Ref BRE 72/1/2

Advance copy - Still needing minor corrections.

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SPECIFICATION FOR STABILISED SOIL BUILDING BLOCKS

by

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BUILDING RESEARCH ESTABLISHMENT

REPORT ADOPTED BY PARTICIPANTS AT

WORKSHOP ON KENYA STANDARD SPECIFICATION

ON SOIL BLOCKS

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Kenya Specification for Stabilised Soil Blocks.

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Kenya Standard Specification for Soil Blocks

1.0 Scope - This standard specifies the requirement for soil blocks for use as load bearing blockwork for one or two storey buildings in general building construction in Kenya and other African countries.

2.0 Definitions - For the purpose of this standard the following definitions shall apply

Stabilise - Methods to improve the natural durability and strength of a soil by the addition of the other materials

Optimum Moisture Content - The moisture content at which a specified amount of compaction will produce the maximum 'dry' density.

Work Size - The size of a block specified for its manufacture to which its actual size should conform within specified permissible deviations.

Compressive Strength - The average value taken when five blocks have been crushed in a compression test machine at a loading rate of 150KN per minute.

3.0 Materials

3.1 Cement -

The cement used for the manufacture of stabilised soil blocks shall be ordinary Portland cement conforming to KS02-21

3.2 Lime -

Lime used for the manufacture of stabilised soil blocks shall conform to KS02-97.

3.3 Soils -

3.3.1 - General - The soil used for the manufacture of soil blocks shall be of a suitable quality such that the specified requirements are achieved.

3.3.2 - Recommended Soil properties.

Soils with the following properties are considered suitable for the manufacture of stabilised soil blocks.

(i) The soil shall be free of deleterious materials such as organic matter and soluble salts.

ie Loss on Ignition less than 12 per cent.

(ii) The maximum size of soil to be classified as a fine gravel - less than 6mm.

(iii) The sum of the Alumina Oxide, Silica Oxide and the Iron Oxide

should be greater than 75 per cent.

(iv) The clay and silt content should exceed 10 per cent.

4.0 Manufacture of Blocks

4.1 Mixing

4.1.1 - Methods of Mixing.

Soil blocks shall be manufactured from a mixture of suitable soil, plus maybe sand and a stabiliser. Thoroughly mixed together, either by hand or a mechanical mixer. Mixing shall be continued until there is a uniform distribution of materials, and the mass is of uniform colour and consistency. Finally water is added to the mix by sprinkling until the optimum moisture level is reached.

4.1.2 Mixing by hand.

When mixing by hand the same precautions are necessary as 4.1.1 and the mixing should be performed on a water-tight platform.

4.2 Placement of Mix into Mould.

Quality control must be maintained by placing the same volume of mix into the mould. The mixture shall be moulded and cast into blocks.
Care must be taken to ensure that the moulds are regularly well oiled and are true to dimensions.

4.3 Compaction.

The compaction of stabilised soil blocks shall preferably be done by mechanical means at the optimum moisture content of the mixture so as to produce a minimum uniform density of 1900 kg/cubic metre at 28 days.

4.4 Curing

4.4.1 Primary Curing

Immediately the block is made it shall be released from the mould and removed to a covered area; which will retain the moisture within the block and provide protection against sun, strong winds and rain. The blocks shall be stored in the covered area until they are sufficiently hardened to permit handling without damage, but in no case will this period be less than 2 days.

4.4.2 Secondary Curing

After removal from the covered area the blocks can be stock piled, occasionally wetted and cured under cover for at least

14 days.

4.4.3 Cement stabilised blocks shall be cured in humid conditions to ensure complete hydration of the cement; this can be achieved by the use of wet sacking or hessian cloth or any other suitable material.

4.4.4 Lime stabilised soil blocks will probably take twice as long as cement stabilised soil blocks to cure.

5. Dimensions and Tolerances

5.1 Dimensions of stabilised soil blocks shall conform to Table 1.

Length (mm)		Height (mm)		Width (mm)	
Nominal Size	Work Size	Nominal Size	Work Size	Nominal Size	Work Size
300	290	100	90	150	140
400	390	130	120	200	190

TABLE 1 : Standard Formats for Soil Blocks.

5.2 Tolerances
The maximum dimensional deviations for soil blocks measured in accordance with Appendix A shall be as specified in Table 2

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

Table 2 : Dimensional Tolerances for Soil Blocks

6.0 Physical Properties

6.1 Compressive Strength

When stabilised soil blocks are tested in accordance with Appendix B, the minimum average compressive strength shall not be less than 1.5 N/mm^2 at 28 days after being immersed in water for 24 hours. The Dry strength compared to the wet compressive strength shall not be more than 50 per cent.

ie F dry = Twice x F wet.

6.2 Water Absorption

After 24 hours water immersion the water absorption of stabilised soil blocks when determined as described in Appendix C shall not exceed 15 per cent.

6.3 Density

The specific density of dry blocks shall be not less than 1900 Kg/m^3 at 28 days

6.4 Weathering

When subjected to the weathering test carried out in accordance with Appendix E the maximum loss shall not exceed 10 per cent.

6.5 Shrinkage Cracks

Shrinkage cracks shall not be more than 3 mm wide and 75 mm in length. No block shall have more than three such cracks.

6.6 Visual Inspection

All soil blocks on visual inspection shall be sound, free from cracks, broken edges, honey combing, warping and other defects that would interfere with the proper placing of the blocks or impair the strength or permanence of construction.

6.7 Rupture Test

Stabilised soil blocks should be tested for bending stress. Maximum bending stress to be a minimum of 1/6 of the wet compressive strength.

APPENDIX A

MEASUREMENT OF DIMENSIONS

A.1 TEST SPECIMENS

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

A.2 APPARATUS

A.2.1 GO/NO GO gauges appropriate to the specified length, width and height of block.

A.2.2 External calipers

A.2.3 A rule graduated to 1 mm, for use with the calipers.

A.3 LENGTH AND HEIGHT

A.3.1 Measurements

Check the compliance of each block for length at the four corners of the end faces, using a GO/NO Go gauge.

Similary check the compliance of each block for height at six points.

A.3.2 Reporting

Report the average length and height of the blocks.

A.4 THICKNESS

Measure the thickness of each block, at seven random-positions, using the Calipers and rule and measuring to the nearest millimetre. Calculate and report the average of the seven results to the nearest millimetre.

APPENDIX B

DETERMINATION OF COMPRESSIVE STRENGTH

B.1 Test specimens

From the sample, five blocks shall be selected at random after carrying out the dimensional checks.

B.2 The two surfaces of each block that would normally be placed horizontally in the wall, shall for purpose of this test termed as bed faces. The overall dimension of each bed face shall be measured to the nearest millimetre in accordance with Appendix A. The area of that face having the smaller area shall be taken as the area of the block for the purpose of calculating the compressive strength.

B.3.1 The bearing surface of the test machine shall be wiped clean and any loose grit removed from the bed faces of the test specimen. The specimens shall be placed in the testing machine so that the centre of the specimens coincides with the axis of the machine. All specimens shall be tested between two 3-ply plywood sheets approximately 3mm. thick, whose length and width shall exceed the corresponding mark size by not less than 5mm by more than 15mm; each sheet shall be used once.

B.3.2 The load shall be applied without shock and increased continuously at a rate of 150KN/MIN. The appropriate loading rate shall be maintained as far as maximum load in newtons carried by the specimen shall be recorded.

B.4 CALCULATION OF COMPRESSIVE STRENGTH

The compressive strength of the specimen shall be calculated by dividing its maximum failure load by its area as defined in B.2 and shall be expressed in N/mm^2 to the nearest $0.01N/mm^2$.

APPENDIX C

C. DETERMINATION OF WATER ABSORPTION AND MOISTURE CONTENT

C.1 TEST SPECIMENS

C.1.1 Five whole blocks taken at random from the samples selected for test, shall be used.

C.2 APPARATUS

C.2.1 Balance

The balance used shall be sensitive to within 0.5 percent of the weight of the smallest specimen tested.

C.2.2 Drying Oven

A thermostatically controlled drying oven capable of maintaining temperature of 105 $\pm$ 5°C.

C.3.1 Saturation

The test specimen shall be weighed immediately after sampling and shall then be completely immersed in water at 15°C to 25°C for 24 hours. The specimens shall then be weighed.

C.3.2 DRYING

Subsequent to saturation, all specimens shall be dried in a ventilated oven at 100° to 115° for not less than 24 hours and until two successive weighings, at intervals of 2 hours, shown on increment of loss not greater than 0.2 percent of the last previously determined weight of the specimen.

C.4 CALCULATION AND REPORT

C.4.1 Water Absorption: Calculate the water absorption as follows.

$$\text{Water Absorption, percent, } = \frac{M_2 - M_1}{M_1} \times 100$$

Where M_1 = Mass of specimen oven dry (g)

M_2 = Mass of specimen after 24 hours in water (g)

C.4.2 Moisture content - Calculate the moisture content as follows

$$\text{Moisture content, percent} = \frac{M_2 - M_1}{M_1} \times 100$$

Where M_s = Mass of specimen as sampled (g)
M_1 = Mass of specimen oven dry (g)

C.4.3 Report - Report all results separately for each unit and as average for the five units.

APPENDIX D

D. DETERMINATION OF DENSITY

D.1 Test specimens

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

D.2 Apparatus

D.2.1 Drying oven - Thermostatically controlled drying oven capable of maintaining temperature of 105 $\pm$ 5°C.

D.2 Calculation of Volume

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

D.3 Procedure

Dry the three specimen blocks for at least 16 hours in a ventilated oven at 105 $\pm$ 5°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.

D.4 Calculation of density

Calculate the block density by using the following formula.

$$C_b = \frac{M}{V,}$$

C_b = block density (in Kg/m^3)

M = Oven dry mass (in Kg)

V = gross volume of block (in m^3)

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

APPENDIX E

WEATHERING TEST

E.1 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. These blocks shall be designated 'Specimen A' and 'Specimen B' respectively.

E.2 APPARATUS

E.2.1 Balance - a balance or a scale of 20-kg capacity, sensitive to 50 grams.

E.2.2 Drying Oven - two thermostatically controlled drying ovens, one capable of maintaining temperature

105 ± 5°C and the other capable of maintaining temperature of 70 ± 5°C.

E.2.3 Water-Bath - a suitable tank for submerging specimens in water at room temperature.

E.2.4 Wire Scratch Brush - A brush made of 50 x 1.6mm flat with 0.40mm wire bristles assembled in 50 groups of 10 bristles each and mounted to form 5 longitudinal rows and 10 transverse rows of bristles on 200 x 60mm hardwood block.

E.3 PROCEDURE

E.3.1 Oven dry specimen A at 110 ± 5°C for at least 12 hours or to constant weight. From this weight, calculate the oven-dry weight (Wi) of the specimen B. Carry out further operations on specimen B only.

E.3.2 Now submerge the specimen B in water at room temperature for 6 hours. Remove. Place it in an oven at 70°C for 42 hours and remove. Brush all areas of the specimen twice with the wire scratch brush. Hold the brush with the long axis of the brush paralled to the longitudinal axis of the specimen or paralled 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.

E.3.3 The procedure described in E.3.2 constitutes one cycle (48 hr) of the weathering test. Continue the procedure for 12 cycles. After 12 cycles of test, dry the specimen to constant weight at 110 ± 5°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.

E.4 CALCULATION AND REPORT

E.4.1 Calculate the soil-cement loss of the specimen as percentage of the originally calculated oven-dry weight (Wi) of the specimen as follows:

$$\text{Soil-cement loss, percent} = \frac{Wi - W_f}{Wi}$$

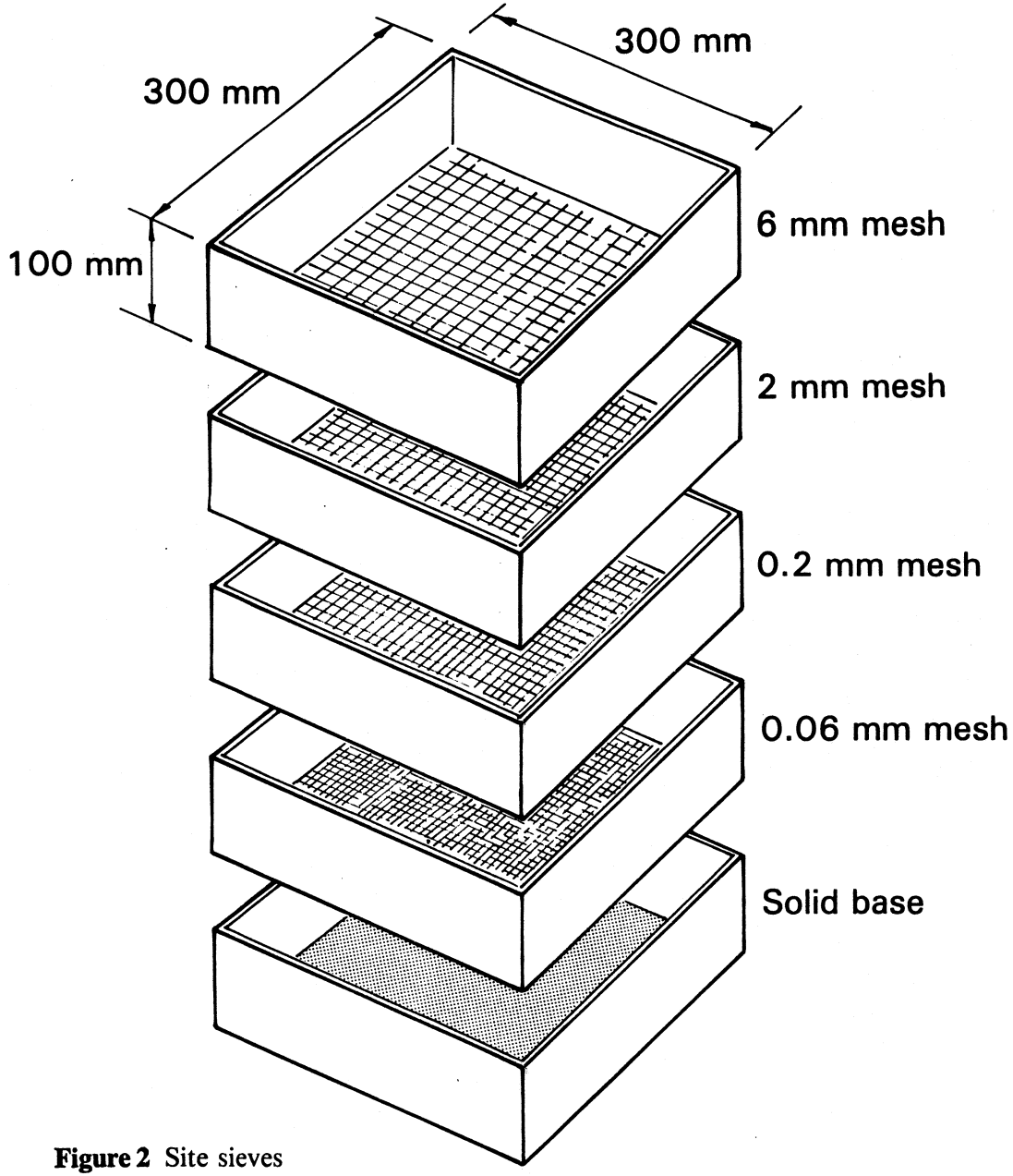

Figure 2 Site sieves

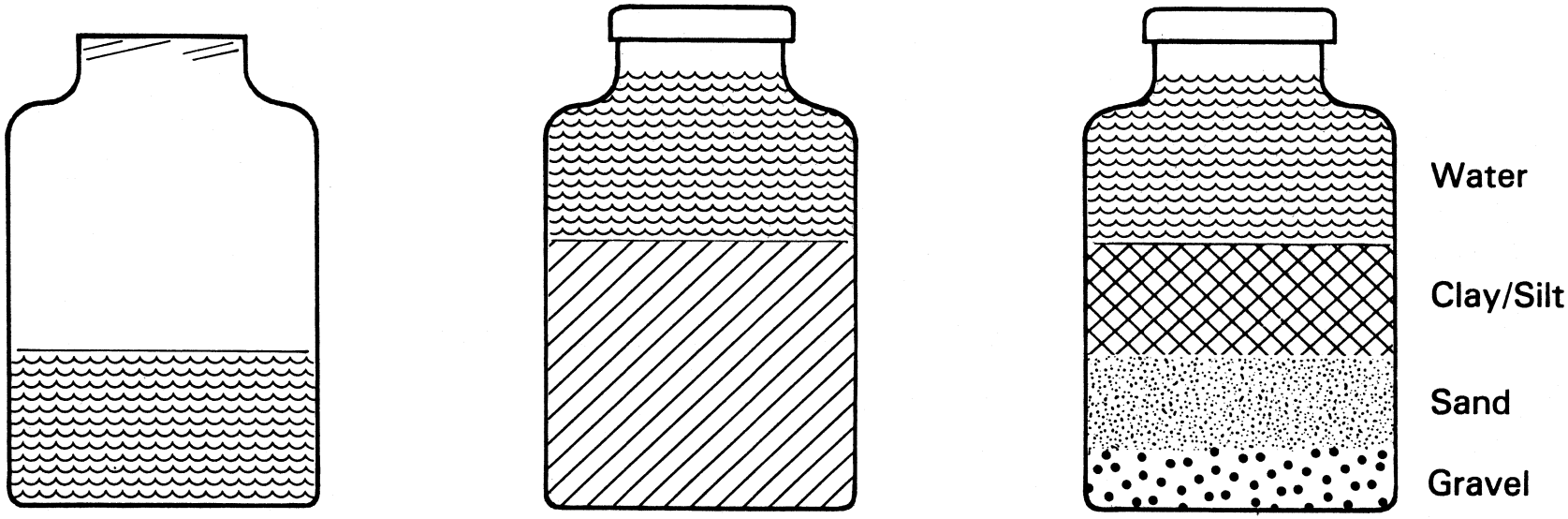

Figure 3 Sedimentation bottle test

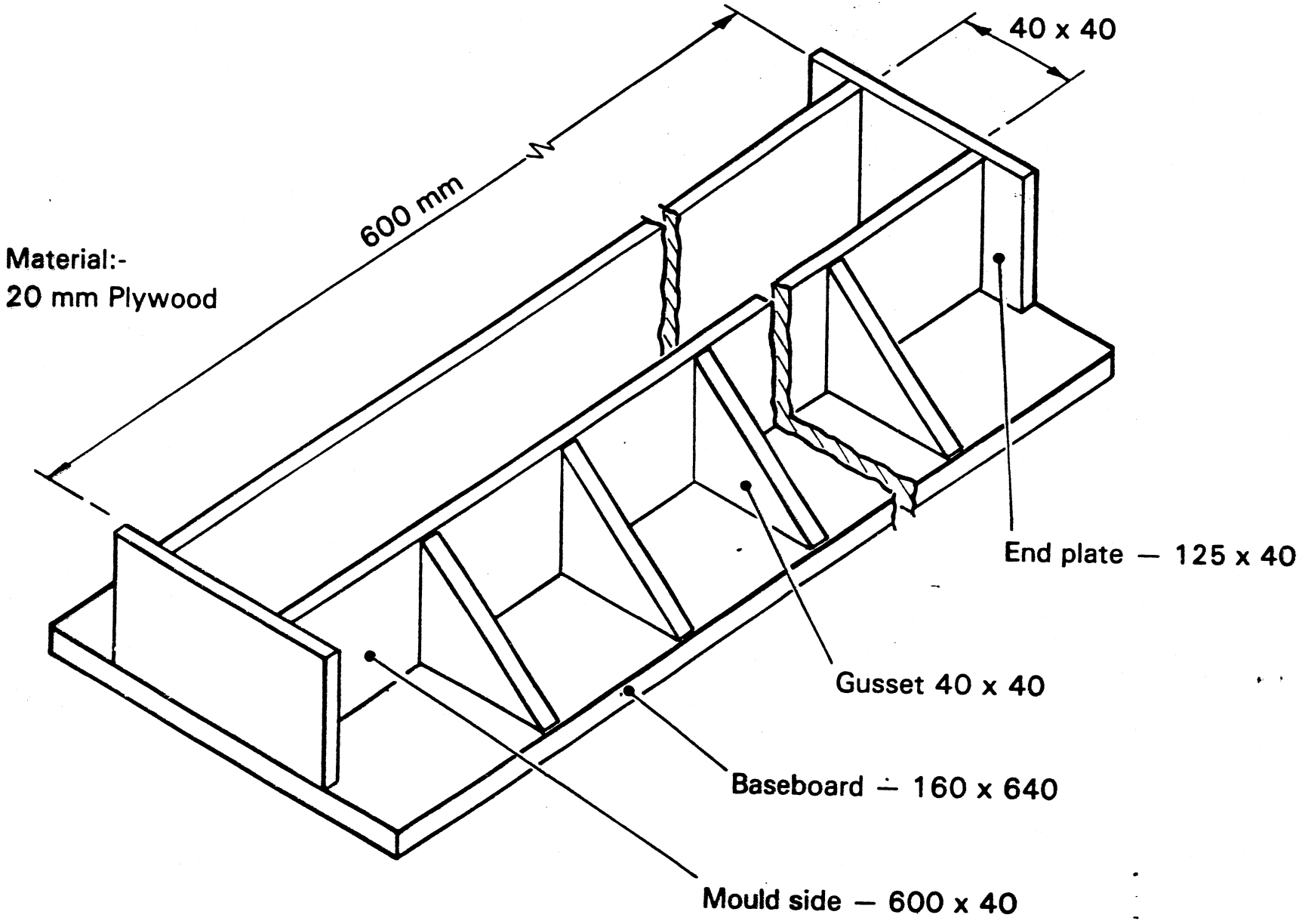

Figure 4 Linear shrinkage mould

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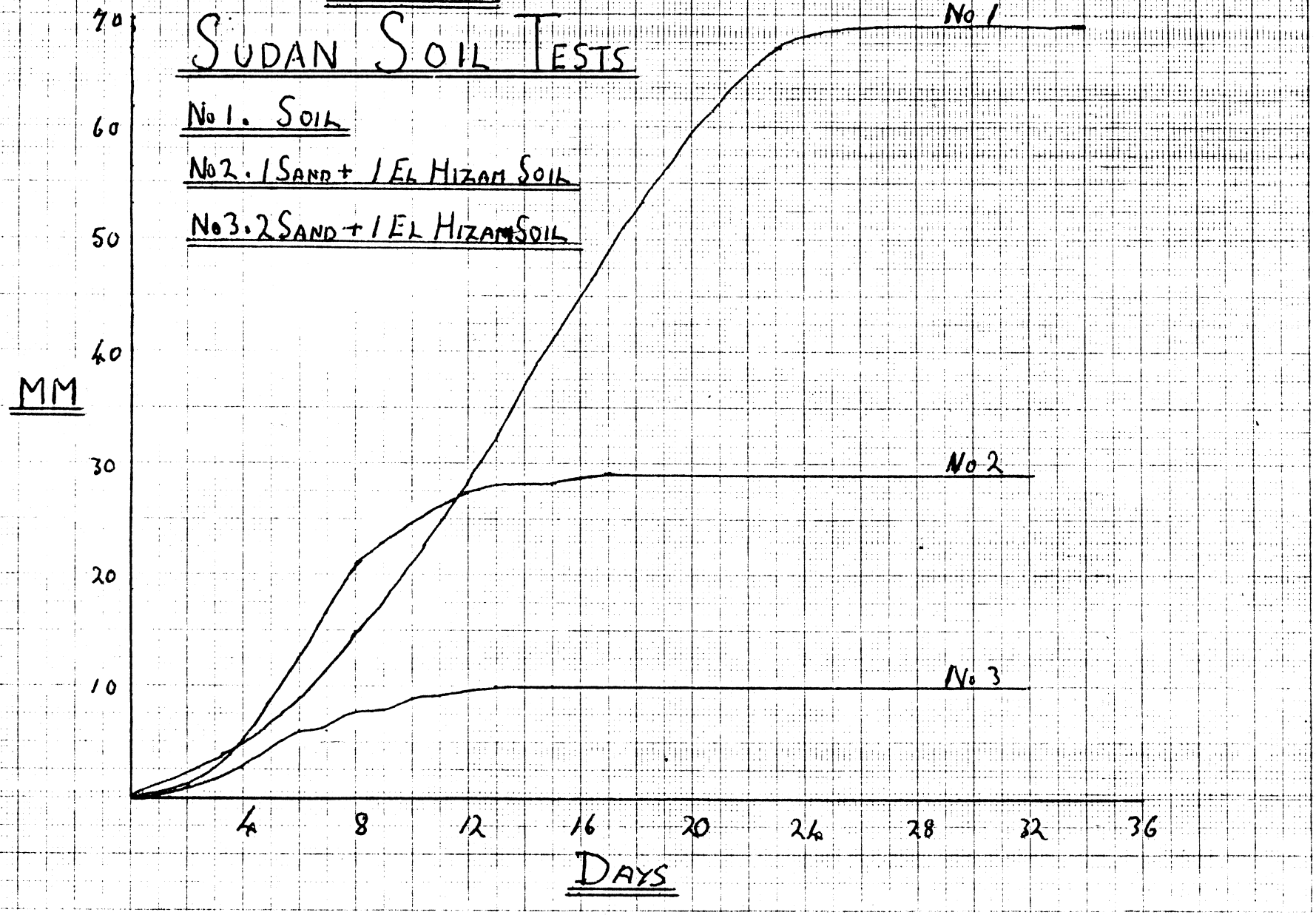
SUDAN SOIL TESTS

No 1. SOIL

No 2. 1 SAND + 1 EL HIZAM SOIL

No 3. 2 SAND + 1 EL HIZAM SOIL



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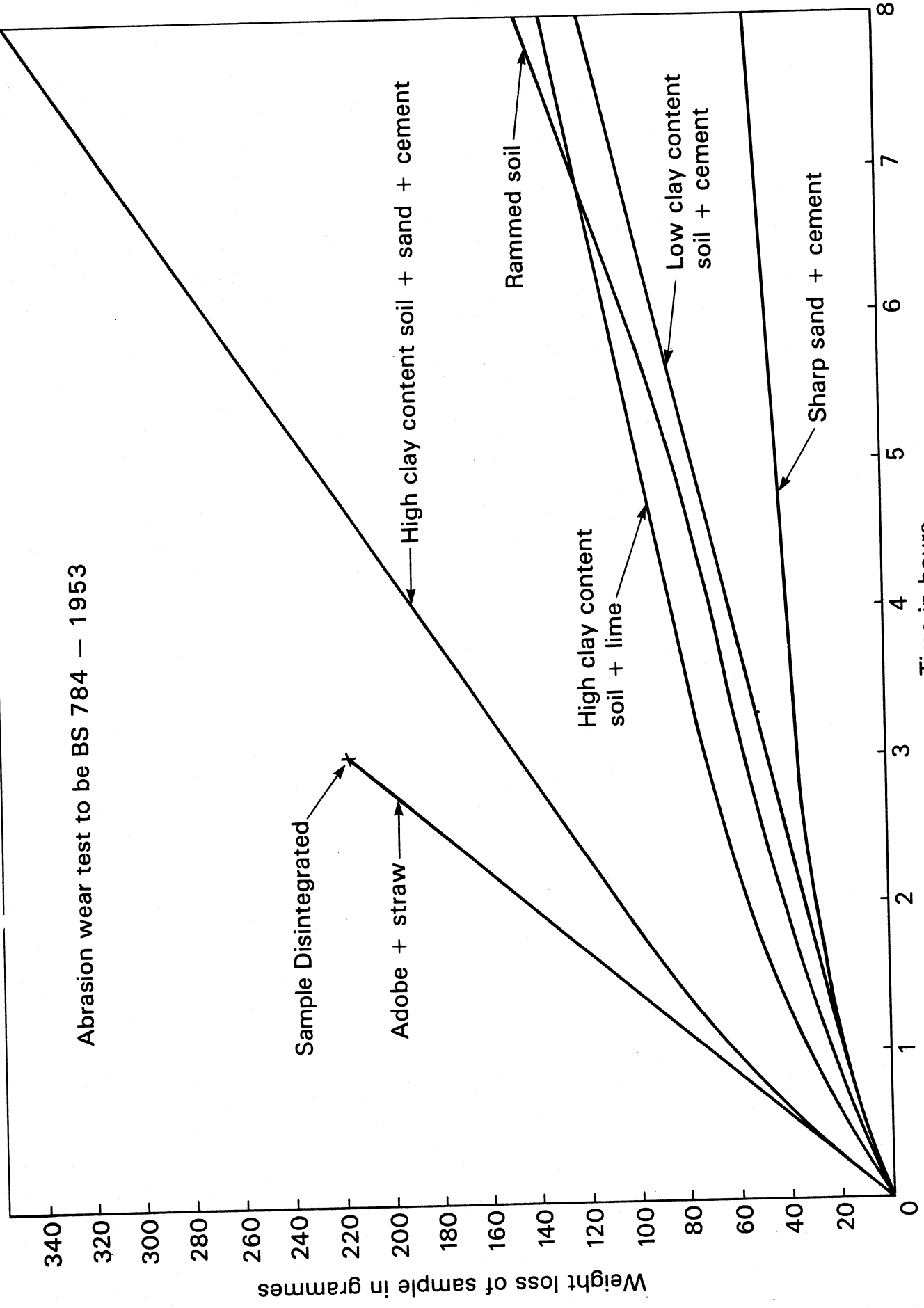

Figure 14 Abrasion test curve for various stabilised soil samples