DARBHANGA COLLEGE OF ENGINEERING

COURSE FILE

OF

Geotechnical Engineering - I (101503)

Faculty Name:

AHSAN RABBANI

Assistant Professor, DEPARTMENT OF CIVIL ENGINEERING

विज्ञान एवं प्रावैधिकी विभाग
Department of Science and Technology
Government of Bihar

CONTENTS

DEPARTMENT OF CIVIL ENGINEERING
DARBHANGA COLLEGE OF ENGINEERING, DARBHANGA

Vision of Department

To bring forth competent engineers to serve national & multi-national industries and society and, encouraging them towards higher studies

Mission of Department

M1. To nurture graduates into competent and technologically capable professionals through motivated teaching-learning ambience and by collaborating with relevant industries.

M2. To encourage graduates towards research and innovation in the field of civil engineering.

M3. To inculcate humanitarian ethical values in graduates through various social-cultural activities.

Program Educational Objectives (PEOs)

PEO1. The graduates will be able to demonstrate knowledge and skills of civil engineering to solve engineering problems related to structural design.

PEO2. The graduates will be able to function in the evolving research and development as design consultant in the relevant industry using modern software tools.

PEO3. The graduates will be able to showcase professional skills encompassing societal and ethical values.

Program Specific Outcomes (PSO):

PSO1: Students will be able to use advanced modern methods and tools like GIS, Auto CAD, Staad Pro, Total station to function as design consultants.

PSO2: Graduates will able to develop knowledge in some specific technical areas of civil engineering like Structural, Geotechnical, Transportation, Earthquake, Geomatics and Environmental Engineering.

CIVIL ENGINEERING PROGRAM EDUCATIONAL OBJECTIVES

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1	To prepare our graduates to have successful careers in design and analysis of various Civil Engineering structures and also motivate them to pursue higher studies and research in the relevant fields.
PEO2	To prepare our graduates as a good cognizance of Societal, Environmental and Ethical issues and have effective communication skills.
PEO3	To develop awareness of contemporary professionals issues and encourage them to support the Engineering profession through contribution in professional's societies and/or Educational Institutions.

PROGRAM SPECIFIC OUTCOMES (PSOs)

The PSOs of Civil engineering programme supported by the curriculum are given below.

PSO1	To function as design consultants in the relevant industry for the design of civil engineering structures using modern software tool.
PSO2	To develop knowledge in some specific technical areas of civil engineering; Structural, Geotechnical, Transportation, Earthquake and Environmental engineering.

PROGRAMME OUTCOMES (PO)

PO1	**Engineering knowledge**: An ability to apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to get the solution of the engineering problems.
PO2	**Problem analysis:** Ability to Identify, formulates, review research literature, and analyze complex engineering problems.
PO3	**Design/development of solutions:** Ability to design solutions for complex engineering problems by considering social, economical and environmental aspects.
PO4	**Conduct investigations of complex problems:** Use research-based knowledge to design, conduct analyse experiments to get valid conclusion.
PO5	**Modern tool usage:** ability to create, select, and apply appropriate techniques, and to model complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society:** Ability to apply knowledge by considering social health, safety, legal and cultural issues.
PO7	**Environment and sustainability:** Understanding of the impact of the adopted engineering solutions in social and environmental contexts.
PO8	**Ethics**: Understanding of the ethical issues of the civil engineering and applying ethical principles in engineering practices.
PO9	**Individual and teamwork:** Ability to work effectively as an individual or in team, as a member or as a leader.
PO10	**Communication:** An ability to communicate clearly and effectively through different modes of communication.
PO11	**Project management and finance:** Ability to handle project and to manage finance related issue
PO12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning.

Institute/college Name	Darbhanga College of Engineering, Darbhanga
Corse/Branch	B.Tech./Civil Engineering
Year/Semester	III/V
Course Code/Choice	101503 / Core
Course credits	4
Course Name	Geotechnical Engineering-I
Lecture/ Sessional (per week)	4/0
Course Teacher name	Mr. Ahsan Rabbani
Deptt./Designation	Civil Engineering/Assistant Professor

Objective:

I. To prepare civil engineering graduate students for their professional careers as good geotechnical engineers - in academics/research, construction, consulting, design, development, regulation, etc.

II. To achieve/groom an ability to plan, innovate and design any geotechnical system, with an intelligent understanding

III. To impart practical perspectives of geotechnical engineering this will enable geotechnical engineers to give techno-economically feasible and sustainable practical solutions to geotechnical problems in infrastructure development projects

COURSE OUTCOMES (COs): After the completion of this course, students will be able to;

CO1: Understand the different types of soil based on their formation mechanism
CO2: Analyse the behaviour of soils based on their physical properties
CO3: Determine the seepage quantities and pore water pressures below the ground
CO4: Understand the effect of capillary action and seepage flow direction on the effective stress at a point in the soil mass
CO5: Compute the compactive effort required to obtain necessary degree of compaction in-situ

CO-PO MAPPING

Sl No.	Course Outcome	PO
1	CO1: Understand the different types of soil based on their formation mechanism	PO1, PO2, PO4, PO6, PO9, PO12, PSO1, PSO2
2	CO2: Analyse the behaviour of soils based on their physical properties	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO11, PO12, PSO1, PSO2
3	CO3: Determine the seepage quantities and pore water pressures below the ground	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO11, PO12, PSO1, PSO2
4	CO4: Understand the effect of capillary action and seepage flow direction on the effective stress at a point in the soil mass	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO9, PO11, PO12, PSO1, PSO2
5	CO5: Compute the compactive effort required to obtain necessary degree of compaction in-situ	PO1, PO2, PO4, PO5, PO7, PO8, PO9, PO12, PSO1, PSO2

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1: Understand the different types of soil based on their formation mechanism	3	2	-	1	-	1	-	-	1	-	-	2	2	3
CO2: Analyse the behaviour of soils based on their physical properties	3	3	1	3	3	2	2	2	2	-	1	2	2	3
CO3: Determine the seepage quantities and pore water pressures below the ground	3	3	2	2	2	3	1	1	2	-	1	3	3	3
CO4: Understand the effect of capillary action and seepage flow direction on the effective stress at a point in the soil mass	3	3	1	3	2	1	1	-	1	-	1	3	2	3
CO5: Compute the compactive effort required to obtain necessary degree of compaction in-situ	3	2	-	2	1	-	1	1	2	-	-	1	2	3

Correlation Level: 1- Slight (Low) 2- moderate (Medium) 3 – Substantial (High)

101503	Geotechnical Engineering - I	3L:0T:2P	4 credits

Module 1: Introduction–Types of soils, their formation and deposition, Definitions: soil mechanics, soil engineering, rock mechanics, geotechnical engineering. Scope of soil engineering. Comparison and difference between soil and rock. Basic Definitions and Relationships-Soil as three-phase system in terms of weight, volume, voids ratio, and porosity. Definitions: moisture content, unit weights, degree of saturation, voids ratio, porosity, specific gravity, mass specific gravity, etc. Relationship between volume weight, voids ratio- moisture content, unit weight- percent air voids, saturation-moisture content, moisture content- specific gravity etc. Determination of various parameters such as: Moisture content by oven dry method, pycnometer, sand bath method, torsional balance method,nuclear method, alcohol method and sensors. Specific gravity by density bottle method, pycnometer method, measuring flask method. Unit weight by water displacement method, submerged weight method, core-cutter method, sand-replacement method.

On completion of this module, the students must be able to:
• Understand the different types of soil based on their formation mechanism;
• Understand the various phase diagrams and derive various phase relationships of the soil; Perform various laboratory experiments to determine moisture content, specific gravity; Perform field experiments to estimate the field density of the soil mass.

Module 2: Plasticity Characteristics of Soil - Introduction to definitions of: plasticity of soil, consistency limits-liquid limit, plastic limit, shrinkage limit, plasticity, liquidity and consistency indices, flow & toughness indices, definitions of activity and sensitivity. Determination of: liquid limit, plastic limit and shrinkage limit. Use of consistency limits. Classification of Soils-Introduction of soil classification: particle size classification, textural classification, unified soil classification system, Indian standard soil classification system. Identification: field identification of soils, general characteristics of soil in different groups.

On completion of this module, the students must be able to:
• Understand the behaviour of soils based on their moisture contents;
• Perform laboratory experiments to estimate various Atterberg limits and evaluate index properties of soils;
• Classify any soils based on their particle size distribution and index properties;

Module 3: Permeability of Soil - Darcy's law, validity of Darcy's law. Determination of coefficient of permeability: Laboratory method: constant-head method, falling-head method. Field method: pumping- in test, pumping- out test. Permeability aspects: permeability of stratified soils, factors affecting permeability of soil. Seepage Analysis- Introduction, stream and potential functions, characteristics of flow nets, graphical method to plot flow nets.

On completion of this module, the student must be able to:
• Determine the permeability of soils through various laboratory and field tests;
• Analytically calculate the effective permeability of anisotropic soil mass;
• Determine the seepage quantities and pore water pressures below the ground;
• Graphically plot the equipotential lines and flow lines in a seepage flow.

Module 4: Effective Stress Principle - Introduction, effective stress principle, nature of effective stress, effect of water table. Fluctuations of effective stress, effective stress in soils saturated by capillary action, seepage pressure, quick sand condition.

On completion of this module, the student must be able to:
• Understand the physical significance of effective stress and its relation with pore pressure;
• Plot various stress distribution diagrams along the depth of the soil mass;
• Understand the effect of capillary action and seepage flow direction on the effective stress at a point in the soil mass.

Module 5: Compaction of Soil-Introduction, theory of compaction, laboratory determination of optimum moisture content and maximum dry density. Compaction in field, compaction specifications and field control.

On completion of this module, the student must be able to:

• Perform laboratory test to determine the maximum dry density and optimum moisture content of the soil;
• Variation in compaction curve with compaction effort and soil type;
• Determine the compactive effort required to obtain necessary degree of compaction in-situ;
• Differentiate among various field methods of compaction and their usage based on the type of soil.

Module 6: Stresses in soils – Introduction, stresses due to point load, line load, strip load, uniformly loaded circular area, rectangular loaded area. Influence factors, Isobars, Boussinesq's equation, Newmark's Influence Chart. Contact pressure under rigid and flexible area, computation of displacements from elastic theory. On completion of this module, the student must be able to:
• Analytically compute the vertical stress in a semi-infinite soil mass due to various loading conditions; Plot isobars due various loading conditions.

Text/Reference Books:
1. Soil Mechanics by Craig R.F., Chapman & Hall
2. Fundamentals of Soil Engineering by Taylor, John Wiley & Sons
3. An Introduction to Geotechnical Engineering, by Holtz R.D. and Kovacs, W.D., Prentice Hall, NJ
4. Principles of Geotechnical Engineering, by Braja M. Das, Cengage Learning
5. Principles of Foundation Engineering, by Braja M. Das, Cengage Learning
6. Essentials of Soil Mechanics and Foundations: Basic Geotechnics by David F. McCarthy
7. Soil Mechanics in Engineering Practice by Karl Terzaghi, Ralph B. Peck, and Gholamreza Mesri.
8. Geotechnical Engineering: Principles and Practices of Soil Mechanics and Foundation Engineering (Civil and Environmental Engineering) by V.N.S. Murthy

Time Table: 5th Semester

Darbhanga College of Engineering

5th Semester w.e.f:

DAY	Dept.	09:00-11:00	11:00-01:00	01:00-02:00	02:00-5:00
MONDAY	EEE	CS	PS-I	LUNCH	√. PE Lab
	CE	EE-1	MOM		√. HE LAB
	CSE	REMIDAL CLASSES	DBMS		MOOC
	ME	HT	F M/C		
TUESDAY	EEE	√. CS Lab	ADC		Intership
	CE	H & WRE	HE		√. Geo Tech Lab
	CSE	AI	DBMS		REMIDAL CLASSES
	ME	MP	√.REMIDAL LAB		
WEDNESDAY	EEE	PE	CS		√. PS-I Lab
	CE	ADCS	MOM		√. TRE LAB
	CSE	SWE	AI		√. DBMS Lab
	ME	HT	EIKT		
THURSDAY	EEE	REMIDAL CLASSES	PS-I		√. CS Lab
	CE	GEO TECH-1	TRE		√. EE-1 LAB
	CSE	√. DBMS Lab	SWE		Seminar
	ME	KOM	√. REMIDAL LAB		
FRIDAY	EEE	√. PE Lab	PE		√. ADC lab
	CE	COI	ADCS		GEO TECH-I
	CSE	PS	FLAT		Intership
	ME	MP	F M/C		
SATURDAY	EEE	Intership	ADC		REMIDAL CLASSES
	CE	EE-1	TRE		√. H & WRE LAB
	CSE	PS	FLAT		MC 501
	ME	KOM	√. REMIDAL LAB		

EEE (5th Sem)

SN	Subject	Faculty
1	PS-I	Mr. Tabish Shanu
2	CS	Mr. Sanjay Kumar
3	PE	Mr. Abhishek Sharma
4	ADC	Dr. Ravi Ranjan
5	Intership	All Faculty
6	MOOC	All Faculty

CE (5th Sem)

SN.	Subject	Faculty
1	MOM	Mr. Ravi Ranjan Kumar
2	HE	Mr. Loknath Kumar
3	ADCS	Mr. S. S. Chhoudhary
4	Geo Tech -I	Mr. Ahsan Rabbani
5	H & WRE	Mr. Prashant Kumar
6	EE-I	Mr. Jitendra Kumar
7	TE	Mr. Aditya Kumar
8	COI	Mr. Loknath Kumar
9	Intership	All Faculty

ME (5th Sem)

SN.	Subject	Faculty
1	HT	Mr. Madhav Ram
2	F M/C	Mr. Prabhakar Kumar
3	MP	Mr. Rajat Gupta
4	KOM	Mr. Prashant Kr. Singh
5	EIKT	Mr. Prashant Kr. Singh
6	MOOC	Mr. Vikash Kumar

CSE (5th Sem)

SN.	Subject	Faculty
1	DBMS	Mr. Akhilesh Kumar
2	SWE	Mr. Sunil Kumar Sahu
3	AI	Mr. Dhirendra Kumar
4	FLAT	Mr. Ajit Kumar Gupta
5	PS	
6	MOOC	Anand Kamal
7	Intership	Mr. Sunil Kumar Sahu
8	MOOC	Mr Anand Kamal

15/07/2020
HOD (EEE)

15/7/2020
Asst. Routine Incharge

15/07/2020
HOD (ME)

15/7/2020
Routine Incharge

15/07/2020
HOD(CSE)

15/07/2020
DCE Darbhanga

List of Student: B Tech Civil Engineering (5th Semester)			
Sl. No.	**Name of Student**	**Roll No.**	**Registration No.**
1	Saurav Kumar Suman	18-C-59	18101111002
2	Raju Kumar Mishra	18-C-74	18101111004
3	Aryan Kumar	18-C-02	18101111005
4	Md. Istaba	18-C-04	18101111006
5	Kumar Shubhendu Shubham	18-C-13	18101111007
6	Kanhaiya Kumar	18-C-20	18101111008
7	Satish Kumar	18-C-15	18101111009
8	Sagar Kumar	18-C-12	18101111010
9	Pradeep Kumar	18-C-08	18101111011
10	Nivedita Kumari	18-C-09	18101111012
11	Suraj Kumar	18-C-26	18101111014
12	Kunal Kumar	18-C-05	18101111015
13	Ankit Chandra	18-C-23	18101111016
14	Ashutosh Anand	18-C-39	18101111018
15	Rahul Kumar	18-C-40	18101111019
16	Kaushal Kumar	18-C-37	18101111020
17	Md Naimuddin	18-C-27	18101111021
18	Kartik Kumar	18-C-36	18101111023
19	Nikita Raj	18-C-43	18101111024
20	Bandana Kumari	18-C-34	18101111025
21	Ganesh Kr. Sah	18-C-41	18101111027
22	Robins Kumar	18-C-46	18101111028
23	Rahul Dutta	18-C-51	18101111029
24	Manish Kumar	18-C-47	18101111030
25	Raja Kumar	18-C-50	18101111031
26	Bipin Kumar	18-C-44	18101111032
27	Mohit Kumar	18-C-52	18101111033
28	Md. Shahadat	18-C-56	18101111034
29	Bharat Pandit	18-C-55	18101111035
30	Kumar Purendra Shekhar	18-C-53	18101111036
31	Rahul Kumar Das	18-C-57	18101111037
32	Shubham Kumar	18-C-58	18101111038
33	Karanjeet Kumar	18-C-75	18101111039
34	Anand Kumar	18-C-62	18101111040
35	Kamaljee Mandal	18-C-68	18101111041
36	Rishav Kumar	18-C-67	18101111045
37	Rajiv Ranjan	18-C-63	18101111046

38	Md. Abdul Kalam	18-C-70	18101111047
39	Siddharth Raj	18-C-79	18101111049
40	Gajendra Kr. Sharma	18-C-60	18101111050
41	Sahil Raj	18-C-61	18101111051
42	Ram Kumar Suman	18-C-65	18101111052
43	Prahlad Kumar	18-C-69	18101111053
44	Rishav Krishna	18-C-72	18101111054
45	Mayank Vishwabandhu	18-C-81	18101111055
46	Prince Kumar	18-C-71	18101111056
47	Dhirendra Kumar Verma	18-C-73	18101111057
48	Ankit Kumar	18-C-66	18101111058
49	Aashish Kr. Choudhary	18-C-80	18101111059
50	Satya Prakash	19LEC	19101111901
51	Anjali Sahani	19LEC08	19101111902
52	Manoj Kumar	19LEC02	19101111903
53	Rima Kumari	19LEC01	19101111904
54	Sanyukta Kumari	19LEC	19101111905
55	Om Prakash Singh	19LEC06	19101111906
56	Himanshu Ranjan	19LEC03.	19101111907
57	Avinash Kumar	19LEC04	19101111908
58	Prince Raj	19LEC05	19101111909
59	Anshu	19LEC10	19101111910
60	Manzar Imam	19LEC11	19101111911

Lecture Plan:

Lecture on topic	Lecture Number	Proposed Date of Lecture
Module 1		
Introduction–Types of soils, their formation and deposition	**1**	
Definitions: soil mechanics, soil engineering, rock mechanics, geotechnical engineering. Scope of soil engineering.	**2**	
Comparison and difference between soil and rock. Basic Definitions and Relationships	**3**	
Soil as three-phase system in terms of weight, volume, voids ratio, and porosity.	**4**	
Definitions: moisture content, unit weights, degree of saturation, voids ratio, porosity, specific gravity, mass specific gravity, etc.	**5**	
Relationship between volume weight, voids ratio- moisture content, unit weight-percent air voids, saturation- moisture content, moisture content- specific gravity etc.	**6**	
Determination of various parameters such as: Moisture content by oven dry method, pycnometer, sand bath method, torsional balance method, nuclear method, alcohol method and sensors.	**7**	
Specific gravity by density bottle method, pycnometer method, measuring flask method. Unit weight by water displacement method, submerged weight method, core-cutter method, sand-replacement method.	**8**	
Numerical questions related to various physical properties and their relations	**9**	
Module 2		
Plasticity Characteristics of Soil - Introduction to definitions of: plasticity of soil, consistency limits-liquid limit, plastic limit & shrinkage limit	**10**	
Definition of plasticity, liquidity and consistency indices, flow & toughness indices, definitions of activity and sensitivity	**11**	
Determination of: liquid limit, plastic limit and shrinkage limit. Use of consistency limits	**12**	
Classification of Soils-Introduction of soil classification: particle size classification, textural classification	**13**	
Unified soil classification system, Indian standard soil classification system	**14**	
Identification: field identification of soils, general characteristics of soil in different groups	**15**	
Numerical questions related to consistency limits	**16**	
Numerical questions related to classification of soil	**17**	
Module 3		
Permeability of Soil - Darcy's law, validity of Darcy's law.	**18**	
Determination of coefficient of permeability: Laboratory method: constant-head method, falling-head method.	**19**	
Field method: pumping- in test, pumping- out test.	**20**	
Permeability aspects: permeability of stratified soils, Factors affecting permeability of soil.	**21**	
Seepage Analysis- Introduction, stream and potential functions,	**22**	
Characteristics of flow nets, graphical method to plot flow nets.	**23**	
Numerical questions related to permeability of soil	**24**	
Numerical questions related to seepage flow	**25**	
Module 4		
Effective Stress Principle - Introduction, effective stress principle	**26**	
Nature of effective stress, effect of water table.	**27**	
Fluctuations of effective stress, effective stress in soils saturated by capillary action	**28**	
Seepage pressure, quick sand condition	**29**	

Numerical questions related to effective stress	**30**	
Numerical questions related to seepage pressure and quick sand condition	**31**	
Module 5		
Compaction of Soil-Introduction, theory of compaction	**32**	
Laboratory determination of optimum moisture content and maximum dry density	**33**	
Compaction in field, compaction specifications and field control	**34**	
Numerical questions related to compaction	**35**	
Module 6		
Stresses in soils – Introduction, stresses due to point load, line load, strip load, uniformly loaded circular area, rectangular loaded area.	**36**	
Influence factors, Isobars, Boussinesq's equation, Newmark's Influence Chart.	**37**	
Contact pressure under rigid and flexible area, computation of displacements from elastic theory.	**38**	
Numerical questions related to stresses due to point load, line load, strip load	**39**	
Numerical questions related to stresses due to uniformly loaded circular area, rectangular loaded area	**40**	
Numerical questions on Boussinesq's equation, Newmark's Influence Chart	**41**	

DARBHANGA COLLEGE OF ENGINEERING

Department of Civil Engineering

Semester: 5th Subject: Geotechnical Engineering – I Code: 101503

Note:

1. Maximum time permitted: 45 minutes
2. No negative marking

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1. Geologic cycle for the formation of soil is:
   a. Upheaval-transportation-deposition-weathering
   b. Weathering-upheaval-transportation-deposition
   c. Transportation-upheaval-weathering-deposition
   d. Weathering-transportation-deposition-upheaval

2. Which of the following types of soil is not transported by gravitational forces? 1. Loess 2. Peat 3. Talus
   a. Only 3
   b. Both 1 and 3
   c. Both 1 and 2
   d. 1, 2 and 3

3. A soil has a liquid limit of 70%, plastic limit of 35% and shrinkage limit of 20% and it has a natural moisture content of 55%. The liquidity index of soil is?
   a. 0.54
   b. 0.57
   c. 0.60
   d. 0.63

4. The unit weight of sand backfill was determined by field measurements to be 1746 kg/m^3. The water content is 8.6% and unit weight of soil constituents is 2.6 gm/cc. In the laboratory the void ratios in the loosest and densest states were found to be 0.642 and 0.462 respectively. The relative density of the soil is
   a. 23.4 %
   b. 13.9 %
   c. 27.2 %
   d. None

5. The average coefficient of permeability of natural deposits:
   a. Parallel to stratification is always greater than that perpendicular to stratification
   b. Parallel to stratification is always less than that perpendicular to stratification
   c. Is always same in both directions
   d. Parallel to stratification may or may not be greater than that perpendicular to stratification
6. Hydrometer readings are corrected for:
   a. Temperature correction
   b. Meniscus correction

c. Dispersing agent correction
d. Temperature, meniscus and dispersing agent corrections

7. Dispersed type of soil structure is an arrangement comprising particles having
   a. Face to face or parallel orientation
   b. Edge to edge orientation
   c. Edge to face orientation
   d. All of the above

8. Pick up the correct statement from the following:
   a. In soils, the flow index indicates variation in shear strength with water content
   b. Liquid limit minus plastic limit, is known as plasticity index of the soil
   c. Plastic limit minus shrinkage limit, is known as shrinkage index of the soil
   d. All the above

9. Stoke's law is valid only if the size of the particle is:
   a. between 0.2 mm and 0.0002 mm
   b. greater than 0.2 mm
   c. less than 0.0002 mm
   d. all of the above

10. Valid range for S, the degree of saturation of soil in percentage is
    a. $S > 0$
    b. $S \leq 0$
    c. $0 < S < 100$
    d. $0 \leq S \leq 100$

11. Due to rise of temperature, the viscosity and unit weight of the percolating fluid are reduced to 75% and 97% respectively. Other things being constant, what will be the percentage change in co-efficient of permeability?
    a. 25
    b. 29
    c. 31
    d. 37
12. A soil sample is having a specific gravity of 2.6 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

13. 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
    d. 1.5

14. The difference between maximum void ratio and minimum void ratio of a sand sample is 0.30. If the relative density of this sample is 66.6% at a void ratio of 0.40, then the void ratio of the sample at its loosest state will be?
    a. 0.40
    b. 0.60
    c. 0.70
    d. 0.75
15. Consider the following statements related to clays which exhibit high activity:
    1. Contain montmorillonite
    2. Contain kaolinite
    3. Have a high silt content
    4. Have a high plasticity index
    5. Have a low plasticity index

    of these statements

    a. 1, 3 and 5 are correct
    b. 2, 3 and 5 are correct
    c. 2 and 4 are correct
    d. 1 and 4 are correct

16. On analysis of particle size distribution of a soil, it is found that D_{10} = 0.1 mm, D_{30} = 0.3 mm and D_{60} = 0.8 mm. The uniformity co-efficient and co-efficient of curvature, as given by the particle size distribution curve are respectively
    a. 1.25 and 2.67
    b. 2.67 and 1.25
    c. 1.125 and 8
    d. 8 and 1.125

17. 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. 27.2 %
    c. 31.2 %
    d. 37.2 %
18. A soil sample in its natural state has mass of 2.290 kg and a volume of 1.15×10^{-3} m^3. After being oven dried the mass of the soil sample is 2.035 kg. G_s for soil is 2.68. The void ratio of the natural soil is
    a. 0.40
    b. 0.45
    c. 0.55
    d. 0.53
19. A borrow pit soil has a dry density of 17 kN/m^3. How many cubic meters of this soil will be required to construct an embankment of 100 m^3 volume with a dry density of 16 kN/m^3
    a. 94 m^3
    b. 106 m^3
    c. 100 m^3
    d. 90 m^3

20. A saturated soil mass has a total density 22 kN/m^3 and a water content of 10%. The bulk density and dry density of this soil are:
    a. 12 kN/m^3 and 20 kN/m^3 respectively
    b. 22 kN/m^3 and 20 kN/m^3 respectively
    c. 19.8 kN/m^3 and 19.8 kN/m^3 respectively
    d. 23.2 kN/m^3 and 19.8 kN/m^3 respectively