Experimental Investigation of an Approach to Conduct Standard Compaction Tests Alternatively

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Abstract- **For proper control over the field compaction, standard laboratory compaction tests are devised to obtain optimum moisture content and maximum dry density of a soil. The paper presents an experimental investigation of an approach which enables to perform standard laboratory compaction test alternatively in more personalized manner. For this, a parent compaction test and three alternative tests that are developed using the approach, having different volume of moulds and test parameters, were performed. The results obtain were conclusive to show the flexibility in execution of the compaction tests and possibility of conducting standard tests alternatively. Additionally, the material, time and effort involved were less in compaction test that are carried out in smaller volume of mould, thus signifying the usefulness of the approach.**

Keywords: Laboratory compaction tests, optimum moisture content, maximum dry density, alternative tests

I. INTRODUCTION

In the construction of engineering structures such as highway embankments or earth dams, for example, loose fills are required to be compacted to increase the soil density and improve their strength characteristics [7]. The standard reference [1, 2] Proctor compaction tests are most commonly used in laboratories, to determine the compaction characteristics for proper control over the field compaction and to carry out research works [5]. However in India, light compaction test [9] and heavy compaction test [8] are the standardized equivalent form of these, respectively.

This paper presents an experimental investigation of a theoretical approach i.e. varying the test parameters and maintaining the same compactive effort [4], which enables to perform any compaction test alternatively in more flexible and personalized manner. Total four compaction tests were conducted on three different soil samples, one being the parent test conducted on a larger volume of mould and rest three are alternate tests (developed using the approach) conducted on smaller volume with other varying test parameters. The results obtained shows there are marginal differences in optimum moisture content (OMC) and maximum dry density (MDD) for respective soil samples, signifying the independency of a compaction tests. In addition, since the alternate tests were carried out in smaller apparatus, the used quantity of soil and water were less and hence the effort and time required for testing reduces too. Thereby the approach can be used to develop a personalized apparatus to carry out any standard compaction test alternatively for a large-scale testing in less duration, specifically when there is shortage of testing materials.

II. CONCEPTUAL APPROACH

For confined compaction test in laboratory, the compactive effort is a function of number of blows per layer (N_b), number of layers involved (L), mass of the hammer (M), height of hammer fall (H), and volume of the mould (V) that can be expressed in terms of these parameters as [4];

$$E = \frac{N_b \times L \times M \times H}{V} \tag{1}$$

In parent test the soil is compacted in Indian Standard (IS) heavy compaction apparatus of volume 2250 cm^3 in 5 layers using a rammer weighing 4.9 Kg falling from a height of 45 cm. The compactive effort imparted in this test can hence be evaluated as;

$$E = \frac{25 \times 5 \times 4.9 \times 45}{2250} = 12.25 Kg - cm / cm^3 \tag{2}$$

The alternate tests are performed in this study in IS light compaction apparatus of volume 1000 cc, weight of hammer 2.6 Kg, and its height of drop 31 cm.

The remaining two parameters; i.e. number of layers and number of blows per layer are altered in such a manner that the compactive effort imparted in the former case is identical to each of the alternate approaches. Substituting, H=31 cm, M=2.6 Kg, V=1000 cm^3 in (1); the compactive effort can be expressed in terms of N_b and L as $0.0806 \times N_b \times L$ Kg-cm/cm^3. Since, objective is to carry out alternate tests keeping compactive effort unaltered; this expression is equated to 12.25 Kg-cm/cm^3 which gives a set of values of N_b and L satisfying this criterion (refer table I).

Table 1: Alternate approaches of is heavy compaction test

Sl. no.	No. of layers (L)	No. of blows per layer (N_b)	Constant parameters
Alternate test #1	3	51	V=1000 cm^3, M=2.6 Kg, and H= 31 cm
Alternate test #2	4	38	
Alternate test #3	5	31	

III. MATERIAL SPECIFICATION

The study was conducted on three different types of soils (refer table II), their specific gravity of solids (G_S), percentage finer fraction (fraction finer than 0.075 mm), liquid limit (W_L), plastic limit (W_P), and plasticity indices (I_P) are calculated for characterizing them according to unified soil classification.

Table 2: Soil properties and their respective group symbols

Sam ple no.	G_S	% fine r	Soil type	W_L	W_P	I_P	Grou p symb ol
#1	2.72	56	Fine grained	34.62	23.86	10.7 6	CL
#2	2.68	54	Fine grained	27.14	21.97	5.17	ML
#3	2.65	36	Sands with fines	23.39	14.42	8.97	SC

IV. RESULTS AND DISCUSSIONS

Fig. 1 to 3 shows the compaction curves, obtained by each tests on the respective soil samples. From figures it is observed that for individual soils, alternate compaction tests curve patterns shows the close resemblance to parent compaction test. The changes observed are because of small variations in kinetic energy transformation into soil while hammering. Energy losses i.e. energy dissipated in to heat, sound, high frequency vibrations [6, 3] and due to local deformations at the plane of contact of energy transferring foot and hammer during the time of impact [5] may vary per blow.

Further, table III to V shows the percentage error in OMC and MDD of alternate tests with respect to parent compaction test. The errors in maximum dry density varies from (-) 0.60% to 0.60% and that of optimum water content ranges from (-) 4.46% to 4%. Hence the errors are marginal and may be ignored in all practical issues.

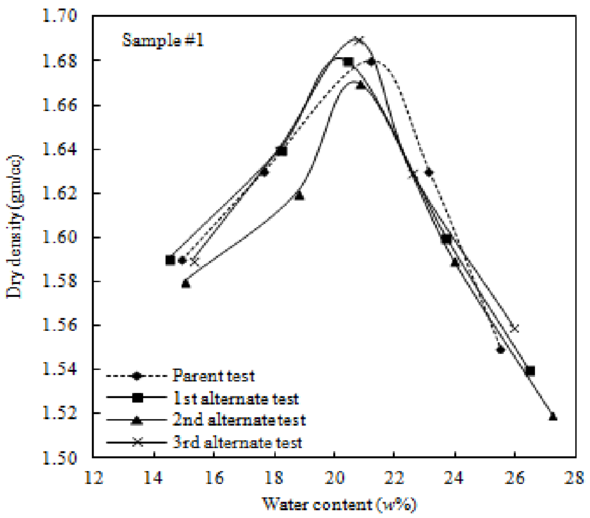

Fig 1: Comparsion graphs of compaction test in sample #1

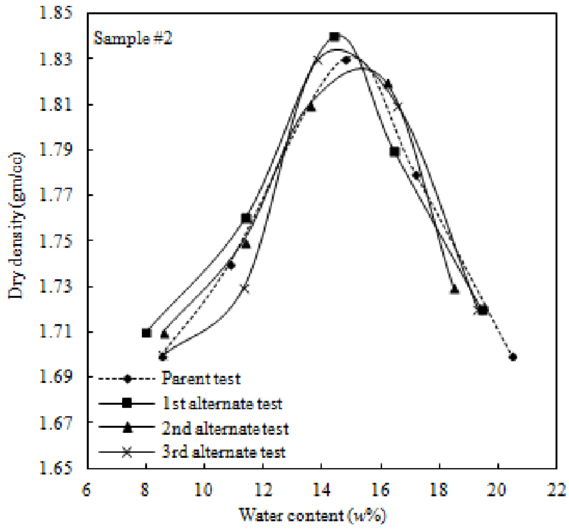

Fig 2: Comparsion graphs of compaction test in sample #2

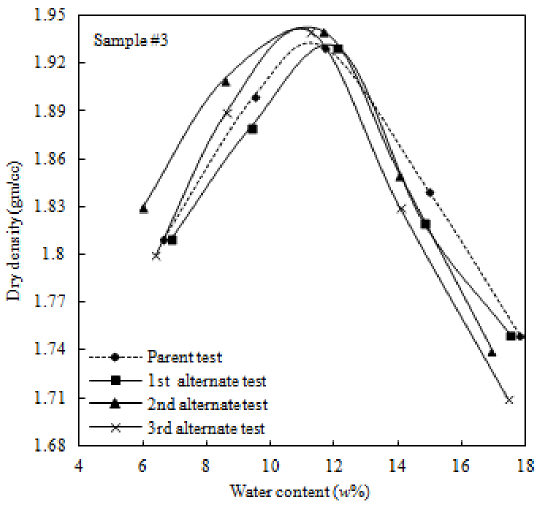

Fig 3: Comparsion graphs of compaction test in sample #3

Table 3: Soil properties sample #1 error in omc and mdd of alternate tests with respect to parent test

Tests	OMC (%)	MDD (gm/cc)	Errors in OMC (%)	Errors in MDD (%)
Parent test	21.21	1.68	0	0
1st Alternate test	20.38	1.68	3.91	0
2nd Alternate test	20.8	1.67	1.93	0.60
3rd Alternate test	20.75	1.69	2.17	-0.60

Table 4: Soil properties sample #2 error in omc and mdd of alternate tests with respect to parent test

Tests	OMC (%)	MDD (gm/cc)	Errors in OMC (%)	Errors in MDD (%)
Parent test	15.00	1.83	0	0
1st Alternate test	14.40	1.84	4.00	-0.55
2nd Alternate test	15.55	1.83	-3.66	0
3rd Alternate test	14.60	1.84	2.66	-0.55

Table 5: Soil properties sample #3 error in omc and mdd of alternate tests with respect to parent test

Tests	OMC (%)	MDD (gm/cc)	Errors in OMC (%)	Errors in MDD (%)
Parent test	11.20	1.93	0	0
1st Alternate test	11.70	1.93	-4.46	0
2nd Alternate test	11.20	1.94	0	-0.52
3rd Alternate test	11.00	1.94	1.79	-0.52

V. CONCLUSIONS

- The outcomes of the alternate tests closely matches to that of parent compaction, having marginal errors in OMC and MDD signifies the effectiveness of the approach
- Since it is evident that the input energy per unit volume is the only factor in which the compaction of a soil depends upon, the validity of the used approach can be extended for any standard compaction tests.
- It is apparent that the results does not depend upon volume of the mould rather there is a possibility of developing personalized testing apparatus and method to conduct any standard compaction test alternatively using the same approach.
- The use of alternate tests also led us to conclude that standard compaction tests can alternately be conducted in a mould of smaller volume, thus less quantity of water and soil is required and consequently saving manual labour and experimental time.

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VI. REFERENCES

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