materials

The specification of all incoming raw materials and the process for ensuring conformity shall be documented.

A.3.4 Manufacturing control

Procedures shall be established to ensure that the stated values of all the properties are maintained. The properties and the means of control shall be in accordance with the minimum requirements of Appendix B.

Appendix B
(normative)

Manufacturing control

B.1 Scope and application

B.1.1 Scope

Manufacturing control applies to all aspects of production, from steel making through steel processing to the dispatch of end products to the purchasers (steel processors or end-users).

B.1.2 Application

Reinforcing steel shall be sampled and tested in accordance with Clause B.2. The results shall satisfy both the batch and long-term quality levels in accordance with Clauses B.3 and B.5.

Where LTQ levels are not available or are non-conforming, reinforcing steel shall be sampled, tested and evaluated in accordance with Clause B.6.

NOTE See Appendix E for an explanation of LTQ levels.

B.2 Sampling and testing frequency

The minimum frequency of sampling and testing for each of the parameters specified shall be as set out in Tables B.1, B.2 and B.3. The values shall be used for evaluation and determination of the batch quality parameters (see Clause 3.4.1) in accordance with Clause B.3.

For decoiled products test samples shall be taken from any straight section after processing. Where manufactured shapes do not include a straight section of reinforcing steel long enough for testing, e.g. spirals or circles, test samples shall be taken from the last practical point after the straightening or drive equipment. Where no straightening or drive equipment is used then the sampling point shall be from the coil.

Chemical composition shall be determined in accordance with AS/NZS 1050.1 and ASTM E415 or other procedures which achieve the same or better degree of accuracy.

Table B.1 — Production tests and inspections — Bar and coil products

Characteristic	Clause	Requirement	Test method	Frequency
Manufacturing methods	6.1	Production	Method recorded	Once
Chemical composition and weldability	7.1	Cast/Product analysis	AS/NZS 1050.1 and ASTM E415 or equivalent methods	One test per batch
Mechanical properties	7.2.1 and 7.2.2	R_e, R_m/R_e and A_{gt}	AS 1391 or ISO 6892-1, for R_e and R_m/R_e ISO 15630-1 for A_{gt}	One test for each 50 t of product or part thereof but not less than 3 per batch
	7.2.3	Bending and rebending properties	Bend test to Table 7.4 requirements	One test per batch

Table B.1 *(continued)*

Characteristic	Clause	Requirement	Test method	Frequency
Geometric properties	7.3.1	Diameters and mass per metre	Gauging equipment, scales	One test per batch
	7.3.3	Straightness for bar products	Visual inspection, gauging equipment	
Surface Geometry	7.4	Geometry of ribs or indentations	Clauses C.3.1 and C.3.2	One test per batch

Table B.2 — Production tests and inspections — Decoiled products

Characteristic	Clause	Requirement	Test method	Frequency
Manufacturing methods	6.2	Assess conformance of input feed	Records inspection, or initial supplier letter of conformance or ongoing certification	Each feed batch
Chemical composition and weldabilty	7.1	Assess conformance of input feed	Records inspection, or initial supplier letter of conformance or ongoing certification	Each feed batch
Mechanical properties	7.2.1 and 7.2.2	R_e, R_m/R_e and A_{gt}	AS 1391 or ISO 6892-1 for R_e and R_m/R_e ISO 15630-1 for A_{gt}	Two tests per decoiled batch but not less than one test per 25 tonnes per machine[a]
	7.2.3	Bending and rebending properties	Bend test to Table 7.4 requirements	Two tests per decoiled batch but not less than one test per 25 tonnes per machine
Surface geometry	7.4	Rib heights or depth of indentations	Clauses C.3.1 and C.3.2	One test per decoiled batch but not less than one test from that batch per machine per production day and at each size setup

[a] If LTQ conformance is further assessed using the test result data and method detailed in Clause B.5 with K factors taken from Table B.4 at the 99 % confidence level, using a minimum of 50 test results and at least nine batches, for each of R_e, R_m/R_e and A_{gt}, testing frequency shall be reduced to one test per batch. Assessments detailed in Product Conformity Reports (Clause 10.4) shall be reported at the 90 % confidence level.

NOTE This frequency is a sampling mechanism only and does not require that LTQ assessment is made on a machine by machine basis. Any number of machines performing the same processing under the same operating procedures and quality management system may be combined in one LTQ assessment.

Table B.3 — Production tests and inspections — Mesh products

Characteristic	Clause	Requirement	Test method	Frequency
Manufacturing methods	6.2	Assess conformance of input feed	Records inspection, or initial supplier report or certificate	Each batch
Chemical composition and weldabilty	7.1	Assess conformance of input feed	Records inspection, or initial supplier report or certificate	Each batch

Table B.3 *(continued)*

Characteristic	Clause	Requirement	Test method	Frequency
Mechanical properties	7.2.1 and 7.2.2	R_e, R_m/R_e and A_{gt}	AS 1391 or ISO 6892-1 for R_e and R_m/R_e ISO 15630-2 for A_{gt}	One test per batch on each of two separate longitudinal and two separate transverse bars, i.e. four tensile tests per batch. An additional test is required on edge bars if they are of a different diameter
	7.2.5	Shear strength of welds in mesh	Clause C.5	One test per batch on each of 2 separate intersections from different bars. An additional test is required on the edge bars from each side of the sheet if they are of a different diameter, i.e. two additional tests
Surface geometry	7.4, 7.4.9	Ribs height or depth of indentations	Clauses C.3.1 and C.3.2	One test per batch on any one longitudinal bar and one transverse bar
Form and dimensions	7.5	No. of bars, bar spacing, bar arrangement and sheet size	Gauging equipment and visual inspection	One test per batch

B.3 Evaluation and conformance of batch quality parameters

B.3.1 Tensile parameters

B.3.1.1 Batch parameters

The value for a batch of each of the tensile parameters R_e and R_m/R_e and A_{gt} shall be taken as the mean $\bar{X}_b$ of the individual test values (x_s) from the test pieces.

$$\bar{X}_b = \frac{\Sigma x_s}{n_b} \qquad \text{B.3.1.1}$$

B.3.1.2 Batch conformance

A batch shall be deemed to conform to the tensile parameters specified in Table 7.2(A) and Table 7.2(B) if the following are satisfied:

(a) For R_e:

(i) For Class L and N reinforcing steels:

(A) $1.02\,C_{vL} \leq \bar{X}_b \leq 0.98\,C_{vU}$ and no individual test value of R_e is less than 0.95 C_{vL} or greater than 1.05 C_{vU}.; or

(B) all test values of R_e fall between C_{vL} and C_{vU}.

(ii) For Class E reinforcing steels: $\overline{X}_b \geq 0.98 C_{vL}$, and $\overline{X}_b \leq 1.02 C_{vU}$. No individual value of R_e shall be less than 0.95 C_{vL} or greater than 1.05 C_{vU}.

(b) For A_{gt}: $\overline{X}_b \geq 0.95 C_{vL}$.

(c) For R_m/R_e: $\overline{X}_b \geq 0.95 C_{vL}$, and where applicable $\overline{X}_b \leq 1.05 C_{vU}$.

If any requirements in Items (a), (b) or (c) above are not satisfied, the batch shall be deemed to be non-conforming and subject to further action in accordance with Clause B.4.

NOTE This Clause is for individual batches where a LTQ plan is used to determine conformance in accordance with Clause B.5. Where a LTQ plan is not used, conformance is determined in accordance with Clause B.6.

B.3.2 Other parameters

B.3.2.1 Chemical composition

The chemical composition of reinforcing steel shall conform to the requirements listed in Table 7.1(A) and Table 7.1(B).

B.3.2.2 Shear strength of joints in mesh

The shear strength of the welded joints shall satisfy the requirements of Clause 7.2.5.

B.3.2.3 Bend and rebend suitability

The bend and rebend properties of the test piece shall satisfy the requirements of Clause 7.2.3.

B.3.2.4 Mass per unit length

The measured mass per unit length of each test piece shall satisfy the mass determined from the nominal diameter of the reinforcing steel and conform to the tolerances specified in Clause 7.3.1.

B.3.2.5 Surface geometry

The surface geometry of the test piece shall satisfy the relevant parts of Clause 7.4.2 or, if applicable, shall be such that Clause C.4 is satisfied.

B.4 Action on non-conforming batches

When a production batch is deemed to be non-conforming in accordance with Clause B.3, the batch shall be isolated.

For the non-conforming batch, twice as many additional test pieces shall be taken from the batch and tested for the particular non-conforming parameter(s). If the additional test results demonstrate conformance in accordance with Clause B.3, then the batch shall be deemed to conform to this Standard, and all of the additional results included for long-term conformance along with the original test results (see Clause B.5).

If the additional test results demonstrate non-conformance, then the batch shall be rejected as non-conforming and the steel producer or steel processor, as applicable, shall take immediate action to minimize the probability of further non-conformances of the same kind. The results from the rejected batch shall be excluded from the long-term conformance calculations.

B.5 Determination of LTQ level

B.5.1 General

Test results for R_e, R_m/R_e and A_{gt} shall be continually collected from the batch testing program, grouped under the same designation (see Clause 5.3) by diameter and their long-term characteristic values determined statistically in accordance with Clause B.5.2.

For mesh edge bars of a different diameter, LTQ shall be calculated separately from the mesh main bars.

For each parameter, the determinations shall be made on a continual basis (but at intervals of not more than one month), covering at least four separate batches and the higher number of test results from the following:

(a) The preceding six months' test results.

(b) The last 200 consecutive test results.

The results from type testing shall be included in the LTQ data set where applicable.

For Class E mesh used in New Zealand the application of long-term quality conformance with respect to R_m/R_e and A_{gt} may be waived where $\bar{X}_b$ meets the requirements in Table 7.2(A).

NOTE The evaluation of LTQ levels is based on the assumption that the distribution of a large number of test results is normal; however, this is not a requirement.

B.5.2 Evaluation of results

B.5.2.1 Estimation of population parameters

The mean $\bar{X}_p$ and standard deviation s_n shall be estimated from the test results using the following equations, respectively:

$$\bar{X}_p = \frac{(\Sigma x_s)}{n} \quad \text{B.5.2.1(1)}$$

$$S_n = \sqrt{\left[\frac{\Sigma\left(x_s - \bar{X}_p\right)^2}{(n-1)}\right]} \quad \text{B.5.2.1(2)}$$

Table B.4 — Statistical multiplier "K"

No. of samples (n_p)	Coefficient K at 90 % confidence level		Coefficient K at 99 % confidence level (for decoiled product only. See Table B.2)	
	For R_e (P = 0.95)	For R_m/R_e, A_{gt} (P = 0.90)	For R_e (P = 0.95)	For A_{gt}, R_m/R_e (P = 0.90)
5	3.40	2.74		
6	3.09	2.49		
7	2.89	2.33		
8	2.75	2.22		
9	2.65	2.13		
10	2.57	2.07		
11	2.50	2.01		
12	2.45	1.97		

Table B.4 *(continued)*

No. of samples (n_p)	Coefficient K at 90 % confidence level		Coefficient K at 99 % confidence level (for decoiled product only. See Table B.2)	
	For R_e (P = 0.95)	For R_m/R_e, A_{gt} (P = 0.90)	For R_e (P = 0.95)	For A_{gt}, R_m/R_e (P = 0.90)
13	2.40	1.93		
14	2.36	1.90		
15	2.33	1.87		
16	2.30	1.84		
17	2.27	1.82		
18	2.25	1.80		
19	2.23	1.78		
20	2.21	1.77		
30	2.08	1.66		
40	2.01	1.60		
50	1.97	1.56	2.27	1.82
60	1.93	1.53	2.20	1.76
70	1.90	1.51	2.15	1.72
80	1.89	1.49	2.11	1.69
90	1.87	1.48	2.08	1.66
100	1.86	1.47	2.06	1.64
150	1.82	1.43	1.97	1.57
200	1.79	1.41	1.92	1.52
250	1.78	1.40	1.89	1.50
300	1.77	1.39	1.87	1.48
400	1.75	1.37	1.84	1.45
500	1.74	1.36	1.81	1.43
1000	1.71	1.34	1.76	1.38
≥ 2000	1.65	1.30		

B.5.3 Conformance to LTQ levels

The process shall be deemed to conform to LTQ levels if, for each quality parameter —

$$J_{kL} \geq C_{vL} \qquad \text{B.5.3(1)}$$

and

$$J_{kU} \leq C_{vU} \qquad \text{B.5.3(2)}$$

as applicable, where K is obtained from the applicable column of Table B.4 and where:

$$J_{kL} = \bar{X}_p - Ks_n \qquad \text{B.5.3(3)}$$

$$J_{kU} = \bar{X}_p + Ks_n \qquad \text{B.5.3(4)}$$

Where the sample size of a batch falls between sample sizes given the value of multiplier K shall be interpolated linearly between the next lowest and highest number of samples.

B.6 Material not covered by LTQ level

B.6.1 General

Reinforcing steel not covered by LTQ level in accordance with Clause B.5 shall be assessed by acceptance tests on each batch (see Clause 3.4 for definitions of batch).

NOTE The evaluation of LTQ levels is based on the assumption that the distribution of a large number of test results is normal; however, this is not a requirement.

B.6.2 Extent of sampling and testing

Each batch shall comprise reinforcing steel of the same steel designation.

Representative test pieces shall be taken from each batch as follows:

(a) Fifteen test pieces from different bars or coils for testing in accordance with Table A.1, Table A.2, or Table A.3 as applicable.

(b) Two test pieces from different bars or coils, for testing in accordance with Clause B.6.3(c).

B.6.3 Properties to be tested

Test pieces selected in accordance with Clause B.6.2 shall be tested for the following:

(a) Statistically assessed:

(i) Yield stress, R_e.

(ii) Tensile to yield ratio, R_m/R_e.

(iii) Uniform elongation, A_{gt}.

(b) Measured properties:

(i) Deviations from the nominal diameter.

(ii) Mass per metre.

(iv) Relative projected rib or indentation area or bond.

(v) Behaviour in the bend and rebend test.

(iv) Shear strength of joints in mesh.

(c) Chemical composition according to the product analysis shall be in accordance with Clause 7.1. Chemical testing is not required if the results of an analysis conforming with this Standard are supplied by the manufacturer.

All elements listed in Table 7.1(A) or Table 7.1(B) and the carbon equivalent (CEV) shall be determined.

The test procedures shall be as specified in Appendix C.

B.6.4 Evaluation of results

B.6.4.1 Statistical assessment

For properties that have characteristic values in Tables 7.2(A) and 7.2(B), the lower (and upper when stated) characteristic values shall be determined using Equations B.5.3(3) and B.5.3(4) from the results of the 15 test pieces. The K value is to be taken from the applicable column of Table B.4 where n = 15.

The batch shall be deemed to satisfy this Standard if all the calculated lower characteristic values are greater than the applicable specified lower characteristic values in Table 7.2(A) or 7.2(B) and if all the calculated upper characteristic values are less than the applicable specified upper characteristic values in Table 7.2(A) or 7.2(B).

For Class E mesh used in New Zealand the application of statistical assessment with respect to A_{gt} may be waived where all batch test results are above specified values.

If the batch is deemed not to conform to the first part of this Clause, a secondary calculation, the acceptability index (k), shall be determined, where —

$$k = \frac{x_{15} - J_{kL}}{s_{15}} \text{ or } \frac{J_{kU} - \bar{x}_{15}}{s_{15}} \text{ as applicable} \qquad \text{B.6.4.1}$$

If $k \leq 2$, the batch shall be deemed “non-conforming”.

If $k > 2$, testing shall continue. Forty-five further test specimens shall be taken and tested from different items in the test unit, so that a total of 60 test results are available ($n = 60$).

The batch shall be deemed to conform to this Standard if all the calculated lower characteristic values are greater than the applicable specified lower characteristic values in Table 7.2(A) or 7.2(B) and if all the calculated specified upper characteristic values are less than the applicable upper characteristic values in Table 7.2(A) or 7.2(B).

B.6.4.2 Measured properties attributes

When testing the properties listed in Clause B.6.3(b), the following applies to each property separately:

(a) If the results determined on the 15 test pieces conform to this Standard, then the batch shall be deemed to conform.

(b) If a maximum of two of the 15 results do not conform to this Standard, 45 further test pieces shall be taken and tested from different items in the batch, making 60 test results available.

The batch shall be deemed to satisfy this Standard if no more than two of the 60 test pieces fail the test.

Appendix C
(normative)

Requirements for determining the mechanical and geometric properties of reinforcement

C.1 General

This Appendix sets out requirements for the determination of mechanical and geometric properties of reinforcement, which are additional to the requirements given in Clauses 7.2, 7.3, 7.4 and Clause 9.

C.2 Mechanical properties

C.2.1 General

Tests for the determination of the mechanical properties of reinforcement shall be carried out at ambient temperatures in the range 10 °C to 35 °C.

The condition of test pieces at the time of testing shall be in accordance with Clause 7.2.1 and Table 7.3.

Unless otherwise specified, tests on bars and coils shall be carried out on straight test specimens of full cross-section having no machining within the gauge length.

Test specimens cut from mesh shall include at least one welded intersection. Before testing a twin-bar specimen, the bar not under test shall be removed without damage to the bar to be tested.

C.2.2 Tensile properties — Uniform elongation

A_{gt} shall be determined in accordance with ISO 15630-1 or ISO 15630-2 as applicable except that the minimum extensometer gauge length shall be 50 mm and the manual method described in ISO 15630-1 and ISO 15630-2 shall only be applied to Class E and Class N reinforcing steel.

In the event of a dispute, the extensometer method shall take precedence.

Where possible when testing for A_{gt}, the gauge length for the measurement of elongation should exclude any welded intersection and be located at least 20 mm away from the weld.

C.3 Geometric properties

C.3.1 Rib geometry

C.3.1.1 Height of transverse ribs

The height of a transverse rib shall be measured to an accuracy of 0.01 mm for each row of ribs at the point where the rib height is greatest. The height of the transverse rib (h) shall be reported as the mean of these measurements.

C.3.1.2 Circumferential spacing of transverse ribs

The sum of the circumferential gaps (g) between adjacent rows of transverse ribs shall be measured to an accuracy of 0.1 mm at each of three separate cross-sections and the mean value of the sum calculated. The measurement shall be reported to an accuracy of 0.1 mm.

C.3.1.3 Longitudinal spacing of transverse ribs

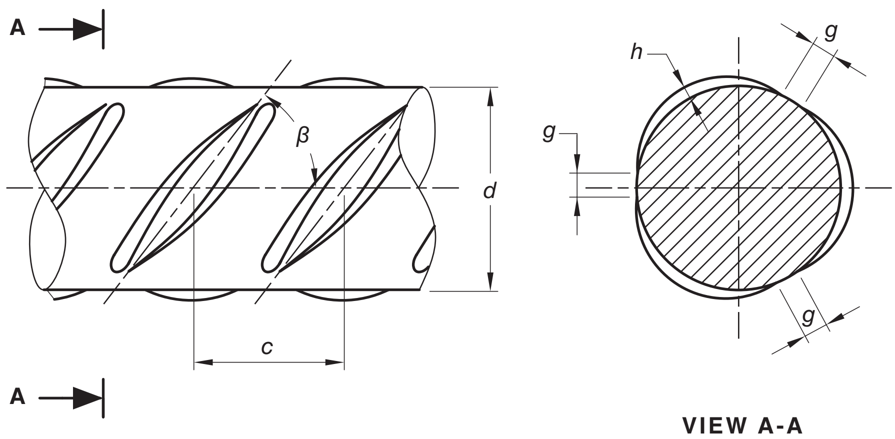
The spacing of the transverse ribs (c) shall be taken as the length of the measuring distance in millimetres divided by the number of the rib gaps contained within that length. The measuring distance is deemed to be the interval between the centre-line of a rib and the centre-line of another rib on the same side of the product, determined in a straight line parallel to the longitudinal axis of the product. The length of the measuring distance shall contain at least 10 rib gaps.

C.3.1.4 Calculation of the relative projected rib area (f_R)

The relative projected rib area (f_R) shall be calculated from the following equation, and with reference to Figure C.1:

$$f_R = k_i \frac{(\pi d - \Sigma g) \cdot h}{\pi d.c} \qquad \text{C.3.1.4}$$

where



k_i	=	0.72 for crescent shaped ribs; or
	=	1.0 for uniform height ribs
d	=	nominal diameter of the reinforcing steel
Σg	=	sum, at a cross-section, of the circumferential gaps between adjacent rows of transverse ribs (see Clause C.3.1.2)
h	=	mean of the maximum rib heights (see Clause C.3.1.1)
c	=	longitudinal spacing of the transverse ribs (see Clause C.3.1.3)

Figure C.1 — Terms for relative projected rib area

C.3.2 Indentation geometry

C.3.2.1 Depths of transverse indentations

The depth of transverse indentations (h) shall be measured to an accuracy 0.01 mm for each row of indentations at the point where the indentation depth is greatest. The depth of transverse indentations shall be reported as the mean of these measurements to an accuracy 0.01 mm.

C.3.2.2 Circumferential spacing of transverse indentations

The sum of the circumferential gaps (g) between adjacent rows of transverse indentations shall be measured to an accuracy of 0.1 mm at each of three separate cross-sections and the mean value of the sum calculated. The measurement shall be reported in millimetres to an accuracy of 0.1 mm.

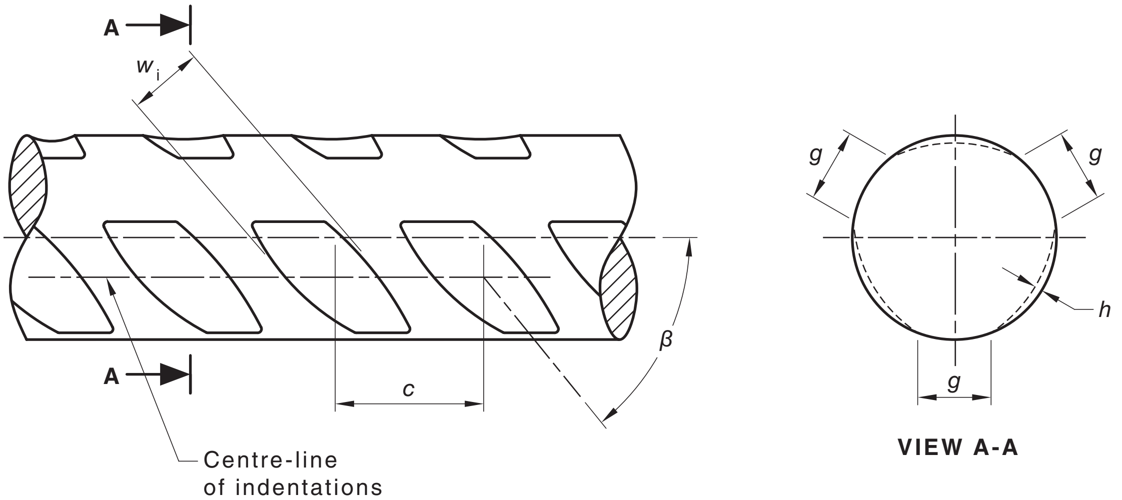
C.3.2.3 Longitudinal spacing of transverse indentations

The spacing of the transverse indentations (c) shall be taken as the length of the measuring distance in millimetres divided by the number of the indentation gaps contained within that distance. The measuring distance is deemed to be the interval between the centre-line of an indentation and the centre-line of another indentation on the same side of the product determined in a straight line parallel to the longitudinal axis of the product. The length of the measuring distance shall contain at least 10 indentation gaps.

C.3.2.4 Calculation of the relative projected indentation area (f_P)

The relative projected indentation area (f_P) shall be calculated from the following equation, and with reference to Figure C.2:

$$f_p = k_i \frac{(\pi d - \Sigma g) \cdot h}{\pi d.c} \qquad \text{C.3.2.4}$$



k_i = 0.72 for indents of non-uniform depth; or

= 1.0 for indents of uniform depth

d = nominal diameter of the reinforcing steel

Σg = sum, at a cross-section, of the circumferential gaps between adjacent rows of transverse indentations (see Clause C.3.2.2)

h = mean of the maximum indentation depths (See Clause C.3.2.1)

c = longitudinal spacing of the transverse indentations (see Clause C.3.2.1)

Figure C.2 — Terms for relative projected indentation area

C.3.3 Mass per unit length of reinforcing steels

C.3.3.1 General

The mass per unit length of bars in a batch shall be determined in accordance with Clauses C.3.3.2 and C.3.3.3 and the result expressed in kg/m. For plain round bar, the mass per unit length may be determined in accordance with Clause C.3.3.4.

C.3.3.2 Test specimens

The determination shall be carried out on test specimens of a combined length not less than the greater of 300 mm or 20*d*, for diameters less than or equal to 25 mm and not less than 500 mm for diameters greater than 25 mm.

C.3.3.3 Procedure

The procedure for determination shall be as follows:

(a) Cut a test specimen randomly selected from the batch, the length of the specimen being at least the minimum length specified in Clause C.3.3.2 plus two bar diameters.

(b) Grind the ends of the specimen perpendicular to the longitudinal axis of the bar.

(c) For the specimen —

  (i) measure its length in millimetres to the nearest 1 mm;

  (ii) weigh the specimen to determine its mass in grams to an accuracy of three significant figures; and

  (iii) calculate its mass per unit length (kg/m) to an accuracy of three significant figures.

C.3.3.4 Alternative procedure for plain round bar

For each test specimen, measure its diameter in two locations, 90 degrees apart around the same circumference of the test specimen and then calculate its mass per unit length (kg/m) using the average of the two measurements, to an accuracy of three significant figures.

d = mean of the measured diameters, in mm

$A = 0.7854 \times d^2$

Mass per unit length = $7.85 \times 10^{-3} \times A$

The calculated mass per unit length shall be given to three significant figures, expressing the results in kg/m.

C.4 Bond test for profile designation

C.4.1 Objective

The objective of the test is to demonstrate that reinforcing bars not conforming to the requirements of Clause 7.4.2.4(a) will develop their specified characteristic yield stress (see Table 7.2) in a pull-out test with a free-end slip not greater than 0.2 mm.

C.4.2 Test pieces

The surface deformations of the bars to be tested shall conform to the published specification of the steel producer or steel processor, and shall be as near to the minimum values as possible. Six test pieces of each size shall be tested. Each test piece shall be long enough to allow attachment of the stressing system and measuring device. All test pieces shall be wire brushed to remove loose rust and mill scale.

C.4.3 Test prism or cylinder and apparatus

For each of the test pieces, prepare a concrete test prism or cylinder having a square or circular cross-section of 150 mm width or diameter for bar sizes up to and including 20 mm, and 250 mm width or diameter for bar sizes over 20 mm. The length of the prism or cylinder (L) in mm shall be calculated as follows:

$$L = \frac{0.45d \cdot C_{\mathrm{vL}}}{\sqrt{f_{\mathrm{c}}}} \geq b \qquad \text{C.4.3}$$

where

b = width of prism sides or diameter of cylinder, in mm

f_{c} = the compressive strength of the concrete at time of test, in MPa

Prepare the concrete prism or cylinder having a cylinder compressive strength of between 32 MPa and 40 MPa at the time of the pull-out test. Support the test piece so that it is rigidly embedded and passes completely through the prism or cylinder of concrete along its longitudinal axis protruding approximately 20 mm from the end as cast. Reinforce the prism or cylinder along the embedded length with a helix of 6 mm diameter plain mild steel having a pitch of 25 mm, the outer diameter of the helix being 5 mm less than the side or diameter of the concrete section.

The apparatus shall consist of a suitable testing device capable of accepting the test specimen and a strain gauge or other suitable measuring device (see Figure C.3).

C.4.4 Procedure

The procedure shall be as follows:

(a) Mount the test specimen in the testing device so that the bar is pulled axially from the prism.

(b) Arrange the test prism so that the end of the bar at which tension is applied is that which is projected from the top end of the prism as cast.

(c) Place rubber or plywood packing and bearing plate with central hole 2d in diameter, between the top end of the prism and the bearing surface of the testing device.

(d) Mount the measuring device so that the gauge records the relative slip between the unloaded end of the bar and the bottom end of the prism as cast.

NOTE A schematic arrangement of a specimen and testing device is shown in Figure C.3.

(e) During a period of 2 min, steadily increase the axial force in the bar protruding from the top end of the prism until the tensile stress in the bar attains the specified lower characteristic yield stress (C_{vL}) for the grade of reinforcing steel from which the bars are made.

(f) Maintain this axial force for a further two minutes, then record the free-end slip of the bar.

C.4.5 Free-end slip

If the average free-end slip of the six test pieces does not exceed 0.2 mm, the surface geometry of reinforced steel represented by the test pieces shall be deemed to satisfy the surface geometry requirements for a deformed reinforcing steel profile.

C.4.6 Test report

The test report shall contain the following:

(a) Mill of manufacture.

(b) Nominal diameter of test pieces.

(c) Surface geometry.

(d) Concrete compressive strengths at time of testing.

(e) Profile designation.

(f) Reference to this test method, i.e. AS/NZS 4671 Appendix C.

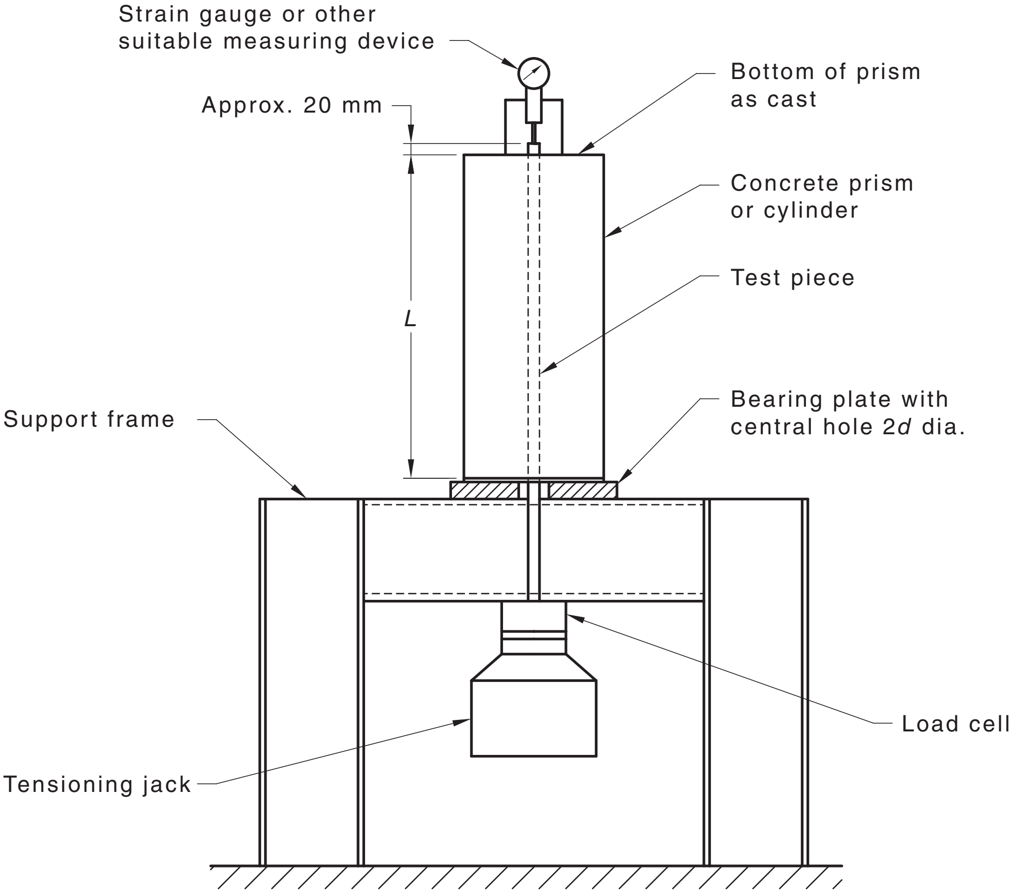


Figure C.3 — Sample schematic arrangement of bond test equipment and test specimen

C.5 Mesh weld shear strength

The weld shear strength of welded joints on mesh shall be determined in accordance with ISO 15630-2, except where it can be demonstrated by non-destructive means that the welded joints are capable of withstanding at least 5 % more than the shear force specified in Clause 7.2.5 of this Standard. The holders in ISO 15630-2 may be substituted by alternative holders that better prevent cross wire rotation.

In the event of a dispute, the ISO 15630-2 test procedure shall take precedence.

Appendix D
(informative)

Purchasing guidelines

D.1 Information to be supplied by the purchaser

The purchaser should supply the following information at the time of enquiry or order, after making due reference to the explanation, advice and recommendations contained in this Appendix:

(a) Designation of grade and Standard number.

(b) Quantity and delivery instructions.

(c) Dimensions of reinforcing steel, e.g. bar size and length, mass of bundle or coil.

(d) Whether a manufacturing report or certificate is required.

(e) Any information concerning processing or end-use that the purchaser considers would assist the steel producer or steel processor.

(f) Whether it is the intention of the purchaser to inspect the reinforcing steel at the steel producer's or steel processor's works.

(g) Any exceptions to requirements of this Standard and any special or supplementary requirements.

NOTE Some mechanical properties (e.g. A_{gt}) may be quite sensitive to cold working. Hence, it is important to be aware that the properties of conforming batches of reinforcing steel may be rendered non-conforming by subsequent cold-working procedures, such as straightening, that are applied without due caution.

D.2 Inspection

If it is the purchaser's intention to undertake any of the following functions at the supplier's works, this should be notified at the time of the enquiry or order, and should be accomplished in a manner that will not interfere with the operation of the works:

(a) Inspect the steel during manufacture.

(b) Select and identify test samples.

(c) Witness the tests being made.

The supplier should provide all reasonable facilities to enable the purchaser to be satisfied that the reinforcing steel is in accordance with this Standard.

Appendix E
(informative)

Long term quality data

E.1 Long term quality (LTQ) data

The long-term quality (LTQ) data from a facility with factory production control provides significantly greater confidence that the material conforms to this Standard when compared with a single batch test result (even if it is specific to that batch).

All manufacturing facilities will produce reinforcing steel products with some variation in mechanical properties. This variation will occur across different batches but also within a single batch. Australian and New Zealand Standard Technical Committees have taken this into account in the development of Australian and New Zealand design standards. This is consistent with probabilistic models that have been used to determine both the design loads and the member capacities in the limit state design method prescribed in design standards, including AS 3600 and NZS 3101. Manufacturers, designers and site personnel need to recognize the importance of this concept so they can understand why LTQ data is far more significant in assessing conformity than a single batch test result.

NOTE For a more detailed discussion on the reliability of structures, see AS 5104.

Design standards account for the probabilistic nature of a structural member's capacity by applying a capacity reduction factor. This reduction factor accounts for variations such as eccentricities in the product and building tolerances; the actual degree of ductility and stability; member behaviour, simplification and inaccuracies in the design models; and, most importantly for the following discussion, the variation in material properties. This capacity reduction factor in design standards has been calibrated with product Standards (e.g. AS/NZS 4671) to ensure that the probability of failure is low (within acceptable limits). Therefore, the use of products, which are compatible (i.e. have been calibrated) with the design standard, is important to ensure the probability of failure for a structure meets those acceptable limits.

Figure E.1 shows the probability distribution of the ultimate load and the member capacity with the reduction factor applied (nominal design capacity). The shaded area represents the probability that the ultimate load exceeds the nominal capacity (probability of failure).

NOTE For a more detailed discussion on the reliability of structures, see AS 5104.

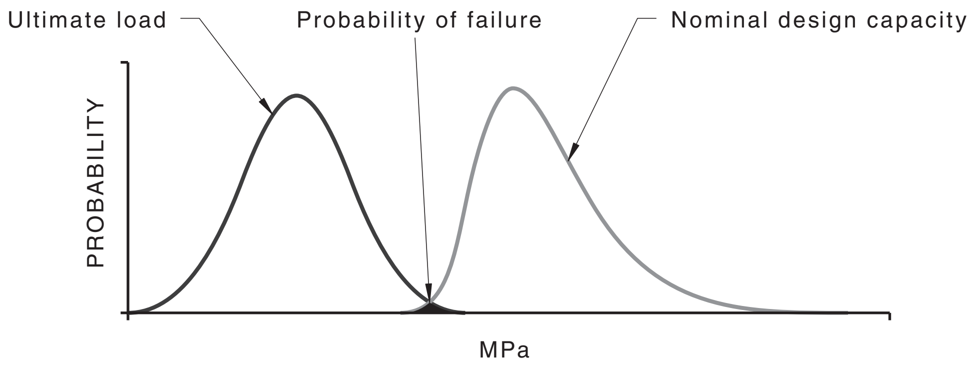


Figure E.1 — Probability distributions — Ultimate load vs nominal design capacity

E.2 Long-term quality distributions

The mechanical properties of products conforming to this Standard are expressed as characteristic values with a probability requirement. For example, the specified lower characteristic yield stress, C_{vL}, in Table 7.2(A) requires a 95 % probability of that value being exceeded. This means that there is up to a 5 % probability that a single yield stress test result will fall below the specified lower characteristic value, C_{vL}.

A product with a single test result, which falls below the specified lower characteristic value can still conform to the Standard, provided that the batch and LTQ results for that same product meet the requirements of the Standard. This is because product Standards and the related design standards utilize a probabilistic methodology. The application of a capacity reduction factor in design accounts for various factors including a single test result below the lower characteristic value which in turn ensures the probability of failure remains below an acceptable limit.

Figure E.2 shows a representative LTQ distribution of yield stress results from a steel producer with factory production control satisfying the C_{vL} of 500 MPa with 95 % probability. In this example, the producer's calculated lower characteristic value $R_{ek.L}$ is 502 MPa, which exceeds the minimum C_{vL} requirement of 500 MPa shown on Figure E.2. Note that a very small number of individual results can be expected to be below 500 MPa in this particular case.

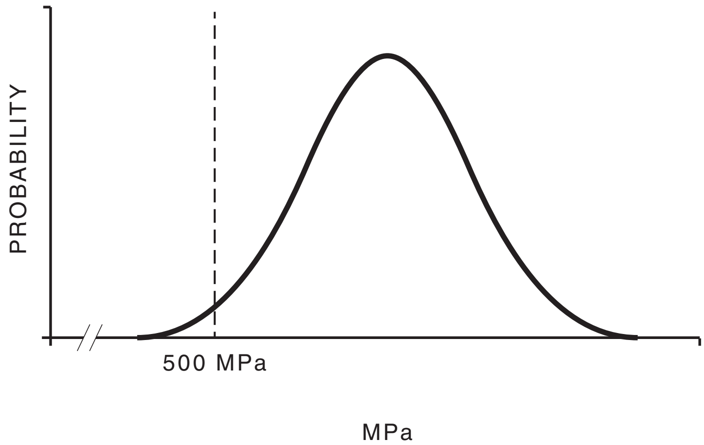


Figure E.2 — Representative probability distribution for C_{vL} = 500 MPa to Table 7.2(A) exceeds the minimum C_{vL} requirement of 500 MPa

E.3 Single test results versus long-term quality test results

The simplest way to demonstrate why a single test result is of limited value for a design standard which is based on a probabilistic methodology is to look at an example to demonstrate how these results can be misleading. Consider a design to AS 3600, the concrete structures Standard, which requires 500N reinforcing products for a particular structural element. Two products available for the construction of the structural element are shown in Table E.1 with the relevant single test data for each product.

Table E.1 — Single batch test results for product options

Property	Specified C_{vL}	Product A	Product B
Yield stress, R_e (MPa)	500	510	495
Ratio, R_m/R_e	1.08	1.10	1.10
Uniform elongation, A_{gt} (%)	5	7.5	7.5

If the decision on which product to use was based on a single test result; Product A would be chosen as the yield stress test result for Product A exceeds the minimum value required while the yield stress test result for Product B falls marginally short. Although the tests are directly related to the batches, where the products were sourced, they do not provide any indication of the variation that may occur across and within the batches.

This is best explained by examining the LTQ data for each of the Products A and B. Figure E.3 shows a plot of long term quality results for Product A. This plot indicates that while the single test result is 510 MPa, the facility making Product A has a $R_{ek.L}$ of 400 MPa with a 95 % probability. Figure E4 shows a plot of the LTQ results for Product B with a single test result of 495 MPa, and a R_{ekL} of 502 MPa with a 95 % probability.

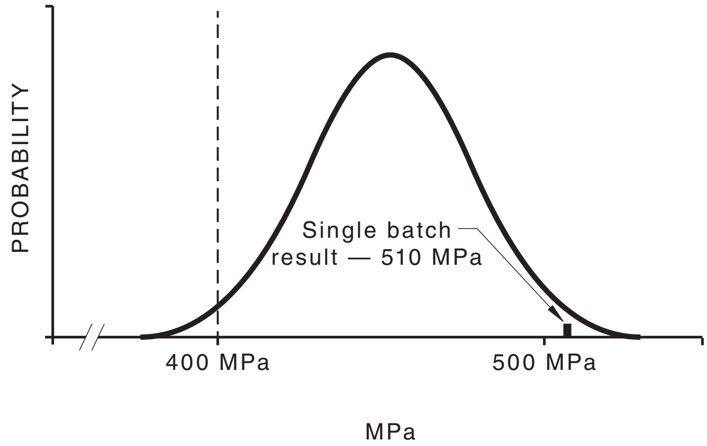


Figure E.3 — Product A — Long-term quality data

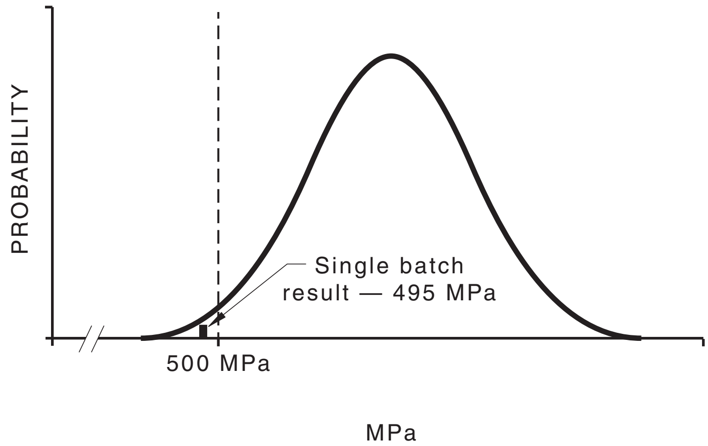


Figure E.4 — Product B — Long-term quality data

If the LTQ results were used to select the reinforcing material, Product B would be the clear choice as it meets both the product conformity requirements of this Standard and the design methodology of AS 3600. The LTQ test results for Product A indicates that the facility is actually making 400 MPa product and the single test result is consistent for that facility making that product. The LTQ test results for Product B indicates that the facility is making 500 MPa product. While the single test result is below the C_{vL} the facility is consistently making product, which exceeds the C_{vL} of 500 MPa with at least a 95 % probability.

Furthermore, the LTQ results for Product B indicates that it is consistent with the probabilistic design methodology employed in other Standards.

Clause B.6 addresses products without LTQ but still provide a level of confidence that the batch of reinforcing steel conforms to this Standard, by requiring a more intensive testing frequency, consistent with type testing, for a single batch of reinforcing steel.

E.4 Test certificates

The minimum requirements for test certificates (when supplied) are covered in Clause 10.4. This is recognition that long term test data is the most significant criteria to determine whether the tensile properties meet the product conformity requirements of this Standard.

The request for or supply of a batch test report, which relates only to a specific element of reinforcing steel, is not preferred, and the reasons for this are explained in the text above. It would be relevant only if the manufacturer has not established a LTQ data set.

Appendix F
(informative)

Rationale for product conformity and sampling

F.1 Introduction

This Appendix provides the rationale for the testing requirements to demonstrate product conformity using long term quality (LTQ), when applicable, and a batch testing protocol when LTQ is not available. Commentary is also provided on the selection of test samples for decoiled material.

Reinforcing steel manufacturers typically make bar and coil products and will have separate LTQ data sets for each diameter and grade in the range. For reinforcing steel manufactured in coils for ease of transport and processing productivity, the reinforcing steel is commonly passed through a set of straightening and/or drive equipment, which may change the properties. This means that after processing, testing is required to demonstrate products meet the requirements of this Standard.

F.2 Product conformity

Two fundamentals of the product conformity requirements of this Standard are as follows:

(a) The best way to ensure that all reinforcing steel from a manufacturer/processor conforms to the Standard is to know processes are under good control and can be relied on to consistently output conforming products.

(b) Where practical, reinforcing steel is tested and proven to conform in the final form that is being used.

To achieve the first objective, minimum testing and assessment regimes are specified for the mechanical properties to estimate the average value and expected spread of those properties. The LTQ testing is explained further in Appendix E. Intensive testing is required initially to demonstrate conformance and this is often referred to as “type testing”. Once a manufacturer/processor has established an average and typical spread of results over time for each reinforcing steel showing consistent conformance to the Standard, the frequency of testing outlined in Clause B.2 can be applied. The calculated lower and upper limits of the spread for each set of results are referred to as lower and upper characteristic values ($R_{ek.L}$ and $R_{ek.U}$). These values are calculated from the average and standard deviation of those sets of results, and a multiplier K, which is higher for a lower number of results. The results that are assessed are for either the last 6 months of production or the last 200 results, whichever provides the greater number of results. If there are less than 200 test results for that reinforcing steel then all the available results are used, and a larger multiplier K is used to more conservatively predict the spread.

The following is a worked example of lower and upper characteristic yield stress calculations for grade 500E:

Data set = 100 test results,

$\overline{X}_{100}$ = 550 MPa,

s_{100} = 20 MPa,

Statistical multiplier K from Table B.4 = 1.86

So, the lower and upper characteristic values are:

$R_{ek.L}$ = 513 MPa

$R_{ek.U}$ = 587 MPa

The conclusion is that long term quality has passed for 500E (limits 500 MPa to 600 MPa).

NOTE Similar calculations may be performed for A_{gt} and R_m/R_e. However, the statistical multiplier K would be 1.47.

F.3 Selection of test samples in decoiled product

Coiled products may be changed into many shapes. Identification of the correct location for testing for conformity is important to ensure sampling consistency. For straightened reinforcing steel, the test samples are taken from a straightened bar. Where coil is not straightened or not passed through drive equipment, the sampling point is at the coil. If the sampling point is at the coil, then the test results provided by the manufacturer of the coil can be relied on to demonstrate conformity. Where coil is straightened or partially straightened and then subsequently recoiled, e.g. Spiral ligatures, a section of straightened bar is tested.

Reinforcing steel is required to have the strength and ductility parameters specified by the design standard. For assurance that this is the case, these parameters of reinforcing steel are tested and measured necessarily after final processing, i.e. decoiling and straightening. This requirement excludes bends in bar made to conform to the bend requirements of standards such as NZS 3101 and AS 3600 as they are outside the scope of this Standard and are already covered by those design standards. Reinforcing steel that has been supplied in straight lengths, conforming to this Standard, can be cut and bent in accordance with the requirements of NZS 3101 or AS 3600, with no further testing required.

Some decoiling machines have multiple devices which straighten reinforcing steel. Each device should be treated as a separate machine.

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