1

(a)

In this section, we explain the usage of the terms uniform, medium as prefix to the materials. later, a new term coefficient of uniformity is also introduced which measures the previous parameters.

The term ‘uniform’ here stands for describing the range of the particle size. Parallely used term is ‘well-graded’. A ‘well-graded’ implies availability of wide range of the particle sizes of the constituent (here it is sand). A ’uniform’ implies availability of restricted range of particle size. This can be obtained from the coefficient of uniformity.

Coefficient of Uniformity is defined as,

$$C_u = \frac{D60}{D10}$$

where,

D60 =particle size at 60% finer,

D10= particle size at 10% finer.

Larger the uniformity coefficient value, larger will be the difference in uniformity. This implies poorly graded and is highly impermeable. For a smaller difference in both of them, will result in a unity value for the uniformity of coefficient. This implies highly permeable and well graded sand.

(b)

In this section we explain some of the lab experiments that can be performed to evaluate the strength, compressibility and settlement characteristics of the material.

Experiment 1-

Sieve Analysis:

References:

ASHTO-T88
ASTM D422, D1140

Method and Summary:

This helps in determining various particle grain sizes. The grain size distribution can be used to determine the texture classification. This in turn will be useful in calculating the other engineering characteristics such as permeability strength swelling, potential and susceptibility to frost actions.

Wash the representative sample through a series of sieves. The amount retained on each sieve will be collected dried and weighed to determine the potential percentage of the sieve Settlement

Experiment 2:

Hydrometer Analysis:

References:

AASHTO T89 T90
ASTM D 4318.
Method and Summary:

Soil passing the No. 200 Sieve is mixed with a disperant and distilled water and placed in a special graduated cylinder in a state of liquid suspension. The specific gravity of the mixture is frequently measure using a calibrated hydrometer to determine the rate of settlement of the soil particles. The relative size and percentage of fine particles are determined based on the Stokes law for settlement idealised spherical particles

(c)

The ways to prevent collapses during working in excavations and make the work safe are either by :

1. Battering the sides to a safe angle,
2. timbering/shoring, i.e., supporting the sides .
   However, it is mentioned that there cannot be any extra use of sheet piles, hence case 2 is ignored.
   With the case 1, in the battering, it is required that the sides of the excavations are to be sloped not more than angle of repose of the soil.
   Angle of repose is the natural slope of the that is formed with the pile of the excavated soil. This is completely based on the nature of the soil.
   The approximate angle of repose for different soils are as follows:

	Slope Ratio	Angle of Repose
Granular Soils	1.5:1	34
Weak cohesive, Silt	1.0:1	45
Cohesive, silty clay, sandy clay	0.75:1	53

The angle of repose has to be not more than 45 degrees to the horizontal and often very low almost around 30 degrees. Hence from the figure, it is silty clay and with an angle of repose greater than 53 degrees it is not preferred to go for battering even if there is space available for the same.

2

(a)

(1)

$At\ 3m;$

$Total\ Stress = Td * x1 = 16.5 * 3 = 49.50kN/m3;$

where Td is kN/m2 for Sand, x1 is 3m given in question.

$Pore\ water\ pressure = Tw * (x1) = 9.81 * (3) = 27.43kN/m3$

where Tw is for water, x1 is 3m given in question.

$Effective\ Stress = Total\ Stress - Pore\ water\ pressure = 49.50 - 27.43 = 22.07kN/m3;$

(2)

$At\ 7m$:

$Total\ Stress = Td * x1 + Tc * x2 = 16.5 * 3 + 20 * 4 = 49.50 + 80 = 129.5kN/m3;$

$Pore\ water\ pressure = Tw * (x1 + x2) = 9.81 * (3 + 4) = 68.6kN/m3$

$Effective\ Stress = 129.5 - 68.6 = 60.9kN/m3;$

(b)

$Cylinder\ Area = 2(pi)rh + 2(pi)r^2 = 2 * 3.14 * 19 * (19 + 76) * (1e - 6) = 0.0113m2;$

$Cylinder\ Volume = (pi)r^2h = 86e - 6m3;$

1.

$Bulk\ Density\ = \ Mass/Area = 183.4g/(0.0113m2) = 1.6e - 4g/m2;$

$Bulk\ Weight = Mg\ = 183.4 * 9.8 = 1.797kN.$

$Bulk\ Unit\ Weight = Bulk\ Weight/Volume = (1.797kN)/(86e - 6) = 20e6N/m3;$

2.

$Dry\ Density = \ Oven\ Dry\ Mass/Area = 157.7g/(0.0113m2);$

$Dry\ Weight = Mg\ = 157.7 * 9.8 = 1.545kN.$

$Dry\ Unit\ Weight = Dry\ Weight/Volume = (1.545kN)/(86e - 6) = 17.9e6N/m3;$

3.

$$Moisture\ Content = (1 - Dry\ Weight/Bulk\ Weight) = (1 - 157.7/183.4) = 1 - 0.8561 \\ = 0.1439 = 14\%;$$

4.

$Void\ Ratio$:

$Volume\ of\ the\ Solid\ Particle = \ Vs = Ws/GsTw;$

$Volume\ of\ the\ water = Vw = Ww/GsTw;$

$Volume\ of\ the\ air = Va$

$Vv = Vw + Va;$

$V = Vs + Vw + Va;$

$Ww = 0.14 * (1.797kN) = 251N;$

$Ws = 0.86 * (1.797kN) = 1.545kN;$

$Void\ ratio = Vv/Vs = Ww/Ws = 251/1545 = 0.1625;$

$porosity = Vv/V = Ww/(Ws + Ww) = 251/(251 + 1545) = 0.1398;$

5.

$Degree\ of\ Saturation = Vw/Vv = Vw/Vw = 1;$

6.

$Air\ voids\ content = 1 - Degree\ of\ Saturation = 0;$

7.

$Saturated\ Water\ content = Vs/V = Ws/(Ws + Ww) = 1545/(251 + 1545) = 0.8602;$

3.

(a)

Given:

$Quantity\ of\ water\ collected\ (Q) = 200ml$

$Total\ time\ required\ for\ collecting\ Q\ of\ water$ (t)= $3\ minutes\ 45\ seconds$

$= 225 seconds.$

$The\ difference\ in\ between\ water\ levels\ of\ overhead\ and\ bottom\ tank\ (h) = 234mm;$

$Cross\ section\ area\ of\ the\ sample\ (A) = pi * (75)^2 = 17671mm^2;$

Coefficient of Permeability is given by the following formula,

$$C = \frac{Q * L}{t * h * A}$$

$$C = \frac{200 * 25}{225 * 234 * 17671}$$

$$C = 5.3742 * 10^{-6} mm/sec$$

(b)

Let C1 be the coefficient for the previous case,

Let C2 be the new coefficient. Then,

$$\frac{C1}{C2} = \frac{Q1 * t2 * h2}{t1 * Q2 * h1}$$

$$\frac{C1}{C2} = \frac{200 * 745 * 672}{225 * 100 * 234}$$

$$\frac{5 * 10^{-6}}{C2} = \frac{100128000}{930378150}$$

$$C2 = 5.38 * 10^{-7} mm/sec$$

4.

$Shear\ Strength\ = Force/Area$

Normal Load (N)	105	203	294
Shear Strength at Normal Load=Force/Area(kN/m2)	1050/60=17.5	2030/60=33.833	2940/60=49
At Peak (kN/m2)	950/60=15.83	1830/60=30.500	2650/60=44.167
At Ultimate (kN/m2)	650/60=10.833	1270/60=21.167	1840/60=30.667

$Angle\ of\ Obliquity$:

$$tau = sig1 - sig2 = 60 - 20 = 40;$$

$$alpha = sig1 + sig2 = 60 + 20 = 80;$$

$$Angle\ of\ Obliquity = \tan^{-1} \quad (tau/alpha) = \tan^{-1} \quad (1/2).$$

The maximum shear stress prior to failure has an angle of obliquity of 45 degrees, and hence the above stress won’t result in failure.