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Indian Standard

METHODS OF TEST FOR STABILIZED SOILS

PART VIII DETERMINATION OF LIME CONTENT OF LIME STABILIZED SOILS

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Indian Standard
METHODS OF TEST FOR STABILIZED SOILS
PART VIII DETERMINATION OF LIME CONTENT OF LIME STABILIZED SOILS

0. FOREWORD

0.1 This Indian Standard (Part VIII) was adopted by the Indian Standards Institution on 10 June 1969, 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 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, lime, 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, both in the laboratory and the field certain standard methods of test are required and these are being published in parts. This part [IS:4332 (Part VIII)-1969] lays down the method for the determination of lime content of lime stabilized soils.

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 the field in this country. This has been met by basing the standard on BS 1924:1967 'Methods of test for stabilized soils' issued by the British Standards Institution.

0.4 In reporting the results 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*.

1. SCOPE

1.1 This standard (Part VIII) covers the determination of the proportion by weight of the lime present in a lime stabilized soil. It is done by comparing the combined calcium and magnesium contents of the stabilized

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

soil with those of the natural soil and lime and it is essential that samples of these should all be available. The method is not applicable to soils containing a large or variable amount of calcium or magnesium salts or to soils which also contain cement, and in such cases it may not be possible to determine the lime content by chemical means.

2. DEFINITIONS

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

Grading	*Definition*
Fine grained soil or soil-lime mixture	90 percent of the soil or soil-lime mixture should pass a 2-mm IS Sieve
Medium grained soil or soil-lime mixture	90 percent of the soil or soil-lime mixture should pass a 20-mm IS Sieve
Coarse grained soil or soil-lime mixture	90 percent of the soil or soil-lime mixture should pass a 40-mm IS Sieve

3. APPARATUS

3.1 Thermostatically-Controlled Drying Oven — capable of maintaining a temperature of 105-110°C.

3.2 Balance — readable and accurate to 1 g.

3.3 Balance — readable and accurate to 0·001 g.

3.4 Desiccator — containing anhydrous silica gel.

3.5 Sieves — 40-mm, 20-mm, 12·5-mm, 6·3-mm, 2-mm IS Sieves and 425-micron IS Sieve conforming to the requirements of IS:460-1962*.

3.6 Volumetric Flasks — four of 500 ml capacity.

3.7 Graduated Measuring Cylinders — one 10-ml, one 25-ml, one 100-ml and one 1 000-ml.

3.8 Sample Dividers — of the multiple slot type (riffle box) having the following widths of openings:

Soil Type	*Width of Opening*
a) For fine-grained soils	6 mm
b) For medium-grained soils	6 mm and 2·5 cm
c) For coarse-grained soils	6 mm and 5 cm

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*Specification for test sieves (*revised*).

3.9 Pulverizer — preferably mechanical.

3.10 Glass Weighing Bottles — three, approximately 5 cm high and 2·5 cm in diameter, fitted with ground glass stoppers.

3.11 Plastics Wash Bottle — containing distilled water.

3.12 Glass Funnels — three, approximately 7·5 cm diameter.

3.13 Burettes — one, 50 ml; and two, 25 ml.

3.14 Pipettes — three, 25 ml; and two, 50 ml.

3.15 Conical Flasks — three, of 250 ml capacity.

3.16 Volumetric Flasks — six, of 250 ml capacity.

3.17 Electric Bench Lamp

3.18 Round or Flat-Bottomed Flasks — two, fitted with reflux condensers, as follows:

a) For medium-grained soils 500 ml capacity.

b) For coarse-grained soils 1 000 ml capacity.

3.19 Electric Hotplate or Bunsen Burner

4. REAGENTS

NOTE — The reagents shall be of analytical quality.

4.1 EDTA — Dissolve 4 g of disodium dihydrogen ethylenediamine tetraacetate (also known as EDTA, versene, sequestric acid and complexone) in one litre of distilled water. The exact strength of this reagent need not be known since the calculations are on a relative basis.

4.2 Buffer Solution — Dissolve 33·7 g of ammonium chloride in 285 ml of ammonia solution (sp gr 0·880) and dilute to 500 ml.

4.3 Dilute Ammonia Solution (1:4) — Dilute 100 ml of ammonia solution (sp gr 0·880) to 500 ml with distilled water.

4.4 Hydrochloric Acid, 50 Percent Solution — Add 250 ml of concentrated hydrochloric acid to 250 ml of distilled water. (Larger volumes will be required in the case of medium and coarse grained soils and soil-lime samples.)

4.5 Indicator — Dissolve 0·1 g of metalphthalein (*o*-cresolphthalein dimethylimino diacetic acid), 0·005 g of methyl red and 0·05 g of naphthol green in a few drops of the ammonia solution and dilute to 100 ml with distilled water. This solution should be freshly prepared at least once a week (eriochrome blue black or eriochrome black T prepared by dissolving 0·5 g in 100 ml of methanol may also be used but the end-point is less distinct).

4.6 Ammonium Chloride, 20 Percent Solution — Dissolve 100 g of ammonium chloride in water and dilute to 500 ml; (larger volumes will be required in the case of medium and coarse-grained soil and soil-lime samples).

4.7 Red Litmus Papers

5. PREPARATION OF SAMPLE OF THE SOIL-LIME MIXTURE AND NATURAL SOIL

5.1 The bulk sample may, if desired, be roughly broken up and, in order to facilitate further breaking, shall be dried either in air or in the oven at 105-110°C and cooled. It shall then be broken down by crushing or other similar means until the whole sample passes the appropriate sieve. The fine-grained materials shall pass a 2-mm IS Sieve, the medium-grained materials shall pass a 6·3-mm IS Sieve and the coarse-grained materials shall pass a 12·5-mm IS Sieve. Throughout these and all subsequent operations it is essential that there is no loss of fines of any material.

5.2 The material treated as in **5.1** shall then be divided by successive riffling on the appropriate sample divider to produce a representative sample of the weight indicated below:

Soil Type	*Weight of Soil Sample to be taken*
a) Fine-grained soils	250-300
b) Medium-grained soils	2 500-3 000
c) Coarse-grained soils	6 000-6 500

5.2.1 Throughout this and any subsequent operations, the material available for any division shall be thoroughly mixed and all precautions taken to avoid segregation during riffling.

5.3 The representative sample obtained as in **5.2** shall then be ovendried at 105-110°C for not less than 16 hours, and cooled, preferably in a desiccator. The ovendried material shall be pulverized, using a mechanical pulverizer or any other suitable means, so that the whole of the sample passes 425-micron IS Sieve. The ovendried pulverized material shall then be sub-divided by riffling on a sample divider having a width of opening of 6 mm until a sample weighing approximately 5 g for fine-grained soils, 25 g for medium-grained soils and 50 g for coarse-grained soils is obtained (in the case of the medium-and coarse-grained soil samples, riffling may more conveniently be done on the larger sample dividers but when the size of sample has been reduced to 250 g the sample divider having a width of opening of 6 mm shall be used). This sample shall be placed in the glass weighing bottle and dried at 105-110°C. The period required for drying may vary with the type of soil and size of sample. The sample shall be deemed to be dry when the differences in successive weighings of the cooled sample at intervals of 4 hours do not exceed 0·1 percent of the original weight of the sample. For practical purposes 16-24 hours is usually sufficient.

6. ANALYTICAL PROCEDURE

6.1 Analysis of the Prepared Soil and Soil-lime Samples

6.1.1 For soils of low sesquioxide content, where effects of co-precipitation of calcium can be ignored (*see* Note), the procedure given in **6.1.1.1**(a) to (d) shall be followed.

NOTE — Two procedures are given for extracting the lime from the stabilized soil. Hydrochloric acid is the more effective extractant but with soils of high sesquioxide content it also removes the sesquioxides which may cause interference with the determination of the calcium. Ammonium chloride solution extracts the lime but does not remove the sesquioxide and is, therefore, to be preferred with soils of high sesquioxide content, even though it may take 15 minutes or longer to extract the lime from the sample compared with the 2-3 minutes that hydrochloric acid takes. In general, ammonium chloride should be used in cases where a soil containing no calcium and a high proportion of iron or aluminium has been stabilized with a low proportion of lime.

6.1.1.1 *Preparation of the acid extracts*

a) *For fine-grained soils and soil-lime mixtures* — The weighing bottle containing 5 g sample of dried soil or soil-lime shall be removed from the oven, cooled in the desiccator and weighed to the nearest 0·001 g. The sample shall then be transferred to a 250-ml conical beaker, the weighing bottle re-weighed and the weight of the soil or soil-lime sample (W) calculated by difference. Fifty millilitre of 50 percent hydrochloric acid shall than be added and the beaker covered with a cover glass and the contents brought to the boil. After boiling for one minute the beaker shall be removed and allowed to cool. The contents of the beaker shall then be quantitatively transferred through a glass funnel to a 250-ml volumetric flask, care being taken that no solid material remains in the beaker, and the volume adjusted to 250 ml with distilled water. The flask shall be shaken and the suspension shall then be allowed to settle for a few minutes. A 50 ml aliquot shall be removed with a pipette and transferred to another 250-ml volumetric flask.

b) *For medium-grained soils and soil-lime mixtures* — The weighing bottle containing the 25 g sample of dried soil or soil-lime shall be removed from the oven, cooled in the desiccator and weighed to the nearest 0·001 g. The sample shall then be transferred to a dry, 500-ml, round-bottomed or flat-bottomed flask, the weighing bottle re-weighed and the weight of soil or soil-lime (W) calculated by difference. Exactly 250 ml of 50 percent hydrochloric acid shall be added from a volumetric flask, to the flask which shall be fitted with a tight-fitting reflux condenser, and the solution boiled for about five minutes. After the contents of the flask have ceased to boil, exactly 250 ml of distilled water shall be added and the contents of the flask mixed by shaking. 25 ml of this solution after cooling shall be removed with a pipette and transferred to a 250-ml volumetric flask.

c) *For coarse-grained soils and soil-lime mixtures* — The procedure given in (b) shall be followed except that a 1 000-ml flask containing 500 ml of 50 percent hydrochloric acid shall be used and this solution after cooling shall be removed with a pipette and transferred to a 250-ml volumetric flask.

d) *For the lime* — About 1 g of lime shall be placed in a weighing bottle and dried at 105-110°C. The sample shall be deemed to be dry when the differences in successive weighings of the cooled sample at intervals of 4 hours do not exceed 0·1 percent of the original weight of the sample. The procedure given in **6.1.1.1** (a) shall be followed, except that 10 ml of 50 percent hydrochloric acid and 25 ml of distilled water shall be used for the digestion and a 25 ml aliquot portion of the 250 ml solution retained for analysis.

6.1.2 For soils of high sesquioxide content where co-precipitation of calcium occurs, the procedure given in **6.1.1.1** (a) to (d) shall be followed except that a 20 percent solution of ammonium chloride shall be used in the place of 50 percent hydrochloric acid as the extractant. The soil-lime mixtures, the soils and the lime samples shall be boiled with the appropriate quantity of ammonium chloride solution until no further evolution of ammonia occurs. This may be checked by holding a moistened red litmus paper over the mouth of the beaker; the paper will turn blue if ammonia is still being evolved. Care shall be taken during boiling to ensure that the solution is not boiled dry, and if necessary additional water shall be added to prevent this occurring.

6.2 Analysis of the Acid or Ammonium Chloride Extracts — A small piece of red litmus paper shall be dropped into each volumetric flask and dilute ammonia solution shall be added (preferably from a burette) until the litmus changes from red to blue (this may not be necessary if ammonium chloride was used as the extractant). After the addition of the ammonia solution the volume of the suspension shall be adjusted to exactly 250 ml with distilled water and the contents of the flask thoroughly mixed by shaking. The flask shall then be set aside until the precipitate has settled to the bottom. When the precipitate has settled, 50 ml of the clear supernatant liquid shall be removed by means of a pipette, and placed in a 250-ml conical flask or beaker. Add 2 ml of the buffer solution and 3 or 4 drops of the indicator. The EDTA solution shall then be added from the 50 ml burette until the colour changes from pale purple to colourless and then to pale green (metalphthalein indicator) or from pink to blue (eriochrome indicator) (*see* Note). The volume of EDTA required shall be noted to the nearest 0·05 ml (V).

NOTE — The colour change of the metalphthalein indicator is from purple to grey or colourless and then to green. The end point is best observed in artificial light. It is advisable to carry out practice titrations in order to obtain experience of the colour change at the end-point. If eriochrome is used the colour change is from pink to blue; the actual end-point occurs when all traces of pink colour have disappeared when the solution is viewed in artificial light.

7. CALCULATIONS

7.1 The lime content shall be calculated as given in **7.1.1**.

7.1.1 The volume of EDTA solution which would be required to neutralize the calcium and magnesium in 1 g of soil (X ml), 1 g of the uncarbonated soil-lime (Y ml) and 1 g of lime (Z ml) shall be caculated from the following formula:

a) For fine-grained soil or soil-lime samples,

$$X \text{ or } Y = \frac{25\,V}{W}\text{ ml}$$

where

V = volume of EDTA solution required in titration (ml), and
W = weight of prepared oven-dry soil or soil-lime sample (g).

b) For medium or coarse-grained soil or soil-lime samples,

$$X \text{ or } Y = \frac{100\,V}{W}\text{ ml}$$

c) For lime samples,

$$Z = \frac{50\,V}{W}\text{ ml}$$

where

W = weight of prepared oven-dry lime sample (g).

d) The lime content of an uncarbonated soil-lime sample (C_1) (*see* Note) expressed as a percentage of the weight of soil lime shall be calculated from the formula:

$$C_1 = \frac{100\,(Y - X)}{Z - X}\text{ percent}$$

e) The lime content of the uncarbonated soil-lime sample (C_2) (*see* Note) expressed as a percentage of the dry soil weight shall be calculated from the formula:

$$C_2 = \frac{100\,C_1}{100 - C_1} \text{ percent}$$

NOTE — A soil-lime mixture may, on exposure to air, increase in weight due to the carbonation of the lime present. To allow for this weight increase in calculating the lime content of a mixture which has carbonated, it is necessary to know the calcium and carbonate contents of the natural soil, the soil-lime mixture and the lime. In addition, if appreciable amounts of magnesium are present in either the soil or the lime, it is also necessary to know the magnesium contents of the natural soil, the soil-lime mixture and the lime. Since, however, the error involved in ignoring the weight increase due to the carbonation is in most cases quite small, the lime content for carbonated soil-lime mixtures is usually calculated in the manner described in **7.1** for uncarbonated samples.

7.2 Reporting of Results — The results (C_1 or C_2) shall be reported to the nearest 0·2 percent.

7.2.1 The observations and results of the analysis shall be recorded suitably. A recommended proforma for such a record is given in Appendix A.

APPENDIX A

(*Clause* 7.2.1)

DETERMINATION OF THE LIME CONTENT OF LIME STABILIZED SOIL

Name of job
Sample reference
Location

Operator
Date

Sample No.			
Description of sample			
Weighing bottle number			
Weight of weighing bottle + oven-dry sample in g			
Weight of weighing bottle in g			
Weight of oven-dry sample (W) in g			
Initial burette reading in ml			
Final burette reading in ml			
Volume of EDTA solution titrated (V) in ml			
Soil Sample $\left(X = \frac{25\,V}{W}\right)$ or $\left(X = \frac{100\,V}{W}\right)$ ml (fine-grained soils) (medium- and coarse-grained soils)			
Soil lime sample $\left(Y = \frac{25\,V}{W}\right)$ or $\left(Y = \frac{100\,V}{W}\right)$ ml (fine-grained soils) (medium- and coarse-grained soils)			
Lime sample $\left(Z = \frac{50\,V}{W}\right)$ ml			

Lime content (percentage of the weight of soil-lime) $\left[C_1 = \frac{100\ (Y - X)}{Z - X}\right]$ percentage			
Lime content (percentage of the weight of dry soil) $\left[C_2 = \frac{100\ C_1}{100 - C_1}\right]$ percentage			

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

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Alterations

(*Page 4, clause 3.5, line 2*) - Substitute 'IS:460(Part I)-1978*' *for* 'IS:460-1962*'.

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

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

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