INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal, Hyderabad -500 043

CIVIL ENGINEERING

COURSE DESCRIPTOR

Course Title	**GROUND IMPROVEMENT TECHNIQUES**				
Course Code	ACE509				
Programme	B.Tech				
Semester	VII	CE			
Course Type	Elective				
Regulation	IARE - R16				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	-	3	-	-
Chief Coordinator	Mr. Ch.Balakrishna, Assistant Professor				
Course Faculty	Mr. S Siva Rama Krishna, Assistant Professor Mr. Ch.Balakrishna, Assistant Professor				

I. COURSE OVERVIEW:

The most common traditional objectives include improvement of the soil and ground for use as a foundation or construction material. The typical Engineering objectives have been: Increasing shear strength, durability, stiffness, stability, mitigating undesirable properties (eg. Shrink/ swell potential, compressibility, modifying permeability, the rate of fluid to flow through a medium; and Improving efficiency and productivity by using methods that save time and expense, The engineer must take a determination on how best to achieve the desired goals required by providing a workable solution for each project encountered. Ground improvement methods have provided adverse choice of approaches to solving these challenges.

II. COURSE PRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	ACE006	IV	Geotechnical Engineering	4

III. MARKSDISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
Ground Improvement Techniques	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 to 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, 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.	3	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	Guest Lectures
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	Presentation on real world problems
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.	2	Seminars

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, construction aspects of civil engineering infrastructure, along with good foundation in mathematics and basic sciences.	3	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.	2	Seminars
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.	-	-

3 = High; 2 = Medium; 1 = Low

VIII. COURSE OBJECTIVES :

The course should enable the students to:	
I	Identify the types of soils and categorize the problematic soils by in-situ laboratory tests.
II	Design dewatering systems to prevent significant groundwater seepage into the excavation and to ensure stability of excavation side slopes.
III	Modify the ground by different procedures such as admixtures, shot Crete, grouting and ground freezing.
IV	Apply different methods of soil reinforcement like soil anchors, rock bolts and soil nails in cohesive and granular soils.

IX. COURSE OUTCOMES (COs):

COs	Course Outcome	CLOs	Course Learning Outcome
CO 1	Describe different types of soils, In situ and laboratory tests to characterize soils.	CLO 1	Understand the needs and objectives of ground improvement techniques.
		CLO 2	Identify soil types by performing In Situ and laboratory tests to characterize problematic soils.
		CLO 3	Analyze Mechanical, hydraulic, physic-chemical methods of ground improvement techniques.
		CLO 4	Understand Electrical, Thermal methods, and their applications of ground modification.
CO 2	Describe various mechanical modification techniques like blasting,	CLO 5	Understand the need for mechanical modification
		CLO 6	Analyze Deep Compaction techniques

COs	Course Outcome	CLOs	Course Learning Outcome
	vibrocompaction, dynamic tamping and compaction piles.	CLO 7	Recognize the need for Blasting vibrocompaction
		CLO 8	Understand the objectives and techniques of hydraulic modification.
CO 3	Describe various dewatering methods, their choice and various hydraulic ground modification techniques.	CLO 9	Identify traditional dewatering methods and their choice
		CLO 10	Design of dewatering system and understanding electro-osmosis technique
		CLO 11	Understand Electro kinetic dewatering technique and Filtration technique used in geosynthetics.
		CLO 12	Analyze drainage and seepage control with geosynthetics.
CO 4	Explore the concept of soil modification by physical and chemical methods.	CLO 13	Identify preloading the vertical drains and understand Physical and Chemical Modification of admixtures.
		CLO 14	Analyze the importance of shotcreting and guniting Technology.
		CLO 15	Understand modification at depth by grouting, Crack grouting and compaction grouting
		CLO 16	Understand Jet grouting technique, Thermal modification, Ground freezing.
CO 5	Explain soil reinforcement technique, reinforcement with strip, in-situ ground reinforcement, ground anchors and soil nailing.	CLO 17	Understand modification by inclusions and confinement
		CLO 18	Recognize the need for Soil reinforcement and grid reinforced soil.
		CLO 19	Analyze the importance of In-situ ground reinforcement.
		CLO 20	Understand ground anchors, Rock bolting and soil nailing.

X. 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
ACE509.01	CLO 1	Understand the needs and objectives of ground improvement techniques.	PO 1	2
ACE509.02	CLO 2	Identify soil types by performing In Situ and laboratory tests to characterize problematic soils.	PO 1, PO 3	3
ACE509.03	CLO 3	Analyze Mechanical, hydraulic, physic-chemical methods of ground improvement techniques.	PO 1, PO 2	2
ACE509.04	CLO 4	Understand Electrical, Thermal methods, and their applications of ground modification.	PO 1, PO 2	3
ACE509.05	CLO 5	Understand the need for mechanical modification	PO 1	2
ACE509.06	CLO 6	Analyze Deep Compaction techniques	PO 2	3
ACE509.07	CLO 7	Recognize the need for Blasting vibrocompaction	PO 1, PO 3	3
ACE509.08	CLO 8	Understand the objectives and techniques of hydraulic modification.	PO 1	3
ACE509.09	CLO 9	Identify traditional dewatering methods and their choice	PO 1, PO 6	3
ACE509.10	CLO 10	Design of dewatering system and understanding electro-osmosis technique	PO 1, PO 3	2
ACE509.11	CLO 11	Understand Electro kinetic dewatering technique and Filtration technique used in geosynthetics.	PO 1	3
ACE509.12	CLO 12	Analyze drainage and seepage control with geosynthetics.	PO 2	3

CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
ACE509.13	CLO 13	Identify preloading the vertical drains and understand Physical and Chemical Modification of admixtures.	PO 6	3
ACE509.14	CLO 14	Analyze the importance of Shotcreting and Guniting Technology.	PO1, PO2	3
ACE509.15	CLO 15	Understand modification at depth by grouting, Crack grouting and compaction grouting	PO 1	3
ACE509.16	CLO 16	Understand Jet grouting technique, Thermal modification, Ground freezing.	PO1, PO2	3
ACE509.17	CLO 17	Understand modification by inclusions and confinement	PO1	3
ACE509.18	CLO 18	Recognize the need for Soil reinforcement and grid reinforced soil.	PO1, PO6	3
ACE509.19	CLO 19	Analyze the importance of In-situ ground reinforcement.	PO2	3
ACE509.20	CLO 20	Understand ground anchors, Rock bolting and soil nailing.	PO2	3

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XI. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES

Course Outcomes (COs)	Program Outcomes (POs)					
	PO 1	PO 2	PO 3	PO 6	PSO1	PSO2
CO 1	3	2	1		2	1
CO 2	2	1	1		2	1
CO 3	2	1	1	1	2	2
CO 4	2	1		1	2	1
CO 5	2	2		1	1	3

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

Course Learning Outcomes (CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 1	2												2		
CLO 2	3		3											2	
CLO 3	2	3											2		
CLO 4	3	2											3		
CLO 5	2												2		

Course Learning Outcomes (CLOs)	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CLO 6		3												2	
CLO 7	2		3											3	
CLO 8	3												2		
CLO 9	3					2								3	
CLO 10	3		2											2	
CLO 11	2												3		
CLO 12		3											2		
CLO 13						2								3	
CLO 14	3	3											3		
CLO 15	3												2		
CLO 16	2	3											3		
CLO 17	3												3		
CLO 18	3					2								2	
CLO 19		3												3	
CLO 20		3												3	

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XIII. ASSESSMENT METHODOLOGIES–DIRECT

CIE Exams	PO1, PO2, PO3, PO6, PSO1, PSO2	SEE Exams	PO1, PO2, PO3, PO6, PSO1, PSO2	Assignments	PO 1, PSO 1	Seminars	PO6
Laboratory Practices	-	Student Viva	-	Mini Project	-	Certification	-
Term Paper	-						

XIV. ASSESSMENT METHODOLOGIES-INDIRECT

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

XV. SYLLABUS

Unit-I	**INTRODUCTION TO GROUND MODIFICATION**
Need and objectives, identification of soil types, in situ and laboratory tests to characterize problematic Soils, mechanical, hydraulic, physical, chemical, electrical, thermal methods and their applications.	
Unit-II	**MECHANICAL MODIFICATION**
Deep compaction techniques- blasting, vibrocompaction, dynamic tamping and compaction piles	
Unit-III	**HYDRAULIC MODIFICATION**
Objective and techniques, traditional dewatering methods and their choice, design of dewatering system, electro-osmosis, electro kinetic dewatering. Filtration, drainage and seepage control with geosynthetics, preloading the vertical drains.	
Unit-IV	**PHYSICAL AND CHEMICAL MODIFICATION**
Modification by admixtures, shotcreting and guniting technology, modification at depth by grouting, crack grouting and compaction grouting. Jet grouting, thermal modification, ground freezing.	
Unit-V	**MODIFICATION BY INCLUSIONS AND CONFINEMENT**
Soil reinforcement, reinforcement with strip, and grid reinforced soil. In-situ ground reinforcement, and ground anchors, rock bolting and soil nailing.	
Text Books:	
1. Haussmann, M.R "Engineering principles of Ground Modifications", Tata McGraw-Hill publications,1990.	
Reference Books:	
1. Koener, R.M, "Designing with Geosynthetics", Prentice Hall, New Jersey,1994. 2. Jones C.J.P, "Earth Reinforcement and soil structures", Butter worths, London,1985.	

XVI. 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	Introduction to ground modification	CLO 1	T1:11.1
2-4	Need and objectives of ground modification techniques.	CLO 1	T1:11.4 R1:10.1
5-7	Identification of soil types.	CLO 2	T1:16.6
8-11	In Situ and laboratory tests to characterize problematic soils.	CLO 2	T1:13.1
12-13	Mechanical, hydraulic, physic-chemical methods of ground improvement techniques.	CLO 3	R1:13.15
14-15	Electrical, Thermal methods, and their applications of ground modification.	CLO 4	T1:13.3 R1:15.5
16	Introduction to mechanical modification	CLO 5	T1:13.8
17	Analyzing Deep Compaction techniques	CLO 6	T1:13.9
18-19	Blasting vibrocompaction	CLO 7	T1:14.3
20	Objectives and techniques of hydraulic modification	CLO 8	T1:15.9
21	Traditional dewatering methods and their choice	CLO 9	T1:15.5
22-23	Design of dewatering system	CLO 10	T1:15.6
24	Electro-osmosis technique.	CLO 10	T1:15.8
25	Electro kinetic dewatering technique.	CLO 11	T1:16.9
26-28	Filtration technique used in geosynthetics.	CLO 11	T1:16.5

Lecture No	Topics to be covered	Course Learning Outcomes (CLOs)	Reference
29-30	Drainage and seepage control with geosynthetics.	CLO 12	T1:16.3
31-33	Preloading the vertical drains.	CLO 13	T1:17.22
34	Physical and Chemical Modification of admixtures.	CLO 13	T1:17.22
35	Shotcreting and Guniting Technology.	CLO 14	T1:19.3
36-37	Modification at depth by grouting.	CLO 15	T1:19.6.1
38	Crack grouting and compaction grouting.	CLO 15	R2:19.6.2
39-40	Jet grouting technique, Thermal modification, Ground freezing.	CLO 16	R2:21.6.2
41	Modification by inclusions and confinement.	CLO 17	R2:22.6.3
42-43	Soil reinforcement and grid reinforced soil.	CLO 18	T1:17.4 R2: 15.4
44	In-situ ground reinforcement and ground anchors.	CLO 19	R2:17.2.1
45	Rock bolting and soil nailing	CLO 20	R2:17.2.4

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

S NO	DESCRIPTION	PROPOSED ACTIONS	RELEVANCE WITH POs	RELEVANCE WITH PSOs
1	Emerging trends in ground improvement techniques.	NPTEL Videos	PO 3	PSO 1
2	Methods for remediation of contaminated soils.	Seminars/ Guest Lectures.	PO 1	PSO 1
3	Applications in filtration, drainage and erosion control.	Seminars	PO 2	PSO 1

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