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High yield steel bars for the reinforcement of concrete — Specification

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High yield steel bars for the reinforcement of concrete — Specification

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Foreword

This Kenya Standard was prepared by the Steel Technical Committee under the guidance of the Standards Projects Committee and it is in accordance with the procedures of the Kenya Bureau of Standards.

In Kenya, high tensile steel for the reinforcement of concrete mainly comes in the form of cold-twisted square bars. However, hot-formed deformed bars are steadily gaining ground in this field, and this issue addresses this changing trend.

This edition of the standard also aims at making the steel bars easily traceable to the manufacturers, thus introducing a measure of enhanced quality control into the industry. The bars will also be more easily identified by the sizes as a result of the incorporated colour coding requirement, thus assisting the general public while purchasing the steel.

In formulating this standard, due consideration was given to experiences gained in the use of other Kenya Standards on steel reinforcement, especially KS 02-22, Specification for hot-rolled mild steel bars for reinforcement of concrete.

During the preparation of this standard, reference was made to the following documents:

BS 4449, Carbon steel bars for the reinforcement of concrete.

SABS 920, Steel bars for concrete reinforcement.

The assistance derived from these sources is hereby acknowledged.

KENYA STANDARD

High yield steel bars for the reinforcement of concrete — Specification

1 Scope

This Kenya Standard specifies requirements for rolled steel bars, other than plain round bars, for use in the reinforcement of concrete. It does not cover steel for pre-stressing concrete.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this KS 573. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this KS 573 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

KS 02-18, Specification for steels for building construction

KS 06-141, Specification for tensile testing – Part 1: Steel in general

3 Terms and definitions

4 Physical requirements

For the purposes of this standard, the following definitions shall apply:

3.1

bar

a steel product of any form of cross section, as-rolled, including a rod of steel

3.2

cold-worked deformed bar

a bar which has been cold-worked to comply with the property requirements of this standard

3.3

nominal size

the diameter of a circle with an area equal to the effective cross-sectional area of the bar, in accordance with 4.1 and 4.4

3.4

nominal density

the value of 0.00785 kg/mm² per metre run, taken for purposes of converting a length and cross-sectional area of a bar to its mass, as described in 4.5

3.5

yield stress

the stress at which a marked increase in deformation of the specimen occurs without increase of load during a tensile test

3.6

proof stress

the nominal stress that produces a non-proportional elongation equal to a specified percentage (0.2% for this standard) of the extension diagram or a stress-strain diagram

3.7

characteristic strength

the value of yield strength, having a prescribed probability of not being attained in a hypothetical unlimited test series. The characteristic value is the lower limit of the one sided statistical tolerance interval at which there is a 90% probability (i.e. $1 - \alpha = 0.90$) that 95% (p = 0.95) of the values are at or above this lower limit; this definition refers to the long-term quality level of production

3.8

tensile strength

the ultimate tensile stress obtained from the stress/strain curve

3.9

batch

any quantity of bars of one size and material type, whether in coils, or in bundles, presented for examination and testing at any one time

3.10

longitudinal rib

a uniform continuous rib parallel to the axis of the bar

3.11

length

a piece of nominally straight bar cut to a specified length

3.12

transverse rib

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

3.13

hot rolled deformed bar

a bar that has been so shaped during hot rolling that it conforms to either the geometrical or the performance test classification given in 4.7

4 Physical requirements

4.1 Standard/Nominal size

4.1.1 Nominal sizes

The nominal size of bars given in Table 1 shall be the standard sizes.

Table 1 — Standard sizes

Nominal size, mm	8	10	12	16	20	25	32	40			
NOTE Only sizes given in Table 1 shall be allowed for manufacture.											

4.1.2 Tolerance

The deviation of any cross-sectional dimension from its nominal size (other than those of ribs), shall not exceed 8 %.

4.2 Lengths

4.2.1 Standard lengths

Steel supplied in accordance with this standard shall be supplied in lengths of 12 m or 6 m and shall be cut to within +100, -0 mm.

4.2.2 Specified lengths

When bars of specific lengths are required, the actual length shall be at least equal to the specific value and shall not exceed that value by more than 50 mm.

4.3 Nominal cross-sectional area and nominal mass

The nominal values for the cross-sectional area and mass of individual bars shall be as given in Table 2.

Nominal size (mm)	Cross-sectional area (mm ²)	Mass per metre (kg)	Mass for full bar (12 m) (kg)	Mass for full bar (6 m) (kg)
8	50.3	0.395	4.74	2.37
10	78.5	0.616	7.39	3.70
12	113.1	0.888	10.66	5.33
16	201.2	1.579	18.95	9.47
20	314.2	2.466	29.59	14.80
25	490.9	3.854	46.25	23.12
32	804.2	6.313	75.76	37.88
40	1 256.6	9.864	118.39	59.18

Table 2 — Cross-sectional area and mass

4.3.1 The tolerance on mass per meter run shall be as specified in 4.5.2.

4.3.2 All steel covered by this standard shall be sold or purchased per kilo.

4.4 Effective cross-sectional area of deformed bars

4.4.1 Uniform cross sectional area

For bars whose pattern of deformation is such that, by visual inspection, the cross-sectional area is substantially uniform along the length of the bar, the effective cross-sectional area shall be the cross-sectional area determined by weighing and measuring to a precision of \pm 0.5 %, a length of not less than 0.5 m when:

Effective cross-sectional area (in mm²) = $\frac{W}{0.007 85 L}$

where,

W is mass (in kg), and *L* is length (in m).

4.4.2 Variable cross sectional area

4.4.2.1 For a bar where the cross-sectional area varies along its length, a sample not less than 0.5 m long shall be weighed (*W*) and measured to a precision of \pm 0.5 % in the as-rolled condition, and after the transverse ribs have been removed, it shall be re-weighed (*W*₁).

4.4.2.2 Where the difference between the two masses $(W-W_1)$ is less than 3 % of W_1 , the effective cross-sectional area shall be obtained as in 4.4.1.

4.4.2.3 Where the difference is equal to or greater than 3 %, the effective cross-sectional area (in mm²) shall be taken as:

$\frac{1.03 W_1}{0.007 85 L}$

where,

 W_1 is mass of the bar with transverse ribs removed (in kg), and

L is length of the bar (in m).

4.4.2.4 For routine test purposes, a nominal ratio of effective cross-sectional area to gross cross-sectional area of bars covered by 4.4.2.3 shall be stated by the manufacturer and used when testing samples.

4.5 Mass

4.5.1 For purposes of checking tolerances, the nominal density of steel shall be used (see 3.4).

4.5.2 The mass per metre run of a bar, when determined in accordance with 4.4.1, shall not differ from the nominal value by more than the appropriate tolerance given in Table 3, Column 2.

4.5.3 The actual batch mass of a consignment of bars shall be equal to the value stated in the relevant consignment details subject to the appropriate tolerance given in Table 3, Column 3.

Nominal size	Tolerance on nominal mass per metre run								
(mm)	Individual bar	Batch							
	(%)	(%)							
(1)	(2)	(3)							
8	± 6.0	+ 4.5							
		- 3.5							
10 and over	± 4.0	± 2.5							

Table 3 — Testing tolerances	on nominal mass
------------------------------	-----------------

4.6 Finish

All bars shall be cleanly rolled and shall be free from harmful defects such as surface flaws, rolling defects, piping, foreign bodies and mill scales which cannot be removed by manual wire brushing.

Rust, seams, surface irregularities, or mill scale shall not be cause for rejection, provided the weight, dimensions, cross-sectional areas and tensile properties of a hand wire brushed test specimen are not less than the requirements of this specification.

4.7 Bond classification

4.7.3 General

Deformed bars shall be classified as Type 1 or Type 2 as follows:

- a) in accordance with their surface shape, as specified in 4.7.2; or
- b) if the shapes are not applicable, in accordance with their bond performance as in 4.7.3.

4.7.4 Classification by shape

Type 1 — Either a plain square twisted bar or a plain chamfered square twisted bar, with a pitch of twist not greater than 14 times the nominal size of the bar.

Type 2 — A bar with transverse ribs at substantially uniform spacing, and with the following properties:

- i) Spacing of ribs not greater than 0.8Ø for as-rolled deformed bars or 1.2Ø for cold-formed bars;
- ii) The mean cross-sectional area of ribs (measured above the core) in a unit length of bar shall be not less than 0.15 φ mm²/mm, where φ is the nominal bar size.
- NOTE Recommended formulae for calculation of the projected rib area are given in Annex B.

4.7.5 Classification by performance

The performance tests described in Annex A shall be conducted by an approved testing authority. The classification shall be established as final.

NOTE For the purposes of this standard, approved testing authorities are Kenya Bureau of Standards Laboratories and any other relevant laboratories operating under its accreditation scheme.

4.8 Tensile properties

The tensile strength of the steel, when tested according to 7.3, shall comply with at least one of following two requirements:

- i) The tensile strength shall be at least 10 % greater than the actual yield stress measured in the tensile test.
- ii) The tensile strength shall be between 5 % and 10 % greater than the actual yield stress measured in the tensile test. In this case, the actual yield stress shall be not less than B(2.1 A) N/mm², where A is the ratio of measured tensile strength to the actual yield stress and B = 460 for bars of nominal size 8 mm to 16 mm or 425 for bars of nominal size over 16 mm.

The elongation of the steel complying with this standard shall be as given in Table 4.

Nominal size of bar (mm)	Specified characteristic strength (N/mm ²)	Minimum elongation on gauge length <i>I</i> _o (%)								
8 up to and including 16	460	12								
Over 16	425	14								
NOTE I_o is the gauge length = 5.65 $\sqrt{S_o}$ where S_o is the original cross-sectional area of the test piece.										

Table 4 — Tensile properties

4.9 Resistance to cold bending

4.9.1 Bending

When tested according to 7.4, a bar shall show no sign of fracture or irregular bending deformation.

4.9.2 Re-bending

When tested according to 7.5, a bar shall show no sign of fracture or irregular bending deformation.

4.10 Specified characteristic strength

- **4.10.1** The specified characteristic strength (see 3.7) of bars complying with this standard is given in Table 4.
- **4.10.2** The steel shall be considered to comply with the specified characteristic strength in Table 4 provided that, for each size and type of bar.
- i) not more than two results of yield stress out of the last 40 consecutive results are less than the specified characteristic strength.
- ii) no routine test results are less than 0.93 of the specified characteristic strength.

When a new type of size of bar is introduced, 4.10.2 i) shall apply to any number of tests until the first 40 have been accumulated.

5 Process of manufacture

The manufacture of steel that complies with this standard shall be in accordance with KS 02-18.

6 Product identification, delivery and marking

6.9 Marking

6.9.1 As an indication of the size, each bar shall bear a colour code in the form of a single lateral colour strip, of not less than 25 mm wide, at each end of the bar. The colours shall vary according to the bar sizes as given in Table 5.

Nominal size mm	8 10		12	16	20	25	32	40
Colour code	Yellow	Blue	Red	Green	Orange	Purple	White	Brown

Table 5 — Colour codes

6.9.2 Each bar shall be indelibly branded at one or more points along its length with the name and/or registered trademark of the manufacturer.

6.10 Defects revealed after delivery

Should any or all material after delivery be found not to be in accordance with this specification, such material shall be deemed not to comply with this Kenya Standard. However, notwithstanding any previous acceptance, material delivered, which does not comply with this standard due to bad bending, chemical exposure, heating etc. while on transit or on site, shall not be cause for the manufacturer's liability.

6.11 Storage

To minimize rust and other natural effects of exposure to the atmosphere, steel shall be stored in a dry and cool environment.

6.12 Labelling

Each delivery dispatched from the rolling mill shall be accompanied by a delivery note that bears clearly the following information:

- i) The manufacturer's name and/or trade mark;
- ii) The type of bars as per 4.7;
- iii) The nominal size of the bars;
- iv) The standard lengths of the bars;
- v) The number of bars in the delivery; and
- vi) The number of this Kenya Standard.

6.5 Bar marking

Each bar shall be indelibly and legibly engraved/embossed at least once in every 1.5 metre length with the registered trade mark.

7 Inspection and test methods

7.1 Inspection and sampling

7.1.1 Routine testing and inspection

All materials shall be subject to routine inspection and testing by the manufacturer or supplier in accordance with 7.1.2 of this standard, and a record of the test results of material conforming to this standard shall be kept by the supplier in a form similar to that given in Annex C. Test specimens shall be either at least 600 mm long or 20 times the nominal size, whichever is greater.

7.1.2 Purchaser's test

7.1.2.1 In the circumstances where a purchaser requires to verify that the specified characteristic strength is attained by a batch of steel, he shall first agree with the supplier at what establishment the steel shall be tested. Test results from any other establishment shall not be used. In all cases, an averaging extensometer shall be used.

7.1.2.2 Ten test specimens shall be selected from different bars in the batch.

7.1.2.3 Where the purchaser is satisfied that routine testing has been carried out, he may use an alternative abbreviated purchaser's test as follows:

Three test specimens shall be selected from different bars in the batch. If any one test result is less than 93 % of the specified characteristic strength, the requirements of 7.1.2.2 shall apply. If the three valid test results have a yield stress equal to or greater than the specified characteristic strength the batch shall be deemed to comply with this standard in respect of the specified characteristic strength requirements.

7.1.2.4 Test samples, of sufficient length, for the specified tests shall be selected from each batch at a frequency not less than that specified in Table 6; except that if a batch comprises bars less than the quantity specified in Table 6, at least one test sample shall be selected to represent a day's production.

Nominal size (mm)	Quantity
Under 10	1 sample from each 25 000 kg or part thereof
10 to 16 inclusive	1 sample from each 35 000 kg or part thereof
Over 16	1 sample from each 45 000 kg or part thereof

Table 6 — Frequency of testing, and bend test

7.2 Preparation of test pieces

7.2.1 The tensile, bend and re-bend tests shall normally be carried out on straight bars as produced, without machining.

7.2.2 In order to simulate natural ageing, test samples may be subjected to a temperature of $100 \,^{\circ}$ C for a period of not more than 2 h provided that the tensile, bend and re-bend test samples are so treated and the fact is recorded on the test sheets and certificates. No other form of heat treatment shall be permissible.

7.3 Tensile test

7.3.1 The tensile strength, yield stress and the elongation of the steel shall be determined in accordance with KS 06-141 and shall comply with the requirements specified in 4.8 of this standard. The rate of loading when approaching the yield stress shall not exceed 10 N/mm² per second.

7.3.2 For routine testing, the yield stress may be taken as the stress at which elongation first occurs in the test piece without increasing the load during tensile test. In case of steels with no such definite yield point, the proof stress is the stress under the prescribed testing conditions at which the observed increase in the gauge length is 0.5 % of the gauge length when the rate at which the load applied is not more than 10 N/mm² per second.

7.3.3 The stresses shall be calculated using the cross-sectional area of the bar tested. The effective cross-sectional area shall be determined as in 4.4.

7.4 Bend test

- 7.4.1 The bend test shall be carried out:
- i) on a test piece having a temperature of between 5 °C and 35 °C.
- ii) with apparatus that ensure
 - close contact between the test piece and the mandrel
 - a continuous and uniform production of bending deformation at every section of the bend.
- iii) on a test piece which is adequately supported by plain smooth surfaces or rolls which do not offer resistance to longitudinal movement of the test piece.

7.4.2 The test piece shall be bent through 180° round a mandrel of a diameter six times the nominal size of the bar under test.

7.4.3 Failure is indicated if the bar fractures completely or cracks at the bend are visible to the naked eye.

7.5 Re-bend test

7.5.1 The test shall be carried out in the following manner:

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- i) the test piece shall be bent, under the conditions of the bend test, through 45° round a mandrel of a diameter equal to five times the nominal size of the bar under test;
- ii) it shall then be subjected to a temperature of 100 °C for not less than 30 min, as a result of immersion in boiling water;
- iii) when the test piece has cooled to a temperature between 5 °C and 35 °C, it shall be bent back (partially re-straightened) by a steadily applied force through at least 23° on the same bending machine as used in i) above. The rate of application of the load shall not exceed 3 r/min or equivalent.

7.5.2 Failure shall be indicated if the bar fractures completely, or cracks at the bend are visible to the naked eye.

7.5.3 In the event of failure, if there is any damage to the ribs, caused by carrying out the initial bending, the test shall be deemed invalid.

NOTE Damage to the ribs can be avoided by the use of an aluminium sheet insert placed between the specimen and the former. The aluminium sheet shall have a maximum thickness of 6 mm.

Annex A

(normative)

Performance test for deformed bars

A.1 The principle of the test is to show that deformed bars, claimed to be equal to those satisfying the classification in 4.7.2, will hold for a given time the specified characteristic strength in a pull-out test with a free end slip not greater than 0.2 mm.

A.2 For a range of sizes of bar which are geometrically similar in shape, tests shall be carried out on two sizes, preferably 20 mm and the largest available size. The surface shape of the bars to be tested shall comply with the manufacturer's published specification, and shall be as near to the minimum amount of deformation as is possible. Six specimens of each size shall be tested. The surface condition of the bar shall be no more than lightly rusted.

A.3 The test prisms shall have a square cross section of 150 mm side for bars up to 20 mm size and 250 mm side for bars over 20 mm size.

The length of the prism *I*, in millimetres, shall be calculated as follows:

$$I = \frac{f_y \theta}{21}$$
 mm for deformed Type 1 bars, and

$$I = \frac{f_y \theta}{28} \text{ mm for deformed Type 2 bars}$$

where,

 f_V is the specified characteristic strength of the steel (in N/mm²), and

 θ is the nominal bar size (in mm).

A.4 The test bar shall be rigidly embedded and cast vertically in, and pass completely through, the prism of concrete along its longitudinal axis. The prism shall be reinforced with a helix of 6 mm diameter plain mild steel at 25 mm pitch along the embedded length. The outer diameter of the helix shall be 5 mm less than the side of the square cross section. A suitable mould is shown in Figure A.1.

A.5 At the time of the pull-out test the concrete cube strength shall be between 40 N/mm² and 45 N/mm².

A.6 The test piece shall be mounted in a suitable testing device in such a manner that the bar is pulled axially from the prism. The end of the bar at which the pull is applied shall be that which projected from the top end of the prism as cast. Plaster bedding rubber or plywood packing shall be placed between the top end of the prism and the surface of the testing device bearing on it.

A suitable dial gauge shall be mounted in such a manner that the gauge records the relative slip between the unloaded end of the bar and the bottom end of the prism as cast.

A.7 During a period of approximately 2 min, the axial load in the bar shall be increased steadily until the tensile stress in the bar attains the specified characteristic strength f_y for the grade of steel from which the bars are made. This stress shall be held constant for a further 2 min after which the length of the free end slip of the bar shall be recorded.

A.8 If the average free end slip of the six bars tested exceeds 0.2 mm they shall not qualify for the classification in 4.7.2.

A.9 The test report shall include measurements which define the deformation of the bars tested.



Figure A.1 — Typical mould to be used for bond test

Annex B

(informative)

Recommended formulae for calculating projected rib area

The projected rib area R, in millimetres squared per millimetre length of bar, should be calculated for ribbed bars using one of the following equations:

a) for as-rolled deformed bars:

$$R = n \left(\frac{lh_t \sin \beta}{c} \right)$$

b) for cold twisted bars:

$$R = n \left(\frac{lh_t \sin \beta}{c}\right) + \left(\frac{Nh_1 \pi \varphi}{p}\right)$$

where,

- *n* is the number of rows of transverse ribs (see note 1);
- l is the length of the transverse rib (mm) (see note 2);
- $h_{\rm t}$ is the height of the transverse rib (mm) (see note 3);
- β is the angle between the center line of the transverse rib and the bar axis (°);
- c is the centre to centre spacing between transverse ribs (mm) (see note 4);
- N is the number of longitudinal ribs;
- h_1 is the height of the longitudinal rib (mm) (see note 5);
- *p* is the pitch of twist measured parallel to the bar axis (mm) (see note 6);
- φ is the nominal bar size.

NOTE 1 If more than one pattern of transverse ribs exists, e.g. alternate ribs are set at different angles, or there are different rib patterns in each row, the term containing n should be calculated for each different set of ribs, and the summation of values obtained.

NOTE 2 The length of the transverse rib is measured at the rib to core interface. The length should be determined as the average of three measurements on each row or set of transverse ribs.

NOTE 3 The height of the transverse rib is measured perpendicular to the core of the bar. The height should be determined as the average of three measurements on each row or set of transverse ribs. (Using Simpson's rule for approximation under a curve, with rib height measurements at the mid and quarter points, the rib height for each rib profile may be established as a proportion of its mid point height. For transverse ribs of parabolic profile, the rib height should be taken as two thirds of the mid point height).

NOTE 4 The centre to centre spacing between transverse ribs is determined by dividing the distance, measured parallel to the axis of the bar, between the mid points of two ribs, of about ten ribs apart, by the number of rib spaces in between. For twisted bars, the rib spaces should be counted in a helical fashion.

NOTE 5 The height of the longitudinal rib is determined as the average of three measurements on each rib.

NOTE 6 The pitch of twist measured parallel to the bar axis is determined as the average of three measurements.

Annex C (normative)

Test results

C.1 Tensile test results

Customer:	Test certificate No.
Material:	Rate of loading:

Sample			Specified characteristic strength						Increase from			Elongation			
			Strength		Requirement		Ultimate tensile		yield	Gauge length		20			
No.	Size mm	Load kN	Stress N/mm ²	Load kN	Stress N/mm ²	Specified N/mm ²	0.93 min. N/mm ²	Load kN	Stress N/mm ²	Per cent	Initial mm	Final mm	Extn. mm	Per cent	Remarks

C.2 Physical test results

	Samp	ble	Length	Are	ea	Mass	Mass per M		Variation		Variation		Aver. Var	Perm vari	issible ation	Bend Test	Re-bend	Other Remarks
No.	Size mm	Section shape	m	Nominal mm ²	Actual mm ²	kg	Nominal kg	Actual kg	kg	%	%	%	%					
																Operator		
																Checked		

KENYA BUREAU OF STANDARDS (KEBS)

KEBS CERTIFICATION MARKS

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SYMBOL FOR PRODUCT QUALITY



Diamond Mark of Quality

Import Standardization Mark SYMBOL FOR PRODUCT QUALITY

Systems Certification Marks







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INFORMATION ON STANDARDS

Standards are documents that provide a common reference point for the assessment of the quality of goods and services. Standards facilitate tranparency in the exchange of products and enhance market access of Kenyan products into local, regional and international markets.

Information on standards and related documents is available at the KEBS standards information centre.

KEBS houses the WTO-TBT National Enquiry Point (NEP) which disseminates notification likely to affect international trade to the industry.

KEBS also provides technical advice on installation and improvement of quality goods and services to the industry so as to facilitate efficient implementation of standards. Some of the advantages of standards include: enhancement of quality assurance, safety and environmental protection measures, minimization of wastage, reduction of costs and unecessary varieties and promotion of interchangeability and increased productivity in industry.

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2.