26 Years
Previous Solved Papers

ESE 2021

UPSC ENGINEERING SERVICES EXAMINATION

Preliminary Examination

Civil Engineering

Topicwise **Objective** Solved Questions

Volume-II

Topicwise Presentation | ***Thoroughly Revised and Updated***

Also useful for State Engineering Services Examinations, Public Sector Examinations & Other Competitive Examinations

MADE EASY Publications

www.madeeasypublications.org

MADE EASY Publications

Corporate Office: 44-A/4, Kalu Sarai (Near Hauz Khas Metro Station), New Delhi-110016
E-mail: infomep@madeeasy.in
Contact: 011-45124660, 08860378007
Visit us at: www.madeeasypublications.org

ESE-2021 : Preliminary Examination
Civil Engineering : Volume-II
Topicwise Objective Solved Questions : (1995-2020)

1st Edition : 2006
2nd Edition : 2007
3rd Edition : 2008
4th Edition : 2009
5th Edition : 2010
6th Edition : 2011
7th Edition : 2012
8th Edition : 2013
9th Edition : 2014
10th Edition : 2015
11th Edition : 2016
12th Edition : 2017
13th Edition : 2018
14th Edition : 2019

15th Edition : 2020

Director's Message

Engineering is one of the most chosen graduating field. Taking engineering is usually a matter of interest but this eventually develops into "purpose of being an engineer" when you choose engineering services as a carrier option.

B. Singh (Ex. IES)

Train goes in tunnel we don't panic but sit still and trust the engineer, even we don't doubt on signalling system, we don't think twice crossing over a bridge reducing our travel time; every engineer has a purpose in his department which when coupled with his unique talent provides service to mankind.

I believe *"the educator must realize in the potential power of his pupil and he must employ all his art, in seeking to bring his pupil to experience this power"*. To support dreams of every engineer and to make efficient use of capabilities of aspirant, MADE EASY team has put sincere efforts in compiling all the previous years' ESE-Pre questions with accurate and detailed explanation. The objective of this book is to facilitate every aspirant in ESE preparation and so, questions are segregated chapterwise and topicwise to enable the student to do topicwise preparation and strengthen the concept as and when they are read.

I would like to acknowledge efforts of entire MADE EASY team who worked hard to solve previous years' papers with accuracy and I hope this book will stand up to the expectations of aspirants and my desire to serve student fraternity by providing best study material and quality guidance will get accomplished.

B. Singh (Ex. IES)
CMD, MADE EASY Group

Contents

Civil Engineering

Volume-II

Objective Solved Questions

of UPSC Engineering Services Examination

■■■■

UNIT

V

Soil Mechanics and Foundation Engineering

Syllabus

Soil Mechanics: Soil exploration - planning & methods, Properties of soil, classification, various tests and inter-relationships; Permeability & Seepage, Compressibility, consolidation and Shearing resistance, Earth pressure theories and stress distribution in soil; Properties and uses of geo-synthetics.

Foundation Engineering: Types of foundations & selection criteria, bearing capacity, settlement analysis, design and testing of shallow & deep foundations; Slope stability analysis, Earthen embankments, Dams and Earth retaining structures: types, analysis and design, Principles of ground modifications.

Contents

■■■■

1 Properties of Soils

1.1 Match **List-I** (Type of soil) with **List-II** (Mode of transportation and deposition) and select the correct answer using the codes given below the lists:

List-I

A. Lacustrine soils
B. Alluvial soil
C. Aeolian soils
D. Marine soils

List-II

1. Transportation by wind
2. Transportation by running water
3. Deposited at the bottom of lakes
4. Deposited in sea water

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	3	2	1	4
(c)	3	2	4	1
(d)	1	3	2	4

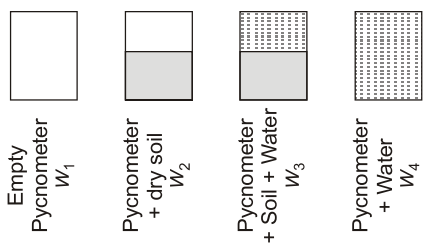
[ESE : 1995]

1.2 The liquid limit and plastic limit of sample are 65% and 29% respectively. The percentage of the soil fraction with grain size finer than 0.002 mm is 24. The activity ratio of the soil sample is

(a) 0.50 (b) 1.00
(c) 1.50 (d) 2.00

[ESE : 1995]

1.3 The given figure indicate the weights of different pycnometers:



The specific gravity of the solids is given by

(a) $\dfrac{W_2}{W_4 - W_2}$

(b) $\dfrac{W_1 - W_2}{(W_3 - W_4) - (W_2 - W_1)}$

(c) $\dfrac{W_2}{W_3 - W_4}$

(d) $\dfrac{W_2 - W_1}{(W_2 - W_1) - (W_3 - W_4)}$

[ESE : 1995]

1.4 A soil sample has a shrinkage limit of 10% and specific gravity of soil solids as 2.7. The porosity of the soil at shrinkage limit is

(a) 21.2% (b) 27%
(c) 73% (d) 78.8%

[ESE : 1995]

1.5 **Assertion (A):** If the water table is very near to the subgrade of the road, it will ultimately cause cracking of the road surface.

Reason (R): The consistency of the soil will change from plastic to liquid state leading to its volumetric decrease.

(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE : 1995]

1.6 In a wet soil mass, air occupies one-sixth of its volume and water occupies one-third of its volume. The void ratio of the soil is

(a) 0.25 (b) 0.5
(c) 1.00 (d) 1.50

[ESE : 1995]

1.7 Lacustrine soils are soils
(a) transported by rivers and streams
(b) transported by glaciers
(c) deposited in sea beds
(d) deposited in lake beds

[ESE : 1996]

1.8 A soil sample is having a specific gravity of 2.60 and a void ratio of 0.78. The water content in percentage required to fully saturate the soil at that void ratio would be
(a) 10 (b) 30
(c) 50 (d) 70

[ESE : 1996]

1.9 A dry soil has mass specific gravity of 1.35. If the specific gravity of solids is 2.7, then the void ratio will be
(a) 0.5 (b) 1.0
(c) 1.5 (d) 2.0

[ESE : 1996]

1.10 A clay sample has a void ratio of 0.50 in dry state and specific gravity of solids = 2.70. Its shrinkage limit will be
(a) 12% (b) 13.5%
(c) 18.5% (d) 22%

[ESE : 1996]

1.11 A soil has liquid limit of 60% plastic limit of 35% and shrinkage limit of 20% and it has a natural moisture content of 50%. The liquidity index of soil is
(a) 1.5 (b) 1.25
(c) 0.6 (d) 0.4

[ESE : 1996]

1.12 Consider the following statements in relation to the given table:

Volume (cc)	Content	Weight (g)
0.2	Air	0
0.3	Water	0.3
0.5	Solids	1.0

1. Soil is partially saturated at degree of saturation = 60%
2. Void ratio = 40%
3. Water content = 30%
4. Saturated unit weight = 1.5 g/cc

Which of these statements is/are correct?
(a) 1, 2 and 3 (b) 1, 3 and 4
(c) 2, 3 and 4 (d) 1, 2 and 4

[ESE : 1996]

1.13 Consider the following statements in the context of aeolian soils:
1. The soil has low density and low compressibility.
2. The soil is deposited by wind.
3. The soil has large permeability.

Which of these statements are correct?
(a) 1, 2 and 3 (b) 2 and 3
(c) 1 and 3 (d) 1 and 2

[ESE : 1997]

1.14 The dry density of a soil is 1.5 g/cc. If the saturation water content were 50% then its saturated density and submerged density would, respectively, be
(a) 1.5 g/cc and 1.0 g/cc
(b) 2.0 g/cc and 1.0 g/cc
(c) 2.25 g/cc and 1.25 g/cc
(d) 2.50 g/cc and 1.50 g/cc

[ESE : 1997]

1.15 The moisture content of a clayey soil is gradually decreased from a large value. What will be the correct sequence of the occurrence of the following limits?
1. Shrinkage limit
2. Plastic limit
3. Liquid limit

Select the correct answer using the codes given below:
(a) 1, 2, 3 (b) 1, 3, 2
(c) 3, 2, 1 (d) 3, 1, 2

[ESE : 1997]

1.16 A fill having a volume of 1,50,000 cum is to be constructed at a void ratio of 0.8. The borrow pit soil has a void ratio of 1.4. The volume of soil required (in cubic meters) to be excavated from the borrow pit will be
(a) 1,87,500 (b) 2,00,000
(c) 2,10,000 (d) 2,50,000

[ESE : 1997]

1.17 Given that Plasticity Index (*PI*) of local soil =15 and *PI* of sand = zero, for a desired *PI* of 6, the percentage of sand in the mix should be

(a) 70 (b) 60
(c) 40 (d) 30

[ESE : 1997]

1.18 A clayey soil has liquid limit = w_L; plastic limit = w_P and natural moisture content = w. The consistency index of the soil is given by

(a) $\frac{W_L - W}{W_L - W_P}$ (b) $\frac{W_L - W_P}{W_L - W}$

(c) $\frac{W_P - W}{W_L - W_P}$ (d) $\frac{W_L - W_P}{W_P - W}$

[ESE : 1998]

1.19 A soil has mass unit weight γ, water content 'w' (as ratio). The specific gravity of soil solids = G, unit weight of water = γ_w; S the degree of saturation of the soil is given by

(a) $S = \frac{1+w}{\frac{\gamma_w}{\gamma}(1+w) - \frac{1}{G}}$

(b) $S = \frac{w}{\frac{\gamma_w}{\gamma}(1+w) - \frac{1}{G}}$

(c) $S = \frac{(1+w)}{\frac{\gamma_w}{\gamma}(1+w) - \frac{1}{G}}$

(d) $S = \frac{w}{\frac{\gamma_w}{\gamma}(1+w) - \frac{1}{wG}}$

[ESE : 1998]

1.20 The saturated and dry densities of a soil are respectively 2000 kg/m^3 and 1500 kg/m^3. The water content (in percentage) of the soil in the saturated state would be

(a) 25 (b) 33.33
(c) 50 (d) 66.66

[ESE : 1999]

1.21 If a soil sample of weight 0.18 kg having a volume of 10^{-4} m^3 and dry unit weight of 1600 kg/m^3 is mixed with 0.02 kg of water then the water content in the sample will be

(a) 30% (b) 25%
(c) 20% (d) 15%

[ESE : 1999]

1.22 Match **List-I** (Terms) with **List-II** (Formulae) and select the correct answer using the codes given below the lists:

List-I	List-II
A. Void Ratio	1. $\frac{V_V}{V}$
B. Porosity	2. $\frac{W_W}{W_S}$
C. Degree of saturation	3. $\frac{V_W}{V_V}$
D. Water content	4. $\frac{W}{V}$
	5. $\frac{V_V}{V_S}$

Codes:

	A	B	C	D
(a)	4	3	5	1
(b)	5	4	3	1
(c)	4	1	5	2
(d)	5	1	3	2

[ESE : 1999]

1.23 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

List-I	List-II
A. Loess	1. Deposited from suspe-nsion in running water
B. Peat	2. Deposits of marine origin
C. Alluvial soil	3. Deposits by wind
D. Marl	4. Organic soil

Codes:

	A	B	C	D
(a)	3	4	2	1
(b)	4	3	1	2
(c)	4	3	2	1
(d)	3	4	1	2

[ESE : 2000]

1.24 The value of porosity of a soil sample in which the total volume of soil grains is equal to twice the total volume of voids would be

(a) 75% (b) 66.66%
(c) 50% (d) 33.33%

[ESE : 2000]

1.25 A soil has a liquid limit of 40% and plasticity index of 20%. The plastic limit of the soil will be

(a) 20% (b) 30%
(c) 40% (d) 60%

[ESE : 2000]

1.26 A sample of saturated sand has a dry unit weight of 18 kN/m^3 and a specific gravity of 2.7. If density of water is 10 kN/m^3, the void ratio of the soil sample will be

(a) 0.5 (b) 0.6
(c) 0.4 (d) 0.9

[ESE : 2000]

1.27 **Assertion (A):** Black cotton soils are clays and they exhibit characteristic property of swelling.
Reason (R): These clays contain Montmorillonite which attracts external water into its lattice structure.

(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE : 2001]

1.28 A dry soil sample has equal amounts of solids and voids by volume. Its void ratio and porosity will be

	Void ratio	Porosity (%)
(a)	1.0	100%
(b)	0.5	50%
(c)	0.5	100%
(d)	1.0	50%

[ESE : 2001]

1.29 The plasticity index and the percentage of grain size finer than 2 microns of a clay sample are 25 and 15, respectively. Its activity ratio is

(a) 2.5 (b) 1.67
(c) 1.0 (d) 0.6

[ESE : 2001]

1.30 A soil sample having a void ratio of 1.3, water content of 50% and a specific gravity of 2.60, is in a state of

(a) partial saturation
(b) full saturation
(c) over saturation
(d) under saturation

[ESE : 2001]

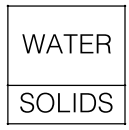
1.31 The natural void ratio of a sand sample is 0.6 and its density index is 0.6. If its void ratio in the loosest state is 0.9, then the void ratio in the densest state will be

(a) 0.2 (b) 0.3
(c) 0.4 (d) 0.5

[ESE : 2001]

1.32 Which one of the following phase diagrams represents a clay at its shrinkage limit?

(a)


(b)


(c)


(d)


[ESE : 2001]

1.33 Which one of the following correctly represents the dry unit weight of a soil sample which has a bulk unit weight of γ_t at a moisture content of w%?

(a) $\frac{w\gamma_t}{100}$ (b) $\gamma_t\left(1+\frac{w}{100}\right)$
(c) $\gamma_t\left(\frac{100}{100+w}\right)$ (d) $\frac{\gamma_t(100-w)}{100}$

[ESE : 2001]

1.34 Which one the following represents relative density of saturated sand deposit having moisture content of 25%, if maximum and minimum void ratio of sand are 0.95 and 0.45 respectively and specific gravity of sand particles is 2.6?

(a) 40% (b) 50%
(c) 60% (d) 70%

[ESE : 2002]

1.35 The correct sequence of plasticity of minerals in soil in an increasing order is

(a) silica, kaolinite, illite, montmorillonite
(b) kaolinite, silica, illite, montmorillonite
(c) silica, kaolinite, montmorillonite, illite
(d) kaolinite, silica, montmorillonite, illite

[ESE : 2002]

1.36 **Assertion (A):** A soil is at its liquid limit if the consistency index of the soil is equal to zero.
Reason (R): The consistency index of a soil is defined as ratio of (liquid limit minus the natural water content) to (natural water content minus plastic limit).

(a) both A and R are true and R is the correct explanation of A

1.72 Consider the following statements:
1. If the soil is not black in colour, it is unlikely to be a swelling soil.
2. The swelling pressure of a fine-grained soil depends on its initial water content and density.
3. The swelling pressure of a fine-grained soil depends on the nature of the pore fluid.

Which of these statements are correct?
(a) 1, 2 and 3 (b) 1 and 2 only
(c) 1 and 3 only (d) 2 and 3 only

[ESE : 2013]

1.73 A soil sample has a void ratio of 0.5; its porosity will be
(a) 50% (b) 66%
(c) 100% (d) 33%

[ESE : 2014]

1.74 A saturated specimen of clay was immersed in mercury and displaced volume was 21.8 cc. The weight of the sample was 32.2 gm. After oven drying for 48 hours, weight reduced to 20.2 gm while volume came down to 11.6 cc. The shrinkage limit of the soil is
(a) 7.9% (b) 8.0%
(c) 8.9% (d) 9.8%

[ESE : 2014]

1.75 **Statement (I):** Clays exhibit more hygroscopicity than sands.

Statement (II): Clays are colloidal and consequently their specific surface is very high.
(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I).
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I).
(c) Statement (I) is true but Statement (II) is false.
(d) Statement (I) is false but Statement (II) is true.

[ESE : 2014]

1.76 The specific gravity of a soil sample is 2.7 and its void ratio is 0.945. When it is fully saturated the moisture content of the soil will be
(a) 25% (b) 30%
(c) 35% (d) 40%

[ESE : 2015]

1.77 A soil sample has shrinkage limit of 6% and the specific gravity of the soil grains is 2.6. The porosity of soil at shrinkage limit is
(a) 7.5% (b) 9.5%
(c) 13.5% (d) 16.5%

[ESE : 2016]

1.78 What is the dry unit weight of a clay soil when the void ratio of a sample there of is 0.50, the degree of saturation is 70% and the specific gravity of soil grains is 2.7? Take the value of γ_w to be 9.81 kN/m^3.
(a) 13.65 kN/m^2 (b) 19.95 kN/m^2
(c) 23.65 kN/m^2 (d) 29.95 kN/m^2

[ESE : 2016]

1.79 A fill having volume of 150000 m^3 is to be constructed at a void ratio of 0.8. The borrow pit solid has a void ratio of 1.4. The volume of soil required to be excavated from the borrow pit will be
(a) 150000 m^3 (b) 200000 m^3
(c) 250000 m^3 (d) 300000 m^3

[ESE : 2016]

1.80 The ratio of dry unit weight to unit weight of water represents
(a) specific gravity of soil solids
(b) specific gravity of soil mass
(c) specific gravity of dry soil
(d) shrinkage ratio

[ESE : 2016]

1.81 Proctor's compaction test for the maximum dry density of a certain soil gave the results as : 1.77 gm/cc and OMC 14.44%. The specific gravity of the clay soil grain was 2.66. What was the saturation degree for this soil?
(a) 44% (b) 55%
(c) 66% (d) 77%

[ESE : 2016]

1.82 The value of porosity of a soil sample in which the total volume of soil grains is equal to twice the total volume of voids would be
(a) 30% (b) 40%
(c) 50% (d) 60%

[ESE : 2016]

1.83 Consider the following statements:
1. Illite the mineral largely responsible for the swelling and shrinkage behaviour of clayey soils.

2. A differential free swell value of 55% indicates a soil with low degree of expansiveness.
3. Higher the plasticity index of a soil, greater its swelling potential.
4. A low shrinkage limit of a soil indicates possibility of swelling at low water content.

Which of the above statements are correct?

(a) 1 and 2 (b) 2 and 3
(c) 1 and 4 (d) 3 and 4

[ESE : 2017]

1.84 Consider the following effects as indicative of complete saturation of a soil sample:

1. Pore water pressure is positive.
2. Volume of water to volume of voids is equal to 1.
3. Relative density is equal to 1.

Which of the above statements are correct?

(a) 1 and 2 (b) 1 and 3
(c) 2 and 3 (d) 1, 2 and 3

[ESE : 2017]

1.85 **Statement (I):** At shrinkage limit, the soil is fully saturated.

Statement (II): Montmorillonite clay minerals are non-expansive.

(a) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I)
(b) Both Statement (I) and Statement (II) are individually true but Statement (II) is ***not*** the correct explanation of Statement (I)
(c) Statement (I) is true but Statement (II) is false
(d) Statement (I) is false but Statement (II) is true

[ESE : 2017]

1.86 Consider the following statements:

1. When a soil sample is dried beyond its shrinkage limit, the volume of the soil slowly decreases.
2. Plastic limit is always lower than the liquid limit for any type of soil.
3. At the liquid limit, the soil behaves like a liquid and possesses no shear strength at all.
4. When subjected to drying, the volume of the soil remains unchanged once the water content of the soil goes below its shrinkage limit.

Which of the above statements are CORRECT?

(a) 1 and 3 only (b) 1 and 4 only
(c) 2 and 3 only (d) 2 and 4 only

[ESE : 2018]

1.87 A sand sample has a porosity of 30% and specific gravity of solids as 2.6. What is its degree of saturation at moisture content of 4.94%?

(a) 40% (b) 35%
(c) 30% (d) 25%

[ESE : 2018]

1.88 What will be the unit weight of a fully saturated soil sample having water content of 38% and grain specific gravity of 2.65?

(a) 19.88 kN/m^3 (b) 17.88 kN/m^3
(c) 16.52 kN/m^3 (d) 14.65 kN/m^3

[ESE : 2018]

1.89 How many cubic metres of soil having void ratio of 0.7 can be made from 30 m^3 of soil with void ratio of 1.2?

(a) 36.6 m^3 (b) 30.0 m^3
(c) 25.9 m^3 (d) 23.2 m^3

[ESE : 2018]

1.90 A sample of dry soil is coated with a thin layer of paraffin and has a mass of 460 g. It displaced 300 cc of water when immersed in it. The paraffin is peeled off and its mass was found to be 9 g. If the specific gravity of soil solids and paraffin are 2.65 and 0.9 respectively, the voids ratio of soil is nearly

(a) 0.92 (b) 0.71
(c) 0.59 (d) 0.48

[ESE : 2018]

1.91 The property of clays by virtue of which they regain, if left alone for a time, a part of the strength lost due to remoulding at unaltered moisture content, is known as

(a) Thixotropy (b) Sensitivity
(c) Consistency (d) Activity

[ESE : 2019]

1.92 The plastic limit and liquid limit of a soil are 30% and 42% respectively. The percentage volume change from liquid limit to dry state is 35% of the dry volume. Similarly the percentage volume change from plastic limit to dry state is 22% of the dry volume. The shrinkage ratio will be nearly

(a) 4.2 (b) 3.1
(c) 2.2 (d) 1.1

[ESE : 2019]

1.93 The ratio of a given volume change in a soil, expressed as percentage of the dry volume, to the corresponding change in water content is called
(a) Specific gravity of soil solids
(b) Mass-specific gravity of soils
(c) Shrinkage ratio of soils
(d) Density ratio of soils

[ESE : 2019]

1.94 A soil sample has porosity of 40%, and the specific gravity of solids is 2.70. If the soil is 50% saturated, the unit weight will be nearly
(a) 22 kN/m^3 (b) 20 kN/m^3
(c) 18 kN/m^3 (d) 16 kN/m^3

[ESE : 2020]

1.95 Oven dry mass of a pat of clay is 10.8 gm and mass of mercury displaced on immersion is 84.2 gm. If the specific gravity of solids is 2.72 and the density of the mercury is 13.6 g/cm^3, the shrinkage limit of the soil will be nearly
(a) 12% (b) 15%
(c) 18% (d) 21%

[ESE : 2020]

1.96 The suitability number of a backfill for D_{50} = 1 mm, D_{20} = 0.5 mm and D_{10} = 0.08 mm will be nearly
(a) 16 (b) 18
(c) 20 (d) 22

[ESE : 2020]

1.97 The porosity of a soil n is

(a) $\frac{e}{1+e}$ (b) $\frac{e}{1-e}$

(c) $\frac{e+1}{e}$ (d) $\frac{e-1}{e}$

Where e = void ratio

[ESE : 2020]

■■■■

Answers Properties of Soils

1.1 (b)	1.2 (c)	1.3 (d)	1.4 (a)	1.5 (c)	1.6 (c)	1.7 (d)	1.8 (b)	1.9 (b)	
1.10 (c)	1.11 (c)	1.12 (b)	1.13 (b)	1.14 (c)	1.15 (c)	1.16 (b)	1.17 (b)	1.18 (a)	
1.19 (b)	1.20 (b)	1.21 (b)	1.22 (d)	1.23 (d)	1.24 (c)	1.25 (a)	1.26 (a)	1.27 (a)	
1.28 (d)	1.29 (b)	1.30 (b)	1.31 (c)	1.32 (b)	1.33 (c)	1.34 (c)	1.35 (a)	1.36 (c)	
1.37 (c)	1.38 (c)	1.39 (c)	1.40 (d)	1.41 (d)	1.42 (c)	1.43 (a)	1.44 (d)	1.45 (c)	
1.46 (d)	1.47 (d)	1.48 (a)	1.49 (c)	1.50 (d)	1.51 (c)	1.52 (a)	1.53 (c)	1.54 (b)	
1.55 (b)	1.56 (c)	1.57 (c)	1.58 (d)	1.59 (d)	1.60 (d)	1.61 (a)	1.62 (d)	1.63 (b)	
1.64 (b)	1.65 (d)	1.66 (b)	1.67 (a)	1.68 (b)	1.69 (c*)	1.70 (b)	1.71 (c)	1.72 (d)	
1.73 (d)	1.74 (c)	1.75 (a)	1.76 (c)	1.77 (c)	1.78 (b)	1.79 (b)	1.80 (d)	1.81 (d)	
1.82 (a)	1.83 (d)	1.84 (a)	1.85 (c)	1.86 (d)	1.87 (c)	1.88 (b)	1.89 (d)	1.90 (b)	
1.91 (a)	1.92 (d)	1.93 (c)	1.94 (c)	1.95 (d)	1.96 (d)	1.97 (a)			

Explanations Properties of Soils

1.1 (b)

Alluvial soil is a fine grained fertile soil deposited by water flowing over flood plains or in river beds.

Lacustrine Soil is deposited at bottom of lakes. The soil material consists of a clay and silt mixture.

Aeolian soils are wind deposited materials that consist primarily of sand or silt-sized particles. These materials tend to be extremely well sorted and free of coarse fragments.

Marine soils are sediments that accumulate in a marine (ocean or sea) environment. These sediments are later exposed and subjected to soil development because either the ocean floor was uplifted or the water receded.

1.2 (c)

$$\text{Activity} = \frac{\text{Plasticity index}}{\text{Percent of clay particles finer than 2}\mu\text{m}}$$

$$= \frac{65-29}{24} = \frac{36}{24}$$

$$= 1.5 > 1.25$$

$\therefore$ The soil is active.

1.3 (d)

Specific Gravity of solids is given by

$$G_s = \frac{W_2 - W_1}{(W_2 - W_1) - (W_3 - W_4)}$$

1.4 (a)

At shrinkage limit ($S = 100\%$)

$\therefore$ $e = wG_s$

$w = 10\%$

$G_s = 2.7$

Porosity, $n = \frac{e}{1+e} \times 100$

$$= \frac{0.27}{1+0.27} \times 100 = 21.2\%$$

1.5 (c)

The volume of soil increases from plastic limit to liquid limit. The cracking in soil is due to reduction in bearing capacity and consequent failure and heaving.

1.6 (c)

Void ratio, $e = \frac{V_V}{V_S}$

V_v = air void + water filled voids

$$= \frac{1}{6}V + \frac{1}{3}V = \frac{V}{2}$$

$$V_s = V - V_v = \frac{V}{2}$$

$\therefore$ $e = \frac{V/2}{V/2} = 1.0$

1.7 (d)

Lacustrine soils are silt and clays which have been deposited in still, fresh water of lakes.

1.8 (b)

Given, $S = 100\%$

$\therefore$ $w = \frac{Se}{G} = \frac{100 \times 0.78}{2.60} = 30\%$

1.9 (b)

$$G_m = G_s(1-n) = \frac{G_s}{1+e}$$

G_m is mass specific gravity

G_s is specific gravity of solids

$\therefore$ $e = \frac{G_s}{G_m} - 1$

$\Rightarrow$ $e = \frac{2.7}{1.35} - 1 = 1$

1.10 (c)

At shrinkage limit, soil is fully saturated.

$\therefore$ $w_s = \frac{e}{G} \times 100 = \frac{0.5}{2.7} \times 100$

$= 18.5\%$

1.11 (c)

Liquidity Index

$$= \frac{w - w_P}{w_L - w_P} = \frac{50-35}{60-35}$$

$$= \frac{15}{25} = 0.6$$

Note: Consistency Index = 1 – 0.6 = 0.4

1.12(b)

Degree of saturation,

$$S = \frac{V_w}{V_V} \times 100$$

$$= \frac{0.3}{0.2+0.3} \times 100 = 60\%$$

$$\text{and void ratio} = \frac{V_v}{V_s} = \frac{0.2+0.3}{0.5}$$

$$= 1 \times 100 = 100\%$$

1.13(b)

Aeolian soils are deposited by winds. It consist of uniformly graded particles. The void ratio and permeability of soil are high. They are non-plastic and can withstand deep vertical cuts due to slight cementation between particles. These soils have high compressibility and density is low in natural states.

Example: Fine sand in dunes; loess.

1.14(c)

$$\gamma_{sat} = \gamma_d(1 + w) = 1.5 \times 1.5$$

$$= 2.25 \text{ g/cc}$$

$$\gamma_{sub} = \gamma_{sat} - \gamma_w = 2.25 - 1.0$$

$$= 1.25 \text{ g/cc}$$

1.15 (c)

As the moisture content of a clayey soil is reduced from a large value, the alterberg limits are encountered in following sequence.

Liquid limit → Plastic limit → Shrinkage limit

1.16(b)

The volume of soil solids from borrow pit soil and from fill should be equated.

$$V_s = \frac{V_1}{1+e_1} = \frac{V_2}{1+e}$$

$$\therefore \quad V_1 = V_2 \times \frac{1+e_1}{1+e_2}$$

$$= 150000 \times \frac{1+1.4}{1+0.8}$$

$$= 200{,}000 \text{ m}^3$$

1.17(b)

Let percentage of sand is x. So plasticity of mix is $x \times 0 + (1 - x) \times 15 = 6$

$$x = \frac{9}{15} = 0.6 \text{ or } 60\%$$

1.18 (a)

The consistency index indicates the consistency (firmness) of a soil. Soil at the liquid limit will have a consistency index of 0, while soil at the plastic limit will have a consistency index of 1.

1.19(b)

$$\gamma = \frac{G(1+w)}{1+e}\gamma_w$$

$$1 + e = \frac{G(1+w)\gamma_w}{\gamma}$$

and $$Gw = Se$$

$$\frac{Gw}{S} = \frac{G(1+w)\gamma_w}{\gamma} - 1$$

Dividing both sides by G, we get

$$\Rightarrow \quad \frac{w}{S} = (1 + w)\frac{\gamma_w}{\gamma} - \frac{1}{G}$$

$$S = \frac{w}{\frac{\gamma_w}{\gamma}(1+w) - \frac{1}{G}}$$

1.20(b)

$$\gamma_d = \frac{\gamma_{sat}}{\left(1 + \frac{w}{100}\right)}$$

$$1 + \frac{w}{100} = \frac{2000}{1500}$$

$$\therefore \quad w = 33.33\%$$

1.21(b)

Dry weight of sample

$$= 1600 \times 10^{-4} = 0.16 \text{ kg}$$

Weight of water in soil before mixing additional quantity

$$= 0.18 - 0.16 = 0.02 \text{ kg}$$

After mixing water the total quantity of water

$$= 0.02 + 0.02$$

$$= 0.04 \text{ kg water}$$

Thus, water content $= \frac{0.04}{0.16} \times 100 = 25\%$

1.22 (d)

Degree of saturation,

$$S = \frac{V_w}{V_v} \times 100 = \frac{W_w}{V_V} \times 100$$

Void ratio, $$e = \frac{V_V}{V_S}$$