University of Waterloo

Department of Civil Engineering

CIV E 353 - Geotechnical Engineering I
Moisture – Unit Weight Relationships (Compaction Test)

Purpose

The purpose of the Standard Compaction Test is to determine a relationship between moisture (water) content and dry unit weight for a soil that is being considered for use in an engineered fill, e.g. an earth dam, road embankment, site development, back fill, etc. The relationship may also be used to determine the suitability of the soil and also to determine the optimum moisture content and the corresponding maximum dry unit weight.

Required reading Das 2006 Sections 5.1 to 5.6 (pages 106 to 125).

Apparatus

(1) Hammer:	mass	= 2.5 kg (5.5 lb)
	diameter	= 50 mm (2 in.)
(2) Mould:	diameter	= 102 mm (4 in.)
	Volume (V)	= $9.44 \times 10^{-4} m^3$ (1/30 $ft.^3$)

Procedure

1. Break up the dry soil sample until approximately 3,000 g passes a 4.75 mm (No. 4) sieve.

2. Determine and record the dry mass of the soil sample (M).

3. Compute the mass of water (M_w) to be added to obtain the following cumulative moisture contents (w):

   w = 7, 9, 11, 13, and 15 percent

4. Determine and record the mass of the mould (M_m) (without the collar).

5. Add seven (7) percent water to the dry soil and mix thoroughly.

6. Attach the collar to the mould and form a specimen by compacting the prepared soil in three equal layers to give a total compacted depth of about twelve (12) cm. Compact each layer by imparting 25 evenly distributed blows from the hammer dropping from a height of 305 mm (12 in.) above the soil. During compaction, the mould should rest on a uniform rigid base weighing not less than 90 kg (200 lbs.).

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7. Remove the collar and trim the excess soil extending above the mould with a straightedge. Determine and record the mass of the moist soil plus mould ($M + M_m$).

8. Subtract the weight of the mould and compute the (bulk) unit weight.

$$\gamma = \frac{W}{V} \left(\frac{kN}{m^3} \right)$$

9. Remove the soil from the mould, cut the specimen vertically through the centre and take a sample for a moisture content determination from one of the cut faces. Weigh this sample **IMMEDIATELY** and place in the oven for at least 12 hours at 110^0 C.

10. Return the specimen to the remainder of the sample and break up the material until it will pass a 4.75 mm (No. 4) sieve. (It is not necessary to actually pass the material through the sieve; use your judgement).

11. Add water to increase the moisture content to the next cumulative moisture content (Step 3) and mix the sample thoroughly.

    NOTE: The amount of dry soil will decrease each time a sample is taken for a moisture content determination. However, for the purpose of Step 3 calculations assume that the dry mass (M_s in Step 2) is constant.

12. Repeat the procedure (Step 6) until there is either a decrease or no change in the unit weight.

13. Calculate (the next day) the moisture content and the dry unit weight for each compacted soil trial using

$$\gamma_d = \frac{\gamma}{1 + w}$$

where γ_d is the dry unit weight.

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Results

To complete the lab

- Finish filling out the data sheet
- Plot dry unit weight vs moisture content curve along with the 80 and 100 percent saturation curves using

$$\gamma_d = \left[\frac{Gs}{1 + \frac{w\,Gs}{S}} \right] \gamma_w$$

where S is degree of water saturation in decimal format and Gs is specific gravity of solids.

- Determine the optimum moisture content and dry unit weight
- Plot the total unit weight curve vs moisture content
- Answer the following questions.

1. Comment on the differences between the bulk unit weight and dry unit weight versus moisture content plots and describe why they are different.

2. Contract specifications require a relative compaction of at least 95 percent standard Proctor. To achieve these specifications, what field moisture content and dry unit weight does the contractor require?

3. Why is soil compaction an important part of earthwork construction in engineering earthworks?

4. Why do most geotechnical engineers specify greater compactive effort than the standard Proctor test?

5. Assume that a modified Proctor was performed instead of the standard Proctor. Comment on expected values of optimum moisture content and maximum dry unit weight.

6. Why does maximum dry unit weight decrease at water contents greater than optimum?

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Selected Bibliography

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Sample ____ Date_______________

Compaction: Blows/Layer_______ No. of Layers ______ Mass of Tamper _____

Mould: Height ________________ Diameter __________ Volume ___________

UNIT WEIGHT DETERMINATION

Trial Number	1	2	3	4	5
Mass of Soil + Mould, kg					
Mass of Mould, M_m, kg					
Mass of Soil, M, kg					
Unit weight, γ, kN/m^3					
Dry Unit weight, γ_d, kN/m^3					

MOISTURE CONTENT DETERMINATION

Moisture Tin Number					
Mass of Soil + Tin, g					
Mass of Dry Soil + Tin, g					
Mass of Tin, g					
Mass of Water, M_w, g					
Mass of Dry Soil, M_s, g					
Moisture content, w, %					