INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

CIVIL ENGINEERING

COURSE DESCRIPTOR

Course Title	**GEOTECHNICAL ENGINEERING**				
Course Code	ACE006				
Programme	B.Tech				
Semester	IV	CE			
Course Type	Core				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	1	4	3	2
Chief Coordinator	Mrs. J. Hymavathi, Assistant Professor				
Course Faculty	Mr. Y. Ravi Kumar, Assistant Professor				

I. COURSE OVERVIEW:

Civil Engineers are required to construct structures on the soil. The loads coming onto these structures, along with the self-weight, have to be safely transmitted to the soil beneath it. A geotechnical engineer must be able to design a footing in such a way that soil below it will not fail there will not be any excessive settlements in the soil. This foundational course in civil engineering is intended to introduce to concepts of types of soils present in nature, properties of soil on which the load carrying capacity of the soil depends For this, the concept of (a) types of soil present in nature and their properties which in turn effect the load carrying capacity of soil, (b) shear strength of the soils, (c) settlement reduction by compaction and consolidation are covered in depth. The important calculations of stresses due to self weight and externally applied loads and the consequent theory of failures for prediction of the strength of the soils are also discussed. Through this course content engineers can design the foundation for safety and serviceability.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites
UG	AME002	II	Engineering Mechanics

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Geotechnical Engineering	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✔	Chalk & Talk	✔	Quiz	✔	Assignments	✘	MOOCs
✔	LCD / PPT	✔	Seminars	✔	Mini Project	✔	Videos
✔	Open Ended Experiments						

V. EVALUATION METHODOLOGY:

The course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into five units and each unit carries equal weightage in terms of marks distribution. The question paper pattern is as follows. Two full questions with "either" or "choice" will be drawn from each unit. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept.
50 %	To test the analytical skill of the concept OR to test the application skill of the concept.

Continuous Internal Assessment (CIA):
CIA is conducted for a total of 30 marks (Table 1), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Quiz/ Alternative Assessment Tool (AAT).

Table 1: Assessment pattern for CIA

Component	Theory		Total Marks
Type of Assessment	CIE Exam	Quiz / AAT	
CIA Marks	25	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 25 marks of 2 hours duration consisting of two parts. Part–A shall have five compulsory questions of one mark each. In part–B, four out of five questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz / Alternative Assessment Tool (AAT):

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are be answered by choosing the correct answer from a given set of choices (commonly four). Marks shall be awarded considering the average of two quizzes for every course. The AAT may include seminars, assignments, term paper, open ended experiments, five minutes video and MOOCs.

VI. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	2	Assignments/ Exams
PO 2	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences	2	Assignments/ Exams
PO 3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	2	Assignments/ Mini project
PO 4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	1	Open Ended Experiments
PO 6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	1	Mini Project
PO 9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	2	Seminars/Mini Project
PO 12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	1	Seminars/ Workshop

3 = High; 2 = Medium; 1 = Low

VII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Strength	Proficiency assessed by
PSO 1	**Engineering Knowledge**: Graduates shall demonstrate sound knowledge in analysis, design, laboratory investigations and construction aspects of civil engineering infrastructure, along with good foundation in mathematics, basic sciences and technical communication.	2	Assignments/ Exams
PSO 2	**Broadness and Diversity:** Graduates will have a broad understanding of economical, environmental, societal, health and safety factors involved in infrastructural development, and shall demonstrate ability to function within multidisciplinary teams with competence in modern tool usage.	-	-
PSO 3	**Self-Learning and Service:** Graduates will be motivated for continuous self-learning in engineering practice and/or pursue research in advanced areas of civil engineering in order to offer engineering services to the society, ethically and responsibly.	1	Seminars/ Workshop

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VIII. COURSE OBJECTIVES (COs):

The course should enable the students to:	
I	Identify the type of soil based on index properties of soils, soil formation & its structure
II	Recognize the importance of permeability for calculating the seepage through soils. Find out the coefficient of permeability using various laboratory & field tests.
III	Analyze the stress at any point below the ground surface due to self weight and externally applied load. Interpret the importance of consolidation and compaction on the settlement of footing.
IV	Recognize the importance of shear strength in load carrying capacity of soil. Calculate the shear strength of soil using various laboratory tests.

IX. COURSE LEARNING OUTCOMES (CLOs):

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
ACE006.01	CLO 1	Calculate the unit weights in various field conditions using different relationships	PO 1, PO 3, PO4, PO6, PO9	2
ACE006.02	CLO 2	Examine water content, specific gravity, bulk density and dry densities of a soil using various laboratory and field tests.	PO1,PO2, PO4,PO12	1
ACE006.03	CLO 3	Identify the type of soil present in the site by using particle size distribution curve & other index properties of soils as per IS soil classification system	PO3	1
ACE006.04	CLO 4	Find the Atterberg limits of soils which is used in classifying the fine grained soils	PO3	1
ACE006.05	CLO 5	Understand the permeability of soil & find out the range of coefficient of permeability in various soil types.	PO1,PO3 PO9	1
ACE006.06	CLO 6	Explain the importance of permeability in calculation of seepage through earthen dams, amount of water to be pumped when the soil is excavated below ground water table.	PO3,PO4, PO6	1
ACE006.07	CLO 7	Evaluate the coefficient of permeability using falling head tests and constant head tests	PO3,PO4, PO9,PO12	1
ACE006.08	CLO 8	Evaluate the coefficient of permeability using pumping in and pumping out tests	PO4,PO6, PO9	2
ACE006.09	CLO 9	Calculate the stresses beneath the ground level due to self weight of soil	PO1,PO2, PO3,PO12	1
ACE006.10	CLO 10	Analyze the importance of total, neutral and effective stress in load carrying capacity of soil	PO1,PO2, PO4,PO6, PO12	1
ACE006.11	CLO 11	Sketch the total, neutral and effective stress distribution diagram for various field conditions	PO1,PO2, PO4,PO12	1
ACE006.12	CLO 12	Explain quick sand condition, its occurrence and its significance	PO1,PO2, PO3,PO4, PO12	1
ACE006.13	CLO 13	Understand the importance of flow net in calculating seepage loss, uplift pressure, exit hydraulic gradient	PO1,PO2, PO3,PO4	1
ACE006.14	CLO 14	Calculate the stress below the ground due to externally applied load using Boussinesq's theory	PO1,PO2, PO3,PO4	1
ACE006.15	CLO 15	Calculate stress due to load using Westergaard's and approximate method of stress distribution	PO1,PO2, PO4,PO12	1
ACE006.16	CLO 16	Importance of compaction in reducing the immediate settlement, improving the load carrying capacity	PO1,PO2, PO3,PO4, PO12	1
ACE006.17	CLO 17	Determining the maximum dry density and optimum moisture content of soil using standard proctor test soil. List the various field equipments used for compacting	PO1,PO2, PO3,PO4, PO9,PO12	1

		the different types of soils.		
ACE006.18	CLO 18	Recognize the importance of consolidation in settlement calculation & calculate the consolidation settlement especially in clayey soils.	PO1,PO2, PO3,PO4, PO12	1
ACE006.19	CLO 19	Determination of consolidation parameters of a soil using laboratory test such as using square root of time fitting method, logarithmic square method and height of solids method.	PO1,PO2, PO3,PO4, PO12	1
ACE006.20	CLO 20	Understand the shear failure criteria proposed by Mohr-coulomb and shear parameters of soil	PO1,PO2, PO3,PO12	2
ACE006.21	CLO 21	Determination of shear strength of soil using direct shear test and tri-axial test in various drainage conditions.	PO1,PO2, PO3,PO9, PO12	2
ACE006.22	CLO 22	Recognize the behavior of soil in normal, over and under consolidated soil. Understand the concept of dilatancy in sandy soil.	PO1,PO2, PO3,PO4, PO6,PO12	1
ACE006.23	CLO 23	Posses the Knowledge and Skills for employability and to succeed in national and international level competitive examinations.	PO1,PO2, PO3,PO4, PO6,PO12	1

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X. MAPPING COURSE LEARNING OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

CLO	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 1	3		2	1		1			1				3		
CLO 2	2	3		1								1	1		
CLO 3			3												1
CLO 4			2										3		
CLO 5	2		1						2				2		
CLO 6			3	1		1							3		
CLO 7			2	1					2			1	3		1
CLO 8				3		1			3				1		
CLO 9	3	3	1									1	3		1
CLO 10	3	2		1		1						1	3		1
CLO 11	2	2		1								1	1		1
CLO 12	2	1	1	1								1	1		
CLO 13	2	2	1	1									2		1
CLO 14	2	3	2	2									1		2
CLO 15	3	3		1								1	3		1
CLO 16	2	2	1	1								2	2		1

CLO 17	2	1	1	2					2			1			1
CLO 18	3	3	1	1								2	3		1
CLO 19	2	2	1	1								1	2		1
CLO 20	1	2	2									1			
CLO 21	3	2	1						2			1	3		
CLO 22	2	1	1	1		1						1	2		
CLO 23	1	1	1	1		1						1			1

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XI. ASSESSMENT METHODOLOGIES – DIRECT

CIE Exams	PO 1, PO2, PO3, PO4, PO6, PO 9, PO12	SEE Exams	PO1,PO2,PO3, PO4, PO6, PO9, PO12	Assignments	PO 1, PO2, PO3	Seminars	PO 9, PO12
Laboratory Practices	PO 1	Student Viva	PO1,PO2,PO 3, PO4, PO6, PO9, PO12	Mini Project	PO3, PO6,PO9	Certificatior	-
Term Paper	-						

XII. ASSESSMENT METHODOLOGIES - INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✘	Assessment of Mini Projects by Experts		

XIII. SYLLABUS

Unit-I	INTRODUCTION AND INDEX PROPERTIES OF SOILS
Soil formation, clay mineralogy and soil structure, moisture content, weight-volume relationships, relative density. Grain size analysis, sieve analysis, principle of hydrometer method, consistency limits and indices, I.S. classification of soils.	
Unit-II	**PERMEABILITY, EFFECTIVE STRESS AND SEEPAGE THROUGH SOILS**
Capillary rise, flow of water through soils, Darcy's Law, Permeability, Factors affecting permeability, Laboratory & field tests for determination of coefficient of permeability, Permeability of layered soils.Total, neutral and effective stress, upward & downward seepage through soils, quick sand condition, flow nets: characteristics and uses.	
Unit-III	**STRESS DISTRIBUTION IN SOILS & COMPACTION**
Boussinesq's theory for point load, uniformly loaded circular and rectangular areas, Westergaard's theory for point load condition, pressure bulb, variation of vertical stress under point load along vertical and horizontal plane, Newmark's influence chart for irregular areas. Mechanism of compaction, factors affecting compaction, effects of compaction on soil properties, field compaction equipment and compaction quality control.	
Unit-IV	**CONSOLIDATION**
Types of compressibility, immediate settlement, primary consolidation and secondary consolidation, stress history of clay, e-p and e-log p curves, normally consolidated soil , over and under consolidated soil, pre-consolidation pressure and its determination, Terzaghi's 1-D consolidation theory, coefficient	

of consolidation square root time and logarithm of time fitting methods, computation of total settlement and time rate of settlement.	
Unit-V	**SHEAR STRENGTH OF SOILS**
Importance of shear strength, Mohr's-Coulomb failure theories, types of laboratory tests for strength parameters, strength tests based on drainage conditions, strength envelops, shear strength of sands, dilatancy, critical void ratio, liquefaction, shear strength of clays.	
Text Books:	
1. Braja M. Das, "Principles of geotechnical engineering" Cengage learning publishers, 2002 2. VNS Murthy, "Soil mechanics and foundation engineering", CBS publishers and distributors, 2003. 3. Gopal Ranjan and ASR Rao, "Basic and Applied Soil Mechanics", New age international Pvt. Ltd, New Delhi, 2000.	
Reference Books:	
1. C. Venkataramiah, "Geotechnical engineering", New Age International Pvt. Ltd, 2002. 2. Manoj dutta and Gulati, "Geotechnical engineering", Tata Mc Grawhill publishers New Delhi, 2005. 3. K.R .Arora, "Soil mechanics and foundation engineering", standard publishers and distributors, New Delhi, 2005. 4. B.C. Punmia, Ashok Kumar Jain and Arun Kumar Jain, "Soil mechanics and foundation", Laxmi publications Pvt. Ltd, New Delhi, 2005.	

XIV. COURSE PLAN:

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
1-2	Introduction to geotechnical engineering, properties of soils	CLO 1	T1:1.1, R2:2.2
3	Formation of soil and soil structures	CLO 1	T1:1.4, R2:2.3
4	Clay mineralogy and adsorbed water	CLO 2	T:6.6, R2:2.6
5-6	Mass volume relationship	CLO 2	T1:3.1, R2:2.8
7	Relative density	CLO 4	T3:3.15,R2:2.9
8-9	Index properties of soils: grain sizes analysis	CLO 3	T1:3.3, R2:2.10
10-11	Sieve and hydrometer method of analysis	CLO 3	T1:3.8, R2:2.11
12-13	Consistency limit and indices of soil	CLO 4	T1:3.9, R2:2.12
14	I.S. classification of soils	CLO 3	T1:4.3, R2:2.13
15-16	Permeability - soil water –capillary rise	CLO 5	T1:5.9, R1:3.1
17-18	Flow of water through soil	CLO 5	T1:5.4, R1:3.2
19-20	Darcy's law	CLO 6	T1:5.4.1, R1:3.3
21-22	Permeability and factors effecting, laboratory determination of coefficient of permeability	CLO 7	T1:5.6, R1:3.4
23-24	Permeability of layered systems	CLO 8	T1:5.8, R1:3.4.1
25-26	Seepage through soils –total, neutral and effective stresses quick sand conditions	CLO 12	T1:6.9 to 6.10, R1:3.5
27	Seepage through soils	CLO 11	T1:6.5, R1:3.5.2
28-30	Flow nets, characteristics and uses	CLO 13	T1:6.3 , R1:3.6
31	Stress distribution in soils – Boussinesq's theory for point loads and areas of different shapes	CLO 14	T1:7.22, R2:4.6
32-33	Westergaard's theory for point loads and area of different	CLO 15	T1:7.22,

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
	shapes		R2:4.7
34-35	Newmark's influences chart	CLO 15	T1:12.3.2, R2:4.8
36-37	Compaction- mechanism of compaction	CLO 16	T1:12.6.1, R1: 4.1
38	Factors effecting compaction of soils properties	CLO 16	T1:12.6.2, R1: 4.1.2
39-40	Effect of compaction on soil properties	CLO 17	T1:12.6.2, R1: 4.2
41-42	Field compaction equipment	CLO 17	T1:12.6.2, R1: 4.3
43-44	Compaction control	CLO 17	T1:12.6.3, R1: 4.4
45-46	Consolidation –stress history of clay	CLO 18	T1:7.4, R1: 6.1
47-49	e-p and e- log p curves	CLO 19	T1:10.2.1, R1: 6.4
50-52	Magnitude and rates of 1-d consolidation	CLO 19	T1:10.2.4, R1: 6.6
53-54	Terzaghi's theory	CLO 18	T1:10.7, R1: 6.7
55-57	shear strength of soils –Mohr and Coulomb failure theories	CLO 20	T1:8.4.2, R2: 8.1
58-60	Types of laboratory strength test	CLO 21	T1:8.8, R2: 8.2
61-62	Strength test based on drainage conditions	CLO 21	T1:8.12.2, R2: 8.2.4
63-64	Shear strength of sands	CLO 22	T1:8.11.3, R2: 8.4
65-66	Critical void ratio of clay	CLO 22	T1:8.11.2, R2: 8.5
67-68	Liquefaction and shear strength of clay	CLO 22	T1:8.12, R2: 8.6

XV. GAPS IN THE SYLLABUS - TO MEET INDUSTRY / PROFESSION REQUIREMENTS:

S No	Description	Proposed actions	Relevance with POs	Relevance with PSOs
1	Methods for obtaining flow nets, seepage in anisotropic soils	Seminars/Guest Lectures/NPTEL	PO 3, PO 4	PSO 1
2	Stresses in soil due to externally applied line, strip and trapezoidal loading	Seminars/Guest Lectures/NPTEL	PO 1	PSO 1
3	Fields tests to determine the shear strength of soils	Seminars/NPTEL	PO 4	PSO 1

Prepared by:
Mrs. J. Hymavathi, Assistant Professor

HOD, CIVIL ENGINEERING