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Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Click here to download immediately!!! Name: Introduction to Geotechnical Engineering Author: Holtz Kovacs Edition: 2nd ISBN-10: 0132496348 Type: Solutions Manual - The file contains solutions and questions for all chapters and all issues. All files are carefully checked and accuracy is ensured. This is the sample chapter CHAPTER 2 INDEX AND CLASSIFICATION PROPERTIES OF SOILS 2-1. Draw a phase diagram from memory (for example, Fig. 2.2, but don't look first!). The phases have the volume side and the Mass side. Mark all components. SOLUTION: See Figure 2.2. 2-2. From memory, write definitions of water content, void ratio, dry density, wet or wet density, and saturated density. SOLUTION: See section 2.2. 2-3. Assuming ρs = 2,7 mg/m, the saturated density range in Table 2.1 shall be subtracted for six soil types and the range calculated/estimated in the empty ratios to be expected for those soils. 3 SOLUTION: Create a table using input values from Table 2.1 and Eq. 2.18. (Given) ρ' - min 3 ρ' - max (see Eq. 2.18) emax emin 3 (Mg/m) (Mg/m) 0.9 1.4 0.89 0.21 0.4 1.1 3.25 0.55 1.1 1.4 0.55 0.21 0.9 1.2 0.89 0.42 0.0 0.1 ∞ 16.00 0.3 0.8 4.67 1.13 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 3 2-4. Prepare a table chart of dry density in 3Mg / m as coordinates versus water content as a percentage as abscissa. Suppose ρs = 2.65 Mg/m and change the saturation rate, S, from 100% to 40% in 10% increments. A maximum water content of 50 % should be adequate. SOLUTION: Solve Eq. 2.12 and Eq. 2.15 for ρd = f(ρs, w, S, Gs) or use Eq. 5.1. ρ dry ρwS = w+ ρw S ρs s= 100 90 80 70 60 50 40 30 20 20 w ρdry ρdry ρdry ρdry ρdry ρdr (Mg/m3) (Mg/m3) (Mg/m3) (Mg/m3) (Mg/m3) (Mg/m3) (Mg/m3) (Mg/m3) (Mg/m3) 0.0 2.65 2.65 2.65 2.65 2.65 2.65 2.65 2.65 2.65 5.0 2.34 2.31 2.27 2.23 2.17 2.09 1.99 1.84 1.59 1.14 10.0 2.09 2.05 1.99 1.92 1.84 1.73 1.59 1.41 1.14 0.73 15.0 1.90 1.84 1.77 1.69 1.59 1.48 1.33 1.14 0.89 0.53 20.0 1.73 1.67 1.59 1.51 1.41 1.29 1.14 0.96 0.73 0.42 25.0 1.59 1.53 1.45 1.36 1.26 1.14 1.00 0.83 0.61 0.35 30.0 1.48 1.41 1.33 1.24 1.14 1.02 0.89 0.73 0.53 0.30 35.0 1.37 1.31 1.23 1.14 1.04 0.93 0.80 0.65 0.47 0.26 40.0 1.29 1.22 1.14 1.05 0.96 0.85 0.73 0.58 0.42 0.23 45.0 1.21 1.14 1.06 0.98 0.89 0.78 0.67 0.53 0.38 0.21 50.0 1.14 1.07 1.00 0.92 0.83 0.73 0.61 0.49 0.35 0.19 S=100% S=90% S=80% S=70% S=60% S=50% S=40% S=30% S =20% S=10% Problem 2-4 3.00 ρdry (Mg/m3) 2.50 2.00 1.50 1.00 0.50 0.00 0 5 10 15 20 25 30 w (%) 35 40 45 50 Introduction to geotechnical Holtz Kovacs 2nd Edition Solutions Manual 55 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 3 2-5a Prepare a graph like this in issue 2.4, use only dry density units kN/m and pounds per cubic foot. ρwS ρ SOLUTION: From Eq. 2.12 and Eq. 2.15: ρ = dry w w+ S ρs S= 100 90 80 70 60 50 40 30 20 10 w γdry γdry γdry (%) (kN/m3) (kN/m3) (kN/m3) (kN/m3) (kN/m3) (kN/m3) (kN/m3) (kN/m3) (kN/m3) 0.0 26.00 26.00 26.00 26.00 26.00 26.00 26.00 26.00 26.00 5.0 22.95 22.66 22.30 21.86 21.29 20.55 19.53 18.03 15.64 11.18 10.0 20.55 20.08 19.53 18.86 18.03 16.99 15.64 13.80 11.18 7.12 15.0 18.60 18.03 17.37 16.58 15.64 14.48 13.04 11.18 8.70 5.23 20.0 16.99 16.36 15.64 14.79 13.80 12.62 11.18 9.40 7.12 4.13 25.0 15.64 14.97 14.22 13.36 12.35 11.18 9.79 8.10 6.03 3.41 30.0 14.48 13.80 13.04 12.17 11.18 10.04 8.70 7.12 5.23 2.90 35.0 13.49 12.80 12.04 11.18 10.21 9.11 7.83 6.35 4.61 2.53 40.0 12.62 11.94 11.18 10.34 9.40 8.33 7.12 5.73 4.13 2.24 45.0 11.86 11.18 10.44 9.62 8.70 7.68 6.53 5.23 3.73 2.01 50.0 11.18 10.52 9.79 8.99 8.10 7.12 6.03 4.80 3.41 1.82 S=100% Problem 2-5a S=90% 30.00 S=80% S=70% S=60% 25.00 S=50% S=40% S=30% γ dry (kN/m3) 20.00 S=20% S=10% 15.00 10.00 5.00 0.00 0 5 10 15 20 25 30 35 40 45 w (%) Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 50 55 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2-5b Prepare a graph like this in problem 2.4, use only dry density units pounds per cubic foot. = Gs γ w S SOLUTION: γ dry S= w S + Gs w 100 90 80 70 60 50 40 30 20 10 γdry γdry γdry γdry γdry γdry γdry γdry (%) (pcf) (pcf) (pcf) (pcf) (pcf) (pcf) (pcf) (pcf) (pcf) 0.0 165.36 165.36 165.36 165.36 165.36 165.36 165.36 165.36 165.36 5.0 146.01 144.14 141.86 139.04 135.45 130.72 124.21 114.70 99.46 71.12 10.0 130.72 127.75 124.21 119.95 114.70 108.08 99.46 87.80 71.12 45.30 15.0 118.33 114.70 110.47 105.47 99.46 92.12 82.94 71.12 55.35 33.24 20.0 108.08 104.07 99.46 94.11 87.80 80.27 71.12 59.77 45.30 26.25 25.0 99.46 95.25 90.45 84.96 78.59 71.12 62.25 51.54 38.34 21.69 30.0 92.12 87.80 82.94 77.43 71.12 63.85 55.35 45.30 33.24 18.48 35.0 85.79 81.44 76.58 71.12 64.95 57.92 49.83 40.41 29.33 16.09 40.0 80.27 75.93 71.12 65.77 59.77 53.00 45.30 36.48 26.25 14.26 45.0 75.42 71.12 66.39 61.16 55.35 48.85 41.53 33.24 23.75 12.79 50.0 71.12 66.89 62.25 57.16 51.54 45.30 38.34 30.53 21.69 11.60 Problem 2-5b S=100% S=90% S=80% 180.00 S=70% S=60% 160.00 S=50% S=40% 140.00 S=30% S=20% 120.00 γ dry (pcf) S=10% 100.00 80.00 60.00 40.00 20.00 0.00 0 5 10 15 20 25 30 35 40 w (%) Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 45 50 55 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions 2.6. Prepare such a graph in problem 2.4 only for S = 100% and change the density of solids 3 from 2.60 to 2.80 mg/m . You can decide the size of the increments that you need to satisfactorily evaluate the relationship as ρs vary. Prepare a final report on your observations. SOLUTION: From Eq. 2.12 and Eq. 2.15: ρ = dry ρwS w + ρw S ρs Note: The relationship between ρdry and w is not very sensitive to ρs. ρs = 2.6 2.65 2.7 2.75 2.8 w ρdry ρdry ρdry ρdry ρdry ρdry ρdry ρdry (%) (Mg/m) (Mg/m) (Mg/m) (Mg/m) (Mg/m) 0.0 2.60 2.65 2.70 2.75 2.80 5.0 2.30 2.34 2.38 2.42 2.46 10.0 2.06 2.09 2.13 2.2,2,0 216 2.19 15.0 1.87 1.90 1.92 1.95 1.97 20.0 1.71 1.73 1.75 1.77 1.79 25.0 1.58 1.59 1.77 7961 1.63 1.65 30.0 1.46 1.48 1.49 1.51 1.52 35.0 1.36 1.37 1.39 1.40 1.41 40.0 1.27 1.39 1.40 1.41 40.0 1.27 1.40 129 1.30 1.31 1.32 45.0 1.20 1.21 1.22 1.23 1.24 50.0 1.13 1.14 1.15 1.16 1.17 25 30 w (%) 35 3 3 3 3 3 3.00 2.50 ρs

(Mg/m3) 2.00 1.50 1.00 0.50 0.00 0 0 0 0 0 5 10 15 20 40 45 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 50 55 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.7. The dry density of compacted sand is 1,87 mg/m and the density of solids is 2,67 3 Mg/m . What is the water content of the material when it is saturated? SOLUTION: ρw S ρ Eq. 2-12 and Eq. 2-15: ρdry = w + Solution for w: w = ρ S w (1 1 ⎞ − S 3 ⎛ ρ dry (1 1 ⎞ with 1.87 Mg / m ⎞ ⎟) ⎞ − = (1Mg / m)(100%) ⎢ ⎥ \ w ps ; Note: S = 100% = 16.0% 2.67Mg / m3 3 ⎝ ⎟ ⎝ 2.8. The soil, which is completely full, has a total density of 2045 kg/m and a water content of 24%. What is the density of solids? What is the dry density of the soil? SOLUTION: a) Solve using equations or phase diagrams: ρ = 2045 = 1649.2 kg / m3 = ρ dry (1+ w) (1+ 0.24) ⎛ ρ ⎞ = ⎢ 1− w ⎟ ρ +ρ sat ρ = s ⎝ ρs ⎠ dry ρw ρdry ρdry + ρw − ρsat w = (1000)(1649.2) (1649.2 + 1000 − 2045) = 2729.6 kg / m3 b) Solve using phase diagram relationships: assume Vt = 1.0 Mt = 2045 kg Mw = 0.24 → M = 0.24M Ms w s Mt = Mw + Ms → 2045 = 0.24Ms + Ms → Ms = 1649.19 kg 0.24Ms M = 0.3958 m3 ρ = 1000 = w → V = w w 1000 Vw Ms 3 ρ = = 1649.19 = 2729.6 kg / m3 s An Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual An Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Vs 1− 0.3958 1649.19 M = 1649.2 kg / m3 = s = ρ dry Vt 1 An Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual An Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 3 2.9 What is the water content of fully saturated soil with a dry density of 1.72 Mg/m ? Suppose ρs = 2.72 mg/m3. SOLUTION: ρw S ρ ρ By Eq. 2-12 and Eq. 2-15: ρdry = w Solution for w: w = ρ S ⎛ 1 1 ⎞ − ρs S ⎛ 3 ⎛ ρ ⎞ ⎟ with ⎞ 2.72 Mg / m3 3 Mg / m ⎟ ⎠ = 21.4% − ρ dry ⎞ 11 = (1Mg / m)(100%) ⎢ w w ; Note: S = 100% ⎝ ⎠ 3 2.10. Dry quartz sand has a density of 1,68 mg/m . Determine its density when the degree of saturation of the system is 75%. The density of solids for quartz is 2,65 mg/m . SOLUTION: Recognize that ρdry (initial) = ρdry (final); S final) = 75% Z Eq. 2-12 and Eq. 2-15: ρdry = ρw S ρ ρ w + Solution for w: w = ρ S ⎛ 1 1 ⎞ − w ρs S ⎛ ρ ⎞ 3 1 1 = (1Mg / m) 0.75 ⎛ 1.68 Mg / m ⎞ ⎟ ⎝ ⎠ = 16.34% → ρ = ρ 3 2.65 Mg / m3 1.68 Mg / m ⎞ ⎢ ⎝ ⎢ ⎥ dry 3 final ρ ρ t = ρdry (1+ w) ρ t = 1.68 (1+ 0.1634) = 1.95 Mg / m3 ⎟ 3 2.11. The dry soil density is 1.60 mg/m and the specific solids are 2.65 mg/m . Find (a) the water content, (b) the ratio penetrated and (c) the total density when the soil is saturated. SOLUTION: Because: S = 100% Eq. 2-12 and Eq. 2-15: ρdry = ρw S ρ w pss S ρ w⎛ 1 w ρss Eq. 2-15 Solution for w: w Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual = ρS Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 1 ⎞ − 3 ⎛ (1Mg / m)(100%) ⎛ 1 ⎞ 24,76 % − w ⎢ ρ⎥ ⎢ ρ ⎥ ⎥ dry with ⎞ wp (b) Z Eq. 2.15: e =s = (24.76)(2.65) = 0.656 (100)(1.0) Sp w 3 2.65 Mg / m ⎞ 1.60 Mg / m ⎟ (c) ρ t = ρdry (1+ w) = 1.60 (1+ 0.2476) = 1.996 = 2.00 Mg / m3 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.12. The natural deposit of the soil is found to have a water content of 20% and is 90% soil-based. What is the ratio of emptiness of this soil? SOLUTION: w = 20% and S = 90%; assume Gs = 2.70 from Eq. 2.15: e = wρ with Sρw = (20.0)(2.70) = 0.60 (90)(1.0) 3 2.13. The piece of soil has a wet weight of 62 lb and a volume of 0.56 ft . When drying in the oven, the soil weighs 50 pounds. If the specific mass of solids are 2,64, the water content, the weight in the wet, the weight of the dryer and the ratio of the soil void shall be determined. SOLUTION: Solve using phase diagram relationships. (a) Ww = Wt − Ws = 62 − 50 = 12 lb W 12(100) w = w × 100% = = 24.0% 50 Ws 62 = 110.7 k sf (b) γ = Wt = t (c) dry γ Vt 0.56 Ws 50 = 89.29 pcf = = Vt 0.56 (d) Vw = Ww = 12 = 0.56 01923 ft 3 62.4 γw Vs = Ws 50 = 0.3035 ft 3 Gs γ w = (2.64)(62.4) V = Vt − Vw = 2 60.56 − 0.3035 = 0.2565 v = = 0.8451 = 0.84 Vs 0.3035 2.14. In the laboratory, the container with the soil was 113,27 g before it was placed in the oven and 100,06 g after the soil had dried. The container itself weighed 49.31 g. The specific weight of solids is 2.80. Determine the ratio of void to water content in the original soil sample. SOLUTION: Solve using phase diagram relationships. M = 100.06 − 49.31 = 50.75 g Mw = 113.27 − 100.06 = 13.21 g Introduction to Geotechnical Engineering Holtz Kovacs 2. Solution Guide Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual (a) w = Mw ×100% = 13.21(100) = 26.03 = 26.0% 50.75 ρ w 2.80(26.03) (b) From Eq. 2.15: e= s = 0.7288 = 0.73 ρw S (1)(100) Ms Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.15. The natural water content of the sample taken from the soil deposit was found to be 12,0 %. It has been calculated that the maximum soil density will be reached when the water content reaches 22.0%. Calculate how many grams of water must be added to every 1000 g of soil (in its natural state) in order to increase the water content to 22.0%. SOLUTION: Natural state M w = 0.12 → w M → (0.12)M w with Mt = Ms + Mw = Ms + 0.12Ms = 1.5 12 Ms = 1000 g M = 892,857 g Mw = 0.12)(892,857) = 107,814 3 g Target state (Note: Ms does not change between natural state and target state) Mw = w × Ms = (0.22)(892.857) = 196 .429 g of additional water needs = 196,429 − 107,143 = 89,286 = 89,29 g 2,16. Immerse a cubic metre of dry quartz sand (Gs = 2,65) with a porosity of 60 % in an oil bath 3 3 with a density of 0,92 g/cm . If the sand contains 0.27 m of trapped air, how much force is needed to prevent it from sinking? Suppose the pattern surrounds a lifeless membrane. (Prof.C.C Ladd.) SOLUTION: V = 1 m3 = 1 000 000 cm3 V = n × V = (0.6)(1.0) = 0,60 m3 n t V = V − V = 1.0 - 0,60 = 0,40 m3 s t n M = G × ρ × V = (2,65)(1000) s)(0.40 m3) = 1060 kg = M kg m3 with 1060 M = 1060 kg ρ = t = t 3 m ρbuoy Vt 1 ,0 = ρt − ρoil = 1060 − 920 = 140 kg m 3 γ buoy = γ buoy × g = (140)(9.81) = 1373.4 N Force = γ buoy × γ <1> <6> (captured air) = 1373.4 m3 N m3 3 × 0.27 m = 370.8 N Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.17. The soil sample taken from the borrowing pit has a natural void ratio of 1,15. The land will be used 3 for the motorway project, where a total of 100 00 m of land is needed in its compacted state; its compacted cavity ratio is 0.73. How much volume must be dug from the borrow pit to meet the requirements for work? SOLUTION: V ∨ = ∨ Vt − Vs → V = Vt. e e +1 Waterfront Vt = 100,000 m3 100,000 V = = 57,803.47 m3 (emb) 0.73 + 1 1 1 Pit =V s(borr) = e +1 s(emb) = V × (e V t(borr) with Vt + 1) = (57,803.47)(1.15 + 1) = 124,277 m3 borr 2.18. A wet soil sample was found to have the following characteristics: 3 Total volume: 0,01456 m Total weight: 25,74 kg Weight after drying in the oven: 22,10 kg Specific weight of solids: 2,69 Find density, unit weight, cavity ratio, porosity and saturation degree for moist soil. SOLUTION: (a) ρt = 25.74 = 1767,857 = 1768 kg m 0.01456 3 b) γ t = t × g = (1767.857)(9.81) = 17,342.68 N m = 17.34 kN m 3 (c) Vs = 3 Ms 22.10 = 0.00822 m3 Gsρ w = (2.69)(1000) Vv = 0.01456 − 0.00822 = 0.006344 m3 0.006344 e = = 0.7718 = 0.77 0.00822 0.7718 (d) n = × 100 = 43.656 43.656 6% 1+ 0.7718 (e) Mw = 25.74 - 22.10 = 3.64 3.64 V = = 0.00364 w 1000 An Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual An Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 0.00 364 × 100 = 57.377 = 57.4% S = 0.006344 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geoengineering Holtz Kovacs 2nd Edition Solutions Manual 2.19. Mud Clay (CL) is sampled from a depth of 12.5 feet. The moist soil was pushed out of a 6-inch brass liner with an internal diameter of 2.83 inches and weighed 777 grams. a) Calculate the moisture density in pounds per cubic foot. (b) A small piece of the original sample had a wet weight of 140,9 grams and weighed 85,2 grams after drying. Calculate the water content, 3 using the correct number of significant numbers. Calculate the dry density in Mg/m and the dry 3 unit mass in kN/m . ŘEŠENÍ: 777 g 1 lb (2 (a) V = π (2,83) × 6 = 37.741 in3 , t γ = Mt t 4 (c) γ t suché w = (1+ w) ρdry = (47,4 lb ft 3) Mw × 100 % = S = 78,4 = 78,429 = 78,4 pcf 45,6 g 3 st) = (37.741 in) (1 ft t w (= V (b) M = M − M = 140,9 − 85,2 = 55,7 g,) 12 v 55,7) = 65,38 = 65,4 % 85,2 = 47,40 ks (1+ 0,654) (1 ft 0,3048 m) (0,3048 m) (0,40 pcf (1+ 0,654 m) (0,3048 m) (0,3048 m) (0,40 pcf (1+ 0,654 m) 4536 kg1 lb) = 759,288 3 m3 3 kg γ suchý = (759,288)(9,81) = 7448,6 N m3 = 0,759 m3 Mg = 7,45 kN m 3 2,20. A cylindrical soil sample is tested in the laboratory. The following properties were obtained: Sample diameter 3 inches Sample length 6 inches Wt. before drying in the oven 2.95 lb Wt. after drying in the oven 2.54 lb Oven temperature 110 ° C Drying time 24 hours Specific weight of solids 2.65 What is the degree of saturation of this sample? ŘEŠENÍ: Vt = Vs = π(3)2 4 × 6 = 42.4115 in3 = 0.02454 ft 3 Ws 2.54 = = 0.01536 ft 3 = 26.542 in3 Gs γw = (2.2 0.065)(62.4) Úvod do geotechnického inženýrství Holtz Kovacs 2nd Edition Solutions Manual Úvod do geotechnického inženýrství Holtz Kovacs 2nd Edition Solutions Manual 3 3 V = V − V = 42.4115 − 26.542 = 15.869 in = 0.009184 ft v t s Ww = Wt − Ws = 2,95 − 2,54 = 0,41 lb W 0,41 Vw = w = = 0,00657 ft3 = 11,354 in3 62,4 γw S = Vw Vv × 100% = 110% = 111 % = 11 % = 11 354 63,4 γw S = Vw Vv × 100% = 111% = 11 % = 11 354 62,4 γw S = Vw Vv × 100% = 111% = 111 % = 111 % = 111 % = 11 11 % = 110 % = 11 % = 11 11 % = 11 11 % = 11 10 % = 11 00 % = 11 11 % = 11 11 % = 11 11 % = 11 11 % = 11 11 % = 11 11 % = 11.354 × 100 = 71.5% 15.869 Úvod do geotechnického inženýrství Holtz Kovacs 2nd Edition Solutions Manual Úvod do geotechnického inženýrství Holtz Kovacs 2nd Edition Solutions Manual 2.21 Vzorek nasyceného bahna je 10 cm v diameter and 2.5 cm thick. Its cavity ratio in this is 1.35 and the specific weight of solids is 2.70. Compress the sample to a thickness of 2 cm without changing the diameter. (a) Find Find mud sample before squeezing. b) After squeezing and changing the water content that occurred from the initial state to the final state, find the void ratio. SOLUTION: (a) Vt = S = 1= π(10)2 4 × 2.5 = 196.350 cm3 Vw → V =V Vv w v Vv = e × Vs = 1.35Vs V = V + V = 1.35V + V = 2.35V 196.350 → V = 83.553 cm3 t v s s s s s s (1.35)(83.553) = 112.797 cm3 V w M = ρ × V = (1 g w w w s s s) (112.797) = 112.797 g cm3 M = G × V × ρ = (2.70)(83.553)(1 g) = 225.594 g cm3 wt M = 112.797 + 225.594 = 338.391 g M = 17723 kg ρ = t = 338.391 = 1.723 g t Vt cm3 196.35 = (b) V m3 π(10)2 × 2.0 = 157.08 cm3 t − 2 4 Vs = 83.553 cm3 (no change) V = V − V = 157.08 − 83.553 = 73.527 cm3 v t s e = final s 73.527 = 0.88 83.553 (c) w initial = 112.797 × 100% = 50.0% 225.594 final conditions V = V = 73.527 cm3 ; M = 73.527 g; M = 225.594 g (unchanged) w v w Final w = (73.527) × 100% = 32.6% 225.594 w = S 0.0 − 32.6 = 17.4% Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.22. The sand sample has the following characteristics: total weight Mt = 160 g; total volume Vt =80 3 cm ; water content w = 20%; specific mass of solids G with =2,70. How much would the sample volume have to change to get 100% saturation, provided that the sample mass of M remained the same? SOLUTION: M = w × Ms = (0.20)Ms Mt = Ms + 0.20 Ms = 160 g Ms = 133.33 g M = (0.20)(133.33) = 26,667 g; V = (1 g w V = s s M s = s ms = 133,33 = 49,383 cm ; 3)M = 26,667 cm3 w V = 80 − 49,383 = 30,617 cm3 in 30,6 17 cm3 in Gs ρ w 2.70 26.667 × 100% = 87.10% 30.617 Required condition: S = 100% Changes Vt, but Vs and Ms remain the same M = 26.667 g; V = 26.667 cm3 w w Vv = Vw (when S = 100%) V = V + V = 49.383 + 26.667 = 76.053 cm3 t s in ΔV = 80 - 76.053 = 3.95 cm3 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.23. Draw a phase diagram and start filling in the blanks: The soil pattern has a total volume of 3 80,000 mm and weighs 145 g. The dry weight of the sample is 128 g and the density of 3 soil solids is 2,68 mg/m . Find: (a) water content, (b) poid ratio, (c) porosity, (d) saturation degree, (e) wet density and (f) dry density. Provide answers to parts (e) and (f) in your British engineering units. SOLUTION: (a) Mw 145 − 128 = 17 g W w = × 100% = 17 × 100 = 13.281 = 13.3% 128 Ms 128 = 47,761.2 mm 3 = 47,761.2 mm3 Gs ρ w = (2.68)(1) (b) Vs = Vv = 80 000 − 47 761.2 = 32 238.8 mm3 e = 32,238.8 = 0.67 47 761.2 (c) n = 32,238.8 × 100% = 40.3% 80,000 (d) Vv Mw = ρ w = (17)(1) = 17 cm 3 = 17,000 mm3 17000 S = × 100% = 32 238.8 × 100% = 52.7% (e) ρ = 145 t = 1.8125 ρ dry = kg m3 (f) ρdry = kg m3 80 ρ = 1812.5 kg t = 1812.5 g ⎛) m3 = 113.2 lbm ⎞ ⎟ ⎠(16,018 ⎞ ft3 1812.5 = 1600.0 (1+ 0.13281) = 1600.0 kg = m3 (1 (16 ⎞ ⎞ ⎟ ⎠(16.018 ⎞ kg m3 = 99.9 lbm (see Appendix A) ft 3 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geoengineering Holtz Kovacs 2nd Edition Solutions Manual 2.24. The soil sample and container weigh 397,6 g if the initial water content is 6,3 %. The container weighs 258.7 g. How much water should be added to the original sample if the water content is to be increased by 3,4 %? After the U.S. Department of the Interior (1990). SOLUTION: Mt = 397.6 − 258.7 = 138.9 g Mw = 0.063 Ms = 138.9 = Mw + M = 0.063 Ms + M = 1.063 Ms = 1 30,668 g ΔM w ΔMw = 0.034 Ms ΔMw = Δw × Ms = (0.034)(130,668) = 4.44 g 2.25. The water content test was carried out on a clay mud sample. The weight of the wet soil plus the container was 18.46 g and the weight of the dry soil plus the container was 15.03 g. The weight of the empty container was 7.63 g. Calculate the water content of the sample. SOLUTION: Ms = 15.03 − 7.63 = 7.40 g Mw = 18.46 − 15.03 = 3.43 g 3.43(100) (a) w = w × 100% = = 46.351 = 46.3% Ms 7.40 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.26. Dry the soil sample in the microwave oven to determine its water content. From the data below, deduce the water content and draw conclusions. The content of dried water in the oven is 23.7%. The weight of the dish is 146.30 grams. After the U.S. Department of the Interior (1990). SOLUTION: Mt = 231.62 − 146.3 = 85.32 g Mw = (0.237)Ms 85.32 = 0.237 Ms + Ms Ms = 68.9733 g (this value is constant throughout drying) column 5 = 231.62 −column 3 × 100% 68.9733 CONCLUSION: The loss of additional water in the soil sample becomes negligible after 8 to 10 minutes in the microwave oven used in the experiment. WHEREAS the calculated time in the oven (min) Total oven time (min) Soil weight + bowl (g) Water weight (g) Water content (%) 0 3 0 3 231.62 217.75 -13.87 -20.11 1 4 216.22 15.4 22.33 1 5,215.72 15.90 23.05 1 6,215.48 16.14 23 40 1 7 215.32 16.30 23.63 1 8 215.22 16.40 23.78 1 9,215.19 16.43 23.82 1 10,215.19 16.43 23.82 Water content (%) 25.0 24.0 23.0 22.0 21.0 20.0 19.0 0 1 2 3 4 5 6 7 8 9 10 11 Oven Time (min) Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.27. The weight of the sample of muddy clay soil and container is 18,43 g and the weight of the dry soil plus the container is 13,67 g. The container weighs 8.84 g. Calculate the water content of the sample. SOLUTION: Ms = 13.67 − 8.84 = 4.83 g Mw = 18.43 − 13.67 = 4.76 g 4.76(100) (a) w = w ×100% = = 98.5%Jmu 4.83 2.28. Sample of fully insoated soil, which weighs 1389 g in its natural state, weighs 982 g after drying. What is the natural water content in the soil? SOLUTION: Mw = 1389 − 982 = 407 g M 407(100) (a) w = w ×100% = = 41.4%Jmu 982 2.29. The volume of water in the wet soil sample is 0,24 m . The volume of solids Vs is 0.25 3 3 m . Given that the density of soil solids ρs is 2600 kg/m , find the water content. SOLUTION: Ms = ρs × Vs = (2600)(0.25) = 650 kg Mw = ρ w × Vw = (1000)(0.24) = 240 kg 240 w = 100% = 36.9% 650 2.30. For a soil sample from problem 2.29, calculate (a) the ratio of void and (b) porosity. SOLUTION: Suppose S = 100% (a) e = Gs w = (2.6)(0.3692) = 0.96 (1) S 0.96 (b) n = ×0100 = 50.0% 1+ 0.96 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.31. For a soil sample from problem 2.29, calculate (a) the total or wet and (b) dry density of 3 3 3. Provide your answers in mg/m , kg/m and lbf/ft. SOLUTION: Suppose S = 100% (a) Vt = 0.25 + 0.24 = 0.49 m3 ρt = 710 = 1448.98 0.49 (b) ρdry = kg m3 = 1.45 Mg m3 = 90.4 lbm ft 3,650 = 1326.53 kg = 1.33 Mg = 82.8 lbm ft m 0.49 3 3 3 2.32. The volume of wet sand with a volume of 592 cm weighs 1090 g. Its dry weight is 920 g and the density of 3 solids is 2680 kg/m . Calculate the ratio of void, porosity, degree of saturation and total density 3 in kg/m . SOLUTION: ρs = 2680 kg m = 2.68 3 Vs = g cm3 920 = 343.284 cm3 2.68 Vv = 592 - 343.284 = 248.716 cm3 V e = v = 0.7245 = 0.72 Vs 343,284 (b) n = 0.7245 × 100% = 42.0% 1+ 0.724 1 5 (c) Mw = 1090 − 920 = 170 g170 V = 170 cm3 w ρw Vw S= × 100% = 170 × 100 = 68.4% 248.71 6 V v) ρ = (d t 1090 592 = 1.841 g = 1841 kg cm3 m3 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.33. The soil density is 137 lbf/ft . Find the buoyancy density of this soil in both 3 lbf/ft and kg/m . 3 SOLUTION: γ ' = 137 - 62.4 = 74.6 (74.6 lbf)=) ft 3 ⎛ 16.018 kg ⎞ 3 ⎝ ⎠ ft3 lbf 1 lbf ft 3 1195 kg ⎞ ⎟ m3 2.34. Sand consists of solid components with a density of 2.68 mg/m3. The void ratio is 0.58. Calculate the density of sand during dryness and saturation and compare it with the density of immersion. SOLUTION: Suppose Vs = 1 m3 V = 0.58, in ρ = dry 2.68 V = 1+ 0.58 = 1.58 m3 t = 1.6962 = 1.70 Mg m3 1.58 Pro S = 100%; V = V = 0.58 m3 w in Mw = (1)(0.58) = 0.58 Mg Mt = 2.68 + 0.58 = 3.26 Mg 3.26 ρ = = 2.06 mg m 1.58 3 Mg ρ ' = 2.06 − 1.0 = 1.06 m3 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.35. A sample of the natural ice box was taken below groundwater. It was found that the water content is 52%. Estimate wet density, dry density, buoyancy density, porosity and void ratio. Clearly state all the necessary prerequisites. ŘEŠENÍ: Předpokládejme V = 1 m3 , Předpokládejme G = 2,7 s S Ms = Gs × Vs × ρs = (2,7)(1)(1) = 2,7 mg, Mw = w × Ms = (0,52)(2,7) = 1,404 mg Mt = 2,7 + 1,404 = 4,104 Mg V 3 M s V = − V , V = V = w w Vv ρw wt Vt = 1,404 + 1.0 = 2.404 m3 4.104 = 1.71 Mg (a) ρ = t m 2.404 2.7 (b) ρdry = = kg m3 = 1.12 Mg m 2.404 3 3 (c) ρ ' = 1.1.71− 1,0 = 0,71 Mg m3 (d) n = (e) = 1,404 2,404 1,404 × 100 % = 58,4 % = 1,4 1,0 2,36. 1-m vzorek vlhké půdy váží 2000 kg. The water content is 10%. Suppose ρs = 2.70 3 Mg/m . With this information, fill in all the blanks in the phase diagram fig. P2.36. 3 SOLUTION: Mw = Ms × w = 0.10 Ms Mt = 2000 = M + 0.10 Ms = 1.10 Ms → Ms = 1818.18 kg Mw = (0.10)(1818.18) = 1818.18 kg 81.82 kg V = Ms ρs Vs = 1818.18 = 0.673 m3 , with ps 2700 V = 1 − 0.673 = 0.327 m3 , V = 181.82 w 1000 V = 0.327 − 0.82 327 − 0.181 = 0.146 m3 v a Weight (kg) Volume (m3) Va = 0.15 Vt = 1.0 = 0.181 m3 Vv = 0.33 Vw = 0.18 air Vs = solid water 0.67 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Mw = 182 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Ms = 1818 Mt = 2000 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.37. For the information given in issue 2.36, calculate (a) the ratio of void, (b) porosity and (c) dry density. SOLUTION: V a) e = (b) n = c) ρ dry 0.327 = 0.4859 = 0.49 0.673 0.327 × 100 = 32.7% 1.0 1818.18 = = 1818 kg m 1.0 3.38. The ratio of cavities of clay soil is 0.6, and the degree of saturation is 75%. Assuming that the density of 3 solids is 2710 kg/m , calculate (a) the water content and (b) dry and wet density in both si and british engineering units. SOLUTION: Assume Vs = 1.0 m3 V = e × V = (0.6)(1.0) = 0.6 m3 , v s V = S × V = (0.75)(0.6) = 0.45 m3 w Mtw = ρ w × Vw = (1000)(0.45) = 450 kg, v Ms = ρs × Vs = (2710)(1.0) = 2710 kg Mt = 450 + 2710 = 3160 kg V = 0.6 + 1.0 = 1.6 m3 M An Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 450 An Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2710 An Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual An Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual s dry An Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual = 2710 = 1693.75 = 1694 kg An Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual = 1694 kg ⎛ ⎞ An Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 1 lbm Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual ft 3 kg Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual ft 3 ρ = Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual ⎛ lbm ⎞ = 105.8 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Mt Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 16.018 3160 ⎝ ⎠ = 1975 kg Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual m3 ⎞ </> <> Vt (a) w = 1.6 × 100 = 16.6% 3 1.6 (b) ρ = t m M = V ( ) 3 1) ρdry = (1975) (m t = m3 = 123.3 16.018 t 3 lbm ft3 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.39. The sample of saturated ice clay has a water content of 38%. Assuming ρs 3 = 2,70 mg/m , calculate the ratio of void, porosity, and a sosy density. SOLUTION: w = 38%, S = 100%, ρs = 2.70 Mg m 3 wρ (a) Z Eq. 2.15: e = s = (38.0)(2.70) = 1.026 = 1.03 (100)(1.0) Spw e (b) n = × 100 = 1,026 × 100 = 50.6% 1+ e 1 1+ 1.026 ρ + e ρ (2.70) + (1.0)(1.026) (c) From Eq. 2.17: ρ = s = = 1.8391 = 1.84 sat 1+ e 1+ 1.026 Mg 3 m 2.40. The minimum e and maximum e values for pure sucpasrated sand were found at 0.50 and 3 0,70. What is the corresponding range in saturated density in kg/m ? SOLUTION: Eq. 2.17: ρ = ρ + ρ e with sat max imum : 1+ e ρ = sat minimum : w ρ = 2.13 Mg m3 1+ 0.50 = sat (2.70) +(1.0)(0.50) (0.50) (0.50) (2.70) +(1.0)(0.70) 1+ 0.70 = 2.00 Mg m3 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.41. Calculate the maximum possible porosity-co-vound ratio for a collection (a) of tennis balls (assuming they have a diameter of 64.14 mm) and (b) small ball bearings with a diameter of 0.3 mm. SOLUTION: The three-dimensional arrangement of particles of the same spheres has been studied in depth by mathematics, statistics and material scientists since 1600. A quick internet search on a package of the same realms reveals numerous mathematical theories and approaches for estimating the densest and loosest possible packaging. In general, the loosest arrangement of the same realms gives an empty fraction of about 0.48, regardless of the balls As an aside, the densest possible pack of same-size balls yields a solid volume of about: π = 0.7405. (These values are approximate— there is no unified consensus in Vs = 18.) Looser packaging for Vt = 1.0, Vv = 0.48 and Vs = 1- 0.48 = 0.52 as follows; = n max Vv × 100 = Vt emax = 0.48 × 100 = 48% 1.0 Vv = 0.48 = 0.92 Vs 0.52 Densest pack (not required in problem command) Vv = 0.7405, Vv = 1.0 − 0.7405 = 0.2595 as follows; nmin = emin 0.2595 × 100 = 26% 1.0 0.2595 = 0.7405 = 0.35 2.42. The plastic limit test has the following results: Wet weight + container = 23,12 g Dry weight + container = 20,84 g Container weight = 1,46 g Calculate soil PL. Can the plastic limit be evaluated by a single-point method? SOLUTION: Mw = 23.12 - 20.84 = 2.28 g, Ms = 20.84 - 1.46 = 19.38 g W 2.28 PL = w × 10 0 = × 100 = 11.8 19.38 Ms Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Plastic Limit cannot be evaluated using a single point method. 2.43. During the plastic limit test, the following data were obtained for one of the samples: Wet Weight + Vessel = 23.13 g Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual It's an introduction to geotechnical engineering Holtz Kovacs 2nd Edition Solutions Manual Dry weight + container = 19.12 g Container weight = 1.50 g What is PL soil? SOLUTION: Mw = 23.13 - 19.12 = 4.01 g, Ws = 19.12 − 1.50 = 17.62 g W 4.01 PL = w × 100 = × 100 = 22.8 17.62 Ws 2.44. The degree of saturation of cohesive soil is 100%. Wet clay weighs 1489 g and after drying weighs only 876 g. Find the water content in the soil. Draw a phase diagram and mark it correctly. SOLUTION: S = 100%, Mt = 1489 g, Ms = 876 g Mw = 1489 − 876 = 613 g; Mt = 876 + 613 = 1489 g M 613 w = w × 100 = × 100 = 70,0 % Z. 876 M 613 V = w = 613 = 613 cm3 , V = V = 613 cm3 w pw in 1.0 g cm S 3 1.0 Assume Gs = 2.70 as follows; Ms = 876 = 324,4 cm3 ; V = 613 + 324 = 937 cm3 Gs ρw = (2,7)(1,0) t Weight (g) Volume (cm3) Va V t = 93 7 Vv = air 613 Vw = 613 water Mw = 613 Vs = 324 fixed Ms = 876 Mt = 1489 2.45. For the soil in the previous problem, calculate the ratio of emptiness and porosity. Is your answer compared to what you would expect for saturated cohesive soil? SOLUTION: e= Vv = 613 = 1,89; n = Vv × 1000 = 613 × 100 = 65.4% Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Vs 324 Vt 937 2.46. Calculate (a) the total density or wet density (b) the dry density 3 3 3 of soil in the previous two problems. Provide your answers in Mg/m , kN/m and lbf/ft. SOLUTION: Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual M 1489 (a) ρ = t = = 1.589 (a (g) ρ = 1.59 Mg t Vt cm3 937 γ t = 15.59 kN m = 99.2 lbf ft 3 3 M = 876 = 0.9349 (b) = ρs dry Vt = dry γ = 9.17 kN m = 58.3 lbf ft = 0.93 Mg g cm3 937 3 m3 m3 3 2.47. The soil sample had a floating density of 73 pounds per cubic foot. Calculate its wet density 3 in kg/m . SOLUTION: γ' = 73 lb ft ; 3 γ t = γ sat = γ' + γ w = 73 + 62.4 = 135.4 lb ft ρ t = (135.4)(135.4) 16.018) = 2169 3 kg m3 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.53. The piece density method is often used to determine the unit weight of an irregular shape sample. In this way, a sample of cemented muddy sand is treated to obtain the density of the pieces. The following information determines (a) wet density, (b) drought density, (c) the ratio of cavities and (d) the degree of saturation of the sample. Sample weight at natural water content in the air = 181.8 g Sample weight + wax layer in the air = 215.9 g Sample weight + wax in water = 58.9 g Natural water content = 215.9 g Sample weight + wax in water = 58.9 g Natural water content = 215.9 g Sample weight + wax in water = 58.9 g Natural water content = 515.9 g 2.5% 3 3 Soil solid density = 2650 kg/m Solid density = 940 kg/m SOLUTION: M −M w = t, w Mt = Mt 181.8 = 177.366 g s 1+ w 1+ 0.025 M = Mt − M = 181.8 - 177.4 = 4.43 g with w t with Ms 1+ w 1+ 025 177,366 g M = 66.93 cm3 → Vw M w 4.43 g = 4.43 cm3 Vs = g 2,650 cm ps ρs w with 1.0 cm 215.9 - 181.8 = 34.1 g t + wax 3 M = 215.9 g t + wax V pw −T + voskový vzduch → 157.0 = 157.0 g vzduchu M = 157.0 ρ vosk 34,1 = 36.28 cm3 0.940 Waxter posunutých = 215.9 − 58.9 = 157.0 g 3 1.0 − V = V + V = 66.93 + 4.43 = 71.35 cm3 s w in V = V w v Ms V t + wax w V + V = 49.36 = 4.43 = 53.79 cm3 v t wax Water displaced =V V t Mwater displaced = Mt + wax − Mwater displaced V → w → V =V t t + wax −V = 157.0 − 36.28 = 120.72 cm3 wax (a) ρ = Mt = 181.8 = 1.50 Mg t 3 m Vt 120.72 M 177.366 = s = = 1.47 Mg (b) ρ dry 120.72 Vv 53.79 (c) e = = = 0.80 Vs 66.93 (d) S = Vt Vw Vv × 100% = 4.43 m 3 × 100 = 8.2 % 53.79 Volume (cm3) An Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Mass (g) An Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Vt+wax = 157.0 Vt = 120.72 Vwax = 36.28 wax Mwax = 34.1 Va = 49.36 air Vw = 4.43 Mw = 4.43 Vs = 66.93 solid Ms = 177.4 53.79 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Mt = 181.1 An Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.54. The laboratory tested sensitive volcanic clay soil, in which the following properties were detected: ρ = 1.28 mg/m , e = 0.90, c) S = 95%, (d) ρs = 2.75 mg/m , (e) w = 311 %. 3 3 When checking the above values, it was found that the with the rest. Find the inconsistent value and report it correctly. Displays all calculations and phase diagrams. SOLUTION: Suppose Vs = 1 cm3 DS = ρs × Vs = 2.75 mg; Mw = w × Ms = (3.11)(2.75) = 8.55 mg Mt = Ms + Mw = 2.75 + 8.55 = 11.3 0 Mg 11,30 Mt = = 8,83 cm3 (1) Vt = ρt 1,28 V = e × V = (9)(1) = 9 cm3 ; v V = Mw = s w ρw 8.55 = 8.55 cm3 1.0 (2) V = V + V = 9 + 1 = 10 cm3 ≠ 8.83 cm3 t in v check s: Gs w = Se (2.65)(3.11) = (0.95)(9.0) 8.55 = 8.55 → These values are in the correct proportion. As a result, the error must be ρt. 11,30 M = 1,13 mg recalculate ρ = t = t 3 Vt Solution : ρ t = 1,13 Mg m m 10 3 Volume (m3) Vv = 9,9 8.83 or Va Mass (Mg) air Vw = 8.55 water Mw = 8.55 Vs = 1.0 fixed Ms = 2.75 10.0? Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Mt = 11.30 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 3 2.55. The cylinder contains 510 cm of free dry sand, which weighs 740 g. With a static load of 200 kPa, the volume is reduced by 1% and vibrations are reduced by 10% of the original volume 3. Suppose the density of sand solids is 2,65 mg/m . Calculate the ratio of void, porosity, dry density and total density corresponding to each of the following cases: (a) Sand. b) Sand under static load. c) Vibrated and loaded sand. SOLUTION: Vs = Ms ρs 3 740 = 2,65 = 279,24 cm ; Mt = 740 g; dry sand: Mw = Vw = 0,0 (a) Free sand - starting state Vt = 510 cm3 V = V − V = 510 − 279,24 = 230,75 cm3 V in e= t Vv s = Vs ρdry = 230,75 = 0,83; n= 279,24 Vv × 100 % = g cm3 × 100 = 45,2 % 510 Vt PŠ = 740 = 1,45 Vt 510 230,75 = 1,45 Mg m3 ρdry = ρt = 1,45 mg m 3 b) Sand under static load 510 V = = 504,95 cm3 t 1,01 V = V − − = 504,95 − 279,24 = 225,71 cm3 V in e= t Vv s = Vs ρ = dry 225,71 = 0,81; n = 279.24 DP = Vt × 100% = = 1.47 504.95 225.71 × 100 = 44.2% 510 Vt 740 ρdry = ρ t = 1.47 Mg m Vv = 1.47 Mg g cm3 m3 (c) Vibrated and loaded sand 510 V = = 454.54 cm3 t 1.10 V = V − − = 454.54 − 279.24 = 175.30 cm3 V in t with Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual e = Vv = 175.30 = 0.63; Vs ρ = dry n = 279.24 Ms Vt = × 100% = = 1.63 454.54 175.30 × 100 = 38.6% 454.54 100 740 ρdry = ρ t = 1.63 Mg m Vv = 1.63 Mg g cm3 m3 3 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.56. On five-cycle semi-logarithmic paper, plot grain size distribution curves from the following mechanical analytical data on six soils, A through F. Determine the effective size for each soil, as well as the uniformity factor and curvature coefficient. Also determine the percentages of gravel, sand (a) ASTM, (b) AASHTO, (c) USCS, and (d) british standard. continuing the next page Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.56. Continued. SOLUTION: C = for D60 C = c D 10 (D30) 2 D ×D 60 10 Particle size distribution GRAVEL Coarse SAND Fine course Medium SILT or CLAY Percentage weight 100 100 90 80 80 70 70 60 50 50 40 30 30 20 20 20 20 10 10 0 100 LEGEND 1 10 Soil A Soil B Soil C Soil D Soil E Soil A B C D E F 0.1 0.01 Grain size in millimetres Soil type: Description: Depth: LL: Cc = Cc = Effective size D30 D60 D10 (mm) (mm) (mm) 0.1 ml6 0 .005 0.001 0.16 0.006 N/D 6 0.04 0.06 0.22 0.015 N/D 28 0.09 1 0.3 0.3 0.003 PI: Cu Cc 46.7 18.0 1 1.9 16.7 N/D 2.1 3.6 3.6 1.0 0.4 N/D continued next page Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 0 0.001 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.56. Continued. and Percentages according to ASTM. Soil A B C D E F Gravel (%) 73 12 19 0 0 0 Sand (%) 23 33 49 100 43 0 Fines (mud + clay) 4 55 32 0 57 100 Mud (%) 4 45 18 0 49 29 Clay (%) 0 10 14 0 8 71 Mud (%) 4 45 18 0 49 29 Clay (%) 0 10 14 0 8 71 Mud (%) ------- Clay (%) ------- (b) Percentages according to AASHTO. Soil A B C D E F Gravel (%) 80 18 30 0 11 0 Sand (%) 16 27 38 100 32 0 Fines (mud + clay) 4 55 32 0 57 100 c) Percentages according to USCS. Soil A B C D E F Gravel (%) 73 12 19 0 0 0 Sand (%) 23 33 49 100 43 0 Fines (mud + clay) 4 55 32 0 57 100 (d) Percentages according to British standard. Soil A B C D E F Gravel (%) 80 18 30 0 11 0 Sand (%) 16 27 38 100 32 0 Fines (mud + clay) 4 55 32 0 57 100 Mud (%) 4 53 21 0 57 48 Clay (%) 0 2 11 0 0 52 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.58. The soils in problem 2.56 have the following Atterberg limits and natural water content. Identify IMs and LI for each soil and comment on their general activities. SOLUTION: PI = LL − PL; LI = w n − PL PI Property Soil A Soil B Soil C Soil D Soil E Soil F wn (%) 27 14 14 11 8 72 LL 13 35 35 -- 28 60 PL 8 29 18 NP NP 28 PI 5 6 17 0 0 32 LI 3.8 -2.5 -0.24 -- -- 1.38 Soil A: very sensitive, highly active soil B: most likely clay above the water level, which has seen a decrease in humidity Soil C: most likely clay above the water level, which has seen a decrease in moisture Soil D: most likely fine sand Soil E: most likely mud Soil F: slightly sensitive and active 2.59. Commentary on the validity of the results of the Atterberg limits on soils G and H. SOLUTION: Based on Atterberg definitions: LL > PL > SL. Soil G violates definitions > PL (25 > 20). Soil H violates the definition because PL > LL (42 > 38). Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.60. The following data were obtained from a test with a restriction of liquid on clay. The two plastic limit determinations had a water content of 23.1% and 23.6%. Specify LL, PI, flow index, and toughness index. The flow index is the slope of the water content versus the recording of the number of strokes in the liquid limit test, and the toughness index is the PI divided by the flow index. SOLUTION: From the chart below LL = 42.6 Flow = slope = IF = w1 − w 2 = 10.6 (from linear regression of the most suitable line) ⎛N ⎞ log ⎢ 2 ⎥ ⎝ N1 ⎠ use the average value of tests PL; PL = 23.1+ 23.6 PI = LL − PL = 42.6 - 23.4 = 19.2 PI 19.2 = = 1.81 Hardness Index = IF = 23.4 2 10.6 50 48 Water content (%) 46 44 42 40 38 LL = 42.6 Flow index = 10.6 36 34 32 30 10 15 20 30 40 Number of strokes Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.61. Classify the following soils according to USCS: (a) A sample of well-graded gravel with sand has a 73% fine on gross subangular gravel, a 25% fine on rough subangular sand and a 2% fine. The maximum particle size is 75 mm. The coefficient of curvature is 2.7, while the coefficient of uniformity is 12.4. (b) Dark brown, wet, organic, organic fragrant soil has 100% screen No. 200. The limit of the liquid is 32% (unsuperied and is 21% when dried in the oven!) and the plastic index is 21% (unsu dried). (c) This sand has 61% mostly fine sand, 23% muddy fine, and 16% fine subrounded gravel size. The maximum size is 20 mm. The limit of liquid is 33% and the limit of plastics is 27%. (d) This material has a 74% fine on coarse subangular reddish sand and 26% organic and muddy dark brown fine. The limit of the liquid (unsu dried) is 37%, while when dried in the oven it is 26%. The plastic index (unsu dried) is 6th (e) Although this soil has only 6% nonplastic muddy fine, it has everything else! It has a gravel content of 78% fine on rough subrounded to subangular gravel, and a 16% fine on rough subrounded to subangular sand. The maximum size of boulders is 500 mm. The uniformity factor is 40, while the curvature coefficient is only 0.8. (After the U.S. Department of the Interior, 1990.) SOLUTION: See Table 2.7 and the corresponding footnotes (a) GW — Well-classified gravel with sand. (b) OL - Organic clay (c) SM – Thick sand with gravel (d) SM – Thick sand with organic fines (e) GP-GM – Poorly sorted gravel with mud, sand, cobblestones and boulders (or GP-GC) 2.62. Classify five soils in the previous question according to the AASHTO soil method SOLUTION: (a) A-1-a (b) A-8 (c) A-2-4 (d) A-2-4 or A-8 (e) A-1-a Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.63. The results of the sieves test below indicate the percentage passing through the sieves. a) Use the table to plot the particle size distribution. (b) The uniformity factor shall be calculated. (c) Calculate the curvature coefficient. Seed Percentage weight 1/2 No. 4 No. 10 No. 20 No. 40 No. 60 No. 100 71 37 32 23 11 7 4 SOLUTION: D C = u (D)2 9,5 60 = D = 24; C = 0.39 = 30 D ×D c 10 60 (1.6)2 = 0.69 (9.5)(0.39) 10 Grain Distribution Size Plot 100 2 1 1 1/2 #4 #10 1/2 #4 #10 #20 #40 #100 #200 #20 #40 #100 #200 90 80% Graduation 70 60 50 40 30 20 10 0 100.00 10.00 1.00 0.10 Grain diameter (mm) Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 0.01 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.64. For the data below, classify the soils according to USCS. For each soil, indicate the letter symbol and the narrative description. (a) 65 % of the material retained on network No 4, 32 % seized on network No 200. Cu = 3, Cc = 1. (b) 100% material passed no. 4 butt, 90% passed no. 200 sueve. LL = 23, PL = 17.c) 70 % material retained on network No 4, 27 % seized on network No 200. Cu = 5, Cc = 1.5. SOLUTION: (a) GP - Poorly graded gravel with sand (b) CL-ML – Thick clay (c) GW - Well sorted gravel with sand 2.65. A soil sample was tested in the laboratory and the following grain size analysis results were obtained. Classify this land according to USCS and provide a group symbol for it. Power Suture Opening (mm) Percentage of coarser weight Percentage by weight 1/2 4 12.7 4.75 30 36 70 64 10 2.00 52 48 20 0.85 64 36 40 0.425 69 69 31 60 0.25 71 29 100 0.15 77 23 200 0.075 99 SOLUTION: (a) PI = LL − PL = 26 - 23 = 3D Cu = 60 D 3.9 = 0.08 = 49; Cc = 10 (D)2 (0.4)2 = 30 D ×D 60 (3.9) (0.08) = 0.51 →∴ well graded 10 SW-SM (W ell-graded sand with mud) 100 2 1 1/ 1 / 1 / 2 #4 #10 #20 #40 #100 #200 90 80 % Passing 70 70 64 60 50 48 40 36 31 30 29 23 20 10 0 10 100,00 #4 2 1 1/2 10. 00 ##20 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 1.00 9 #40 #100 #200 0.10 0 . 0 1 Grain Diameter (mm) Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.66. Minus 40 material had a liquidity index of 0.73, a natural water content of 44.5% and a plasticity index of 24.7. Classify this soil according to USCS, enter the symbol of the group. SOLUTION: LI = w − PL 0.73 = PL PI PI = LL PL; 44.5 − → PL = 26.5 24.7 LL = PI + PL = 24.7 + 26.5 = 51.2 CH (fat clay) 2.67. A soil sample was tested in the laboratory and the following grain size analysis results were obtained. Classify this land according to USCS and provide a group symbol for it. Sute No. Butt hole (mm) Percentage coarser by weight Percentage finer by weight 4 10 4.75 2.00 37 52 63 48 20 40 60 0.85 0.425 0.25 64 10 69 71 36 31 29 100 200 0,15 0,075 77 90 23 10 SOLUTION: (a) PI = LL = PL = 60 - 26 = 34 D 4,75 = 63; Cu = 60 = D 0.075 C = c (D 30)2 D ×D 10 60 = (0.425)2 = 0.51 →∴ well sorted (4.75)(0.075) 10 SW-SC (W ell-graded sandblasted with her 100 2 1 1/2 #4 #10 #20 #40 #100 #200 90 80 % Completion 70 63 60 50 48 40 36 31 30 29 23 20 10 0 10 100,00 #4 2 1 1/2 10. 00 # Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual #20 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 1.00 10 #40 #100 #200 0.10 0 . 0 1 Grain Diameter (mm) Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.68. A soil sample was tested in the laboratory and the following grain size analysis results were obtained: The Atterberg limit value for minus 40 of the material was: LL = 36, PL = 14. Specify the USCS classification symbol for this soil. Extra credit - specify the full AASHTO classification for this soil (symbol index plus groups). Sute No. Butt hole (mm) Percentage Weight 4 10 4.75 2.00 100 100 20 0.85 100 40 0.425 94 60 100 0.25 0.15 82 66 200 Pan 0.075 -- 45 0 0 PI = LL − PL = 36 - 14 = 22 GI = (F − 35)[0.2 + 0.005(LL − 40)] + 0.01(F − 15)(PI − 10) GI = (45 - 35)[0.2 + 0.005(36 − 40)] + 0.01(45 − 15) (22 − 10) GI = 5.4 (a) USCS: SC (Clayey Sand) (b) AASHTO: A-6 (5) Grain size distribution 100 2 1 2 1/2 #4 #10 1/2 #4 #10 #20 #40 #100 #200 #20 #40 #100 #200 90% Passing 80 70 60 50 40 30 20 10 0 100.00 10.00 1.00 0.10 Grain diameter (mm) Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 0.01 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.69. Laboratory tests were carried out on two soil samples (A and B). (a) Specify the USCS classification symbol for sample A. (b) Specify the AASHTO classification for sample B. Screen Opening (mm) A - Percentage Passing 3 inches 1.5 inches 76.2 38.1 100 98 0.75 inches 19.1 96 4 4.75 77 100 10 2.00 -- 96 20 0.85 55 94 40.0 425 -- 73,100,200 0.15 0.075 30 18 -55 32 25 52 32 Liquid limit Plastic Limit B - Percentage Transmission SOLUTION: (a) PI = LL − PL = 32 - 7 D 1.3 C = u 60 = (D)2 = 29.5; C = c D10 0.044 30 D60 × D10 (0.15)2 = = 0.393 →∴ poorly sorted (1.3)(0.044) USCS → SM (Silty sand with gravel) (b) PI = LL - PL − 32 = 20; LL − 30 = 52 - 30 = 22 < 32; GI = (F − 35)[0.2 + 0.005(LL − 40)] + 0.01(F − 15)(PI − 10) GI = (55 - 35)[0.2 + 0.005(52 − 40)] + 0.2 01(55 - 15)(20 - 10) = 9.2 ∴A −7−5 AASHTO → A-7-5 (9) 100 2 1 1 1/2 #10 #4 #20 #40 #100 #200 100 98 96 96 94 Sample A Sample B 90 80 77 73 % Completion 70 60 55 55 50 40 30 30 20 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 18 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 10 0 100.5 2 1 1/2 10.00 #4 #10 #20 #40 1.00 #100 #200 0.10 Grain Diameter (mm) Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 0.01 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.70. A soil sample was tested in the laboratory and the following grain size analysis results were obtained: The Atterberg limit value for minus 40 of the material was: LL = 62, PL = 20. Specify the USCS letter symbol for this soil. Sute No. Butt hole (mm) Percentage coarser by weight Percentage finer by weight 4 10 20 40 60 100 200 Pan 4.75 2.00 0.0 85 0.425 0.25 0.15 0.075 -- 0.0 5.1 10.0 40.7 70.2 84.8 90.5 100.0 100.0 94.9 90.0 59.3 29.8 15.2 9.0 5 0.0 SOLUTION: PI = LL − PL = 62 - 20 = 42 D 0,43 C = at 60 D = (D)2 = 5,7 ≅ 6; C = 0.075 = 30 D ×D c 10 60 (0.25)2 = 1.9 (0.43)(0.075) 10 Cu value is close to 6. Technically, this soil is classified as poorly sorted; however, a well-graduated determination is not unreasonable. USCS → SP − SC (Poorly sorted sand with clay) Grain size Distribution Fence 2 100 1 1/2 #10 #4 #20 #40 #100 #200 100.0 94.9 90 90.0 80% Completion 70 60 59.3 50 40 30 29.8 20 15.2 10 0 100.00 9.5 21 1/2 10.00 #4 #10 #20 #40 #100 1.00 Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual #200 0.10 0.01 Introduction to Geo Technical Engineering Holtz Kovacs 2nd Edition Solutions Manual Grain Diameter (mm) Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual 2.71. A sample of brown sandy clay was obtained to determine the Atterberg limits and then its soil type was classified according to a uniform soil classification system. For one of the PL determinations, wet + bowl = 11,53 g and dry weight + dish = 10,49 g. The dish weighed only 4.15 g. Calculate the plastic limit. Another plastic limit was 16.9%. Three liquid limit determinations were made. For 17 shots, the water content was 49.8%; for 26 shots, the water content was 47.5%; and for 36 shots, the water content was 46.3%. Value the soil type, mark the information in the plasticity chart, and enter the Unified Soil Classification symbol. SOLUTION: Mw = 11.53 − 10.49 = 1.04 g PČ = 10.49 - 4.15 = 6.34 g M 1.04 w PL = PL = w × 100 = 100 = 16.4 ms PL(avg) = 6.34 16.4 + 16.9 = 16.65; From the figure below: LL = 48 2 PI = 48 − 16.7 = 31 Based on the Casagrande plasticity graph (Fig. 2.13), soil fines are classified as CL ∴USCS → CL (Sandy clay) 60 58 Water content (%) 56 54 52 50 48 44 LL = 48.0 Flow index = 10.8 42 40 10 15 20 30 40 Number of strokes Introduction to Geotechnical Engineering Holtz Kovacs 2nd Edition Solutions Manual

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