KENYA STANDARD

KS 02-1070: 1993
ICS 91.100.15

Specification for stabilized soil blocks

KENYA BUREAU OF STANDARDS (KEBS)

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PREFACE

This Kenya Standard was prepared by the Pre-Cast Masonry Technical Committee under the guidance of the Civil Engineering Industry Standards Committee, and it is in accordance with the procedures of the Bureau.

Earth is perhaps the oldest and most abundant building material available to mankind. However, the use of earth as a conventional building material is limited in this country. With increasing need to house an ever growing population, the use of earth must be re-visited in view of its abundance and versatility.

This standard gives the performance characteristics of stabilized soil blocks, which are necessary to good building construction.

Methods of manufacture and use of soil blocks are dealt with in KS 02-1071: Code of Practice for manufacuture and use of stabilized soil blocks.

KENYA STANDARD

SPECIFICATION FOR STABILIZED SOIL BLOCKS

1. SCOPE

This Kenya Standard specifies the requirements for cement and/or lime stabilized soil blocks for use in general building construction.

2. DEFINTIONS

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

2.1 **stabilized soil blocks** — Building blocks made by a mixture of soil with a portion of cement and/or lime added as a stabilizer.

2.2 **norminal size** — The size of a co-ordinating space allocated to a masonry unit including allowances for joints and tolerance.

2.3 **work size** — The size of a block specified for its manufacture to which its actual size should comply within specified permissible deviations.

2.4 **compressive strength** — The average compressive stress at failure taken when five blocks have been crushed in a compression test machine at a loading rate of 150 kN per minute.

2.5 **modulus of rupture** — The nominal transverse breaking strength of the blocks.

3. MATERIALS

3.1 **Cement** — The cement used for the manufacture of stabilized soil blocks shall be Ordinary Portland Cement complying with KS 02-21*

3.2 **Lime** — The lime used for the manufacture of stabilized soil blocks shall comply with KS 02-97†.

3.3 **Soils** — The soil used for the manufacture of stabilized soil blocks shall be of a suitable quality, free of deleterious and organic materials (refer to KS 02-1071‡).

4. SHAPE, DIMENSIONS AND TOLERANCES

4.1 **Dimensions** — Dimensions of stabilized soil blocks shall comply with Table 1.

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* Specification for Ordinary Portland cement.
† Specification and methods of test for building lime (quicklime and hydrated lime).
‡ Code of practice for manufacture and use of stabilized soil blocks.

TABLE 1. STANDARD FORMATS OF STABILIZED SOIL BLOCKS

LENGTH (mm)		WIDTH (mm)		HEIGHT (mm)
Nominal Size	Work Size	Nominal Size	Work Size	Nominal/Work Size
200	190	75	65	55-65
200	190	100	90	75-90
300	290	100	90	80-95
300	290	150	140	100-115
400	390	150	140	105-120
400	390	200	190	125-140

4.2 **Tolerances** — The maximum dimensional deviations for stabilized soil blocks measured in accordance with Appendix A shall be as specified in Table 2.

TABLE 2. DIMENSIONAL TOLERANCES FOR STABILIZED SOIL BLOCKS

DIMENSION	MAXIMUM DIMENSIONAL DEVIATION
Length	+ 1 mm - 3 mm
Width	+ 2 mm - 1 mm
Height	+ 1 mm - 3 mm
Surface smoothness sides	+ 1 mm - 1 mm
Compression surface	+ 3 mm - 1 mm

5. PHYSICAL PROPERTIES

5.1 **Dry Compressive Strength** — The dry compressive strength at 28 days when tested in accordance with Appendix B shall be not less than 2.5 N/mm^2.

5.2 **Wet Compressive Strength** — When stabilized soil blocks are tested in accordance with Appendix B, the minimum average wet compressive strength at 28 days shall be not less than 1.5 N/mm^2.

5.3 **Modulus of Rupture** — The rupture strength, when determined in accordance with Appendix C shall be not less than 0.5 N/mm^2.

5.4 **Water Absorption** — The water absorption of stabilized soil blocks when determined as described in Appendix D shall not exceed 15 per cent of the original mass.

5.5 **Density** — The density of blocks when determined in accordance with Appendix E shall be not less than 1600 kg/m^3.

5.6 **Weathering** — When subjected to the weathering test carried out in accordance with Appendix F, the maximum loss of mass shall not exceed 15 per cent.

5.7 **Shrinkage Cracks** — Shrinkage cracks shall not be more than 0.5 mm wide and shall not exceed in length 50 % of the block dimension to which they are parallel; where they are not parallel, their projected length shall be measured.

5.8 **Visual Inspection** — All blocks on visual inspection shall be free of broken edges, honey combing and such other defects as would interfere with the proper placing of the blocks or impair the strength or permanence of construction.

APPENDIX A

MEASUREMENT OF DIMENSIONS

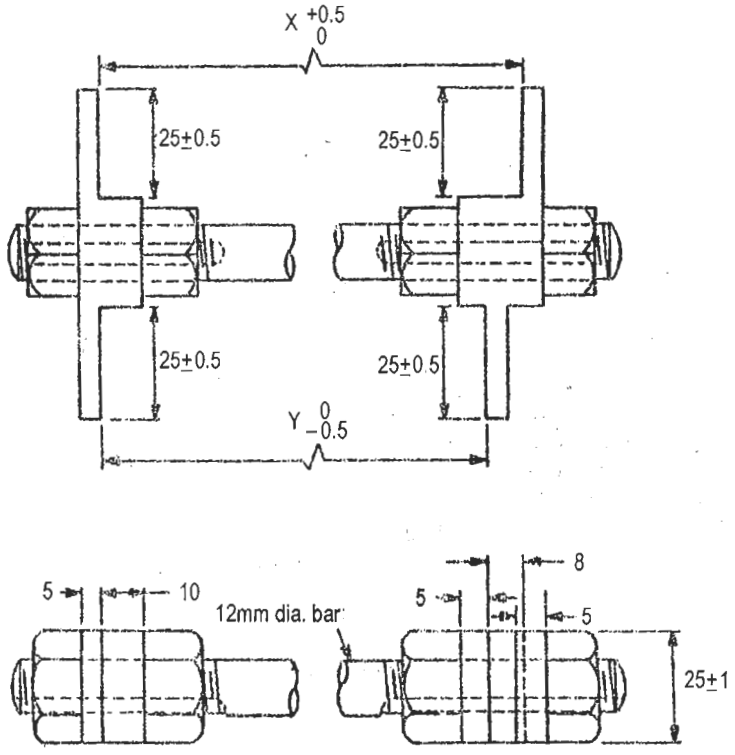
A1. TEST SPECIMENS

20 blocks shall be selected at random for test. They shall be used for dimensional checks and other tests as described.

A2. APPARATUS

A2.1 GO/NOT GO Gauges — GO/NOT GO gauges as shown in Figure 1. The length gauge shall be appropriate to the specified length, width and height of block.

All dimensions are in millimetres



NOTE 1. *x* is the specified dimension of the block plus 3 mm and *y* is the specified dimension of the block minus 5 mm.

NOTE 2. Keys are used for keeping fittings at both ends in the same plane.

FIG.1 — GO/NOT GO GAUGES FOR CHECKING LENGTH AND HEIGHT OF BLOCKS

A2.2 External Calipers

A2.3 A rule graduated to 1 mm, for use with the calipers.

A3. Procedure

A3.1 Length and Height — Check the compliance of each block for length at the four corners of the end faces (*see* Figure 2 (*a*)) using a GO/NOT GO gauge.

Similarly, check the compliance of each block for height at six points (*see* Figure 2 (*b*)). The height of a block is the smallest of the three dimensions, i.e. width, length and height. The length and height of each block shall be reported as the respective average to the nearest mm.

A3.2 Width — Measure the width of each block to the nearest millimetre at seven random positions as shown in Figure 2 (*c*), using the calipers and rule. Calculate and report the average of the seven results to the nearest mm.

APPENDIX B

DETERMINATION OF COMPRESSIVE STRENGTH

B1. TEST SPECIMENS

Ten whole blocks shall be selected at random from the sample after carrying out the dimensional checks. Five blocks shall be used for dry compressive strength and another five for wet compressive strength.

B2. PRINCIPLE

B2.1 **Dry Compressive Strength** — A unit is placed in a compression testing machine and subjected to increased compression until it fails. From the maximum load, the compressive strength is calculated.

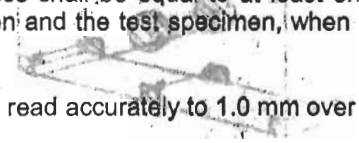
B2.2 **Wet Compressive Strength** — A unit is immersed in water for a specified period of time. The unit is then tested using the same principle as in **8.2.1.**

B3. APPARATUS

B3.1 **Loading Machine** — A compression loading machine either hydraulic or screw type with adequate capacity and capable of applying the loads at rates specified in **B4.**

The machine shall be fitted with two steel platens, which shall be self-aligning.

The bearing faces for both platens should exceed the test specimen by not less than 15 mm in length and breadth and shall not depart from a plane by more than 0.05 mm. Should the bearing faces of the platens be smaller than required, steel plates of adequate size may be placed centrally between them and the test specimen. Their thickness shall be equal to at least one-third of the grater difference in dimension between the machine platen and the test specimen, when centrally placed but not less than 25 mm.



B3.2 **Measuring Rule** — A rule that can be read accurately to 1.0 mm over the dimensions of the units being tested.

B3.3 **Water Bath** — A water bath of sufficient size to hold the specimens without them touching each other and sufficient depth to ensure that the specimens will be completely immersed in water for the full duration of the test.

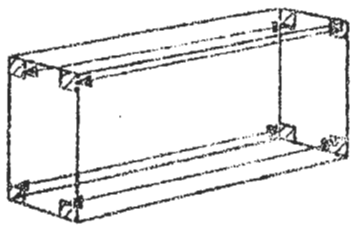
B4. DRY COMPRESSIVE STRENGTH

B4.1 **Procedure** — The procedure of each specimen shall be as follows:

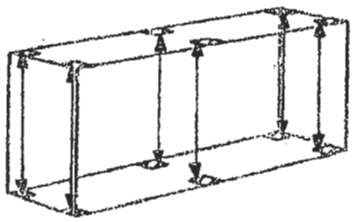
(*a*) Measure and record the following dimensions, to the nearest millimetre:

(i) The width (*B*) of each specimen as described in Appendix **A3**;

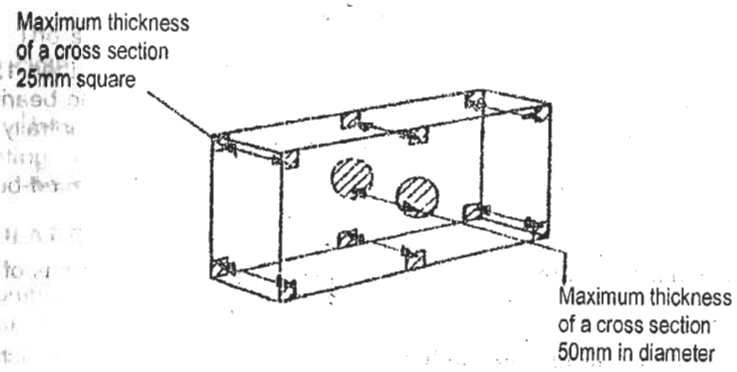
(ii) The length (*L*) of each specimen as described in Appendix **A3**.



(a) Four positions for checking length of whole blocks



(b) Six positions for checking height of whole blocks



(c) Seven measurements of thickness

FIG. 2. CHECKING AND MEASURING DIMENSIONS OF BLOCKS

A4. REPORTING

Report the average length, height and width of the blocks.

B7. REPORTING

Report the average of the compressive strength; either dry or wet of the five specimens.

APPENDIX C

DETERMINATION OF MODULUS OF RUPTURE

C1. TEST SPECIMENS

Five whole blocks shall be selected at random from the sample after carrying out dimensional checks.

C2. PRINCIPLE

Five blocks are tested by applying a load through two bars, with the specimen laid flatwise, until the specimen fails. The maximum bending moment is used to calculate the lateral modulus of rupture.

C3. APPARATUS

C3.1 **Loading Machine** — A testing machine either hydraulic or screw type with adequate capacity and capable of applying the loads at rates specified in **C4.4**

The machine shall be fitted with support bars and loading bars, which will permit the loading of test specimens as simple beams as shown diagrammatically in Figure 3. The support and loading bars shall be not less than 25 mm and not more than 40 mm in diameter, parallel and normal to the axis of the specimen.

C3.2 A rule that can be read accurately to 1.0 mm over the dimensions of the units being tested.

C4. PROCEDURE

C4.1 Measure and record the following dimensions, to the nearest millimetre:

(i) The width (*b*) of each specimen,

(ii) The height (depth) (*d*) of each specimen,

(iii) The distance (*l*) between the supporting bars in the testing machine (*see* Figure 3).

(*b*) Place and wipe the surfaces of the test specimen removing all loose debri. Clean the bearing surfaces of the platens on the testing machine, and any steel plate to be placed between the specimen and the platen.

(*c*) Place the specimen between two pieces of 3 mm thin plywood, the length and width of which shall exceed the corresponding dimensions of the specimen by less than 25 mm; each plywood sheet shall be used only once. The specimen shall be placed in the testing machine such that the centre of the bed face coincides with the loading axis of the machine.

(*d*) Apply the load without shock and increase it continuously at a uniform rate of 150 kN/min until failure occurs.

(*e*) Observe and record the maximum load (W_D) at failure.

B5. WET COMPRESSIVE STRENGTH

B5.1 Procedure — The Procedure for each specimen shall be as follows:

(*a*) Measure and record the following dimensions to the nearest millimetre;

(i) The width (*B*) of each specimen as described in **A3**;

(ii) The length (*L*) of each specimen as described in **A3**.

(*b*) The specimens shall be immersed in water at 15 ^{0}C to 30 ^{0}C for 24 h.

(*c*) The specimen shall be removed from the water bath. They shall then be wiped clean with a cloth.

(*d*) The procedure for compression testing shall proceed as described in **B4.1** (*b*) to **B4.1** (*d*).

(*e*) Observe and record the maximum load (W_W) at failure.

B6. CALCULATION OF RESULTS

The compressive strength of each specimen (dry or wet) shall be calculated from the following expressions;

$$C_D = \frac{W_D}{A} \text{ or } C_w = \frac{W_w}{A}$$

where,

C_D = dry compressive strength in N/mm^2;

C_W = wet compressive strength in N/mm^2;

W_D = total load at which the dry specimen fails, in Newtons;

W_w = total load at which the wet specimen fails, in Newtons;

A = the smaller bed face area; in square millimetres;

= *BL*, taken for whichever of the two bed faces produces the smaller area.

APPENDIX D

DETERMINATION OF WATER ABSORPTION

D1. TEST SPECIMENS

Five whole blocks shall be selected at random from the sample after carrying out dimensional checks.

D2. PRINCIPLE

A block is saturated by immersion in water for a specified period of time. The specimen is then dried and the amount of water absorbed is then determined and used to calculate the percentage water absorption.

D3. APPARATUS

D3.1 **Balance** — A balance sensitive to within 1 g.

D3.2 **Drying oven** — A thermostatically-controlled drying oven capable of maintaining temperature of 105 ± 5 ^{0}C.

D3.3 **Water bath** — A water bath of sufficient size to hold the specimens without them touching each other and sufficient depth to ensure that the specimens will be completely immersed in water for the full duration of the test.

D4. PROCEDURE

(*a*) Immediately after sampling, the specimens shall be weighed to the nearest gramme, the mass shall be recorded as Ms.

(*b*) The specimens shall then be immersed in water at 15 ^{0}C to 30 ^{0}C for 24 h.

(*c*) The specimens shall be removed from the water. They shall then be wiped with a cloth; and within 3 min after removing from the water the mass of the saturated specimen shall be determined by weighing to the nearest gramme. Record the saturated mass as m_2.

(*d*) The saturated specimen shall be dried in a ventilated oven at 105 ± 5 ^{0}C for not less than 24 h and until two successful weighings, at intervals of 2 h show an increment of loss not greater than 0.2 per cent of the last previously determined weight of specimen. Record the mass of the oven dry specimen as m_1.

D5. CALCULATION OF RESULTS

D5.1 **Water Absorption** — The water absorption (per cent) for each specimen shall be calculated from the following expression:

$$A_W = \frac{(m_2 - m_1) \times 100}{m_1}$$

where,

A_W = percentage water absorption

m_1 = mass of oven dry specimen, in grammes.

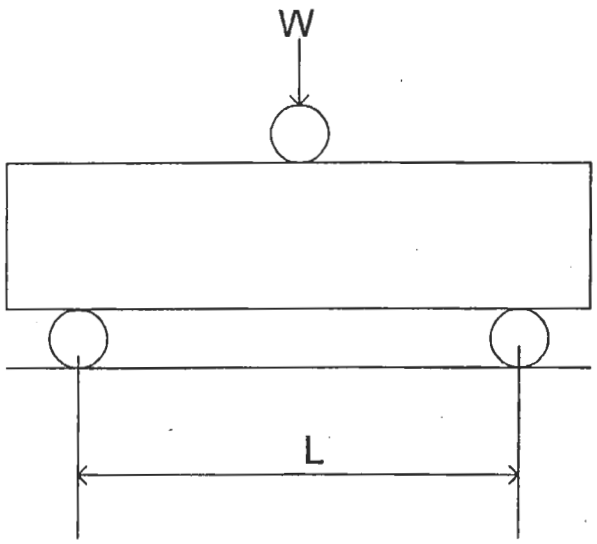


FIG. 3. ARRANGEMENT OF MODULUS OF RUPTURE

C4.2 Support the test specimen flatwise on a span approximately 25 mm less than the basic unit length.

C4.3 Bring the loading bar, which shall be at mid-span of the specimen to bear on the upper surface of the specimen.

C4.4 Apply the test load, without shock, at a uniform rate of 3 kN/min until failure occurs.

C4.5 Observe the maximum load (W) carried by the specimen.

C5. CALCULATION OF RESULTS

The modulus of rupture of each specimen, shall be calculated from the following expression:

Modulus of rupture, $S = \frac{3Wl}{2bd^2}$

where'

S = stress in specimen at midspan, in N/mm^2;

W = maximum load at failure, in Newtons;

l = distance between the supports, in mm;

b = width, face to face, of the specimen in mm;

d = depth, bed face to bed face, of the specimen in mm.

C6. Reporting

Report the average of the modulus of rupture of the five specimens.

m_2 = mass of saturated specimen after immersion in water, in grammes.

D6. REPORTING

Report all results separately for each unit and as average for the five units.

APPENDIX E

DETERMINATION OF BULK DENSITY

E1. TEST SPECIMENS

Select at random three blocks from the sample for testing. Carry out the dimensional measurements as described in Appendix A, noting the average length, height and width of each block.

E2. APPARATUS

E2.1 Drying Oven — Thermostatically-controlled drying oven capable of maintaining temperature of 105 ± 5 ^{0}C.

E2.2 Calculation of Volume — Calculate the gross volume of the block to the nearest 250 mm^3 by multiplying the average thickness by the average length and height of the block.

E3. PROCEDURE

Dry the three specimen blocks for at least 24 h in a ventilated oven at 105 ± 5 ^{0}C.

Cool the blocks to ambient temperature and weigh. Repeat these steps until the mass lost in one cycle does not exceed 0.05 kg.

E4. CALCULATION OF DENSITY

$$C_D = \frac{M}{V}$$

where,

C_D = block density (in kg/m^3);

M = oven dry mass (in kg);

V = gross volume of block (in m^2).

E5. REPORTING

Report the density to the nearest 10 kg/m^3.

APPENDIX F

WEATHERING TEST

F1. TEST SPECIMENS

Two whole blocks shall be selected from the sample of blocks obtained as described under Appendix A, after carrying out the test for dimensional conformity. The blocks shall be designed 'Specimen A' and 'Specimen B', respectively.

F2. APPARATUS

F2.1 **Balance** — A balance or a scale of 20 kg capacity, sensitive to 50 g.

F2.2 **Drying Ovens** — Two thermostatically-controlled drying ovens; one capable of maintaining temperature at 105 ± 5 ^{0}C and the other capable of maintaining temperature of 70 ± 5^0 C.

F2.3 **Water-bath** — A suitable tank for submerging specimens in water at room temperature.

F2.4 **Wire Scratch Brush** — A brush made of 50 mm x 1.6 mm flat with 0.40 mm wire bristles assembled in 50 longitudinal rows and 10 transverse rows of bristles on 200 mm x 60 mm hardwood block.

F3. PROCEDURE

F3.1 Oven dry Specimen A at 105 ± 5 ^{0}C for at least 12 h or to constant mass. From this weight, calculate the oven-dry weight (W_i) of Specimen A. Carry out further operations on Specimen B only.

F3.2 Submerge Specimen B in water at room temperature for 6 h. Remove and immediately place it in an oven at 70 ^{0}C for 42 h and remove. Brush all areas of the specimen twice with the wire scratch brush. Hold the brush with the long axis of the brush parallel to the longitudinal axis of the specimen or parallel to the ends as required to cover all areas of the specimen. Apply these strokes to the full height and width of the specimen with a firm stroke corresponding to approximately 1.5 kg force (*see* note). Eighteen to twenty vertical brush strokes are required to cover the sides of the specimen twice and four strokes are required on each end.

NOTE: Measure the pressure as follows:

Clamp a specimen in a vertical position on the edge of a platform scale and set the scale at zero. Apply vertical brushing strokes to the specimen and note the force necessary to register approximately 1.5 kg.

F3.3 The procedures described in **F3.2** constitutes one cycle (48 h) of the weathering test. Continue the procedure for 12 cycles. After 12 cycles of test, dry the specimen to constant weight at 105 ± 5 ^{0}C and determine the final oven-dry weight (W_f) of the specimen. The data collected permits calculations of the soil-cement loss of the specimen after the prescribed test of 12 cycles.

F4. CALCULATION AND REPORT

F4.1 Calculate the soil-cement loss of the specimen as a percentage of the originally calculated oven-dry weight (W_1) of the specimen as follows:

$$\text{Soil-cement loss, per cent} = \frac{(W_i - W_f) \times 100}{W_i}$$