Appendices.

APPENDIX No. 1

Table showing Recommended mortar mixes for different items of works

S. No.	Type of work	Recommended proportions: Cement	Lime	Sand	Surkhi	Class of lime (I.S. Classification)	Remarks
1.	Masonry work	1	—	2	—	—	Precise mix depending upon loading and type of masonry work.
		1	—	3	—	—	
		1	—	4	—	—	
		1	—	5	—	—	
		1	—	6	—	—	
		1	—	7	—	—	
		—	1	—	2	A,B,C,	
		—	1	2	—	A	
		1	1	6	—	B or C	
		1	2	9	—	B, C,	
		1	3	12	—	B,C,	
2.	Plasters ..	1	—	2	—	—	For external work or internally where a high finish is desired, flooring, damp proofing or water proofing
		1	—	3	—	—	
		1	—	4	—	—	For underside of ceilings and also for external work or internal work where high class finish is desired.
		1	—	5	—	—	Fo internal work.
		1	—	6	—	—	
		1	1	6	—	B, C.	For external work or internally where a high finish is desired
		1	2	9	—	B, C	
		1	3	12	—	B, C.	
		—	1	2	—	A	For internal work.
		—	1	3	—	A	For internal and external work.
		—	1	—	2	A,B,C,	
		—	2	—	3	A,B,C,	
3.	Pointing ..	1	—	2	—	—	For external work.
		1	—	3	—	—	
		—	2	—	3	A,B,C,	

Note—(1) According to Indian Standards Institution Classification, lime have been classified as follow:—

Class 'A'—Eminently hydraulic limes.
Class 'B' —Semi-hydraulic limes.
Class 'C'—Non-hydraulic or fat limes.

(2) Class 'A' & 'B' limes set in presence of water, while class 'C' limes set slowly when exposed to air. Class 'C' limes shall, therefore, be used for surface work like white washing etc. A mortar containing class 'C' lime acquires hydraulic properties, if cement or a pozzelana like surkhi is added to it and the mortar can then be used like other mortars having class 'A' or 'B' limes.

(3) For lime-cement-sand mortars, class 'A' limes have generally been found unsuitable.

APPENDIX NO. II

STANDARD SOIL CLASSIFICATION SYSTEM

General.

1. All soil and earth materials should be identified and classified according to system and procedure described herein.

Terminology.

2. For the purpose of this standard, the following definitions shall apply;—

Clay.—An aggregate of microscopic and sub-microscopic particles derived from the chemical decomposition and disintegration of rock constituents. It is plastic within a moderate to wide range of water content.

Silt.—A fine grained soil with little or no plasticity. If shaken in the palm of the hand, a part of saturated inorganic silt expels enough water to make its surface appear glossy. If the pat is pressed or squeezed between the fingers, its surface again becomes dull.

Sand and Gravel:—Cohesionless aggregates of rounded, sub-rounded, angular, sub-angular, flaky or flot fragments of more or less unaltered rocks of minerals. Particles from 0.06 mm. up to 2 mm. are referred to as sand, and those with a size greater than 2 mm. to 60 mm. as gravel.

Principal Particle Sizes.

3. The principlal particle size scale for the purpose for this standard shall be as follows:—

		Greater Than	But less than or equal to
		mm.	mm.
Gravel	..	2	60
Sand, Coarse	..	0·6	2
Sand, Medium	..	0·2	0·6
Sand, Fine	..	0·06	0·02
Silt, Coarse	..	0·02	0·06
Silt, Medium	..	0·006	0·02
Silt, Fine	..	0·002	0·006
Clay	..	—	0·002

4. The following standard letter symbols shall be used to identify various soil in making field notes, sub surface profiles and maps, in addition to other diagramatic and detailed identifications:— Symbols for Soil Classification.

Type of soil	Description	Letter Symbol
Coarse-grained soils	Gravel	G
	Sand	S
Fine grained soils	Silt	M
	Clay	C
	Organic silt and clays	O
Peat	Peat	Pt.
Applicable to coarse grained soils	Well graded with little or no fines	W
	Well graded with clay binder	B
	Poorly graded with little or no fines	P
Applicable to fine grained soils	Low compressibility	L
	Medium comprissibility	I
	High compressibility	H

These symbols can be combined to represent the various soil groups, such as ML for silt of low compressibility; OH for organic clay, highly compressibility ; GP for gravel, poorly graded.

5. Soils can be divided into the following more prominent groups or classes:— Soil Groups.

Division	and Sub-Divison	Standard Wares and Soils Group Description
1	2	3
Coarse grained soils (more than half of the total material is larger than IS Sieve 8 or B.S. Sieve 200).	Gravelly soils (more than half of the coarse grains are larger than IS Sieve 480 or B. S. Sieve 3/16 in.)	Well graded gravels or gravel sand mixtures, with calay binder.
		Well graded gravels or gravel sand mixtures, little or no fines.
		Clayey gravels poorly graded or gravel sand clay mixtures.

Division	and Sub-Division	Standard Wares and Soils Group Description
1	2	3
		Silty gravel or poorly graded gravel-sand-silt mixtures.
		Poorly graded gravels or grave l and mixtures, little or no fines.
	Sandy soils (more than half of the coarse grains are smaller than IS Sieve 480 or B. S. Sieve 3/16 in.)	Well graded sands or gravelly sand, with clay binder.
		Well graded sands or gravelly sands, little or no fines.
		Clayey sands poorly graded or sand clay mixtures.
		Poorly graded sands or gravelly sands, little or no fines.
Fine grained inorganic soils (more than half of the total)	Inorganic silts and clays low to medium compressibility	Silt and very fine sand, rock flour, silty to clayey fine sands with low plasticity.
Material is smaller than IS Sieve 8 or BS Sieve 200.		Clays or medium plasticit
	Inorganic silts and clays with high compressibility	Very compressible micaceous or distomaceous fine silty soils, silts.
Silt and clay with high organic content.	Silt, organic	Clay of high plasticity. Silt and silt clays of low plasticity.
	Clays organic. Clays, organic.	Clays of medium to high plasticity.
Peat	Peat	Peat and other highly organic swamp soils.

Note.—Indian standard Sieve 8 (or British Standard sieve 200) has mesh size of about the smallest parties visible to the naked eye.

Classification Procedure.

5. Classification of a soil sample should be done in the following steps:—

(*a*) Determine the soil group or class by visual examination and by preliminary indentification tests.

(*b*) Describe the soil in detail giving typical characteristics, peculiarities, properties of undisturbed samples, etc.

(*c*) Border line cases should be described as such.

(*d*) Final classification of soil, if necessary should be arrived at by thorough laboratory tests for the required physical properties.

ANNEXURE

APPENDIX NO. III

FIELD IDENTIFICATION TESTS FOR SOILS

1. **Wet and Manipulated Strength Tests:**—Take a small quantity of the soil specimen in hand moisten it if needed, and work it with fingers and feel it. If the soil is clayey, a soapy touch is felt; if the soil is sandy, a feeling of roughness is experienced and in the case of silty soils, when the soil is squeezed in between fingers, the moisture comes out. Also clay sticks to the fingers and dries slowly, but silt dries fairly quickly and can be dusted off the fingers leaving only a stain. The test helps to distinguish the predominant soil characteristic, that is, whether it is clayey, sandy or silty.

2. **Thread Test:**—Take a specimen of soil about one centimetre cube in size, moisten, if needed, and roll it between the palms of the hands or on a flat, smooth surface into a thread of about 3 mm. in diameter. If crumbling does not occur, fold the thread, knead and re-roll as before. Repeat the process until the moisture content of the soil has been reduced, by drying during manipulation, to the plastic limit, which is indicated by crumbling which occurs as the soil is being rolled. The characteristic of the thread as it approaches the plastic limit affords the means of identification of the soil.

3. **Dilatancy Test:**—After removing particles retaining on IS Sieve 40, prepare a pat of moist soil of a size of 2 cm., cube. Add enough water, if necessary, to make the soil soft but not sticky. Place the pat in the open palm of one hand and shake horizontaliy striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and become glossy. When the sample is squeezed between the fingers the water and loss disappear from he surface, the pat stiffens and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil. Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

4. **Dry Strength Test.**—After removing particles retaining on IS Sieve 40, mould a pat of soil to the consistency of putty adding water, if necessary. Allow the pat to dry completely by oven, sun or air-drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

APPENDIX NO. IV

TESTING OF BRICKS

The samples of bricks shall be taken, so that they form a fairly good representative of the entire number of bricks, which are required to be tested. A sample of 50 bricks shall be taken from every consignment of 50,000 bricks or part thereof. The samples can be taken from either of the two methods:—

(*a*) **Sampling bricks in motion.**—In this method, samples can be taken when the bricks are in motion, i.e. while they are being loaded or unloaded, effort being made to collect the samples at regular intervals so as to get a representative sample of the whole quantity.

(*b*) **Sampling bricks from a stack.**—In this method, the bricks are taken out at random from a stack of bricks. The number of bricks required shall be taken from across the top of the stack, the sides accessible and from the interior of the stack by opening trenches from the top.

The sampels taken by either of the two methods shall be stored in a dry place until these are required for the tests. Whenever, tests are to to be carried out, bricks shall be taken at random from the sample.

I. TEST OF DIMENSIONS OF BRICKS

(a) **Metric Bricks:**—Twenty whole bricks shall be selected at random from the sample selected as described above. All blisters, loose particles of clay and small projections shall be removed. They shall then be arranged upon a level surface in contact with each other and in a straight line. The overall length of the assembled bricks shall be measured with a steel tape or other suitable inextensible measure sufficiently long to measure the whole row one stretch. Measurement by repeated application of a short rule or measure shall not be permitted. If for any reason it is found impracticable to measure 20 bricks in one row, the sample may be divided into two rows of 10 bricks, which shall be measured separately to the nearest millimetres. All these dimensions shall be added together.

The dimensions of bricks when tested in accordance with the above procedure shall be within the following limits:—

Length	..	367.0 cm to 393.0 cm.
Width and height	..	174.0 cm. to 186.0 cm.

(*b*) **Non-metric bricks.**—The test will be carried out exactly in the same manner as described for metric bricks but only 16 bricks shall be used. Their dimensions when tested in accordance with above procedure shall be within the following limits:—

Length	..	140 inches to 148 inches
Width	..	68 inches to 72 inches
Height	..	57 inches to 61 inches

II. TEST FOR DETERMINATION OF WATER ABSORPTION OF BRICKS

(*a*) **Laboratory Test.**—The test specimens shall consist of five whole bricks selected at random from the sample of bricks obtained as already described in this appendix.

Apparatus. The apparatus shall consist of a balance sensitive to within 0·1 per cent of the weight of the specimen.

Procedure. The test specimen shall be dried to constant weight in a ventilated oven at 110° to 115°C. If the specimen is known to be relatively dry this may normally be accomplished in 48 hours but if the specimen is wet, several additional hours may be required to attain constant weight. The specimen shall then be cooled approximately to room temperature and weighed. In a ventilated room, bricks properly separated require four hours for cooling unless an electric fan passes air over them continuously, in which case two hours may suffice. Specimens noticeably warm to the touch shall not be used for the absorption test. The dry specimens shall be completely immersed without preliminary partial immersion, in clean water at 15.5° to 30°C for 24 hours. Each specimen shall then be removed the surface water wiped off with a damp cloth and the specimen weighed. Weighing any one specimen shall be completed within three minutes after removing the specimen from the water.

Evaluations and report of test. The percentage of water absorption by weight shall be calculated as:—

$$\text{Water absorption, percentage by weight} = \frac{W_2 - W_1}{W_1} \times 100$$

W^1 =weight of dry specimen, and
W^2=weight after soaking in water

The average value of the five specimens shall be taken as the water absorption of the lot.

(*b*) **Field Test.**—The test specimen shall consist of five whole dry bricks and shall be selected at random from the sample obtained as described in the beginning of this appendix.

Apparatus. The apparatus shall consist of a balance sensitive of within 0.2 to 0.3 per cent of the weight of the specimen.

Procedure. The test specimen shall be weighed and shall then be completely immersed in clean water at room temperature and allowed to remain in this state for a period of 24 hours. The specimen shall then be taken out, wiped with a damp cloth and then weighed immediately.

Evaluation. The percentage of water absorption by weight shall be calculated as follows:—

$$\text{Absorption, per cent by weight after 24 hours' water immersion} = \frac{100\ (b-a)}{a}$$

Where

a = Weight of the dry specimen, and

b = Weight of the specimen after 24 hours' immersion in cold water

III. TEST FOR DETERMINATION OF EFFLORESCENCE OF BRICKS

(*a*) **Laboratory Test.**—Not less than five dry bricks shall be selected at random from the sample of bricks obtained as already described.

Procedure. Each brick shall be placed on end in a shallow flat bottom dish containing distilled water, the depth of immersion of the brick being not less than 2.5 cm. The whole arrangement shall be allowed to stand in a warm (e.g. 18° to 30° C) and well ventilated room until all the water in the dish evaporated. When the water has been absorbed and the bricks appear to be dry, a similar quantity of distilled water shall again be placed in the dishes and the same allowed to evaporate as before. At the end of this period the bricks shall be examined for efflorescence.

Report of test results. The liability to efflorescence shall be reported as 'nil', 'slight', 'moderate', 'heavy', or 'serious', in accordance with the following definitions:—

(*a*) nil=when there is no perceptible deposit of efflorescence.

(*b*) slight=when not more than 10 per cent of area of the brick is covered with a thin deposit of salts.

(*c*) moderate—when there is heavier deposit that under 'slight' and covering upto 50 per cent of the area of the brick surface but unaccompanied by powdering of flaking of the surface.

(*d*) *heavy*=when there is a heavy deposit of salts covering 50 per cent or more of the brick surface but unaccompanied by powdering or flaking of the surface , and

(*e*) *serious*—when there is a heavy deposit of salts accompanied by powdering and/or flaking of the surfaces and tending to increase with repeated wettings of the specimen.

(*b*) **Field Test for Efflorescence.**—Five bricks shall be selected at random from the sample of bricks obtained as already described.

Each brick shall be placed on end in a shallow dish containing clean potable water. The quantity of water in the dish shall be such that the brick is immersed to a depth of not less than 2.5 cm, (1 inch). The brick shall be allowed to stand in this position for a few days under atmospheric conditions and room temperature until all the water in the dish is evaporated. When the water has been absorbed and the bricks appear to be dry, a similar quantity of clean potable water shall be placed in the dishes and the same allowed to evaporate as before. At the end of this period, the bricks shall be examined for efflorescene. **Pocedure.**

The liablitiy to efflorescence be reported as nil, slight, moderate, heavy or serious in accordance with the definition given above. **Report.**

IV. TEST FOR DETERMINATION OF COMPRESSIVE STRENGTH OF BRICKS

Five whole bricks shall be selected at random from the sample of bricks obtained as described above.

The bricks shall be immersed in water at 25° to 29°C for 24 hours. They shall then be removed and allowed to drain at room temperature for about five minutes and wiped free from surplus moisture. Their frogs shall be filled with mortar composed of one part Portland cement and one and a half parts clean, coarse sand graded to 0.3 cm. (1/8 inch) and down. The bricks shall then be stored under damp sacks for 24 hours. After the expiry of this period, they shall be immersed in water for seven days. **Procedure.**

At the end of seven days, the samples of bricks shall be taken out, wiped dry and placed with the flat surfaces horizontal and the mortar filled face upwards between 2 three-plywood sheets each approximately 0·3 cm. (1/8 inch) thick and a carefully centred between the plates of the compression testing machine. The compression plate of the testing machine shall have a ball-seating in the form of a portion of a sphere, the centre of which coincides with the centre of the face the plate. The shall be applied axially at the uniform rate of approximately 140 kg. per sq. cm. per minute until failure occurs. **Procedure.**

The maximum load at failure divided by the area of bricks shall be taken as the compressive strength.

Evaluation and report of test.

The arithmetic mean of the compressive strength of the five bricks tested shall be taken as the compressive strength of the lot.

The compressive strength of the bricks shall be expressed in kg. per sq. cm.

APPENDIX No. V

Table of Physical Requirement of Building lime

Serial No.	Characteristic	Requirements for Class A	Class B		Class C	
			Quicklime	Hydrated lime	Quicklime	Hydrated lime
(i)	Fineness	Shall leave no residue on IS Sieve 240, not more than 5 per cent on IS Sieve 85 and the fractions after passing through IS Sieve 85 shall leave not more than 10 per cent on IS Sieve 30	— ..	Shall leave no residue on IS Sieve 240, not more than 5 per cent on IS Sieve 85 and the fraction passing through IS Sieve 85 shall leave not more than 10 per cent on IS Sieve 30.	—	Shall leave no residue on IS Sieve 85, not more than 5 per cent on IS Sieve 30 and the fraction passing through IS Sieve 30 shall leave not more than 10 per cent on IS Sieve 20.
(ii)	Setting Time	Initial set shall take place in not less than 2 hours and final set within 48 hours.	—	—	—	—
(iii)	Workability	—	—	—	Shall require not less than 12 bumps to attain an average spread of 19 cm. from an initial spread of 11 cm on the flow table.	Shall require not less than 10 bumps to attain an average spread of 19 cm. from an initial spread of 11 cm. on the flow table.
(iv)	Soundness	The Le Chatelier moulds shall not exhibit more than 10 mm. expansion.	—	As in the case of Class A lime.	—	—
(v)	Compressive strength, min.	17.5 kg. per sq. cm. (250 lb. per sq. in.) after 14 days and 28.0 kg. per sq. cm. (400 lb. per sq. in). after 28 days	— —	In the case of semi-hydraulic lime 12.5 kg. per sq. cm. (175 lb. sq. in) after 14 days and 17.5 kg. per sq. cm. (250 lb. per sq. in.) at 28 days. The strength at 28 days shall, however, show an increase over that at 14 days.		

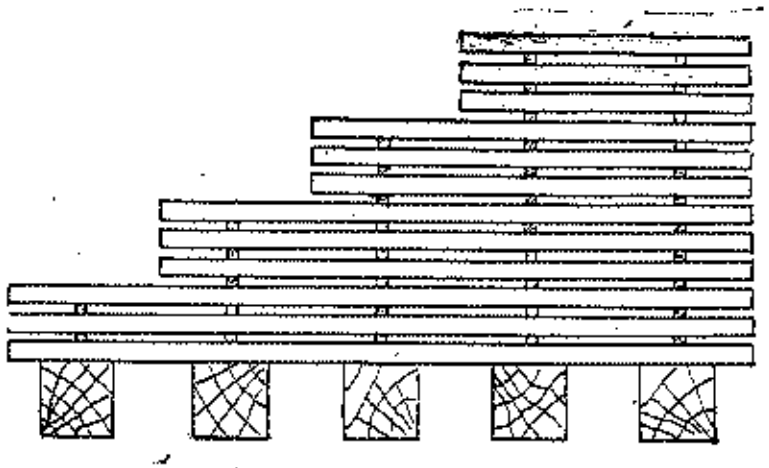
Serial No.	Characteristic	Requirements for				
		Class A	Class B		Class C	
			Quicklime	Hydrated lime	Quicklime	Hydrated lime
(vi)	Tranverse Strength	Modulus of repture not less than 10.5 kg. per sq. cm. (150 lb. per sq. in.) at 28 days.	—	Modulus of rupture not less than 7.0 kg. per sq. cm. (100 lb. per sq.in.) at 28 days.	—	—
(vii)	Volume Yields	—	—	—	1.7 ml. per kg.	
(viii)	Popping and pitting	—	—	—	—	Shall not exhibit any disintegration, popping or pitting on the surface.

APPENDIX NO. VI

STORING OF TIMBER

The recommended practice for storing timber as given in Appendix 'A' of IS 883—1957 is reporoduced below :—

A—1. All timber shall be piled into stacks upon well treated and even surfaced beams, sleepers or brick pillars so as to be above the ground level by at least 6 inches (18 cm.). The various members shall be stored into lengths and material of equal lengths shall be piled together in layers with wooden battens, called 'crossers' separating one layer from another. The crossers shall be of sound wood, straight and uniform in thickness. In cases where separate crossers are not available, smaller sections of the available structural timber may be employed in their place. In any layer an air space about 1.0 in. (2.5 cm.) shall be provided between layers and the shorter pieces in the top layers but one end of the stack shall be in a true vertical plane. The crossers in the different layers shall be in a vertical alignment. The most suitable width and height of a stack are recommended to be about 6.0 ft. (1.8 m.) and 7.0 ft. (2.1 m.). Distance between adjacent stacks is recommended to be at least 12 in. (30 cm.). A side view of such a stack is shown in the figure below. In case the stacking with the help of battens is not possible, the timber may be close-piled in heaps on raised foundations with the precautions specified above.



TIMBER STACK FIG.

A—2. The stack shall be protected from hot dry winds of direct sun and rain. A sloping roof made of rejected planks may be used to drain off the rain water. Decayed or insect attacked planks should not be used. Heavy weights, such as metal rails or large sections of wood are recommended to be placed on the top of the stack to prevent distortion or warping of the timber in the stack. To prevent end-cracking in the material, the ends of all members shall be coated with thick coat of tar or other suitable material.

APPENDIX No. VII

Physical Requirements and tests of stone metal and Grit for Road work

Serial No.	Nature of Test	Test Values	Remarks
1	Attrition-Los Angeles Rattler-Test	Wear not more than 40%	For details, consult I.R.C. paper No. 117 and Appendix (N) of I.S. 383
2	Water absorption .	0·6 per cent by weight maximum	For details, consult I.R.C. paper No. 117 and I.S. 1124
3	Crushing Aggergate strength crushing test.	Percentage of fines to be less than 40	For details, consult I.R.C. paper No. 117 and Appendix (G) of I.S. 383

APPENDIX NO. VIII

Table of makes and grades of tars and bitumens for road construction for surface dressing and semi-grouting

Serial No.	Make	Type of bitumen/tar	Grade	Brand	Application F°	Temperature C°
1	Burmah Shell	Straight-run	R—90	Mexphalt 80/100	350°—375°	177°—191°
		Cut-back	Special	Shelspra B.S.	300°—340°	149°—171°
		Cut-back	RC—3	Shelmac RC 3	80°—150°	27°—66°
		Emulsion	Rs—1	Colas	Cold	Cold
2	Standard Vacuum Oil Co. ...	Straight-run	R—90	Stanvac Paving Asphalt 80/100	350°—370°	177°—191°
		Cut-back	RC—3	Socofix	Cold	Cold
		Emulsion	RS—1	Stanvac Emulsion No. 3	Cold	Cold
3	Caltex (Indian) Ltd. ..	Straight -run	R—90	No. 96 Paving Cement.	350°	177°
4	Shalimar Tar Products ..	Tar	RT—2	Road Tar No. 3	220°	104°
				FOR GROUTING WORK		
1	Burmah Shell ...	Straight-run	R—35	Mexphalta 30/40	350°—400°	177°—204°
		Cut-back	Special	Shelspra B.S.	300°—340°	149°—171°
		Emulsion	RS—I	Colas	Cold	Cold
2	Standard Vacuum Oil Co. ...	Straight-run	R—35	Stanvac Paving Asphalt 30/40	350°—375°	177°—191°
3	Caltex (Indian) Ltd. ..	Straight-run	R—35	No. 34 Paving Cement	350°	177°
4	Shalimar Tar Products ..	Tar	RT—5	Road Tar Grouting Blend	280°	138°
				FOR PREMIX WORK		
1	Burmah Shell ...	Cut-back	Special	Shelspra B.S.	300°—340°	149°—171°
		Cut-back	Special	Shelmac B.S.	300°—340°	149°—171°

		Cut-back	RC—3	Shelmac RC—3	80°—150°	27°—66°
		Emulsion	MS	Cofasmix	Cold	Cold
2	Standard Vacuum Oil Co. ...	Straight-run	R—35	Stanvac Paving Asphalt 30/40 heated and mixed with Socosal at the rate of 1 ounce per lb. of asphalt (or 6%)	300°—350°	149°—177°
		Cut-back	RC—3	Socofix ..	Cold	Cold
3	Caltex (Indian) Ltd. ...	Straight-run	R—35	No. 34 Paving Cement heated and mixed with cut at the rate of 1 ounce per lb. of bitumen (or 6%)	300°—350°	149°—177°
4	Shalimar Tar Products ...	Tar	RT—3	Road Tar Grade No. 3A	240°	116°
		Tar	RT—4	Road Tar Hivis Grade	270°	132°
				FOR PRIMING		
1	Burmah Shell ...	Cut-back	Special	Shell Primer No. 2	100°	38° (or sun-warmed)
		Cut-back	MC—0	Shelmac MC—0	Cold	Cold
		Cut-back	MC—1	Shelmac MC—1	Cold	Cold
2	Standard Vacuum Oil Co. ...	Cut-back	MC—0	Socofix Primer	Cold	Cold

APPENDIX IX

COMPACTION AND PENETRATION RESISTANCE TEST

1. **General.**—Unless otherwise specified, or an alternative test ordered, this laboratory test shall carried out to determine the relationships between the moisture content of a soil and the resulting densities and firmness which are achieved after the soil has been compacted by the procedure described.

2. **Definitions.**—The criteria defined below shall be used to evaluate the results of this test—

(*a*) The greatest dry weight, in pounds per cubic foot, obtained by the standard compaction test procedure is called the maximum standard dry density.

(*b*) The optimum moisture is the moisture content of the soil at maximum standard dry density.

(*c*) The firmness of the soil is expressed in pounds per square inch and is called the penetration resistance of the soil.

(*d*) Compactive effort is measured by the number of blows per layer and the height of fall of the tamping rod.

3. **Equipment required.**—The following equipment is required for the standard compaction test :—

1. Drying oven.

1. Large drying pan.

1. Laboratory compaction cylinder.

1. Tamping rod (5.5 pounds) and gauge.

1. Mixing pan

1. Hand scoop.

1. Small hand scoop.

1. Penetration resistance tester.

1. Set penetration resistence tester needles.

1. Striking paddle.

1. Mixing rake.

1. Portable platform scales, 250—pound capacity, graduated in 0·01 pounds.

2. Porcelain evaporating dishes, 300—ml. capacity.

1. Evaporating dish holder.

3. Glass graduates, one each of 1,000,500, and 100 ml. capacity.

3. 30-pound cans with handles and lids.

1. Rubber hammer.

1. Laboratory balance, 2,000 gram capacity, sensitive to 0.05 grams.

1. Curved handle, wire bristle brush.

1. Dusting brush.

1. Large knife.

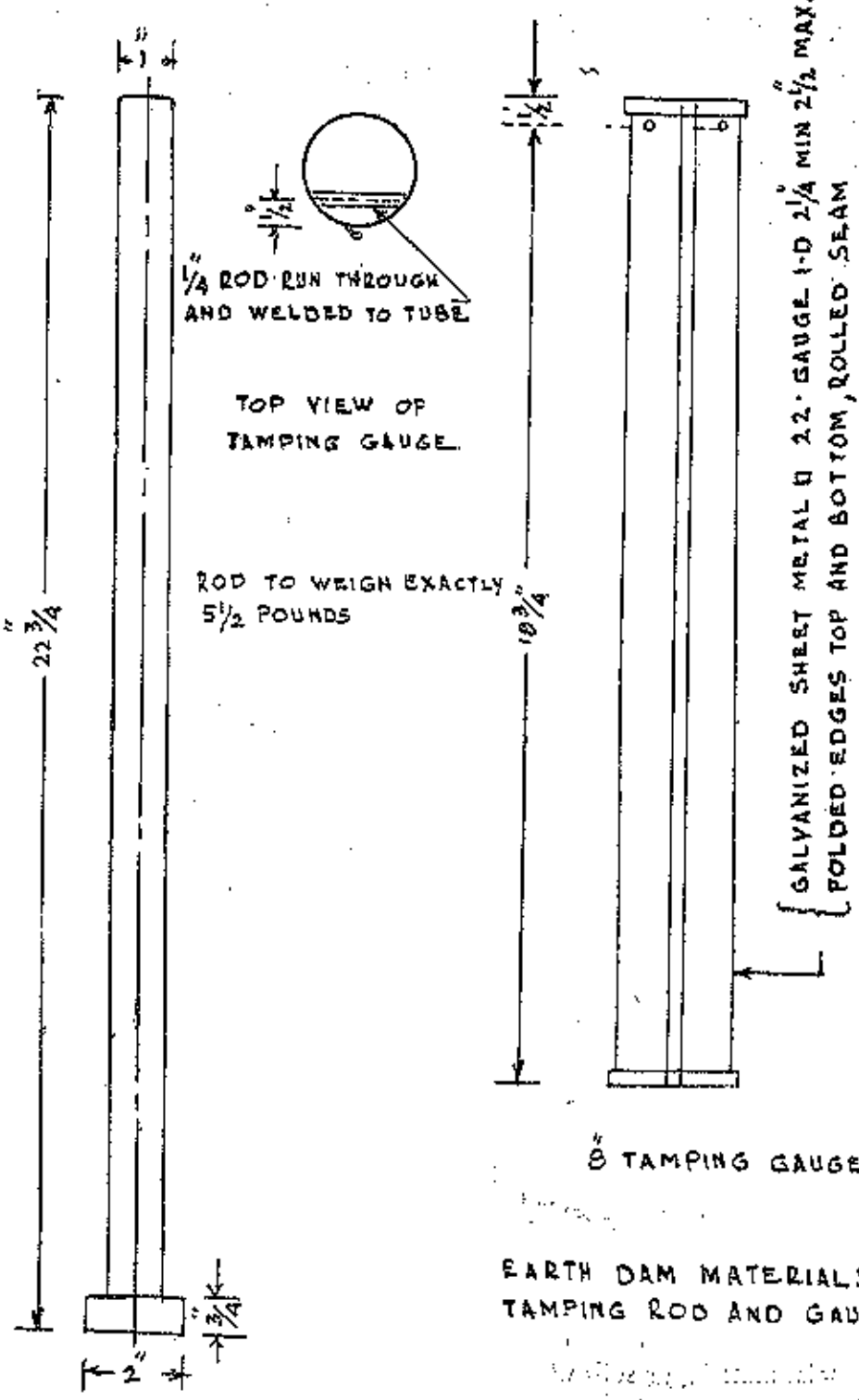
4. Compactive cylinder and penetrometer.—The standard compaction cylinder and the tamping rod and gauge are shown in Figs. on Pages 798 and 800.

The volume of compaction cylinder is 0.05 cubic foot.

The penetration resistance tester is shown in Fig. on page 799. Usually a set of six needles are provided with the tester. The number and areas in square inches of these needles are No. 0=1/40, No. 1—1/20, No. 2=1/10, No. 3=1/4, No. 4=1/2 and No. 5=1.0.

5. Procedure.—A representative specimen of approximately 30 pounds of material, screened through I.S. Sieve No. 480 (U. S. Standard Sieve No. 4) is required for the test. By reprocessing the compacted material the test can be performed on a specimen weighing about 15_5 pounds. However, this procedure shall not be adopted if the soil i friable and the particles get crushed or are broken off during the test. Test data should be recorded in standard form shown in table :—

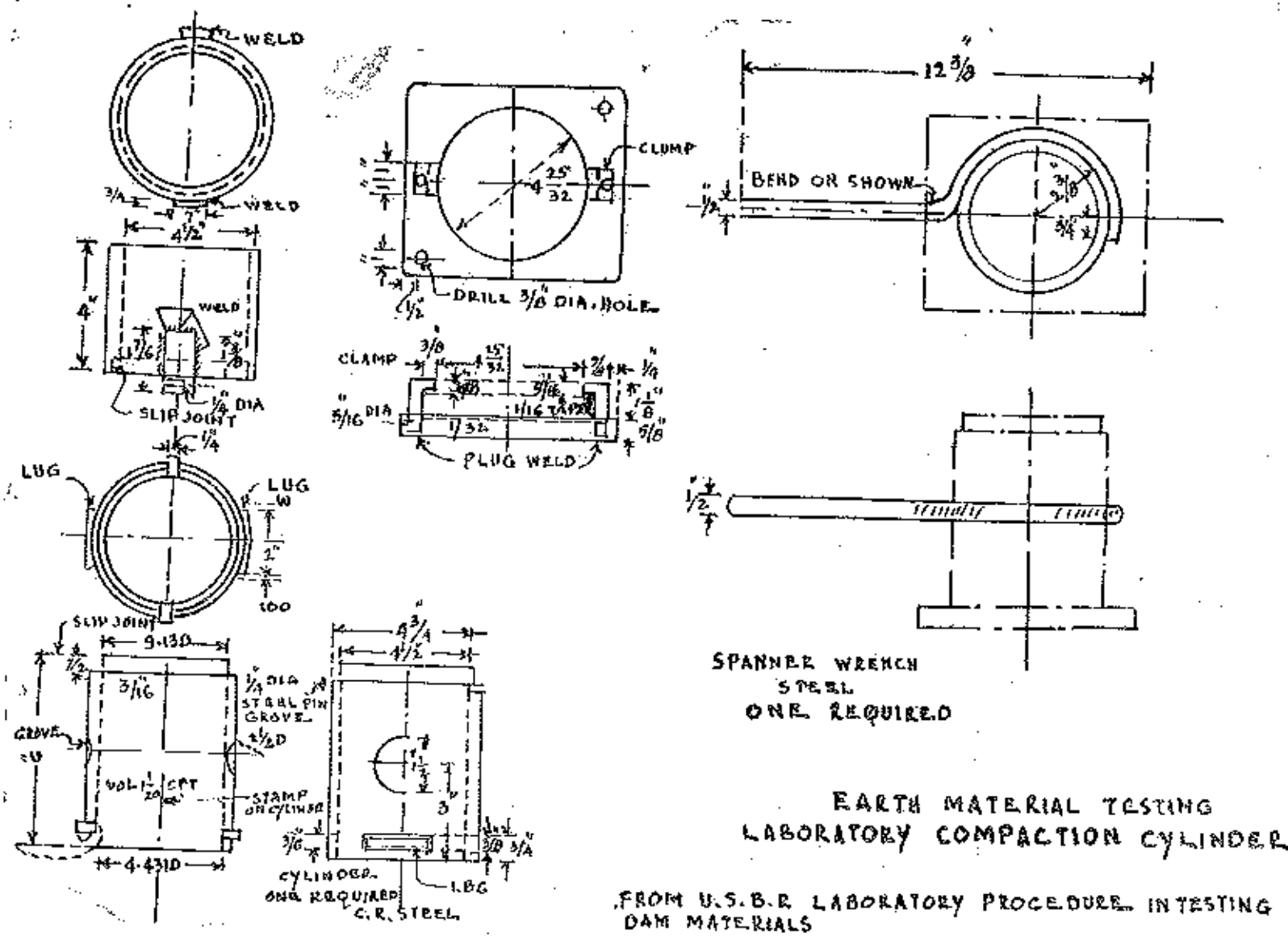
(*a*) Place the sample in the large drying tray. Moisten and mix the sample thoroughly and store in an air-tight container to permit moisture to permeate and spread uniformly through out the soil. Sufficient water should be added to cause the soil to adhere or ball together, slightly when squeezed firmly in the palm of hand. This moisture content is usually less than the optimum moisture. It may not be necessary to store moist material or soils which read ily absorb moisture.



8" TAMPING GAUGE

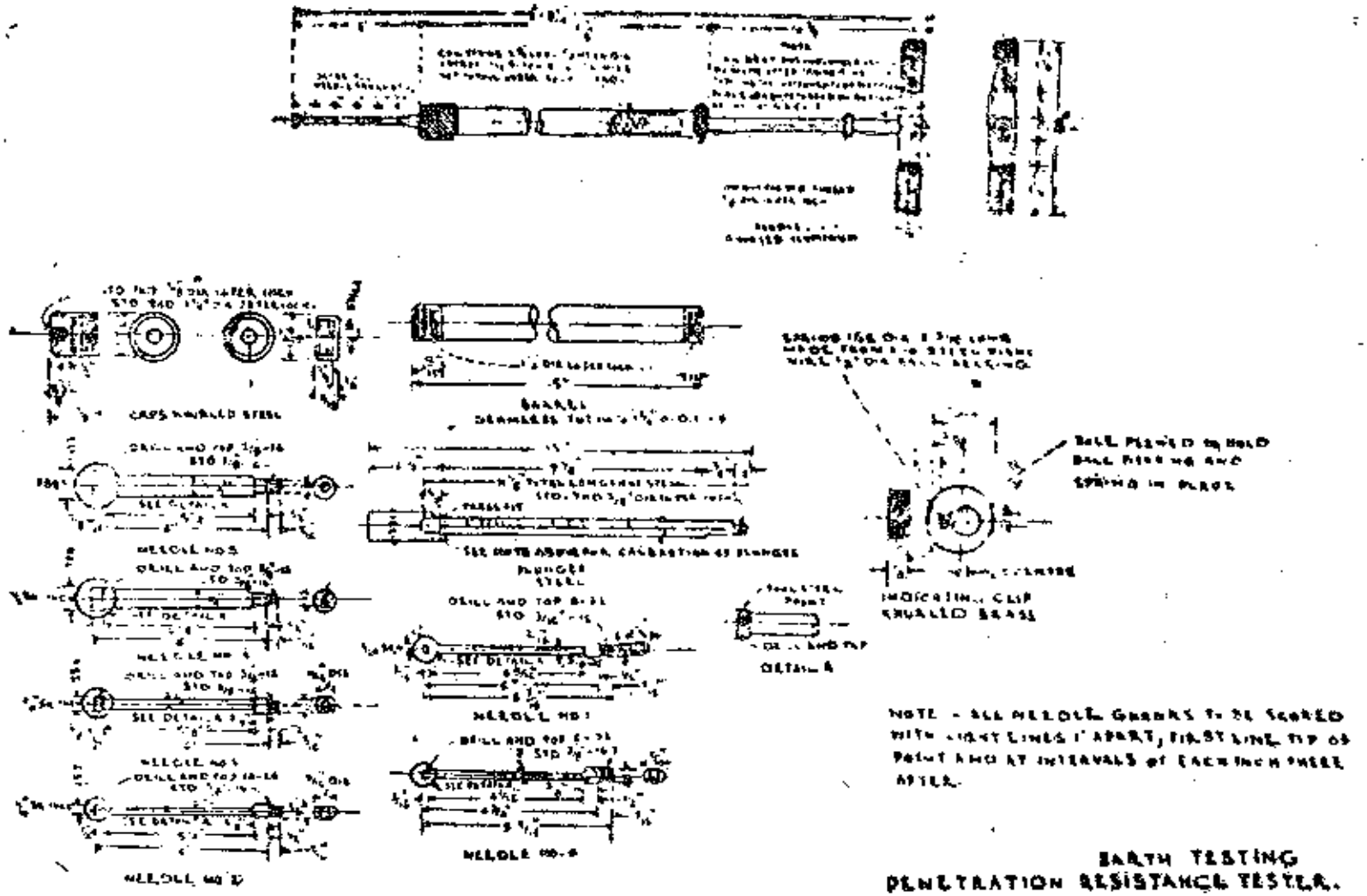
EARTH DAM MATERIALS TESTING
TAMPING ROD AND GAUGE

FROM U.S.B.R LABORATORY PROCEDURE IN TESTING EARTH DAM MATERIAL



EARTH MATERIAL TESTING
LABORATORY COMPACTION CYLINDER

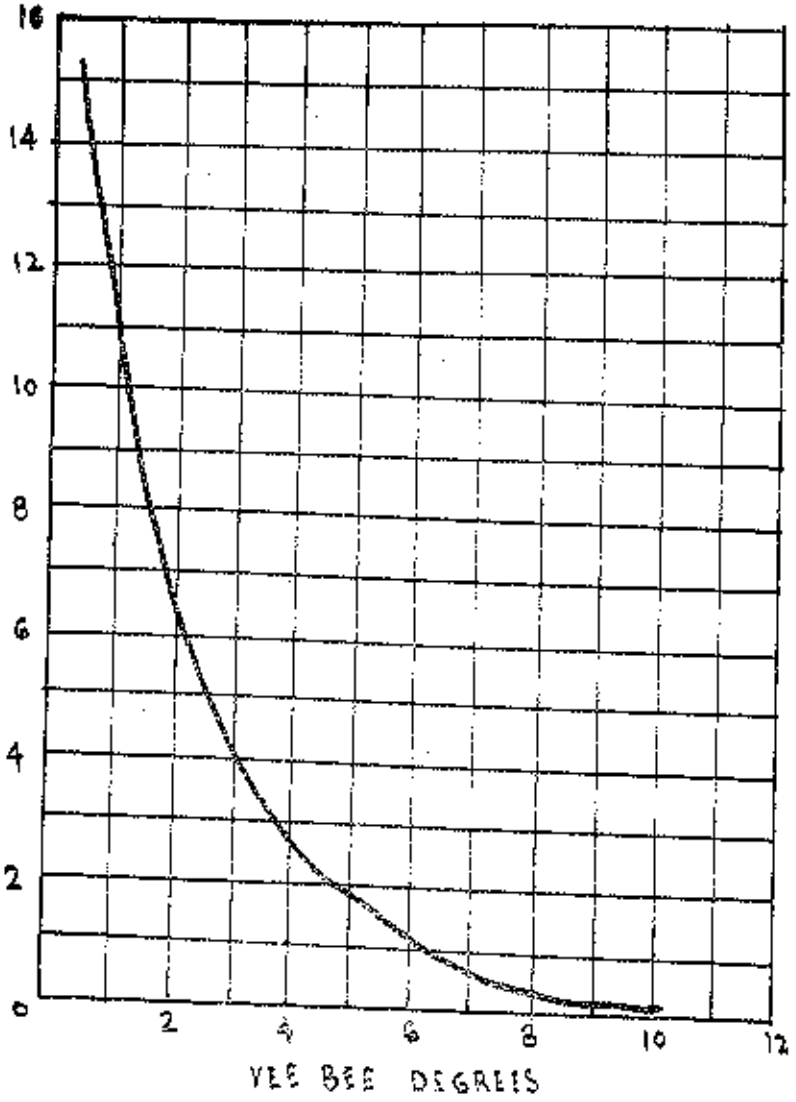
FROM U.S.B.R LABORATORY PROCEDURE IN TESTING EARTH DAM MATERIALS



NOTE - ALL NEEDLE GRADES TO BE SCORED WITH LIGHT LINES 1" APART, FIRST LINE TIP OF POINT AND AT INTERVALS OF EACH INCH THEREAFTER.

EARTH TESTING
PENETRATION RESISTANCE TESTER.

FROM U.S.D.A. LABORATORY-PROCEDURE IN TESTING EARTH CAN MATERIALS



RELATION BETWEEN SLUMP IN CM AND VEE-BEE DEGREES

FIG. 2

(*b*) Weigh and record the weight of laboratory compaction cylinder (cylinder only).

(*c*) Attach the 6-inch high cylinder with the collar to base plate. The base plate should be securely fastened to a work table.

(*d*) Place approximately 7 poinds of the moist soil sample into a mixing, pan, mix, and place a sufficient amount in compaction cylinder to yield approximately 2-inch compacted layer.

(*e*) Place the tamping rod in the gauge, and compact the material in the mould with 25 blows, using an 18-inch drop. The blows should be evenly distributed over the area of cylinder.

(*f*) Repeat process (*e*), for the second and third layers. The third and last layer should extend slightly above the top of the cylinder to allow for trimming to top of sample.

(*g*) Remove the collar from the cylinder and carefully trun the excess portion of the compacted material to the exact level of the top of the cylinder.

STANDARD COMPACTION AND PENETRATION RESISTANCE TEST

1. Sample No.
2. Compacted by
3. Degree of compaction
4. Date
5. Recorded by
6. Vol. of cylinder

Test No,		1	2	3	4	5
DENSITY DETERMINATIONS						
Water added	.. CC	—	—	—	—	—
Wt. cyl. and wet earh	.. lbs.	—	—	—	—	—
Wt. of cylinder	.. lbs.	—	—	—	—	—
Wt. of density	.. lbs./cu.ft	—	—	—	—	—
Needle No.	..	—	—	—	—	—
Area of needle	.. Sq. inch.	—	—	—	—	—
Average reading	.. lbs.	—	—	—	—	—
Penetration resistance	.. lbs./sq. inch.	—	—	—	—	—

MOISTURE DETERMINATIONS

Dish No.	..	—	—	—	—	—
Wt. dish and wet soil	.. gms.	—	—	—	—	—
Wt. dish and dry soil	.. gms.	—	—	—	—	—
Wt. of dish	.. gms.	—	—	—	—	—
Wt. of water	.. gms.	—	—	—	—	—
Wt. of dry soil	.. gms.	—	—	—	—	—
Moisture content % dry wt.	..	—	—	—	—	—
Dry density	.. lbs./cut.	—	—	—	—	—

1. Computed by
2. General remarks about soil and test :
3. Checked by :
4. Date

(*h*) Remove the cylinder along with the compacted sample from base plate, weigh, and record weight.

(*i*) Place the cylinder with contained sample on the workable or floor and carry out the penetration resistance test. This test is made by forcing the penetration resistance needle into the compacted soil at a rate of approximately half an inch per second.

The following precautions should be taken when obtaining a needle reading :—

(1) Place indicator clip against barrel cap

(2) The test should be started by grasping the penetrometer barrel and pushing the needle about half an inch into the compacted specimen. The penetrometer should then be held by the handle, and the needle pushed into the specimen an additional 2½ inches at a rate of half an inch per second.

(3) When the compacted sample contains hard sections or layers, the needle will not penetrate at a uniform rate. The force applied to the penetrometer builds up until the needle 'breaks through'. When such a condition is realized, the reading obtained should be disregarded and another penetration resistance test performed. When the needle reaches the hard section the pressure on the handle should be released and the needle forced through the hard layer by grasping the penetrometer barrel. Then the test should be continued by using the penetrometer in the normal manner.

(4) When the needle has penetrated the specimen at a uniform rate to a depth of approximately 3 inches, the reading on the plunger shaft is obsered. The average of three or more such reading, and the number and area of the needle should be recorded.

(*j*) Remove the compacted specimen from the cylinder and take a sample from the centre of the specimen for moisture content determination.

(*k*) The above-mentioned steps include the procedure for one of a minimum of five trails using a new batch of soil for determining the density and penetration resistance curves for a single soil sample. All the remaining four trials are performed exactly as the first with the exception that the moisture content for each trial is successively increased over the proceeding trial until the wet weight of the sample decreases. This is a definite indication that the maximum standard dry density has been exceeded.

6. Computations and graphical plotting.—After the moisture content determinations for each trial, the dry density for all cases is computed as the wet density divided by (1 + moisture content expressed as a decimal fraction). The wet density is the weight of wet earth divided by the volume of the cylinder in cubic feet. The penetration resistance is the quotient of the average reading divided by the area of the needle.

Data from compaction and penetration resistance tests are plotted in a set of two curves depicting the relationships between moisture content and dry density, and moisture content and penetration resistance, respectively. Dry density and penetration resistance are plotted as ordinate values with the per cent moisture content plotted as abscissa values for both curves. Moisture content is expressed as a percentage of dry weight, dry density expressed in pounds per cubic foot, and the penetration resistance is given in pounds per square inch. The peak value of the density cruve and the corresponding moisture content are designated as maximum standard density and optimum moisture content, respectively.

APPENDIX NO. X

FIELD DENSITY TEST

1. General.—Field density tests shall be carried out on compacted or rolled earth embankments, where and when directed. Where field laboratory facilities permit, comparison should be made between the field density, penetration resistance, and moisture content ; and the maximum density, penetration resistance, and optimum moisture content of the material compacted by a standard method.

2. Equipment.—The following equipment is required for carrying out a field density test —

1 Ore shovel.

1 8-inch diameter posthole auger.

2 5-gallon capacity aritight cans, one for calibrated sand and one to bring back sample.

1 5-gallon capacity can or pail, for salvaging used sand.

1 garden trowel.

50 pounds of coarse uniform-grain-size sand, (Pathankot sand), preweighed.

1 set of penetration-resistance tester stock and needles.

1 18-inches long straight edges board.

1 small 4-ounce can or scoop.

3. Procedure.—

(*a*) Remove loose surface soil from an area approximately 18-inches square till the compacted soil layer is reached. Smoothen and plane the compacted soil surface with the straightedge board.

(*b*) Take penetration-resistance needle readings in the centre of the cleared patch and record the average of three or four readings. These readings will be in pounds per square inch and should be recorded as needle readings (top).

(*c*) Dig a hole in the centre of the area with a garden trowel, finishing it to a depth of about 6 inches using an 8 inch auger. If the soil contains much rock or pebbles to use the auger, the hole should be excavated by hand. The finished hole should be clean, smooth and free of loose

material. While digging the hole care should be taken to avoid stepping too close to it. To avoid this, boards should be placed around the test on which the operator can stand during the test.

(*d*) After removal of the first 6 inches of soil, take penetrometer needle readings again and record the average of three or four readings as needle reading (bottom).

(*e*) Complete the excavation of the hole to a depth of from 12 to 14 inches removing the soil very carefully. All the material removed from the hole should be placed in an airtight container for laboratory testing.

(*f*) Measure the volume of the hole by filling it whith dry, calibrated standard Pathankot sand poured from a container which has previously been weighed. Use the straight-edged board to insure that just enough sand is poured to completely fill the hole. The sand should be poured into the hole in the same manner as was employed while pouring the sand into a container of known volume to calibrate its density in the laboratory. It is suggested that the same person whole calibrated the sand should pour it into the hole in the field.

(*g*) Replace the cover on the container with the unused sand and remove it to the laboratory for weighing. Remove the sand from the hole, place it in a pail or can, and take it to the laboratory where as much of it as possible should be salvaged for reuse, by screening. The density of the sand should be checked frequently by pouring it into a container of known volume and weighing.

(*h*) Before leaving the site of work all necessary information such as test number, location, source of material, number of roller passes, etc., should be recorded.

(*i*) In the laboratory determine the weight of soil removal from the hole and of the sand used in refilling it. The volume of the hole can be determined by dividing the weight of sand used by its density. The wet density of the soil removed equals the wet weight of soil divided by the volume of the hole.

(*j*) Laboratory comparisons of dry densities and moisture contents should be made only in materials passing I.S. Sieve no. 480 (U. S. Standard Sieve no. 4) or the 'earth' fraction. Immediately after the material has been screened through

this sieve, take a 500 gram sample of the material screened through, for determination of moisture content by evaporation. Place remainder of this screened fraction in an airtight can to avoid loss of moisture by evaporation until it is needed.

(*k*) For 'record' field density tests and for representative tests the moisture content, volume, dry weight, and specific gravity of 'rock' or the fraction left on I. S. Sieve no. 480 (U. S. Standard Sieve No. 4) should also be determined. These properties if fraction retained on I. S. Sieve No. 480 (U. S. Sieve No. 4) or rock, may be adopted for all other tests if the general characteristics of this fraction remain unaltered.

(*l*) Knowing the volume end weight of rock retained on I.S. Sieve No. 480 (U.S. Standard Sieve No. 4) compute the wet density of earth alone, and then calculate the dry density of earth using the moisture content determination of earth, mentioned in step (*j*).

$$\text{Wet density of earth} = \frac{\text{Moist weight of earth}}{\text{Volume of hole—volume of rock}}$$

$$\text{Dry density of earth} = \frac{\text{Wet density of earth}}{\text{Weight of sand and container} + \text{Moisture content of earth.}}$$

(*m*) Compact the fraction passing I. S. Sieve No. 480 (U.S. Standard Sieve No. 4) by standard method of laboratory compaction (Appendix IX) at full moisture, at least at two other moisture contents so as to obtain a moisture-density curve that will indicate optimum moisture content and maximum density. Take penetration-resistance needle reading in each compaction cylinder and plot the needle reading moisture content relation. This curve should be used to check the needle reading moisture content relation required for the needle-moisture test described in Appendix XI.

APPENDIX NO. XI

NEEDLE-MOISTURE AND NEEDLE-DENSITY TESTS

1. **General.**—During earthwork construction it is necessary to have a rapid method of determining whether the desired moisture content exists in the soil prior to rolling, and also for determining sufficiency of compaction. With the aid of needle-moisture test it is possible to ascertain in the borrowpit or on the embankment whether the earth materials are too wet, too dry or at the proper moisture content. It is also checked with field density tests from time to time.

The needle-density test checks the degree of compaction by comparing the penetration-resistance needle reading in the compacted fill with the needle reading of the same material when compacted at fill moisture content in the cylinder by standard method of compaction. Needle-density tests should be made immediately after an area has been rolled and at such intervals over the area that will be representative. It is sugested that these tests be made at approximately 100 feet centres, including all locations where needle-moisture tests have previously been made.

2. **Equipment required.**—The following equipment is required for these tests :—

1 Heavy duty screen, 22 inch×35 inch, U. S. Standard Sieve no. 4 (I.S. Sieve no. 480) openings.

1 Standard compaction cylinder with 5.5 lbs. tamping rod and guage.

1 Standard penetration-resistance tester and needles.

1 Ore shovel.

1 Field note book.

3. **Procedure for needle-moisture test.**—

(*a*) Select a representative sample weighing about 25 to 30 pounds, from the spread layer before rolling or from the face of excavation in borrowpit. Remove the rock fraction from the sample by screening the material through I. S. Sieve no. 480 (U. S. Sieve no. 4), screen, the screenings being collected on a cleared and smoothened spot.

(*b*) Place enough of the screened sample into a compaction cylinder, (with collar attached) to fill it about 3-inches. Compact the layer with 25 blows of the tamper at an 18-inches free drop. Repeat this procedure until three layers are compacted. The

thickness of placed layers should be adjusted so that the total compacted thickness will be slightly more than 6-inches. Remove the collar from the cylinder and trim the compacted material to the level of the cylinder.

(*c*) Measure the penetration resistance. Use a needle that will give a reading on the scale when the needle is forced into the sample at a rate of approximately half an inch per second. All the precautions detailed in item 5 of Appendix IX should be observed in taking these readings. Make three or four penetrations and determine the average scale reading for the sample.

(*d*) Divide the average scale reading by the area of the needle used to determine the penetration resistance in pounds per square inch.

(*e*) This data should be recorded as prescribed for the field density test. Compare the observed penetrati on resistance with the allowable limits previously established in the laboratory and indicate whether the material is satisfactory, too wet, or too dry.

4. **Procedure for meedle density test.—**

(*a*) At the spot selected for the test, remove the loose top material until firm compacted soil is reached.

(*b*) Measure the penetration resistance and determine its average value in a manner similar to that described in sub-paragraphs (3—c) and (3—d) above.

(*c*) Excavate about 25 or 30 pounds of material at the spot where the fill needle readings were taken and pass the material through the screen.

(*d*) Compact a sufficient quantity of the screened material in a standard compaction cylinder as described in sub-paragraph (3—b) above, and measure the penetration resistance of the compacted material in the cylinder as in (4—b) above.

(*e*) Record the penetration resistance observed in (b) above in the column headed "fill", and the penetration resistance observed in the column marked 'cylinder'.

(*f*) If the needle-moisture tests indicate moisture content with in the allowable range, an average needle reading in the fill equal to or greater than the average cylinder needle reading

inidcates adequate density and compaction. Where the embankment reading are considerably smaller than the cylinder readings, sufficiency of compaction is doubtful and a field density test should be carried out immediately.

APPENDIX NO. XII

EXPLOSIVE MAGAZINES

(a) Points to be observed in the construction of an explosive magazine

1. Gunpower, dynamite, gelignite, blasting gelatine and safety fuse may be stored in the same room, but detonators and fuses for blasting which are not safety fuses, must be kept in a separate room, and if the number of detonators exceeds 40,000, they must be stored in a separate building at some distance from the magazine.

2. The size of the magazine will depend on the quantity of explosives to be stored. The floor, however, must be at least 12 inches (30 cms. above ground, the outer walls 18 inches (45 cm.) thick, the wall between the magazine and the detonator room two feet (60 cm.) thick, and the outer walls of the detonator room 15 inches (38 cm.) thick.

3. The door and any windows in the magazine must be of at least ¼ inch (5 mm.) thick steel plate faced on the inside with wood. They must open outwards, and as there should be no uncovered steel or iron, inside a magazine bolts, hinges and other internal fitting must be of brass or gun metal.

4. The interior of the magazine floor, walls and roof should be cement plastered, worked to a smooth surface.

5. Dynamite and similar explosive must be kept cool, dry and well ventilated. To ensure this, boxes of explosive must be kept away from the walls and off the floor, on trestles 12 inches (30 cm.) high. The magazines will be ventilated through shaft eight inches (20 cm.) square, and according to Explosives Rule 1949. These will be protected outside with wrought iron gratings, built into the masonry, and inside with brass or copper wire netting (8 meshes to the inch) fixed in a wooden frame and secured flush with the plaster.

6. A space not less then ten yards (10 metres) wide round every magazine will be enclosed with a strong fence provided with a single gate which will be kept locked. This space will be kept clear from trees, bushes and grass.

7. Magazines must be kept well away from roads and buildings, and unless there is high ground intervening, no magazine, intended to hold 500 lbs. (225 kg.) or more of explosives, should be built within 50 yards (50 metres) of a road or within 100 yards (100 metres) of a dwelling house. More space is required for larger magazines and the table attached to the rules framed under the Indian Explosives Act (1884) should be consulted before selecting a site for a new magazine.

8. Every magazine shall be provided with one or more efficient lightening conductors depending upon the size of the building.

(b) General Rules to be observed in explosives magazines

1. The magazine must be at all times kept scrupulously clean.

2. No unauthorised person is at any time to be admitted into the magazine.

3. The person-in-charge of the magazine is to take care that the magazine is well and securely looked.

4. The magazine is on no account to be opened during, or on the approach of a thunderstorm, and no person should remain in the vicinity of the magazine during such a storm.

5. Magazine shoes without nails must be kept at all times in the magazine, and a wooden tub or cement trough about one foot (30cm.) high and eighteen inches (45 cm. in diameter, filled with water is to be fixed near the door of the magazine.

6. People wearing shoes, before entering the magazine must put on the magazine shoes provided for the purpose, and be careful :—

(*a*) not to put their feet on the clean floor unless they have on the magazine shoes ;

(*b*) not to allow the magazine shoes to touch the ground outside the clean floor ; and

(*c*) not to allow any dirt or grit to fall on the clean floor.

7. People with bare feet will, before entering the magazine dip their feet in the water and then step direct from the tub over the barrier on to the clean floor.

8. A brush or broom is to be kept in the magazine for cleaning out the magazine on each occasion it is opened for the receipt, delivery or inspection of explosives.

9. No lights nor smoking are to be allowed inside or near the magazine.

10. No person, having any matches or articles of steel or iron on him, is to be allowed to enter the magazine.

11. Oiled cotton rags and waste or any articles liable to spontaneous ignition must not be taken into the magazine.

12. No tools or implements other than those of copper, brass, gunmetal or wood are to be allowed inside the magazine. Tools must only be used with great gentleness and care.

13. Boxes of explosives are not to be thrown down or dragged along the floor. They must be stacked on wooden trestles. Where there are white ants, the legs of the trestles must rest in shallow copper, lead or brass bowls containing a little water.

14. Empty boxes are not to be kept in the magazine not any loose packing material stored there.

15. The following are to be hung up in the magazine :—

(*a*) A copy of these rules.

(*b*) A statement showing the stock in the magazine.

(*c*) Certificate showing the last date of testing the lightening conductors.