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Indian Standard

METHODS OF TEST FOR STABILIZED SOILS

PART IV WETTING AND DRYING, AND FREEZING AND THAWING TESTS FOR COMPACTED SOIL-CEMENT MIXTURES

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Indian Standard

METHODS OF TEST FOR STABILIZED SOILS

PART IV WETTING AND DRYING, AND FREEZING AND THAWING TESTS FOR COMPACTED SOIL-CEMENT MIXTURES

0. FOREWORD

0.1 This Indian Standard (Part IV) was adopted by the Indian Standards Institution on 5 April 1968, after the draft finalized by the Soil Engineering Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Soil stabilization is the permanent alteration of any property of the soil to improve its engineering performance. One of the methods of stabilization is to add cement to soil and then compact the mixture at the required moisture content. For evaluating the improvement obtained by stabilization standard methods of tests are required and these are being published in parts. This part [IS : 4332(Part IV)] lays down the method for determining the effect of wetting and drying, and freezing and thawing on compacted specimens of cement stabilized soil.

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. This has been met by basing the standard on the following publications:

ASTM D 559-57 (1965) Standard methods for wetting and drying tests of compacted soil-cement mixtures. 1967 Book of ASTM Standards, Part 11.

ASTM D 560-57 (1965) Standard methods for freezing and thawing tests of compacted soil-cement mixtures. 1967 Book of ASTM Standards, Part 11.

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*.

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

SECTION 1 WETTING AND DRYING TEST

1. SCOPE

1.1 Section 1 of this standard (Part IV) covers the procedure for determining the soil-cement losses, moisture changes, and volume changes (swell and shrinkage) produced by repeated wetting and drying of hardened soil-cement specimens.

2. APPARATUS

2.1 Cylindrical Metal Mould — of 1 000 ml capacity satisfying the requirements specified in IS : 4332 (Part III)-1967*.

2.2 Metal Rammer — of weight 2·6 kg ± 25 g satisfying the requirements specified in IS : 4332 (Part III)-1967*.

2.3 Sample Extruder — a jack, lever frame or other device adopted for the purpose of extruding compacted specimens from the mould.

2.4 Balances — one of capacity 10 kg, sensitive to 1 g, and another of capacity 1 kg, sensitive to 0·1 g.

2.5 Oven — thermostatically controlled with interior of non-corroding material to maintain temperature between 105° and 110°C.

2.6 Container — any suitable non-corrodible air-tight container to determine the moisture content.

2.7 Moist Chamber — a moist chamber or suitable covered container capable of maintaining a temperature of 25° to 30°C and a relative humidity of 100 percent for 7-day storage of compacted specimens.

2.8 Water-Bath — a suitable tank for submerging compacted specimens in water at room temperature of 25° to 30°C.

2.9 Wire-Scratch Brush — made of 50 × 1·6 mm flat 0·45 mm thick wire bristles assembled in 50 groups of 10 bristles each and mounted to form 5 longitudinal rows and 10 transverse rows of bristles on a 190 × 65 mm hardwood block.

2.10 Steel Straightedge — about 30 cm in length and having one bevelled edge.

2.11 Sieves — 20-mm and 4·75-mm IS Sieves conforming to the requirements of IS : 460-1962†.

*Methods of test for stabilized soils: Part III Test for determination of moisture content-dry density relation for stabilized soil mixtures.

†Specification for test sieves (*revised*).

2.12 Mixing Tools — Miscellaneous tools, such as mixing pan, and trowel or a suitable mechanical device for thoroughly mixing the soil with cement and water (for mechanical device, *see* IS : 1727-1967*).

2.13 Scarifier — a suitable tool to remove the smooth compaction plane at the top of the first and second layers of the specimen.

2.14 Measuring Device — suitable for accurately measuring the heights and diameters of test specimens to the nearest 0·2 mm.

2.15 Graduated Glass Cylinder — of 250-ml capacity for measuring water.

3. PREPARATION OF SOIL SAMPLE AND SPECIMENS FOR TEST

3.1 Preparation of Material for Moulding Specimens

3.1.1 The soil sample shall be prepared in accordance with the procedure described in **5.1** and **5.2** of IS : 4332 (Part III)-1967†.

3.1.2 A sufficient quantity of the soil sample prepared in accordance with **3.1.1** should be selected to provide four (*see* Note) compacted specimens and required moisture samples.

NOTE — Usually two specimens (identified as No. 3 and 4) are required for routine testing. The other specimens (identified as No. 1 and 2) are made for research work and for testing unusual soils.

3.1.3 The soil, potable water and required amount of cement conforming to IS 269-1967‡ or IS : 455-1967§ shall be mixed as specified in IS : 4332 (Part I)-1967‖. The mixture should be broken up without reducing the natural size of individual particles.

3.2 Preparation of Specimens

3.2.1 The specimens shall be formed by immediately compacting the soil-cement mixture in the mould (with the collar attached) and later trimming the specimens in accordance with IS : 4332 (Part III)-1967†. In addition the tops of the first and second layers shall be scarified to remove smooth compaction planes before placing and compacting the succeeding layers. This scarification shall form grooves at right angles

*Methods of test for pozzolanic materials (*first revision*).

†Methods of test for stabilized soils: Part III Test for determination of moisture content-dry density relation for stabilized soil mixtures.

‡Specification for ordinary, rapid-hardening and low heat Portland cement (*second revision*).

§Specification for portland blastfurnace slag cement (*second revision*).

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

to each other approximately 3 mm in width and 3 mm in depth and approximately 6 mm apart.

3.2.2 During compaction, a representative sample of the soil-cement mixture weighing not less than 100 g shall be taken from the batch and its moisture content determined in accordance with IS : 4332 (Part II)-1967*.

3.2.3 The compacted specimens shall be weighed with the mould. The specimens shall then be removed from the mould. The oven-dry density in g/cm³ shall be calculated. The specimens shall be identified suitably as No. 1 and 2. These specimens may be used to obtain data on moisture and volume changes during the test.

3.2.4 Two more specimens shall be similarly formed and their moisture content and dry density determined. These specimens shall be identified as No. 3 and 4 and used to obtain data on soil-cement losses during the test.

3.2.5 The average diameter and height of specimens No. 1 and 2 shall be measured and their volume shall be determined.

3.2.6 All the four specimens shall be placed on suitable carriers in the moist chamber and protected from free water for a period of seven days.

3.2.7 Specimens No. 1 and 2 should be weighed and measured at the end of the seven-day period to provide data for calculating their moisture content and volume (*see* Note).

NOTE — It is important that all height and diameter measurements be accurate to within 0·2 mm and be taken at the same points on the specimen at all times.

4. PROCEDURE FOR THE WETTING AND DRYING TEST

4.1 At the end of the storage in the moist room, the specimens shall be submerged in potable water at room temperature for a period of 5 h and removed. Specimens No. 1 and 2 shall be weighed and their dimensions measured.

4.2 All four specimens shall then be placed in an oven at 70°C for 42 h and removed. Specimens No. 1 and 2 shall be weighed and their dimensions measured again.

4.3 Specimens No. 3 and 4 shall be given two firm strokes on all areas with the wire-scratch brush. The brush shall be held with the long axis of the brush parallel to the longitudinal axis of the specimen or parallel

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

to the ends as required to cover all areas of the specimen. These strokes shall be applied to full height and width of the specimen with a firm stroke corresponding to approximately 1·4 kgf. For measurement of pressure (*see* Note) 18 to 20 vertical brush strokes may be required to cover the sides of the specimen twice and four strokes may be required at each end.

NOTE — A specimen should be clamped in a vertical position on the edge of a platform scale. Vertical brushing strokes should be applied to the specimen and the force necessary to register approximately 1·4 kg noted.

4.4 The procedures described in **4.1** to **4.3** constitute one cycle (48 h) of wetting and drying. The specimens shall again be submerged in water and the procedure continued for 12 cycles.

NOTE — Weight determinations of specimens No. 3 and 4 before and after brushing may be made at the end of each cycle when conducting research and making special investigations.

4.5 Testing of No. 1 and 2 specimens may be discontinued prior to 12 cycles should the measurements become inaccurate due to soil-cement loss of the specimen.

NOTE — If it is not possible to run the cycles continuously because of Sundays, holidays or for any other reason, the specimens should be held in the oven during the layover period if possible.

4.6 After 12 cycles of test, the specimens shall be dried to constant weight at 110°C and weighed to determine the oven-dry weight of the specimens.

4.7 The data collected will permit calculations of volume and moisture changes of specimens No. 1 and 2 and the soil-cement losses of specimens No. 3 and 4 after the prescribed 12 cycles of test.

5. CALCULATIONS

5.1 The volume and moisture changes and the soil-cement losses of the specimens should be calculated as in **5.1.1** and **5.1.4**.

5.1.1 For specimens No. 1 and 2 the difference between the volumes of specimens at the time of moulding and subsequent volumes as a percentage of the original volume should be calculated.

5.1.2 The moisture content of specimens No. 1 and 2 at the time of moulding and subsequent moisture contents should be calculated as a percentage of the original oven-dry weight of the specimen.

5.1.3 The oven-dry weight of specimens No. 3 and 4 as obtained in **4.6** shall be corrected for water that has reacted with the cement and

soil during the test and is retained in the specimen at 110°C, as follows:

$$\text{Corrected oven-dry weight} = \frac{W_d}{(w + 100)} \times 100$$

where

W_d = oven-dry weight after drying at 110°C, and

w = percentage of water retained in specimen.

The percentage of water retained in the specimens No. 3 and 4 after drying at 110°C for use in the above formula may be assumed to be equal to the average percentage of water retained in specimens No. 1 and 2.

5.1.4 The soil cement loss of specimens No. 3 and 4 shall be calculated as a percentage of the original oven-dry weight of the specimen as follows:

$$\text{Soil cement loss, percent} = \frac{A}{B} \times 100$$

where

A = original calculated oven-dry weight minus final corrected oven-dry weight, and

B = original calculated oven-dry weight.

6. REPORT

6.1 The report should include the following:

a) The designed optimum moisture and maximum density of the moulded specimens.

b) The moisture content and density obtained in moulded specimens (*see* Note).

NOTE — Good laboratory practice permits the following tolerances between design values and those obtained in the moulded specimen:

Moisture content	± 1 percentage point
Density	± 0·05 g/cm³

c) The designed cement content, in percent, of the moulded specimens.

d) The cement content, in percent, obtained in moulded specimens.

e) The maximum volume change, in percent, and maximum moisture content during test of specimens No. 1 and 2.

f) The soil-cement loss, in percent, of specimens No. 3 and 4.

SECTION 2 FREEZING AND THAWING TEST

7. SCOPE

7.1 Section 2 of this standard (Part IV) covers the procedure for determining the soil-cement losses, moisture changes and volume changes (swell and shrinkage) produced by repeated freezing and thawing of hardened soil-cement specimens.

8. APPARATUS

8.1 The apparatus required is the same as described in **2** except the water-bath described in **2.8.** In addition the equipment described in **8.2** and **8.3** are also required.

8.2 Freezing Cabinet — capable of maintaining temperature of — 23°C or lower.

8.3 Absorptive Pads — 5 mm thick felt pads, blotters or similar absorptive material for placing between specimens and specimen carriers.

9. PREPARATION OF SOIL SAMPLE AND SPECIMENS FOR TEST

9.1 The soil sample and specimens shall be prepared in accordance with the procedure laid down in **3.**

10. PROCEDURE FOR THE FREEZING AND THAWING TEST

10.1 At the end of the storage in the moist room, water saturated felts about 5 mm thick, blotters or similar absorptive material shall be placed between the specimens and the carriers. The assembly shall be placed in a freezing cabinet having a constant temperature not warmer than —23°C for 24 h and removed. The No. 1 and 2 specimens shall be weighed and measured.

10.2 The assembly should then be placed in the moist chamber or suitably covered container having a temperature of 25° to 30°C and a relative humidity of 100 percent for 23 h and removed. Free potable water shall be made available to the absorbent pads under the specimens to permit the specimens to absorb water by capillary action during the thawing period. The No. 1 and 2 specimens shall be measured and weighed.

10.3 Specimens No. 3 and 4 shall be given two firm strokes on all areas with the wire-scratch brush. The brush shall be held 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.

The strokes shall be applied to the full height and width of the specimen with a firm stroke corresponding to approximately 1·4 kgf (*see* Note under **4.3**). Eighteen to twenty vertical brush strokes are required to cover the sides of the specimen twice and four strokes are required on each end.

10.4 After being brushed, the specimens shall be turned over end for end before they are placed on the water saturated pads.

10.5 The procedures described in **10.1** to **10.4** constitute one cycle (48 h) of freezing and thawing. The specimens shall be placed in the freezing cabinet and the procedure continued for 12 cycle.

NOTE — Weight determinations of specimens No. 3 and 4 before and after brushing are usually made at the end of each cycle when conducting research and making special investigations. Some Specimens made of silty and clayey soils tend to scale on sides and ends particularly after about the sixth cycle of test. This scale shall be removed with a sharp pointed instrument since the regular brushing may not be effective.

10.6 The No. 1 and 2 specimens may be discontinued prior to 12 cycles should the measurements become inaccurate due to soil-cement loss of the specimen.

10.7 After 12 cycles of test, the specimens shall be dried to constant weight at 110°C and weighed to determine the oven-dry weight of the specimens.

10.8 The data collected will permit calculations of volume and moisture changes of specimens No. 1 and 2 and the soil-cement losses of specimens No. 3 and 4 after the prescribed 12 cycles of test.

11. CALCULATIONS

11.1 The volume and moisture changes and the soil-cement losses of the specimens should be calculated as given in **5**.

12. REPORT

12.1 The report should include the details given in **6**.

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	DEFINITION
Force	newton	N	1 N = 1 $kg.m/s^2$
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
Electromotive force	volt	V	1 V = 1 W/A
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**

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PART 4 WETTING AND DRYING, AND FREEZING AND THAWING TESTS FOR COMPACTED SOIL-CEMENT MIXTURES

Alterations

(*Page 4, clauses 2.1 and 2.2*) - Substitute the following for the existing clauses:

'2.1 Cylindrical Metal Mould - shall conform to IS:10074-1982*.

2.2 Metal Rammer - shall conform to IS:9198-1979†'

(*Page 4, clause 2.11, line 2*) - Substitute 'IS:460(Part 1)-1978‡' *for* 'IS:460-1962†'.

(*Page 4, foot-notes with '*' and '†' marks*) - Substitute the following for the existing foot-notes:

'*Specification for compaction mould assembly for light and heavy compaction test for soils.

†Specification for compaction rammer for soil testing.

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

(*Page 5, clause 3.1.3, line 2*) - Substitute 'IS:269-1976‡ or IS:455-1976‡' *for* 'IS:269-1967‡ or IS:455-1967‡'.

(*Page 5, foot-notes with* '‡' *and* '§' *marks*) - Substitute the following for the existing foot-notes:

'‡Specification for ordinary and low heat Portland cement (*third revision*).

§Specification for Portland slag cement (*third revision*).'

Reprography Unit, ISI, New Delhi, India