CE 34500: Transportation Engineering
Homework 7
Due: Monday, April 27, 2020

Problem 1: A moist soil has a moisture content of 12.5%, weights 43.2 Ib, and occupies a volume of 0.35 ft^3. The specific gravity of the soil particles is 2.6. Find:

a) bulk density
b) dry density
c) void ratio
d) porosity
e) degree of saturation
f) volume occupied by water

Solution:

a) bulk density: $\boldsymbol{\gamma = \frac{W}{V} = \frac{43.2}{0.35} = 123.4\ Ib/ft^3}$
b) dry density: $\boldsymbol{\gamma_d = \frac{\gamma}{1+w} = \frac{123.4}{1+0.125} = 109.7\ Ib/ft^3}$
c) void ratio: $\boldsymbol{e = \frac{(1+w)*G_s*\gamma_w}{\gamma} - 1} = \frac{(1+0.125)*2.6*62.4}{123.4} - 1 = 0.479$
d) porosity: $\boldsymbol{e = \frac{e}{1+e} = 0.324}$
e) degree of saturation $= \boldsymbol{w * \frac{G_s}{V} = 67.8\%}$
f) volume occupied by water:

$$\boldsymbol{W_w = \frac{w}{1+w} * W = 4.8}$$

$$\boldsymbol{V_w = \frac{W_w}{\gamma_w} = \frac{4.8}{62.4} = 0.0769}$$

Problem 2: The following results were obtained by a mechanical analysis. Classify the soil using the AASHTO classification system and give the group index.

Sieve analysis, % finer			LL	PL
No. 10	No. 40	No. 200		
98	81	38	42	23

Solution:

Use Table 17.1 to classify this soil. Since more than 35% of the material is passing No. 200 sieve, the liquid limit is greater than 41, the plasticity index is greater than 11, the soil is Group A-7.

Since the plasticity index (19) is greater than the liquid limit minus 30, the subgroup is A-7-6.

Determine the Group Index using Equation 17.18.

GI = (F – 35)[0.2 + 0.005(LL – 40)] + 0.01(F – 15)(PI – 10) GI = (38 – 35)[0.2 + 0.005(42 – 40)] + 0.01(38 – 15)(19 – 10) GI = 2.7; use GI = 3

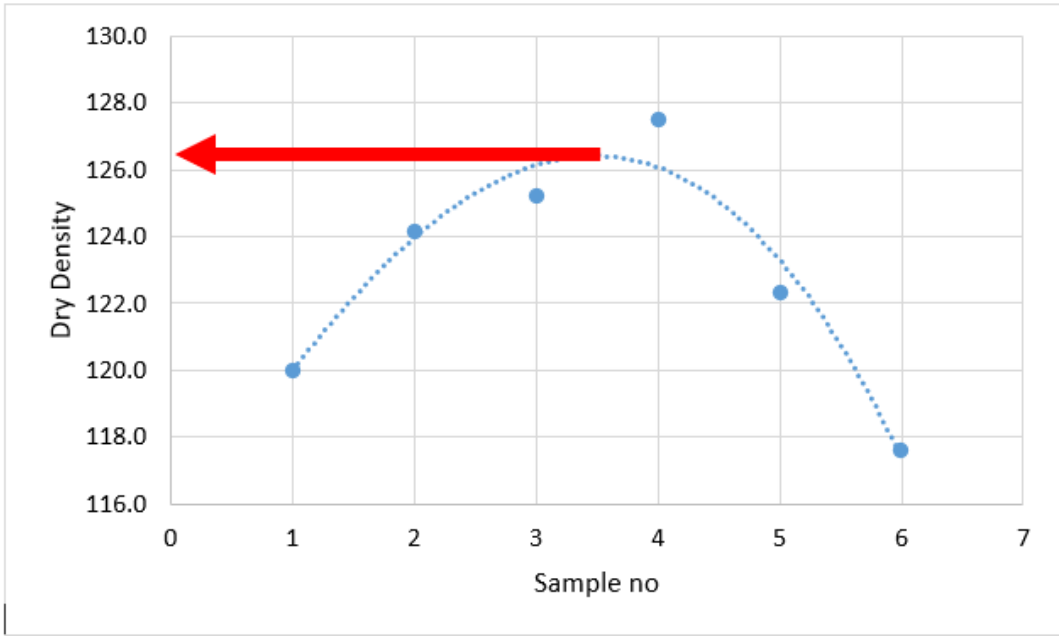
The soil can be classified as A-7-6(3).

Problem 3: The table shows results obtained from a standard AASHTO compaction test on six dry samples, 4 in. diameter, of a soil to be used as fill for a highway. Determine the maximum dry density and the optimum moisture content of the soil.

Sample no	Weight compacted soil, W (Ib)	Moisture Content, w (%)
1	4.16	4
2	4.39	6.1
3	4.5	7.8
4	4.68	10.1
5	4.57	12.1
6	4.47	14.0

Solution:

Sample no	Weight compacted	Moisture Content	Bulk Density, Ib,ft^3	Dry Density
1	4.16	4	124.8	120.0
2	4.39	6.1	131.7	124.1
3	4.5	7.8	135	125.2
4	4.68	10.1	140.4	127.5
5	4.57	12.1	137.1	122.3
6	4.47	14	134.1	117.6



Maximum Dry Density: 126.5 Ib per ft^3.

Problem 4: Interstate Highway (4 lanes both direction) with AADT of 6000 in one direction takes a week for water to be drained from pavement and pavement will be exposed to moisture levels approaching saturation for 30% of the time.

Resilient modulus of asphalt concrete at 68°F = 450,000 lb/in^2
CBR base = 100, M_r = 31,000 lb/in^2
CBR subbase = 22, M_r = 13,500 lb/in^2
CBR of subgrade = 6

Determine suitable pavement structure. Use the tables from your book or handouts.

Solution:

Layer coefficients using figures provided in the handout, $a_1 = 0.44,\ a_2 = 0.14, a_3 = 0.1$
Drainage coefficient, $m = 0.8$

Calculation of ESAL:

Traffic on Design Lane = 0.45*(6000) = 2700
Assume, 90% of traffic are passenger car, and rest are trucks. So, Passenger cars =0.9*2700= 2430
Trucks = 0.1*5400 = 270.
ESAL value for 1 passenger car = 0.0007, trucks = 1.35.
Total ESAL for a year = (2430*.0007+270*1.35)*365= 133664
Total ESAL for 20 years assuming 4% growth = $133664 * ((1 + .04)^{20} - 1) / (0.04) = 3.98X10\text{^}6$
Assume, reliability for interstates = 95 and overall standard deviation= 0.5.

$$M_r for\ roadbed\ soil = 1500 * 6 = 9000$$

Assume, $\Delta PSI = 2.5$.
So, SN from nomograph, Figure 19.10: 4.5
Assume, minimum thickness for AC= 3 inch and Base = 6 in. (using Table 19.11)

$$D_1 * a_1 + D_2 * a_2 * m + D_3 * a_3 * m = 4.5$$

$$=> 3 * .44 + 6 * .14 * .8 + D_3 * .1 * .8 = 4.5$$

$$D_3 = 32\ inch.$$

So, the thickness of AC = 3 inch, Base = 6 inch, Subbase = 32 inch.