भारतीय मानक ब्यूरो
(उपभोक्ता मामले, खाद्य एवं सार्वजनिक वितरण मंत्रालय, भारत सरकार)
BUREAU OF INDIAN STANDARDS
(Ministry of Consumer Affairs, Food & Public Distribution, Govt. of India)

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व्यापक परिचालन मसौदा

हमारा संदर्भ : सीईडी 54/टी-23 **25 अप्रैल 2025**

तकनीकी समिति: कंक्रीट प्रबलन विषय समिति, सीईडी 54

प्राप्तकर्ता :

1. **सिविल अभियांत्रिकी विभाग परिषद, सीईडीसी के सभी सदस्य**
2. **कंक्रीट प्रबलन विषय समिति, सीईडी 54 और इसकी उपसमितियों के सभी सदस्य**
3. **रुचि रखने वाले अन्य निकाय।**

महोदय/महोदया,

निम्नलिखित मानक का मसौदा संलग्न हैं:

प्रलेख संख्या	शीर्षक
सीईडी 54 (27399) WC	**संरचनात्मक कंक्रीट के लिए प्रबलन बार्स — विशिष्टि का भारतीय मानक मसौदा** **भाग 1: रिब्ड स्टील बार्स** (पांचवां पुनरीक्षण) **(ICS: 77.140.15;91.080.40)**

कृपया इस मसौदे का अवलोकन करें और अपनी सम्मतियाँ यह बताते हुए भेजे कि यह मसौदा प्रकाशित हो तो इन पर अमल करने में आपको व्यवसाय अथवा कारोबार में क्या कठिनाइयां आ सकती हैं।

सम्मतियाँ भेजने की अंतिम तिथि: 15 जून 2025

सम्मति यदि कोई हो तो कृपया अधोहस्ताक्षरी को ई-मेल द्वा **ced54@bis.gov.in** पर या उपरलिखित पते पर, संलग्न फोर्मेट में भेजें। सम्मतियाँ बीआईएस ई-गवर्नेंस पोर्टल, https://www.services.bis.gov.in/php/BIS_2.0/dgdashboard/draft/wcdraftDepartment के माध्यम से ऑनलाइन भी भेजी जा सकती हैं।

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यह प्रालेख भारतीय मानक ब्यूरो की वेबसाइट **www.bis.gov.in** पर भी उपलब्ध हैं।

धन्यवाद।

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ह/-
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वैज्ञानिक ई एवं प्रमुख
सिविल अभियांत्रिकी विभाग
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संलग्न: उपरलिखित

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WIDE CIRCULATION DRAFT

Our Reference: CED 54/T-23 **25 April 2025**

TECHNICAL COMMITTEE: CONCRETE REINFORCEMENT SECTIONAL COMMITTEE, CED 54

ADDRESSED TO:

1. All Members of Civil Engineering Division Council, CEDC
2. All Members of Concrete Reinforcement Sectional Committee, CED 54 and its Subcommittees
3. All others interested.

Dear Sir/Madam,

Please find enclosed the following draft:

Doc No.	Title
CED 54 (27399) WC	**Draft Indian Standard Reinforcing Bars for Structural Concrete — Specifications Part 1: Ribbed Steel Bars** (*Fifth Revision* of IS 1786) **(ICS 77.140.15;91.080.40)**

Kindly examine the attached draft and forward your views stating any difficulties which you are likely to experience in your business or profession, if this is finally adopted as National Standard.

Last Date for comments: 15 June 2025

Comments if any, may please be made in the enclosed format and emailed at ced54@bis.gov.in or sent at the above address. Additionally, comments may be sent online through the BIS e-governance portal, https://www.services.bis.gov.in/php/BIS_2.0/dgdashboard/draft/wcdraftDepartment .

In case no comments are received or comments received are of editorial nature, kindly permit us to presume your approval for the above document as finalized. However, in case comments, technical in nature are received, then it may be finalized either in consultation with the Chairman, Sectional Committee or referred to the Sectional Committee for further necessary action if so desired by the Chairman, Sectional Committee.

The document is also hosted on BIS website www.bis.gov.in.

Thanking you,

Yours faithfully,

Sd/-

Dwaipayan Bhadra
Scientist 'E' & Head
Civil Engineering Department
Email: ced54@bis.gov.in

Encl: As above

FORMAT FOR SENDING COMMENTS ON THE DOCUMENT

[Please use A4 size sheet of paper only and type within fields indicated. Comments on each clause/sub-clause/ table/figure, etc, be stated on a fresh row. Information/comments should include reasons for comments, technical references and suggestions for modified wordings of the clause. **Comments through e-mail to ced54@bis.gov.in shall be appreciated**.]

Doc. No.: CED 54 (27399) WC **BIS Letter Ref**: CED 54/T-23

Title: Draft Indian Standard Reinforcing Bars for Structural Concrete — Specifications Part 1: Ribbed Steel Bars (Fifth Revision of IS 1786) (ICS 77.140.15;91.080.40))
Last date of comments: 15 June 2025

Name of the Commentator/ Organization: _____

Sl No.	Clause/ Para/ Table/ Figure No. commented	Type of Comment (General/ Technical/ Editorial)	Comments/ Modified Wordings	Justification of Proposed Change

NOTE- Kindly insert more rows as necessary for each clause/table, etc

BUREAU OF INDIAN STANDARDS

DRAFT FOR COMMENTS ONLY

Draft Indian Standard

Reinforcing Bars for Structural Concrete — Specifications

Part 1: Ribbed Steel Bars

(*Fifth Revision* of IS 1786)

Concrete Reinforcement Sectional Committee, CED 54	Last date of Comments: **15 June 2025**

Foreword

Considering the demand for high yield strength, the Indian Standard Specification for cold-twisted steel bars for concrete reinforcement was first published in 1961 and subsequently revised in 1966, 1979, 1986 and 2008. In its second revision in 1979, the title of the standard was modified to 'Specification for cold-worked steel high strength deformed bars for concrete reinforcement'. In the third revision, IS 1139:1986 'Specification for hot rolled mild steel, medium tensile steel and high yield strength steel deformed bars for concrete reinforcement' was merged in the standard and the title was modified to 'Specification for high strength deformed steel bars and wires for concrete reinforcement'. The restriction to cold-working was removed in the third revision and the manufacturers were allowed to resort to other routes to attain high strength. In the fourth revision, new strength grade Fe 600 was introduced. Two categories based on elongation for each grade except Fe 600 were introduced. New parameter 'percentage total elongation at maximum force' was introduced and nominal sizes were rationalized.

Concrete reinforcing bars are being produced in the country by Thermo-mechanical Treatment (TMT) and micro-alloying. Nowadays, quenching and self-tempering (QST) processes are also viable option for production of reinforcing bars. This revision has been taken up to incorporate various changes found necessary from the experience gained and technological advances made in the field of steel reinforcement for concrete applications; and hence, to improve the mechanical and durability properties of reinforced concrete systems. This part allows the manufacturer to adopt any process to satisfy the performance requirements.

In the formulation of this standard, due weightage has been given to international co-ordination among the standards and construction practices prevailing in different countries.

The following are some of the important modifications incorporated in this revision:

a. The scope has been modified along with the grades and nominal sizes.

b. The existing suffixes of ‘D’ and ‘S’ in the designation have been removed
c. The chemical composition and mechanical properties have been modified.
d. The geometry of ribs and spines have been specified.
e. The marking on bars has been modified.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

BUREAU OF INDIAN STANDARDS

DRAFT FOR COMMENTS ONLY

Draft Indian Standard

Reinforcing Bars for Structural Concrete — Specifications

Part 1: Ribbed Steel Bars

(*Fifth Revision* of IS 1786)

Concrete Reinforcement Sectional Committee, CED 54	Last date of Comments: **15 June 2025**

1 SCOPE

1.1 This standard covers the requirements of ribbed steel bars of grades Fe415, Fe500 and Fe550, for use as reinforcement in concrete structures. Here, the number following the symbol Fe represents the characteristic yield strength in MPa.

1.2 The provisions of this standard are applicable to the following ribbed steel bars:

a) Hot-rolled steel with air cooling,

b) Hot-rolled steel with controlled quenching and self-tempering (QST), and

c) Cold-worked steel.

1.3 This standard admits the use of bars, which are supplied in the form of coils or straight lengths, but the requirements of this standard shall apply to the straightened product in such cases.

1.4 Bars produced by re-rolling finished products (virgin or used or scrap), or by rolling material for which the metallurgical history is not fully documented or not known, are not acceptable as per this standard.

2 REFERENCES

The standards listed in Annex A contain provisions, which through reference in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of these standards indicated next:

IS No.	*Title*
IS 228 Parts	Methods for Chemical Analysis of Steels
IS 1387 : 1993	General Requirements for the Supply of Metallurgical Materials (*Second Revision*)

IS 1599 : 2023/ ISO 7438 : 2020	Metallic Materials — Bend Test (*Fifth Revision*)
IS 1608 (Part 1) : 2022/ ISO 6892-1 : 2019	Metallic Materials — Tensile Testing Part 1 Method of Test at Room Temperature (*Fifth Revision*)
IS 2062 : 2011	Hot Rolled Medium and High Tensile Structural Steel — Specification (*Seventh Revision*)
IS 2770 (Part 1) : 1967	Methods of Testing Bond in Reinforced Concrete Part 1 Pull-Out Test
IS 9417 : 2018	Welding of High Strength Steel Bars for Reinforced Concrete Construction — Recommendations (*Second Revision*)
IS 14650 : 2023	Unalloyed and Alloyed Steel Ingot and Semi-finished Products for Re-Rolling Purposes — Specification (*First Revision*)

3 TERMINOLOGY

For this standard, the following definitions shall apply:

3.1 Batch — Any quantity of bars of same size and grade, whether in coils or bundles, presented for examination and test at one time.

3.2 Bundle — Two or more coils or several lengths properly bound together.

3.3 Characteristic Yield Strength — The strength of steel bar corresponding to 0.2% proof strain, below which not more than 5% of the test results are expected to fall, when finalizing the grade of steel.

3.4 Elongation — The increase in length of a tensile test piece under stress. The elongation at fracture is conventionally expressed as a percentage of the original gauge length of a standard test piece.

3.5 Nominal Diameter — The diameter of an equivalent round bar having the same mass per meter length as the deformed bar.

3.6 Nominal Mass — The mass per meter run of the bar of nominal diameter determined using a density of 7850 kg/m^2.

3.7 Percentage Total Elongation at Maximum Force — The elongation corresponding to the maximum load reached in a tensile test (Also termed as uniform elongation).

3.8 Rib — Any deformation on the surface of a bar or wire other than a spine.

3.9 Spine — A uniform continuous protrusion, parallel to the axis of bar.

3.10 Tensile Strength — The maximum load reached in a tensile test divided by the cross -sectional area of the gauge length portion of test piece (Also termed as ultimate tensile stress).

3.11 Yield Stress — During the tensile test, the stress (that is, load per unit cross-sectional area) at which elongation in the test piece continues to increase without

increasing the load. In the case of steels with no such definite yield point, proof stress shall be applicable

3.12 Thermo-mechanical Treatment (TMT) — It is process of hot rolling followed by controlled cooling.

3.13 Quenching and Self tempering (QST) — Quenching involves rapid cooling of the surface layer of steel from the austenizing temperature by immersion in water, to martensite (stable at temperatures below 350^0C). A part of the original heat remains in the core of steel and on cooling bed this heat migrates towards the surface which results in an automatic self-tempering process, where the surface layer of martensite is tempered.

4 SYMBOLS

A_{tr}	=	Area (mm^2) of longitudinal section of a rib on its own axis (Fig. 2) or area of rib of uniform height on its own axis,
n_{tr}	=	Number of rows of ribs,
α	=	Inclination (°) of the rib to the bar axis (after twisting for cold-worked twisted bars) in degrees. Average value of two ribs from each row of ribs shall be taken,
c	=	Spacing (mm) of ribs,
n_{lr}	=	Number of spines,
d_{lr}	=	Height (mm) of spines,
ϕ	=	Nominal diameter (mm) of bar, and
S_p	=	Pitch (mm) of twist
n'_{lr}	=	Number of discontinuous spines,
l'	=	Average length of discontinuous spines,
d'_{lr}	=	Height of discontinuous spines,
s'_{lr}	=	Average spacing of discontinuous spines,
d_{lr}	=	Height of continuous spines, and
n_{cs}	=	Number of continuous spines.
w	=	Mass (kg) weighed to a precision of ± 0.5 percent, and
L	=	Length (m) measured to a precision of ± 0.5 percent.
ε_{max}	=	Maximum elongation at rupture of the bar obtained from tensile tests, and
ϕ_m	=	Nominal diameter of the bar.
GGG	=	Grade of steel bar (415, 500, or 550)
k	=	Acceptability index according to Table 8, and
s	=	Standard deviation of test results.
f_k	=	Required characteristic value
k	=	Acceptability index obtained from Table 9
x_i	=	Variable
n	=	Number of tests

5 MATERIALS AND MANUFACTURE

5.1 The production processes shall be at the discretion of manufacturer, but shall have at least one step involving melting and homogenization.

5.2 The bars shall be manufactured from properly identified heats of mould cast, continuously cast steel or rolled semis.

5.3 Steel billets and ingots used for rolling to bars shall comply with the provisions of IS 14650.

5.4 The steel bars for concrete reinforcement shall be manufactured by the process of hot rolling. It may be followed by a suitable method of cold working and/or in-line controlled cooling.

5.5 All bars shall be free from surface or other defects that are detrimental to their subsequent processing and to their end-use in concrete structures.

5.6 Direct re-rolling from finished products, such as plates and rails, shall not be permitted.

6 CHEMICAL COMPOSITION

6.1 Cast Analysis

6.1.1 When carried out by the method specified in IS 228 or any other established instrumental or chemical method, the maximum percentage of constituents shall not exceed the permissible specified in Table 1.

a) In case of dispute, the procedure given in IS 228 and its relevant parts shall be the reference method.

b) Where test methods are not specified, the method to be adopted shall be as agreed to between the purchaser and the manufacturer or supplier.

6.1.2 Carbon equivalent (CE) shall be calculated as:

$$CE = C + \frac{Mn}{6} + \frac{(Cr + Mo + V)}{5} + \frac{(Ni + Cu)}{15}$$

Table 1: Maximum permissible limits of elemental composition

Element	Maximum Permissible Limit (% of cast metal)			Maximum Permissible Variation Over Specified Maximum Limit (%)
	Fe415	Fe500	Fe550	All grades
Carbon, C	0.250	0.250	0.270	0.020
Sulphur, S	0.040	0.040	0.040	0.005
Phosphorus, P	0.040	0.040	0.040	0.005
S + P	0.075	0.075	0.075	0.010
Manganese, Mn	1.600	1.600	1.600	0.050
Carbon equivalent, CE	0.45	0.50	0.55	0.02

6.1.3 Alloy elements, such as Cu, Ni, Cr, Mo, V, Nb, Ti, B and Zr, may be added.

a) To improve corrosion resistance, alloying elements (like Cr, Cu, Ni, Mo and P) shall be added either individually or in combination with a total content of at least 0.40 percent. But, the minimum content of Cu shall be 0.20 percent and the maximum content of P shall not exceed 0.12 percent.

b) If the phosphorus content is beyond the limit prescribed in **Table 1**, then the carbon content shall be less than 0.15 percent and in such case the restriction on the maximum content of S and P as given in **Table 1** shall not apply.

c) **Table 1**The manufacturer shall supply the purchaser or his authorized representative with a test certificate stating the individual contents of all elements including micro alloying elements wherever applicable.

6.1.4, Nitrogen content of steel should not exceed 0.012 percent (120 ppm) which will be ensured by the manufacturer by occasional check analysis. Higher nitrogen content of up to 0.025 percent (250 ppm) may be permissible, provided enough nitrogen binding elements (including Nb, V, Ti, and Al) are present. In such case, the following criteria shall be satisfied:

$$(N - 120) < \frac{Al_{free}}{10} + \frac{(T_i + V)}{7} + \frac{N_b}{14},$$

where, the concentrations of the said elements are in ppm.

6.1.4 The Copper content may be between 0.2 percent and 0.35 percent, with a tolerance of ± 0.03 percent on these limiting values**.**

6.2 Product Analysis

6.2.1 In case of product analysis, the permissible variation from the limits of cast analysis specified under **6.1** shall be as per the last column of **Table 1**.

6.2.2 In case of deviations from the specified maximum, two additional test samples shall be taken from the same batch and subjected to the test or tests in which the original sample failed. Should both additional test samples pass the test, the batch from which they were taken shall be deemed to comply with this standard. Should either of them fail, the batch shall be deemed not to comply with this standard.

7 GEOMETRY AND DIMENSIONS

7.1 Requirements for Ribs and Spines

7.1.1 Ribs shall conform to the requirements given in **Table 2**.

Table 2: Requirements on Geometry of Ribs

Rib Geometry Parameter	Nominal Diameter (mm)	Values
Minimum height, d_{tr}	All	0.03ϕ
Spacing, c	$6 \leq \phi \leq 10$ $10 < \phi$	$0.5\phi \leq c \leq \phi$ $0.5\phi \leq c \leq 0.8\phi$
Inclination of rib with the axis of the bar, β	All	$35° \leq \beta \leq 90°$
Flank inclination, α	All	$\alpha \geq 40°$

Maximum part of circumference without rib	All	$0.25\phi\pi$
Maximum top width of rib at mid-point, b	All	0.2ϕ

7.1.2 Ribs shall be uniform in size and shape and spaced along the bar at substantially uniform distances. The ribs on opposite sides of the bar shall be similar in size, shape, and pattern (*see*, **FIG. 1**).

The mean area of ribs (in mm^2) per unit length (in mm) above the core of bar, projected on a plane normal to the axis of bar calculated in accordance with **7.1.6**, shall not be less than the values given below:

0.12ϕ for $\phi \leq 10mm$
0.15ϕ for $10mm < \phi \leq 16mm$
0.17ϕ for $\phi > 16mm$

7.1.4 The presence of spine on the bars is not a mandatory requirement provided it satisfies the mechanical properties given under **8**.

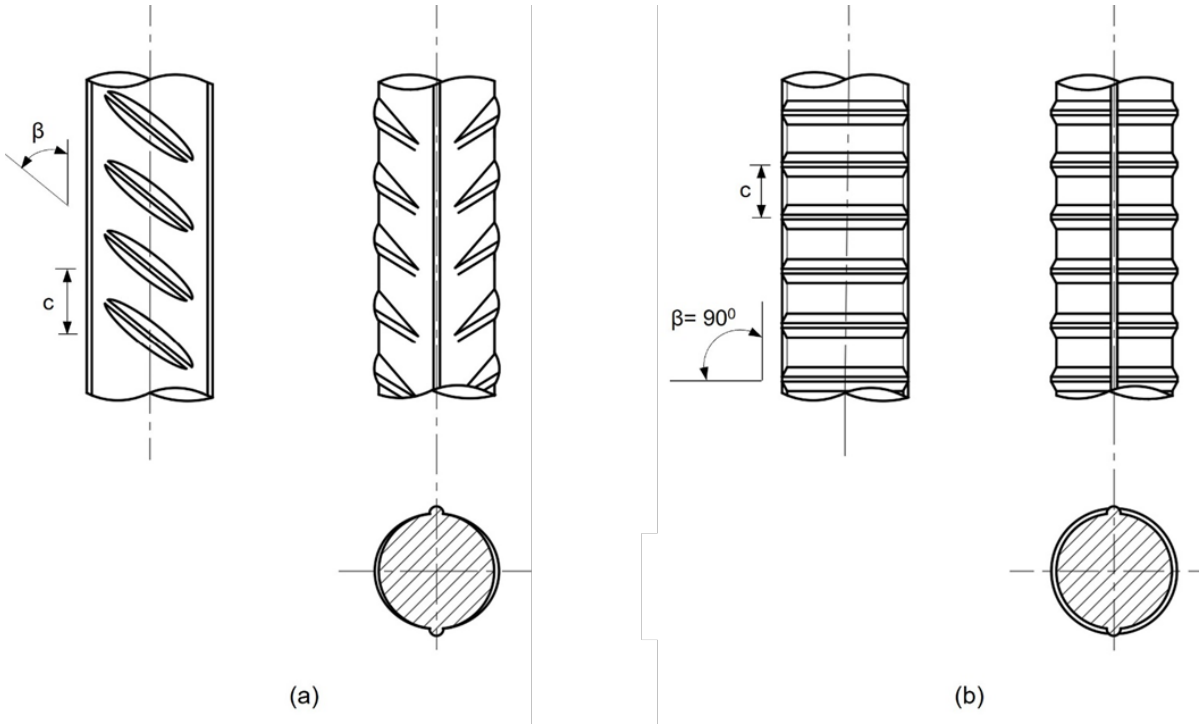


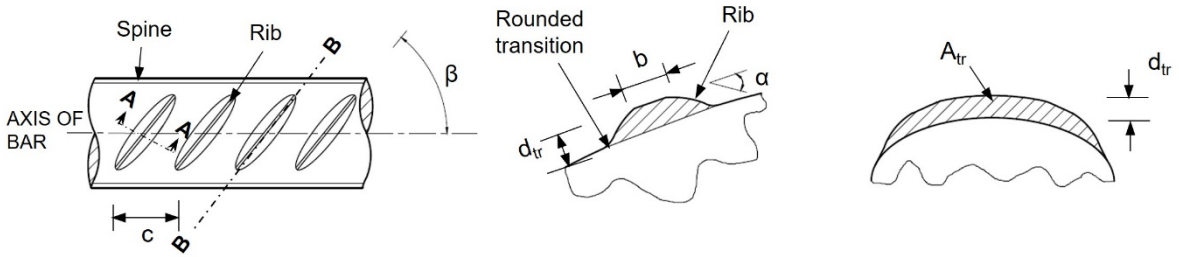
FIG. 1: GEOMETRIES OF TWO ROWS OF TRANSVERSE RIBS PERMITTED ON BARS: (A) RIBS WITH CRESCENT SHAPE OR UNIFORM SHAPE, INCLINATION (35° ≤ B < 90°), AND REVERSING DIRECTION ON OPPOSITE FACES, AND (B) RIBS WITH UNIFORM CROSS-SECTION AND HEIGHT AND INCLINATION (B = 90°)

7.1.5 The mean projected rib area per unit length, A_r (mm^2/mm), shall be estimated as:

$$A_r = \sum_{i=1}^{n_{tr}} \left[\frac{A_{tr} \sin \alpha}{c}\right]_i + \frac{n_{lr} d_{lr} \pi \phi}{S_p} ,$$

Where,

n_{tr} = Number of rows of ribs,
A_{tr} = Area (mm^2) of longitudinal section of a rib on its own axis (**FIG. 2**) or area of rib of uniform height on its own axis,
α = Inclination (°) of the rib to the bar axis (after twisting for cold-worked twisted bars) in degrees. Average value of two ribs from each row of ribs shall be taken,
c = Spacing (mm) of ribs,
n_{lr} = Number of spines,
d_{lr} = Height (mm) of spines,
ϕ = Nominal diameter (mm) of bar, and
S_p = Pitch (mm) of twist.



(a) Inclined ribs (b) Section A-A (c) Section B-B

FIG. 2: GEOMETRY OF TRANSVERSE RIBS [FIG. 2(a), 2(b), AND 2(c) ARE NOT DRAWN TO SAME SCALE]

7.1.5.1 In hot rolled bars which are not subjected to cold twisting, the second term in the expression for A_r in **7.1.5** shall be taken as zero.

7.1.5.2 When ribs are crescent shaped as shown in **FIG. 2**, A_{tr} shall be calculated as:

$$A_{tr} = \frac{2}{3} l_{tr} d_{tr}$$

7.1.5.3 In cold-worked bars with some discontinuous spines, the equivalent number of spines n_{lr} shall be calculated as:

$$n_{lr} = \frac{n'_{lr} l' d'_{lr}}{s'_{lr} d_{lr}} + n_{cs}$$

Where,

n'_{lr} = Number of discontinuous spines,
l' = Average length of discontinuous spines,
d'_{lr} = Height of discontinuous spines,
s'_{lr} = Average spacing of discontinuous spines,
d_{lr} = Height of continuous spines, and
n_{cs} = Number of continuous spines.

7.1.6 The average length of discontinuous spines shall be determined by dividing a measured length of bar (the distance from the center of one rib to that of another, and equal to at least 10ϕ) by the number of discontinuous spines in the measured length.

7.1.7 The height of spines shall not exceed 0.15ϕ.

7.1.8 The average spacing between ribs on each face of the bar shall not exceed 0.70ϕ.

7.1.9 The requirements for geometry of ribs and spine are:

7.1.9.1 The average height of spine shall be obtained from the measurements made at not less than four equally spaced points over a length of 10ϕ or pitch of rib, whichever is greater.

7.1.9.2 The height of a rib (d_{tr}) shall be measured at the highest points on the rib, of 10 successive ribs.

7.1.9.3 The average spacing of ribs shall be determined by dividing a measured length of the bar equal to at least 10ϕ by the number of spaces between ribs in the measured length. The measured length of the bar shall be the distance from the center of one rib to the center of another rib.

7.1.9.4 The overall length of ribs shall be such that the gap (measured as a chord) between the ends of the ribs shall not exceed 12.5 percent of the nominal perimeter of the bar. Where the ends terminate in a rib, the width of the rib shall be considered as the gap between these ends. The summation of the gaps shall not exceed 25 percent of the nominal perimeter of the bar.

7.1.9.5 Each rib flank inclination (α) shall be determined as the mean of the individual inclinations on the same side of the ribs. α shall be measured by determining the line of best fit between two points on the slope, far enough apart to give a representation of the inclined angle, but avoiding the slope at the extreme ends of the base and peak of the ribs.

7.1.9.6 The rib or indentation angle (β) to the longitudinal axis shall be determined as the mean of the individual angles measured for each row of ribs with the same nominal angle.

7.1.9.7 The top-width of rib at mid-point of rib (b) shall be determined as the mean of three measurements on each row made parallel to the longitudinal axis, along a line crossing ribs at the surface level of the bar.

7.2 Cross-Sectional Phase Distribution

7.2.1 This section is applicable only to the bars produced using the **QST** processes.

7.2.2 Acceptable microstructural phase distribution of QST bar, showing Tempered Martensite (TM) outer ring, Bainitic rim and Ferrite Pearlite (FP) core (**FIG. 3**). Note that the Bainitic phase may not be visible with naked eyes in all cases.

7.2.3 The thickness of TM phase at eight points mentioned in **Table 3**, as given in **9.2**, shall be between 0.05ϕ and 0.15ϕ.

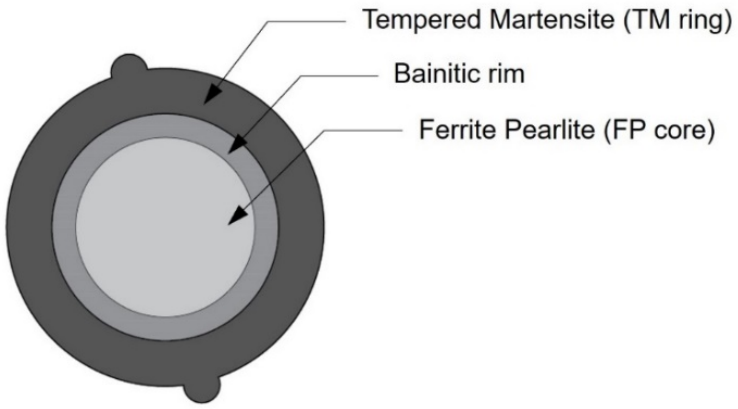
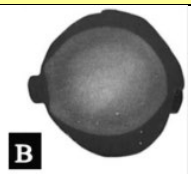
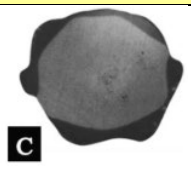
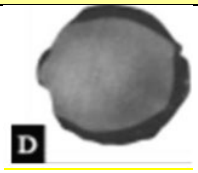
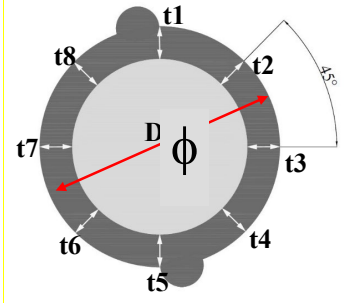


FIG. 3: CROSS-SECTIONAL PHASE DISTRIBUTION OF A GOOD QUALITY QST BAR

Table 3: Method of obtaining CSPD of TM Ring

Step 1: Visual analysis of etched cross-section				
				
	Acceptable	*Not acceptable*	*Not acceptable*	*Not acceptable*
1.	Is a dark grey peripheral region and light grey core seen as in Case A?			Yes/No
2.	Does the dark grey peripheral region form a continuous outer ring?			Yes/No
Step 2: Dimension analysis of TM-Ring thickness				
3.	Diameter ϕ *(mm)* of steel bar			
4.	**Geometry** 	t_1		
		t_2		
		t_3		
		t_4		
		t_5		
		t_6		
		t_7		
		t_8		
		Measured t_{min} *(mm)*		
		Measured t_{max} *(mm)*		
5.	Is the measured $t_{min} \geq 0.05\ \phi$?		Yes / No	
	Is the measured $t_{max} < 0.15\ \phi$?		Yes / No	

7.3 Nominal Diameter

7.3.1 Bars of the nominal diameters shall have the cross-sectional area and mass as given in **Table 4**.

Table 4: Nominal diameter and corresponding cross-sectional area and mass of bars

Nominal Diameter (mm)	**Nominal Cross-Sectional Area** (mm^2)	**Mass per unit Length** (kg/m)
6	28.3	0.222
8	50.3	0.395
10	78.6	0.617
12	113.1	0.888
16	201.1	1.58
20	314.2	2.47
25	490.9	3.85
28	615.8	4.83
32	804.2	6.31
36	1017.9	7.99
40	1256.6	9.86
45	1591.1	12.5
50	1964.4	15.4

7.3.2 Bars of other nominal diameters may be supplied by mutual agreement.

The cross-sectional area, A (mm2), shall be determined using a bar not less than 0.5 m long and as follows:

$$A = \frac{w}{0.00785\ L}$$

where

w = Mass (kg) weighed to a precision of ± 0.5 percent, and

L = Length (m) measured to a precision of ± 0.5 percent.

7.4 Tolerances

7.4.1 *Length*

The tolerance on standard length of bars shall be – 25 / + 75 mm. If other lengths are specified by the user, then the tolerance can be mutually agreed between the manufacturer and purchaser.

7.4.2 *Nominal mass*

The tolerances on nominal mass of bars shall be as given in **Table 5**.

7.4.2.1 The nominal mass per meter run of a sample of a straight bar shall be taken as the mass of the sample divided by the actual length (of at least 0.5 m length) of sample. In case of a coil, the sample can be taken from any one end of the coil.

7.4.3 *Straightness*

The tolerance on straightness of bars shall be:

a) L/50 in bars of nominal size 16 mm or less, and

b) L/100 in bars of nominal size more than 16 mm.

Table 5: **Tolerances on Nominal Mass**

Nominal diameter	**Tolerance on Nominal Mass** (%)	
	Batch	Individual sample for straight bars and coils
≤ 10 mm	– 7 / +7	– 8 / +8
> 10 mm and ≤ 16 mm	– 5 / +5	– 6 / +6
> 16 mm	– 3 / +3	– 4 / +4

8 MECHANICAL PROPERTIES

8.1 Tensile Properties

8.1.1 Modulus of Elasticity shall be determined as the slope of the line connecting the points on the stress-strain graph at stress equal to 50 MPa and 200 MPa. The obtained modulus shall be between 190 and 210 GPa.

8.1.2 Tensile properties of all nominal sizes shall comply with requirements given in **Table 6.**

8.1.3 Measurements can be made using a tensile test performed over a gauge length $5.65\sqrt{A}$, where, A is the nominal cross-sectional area.

8.1.4 Yield stress is measured as 0.2 percent proof stress

8.2 Bent Bar Properties

8.2.1 Bars satisfying the test requirements given in **9.4** shall be deemed to have satisfied bend properties.

8.2.2 The test specimen shall be considered to have passed the test, if there is no rupture or cracks visible to a person of normal or corrected vision on the bent portion.

8.3 Steel-Concrete Bond Properties

8.3.1 The bond strength between the bar and concrete shall be determined using the pull-out test in accordance with IS 2770 (Part 1). The bond strength calculated from the load at a measured slip of 0.025 mm and 0.25 mm for deformed bars shall not be less than $0.64\sqrt{f_{ck}}$ and $1.61\sqrt{f_{ck}}$, respectively.

8.3.2 Bars satisfying the requirements given in **8.3.1** shall be deemed to have satisfied the bond requirements of a deformed bar. The pull-out test in accordance with **8.3.1** shall be performed for approval of new or modified rib geometry, whenever such modifications are made.

Table 6: Mechanical properties of bars

Parameter	Fe415	Fe500	Fe550
Minimum Yield Stress (MPa)	415	500	550
Maximum Yield Stress (MPa)	545	630	680
Maximum Tensile Strength (MPa)	665	750	800
Minimum Elongation (%) at maximum force	7	5	5
Minimum Elongation (%) at fracture	18	16	14.5

9 TESTS

9.1 Conditions of Test

Unless otherwise specified in this standard, the requirements of IS 2062 shall apply.

9.1.1 All test pieces shall be selected by the purchaser or his authorized representative, either,

a) from the cuttings of bars; or
b) if, he so desires, from any bar after it has been cut to the required or specified size and the test piece taken from any part of it.

In neither case, the test piece shall be detached from the bar except in the presence of purchaser or his authorized representative.

9.1.2 The test pieces obtained in accordance with **9.1.1** shall be full sections of bars, and shall be subjected to physical tests without any further modifications. No reduction in size by machining or otherwise shall be permissible, except in case of bars of size 28 mm and above. No test piece shall be annealed, or otherwise subjected to heat treatment except as provided in **9.1.4**. Any straightening which a test piece may require shall be done cold.

9.1.3 To carry out tests for tensile strength, proof stress, percentage elongation and percentage elongation at maximum force for bars 28 mm in diameter and above, deformations of the bars only may be machined. For such bars, the physical properties shall be calculated using the actual area obtained after machining.

In case of any dispute, the results obtained from full bar test pieces (without machining to remove deformations) shall be treated as final and binding.

9.1.4 Notwithstanding the provisions in **9.1.2**, test pieces may be subjected to artificial ageing at a temperature not exceeding 100 °C, and for a period not exceeding 2 hours.

9.1.5 Before the test pieces are selected, the manufacturer or supplier shall furnish the purchaser or his authorized representative with copies of the mill records, giving the mass of bars in each bundle/cast with sizes as well as the identification marks, whereby bars from the cast can be identified.

9.2 TM Ring Test

9.2.1 This is a mandatory test for the bars produced using the **QST** processes.

9.2.2 The test setup to capture the Cross-Sectional Phase Distribution (CSPD) of reinforcement bars is as shown in FIG. 4. For this, cut a 10 mm long piece of the bar using handsaw or an abrasive cutter with continuous supply of coolant. Smoothen the sharp edges using a metal polishing machine. Mould the cut steel piece in translucent or opaque cold setting epoxy with good surface finish. Setting time of epoxy is typically about 10-15 minutes. Care should be taken while mixing and placing the epoxy to avoid air bubbles getting trapped. Silicone rubber mould should be used to remove the molded specimens easily.

9.2.3 The moulded specimen surface should be course polished using abrasive sheets of 80, 150, 220, 320, and 600 grit sizes in order. It is important to avoid rise in the temperature of steel specimen by supplying water or coolant continuously to absorb the heat generated during polishing. Micro-etch the moulded specimen using Nital (5% Nitric acid in alcohol) to capture the CSPD.

9.2.4 The procedures for obtaining CSPD is as follows:

a) Mount the camera and lamps to capture the image,
b) Place the specimen on the movable platform, and
c) Adjust the position of the specimen, as needed.

9.2.5 In case of reinforcing bars, there should be no point in the cross section having zero rim thickness. If not, 3 samples from the same lot shall be drawn for re-check. Only when all three comply with this requirement, then the lot shall be deemed to have passed this test. At least one sample shall be checked in 24 hours rolling and record maintained by manufacturer.

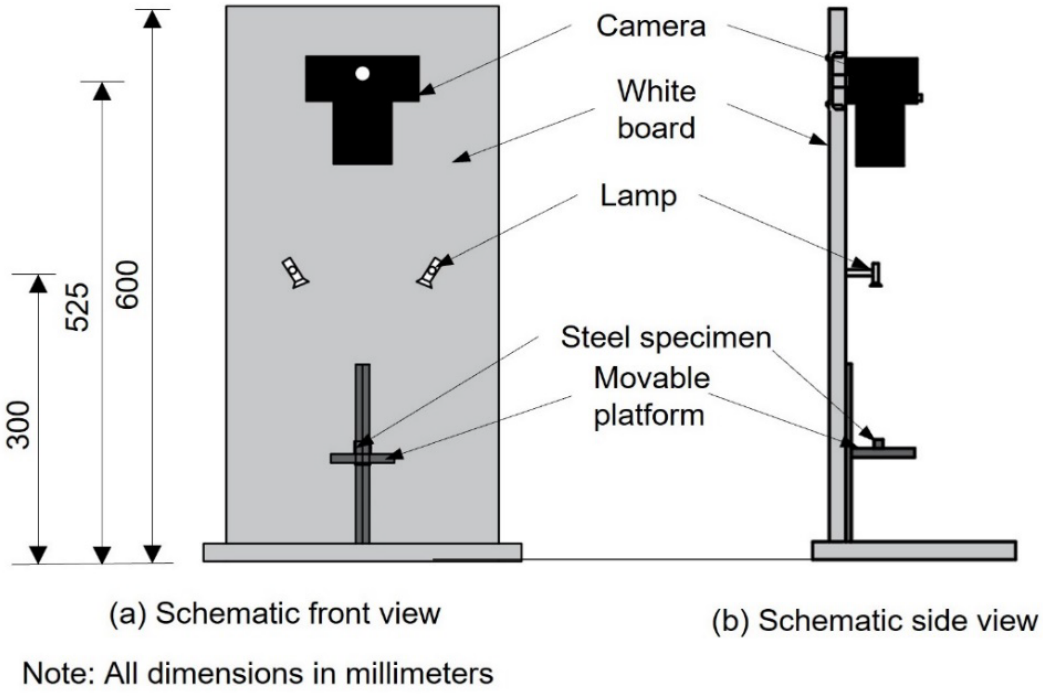


FIG. 4: TEST SETUP FOR CSPD OF TMT REBARS

9.3 Tensile Test

9.3.1 The tensile strength, percentage elongation, percentage total elongation at maximum force and 0.2 percent proof stress of bars shall be determined in accordance with the requirements of IS 1608 (Part 1) read in conjunction with IS 2062.

9.3.2 Alternatively, and by agreement between the purchaser and the supplier, for routine testing, the proof stress may be determined in conjunction with the tensile strength test, and may be taken as the stress measured on the specimen whilst under load corresponding to an increase of total strain on any convenient gauge length, as 0.40 percent for Fe 415, 0.45 percent for grade Fe 500, and 0.47 percent for grade Fe 550 bars. When this alternative is used, the total strain shall be measured only by extensometer and not by any other means. In case of dispute, the proof stress determined in accordance with IS 1608 shall be the deciding criteria.

9.3.3 The stresses shall be calculated using the effective cross-sectional area of bar.

9.4 Bend Test

The bend test and hooks made at site shall comply with the requirements of IS 1599, and the maximum mandrel diameter for different grades for minimum elongation at rupture shall not be less than those specified in **Table 7**.

9.4.1 When bars are produced with larger maximum elongation than the minimum values specified in **Table 7**, the mandrel diameter ϕ_m required for steel bars of any grade shall be estimated as:

$$\phi_m = \left[\frac{1}{\varepsilon_{max}} - 1\right]\phi,$$

Where,

ε_{max} = Maximum elongation at rupture of the bar obtained from tensile tests, and

ϕ = Nominal diameter of the bar.

9.4.2 The test piece, when cold, shall be doubled over the mandrel by continuous pressure until the sides are parallel.

9.4.3 The specimen shall be considered to have passed the test, if there is no rupture or cracks visible to a person of normal or corrected vision on the bent portion.

9.4.4 The mandrel diameter as specified in **Table 7** shall be used also for bending bars during bar-bending during the construction of concrete structures.

Table 7: Mandrel diameter required for different grades of steel bars

Requirement	Grades of Steel		
	Fe415	Fe500	Fe550
Mandrel diameter	4ϕ	5ϕ	7ϕ

10 DURABILITY PROPERTIES

10.1 Bars satisfying the requirements of cross-sectional phase distribution given in **7.2** and **9.2** and the requirements of bend test given in **9.4** shall be deemed to have satisfied the durability requirements of deformed bar.

11 INSPECTION AND TESTING

11.1 Routine Inspection and Testing

11.1.1 All steel bars shall be subjected to routine inspection and testing by the manufacturer or supplier in accordance with this standard and a record of test results of material conforming to this standard shall be kept by the manufacturer or the supplier. The records shall be available for inspection by the purchaser or his representative.

11.1.2 When the material delivered to a supplier, the manufacturer shall supply a certificate containing results of all the required tests on samples taken from the delivered material.

11.2 Delivery, Inspection and Testing Facilities

11.2.1 Unless otherwise specified, general requirements relating to the supply of material, inspection and testing shall conform to IS 1387.

11.2.2 No material shall be dispatched from the manufacturers or supplier's premises prior to its being certified by the purchaser or his authorized representative as having fulfilled the tests and requirements laid down in this standard except where the bundle containing the bars is marked with the Standard Mark (*see* **11.3.3**).

11.2.3 The purchaser or his authorized representative shall be at liberty to inspect and verify the steel maker's certificate of cast analysis at the premises of the manufacturer or the supplier. When the purchaser requires an actual analysis of finished material, this shall be made at a place agreed to between the purchaser and the manufacturer or the supplier.

11.2.4 *Manufacturer's Certificate*

In the case of bars which have not been inspected at the manufacturer's works, the manufacturer or supplier shall supply the purchaser or his authorized representative with the certificate stating the process of manufacture and also the test sheet signed by the manufacturer giving the result of each mechanical test applicable to the material purchased, and the chemical composition, if required. Each test certificate shall indicate the number of the cast to which it applies, corresponding to the number or identification mark to be found on the material. The test certificate shall contain the following information:

a) Place of manufacture of bars;
b) Nominal diameter of bar;
c) Designation of bars in accordance with this document;
d) Rolled-in marking on the steel;
e) Cast/heat number;
f) Date of testing;
g) Mass of tested lot; and

h) Individual test results for all properties.

11.3 Designation and Marking

The manufacturer or supplier shall have ingots, billets and bars or bundles of bars marked in such a way that all finished bars can be traced to the cast from which they were made. Every facility shall be given to the purchaser or his authorized representative for tracing the bars to the cast from which they were made.

11.3.1 *Marking on Bars*

11.3.1.1 All bars should be identifiable by marks/brands introduced during rolling which indicate the name of manufacturer or their brand name.

11.3.1.2 Identification marks like brand name and trade-mark, that are introduced during rolling shall be designed and located in such a manner that the performance and the use of bar is not affected.

11.3.1.3 The label ABCD-GGG shall be embossed on the bar, where these symbols shall represent the following:

ABCD : Four alphabet code to reflect the name of the company
GGG : Grade of steel bar (415, 500 or 550)

11.3.2 *Identification of Bundles*

For each bundle of bars, a tag shall be attached indicating the following details.

a) Symbol of grade
b) Heat number or other manufacture number (inspection number)
c) Nominal diameter or designation
d) Manufacturer’s name or its abbreviation/ Mill name

11.3.3 *BIS Certification Marking*

The bundle containing the bars conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations framed thereunder, and the bundle containing the bars may be marked with the Standard Mark.

12 EVALUATION OF CONFORMITY

12.1 General

The certification and inspection of steel bars shall be performed in accordance with the following methods:

a) A certification following a conformity assessment scheme, *see* **12.2**.
b) Testing of a specific delivery, *see* **12.3**.

12.2 Evaluation of Conformity During Production

12.1 For each of the characteristics specified in this document except chemical composition, one test piece shall be taken per 40 T for all nominal diameters, with at least three test pieces per cast and nominal diameter.

12.2 The chemical composition (cast analysis) listed in shall also be determined for all casts. The contents of elements specified in this document shall be determined in the analysis.

12.3 Each individual value, xi should satisfy the following criterion:

$$x_i \geq 0.95 f_k$$

where f_k is the required characteristic value given in **Table 6**.

12.4 The mean value of the test unit shall satisfy the following criterion:

$$m \geq f_k + ks,$$

where

k = Acceptability index according to **Table 8**, and
s = Standard deviation of test results.

12.4.1 Proven values of ks for each product and manufacturer shall be used (for a failure rate of 5 % (p = 0.95) at a probability of 90 % (1 – t = 0.90). The mean value requirement given above shall not apply, if all individual values lie above the required characteristic value.

12.4.2 All casts shall comply with the requirements for chemical composition including carbon equivalent. All other requirements shall be met for each individual test piece.

12.4.3 Where test results are unsatisfactory according to this clause, the manufacturer shall immediately take the necessary precaution. Casts that do not conform to the requirements shall be set aside.

Table 8: Acceptability index k for tests of different number n of tests

n	*k*	*n*	*k*
5	3.40	30	2.08
6	3.09	40	2.01
7	2.89	50	1.97
8	2.75	60	1.93
9	2.65	70	1.90
10	2.57	80	1.89
11	2.50	90	1.87
12	2.45	100	1.86
13	2.40	150	1.82
14	2.36	200	1.79
15	2.33	250	1.78
16	2.30	300	1.77
17	2.27	400	1.75
18	2.25	500	1.74
19	2.23	1,000	1.71
20	2.21	>1,000	1.64

12.5 Acceptance Testing of a Specific Delivery

12.5.1 *General*

a) Provisions regarding the nature, extent and evaluation of acceptance testing on deliveries of reinforcing bars not subject to certification following a conformity assessment scheme are given in **12.3.2** and **12.3.3**.
b) Acceptance testing of a specific delivery shall be performed according to **12.3.2**.
c) Rust, seams, surface irregularities or mill scale shall not be the cause for rejection provided a hard wire brushed test specimen fulfils all the requirements of this specification.

12.5.2 *Evaluation of Characteristic Values*

12.5.2.1 *Organization*

The tests shall be organized and carried out in accordance with the agreement between the purchaser and manufacturer, considering the national rules of the receiving country.

12.5.2.2 *Extent of sampling and testing*

a) Each test unit shall consist of bars of the same steel grade and the same nominal diameter from the same cast. The manufacturer shall confirm in the test report that all samples in the test unit originate from the same cast.

b) Two test pieces from various bars for testing the chemical composition (product analysis)

c) For checking shape and dimensions of ribs of deformed steel bars, one sample of 0.5 m or over in length from each lot of products rolled to the same shape and dimensions within an identical roll chance shall be taken.

d) For checking nominal mass, tensile properties, and bend property, test specimens of sufficient length shall be taken from each size of the test unit at random at a frequency not less than that specified in **Table 9**.

e) The frequency of bond test as required in **12.3.2.2** shall be as agreed to between the manufacturer and the purchaser/testing authority.

Table 9: Sampling required for bars

Diameter	*For consignment below 100 T*	*For consignment above 100 T*
< 10 mm	One sample for every 25 T	One sample for every 40 T
10 mm - 16 mm	One sample for every 35 T	One sample for every 45 T
> 16 mm	One sample for every 45 T	One sample for every 50 T

12.5.2.3 *Evaluation of results*

a) Inspection by variables

The test unit shall be deemed to satisfy requirements, if the condition stated below is fulfilled for all properties

$$m - ks \geq f_k$$

where

f_k = required characteristic value
k = acceptability index obtained from **Table 9**
$m = \frac{\sum_{i=1}^{n} x_i}{n}$,
$s = \sqrt{\frac{\left[\sum_{i=1}^{n}(x_i - m)\right]^2}{n-1}}$.
x_i = variable
n = number of tests

The test unit corresponds to the requirements, if the above condition is fulfilled for all properties: If not, the modified index k' shall be calculated from the test results available. as:

$$k' = \frac{m - f_k}{s},$$

where $k' \geq 2$, testing can be continued. In this case, $3n$ additional test pieces shall be taken and tested from different bars in the test unit.

b) Inspection by attributes

When testing properties are specified as maximum or minimum values, all results determined on test pieces shall comply with the requirements of this document. In this case, the test unit shall be considered to comply with requirements. Tests may be continued when, at most, 2 results not conforming to the conditions occur. In this case, 3 times the additional number of test pieces from various bars in the test unit shall be tested. The test unit complies with requirements, if not more than 2 of the total results do not conform to conditions.

c) Chemical composition

Both test pieces shall comply with requirements in this document.

12.5.3 *Evaluation of Specified Minimum/Maximum Values*

Tests shall be carried out in accordance with the following.

a) Bars of the same cast shall constitute one group. Clause **12.3.2.2** shall be used for the sampling criteria.
b) Each individual test result shall meet the required values in **Table 6** and the required bending properties given in **8.2**. One cast analysis shall be carried out for every cast to verify chemical composition (**6.1**). Samples shall be taken in accordance with **Table 9**.
c) If any test result does not meet requirements, retests may be carried out in accordance with **12.5.2.3** b).
d) The manufacturer shall submit a test report stating that the bars of delivery satisfy the chemical and mechanical properties defined in Clauses **6** and **8**, and a confirmation that the other requirements of this document are fulfilled.

12.5.4 *Test Report*

The test report shall at least contain the following information:

a) Designation of bars in accordance with this document
b) Marking on bars
c) Date of testing
d) Mass of test unit
e) Test results

All the test reports on bars should report values as per **Table 11**.

Table 11: **Reporting** of test data

Test / Property	Observed value	Remarks / Acceptable range of results

13 ORDERING INFORMATION

Orders for deformed steel bars for concrete reinforcement under this specification shall contain the following particulars:

a) Weight (mass)
b) Bar designation number (size)
c) Cut lengths
d) Grade of steel
e) IS designation (IS 1786) and the year of issue
f) The purchaser shall have the option to specify additional requirements, including but not limited to, the following:
   i) Requirements for inspection.

ii) Require bars in each bundle to be supplied from a single heat.
iii) Special package marking requirements, and
iv) Other special requirements, if any.