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Laboratory Project 2 Temporary Surcharge Fill: Compaction Test

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Temporary Surcharge Fill: Compaction Test

Report due in Laboratory Period 4

Problem Statement: A new retail store is to be built at a project site in western Iowa in an area where the existing soils consist of compressible silts and clays. The designer for the facility has decided to implement a ground improvement strategy whereby a temporary embankment fill is constructed over the footprint area of the building to *pre-load* the site. Preloading improves the shear strength of the subsoil by increasing the density, reducing the void ratio, and decreasing the natural water content. Preloading will be accomplished at this site by building a temporary surcharge embankment, which is a common approach used to eliminate settlements that would otherwise occur after the structure is completed. Your objective is to design the pre-load embankment fill considering the target pre-load stress, weight of the compacted soil, total volume of borrow material needed, and compaction costs. As part of this evaluation, you will carry out standard and modified Proctor tests on a representative sample of the western Iowa loess soil which has been delivered to our laboratory.
After defining the dry unit weight vs. moisture content relationship for the soil, the next steps in the evaluation involve determining the temporary surcharge embankment fill height and volume based on the total unit weight at 95% relative compaction, selecting the moisture content limits (use a 2% maximum range), and calculating the borrow and total fill volumes and placement and compaction costs. Your solution should be optimized to minimize costs.

Assumptions:

- The target surcharge pressure = 2800 lb/ft^2
- Cost to place the preload embankment fill = \$2.05/yd^3
- Cost to compact the fill is \$0.07/roller pass/yd^3
- 8 roller passes are need to achieve 95% standard Proctor relative compaction
- 12 roller passes are needed to achieve 95% modified Proctor relative compaction
- Compacted lift thickness = 8 inches
- The building footprint is 560 ft x 300 ft
- The full height of the preload embankment fill should extend 10 ft outside the building footprint area, outside of which the slide slopes of the fill should be 1:1
- The borrow fill dry unit weight is 94 lb/ft^3 at 21.0% moisture content (G_s = 2.70)

Instructions:

1. Carry out a Standard or Modified Proctor test on the sample of western Iowa loess in the laboratory according to the instructions given in the laboratory. We will generally be following ASTM D 698 and ASTM D 1557. Each group will carry out four tests at targeted moisture contents assigned during the laboratory period. To define the compaction curve our goal is to have at least two specimens on the dry side of optimum and two specimens on the wet side of optimum.

Note: The final compacted layer should not be below the collar of the mold, and should extend slightly above it by not more than 6 mm (1/4 inch). If these conditions are not met, ASTM states that the test must be redone. Note whether this specification is in fact met in your trials.

2. After the actual water contents have been determined, plot your group's Proctor curve by hand on the provided data sheet. On a separate page, plot the data points from all groups (using the table provided) and then construct one curve for the Standard Proctor test data and one curve for the Modified test data.

3. Determine and indicate the maximum dry unit weight and optimum moisture content for each of the three Proctor curves described in #2 above. Plot the zero air voids curve on each graph as well. When drawing the zero air voids curves, use $G_s = 2.70$ and plot at least 5 moisture content values, ranging from about 3% drier than the lowest OMC to about 2% wetter than the highest OMC obtained.

4. On the graph of data from all groups, plot the 80% saturation curve using the same moisture content values as for the zero air voids curves.

5. On the graph of data from all groups, determine the acceptable ranges of moisture content and dry unit weight for both the Standard and Modified Proctor tests if the field specification is for 95% relative compaction. Show these ranges as shaded areas on the graphs.

6. Using ChatGPT to proposal a plan to use the above data to address the problem statement.

6. Show a sample calculation of dry unit weight and moisture content for one point on your group's Proctor curve, one point on the zero air voids curve, and one point on the 80% saturation curve.

7. Show a calculation indicating the preload embankment fill height and associated fill placement and compaction costs. You need to optimize the solution to minimize costs.

8. Show your calculations for estimating the borrow fill and embankment fill volumes.

9. Use GhatGPT to format a structure of individual lab report

10. Incorporate the assistance of ChatGPT for the discussion section of the lab report

<u>Note the following regarding our compaction test</u>

1. Instead of using "fresh" soil for each point and allowing it to stand or cure for at least 16 hours after mixing with water as specified by ASTM, we will reuse soil for the compaction trials at different moisture contents.

2. According to ASTM, compaction must be carried out with the base plate secured to a uniform rigid foundation. Ensure that you carry out your compaction trials with the mold resting on the concrete floor.

3. After the first compaction trial, break the sample to (-) #4 sieve size by visual appearance and add water to increase the moisture content by the amount specified in the lab. Carefully remix and compact your other trial specimens. Moisture contents are to be determined using oven drying.

<u>Report Outline (Please use ChatGPT to help organize an individual lab report)</u>

Several key points to assist your team with preparing the report are noted below.

7. <u>Introduction</u>:

Give the background of the problem at hand and discuss how the laboratory testing program relates to it. This information may be taken largely from the problem statement.

- Note that your test results are being combined with those of other groups in your lab section for the second plot.

- Describe the sample; western Iowa loess

7. Test Procedures: Simply reference the test procedures that were generally followed.

- ASTM D 698, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort
- ASTM D 1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort

7. Test Results and Analysis

Compaction Test Summary:

- Include the tabulation of dry unit weight and moisture content data (see page 5). Express the moisture contents to the nearest 0.1% and unit weights to the nearest 0.1 lb/ft^3.
- Include the plot of your group's data on the provided data sheet and a separate plot using the data combined from all groups as described above. Remember to indicate and label the maximum dry unit weights, optimum moisture contents and zero air voids curves on both plots, and include the 80% saturation curve and 95% relative compaction zones on the plot of combined data.

4. Discussion:
   - Discuss the shape of your compaction curve and compare it to the shape of the standard compaction curve (i.e. the textbook curve is bell shaped with the portion wet of optimum roughly parallel to the zero air voids curve).
   - How do your maximum dry unit weight and optimum moisture content values compare with the expected values given (see attached figures for Iowa loess)?
   - Explain your calculations to arrive at the preload embankment fill volume, required borrow fill volume, target fill moisture content range and dry unit weight, and fill placement/compaction costs.
   - Briefly discuss any mistakes or errors which may have occurred in the test and their potential impact on the results.

5. Conclusions:

Be brief, explicit and quantitative. The conclusions should satisfy the objectives stated in the Introduction.

6. References

- ASTM D 698, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort
- ASTM D 1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort

7. Appendix
   - Include signed and completed test data sheets from all members.
   - Sample calculations.

Group Discussion:

Kindly provide a group summary that discusses both the merits and drawbacks of utilizing ChatGPT.

Compaction Procedure

1. Each group will perform compaction tests at four different moisture contents.
2. Prepare 5 lb of Iowa Loess passing Sieve No. 4.
3. Assuming that the hygroscopic (air dried) moisture content is 2%, add the amount of water needed to reach your target moisture content (show me your calculations before you add water).
4. Remove the collar from the Proctor mold and weigh the mold with the base plate.
5. Using the extension collar on top of the mold, prepare the soil layer according to the following table and apply the specified compaction.

	Standard Proctor	**Modified Proctor**
No. of Layers	3	5
Compaction of each layer	25 blows using 5.5 lb hammer	25 blows with 10 lb hammer
Height of loose soil layers	½, full, middle of collar	1/3, 1/2, 2/3, full, 1/2" above top of mold

6. Remove the collar and trim the soil to the top of the mold, make sure to produce a uniform surface.
7. Weigh the mold and soil.
8. Knowing the volume of the mold (1/30 ft^3) and weight of the soil, calculate the total unit weight γ_t (total weight / total volume).
9. Extrude the compacted specimen from the Proctor mold and collect a moisture content sample from the middle of the specimen. Weigh the moisture content sample and place it in the oven.
10. Break the compacted specimen up and return it to the soil bucket.
11. Calculate the amount of water required to reach the second target moisture content and repeat steps 5 through 11.
12. After 24 hours, weight the moisture content samples and determine the moisture contents.
13. Calculate the dry unit weight from the total unit weight and the measured moisture content;

$$\gamma_d = \frac{\gamma_t}{1 + w}.$$

14. Plot the dry unit weight vs. moisture content on the data sheet and draw a compaction curve through the data points.
15. Indicate the optimum moisture content w_{opt} and maximum dry unit weight $\gamma_{d,max}$ on the graph.

Standard / Modified Proctor Data

Group	Standard/ Modified	Target w (%)	Total weight (lb)	Actual w (%)	γ_m (lb/ft^3)	γ_d (lb/ft^3)
1	S	10				
		13				
		17				
		20				
2	M	10				
		13				
		17				
		20				
3	S	10				
		13				
		17				
		20				
4	M	10				
		13				
		17				
		20				
5	S	10				
		13				
		17				
		20				

COMPACTION TEST

Data Sheet 10

Project ______________________ Job No. ______________

Location of Project ______________________ Boring No. ________ Sample No. ________

Description of Soil ____

Test Performed By ______________________ Date of Test ______________

Blows/Layer ______________ No. of Layers ______________ Wt. of Hammer ________

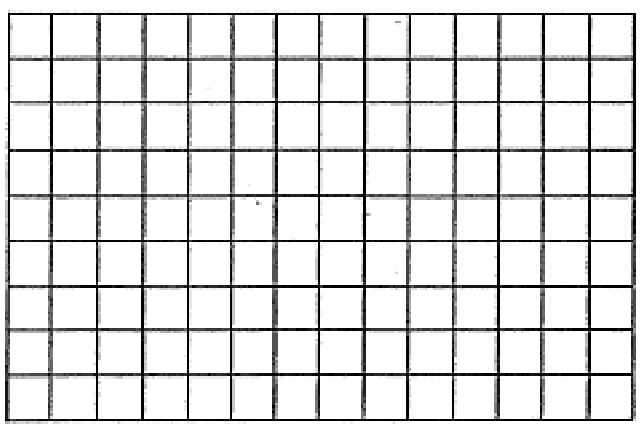
Mold dimensions: Diam. ______________ Ht. ______________ Vol. ______________

Water Content Determination

Sample no.	1		2		3		4		5		6	
Moisture can no.												
Wt. of can + wet soil												
Wt. of can + dry soil												
Wt. of water												
Wt. of can												
Wt. of dry soil												
Water content, w%												

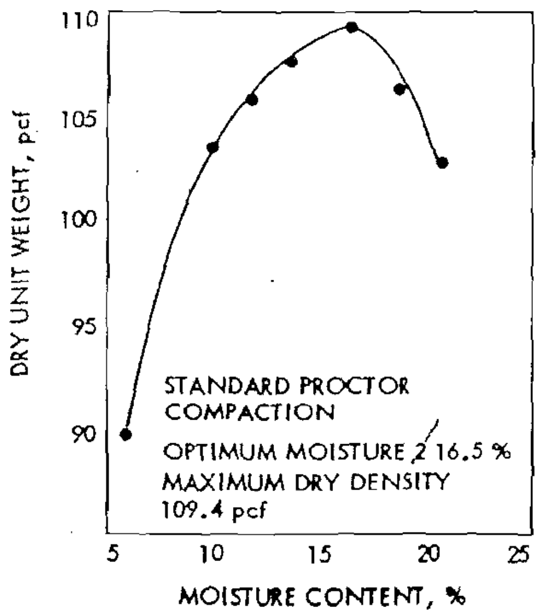
Density Determination

Assumed water content						
Water content, w%						
Wt. of soil + mold						
Wt. of mold						
Wt. of soil in mold,						
Wet density,						
Dry density γ,						



Optimum moisture = ____________% Maximum dry density = ____________

WESTERN IOWA LOESS PROPERTIES



*Data from Davidson et al. 1960

PLASTICITY INDEX -- 5.7 %*
AASHO CLASSIFICATION -- A-4(8)*
SPECIFIC GRAVITY -- 2.70
IN-PLACE DRY DENSITY -- 82-85 pcf
FIELD MOISTURE CONTENT — 7-10 %

Soil texture and plasticity data

No.	Description	Sand	Silt	Clay	LL	PI
1	Well-graded loamy sand	88	10	2	16	N.P.
2	Well-graded sandy loam	72	15	13	16	N.P.
3	Med-graded sandy loam	73	9	18	22	4
4	Lean sandy silty clay	32	33	35	28	9
5	Lean silty clay	5	64	31	36	15
6	Loessial silt	5	85	10	26	2
7	Heavy clay	6	22	72	67	40
8	Poorly graded sand	94	— 6 —		N.P.	—

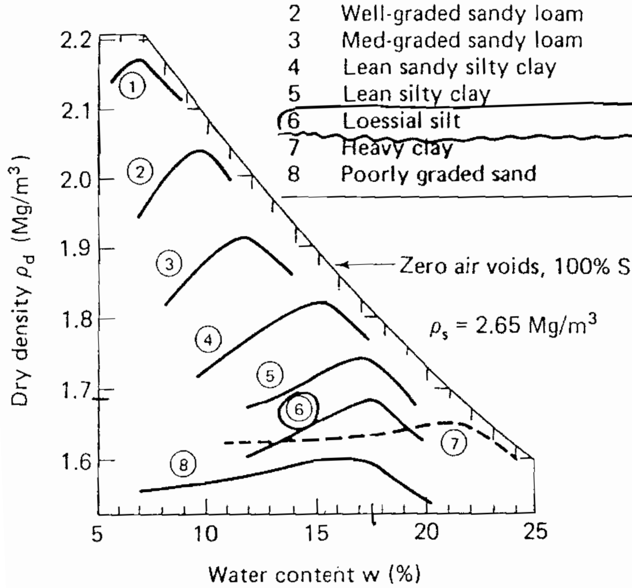


Fig. 5.2 Water content-dry density relationships for eight soils compacted according to the standard Proctor method (after Johnson and Sallberg, 1960).