A NEW LABORATORY COMPACTION DEVICE AND ITS COMPARISON WITH THE PROCTOR TEST

ALAM SINGH and B. C. PUNMIA
Respectively, Reader in Civil Engineering (Soils), and
Lecturer in Civil Engineering, Faculty of Engineering, University of Jodhpur
Jodhpur (Rajasthan) India

A small-sized laboratory compaction device, known as the Jodhpur Mini-Compactor*, is described in this paper. In this device soil is compacted to a volume of 0.3 liter by means of a dynamic ramming tool under a compactive energy nearly the same as used in the Standard Proctor test. Within the limitations of the experimental error the values of the maximum dry density and the optimum water content obtained with this apparatus are the same as for the Proctor test. Apart from the object of establishment of water-density relationships this device is also used for preparing remolded specimens for other tests.

Since 1933 when Proctor (1) first emphasized the principles of soil compaction, a knowledge of the water-density relationship has always been considered of paramount importance in all earth compaction works. While it is very difficult to simulate exactly the field-compaction behavior of a soil in a laboratory test, the execution of a laboratory compaction test is often needed for arriving at the preliminary specifications for the field job. The success of a laboratory compaction test depends on how far it approaches the field compaction. For this purpose the Standard Proctor test (1, 2) is widely used and will, perhaps, be continued to be used for times to come. However, modifications (2, 3) are suggested to increase the mold size when a much coarser soil material is used or to increase the compactive energy when heavier compaction is expected in the field. On the other hand, when an economy is the quantity of soil used for the test or a saving in test-time is of importance, compaction is carried out in miniature compaction apparatus a few types (4, 5) of which are in use. The Jodhpur Mini-Compactor, designed by the senior author, is an addition to the family of small-sized laboratory compaction apparatus, which, apart from the purpose of establishing water-density relationships for soils, is also meant for preparing remolded specimens, 50 cm^2 in cross-sectional area, for use in some other apparatus designed by the senior author, e.g. the Jodhpur Pattern Permeameter (6, 8) and the Jodhpur Pattern Consolidometer (8).

An earlier model (9) of the Jodhpur Mini-Compactor consisted of a compaction mold 75 mm in diameter and 67.9 mm high (volume 0.3 liter) in which soil was compacted with a 2-kg drop weight rammer. The old model is now superseded by the present model described in this paper, because of a change effected in the dimensions of other apparatus requiring remolded specimens, prepared by compaction in the Mini-Compactor and also because the former model could give a better performance only with soils of low plasticity. The present model is found to work better both for coarse-grained and fine-grained soils and it is found to have a much nearer similarity in results when compared to Proctor's apparatus.

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*The design of the apparatus is the trust property of Smt. Kalavati Education Foundation, University of Jodhpur, Jodhpur. The apparatus is available in India exclusively from M/s Associated Instrument Manufacturers (P)Ltd., 26-27 Asaf Ali Road, New Delhi. For a formal permission to manufacture in countries other than India please contact the senior author or the Dean, Faculty of Engineering, University of Jodhpur, Jodhpur.

Figure 1. Component parts of the Jodhpur Mini-Compactor.

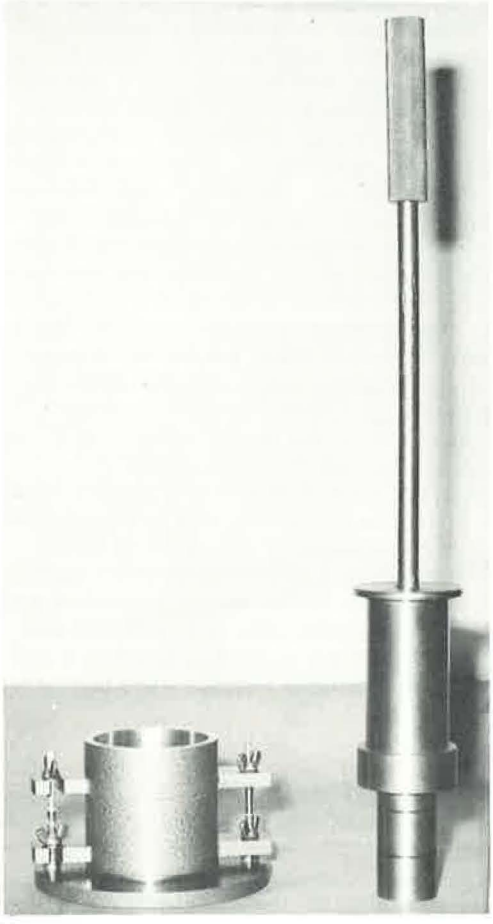

Figure 2. Mold assembly and the 2.5-kg DRT.

Description of Apparatus

The Jodhpur Mini-Compactor (Fig. 1) comprises a cylindrical compaction, mold, a collar, a base plate and a dynamic ramming tool. The compaction mold is 7.98 cm in internal diameter (cross-sectional area 50 cm^2) and 6 cm high; the capacity thus equals 0.3 liter. The collar with an effective height of 3 cm fits on the top of the mold. The collar and the mold are clamped to a detachable base plate during compaction (Fig. 2). The dynamic ramming tool, called the 2.5-kg DRT, has a drop weight of 2.5 kg which falls freely through a height of 25 cm over the tamping foot, 4 cm in diameter and 7.5 cm high. The drop weight is guided on a vertical stem passing through its axial bore. The tamping foot has two circular grooves around it at distances of 3 cm and 6 cm, respectively, from the bottom. The position of these grooves relative to the top edge of the collar during compaction facilitates in judging the thickness of the compacted layers.

Recommended Test Procedure

About six (or eight) 800-g samples of air dried and pulverized soil passing a $^3/_{16}$-in. sieve are taken. Varying amounts of water are added to the samples to give a range of water content on either side of the expected optimum value for the maximum density. Each sample is thoroughly mixed on a non-absorbent surface and then stored for a suitable maturing time. (The maturing time varies with the type of soil. Heavy clays are matured for 10-12 hours. For sandy soils a rest period of 10-15 minutes will do.) After the maturing time each sample is remixed before compaction.

Each sample is compacted into the mold in two layers, each layer being given 15 blows of the 2.5-kg DRT. The first blow is given in the center of the mold and the remaining 14 blows are uniformly distributed over the soil with the foot always touching the inner side of the mold. The second layer should project not more than 5 mm into the collar. After compaction, the collar is removed, excess soil is cut off and the mold with compacted specimen inside is weighed to determine the weight of soil in grams. The weight of compacted specimen divided by 300 gives the bulk density in g/cm^3. A

TABLE 1

A COMPARISON OF THE JODHPUR MINI-COMPACTOR TEST AND THE STANDARD PROCTOR TEST

Test Feature	Jodhpur Mini-Compactor Test	Standard Proctor Test
Size of compacted specimen.	Diameter = 7.98 cm Height = 6 cm Sectional area = 50 cm^2 Volume = 300 cm^3	Diameter = 10.15 cm Height = 11.7 cm Volume = 945 cm^3
Rammer	2.5-kg drop-weight Free fall = 25 cm Energy transferred through a tamping foot.	2.5-kg drop-weight Free fall = 30.5 cm Drop weight falling directly on the soil
Layers and blows	2 layers, 15 blows to each layer	3 layers, 25 blows to each layer
Compactive energy	6,250 kg-cm per 1,000 cm^3 of soil	6,050 kg-cm per 1,000 cm^3 of soil

representative specimen is kept from the compacted soil for water content determination. By knowing the water content and the bulk density, the dry density is calculated. A relation between water content and dry density can then be plotted.

Some of the features of compaction tests by the Jodhpur Mini-Compactor and the Standard Proctor apparatus are compared in Table 1.

Laboratory Investigations

A total of four soils whose index properties and classification are given in Table 2 were selected for this study. Compaction tests on each soil were performed with increasing water contents simultaneously with the Jodhpur Mini-Compactor and with a manually operated Proctor compaction apparatus. For this purpose each soil was divided into a number of batches to which different amounts of water were added so as to give a fairly wide range of water content considered sufficient for the test. The maturing times for the soils were as follows: soil I-1 hour, soil II-6 hours, soil III-6 hours, soil IV-8 hours. Samples from the same batch at a particular water content were compacted at one time in the Jodhpur Mini-Compactor and the Proctor apparatus. For further tests fresh samples from other batches at higher water contents were used and the once-compacted material was rejected. The tests were carried out on the rigid floor of the laboratory. The water content of compacted specimens was determined by oven-drying method. The compaction curves giving a relation between the water content (%) and the dry density (g/cm^3) for the various soils are shown in Figures 3 through 6. The Jodhpur Mini-Compactor curves are shown continuous and the Proctor

TABLE 2

INDEX PROPERTIES AND CLASSIFICATIONS OF SOILS TESTED

Soil No.	Specific Gravity	Liquid Limit	Plasticity Index	Gradation			Classification	
				% Sand +0.06	% Silt 0.06-0.002	% Clay -0.002	AASHO	USC
I	2.66	21	2	78	18	4	A-4	SM
II	2.70	27	9	53	41	6	A-4	CL
III	2.68	31	13	50	42	8	A-6	CL
IV	2.75	50	25	20	51	29	A-7	CL-CH

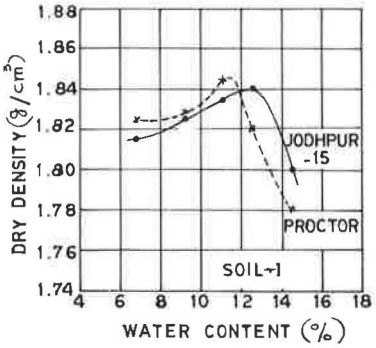

Figure 3. Compaction curves.

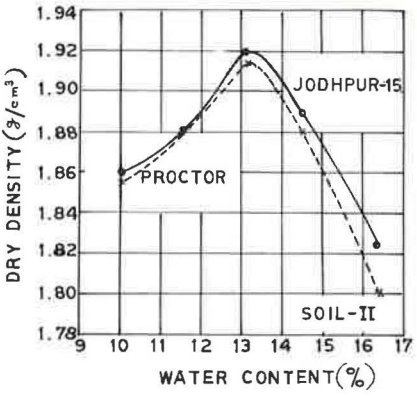

Figure 4. Compaction curves.

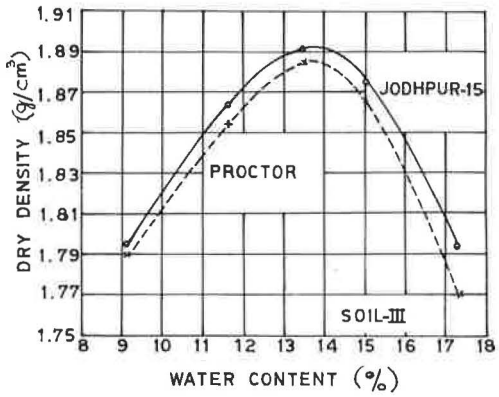

Figure 5. Compaction curves.

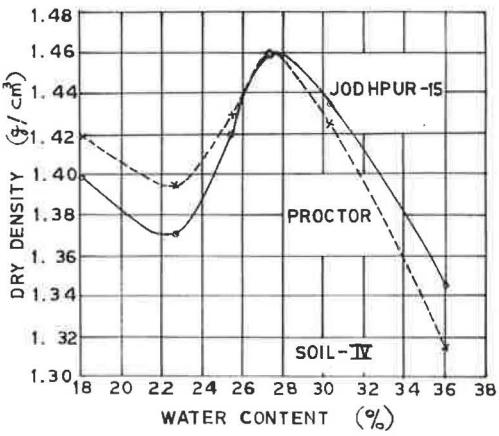

Figure 6. Compaction curves.

TABLE 3

COMPARISON OF MAXIMUM DRY DENSITIES AND OPTIMUM WATER CONTENTS

Soil	Max. Dry Density (g/cm^3)		Optimum Water Content (%)	
	Jodhpur Mini-Comp. (15 blows)	Standard Proctor Apparatus	Jodhpur Mini-Comp. (15 blows)	Standard Proctor Apparatus
I	1.840	1.846	12.5	11.5
II	1.920	1.914	13.1	13.1
III	1.891	1.885	13.8	13.8
IV	1.458	1.458	27.4	27.4

curves as dotted lines. The values of the maximum dry densities and the corresponding optimum water contents for the various soils are given in Table 3.

In addition to the comparative tests given in Table 3, the effect of increasing the number of blows in the Jodhpur Mini-Compactor was studied on soil II. The compaction curves obtained with 10, 15, 20 and 25 blows of the 2.5-kg DRT, the line of optimum and the saturation line are shown in Figure 7.

The effect of the mass of the support or the base over which a Proctor mold is kept during compaction has been studied by Ray and Chapman (10). A similar comparative study was made by compacting soil III in the Jodhpur Mini-Compactor placed during compaction on a light wooden stool weighing 5 kg. The two compaction curves obtained with the mold placed on the concrete floor and on the stool are shown in Figure 8

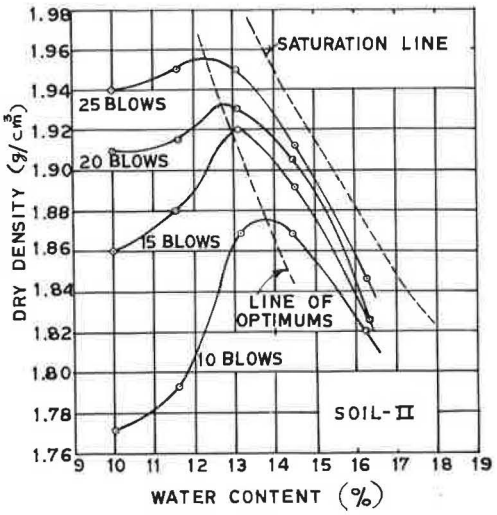

Figure 7. A typical effect of increased compactive energy in the Jodhpur Mini-Compactor test.

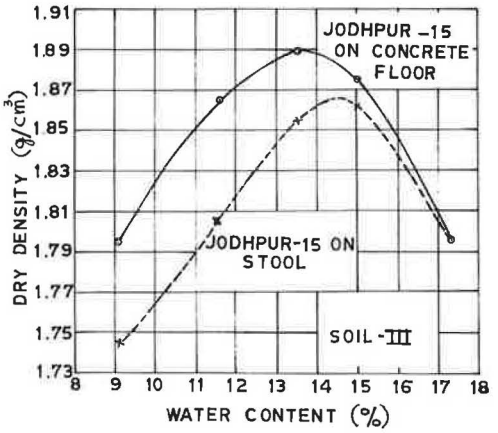

Figure 8. A typical effect of the rigidity of base in the Jodhpur Mini-Compactor test.

Conclusion

The results obtained with the Jodhpur Mini-Compactor compare very favorably with those of Standard Proctor Compaction. At the same time the operation of compaction in the Jodhput Mini-Compactor test is relatively quicker and there is considerable saving in the quantity of soil required for the test.

Because of the small size of the mold, the Jodhpur Mini-Compactor test is considered suitable for soil finer than $^{3}/_{16}$ inch. The test should be performed on a rigid base.

Acknowledgment

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References

1. Proctor, R. R., "The Design and Construction of Rolled Earth Dams." Eng. News-Record, 3 (Aug./Sept. 1933).
2. AASHO-Test Designation: T 99-57; British Standard Test 10, BS.1377-1961.
3. AASHO-Test Designation: T 180-57; British Standard Test 11, BS.1377-1961.
4. Wilson, S. D., "Small Soil Compacting Apparatus Duplicates Field Results Closely." Eng. News-Record, 145(18) (Nov. 1940).
5. "Abbot Compaction Test." Standards for Testing Soils, Central Board of Irrigation (Simla) Pub. 42, pp. 96-97 (1948).
6. Singh, Alam, "Jodhpur Pattern Permeameter." Current Eng. Practice (Bombay), 1(3) (Sept. 1958).
7. Singh, Alam, "A Note on Jodhpur Pattern Permeameter." Jour. Ind. Nat. Soc. Soil Mech. Found. Eng. (1) (Jan. 1962).
8. Singh, Alam, "Development of Some New Apparatus and Procedures for Soil Testing." Inst. Eng. (India), Rajasthan Centre, Jaipur, in press.
9. Singh, Alam, and Punmia, B. C., "Some Experiments with the Jodhpur Mini-Compactor." Roads and Road Construction (London), 41 (484):106-109 (April 1963).
10. Ray, P. N., and Chapman, T. G., "The British Standard Compaction Test for Soils: A Study of Some Factors Affecting the Test Results." Geotechnique, 4(4) (Dec. 1954).