2019

Optimum Moisture Content and Maximum Dry Unit Weight for Compaction of Interdisciplinary Science Center Soil

Rachel A. Lunstroth
rachellunstroth@gmail.com

Maria Camilla O'Toole
Eastern Washington University, Cami.otoole@gmail.com

Melissa Simbler
Eastern Washington University, m.dc1896@hotmail.com

Optimum Moisture Content and Maximum Dry Unit Weight for Compaction of Interdisciplinary Science Center Soil

Rachel Lunstroth, Maria O'Toole, Melissa Simbler; Dr. Richard Orndorff

Abstract

Eastern Washington University's is currently undergoing construction with the addition of the Interdisciplinary Science Center. A soil sample was collected from the construction site and over the course of Fall Quarter 2018 we performed a series of tests on this soil allowing us to classify the soil based on the Unified Soil Classification System. These tests include: a specific gravity determination test according to the American Society for Testing and Materials (ASTM) standard D854, a sieve and hydrometer analysis according to the ASTM standard D422, and an Atterberg limits test according to the ASTM standard D-4318. We also performed a compaction test according to the ASTM standard D698 in which we determined the soils optimum water content, the maximum dry unit weight, and the allowable range for water content for compaction. We found that the optimum water content for compaction is 16.5%.

Site Location

Eastern Washington University is currently building an addition to the science building, the Interdisciplinary Science Center (ISC). Prior to construction, this location was used as a student recreational area. The water table and the water content fluctuates in this area seasonally with the help of a nearby natural spring.

Fig.1- A photograph of the ISC construction site taken on October 16, 2018.

Unified Soil Classification System Tests

- Liquid Limit: 33%
  - ASTM D-4318
- Plastic Limit: 23%
  - ASTM D-4318
- Plasticity Index: 10%
  - ASTM D
- Sieve Analysis: 0% gravel, 49% sand, 51% fines
  - ASTM D-422
- Specific Gravity: 2.34
  - ASTM D-854
- USCS Classification: CL (Low Liquid Limit Clay)

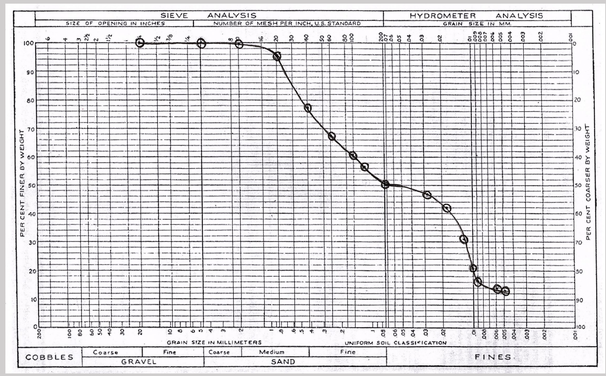

Fig. 2 – Particle size distribution chart for the ISC soil using the ASTM grain-size scale.

Fig. 3 - Maria holding the 5.5 pound compaction hammer, used to deliver 25 blows per lift. The bin contains the ISC soil.

Methods

We performed a standard proctor compaction test on soil sample ISC according to ASTM standard D698 in order to find the optimum water content and the max dry unit weight.

1. We weighed 7.00 lbs of ISC soil that was less than #4 sieve
2. We prepared and weighed five drying pans
3. 5% water content was calculated to be 0.35 lbs. of water, which was then added to the soil and mixed till the soil was homogenous
4. The weight of the cylinder and the base of the mold was taken and recorded. The collar was added to the mold and soil was added in.
5. Soil was added to the compaction mold in three even lifts, to get the final compacted soil to be a quarter of an inch above the collar
6. We compacted the soil by dropping a compaction hammer twenty-five times per lift in a star pattern.
7. We removed the collar and, using a straight edge, trimmed the soil flat, and cleaned off the mold with a brush.
8. The weight of the soil, cylinder, and base was taken and recorded. We then removed the base.
9. A hydraulic device was used to extrude the soil from the cylinder
10. We sampled equal amounts of soil from all three lifts into a single pan, weighed it and placed it in the oven to dry
11. Once the soil was dry we measured the final weight
12. This process was then repeated for 10%, 15%, 20%, and 25% water contents.
13. We plotted water content (%) vs. dry unit weight (pcf) to determine the optimum water content for compaction and max dry unit weight.

Fig. 4- Rachel and Melissa working together using a hydraulic system to extrude the compacted soil from the cylinder.

Fig. 5- The compacted soil, with super imposed lines showing the three lifts.

Fig. 6- Maria and Rachel are working together taking samples from all three lifts for the drying pan.

Results

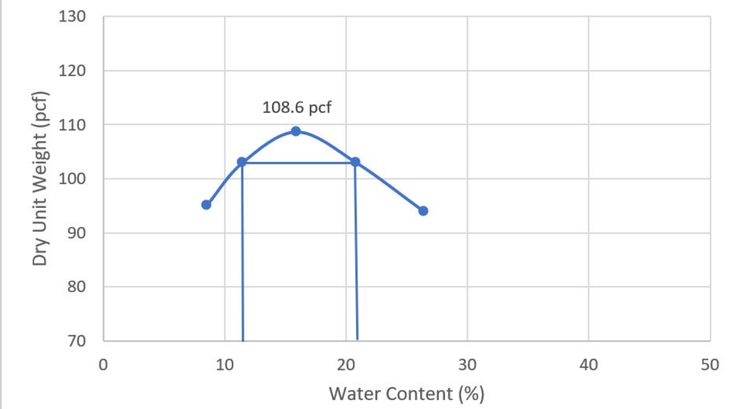

Fig. 7- Plot dry unit weight versus water content. Allowable range for the optimum water content for compaction was 11.5% - 20.5%. This range results in 95% or greater maximum dry unit weight.

Weight wet/soil	12.88	13.26	13.64	13.58	13.4
Cylinder (lbs.)	9.44	9.44	9.44	9.44	9.44
Weight Cylinder (lbs.)	3.44	3.82	4.2	4.14	3.96
weight wet soil (lbs.)	3.17	3.43	3.62	3.43	3.13
weight dry soil (lbs.)	1/30	1/30	1/30	1/30	1/30
volume cylinder (Ft^3)	130.2	114.6	126.0	124.2	118.8
Unit wet weight ($lbs./Ft^3$)	95.1	102.9	108.6	102.9	93.9
Pan #	**PPG 1**	**PPG 2**	**PPG 3**	**PPG 4**	**PPG 5**
W_P (G)	13.19	13.15	13.25	13.06	13.18
W_{PSM} (G)	46.5	65.96	52.75	53.83	64.49
W_{PS} (G)	43.88	60.53	47.32	46.79	53.76
W_S (G)	30.69	47.38	34.07	33.73	40.58
W_W (G)	2.62	5.43	5.43	7.04	10.73
Water Content %	**8.54%**	**11.47%**	**15.94%**	**20.87%**	**26.44%**

Table 1- Compaction test results

Conclusion

We performed the standard proctor compaction test according to the ASTM standard D698 on the ISC soil. The calculated optimum water content for compaction is 16.5% and the maximum dry unit weight is 108.6 pcf. Since field conditions can never insure optimal moisture conditions there is an allowable range that is used by to achieve at least 95% of the maximum dry unit weight. The allowable range (Figure 1) for water content for compaction is between 11.5% and 20.5% to acheieve at least 95% of max dry unit weight.

Reference for compaction:
ASTM D698-12e2, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3 (600 kN-m/m^3)), ASTM International, West Conshohocken, PA, 2012.