Pavement Materials

1–1. List the main soil types. Describe how they differ with regard to (a) grain size, (b) grain shape, and (c) forces between grains.

1–2. Surface properties of the grain are more important in clays than in silts. Why?

1–3. How do the grain structures differ between deposits of clay and deposits of sands? Why?

1–4. Why do clays absorb a relatively large quantity of water?

1–5. List five methods of testing for silt and clay in the field. Describe how you would tell the difference between silt and clay.

1–6. **a.** The mass of a quantity of water is 32.7 g. What is its volume in cm^3?
b. The volume of a quantity of water is 0.42 cm^3. Find its mass in g.

1–7. Find density, dry density, void ratio, water content, porosity, and degree of saturation:
a. Total mass = 89.3 g, mass of water = 21.4 g, total volume = 49.3 cm^3, RD = 2.66.
b. Volume = 1.00 cm^3, mass of water = 0.49 g, dry mass = 1.32 g, RD = 2.70.

1–8. A soil sample is 5.08 cm in diameter and 47.3 mm high. Find volume in cm^3. Also find density (g/cm^3) if its mass is 137.33 g.

1–9. Mass of soil plus container = 241.13 g.
Mass of container = 106.72 g.
Mass of dry soil plus container = 188.73 g.
Find water content of the soil in usual terms.

1–10. A sample of soil has a mass of 183.4 g. After drying, its mass is 126.2 g. The total volume was measured as 112.2 cm^3. The relative density of the soil solids is 2.66. Find density, dry density, water content, and void ratio.

1–11. A sample of soil has a mass of 1.693 kg. The water content is 84.4%. Find dry mass.

1–12. Density of a soil is 1.96 g/cm^3, dry density 1.68 g/cm^3, RD 2.65. Find water content, void ratio, porosity, and degree of saturation.

1–13. Find dry density, void ratio, and porosity:
a. Total mass is 101.4 g, total volume is 55.1 cm^3, water content is 28.5%, and RD is 2.70.
b. Density is 2.27 g/cm^3, water content is 8.5%, and RD is 2.64.

1–14. The relative density of soil solids for a sand is 2.68. Find the dry density of the sand if it is deposited with a void ratio of 0.90.

1–15. A saturated soil sample (S = 100%) contains 33.4 g of soil solids and 41.6 g of water. The total volume of the sample is 54.1 cm^3. Find water content, density, and relative density of the soil solids.

1–16. Following are the results of a sieve analysis on a granular soil:

Sieve	*Retained Mass*
12.5 mm (1/2 in.)	0 g
9.5 mm (3/8 in.)	74.5 g
4.75 mm (No. 4)	217.1 g
2.36 mm (No. 8)	192.3 g
1.18 mm (No. 16)	75.8 g
300 μm (No. 50)	116.9 g
75 μm (No. 200)	83.2 g
Pan	47.4 g

Complete the calculations for the grain-size distribution curve and plot the results. Calculate the percent of gravel, sand, and fines. Calculate the effective size and uniformity coefficient.

1–17. Results of a grain-size test are:

Pass 19 mm (3/4 in.)	100%
9.5 mm (3/8 in.)	82%
2.36 mm (No. 8)	61%
0.60 mm (No. 30)	52%
0.15 mm (No. 100)	36%
0.06 mm	22%
0.01 mm	16%
0.002 mm	11%

Find the percent of gravel, sand, silt, and clay.

1–18. Results of grain-size analysis tests for three soils, X, Y, and Z are:

Soil X Size	*% Passing*	*Soil Y Size*	*% Passing*	*Soil Z Size*	*% Passing*
19 mm (3/4 in.)	100	9.5 mm (3/8 in.)	100	4.75 mm (No. 4)	100
9.5 mm (3/8 in.)	97	4.75 mm (No. 4)	97	0.60 mm (No. 30)	99
2.36 mm (No. 8)	68	1.18 mm (No. 16)	72	0.15 mm (No. 100)	95
0.60 mm (No. 30)	35	0.60 mm (No. 30)	52	0.075 mm (No. 200)	91
0.15 mm (No. 100)	13	0.30 mm (No. 50)	44	0.04 mm	87
0.05 mm	6	0.15 mm (No. 100)	39	0.02 mm	79
0.01 mm	3	0.075 mm (No. 200)	31	0.01 mm	64
		0.05 mm	22	0.005 mm	57
		0.02 mm	6	0.002 mm	46

Plot grain-size distribution curves.
Find—for soils X, Y, % gravel, sand, fines, D_{10}, C_u, C_c
—for soil Z, % gravel, sand, silt, clay

1–19. Results of a sieve analysis are:

Sieve	*Mass Retained*	*Find:*
9.5 mm (3/8 in.)	0	(a) % gravel
4.75 mm (No. 4)	173 g	(b) % fines (silt and clay)
1.18 mm (No. 16)	104 g	(c) % coarser than 0.30 mm
0.30 mm (No. 50)	216 g	(No. 50).
0.075 mm (No. 200)	97 g	
Pan	32 g	

1–20. A soil has a plastic limit of 27 and a liquid limit of 38. Find the index of plasticity for this soil. Describe the soil. If its natural moisture content is 40%, how would you describe its consistency in the field?

1–21. A soil has a plasticity index of 14.7. It can be rolled to a thread at a water content of 33.1%. The water content in the field is 46%. Find the Atterberg Limits. Describe condition of the soil in the field.

1–22. Classify soils *A* to *R* in Figure 1–30
a. according to the Unified System.
b. according to the AASHTO System.

1–23. What are the two main properties measured in laboratory tests to identify and classify soils?

1–24. What tests are used in determining grain-size distribution in soils? When is each test used?

1–25. For soil *A*, $w_L = 35$, $w_P = 26$. For soil *B*, $w_L = 63$, $w_P = 36$. Samples of the two soils are taken in the field. Their natural moisture contents are 41% for soil A and 58% for soil *B*. Which soil is softer? Why? Describe the consistency of each.

1-26 Solve for indicated values:

a. $W_W = 31.5$ lb, $V_W =$ ft^3

b. $W_S = 4.04$ lb, $G_S = 2.68$, $V_S =$ ft^3

c. $V_S = 0.613$ ft^3, $G_S = 2.71$, $W_S =$ lb

d. $V_W = 0.010$ ft^3, $W_W =$ lb

e. $W_S = 118$ lb, $V_S = 0.703$ ft^3, $G_S =$

1-27 The volume of a container is 0.40 ft^3. It holds 43 lb of dry sand, which has a specific gravity of 2.65. Find the void ratio and unit weight.

1-28 The unit weight of a soil is 122 lb/ft^3 at a water content of 12.6%. The specific gravity of the soil is 2.72. Find the dry unit weight, porosity, and degree of saturation.

1-29 The unit weight of a fully saturated organic soil is 79 lb/ft^3. A sample of it with a mass of 161.2 g is dried, and the dry mass is 52.3 g. Find the water content and dry unit weight of the soil and the specific gravity of the soil particles.

1-30 The unit weight of a soil being used in a highway fill is 126 lb/ft^3, and the dry unit weight is 112 lb/ft^3. If the specific gravity of soil solids is 2.65, find the water content, void ratio, and degree of saturation.

1-31 Soil in a highway is compacted to a unit weight of 133 lb/ft^3. A sample of it is tested for water content. The original mass was 163.5 g and the dried mass was 140.4 g. Find the dry density of the highway soil.

1-32 The unit weight of a soil is 114 lb/ft^3. A sample is tested for water content as follows:

weight of soil + beaker 228.41 g

weight of dry soil + beaker 197.94 g

weight of beaker 104.17 g

Find the water content and dry unit weight.

1-33 The dry unit weight of a soil in the field is 98 lb/ft^3. Lab tests indicate that its maximum dry unit weight is 113 lb/ft^3 and minimum dry unit weight is 89 lb/ft^3. Find the relative density.

1-34 If the specific gravity of the soil particles in Problem 1–70 is 2.65, find e, e_{max}, and e_{min}, and check the relative density calculation.

1-35 The soil in Problem 1–70 is densified by a vibrating probe in the field to a relative density of 80%. Find the dry unit weight of the soil after compaction. Also calculate its total unit weight if the water content is 11%.

1-36 A cofferdam is built as shown to allow construction along the shore. The dam is 28 ft wide at the bottom and underlaid by 3.0 ft of sand with $k = 0.0029$ ft/s. The head difference is 3.5 ft. Find the seepage in (a) ft^3/hr per linear foot and (b) gallons/hr for the whole dam. Assume that the length of flow path is 28 ft.

1-37 Design soil filters for soils C and G given in Figure I-30

Size \ Soil	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R
38 mm (1½ in.)			100										100			
19 mm (3/4 in.)	100		85				100			100	100					
9.5 mm (3/8 in.)	95		72					100					80			
4.75 mm (No. 4)	86			100			87	94		71	51		51			
2.00 mm (No. 10)	71	100	51			100	72						40			
850 μm (No. 20)	57	91	44	82			55	66	100				29		100	
425 μm (No. 40)	46	70	39	77	100	73		41		42	29	100	22			
150 μm (No. 100)	33	20		57			36	18					13	100	82	
75 μm (No. 200)	26	8	32	40	81	56	33	10	89	27	3	66	9	93	70	100
Limits																
w_L	30		42	41	61	48	35		39	32		33	13		41	82
I_P	18	N.P.	11	10	36	8	8	N.P.	22	19	N.P.	5	3	N.P.	8	50

Figure 1–30 Grain-size distribution (% passing each sieve) and Atterberg Limits.