IS : 4332 (Part III) - 1967
(Reaffirmed 1995)

Indian Standard

METHODS OF TEST FOR STABILIZED SOILS

PART III TEST FOR DETERMINATION OF MOISTURE CONTENT-DRY DENSITY RELATION FOR STABILIZED SOIL MIXTURES

(First Reprint MAY 1980)

UDC 624.131.431.2/.3

INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Price Rs 6·00

January 1968

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PART III TEST FOR DETERMINATION OF MOISTURE CONTENT-DRY DENSITY RELATION FOR STABILIZED SOIL MIXTURES

0. FOREWORD

0.1 This Indian Standard (Part III) was adopted by the Indian Standards Institution on 20 October 1967, after the draft finalized by the Soil Engineering Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Soil stabilization, in the broadest sense, is the alteration of any inherent property of a soil to improve its engineering performance. The classification of the methods of stabilization is based on the treatment given to the soil (for example dewatering, compaction, etc), process involved (for example, thermal, electrical, etc) and on additives employed (for example, asphalt, cement, etc). The choice of a particular method depends on the characteristics of the problem on hand. For studying the effectiveness of a stabilization technique under investigation, certain standard methods of test are required and these are being published in parts. This part [IS : 4332 (Part III)] lays down the method of test for determination of moisture content dry density relation for stabilized soil mixtures.

0.3 In the formulation of this standard due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practices in this field in this country.

0.4 In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

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1. SCOPE

1.1 This standard (Part III) lays down the method for the determination of the relation between the moisture content and the dry density of a stabilized soil mixture. In this test a 2·6 kg rammer falling through a height of 310 mm (light compaction) or a 4·89 rammer falling through a height of 450 mm (heavy compaction) is used.

*Rules for rounding off numerical values (*revised*).

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 2809-1964* shall apply.

3. APPARATUS

3.1 Cylindrical Metal Mould — It shall be of non-corrodible material with essential dimensions as given below (*see* Fig. 1).

a) 100 mm mould having a capacity of 1 000 ml with an internal diameter of 100 ± 0·1 mm and an internal effective height of 127·3 ± 0·1 mm.

b) 150 mm mould having a capacity of 2 250 ml with an internal diameter of 150 ± 0·1 mm and an internal effective height of 127·3 ± 0·1 mm.

3.1.1 The mould shall be fitted with a detachable base plate and a removable extension approximately 60 mm high. The weight of the mould with the base plate attached shall be known. The internal surface of the mould shall be smooth.

3.2 Metal Rammer — The characteristics of metal rammer shall be as given below:

a) For light compaction, the rammer shall have a 50 mm diameter circular face, and weigh 2·6 kg ± 25 g. The rammer shall be equipped with a suitable arrangement for controlling the drop to the specified amount of 310 mm ± 1 mm. A suitable form of hand apparatus is shown in Fig. 2.

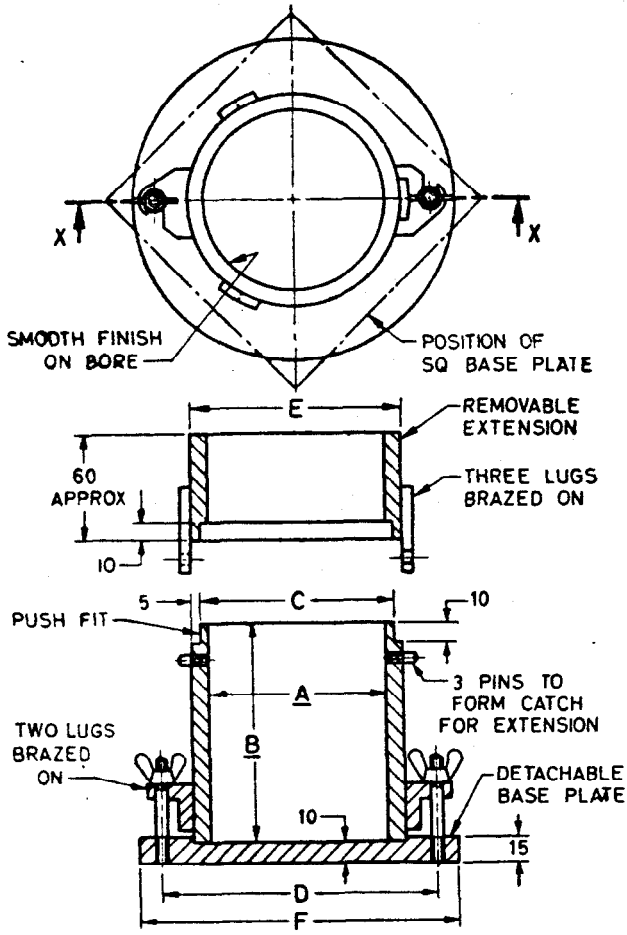
b) For heavy compaction, the rammer shall have a 50 mm diameter circular face, and weigh 4·89 kg ± 50 g. The rammer shall be equipped with a suitable arrangement for controlling the drops to 450 mm ± 1 mm. A suitable form of hand apparatus is shown in Fig. 3.

3.2.1 A mechanical form of the apparatus may be used provided the essential dimensions of the rammer and mould are adhered to, and provided that the rammer has a free vertical fall of the correct controlled height. It is also essential that the design of the machine is such that the mould rests on a heavy solid base.

3.3 Balance — one of capacity 10 kg, sensitive to 1 g and another of capacity 200 g, sensitive to 0·01 g.

3.4 Palette Knife — A convenient size is one having a blade approximately 10 cm long and 2 cm wide.

*Glossary of terms and symbols relating to soil mechanics.

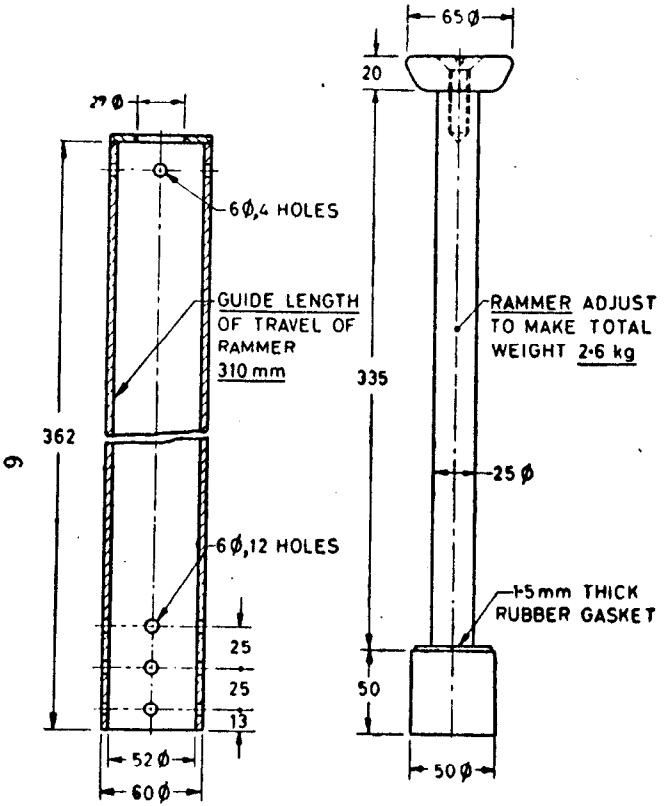


SECTION XX

VOLUME mm	*A* dia	*B*	*C* dia	*D*	*E* dia	*F*
1 000	100·0±0·1	127·3±0·1	110	150	120	180 dia or 150 square
2 250	150·0±0·1	127·3±0·1	160	200	170	230 dia or 200 square

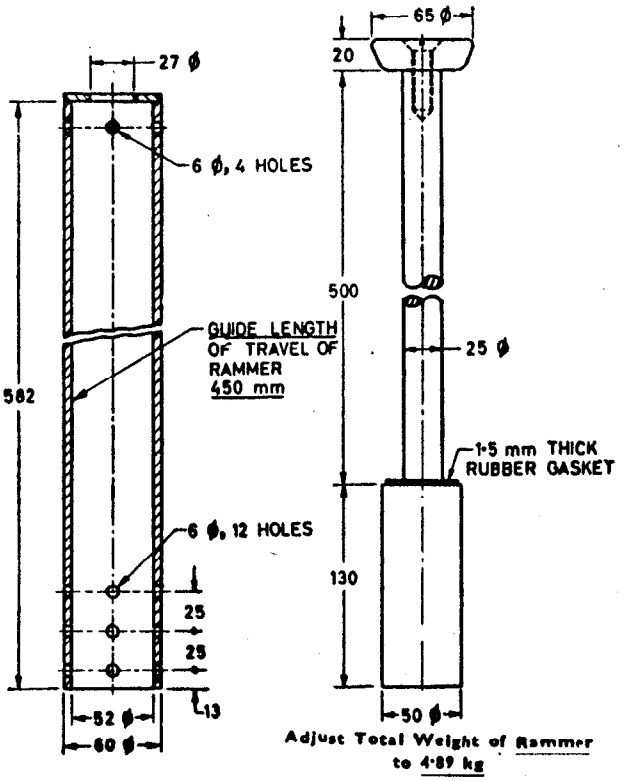
Essential dimensions underlined.
All dimensions in millimetres.

FIG. 1 TYPICAL MOULD FOR COMPACTION



Essential dimensions underlined.
All dimensions in millimetres.

FIG. 2 TYPICAL METAL RAMMER FOR COMPACTION (LIGHT COMPACTION)



Essential dimensions underlined.
All dimensions in millimetres.

FIG. 3 TYPICAL METAL RAMMER FOR COMPACTION (HEAVY COMPACTION)

3.5 Steel Straight Edge — about 30 cm in length and having one bevelled edge.

3.6 Sieves — 50-mm, 20-mm and 4·75-mm IS Sieves conforming to the requirements of IS : 460-1962*.

3.7 Large Metal Tray — A convenient size is one about 60 cm × 45 cm and with sides 7 cm deep.

3.8 Mixing Tools — Miscellaneous tools, such as mixing pan, spoon trowel, spatula, etc, or a suitable mechanical device.

3.9 Apparatus for the determination of moisture content shall be in accordance with IS : 4332 (Part II)-1967†.

3.10 Sample Extruder (Optional) — It consists of a jack, lever frame or other device adopted for the purpose of extruding compacted specimens from the mould.

4. MARKING

4.1 The cylindrical metal moulds and the metal rammers shall have firmly attached to them a marking plate bearing the following information:

a) Manufacturer's name or trade-mark,

b) Year of manufacture, and

c) Essential dimensions.

4.1.1 The cylindrical metal moulds and the metal rammers may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act, and the Rules and Regulations made thereunder. Presence of this mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard, under a well-defined system of inspection, testing and quality control during production. This system, which is devised and supervised by ISI and operated by the producer, has the further safeguard that the products as actually marketed are continuously checked by ISI for conformity to the standard. Details of conditions, under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

5. PREPARATION OF SOIL SAMPLE

5.1 Preparation of Sample Passing 20-mm IS Sieve — A representative sample weighing about 20 kg or more of the thoroughly mixed material obtained in accordance with IS : 4332 (Part I)-1967‡.

*Specification for test sieves (*revised*).

†Methods of test for stabilized soils: Part II Determination of moisture content of stabilized soil mixtures.

‡Methods of test for stabilized soils: Part I Method of sampling and preparation of stabilized soils for testing.

5.1.1 The soil sample shall be made to pass through 20-mm and 4·75-mm IS Sieves, separating the fractions retained and passing these sieves. Care shall be exercised so as not to break the aggregates while pulverising. The percentage of each fraction shall be determined. The fraction retained on 20-mm IS Sieve shall not be used in the test. The percentage of soil coarser than 4·75-mm IS Sieve and the percentage of soil coarser than 20-mm IS Sieve shall be determined.

5.1.2 The ratio of fraction passing 20-mm IS Sieve and retained on 4·75-mm IS Sieve to the soil passing 4·75-mm IS Sieve shall be determined. The material retained on and passing 4·75-mm IS Sieve shall be mixed thoroughly in the determined proportion to obtain about 16 kg of soil sample.

NOTE — In case of material passing 20-mm IS Sieve and retained on 4·75-mm IS Sieve is more than 20 percent, the ratio of such material to the material passing 4·75-mm IS Sieve shall be maintained for each determination in a test. If the coarse material retained on 4·75-mm IS Sieve is less than 20 percent the sample may be used as such.

5.2 Preparation of Sample Passing 4·75-mm IS Sieve — A representative sample weighing approximately 16 kg of the thoroughly mixed material obtained in accordance with IS : 4332 (Part I)-1967*, shall be taken.

5.3 Mixing of Water and Stabilizer — Out of the soil sample obtained as described in **5.1** and **5.2**, eight 2-kg samples of stabilized soil shall be prepared in the manner described in IS : 4332 (Part I)-1967*.

6. PROCEDURE

6.1 The empty mould shall be cleaned, dried, greased lightly on the inside, if necessary, and weighed to the nearest one gram.. The mould with the collar shall be fitted on to the base plate and placed on a solid base.

6.2 Water shall be mixed with each of the samples (one sample for each moisture content) obtained as described in **5** before compaction so as to give moisture content as follows:

a) *Sandy and Gravelly Soils* — 7 percent and above in steps of about 1½ percent.

b) *Clayey Soils* — 10 percent and above in steps of about 3 percent.

6.3 Each of the samples of stabilized soil water mixture shall be compacted in the desired mould with the desired compactive efforts using the

*Methods of test for stabilized soils: Part I Method of samling and preparation of stabilized soils for testing.

appropriate rammer as follows:

Type of Compaction	*Size of Mould*	*Number of Layers*	*Number of Blows per Layer*
Light	1 000 ml	3	25
	2 250 ml	3	56
Heavy	1 000 ml	5	25
	2 250 ml	5	56

6.3.1 The compaction on each sample shall be completed within 20 minutes of completion of mixing. The blows shall be uniformly distributed over the surface of each layer. Care shall be taken to keep the sleeve free from the stabilized soil mixture to ensure a free fall of the rammer and any lump of soil sticking to the rammer at any stage shall be removed. Each layer of the compacted stabilized soil mixture shall be scored with a spatula before putting the stabilized soil mixture for the succeeding layer. The amount of the stabilized soil mixture used shall be just sufficient to fill the mould leaving about 5 mm to be struck off (*see* Note) when the collar is removed. The collar shall then be removed and the compacted stabilized soil mixture shall be carefully levelled off to the top of the mould by means of the straight edge. The mould with the compacted stabilized soil mixture shall then be weighed to the nearest one gram.

NOTE — It is necessary to control the total volume of stabilized soil mixture compacted, since it has been found that if the amount of soil struck off, after removing the extension, is too great the test results will be inaccurate.

6.4 The compacted specimen shall be ejected out of the mould, cut in the middle and a representative soil specimen shall be taken in an air-tight container from the cut surface. The moisture content of this representative specimen shall be determined in accordance with IS : 4332 (Part II)-1967*.

7. CALCULATION

7.1 Soils Stabilized with a Solid Stabilizer

7.1.1 *Wet Density* — The wet density of the compacted stabilized soil mixture shall be calculated as follows:

$$\gamma_m = \frac{W - W_m}{1\,000} \text{ g/cm}^3$$

where

γ_m = wet density of compacted stabilized soil in g/cm^3,

W = weight of mould with moist compacted stabilized soil in g, and

W_m = weight of empty mould in g.

*Methods of test for stabilized soils: Part II Determination of moisture content of stabilized soil mixtures.

7.1.2 *Dry Density* — Dry density of the compacted stabilized soil mixture shall be calculated as follows:

$$\gamma'_d = \frac{m}{\left(1 + \frac{w'}{100}\right)} \text{ g/cm}^3$$

where

γ'_d = dry density of compacted stabilized soil in g/cm³,
γ_m = wet density of compacted stabilized soil in g/cm³, and
w' = moisture content of the soil plus solid stabilizer (percent).

7.1.3 *Air Voids Lines* — For determining the air voids lines the following formula may be used:

$$\gamma'_d = \frac{\gamma_w \left(1 - \frac{V_a}{100}\right)}{\frac{1}{G} + \frac{w'}{100}}$$

where

γ'_d = dry density of soil plus solid stabilizer in g/cm³;
γ_w = density of water in g/cm³ (= 1 g/cm³);
V_a = volume of air voids in the compacted stabilized soil mixture expressed as a percentage of the total volume of the mixture;
w' = moisture content of the soil plus solid stabilizer, percent; and
G = combined specific gravity of the soil plus stabilizer (*see* **7.1.3.1**).

7.1.3.1 The combined specific gravity of the soil plus stabilizer (G) may be calculated from the following formula:

$$G = \frac{1 + \frac{x}{100}}{\frac{1}{G_s} + \frac{x}{100\, G_c}}$$

where

x = stabilizer content, expressed as a percentage of the weight of dry soil;
G_s = specific gravity of the soil particles, determined in accordance with the method given in IS : 2720 (Part III)-1964*; and
G_c = specific gravity of the solid stabilizer.

7.2 Soil Stabilized with a Fluid Stabilizer

7.2.1 *Wet Density* — The wet density of the compacted stabilized soil mixture shall be calculated as in **7.1.1.**

*Methods of test for soils : Part III Determination of specific gravity.

7.2.2 *Dry Density* — The dry density of the compacted stabilized soil mixture shall be calculated as follows:

$$\gamma_d = \frac{\gamma_m}{1 + \left(\frac{w + s}{100}\right)}$$

where

γ_d = dry density of compacted stabilized soil in g/cm³,
γ_m = wet density of compacted stabilized soil in g/cm³,
w = moisture content of the soil (percent), and
s = the nonaqueous fluid stabilizer content of the soil (percent).

7.2.3 *Air Voids Line* — For determining the air voids lines the following formula may be used:

$$\gamma_d = \frac{\gamma_w \left(1 - \frac{V_a}{100}\right)}{\left(\frac{1}{G_s}\right) + \frac{w + s}{100}}$$

where

γ_d = dry density of soil in g/cm³,
γ_w = density of water in g/cm³ (= 1 g/cm³),
V_a = volume of air voids in the compacted stabilized soil mixture expressed as a percentage of the total volume of the mixture,
w = moisture content of the soil (percent),
s = the nonaqueous fluid stabilizer content of the soil (percent), and
G_s = specific gravity of the soil particles, determined in accordance with IS : 2720 (Part III)-1964*.

8. REPORT

8.1 Record of Results — The test results shall be recorded suitably. A recommended proforma for recording the results is given in Appendix A.

8.2 Moisture (Dry Density Curve) — The dry densities of the compacted soil stabilizer mixture obtained in a series of determinations shall be plotted against the corresponding moisture contents. A smooth curve shall be drawn through the resulting points. The dry density corresponding to the maximum point of the curve and the corresponding moisture content shall also be reported.

8.3 The following shall also be reported:

a) The amount of soil retained on the 20-mm IS Sieve, passing the 20-mm IS Sieve and passing 4·75-mm IS Sieve;
b) The method of obtaining the results namely, light compaction or heavy compaction; and
c) The amount and type of stabilizer used.

*Methods of test for soils : Part III Determination of specific gravity.

APPENDIX A

(*Clause* 8.1)

COMPACTION TEST DATA SHEET

Name of the project — Location

Sample reference — Height of fall of the rammer

Type of Test : Light/Heavy compaction

Volume of the mould

Weight of the rammer

Percentage of material { a) Retained on 20-mm IS Sieve; b) Passing 20-mm IS Sieve; c) Passing 4·75-mm IS Sieve

Ratio of (b) to (c)

Stabilizer used

Quantity of stabilizer used

Specific gravity of the soil

Specific gravity of the stabilizer

Remarks:

Determination No.	1	2	3	4	5	6	7
Weight of mould + compacted soil-stabilizer mixture in g							
Weight of mould in g							
Weight of compacted soil-stabilizer mixture in g							
Wet density in g/cm^3							
Average moisture content percent							
Fluid stabilizer content percent							
Dry density in g/cm^3							

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	*Unit*	*Symbol*	*Conversion*
Force	newton	N	1 N = 1 kg.1 m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

INDIAN STANDARDS INSTITUTION

Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002

Telephones : 26 60 21, 27 01 31 **Telegrams : Manaksanstha**

Regional Offices:		Telephone
Western : Novelty Chambers, Grant Road	BOMBAY 400007	37 97 29
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AMENDMENT NO. 1 AUGUST 1983

TO

IS:4332(Part 3)-1967 METHODS OF TEST FOR STABILIZED SOILS

PART 3 TEST FOR DETERMINATION OF MOISTURE CONTENT-DRY DENSITY RELATION FOR STABILIZED SOIL MIXTURES

Alterations

(*Page 4, clause 2.1*) - Substitute 'IS:2809-1972*' *for* 'IS:2809-1964*'.

(*Page 4, clauses 3.1 to 3.2.1*) - Substitute the following for the existing clauses:

'3.1 Cylindrical Metal Mould - shall conform to IS:10074-1982†.

3.2 Metal Rammer - shall conform to IS:9198-1979‡.'

(*Page 4, foot-note with '*' mark*) - Substitute the following for the existing foot-note:

'*Glossary of terms and symbols relating to soil engineering (*first revision*)

†Specification for compaction mould assembly for light and heavy compaction test for soils.

‡Specification for compaction rammer for soil testing.'

(*Pages 5 and 6, Fig. 1, 2 and 3*) - Delete.

(*Page 7, clause 3.6, line 2*) - Substitute 'IS:460(Part 1)-1978*' *for* 'IS:460-1962*'.

(*Page 7, foot-note with '*' mark*) - Substitute the following for the existing foot-note:

'*Specification for test sieves: Part 1 Wire cloth test sieves (*second revision*).'

(*Page 10, clause 7.1.3.1, last but one line*) - Substitute 'IS:2720(Part 3/Sec 2)-1980*' *for* 'IS:2720 (Part 3)-1964*'.

(*Page 10, foot-note with '*' mark*) - Substitute the following for the existing foot-note:

'*Methods of test for soils: Part 3 Determination of specific gravity, Section 2 Fine, medium and coarse grained soils (*first revision*).'

(*Page 11, clause 7.2.3, last line*) - Substitute 'IS:2720(Part 3/Sec 2)-1980*' *for* 'IS:2720(Part 3)-1964* '

(*Page 11, foot-note with '*' mark*) - Substitute the following for the existing foot-note:

'*Methods of test for soils: Part 3 Determination of specific gravity, Section 2 Fine, medium and coarse grained soils (*first revision*).'

Reprography Unit, ISI, New Delhi, India