DEPARTMENT OF CIVIL ENGINEERING, IIT DELHI

M.Tech. (Geotechnical and Geoenvironmental Engineering) — CEG

New Structure

Total Credits = 48
1. Programme Core (PC) Lecture/Practical Credits (excluding project) = 18 (12L+6P)
2. Credits for the M.Tech. Project (excluding core/practical courses) = 18 (6+12)
3. Programme Elective (PE) Course Credits = 12 (4*3 = 12)

Semester-wise Structure

Ist Semester	IInd Semester	Summer Semester	IIIrd Semester	IVth Semester
(Sem. Credits)	(Sem. Credits)	(Sem. Credits)	(Sem. Credits)	(Sem. Credits)
CVL700	CVL702		CVD800	CVD801
CVL701	CVL703		PE-4	
CVP700	CVP800			
PE-1	PE-2			
	PE-3			
Total = 12 Credits	Total = 15 Credits		Total = 9 Credits	Total = 12 Credits

List of Program Core Courses (PC):

1. CVL700 - Engineering Behaviour of Soils
2. CVL701 - Site Investigation and Foundation Design
3. CVL702 - Ground Improvement and Geosynthetics
4. CVL703 - Geoenvironmental Engineering
5. CVP700 - Soil Engineering Lab
6. CVP800 - Geoenvironmental and Geotechnical Engg Lab
7. CVD800 - Major Project Part-1
8. CVD801 - Major Project Part-2

List of Program Electives (PE):

1. CVL704 - Finite Element Method in Geotechnical Engineering
2. CVL705 - Slopes and Retaining Structures
3. CVL706 - Soil Dynamics and Earthquake Geotechnical Engg.
4. CVL707 - Soil-Structure Interaction Analysis
5. CVL708 - Geotechnology of Waste Disposal Facilities
6. CVL709 - Offshore Geotechnical Engineering
7. CVL800 - Emerging Topics in Geotechnical Engineering
8. CVL801 - Constitutive Modelling in Geotechnics
9. CVD700* - Minor Project
10. CVS800 - Independent Study

***CVD700 may be considered as core course in place of CVP800, for Part-Time Students**

Major Changes: Based on the feedback and the requirement of the industry, the courses have been modified/restructured to take into account the present need of the industry as well as recent developments. Significant self-study component is introduced through restructuring.

MINOR PROJECT TEMPLATE

1.	**Department/Centre proposing the course**	CIVIL ENGINEERING
2.	**Course Title** *(< 45 characters)*	MINOR PROJECT
3.	**L-T-P structure**	0-0-6
4.	**Credits**	3
5.	**Course number**	CVD700
6.	**Status** (*category* for *program*)	PROGRAMME ELECTIVE

7.	**Pre-requisites** (course no./title)	NONE

8.	Supersedes any existing course	NONE

9.	**Frequency of offering**	☐Every sem ☐1st sem ☐2nd sem ☒Either sem

10.	**FACULY WHO WILL SUPERVISE PROJECT STUDY** ALL GEOTECHNICAL SECTION FACULTY	
11.	**Will the PROJECT SUPERVISION require any visiting faculty?**	MAY BE INVITED ON REQUEST BY FACULTY SUPERVISOR/STUDENT

12.	**PROJECT objective** *(about 50 words)***:** (1) TO EXPLORE A PRESCRIBED PROBLEM BASED ON LABORATORY AND/OR NUMERICAL MODELLING BASED APPROACHES (2) TO EXPLORE DESIGN METHODOLOGIES IN THE AREA OF GEOTECHNICAL AND GEOENVIRONMENTAL ENGINEERING

13. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	SPECIFIC TO THE PROBLEM TAKEN UP FOR THE STUDY	OPEN

14. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

RELEVANT, CONTEXTUAL RESEARCH ARTICLES, REPORTS AND BOOKS

15. Resources required for the STUDY *(itemized & student access requirements, if any)*

19.1	Software	YES
19.2	Hardware	YES
19.3	PRESENTATION aides (videos, etc.)	YES
19.4	Laboratory	YES
19.5	Equipment	YES
19.6	Classroom infrastructure	NO
19.7	Site visits	MAY BE REQUIRED AS PART OF THE STUDY

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	CIVIL ENGINEERING
2.	**Course Title** *(< 45 characters)*	ENGINEERING BEHAVIOUR OF SOILS
3.	**L-T-P structure**	3-0-0
4.	**Credits**	3
5.	**Course number**	CVL700
6.	**Status** (*category* for *program*)	PC

7.	**Pre-requisites** (course no./title)	NIL

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	<20 %, CVL222
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	**Not allowed for** (indicate program names)	Students of other programs need approval of CourseInstructor

10.	**Frequency of offering**	☐ Every sem ☐ 1st sem ☐ 2nd sem ☒ Either sem

11.	**Faculty who will teach the course** Prof. Manoj Datta, Prof. K.S. Rao, Prof. G.V. Ramana, Prof. J. T. Shahu, Dr. R. Ayothiraman, Dr. B. Manna, Dr. Tanusree Chakraborty	
12.	**Will the course require any visiting faculty?**	NO

13.	**Course objective** *(about 50 words)*: To learn (i) Engineering behaviour of soils under static conditions and (ii) enable the students to use appropriate parameters
14.	**Course contents** *(about 100 words) (Include laboratory/design activities)*: Origin, nature and distribution of soils. Description of individual particle. Clay mineralogy, clay-water-electrolytes. Soil fabric and structure. Effective stress principle. Steady state flow in soils. Effect of flow on effective stress. Determination of coefficient of permeability. Consolidation. one, two, three and redial consolidation. Various consolidation tests and determination of parameters. Stress-path. Traixial and direct shear tests. Shear behaviour of soils under static and dynamic loads. Factors affecting shear beahviour. Determination of parameters. Shear behavior of fine grained soils. Pore-pressure parameters. UU, CU, CD tests. Total and effective stress-strength parameters. Total and effective stress-paths. Water content contours. Factors

	affecting strength : stress history, rate of testing, structure and temperature. Anisotropy of strength, thixotropy, creep. Determination of in-situ undrained strength. Stress-strain characteristics of soils. Determination modulus values. Critical state model, Engineering Behaviour of soils of India: Black cotton soils, alluvial silts and sands, laterites, collapsible and sensitive soil.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	lOrigin, nature and distribution of soils. Description of individual particle. Clay mineralogy, clay-water-electrolytes. Soil fabric and structure.	8
2	Effective stress principle. Steady state flow in soils. Effect of flow on effective stress. Determination of Coefficient of Permeability	4
3	Consolidation. one, two, three and redial consolidation. Variation of effective stress during consolidation. Various consolidation tests and determination of parameters.	6
4	Stress-path. Traixial and direct shear tests. Shear behaviour soils. under static and dynamic conditions. Factors affecting shear beahviour. Determination of parameters. Shear behavior of fine grained soils. Pore-pressure parameters. UU, CU, CD tests. Total and effective stress-strength parameters	8
5	Total and effective stress-paths. Water content contours. Factors affecting strength : stress history, rate of testing, structure and temperature. Anisotropy of strength, thixotropy, creep.	6
6	Determination of in-situ undrained strength. Stress-strain characteristics of soils. Determination modulus values.	6
7	Critical state model,	6
8	Engineering Behaviour of soils of India: Black cotton soils, alluvial silts and sands, laterites, collapsible and sensitive soil	3
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COURSE TOTAL *(14 times 'L')*		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL *(14 times 'P')*		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Lambe and Whitman, Soil Mechanics, Wiley India Private Limited, 2008
2. Mitchell J K and Soga, Fundamentals of Soil Behaviour, Wiley India Private Limited, 2012
3. Freduland and Rahardjo, Soil Mechanics for Unsaturated Soils, Wiley, 1993
4. Holtz and Kovacs, An introudction to Geotechnical Engineering, Prentice Hall, 2010

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Available
19.2	Hardware	Available
19.3	Teaching aides (videos, etc.)	Black board, OHP, PPT, Videos and site visits
19.4	Laboratory	NA
19.5	Equipment	NA
19.6	Classroom infrastructure	Black board and PPT Projector required
19.7	Site visits	YES

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Upto 20%
20.2	Open-ended problems	Upto 20%
20.3	Project-type activity	Upto 10%
20.4	Open-ended laboratory work	Upto 10%
20.5	Others (please specify)	Selfstudy component: Upto 20%

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	CIVIL ENGINEERING
2.	**Course Title** *(< 45 characters)*	SOIL ENGINEERING LABORATORY
3.	**L-T-P structure**	0-0-6
4.	**Credits**	3
5.	**Course number**	CVP700
6.	**Status** (*category* for *program*)	PC

7.	**Pre-requisites** (course no./title)	NIL

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	Less than 10%
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	**Not allowed for** (indicate program names)	Students of other programs need approval of CourseInstructor

10.	**Frequency of offering**	☐Every sem ☐1st sem ☐2nd sem ☒Either sem

11.	**Faculty who will teach the course** Prof. M. Datta, Prof. K.S. Rao, Prof. G.V. Ramana, Prof. J. T. Shahu, Dr. R. Ayothiraman, Dr. B. Manna, Dr. Tanusree Chakraborty	
12.	**Will the course require any visiting faculty?**	No

13.	**Course objective** *(about 50 words)***:** To teach the engineering behavior of soil experimentally

14.	**Course contents** *(about 100 words) (Include laboratory/design activities)***:** Laboratory Tests: Preparation of samples - Sand and Clay, Consolidation test, Direct shear test, Vane shear test, Unconfined compression test, Unconsolidated undrained triaxial test, Consolidated drained triaxial test, Consolidated undrained triaxial test with pore water pressure measurement, Free swell index test, Swelling pressure test. Field Investigations and field tests: Drilling of bore hole, standard penetration test. undisturbed and representative sampling. SCP Test, Electrical resistivity, Plate load test, Pile load test.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
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COURSE TOTAL *(14 times 'L')*		

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Introduction to soil testing equipments, Preparation of samples: Sand - Loose, Dense; Clay - Thumb, Kneading, static compaction and trimming of cake	12
2	Consolidation test	9
3	Direct shear test	6
4	Vane shear test	3
5	Unconfined compression test	3
6	Unconsolidated undrained triaxial test	6
7	Consolidated drained triaxial test	9
8	Consolidated undrained triaxial test with pore water pressure measurement	12
9	Free swell index test, Swelling pressure test.	9
10	Field Investigations and field tests	15
COURSE TOTAL *(14 times 'P')*		84

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Head, K. H., Manual of Soil Laboratory Testing, Vol. I, II, and III, 3rd Edition, Whittles Publishing, 2006.
2. Das, B. M., Soil Mechanics Laboratory Manual, 7th Edition, Oxford University Press, 2009.
3. Bowles, J., Engineering Properties of Soils and their Measurement, McGraw-Hill, 4th Edition, 1992.
4. Lambe, T. W., Soil Testing for Engineers, Wiley, 1st Edition, 1951.
5. Relevant IS Codes

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Available
19.2	Hardware	Available
19.3	Teaching aides (videos, etc.)	Black board, OHP, PPT, Videos and site visits
19.4	Laboratory	NA
19.5	Equipment	NA
19.6	Classroom infrastructure	Black board and PPT Projector required
19.7	Site visits	YES

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Upto 20%
20.2	Open-ended problems	Upto 20%
20.3	Project-type activity	Nil
20.4	Open-ended laboratory work	Upto 20%
20.5	Others (please specify)	Selfstudy component: Upto 20%

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	CIVIL ENGINEERING
2.	**Course Title** *(< 45 characters)*	SITE INVESTIGATION AND FOUNDATION DESIGN
3.	**L-T-P structure**	3-0-0
4.	**Credits**	3
5.	**Course number**	CVL701
6.	**Status** (*category* for *program*)	PC

7.	**Pre-requisites** (course no./title)	NIL

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	Less than 20%, CVL321, CVL431
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	**Not allowed for** (indicate program names)	Students of other programs need approval of CourseInstructor

10.	**Frequency of offering**	☐Every sem ☐1st sem ☐2nd sem ☒Either sem

11.	**Faculty who will teach the course** Prof. Manoj Datta, Prof. K.S. Rao, Prof. G.V. Ramana, Prof. J. T. Shahu, Dr. R. Ayothiraman, Dr. B. Manna, Dr. Tanusree Chakraborty	
12.	**Will the course require any visiting faculty?**	No

13.	**Course objective** *(about 50 words)*: To learn how to plan a site investigation program to design of shallow foundations, deep foundations and laterally loaded piles

14.	**Course contents** *(about 100 words) (Include laboratory/design activities)*: Site Investigation: Geophysical methods-Seismic, electical; Drilling methods; Boring in soils and rocks. Field tests: In-situ tests, SPT, DCPT, SCPT, in-situ vane shear test, pressure meter test, plate load test. Sampling techniques and disturbances. Shallow Foundations: Design considerations, codal provisions. Bearing capacity theories, Layered soils, Choice of shear strength parameters. Bearing capacity from field tests.Total and differential settlements. Deep foundations: Types of piles. Construction methods. Axial capacity of single piles. Axial capacity of groups. Settlement of single piles and groups. Uplift capacity (including under-reamed piles) . Negative skin friction. Pile load tests.

	Pile integrity tests. Codal provisions. Caissons. Laterally Loaded Piles: Analysis and Design; Foundations in Difficult soil conditions

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Planning of investigation programmes, Information required for planning different stages of investigation. Geophysical methods: electrical resistivity, and seismic refraction methods.	4
2	Methods of site investigation: Direct methods, semi-direct methods and indirect methods, Drilling methods. Boring in soils and rocks, methods of stabilizing the bore holes, measurement of water table, field record.	4
3	Field tests: In-situ shear test, in-situ permeability test, SPT, DCPT, SCPT, in-situ vane shear test, pressure meter test, plate load test. Codal provisions. Sampling techniques, Sampling disturbances, storage, labeling and transportation of samples, sampler design, influence on properties. Report writing. Safety measures.	6
4	Shallow Foundations: Design considerations – factors of safety (including limit state), allowable settlements, location and depth of foundations, codal provisions. Presumptive bearing capacity.	2
5	Bearing capacity theorie, Layered soils, Choice of shear strength parameters . Bearing capacity from N-values, Static cone tests, Plate load tests.	4
6	Shallow foundations: Total and differential settlement. Stress distribution. Consolidation settlement in clays (with correction factors). Immediate settlement. Settlement in sands from N-values, elastic solutions. static cone tests , plate load tests.	3
7	Deep foundations: Types of piles. Construction methods. Axial capacity of single piles – dynamic formula , soil mechanics approach. Skin friction and end bearing in sands and clay.Axial capacity of groups. Settlement of single piles and groups.	7
8	Uplift capacity (including under-reamed piles) . Negative skin friction. Pile load tests. Pile integrity tests . Codal provisions. Caissons.	4
9	Laterally Loaded Piles: Short and long piles; Free head and fixed head piles; Lateral load capacity of single piles; Lateral deflection; Elastic analysis; Group effect; Lateral load test; Code provisions.	6
10	Foundations in difficult soils: expansive soils, chemically aggressive environment, soft soils, fills, regions of subsidence.	2
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COURSE TOTAL *(14 times 'L')*		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL *(14 times 'P')*		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Clayton R, Mathews, C. M. and Simons, N E, Site Investigation, Wiley Blacwell, 1995
2. Bowles J Foundation Analysis and Design, McGrawHill, 2008
3. Kurian, N. P. (1994), Design of Foundation Systems - Principles and Practices, 2nd Edition, Narosa Publishing House, 1994.
4. Tomlinson M. and Woodward, J. Pile design and construction Practice, 5th Edition, Taylors & Francis, 2008.
5. Coduto, D. P. Foundation Design, Prentice Hall, 2012

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Available
19.2	Hardware	Available
19.3	Teaching aides (videos, etc.)	Black board, OHP, PPT, Videos and site visits
19.4	Laboratory	NA
19.5	Equipment	NA
19.6	Classroom infrastructure	Black board and PPT Projector required
19.7	Site visits	YES

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Upto 20%
20.2	Open-ended problems	Upto 20%
20.3	Project-type activity	Upto 10%
20.4	Open-ended laboratory work	Upto 10%
20.5	Others (please specify)	Selfstudy component:Upto 20%

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	CIVIL ENGINEERING
2.	**Course Title** *(< 45 characters)*	GROUND IMPROVEMENT AND GEOSYNTHETICS
3.	**L-T-P structure**	3-0-0
4.	**Credits**	3
5.	**Course number**	CVL702
6.	**Status** (*category* for *program*)	PC

7.	**Pre-requisites** (course no./title)	NIL

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	Less than 20%, CVL421
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	**Not allowed for** (indicate program names)	Students of other programs need approval of CourseInstructor

10.	**Frequency of offering**	☐Every sem ☐1st sem ☐2nd sem ☒Either sem

11.	**Faculty who will teach the course** Prof. Manoj Datta, Prof. K.S. Rao, Prof. G.V. Ramana, Prof. J. T. Shahu, Dr. R. Ayothiraman, Dr. B. Manna, Dr. Tanusree Chakraborty	
12.	**Will the course require any visiting faculty?**	No

13.	**Course objective** *(about 50 words)***:** To learn (i) basic concepts and applications of ground improvement methods (ii) basic concepts of using geosynthetics for ground improvement and containment purpose.

14.	**Course contents** *(about 100 words) (Include laboratory/design activities)***:** Principles of compaction, Engineering behaviour of compacted clays. Shallow stabilization with additives: lime, flyash and cement. Deep stabilization: stone column, sand drains, prefabricated drains, lime column, soil-lime column, vibro-floatation, dynamic compaction, electro-osmosis. Grouting : permeation, compaction and jet; Dewatering systems. Geosynthetics: types and functions, materials and manufacturing processes, testing and evaluation; Reinforced soil structures: principles of soil reinforcement, application of geotextiles and geogrids in roads, walls, and embankments. Application of geotextiles,

	geonets and geocomposites as drains and filters. Multiple functions: railways and overlay design. Geosynthetics in environmental control: covers and liners for landfills – material aspects and stability considerations.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Principles of compaction, Engineering behaviour of compacted clays.	3
2	Shallow stabilization with additives: lime, flyash and cement.	3
3	Deep stabilization: stone column, sand drains, prefabricated drains, lime column, soil-lime column, vibro-floatation, dynamic compaction,	5
4	Electro-osmosis. Grouting : permeation, compaction and jet; Dewatering systems.	3
5	Geosynthetics: types and functions, materials and manufacturing processes, testing and evaluation;	7
6	Reinforced soil structures: principles of soil reinforcement, application of geotextiles and geogrids in roads, walls, and embankments.	7
7	Application of geotextiles, geonets and geocomposites as drains and filters. Multiple functions: railways and overlay design.	7
8	Geosynthetics in environmental control: covers and liners for landfills – material aspects and stability considerations, covers for water tanks, geotubes.	7
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COURSE TOTAL *(14 times 'L')*		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL *(14 times 'P')*		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Hausmann, M. R., Engineering Principles of Ground Modification, Mcgraw Hill, 2013.
2. Van Impe W.F., Soil improvement techniques and their evolution, Balkema, 1989.
3. Moseley, M.P. and Kirsch K., Ground Improvement, Taylor and Francis, 1993.
4. Koerner, R., Designing with Geosynthetics, 6th Ed. Prentice Hall, 2005.

5. Colins J.F.P. Jones, Earth reinforcement and soil structures, Butterworths, 1996.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Available
19.2	Hardware	Available
19.3	Teaching aides (videos, etc.)	Black board, OHP, PPT, Videos and site visits
19.4	Laboratory	NA
19.5	Equipment	NA
19.6	Classroom infrastructure	Black board and PPT Projector required
19.7	Site visits	YES

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Upto 20%
20.2	Open-ended problems	Upto 20%
20.3	Project-type activity	Upto 10%
20.4	Open-ended laboratory work	Upto 10%
20.5	Others (please specify)	Selfstudy component: Upto 20%

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	CIVIL ENGINEERING
2.	**Course Title** *(< 45 characters)*	GEOENVIRONMENTAL ENGINEERING
3.	**L-T-P structure**	3-0-0
4.	**Credits**	3
5.	**Course number**	CVL703
6.	**Status** (*category* for *program*)	PC

7.	**Pre-requisites** (course no./title)	NIL

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	Less than 20%, CVL424
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	**Not allowed for** (indicate program names)	Students of other programs need approval of CourseInstructor

10.	**Frequency of offering**	☐Every sem ☐1st sem ☐2nd sem ☒Either sem

11.	**Faculty who will teach the course** Prof. Manoj Datta, Prof. K.S. Rao, Prof. G.V. Ramana, Prof. J. T. Shahu, Dr. R. Ayothiraman, Dr. B. Manna, Dr. Tanusree Chakraborty	
12.	**Will the course require any visiting faculty?**	No

13.	**Course objective** *(about 50 words)***:** To learn concepts of geoenvironmental engineering, and planning and design of waste in landfills, ash ponds and tailing ponds.
14.	**Course contents** *(about 100 words) (Include laboratory/design activities)***:** Subsurface Contamination and Contaminant Transport; Waste disposal on Land and Contiament, Monitoring of subsurface contamination, Control and Remediation. Engineering Properties of waste and geotechnical reuse, erosoin contro, sustainability, energy geotechnics

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction: Sources and effects of subsurface contamination; Waste characteristics; Soil-water-waste interaction: Contaminant transport; Laboratory and field evaluation of permeability	6
2	Waste Disposal Facilities: Types, Siting criteria, Waste containment principles, Types of barrier materials.	7
3	Planning and design aspects relating to waste disposal in landfills, in ash ponds and tailings ponds, and in rocks.	9
4	Environmental monitoring around landfills. Detection, control and remediation of subsurface contamination.	8
5	Engineering Properties of Waste materials and their geotechnical reuse: coal ash, mining waste, demolition waste	6
6	Erosion: causes and techniques for control	2
7	Sustainability	2
8	Energy geotechnics	2
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COURSE TOTAL *(14 times 'L')*		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
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COURSE TOTAL *(14 times 'P')*		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Qian, X., Koerner, R., and Gray, D.H., Geotechnical aspects of landfill design and construction, Prentice Hall, 2002.
2. Daniel, D.E., Geotechnical practice for waste disposal, Chapman and Hall, 1993.
3. Sarsby, R., Environmental Geotechnics, Thomas Telford, 2000.
4. Bagchi, A., Design, construction and monitoring of landfills, Wiley Interscience, 1994.

5. Datta, M., Waste disposal in Engineered landfills, Narosa Publishers, 1998.
6. Gulhati, S.K. and Datta M., Geotechnical Engineering, Mcgraw Hill, 2005.
7. Vick, S.G., Planning, analysis and design of tailings dams, John Wiley & Sons, 1970
8. Yong, R. N., Catheriene, M and Fukue, M,Geoenvironmental Sustainability, CRC Press, 2007.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Available
19.2	Hardware	Available
19.3	Teaching aides (videos, etc.)	Black board, OHP, PPT, Videos and site visits
19.4	Laboratory	NA
19.5	Equipment	NA
19.6	Classroom infrastructure	Black board and PPT Projector required
19.7	Site visits	YES

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Upto 20%
20.2	Open-ended problems	Upto 20%
20.3	Project-type activity	Upto 10%
20.4	Open-ended laboratory work	Upto 10%
20.5	Others (please specify)	Selfstudy component: Upto 20%

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	CIVIL ENGINEERING
2.	**Course Title** *(< 45 characters)*	FINITE ELEMENT METHOD IN GEOTECHNICAL ENGINEERING
3.	**L-T-P structure**	3-0-0
4.	**Credits**	3
5.	**Course number**	CVL704
6.	**Status** (*category* for *program*)	PE

7.	**Pre-requisites** (course no./title)	NIL

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	Less than 10%, This course will be offered also for Geotechnical and Geoenvironmental Engineering students.
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	**Not allowed for** (indicate program names)	Approval from course coordinator required for registration
10.	**Frequency of offering**	☐Every sem ☐1st sem ☐2nd sem ☒Either sem
11.	**Faculty who will teach the course** Prof. K. S. Rao, Prof. M. Datta, Prof. G.V. Ramana, Prof. J. T. Shahu, Dr. R. Ayothiraman, Dr. B. Manna, Dr. T. Chakraborty	
12.	**Will the course require any visiting faculty?**	No

13. Course objective *(about 50 words)*:

The students would learn

1. the formulation and steps in finite element methods, solution algorithms
2. the application of finite element method in geotechnical and rock engineering
3. the application of commercial packages in finite element simulation

14. Course contents *(about 100 words) (Include laboratory/design activities)*:

Introduction. Steps in FEM. Variational Methods, Stress-deformation analysis:One-,Twodimensional formulations; Three-dimensional formulations;

	Boundary conditions; Solution algorithms; Descretization; use of FEM2D Program and Commercial packages. Analysis of foundations, dams, underground structures and earth retaining structures. Analysis of flow (seepage) through dams and foundations. Consolidation Analysis, Linear and non-linear analysis. Insitu stresses. Sequence construction and excavation. Joint/interface elements. Infinite elements. Dynamic analysis. Evaluation of material parameters for linear and non-linear analysis, Recent developments.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction. Steps in FEM, Variational methods;	4
2	Stress-deformation analysis:One-,Two-dimensional formulations; Three-dimensional formulations;	5
3	Boundary conditions; Solution algorithms; Descretization;	5
4	Use of FEM2D Program and Commercial packages.	3
5	Analysis of foundations, dams, underground structures and earth retaining structures.	5
6	Analysis of flow (seepage) through dams and foundations, Consolidation analysis.	5
7	Linear and non-linear analysis.	3
8	Insitu stresses. Sequence construction and excavation.	3
9	Joint/interface elements. Infinite elements.	3
10	Dynamic analysis.	3
11	Evaluation of material parameters for linear and non-linear analysis,	2
12	Recent developments	1
COURSE TOTAL *(14 times 'L')*		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL *(14 times 'P')*		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Daryl L. Logan, A First Course in the Finite Element Method, Cengage Learning, 2010.
2. Robert D. Cook and David S. Malkus. Concepts and Applications of Finite Element Analysis, 4th Edition. Wiley and Sons.
3. Desai, C.S. and Kundu T. Introductory Finite Element Method. CRC Press, 2001.
4. K.J. Bathe. Finite Element Procedures. Prentice Hall, 1982.
5. Desai, C.S. and Abel, J.F. Introduction to Finite Element Method. Van Nostrand Reinhold, New York, 1972.
6. Naylor, D.J. and Pande, G.N. Finite Elements in Geotechnical Engineering. Pineridge Press, 1981.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Available
19.2	Hardware	Available
19.3	Teaching aides (videos, etc.)	Black board, OHP, PPT, Videos and site visits
19.4	Laboratory	NA
19.5	Equipment	NA
19.6	Classroom infrastructure	Black board and PPT Projector required
19.7	Site visits	YES

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Up to 20%
20.2	Open-ended problems	Up to 15%
20.3	Project-type activity	Up to 15%
20.4	Open-ended laboratory work	Up to 10%
20.5	Others (please specify)	Self study up to 20%

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	CIVIL ENGINEERING
2.	**Course Title** *(< 45 characters)*	SLOPES AND RETAINING STRUCTURES
3.	**L-T-P structure**	3-0-0
4.	**Credits**	3
5.	**Course number**	CVL705
6.	**Status** (*category* for *program*)	PE

7.	**Pre-requisites** (course no./title)	NIL

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	Less than 20%, CVL321, CVL431
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	**Not allowed for** (indicate program names)	Students of other programs need approval of CourseInstructor

10.	**Frequency of offering**	☐Every sem ☐1st sem ☐2nd sem ☒Either sem

11.	**Faculty who will teach the course** Prof. Manoj Datta, Prof. K.S. Rao, Prof. G.V. Ramana, Prof. J. T. Shahu, Dr. R. Ayothiraman, Dr. B. Manna, Dr. Tanusree Chakraborty	
12.	**Will the course require any visiting faculty?**	No

13.	**Course objective** *(about 50 words)***:** To learn basic concepts of analysing stability of slopes; seepage; design of different types of retaining retaining structures and tunneling methods.

14.	**Course contents** *(about 100 words) (Include laboratory/design activities)***:** Slope stability: infinite slopes; finite height slopes – Swedish method, Bishop's simplified method and other limit equilibrium methods; Stability charts; conditions of analysis – steady state, end of construction and sudden draw down; earthquake effects. Seepage: flownet in isotropic, anisotropic and layered media; entrance-exit conditions; determination of phreatic line. Earth Dams: Introduction, factors influencing design, design of components, construction, instrumentation. Road and rail embankments. Reinforced slopes. Soil nailing; Gabions. Earth Pressure: Types; Rankine's theory and Coulomb's theory; Effects due to wall friction; Graphical methods; Earthquake effects.

	Rigid retaining structures: Types; stability analysis. Flexible retaining structures: Types; material; cantilever sheet piles; anchored bulkheads–methods of analysis, moment reduction factors; anchorage. Reinforced soil walls: Elements and stability. Soil arching. Braced excavation: Pressure distribution in sands and clays; bottom heave. Underground structures in soils: Pipes; tunnels. Tunneling techniques.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Slope stability: infinite slopes; finite height slopes – Swedish method, Bishop's simplified method and other limit equilibrium methods; Stability charts; conditions of analysis – steady state, end of construction and sudden draw down; earthquake effects.	8
2	Seepage: flownet in isotropic, anisotropic and layered media; entrance-exit conditions; determination of phreatic line.	6
3	Earth Dams: Introduction, Factors influencing design, design of components, construction, instrumentation.	4
4	Road and rail embankments. Reinforced Slopes. Soil nailing; Gabions.	4
5	Earth Pressure: Types; Rankine's theory and Coulomb's theory; Effects due to wall friction; Graphical methods; Earthquake effects.	4
6	Rigid retaining structures: types; stability analysis.	2
7	Flexible retaining structures: types; material; cantilever sheet piles; anchored bulkheads–methods of analysis, moment reduction factors; anchorage.	5
8	Reinforced soil walls: Elements; construction methods; external stability; internal stability.	3
9	Soil arching. Braced excavation: Pressure distribution in sands and clays; bottom heave; design.	3
10	Underground structures in soils: Pipes; tunnels. Tunneling techniques: cut-and-cover and shield tunneling.	3
11		
12		
COURSE TOTAL *(14 times 'L')*		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
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7		
8		
9		
10		
COURSE TOTAL *(14 times 'P')*		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Anderson M.G. and Richards K.S., Slope stability, Geotechnical Engineering and

Geomorphology, Wiley-Blackwell, 1987.
2. Duncan M. and Wright, S.G., Soil Strength and Slope stability, John Wiley, 2005.
3. Sowers, G.F., Earth and Rockfill Dam Engineering, Asia Publishing House, 1962.
4. Das, B.M., Advanced Soil Mechanics, Taylor and Francis, 1997.
5. Kurian, N. P. (1994), Design of Foundation Systems - Principles and Practices, 2nd Edition, Narosa Publishing House, 1994.
6. Tomlinson M. and Woodward, J. Pile design and construction Practice, 5th Edition, Taylors & Francis, 2008.
7. Clayton, C. R. I., Milititsky, J. and Woods, R. I., Earth Pressure and Earth Retaining Structures, Blackie Academic & Professional, 1993.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Available
19.2	Hardware	Available
19.3	Teaching aides (videos, etc.)	Black board, OHP, PPT, Videos and site visits
19.4	Laboratory	NA
19.5	Equipment	NA
19.6	Classroom infrastructure	Black board and PPT Projector required
19.7	Site visits	YES

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Upto 20%
20.2	Open-ended problems	Upto 20%
20.3	Project-type activity	Upto 10%
20.4	Open-ended laboratory work	Upto 10%
20.5	Others (please specify)	Selfstudy component: Upto 20%

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	CIVIL ENGINEERING
2.	**Course Title** *(< 45 characters)*	SOIL DYNAMICS AND EARTHQUAKE GEOTECHNICAL ENGINEERING
3.	**L-T-P structure**	3-0-0
4.	**Credits**	3
5.	**Course number**	CVL706
6.	**Status** (*category* for *program*)	PE

7.	**Pre-requisites** (course no./title)	NIL

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	<20 %, CVL423
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	**Not allowed for** (indicate program names)	Students of other programs need approval of CourseInstructor

10.	**Frequency of offering**	☐Every sem ☐1st sem ☐2nd sem ☒Either sem

11.	**Faculty who will teach the course** Prof. Manoj Datta, Prof. K.S. Rao, Prof. G.V. Ramana, Prof. J. T. Shahu, Dr. R. Ayothiraman, Dr. B. Manna, Dr. Tanusree Chakraborty	
12.	**Will the course require any visiting faculty?**	NO

13.	**Course objective** *(about 50 words)***:** To learn (i) behaviour of soil under dynamics loads and (ii) design of foundations and retaining structures under dynamic loads

14.	**Course contents** *(about 100 words) (Include laboratory/design activities)***:** Engineering problems involving soil dynamics; Role of inertia; Theory of Vibrations: Single and two-degree freedom systems, vibration measuring instruments, Vibration absorption and isolation techniques. Wave propagation: elastic continuum medium and semi-infinite elastic continuum medium. Measurement of small strain and large strain dynamic soil properties: Field and Laboratory tests. Selection of design values. Design criteria for machine foundations, elastic homogeneous half space solutions, lumped parameter solutions. Codal provisions; Design of Pile-supported machine foundations.Strong Ground Motion: Measurement, characterization and estimation; Amplification theory and ground response analysis. Liquefaction of

	soils: evaluation using simple methods and mitigation measures. Seismic slope stability analysis, Seismic bearing capacity and earth pressures. Codal provisions.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Engineering problems involving soil dynamics; Role of inertia; Theory of Vibrations: Single and two-degree freedom systems, vibration measuring instruments, Vibration absorption and isolation techniques.	8
2	Wave propagation: elastic continuum medium and semi-infinite elastic continuum medium.	4
3	Measurement of small strain and large strain dynamic soil properties: Field and Laboratory tests. Selection of design values.	6
4	Design criteria for machine foundations, elastic homogeneous half space solutions, lumped parameter solutions. Codal provisions; Design of Pile-supported machine foundations.	8
5	Causes of Earthquakes: Mechanism, Plate techtonic and elastic rebound theories, Magnitude and Intensity. Strong Ground Motion: Measurement, characterization and estimation; Amplification theory and ground response analysis.	7
6	Liquefaction of soil: Definition, Assessment of liquefaction susceptibility, Evaluation of liquefaction potential, Prinicples of liquefaction remediation	5
7	Seismic slope stability analysis, Seismic bearing capacity and earth pressures. Codal provisions.	4
8		
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12		
COURSE TOTAL *(14 times 'L')*		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL *(14 times 'P')*		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Das, B.M. and Ramana, G. V. Principles of Soil Dynamics,2nd Edition, CENGAGE Learning, USA, 2011.
2. Day, R. W. Geotechnical Earthquake Engineering Handbook. McGraw-Hill, New York, 2002.
3. Kramer, S.L. Geotechnical Earthquake Engineering. Prentice-Hall, Inc., 1996.
4. Prakash, S., Soil Dynamics, McGraw Hill, 1981.
5. Prakash, S. and Puri, V. K., Foundation for machines: Analysis and Design, John Wiley & Sons, 1998.
6. Swami Saran. Soil Dynamics and Machine Foundations. Galgotia Publishers, New Delhi, 2006.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Available
19.2	Hardware	Available
19.3	Teaching aides (videos, etc.)	Black board, OHP, PPT, Videos and site visits
19.4	Laboratory	NA
19.5	Equipment	NA
19.6	Classroom infrastructure	Black board and PPT Projector required
19.7	Site visits	YES

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Upto 20%
20.2	Open-ended problems	Upto 20%
20.3	Project-type activity	Upto 10%
20.4	Open-ended laboratory work	Upto 10%
20.5	Others (please specify)	Selfstudy component: Upto 20%

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	CIVIL ENGINEERING
2.	**Course Title** *(< 45 characters)*	SOIL-STRUCTURE INTERACTION ANALYSIS
3.	**L-T-P structure**	3-0-0
4.	**Credits**	3
5.	**Course number**	CVL707
6.	**Status** (*category* for *program*)	PE

7.	**Pre-requisites** (course no./title)	NIL

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	Less than 10%
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	**Not allowed for** (indicate program names)	Students of other programs need approval of CourseInstructor

10.	**Frequency of offering**	☐Every sem ☐1st sem ☐2nd sem ☒Either sem

11.	**Faculty who will teach the course** Prof. Manoj Datta, Prof. K.S. Rao, Prof. G.V. Ramana, Prof. J. T. Shahu, Dr. R. Ayothiraman, Dr. B. Manna, Dr. Tanusree Chakraborty	
12.	**Will the course require any visiting faculty?**	No

13.	**Course objective** *(about 50 words)***:** To learn concepts of soil-structure interaction and techniques for evaluation of responses of various foundation types.
14.	**Course contents** *(about 100 words) (Include laboratory/design activities)***:** Basic Soil Models: Single parameter model - Winkler; Two parameter models - Bilonenko-Borodick, Pasternak; Elastic Continuum - plane strain, plane stress, Boussinesq's problem, line load strip load; Special models starting with elastic continuum - Vlazov, Reissner; Three parameter model - Kerr model; Evaluation of model parameters for different conditions. Beam on Winkler foundation: solutions for infinite and semi-infinite beams; Finite beams: method of initial parameters, method of superposition. Beams on Elastic continuum: Use of finite difference method, rigid and flexible beams, lift-off, non-homogeneous soil, non-linear soil, plastic yielding of soil. Raft of Mat foundations: thin rectangular plates, approximate theory of plates, circular

	plates. Pile on Winkler foundation: Vertically loaded pile - rigid pile, evaluation of spring stiffness, non-homogeneous soil, compressible pile; Laterally loaded pile - rigid pile, Elastic pile, standard solutions for different end conditions; Pile on elastic continuum - vertically loaded piles - rigid pile.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Basic Soil Models: Single parameter model - Winkler; Two parameter models - Bilonenko-Borodick, Pasternak.	4
2	Elastic Continuum - plane strain, plane stress, Boussinesq's problem, line load strip load.	4
3	Special models starting with elastic continuum - Vlazov, Reissner; Three parameter model - Kerr model; Evaluation of model parameters for different conditions. Beam on Winkler foundation: solutions for infinite and semi-infinite beams.	6
4	Finite beams: method of initial parameters, method of superposition.	4
5	Beams on Elastic continuum: Use of finite difference method, rigid and flexible beams, lift-off, non-homogeneous soil, non-linear soil, plastic yielding of soil.	5
6	Raft of Mat foundations: thin rectangular plates, approximate theory of plates, circular plates.	5
7	Pile on Winkler foundation: Vertically loaded pile - rigid pile, evaluation of spring stiffness, non-homogeneous soil, compressible pile	5
8	Laterally loaded pile - rigid pile, Elastic pile, standard solutions for different end conditions	5
9	Pile on elastic continuum - vertically loaded piles - rigid pile.	4
10		
11		
12		
COURSE TOTAL *(14 times 'L')*		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL *(14 times 'P')*		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Hetenyi, M., Beams on elastic foundation, Michigan press, 1979.
2. Selvadurai, A.P.S., Elastic analysis of soil foundation interaction, Elsevier, 1979.

3. Tsudik, E., Analysis of structures on elastic foundation, J.Ross publishing, 2012.
4. Scott, R.F., Foundation Analysis, Prentice Hall, 1981.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Available
19.2	Hardware	Available
19.3	Teaching aides (videos, etc.)	Black board, OHP, PPT, Videos and site visits
19.4	Laboratory	NA
19.5	Equipment	NA
19.6	Classroom infrastructure	Black board and PPT Projector required
19.7	Site visits	YES

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Upto 20%
20.2	Open-ended problems	Upto 20%
20.3	Project-type activity	Upto 10%
20.4	Open-ended laboratory work	Upto 10%
20.5	Others (please specify)	Selfstudy component: Upto 20%

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	CIVIL ENGINEERING
2.	**Course Title** *(< 45 characters)*	GEOTECHNOLOGY OF WASTE DISPOSAL FACILITIES
3.	**L-T-P structure**	3-0-0
4.	**Credits**	3
5.	**Course number**	CVL708
6.	**Status** (*category* for *program*)	PE

7.	**Pre-requisites** (course no./title)	NIL

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	Less than 20%, CVL424
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	**Not allowed for** (indicate program names)	Students of other programs need approval of CourseInstructor

10.	**Frequency of offering**	☐Every sem ☐1st sem ☐2nd sem ☒Either sem

11.	**Faculty who will teach the course** Prof. Manoj Datta, Prof. K.S. Rao, Prof. G.V. Ramana, Prof. J. T. Shahu, Dr. R. Ayothiraman Dr. B. Manna, Dr. Tanusree Chakraborty	
12.	**Will the course require any visiting faculty?**	No

13.	**Course objective** *(about 50 words)***:** To enable the students learn desing issues related to waste containment.

14.	**Course contents** *(about 100 words) (Include laboratory/design activities)***:** Integrated waste management, Detailed design MSW Landfills and HW Landfills including individual componets, Closure of Old landfills, Expansion of old landfills, Ashponds and Tailings Ponds, Seismic Stability; Disposal of Nuclear Waste

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Integrated Solid waste management	2
2	Planning, Design, Construction of MSW Landfills inluding leachate and gas management	9
3	Design and Construction of HW Landfills.	5
4	Closure of Old landfills	3
5	Expansion of Old landfills	3
6	Planning and Design of Ash Ponds and Tailings Ponds	9
7	Seismic Stabillity assesssment	5
8	Disposal of nuclear waste	4
9	Regulatory Frame work	2
10		
11		
12		
COURSE TOTAL *(14 times 'L')*		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL *(14 times 'P')*		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Qian, X., Koerner, R., and Gray, D.H., Geotechnical aspects of landfill design and construction, Prentice Hall, 2002.
2. Daniel, D.E., Geotechnical practice for waste disposal, Chapman and Hall, 1993.
3. Sarsby, R., Environmental Geotechnics, Thomas Telford, 2000.
4. Bagchi, A., Design, construction and monitoring of landfills, Wiley Interscience, 1994.
5. Datta, M., Waste disposal in Engineered landfills, Narosa Publishers, 1998.
6. Gulhati, S.K. and Datta M., Geotechnical Engineering, Mcgraw Hill, 2005.
7. Vick, S.G., Planning, analysis and design of tailings dams, John Wiley & Sons, 1970
8. Yong, R. N., Catheriene, M and Fukue, M,Geoenvironmental Sustainability, CRC Press, 2007.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Available
19.2	Hardware	Available
19.3	Teaching aides (videos, etc.)	Black board, OHP, PPT, Videos and site visits
19.4	Laboratory	NA
19.5	Equipment	NA
19.6	Classroom infrastructure	Black board and PPT Projector required
19.7	Site visits	YES

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Upto 20%
20.2	Open-ended problems	Upto 20%
20.3	Project-type activity	Upto 10%
20.4	Open-ended laboratory work	Upto 10%
20.5	Others (please specify)	Selfstudy component: Upto 20%

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	CIVIL ENGINEERING
2.	**Course Title** *(< 45 characters)*	OFFSHORE GEOTECHNICAL ENGINEERING
3.	**L-T-P structure**	3-0-0
4.	**Credits**	3
5.	**Course number**	CVL709
6.	**Status** (*category* for *program*)	PE

7.	**Pre-requisites** (course no./title)	NIL

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	Less than 10%
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	**Not allowed for** (indicate program names)	Students of other programs need approval of CourseInstructor

10.	**Frequency of offering**	☐Every sem ☐1st sem ☐2nd sem ☒Either sem

11.	**Faculty who will teach the course** Prof. Manoj Datta, Prof. K.S. Rao, Prof. G.V. Ramana, Prof. J. T. Shahu, Dr. R. Ayothiraman, Dr. B. Manna, Dr. Tanusree Chakraborty	
12.	**Will the course require any visiting faculty?**	No

13.	**Course objective** *(about 50 words)***:** To enable the students to learn basics of marine soil behaviour, design of offshore foundations, seabed anchors, and submarine pipelines.
14.	**Course contents** *(about 100 words) (Include laboratory/design activities)***:** Submarine soils: Origin, nature and distribution. Terrigenic and pelagic soils. Submarine soils of India. Engineering behaviour of submarine soils: under-consolidated soils, calcareous soils, cemented soils, corals; Offshore site investigations: sampling and sampling disturbance, insitu testing, wireline technology. Offshore pile foundations for jacket type structures. Foundations of gravity structures; Foundations for jackup rigs. Anchors and breakout forces; anchor systems for floating structures. Stability of submarine slopes. Installation and stability of submarine pipelines.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Submarine soils: Origin, nature and distribution. Terrigenic and pelagic soils. Submarine soils of India.	4
2	Engineering behaviour of submarine soils: under-consolidated soils, calcareous soils, cemented soils, corals.	4
3	Offshore site investigations: sampling and sampling disturbance, insitu testing, wireline technology.	8
4	Offshore pile foundations for jacket type structures.	6
5	Foundations of gravity structures; Foundations for jackup rigs.	6
6	Anchors and breakout forces; anchor systems for floating structures.	6
7	Stability of submarine slopes.	4
8	Installation and stability of submarine pipelines.	4
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10		
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12		
COURSE TOTAL *(14 times 'L')*		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
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4		
5		
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7		
8		
9		
10		
COURSE TOTAL *(14 times 'P')*		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. E.T. Richard Dean. Offshore Geotechnical Engineering, ICE, UK, London, 2009.
2. Mark Randolph and Susan Gourvenec. Offshore Geotechnical Engineering, CRC Press, 2011.
3. H. G. Poulos. Marine Geotechnics, Unwin Hyman, 1988.
4. Susan Gourvenec and Mark Cassidy. Frontiers in Offshore Geotechnics,Taylor & Francis, 2005.
5. William O. McCarron. Deepwater Foundations and Pipeline Geomechanics, J. Ross Publishing, 2011.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Available
19.2	Hardware	Available
19.3	Teaching aides (videos, etc.)	Black board, OHP, PPT, Videos and site visits
19.4	Laboratory	NA
19.5	Equipment	NA
19.6	Classroom infrastructure	Black board and PPT Projector required
19.7	Site visits	YES

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Upto 20%
20.2	Open-ended problems	Upto 20%
20.3	Project-type activity	Upto 10%
20.4	Open-ended laboratory work	Upto 10%
20.5	Others (please specify)	Selfstudy component: Upto 20%

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	CIVIL ENGINEERING
2.	**Course Title** *(< 45 characters)*	EMERGING TOPICS IN GEOTECHNICAL ENGINEERING
3.	**L-T-P structure**	3-0-0
4.	**Credits**	3
5.	**Course number**	CVL800
6.	**Status** (*category* for *program*)	PE

7.	**Pre-requisites** (course no./title)	NIL

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	Less than 10%
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	**Not allowed for** (indicate program names)	Students of other programs need approval of CourseInstructor

10.	**Frequency of offering**	☐Every sem ☐1st sem ☐2nd sem ☒Either sem

11.	**Faculty who will teach the course** Prof. Manoj Datta, Prof. K.S. Rao, Prof. G.V. Ramana, Prof. J. T. Shahu, Dr. R. Ayothiraman, Dr. B. Manna, Dr. Tanusree Chakraborty	
12.	**Will the course require any visiting faculty?**	No

13.	**Course objective** *(about 50 words)***:** To enable the students to learn emerging topics related to geotechnical and geoenvironmental engineering
14.	**Course contents** *(about 100 words) (Include laboratory/design activities)***:** A course which will vary from year to year to study new and exicting developments in the broad spectrum of Geotechnical and Geoenvironmental Engineering. The course will also focus on new offshoots of Geotechnical and Geoenvironmental Engineering.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	A course which will vary from year to year to study new and exicting developments in the broad spectrum of Geotechnical and Geoenvironmental Engineering. The course will also focus on new offshoots of Geotechnical and Geoenvironmental Engineering.	42
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COURSE TOTAL *(14 times 'L')*		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
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4		
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COURSE TOTAL *(14 times 'P')*		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Relevant text books, reference books and journals articles would be used and provided.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Available

19.2	Hardware	Available
19.3	Teaching aides (videos, etc.)	Black board, OHP, PPT, Videos and site visits
19.4	Laboratory	NA
19.5	Equipment	NA
19.6	Classroom infrastructure	Black board and PPT Projector required
19.7	Site visits	YES

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Upto 20%
20.2	Open-ended problems	Upto 20%
20.3	Project-type activity	Upto 10%
20.4	Open-ended laboratory work	Upto 10%
20.5	Others (please specify)	Selfstudy component: Upto 20%

Date: (Signature of the Head of the Department)

MAJOR PROJECT TEMPLATE

1.	**Department/Centre proposing the course**	CIVIL ENGINEERING
2.	**Course Title** *(< 45 characters)*	MAJOR PROJECT I
3.	**L-T-P structure**	0-0-12
4.	**Credits**	6
5.	**Course number**	CVD800
6.	**Status** (*category* for *program*)	PROGRAMME CORE

7.	**Pre-requisites** (course no./title)	EARNED ROGRAMME CORE CREDITS AND MINIMUM OF 24 CREDITS BY THE END OF FIRST YEAR

8.	Supersedes any existing course	CED 811

9.	**Frequency of offering**	☐ Every sem ☐ 1st sem ☐ 2nd sem ☒ Either sem

10.	**FACULY WHO WILL SUPERVISE PROJECT STUDY** ALL GEOTECHNICAL SECTION FACULTY	
11.	**Will the PROJECT SUPERVISION require any visiting faculty?**	MAY BE INVITED ON REQUEST BY FACULTY SUPERVISOR/STUDENT

12.	**PROJECT objective** *(about 50 words)***:** (1) TO INITIATE STUDENTS INTO RESEARCH ON WELL DEFINED OR OPEN ENDED PROBLEMS (2) TO FOSTER/PROMOTE UNDERSTANDING OF IDENTIFIED PROBLEM DOMAINS BASED ON LABORATORY AND/OR NUMERICAL MODELLING BASED APPROACHES (3) TO DEVELOP THEORETICAL FORMULATIONS OF SPECIFIC CONTEXTUAL PHYSICAL PROCESSES (4) TO DEVELOP IMPROVED DESIGN METHODOLOGIES IN THE AREA OF GEOTECHNICAL AND GEOENVIRONMENTAL ENGINEERING

13. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	SPECIFIC TO THE PROBLEM TAKEN UP FOR THE STUDY	OPEN

14. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

RELEVANT, CONTEXTUAL RESEARCH ARTICLES, REPORTS AND BOOKS

15. Resources required for the STUDY *(itemized & student access requirements, if any)*

19.1	Software	YES
19.2	Hardware	YES
19.3	PRESENTATION aides (videos, etc.)	YES
19.4	Laboratory	YES
19.5	Equipment	YES
19.6	Classroom infrastructure	NO
19.7	Site visits	MAY BE REQUIRED AS PART OF THE STUDY

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	CIVIL ENGINEERING
2.	**Course Title** *(< 45 characters)*	GEOENVIRONMENTAL AND GEOTECHNICAL ENGINEERING LAB
3.	**L-T-P structure**	0-0-6
4.	**Credits**	3
5.	**Course number**	CVP800
6.	**Status** (*category* for *program*)	PC

7.	**Pre-requisites** (course no./title)	CVP700 - Soil Engineeering Laboratory

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	Less than 10%
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	**Not allowed for** (indicate program names)	Students of other programs need approval of CourseInstructor

10.	**Frequency of offering**	☐Every sem ☐1st sem ☐2nd sem ☒Either sem

11.	**Faculty who will teach the course** Prof. M. Datta, Prof. K.S. Rao, Prof. G.V. Ramana, Prof. J. T. Shahu, Dr. R. Ayothiraman, Dr. B. Manna, Dr. Tanusree Chakraborty	
12.	**Will the course require any visiting faculty?**	No

13.	**Course objective** *(about 50 words)***:** Project based laboratory for evaluation of engineering properties of waste materials and geosynthetics and for design of embankments and foundations.
14.	**Course contents** *(about 100 words) (Include laboratory/design activities)***:** Engineering properties and compaction characteristics of waste - coal ash , mine tailings. Permeability of clays and bentonite amended soils. Physical, Mechanical and Hydraulic Testing of Geosynthetics Landfill liner and cover: Evaluation of shear strength parameters of various Interfaces and design. Project based laboratory for evaluation of engineering properties of soils for design of embankments.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
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COURSE TOTAL *(14 times 'L')*		

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Engineering properties and compaction characteristics of waste materials - coal ash, mine tailings.	27
2	Physical, Mechanical and Hydraulic Testing of Geosynthetics	27
3	Landfill liner and cover: Evaluation of shear strength parameters of various Interfaces and design	15
4	Project based laboratory for evaluation of engineering properties of soils for design of embankments.	15
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COURSE TOTAL *(14 times 'P')*		84

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Koerner, R. M., Designing with Geosynthetics, 5th Edition, Prentice Hall, 2005.
2. Rao, G. V. and Pothal, G. K., Geosynthetics Testing - A Laboratory Manual, Sai Master Geoenvironmental Service Pvt. Ltd. (SAGES), 2008.
3. Head, K. H., Manual of Soil Laboratory Testing, Vol. I, II, and III, 3rd Edition, Whittles Publishing, 2006.
4. Das, B. M., Soil Mechanics Laboratory Manual, 7th Edition, Oxford University Press, 2009.
5. Bowles, J., Engineering Properties of Soils and their Measurement, McGraw-Hill, 4th Edition, 1992.

6. Relevant ASTM Codes

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Available
19.2	Hardware	Available
19.3	Teaching aides (videos, etc.)	Black board, OHP, PPT, Videos and site visits
19.4	Laboratory	NA
19.5	Equipment	NA
19.6	Classroom infrastructure	Black board and PPT Projector required
19.7	Site visits	No

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Upto 20%
20.2	Open-ended problems	Upto 10%
20.3	Project-type activity	Upto 30 %
20.4	Open-ended laboratory work	Upto 40 %
20.5	Others (please specify)	Selfstudy component: Upto 20%

Date: (Signature of the Head of the Department)

INDEPENDENT STUDY TEMPLATE

1.	**Department/Centre proposing the course**	CIVIL ENGINEERING
2.	**Course Title** *(< 45 characters)*	INDEPENDENT STUDY
3.	**L-T-P structure**	0-3-0
4.	**Credits**	3
5.	**Course number**	CVS800
6.	**Status** (*category* for *program*)	PROGRAMME ELECTIVE

7.	**Pre-requisites** (course no./title)	NONE

8.	Supersedes any existing course	NONE

9.	**Frequency of offering**	☐Every sem ☐1st sem ☐2nd sem ☒Either sem

10.	**FACULY WHO WILL SUPERVISE PROJECT STUDY** ALL GEOTECHNICAL SECTION FACULTY	
11.	**Will the PROJECT SUPERVISION require any visiting faculty?**	MAY BE INVITED ON REQUEST BY FACULTY SUPERVISOR/STUDENT

12.	**PROJECT objective** *(about 50 words)***:** TO STUDY AN INDENTIFIED RESEARCH AREA AND PREPARE A REPORT ON THE STATE-OF-THE-ART

13. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	SPECIFIC TO THE PROBLEM TAKEN UP FOR THE STUDY	OPEN

14. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

RELEVANT, CONTEXTUAL RESEARCH ARTICLES, REPORTS AND BOOKS

15. Resources required for the STUDY *(itemized & student access requirements, if any)*

19.1	Software	YES
19.2	Hardware	YES
19.3	PRESENTATION aides (videos, etc.)	YES
19.4	Laboratory	YES
19.5	Equipment	YES
19.6	Classroom infrastructure	NO
19.7	Site visits	MAY BE REQUIRED AS PART OF THE STUDY

Date: (Signature of the Head of the Department)

MAJOR PROJECT TEMPLATE

1.	**Department/Centre proposing the course**	CIVIL ENGINEERING
2.	**Course Title** *(< 45 characters)*	MAJOR PROJECT II
3.	**L-T-P structure**	0-0-24
4.	**Credits**	12
5.	**Course number**	CVD801
6.	**Status** (*category* for *program*)	PROGRAMME CORE

7.	**Pre-requisites** (course no./title)	STUDENT SHOULD HAVE CLEARED MAJOR PROJECT PART I

8.	Supersedes any existing course	CED 812

9.	**Frequency of offering**	☐Every sem ☐1st sem ☐2nd sem ☒Either sem

10.	**FACULY WHO WILL SUPERVISE PROJECT STUDY** ALL GEOTECHNICAL SECTION FACULTY	
11.	**Will the PROJECT SUPERVISION require any visiting faculty?**	MAY BE INVITED ON REQUEST BY FACULTY SUPERVISOR/STUDENT

12.	**PROJECT objective** *(about 50 words)***:** (1) TO INITIATE STUDENTS INTO RESEARCH ON WELL DEFINED OR OPEN ENDED PROBLEMS (2) TO FOSTER/PROMOTE UNDERSTANDING OF IDENTIFIED PROBLEM DOMAINS BASED ON LABORATORY AND/OR NUMERICAL MODELLING BASED APPROACHES (3) TO DEVELOP THEORETICAL FORMULATIONS OF SPECIFIC CONTEXTUAL PHYSICAL PROCESSES (4) TO DEVELOP IMPROVED DESIGN METHODOLOGIES IN THE AREA OF GEOTECHNICAL AND GEOENVIRONMENTAL ENGINEERING

13. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	SPECIFIC TO THE PROBLEM TAKEN UP FOR THE STUDY	OPEN

14. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

RELEVANT, CONTEXTUAL RESEARCH ARTICLES, REPORTS AND BOOKS

15. Resources required for the STUDY *(itemized & student access requirements, if any)*

19.1	Software	YES
19.2	Hardware	YES
19.3	PRESENTATION aides (videos, etc.)	YES
19.4	Laboratory	YES
19.5	Equipment	YES
19.6	Classroom infrastructure	NO
19.7	Site visits	MAY BE REQUIRED AS PART OF THE STUDY

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	CIVIL ENGINEERING
2.	**Course Title** *(< 45 characters)*	CONSTITUTIVE MODELLING IN GEOTECHNICS
3.	**L-T-P structure**	3-0-0
4.	**Credits**	3
5.	**Course number**	CVL801
6.	**Status** (*category* for *program*)	PE

7.	**Pre-requisites** (course no./title)	NIL

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	Less than 10%
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	**Not allowed for** (indicate program names)	Students of other programs need approval of CourseInstructor

10.	**Frequency of offering**	☐Every sem ☐1st sem ☐2nd sem ☒Either sem

11.	**Faculty who will teach the course** Prof. Manoj Datta, Prof. K.S. Rao, Prof. G.V. Ramana, Prof. J. T. Shahu, Dr. R. Ayothiraman, Dr. B. Manna, Dr. Tanusree Chakraborty	
12.	**Will the course require any visiting faculty?**	No

13.	**Course objective** *(about 50 words)***:** To learn constitutive modelling as applied to geotechnical materials and its application in solving geotechnical engineering problems.
14.	**Course contents** *(about 100 words) (Include laboratory/design activities)***:** Introduction: fundamental relations, models and soil mechanics. Elasticity: Isotropic, anisotropic, soil elasticity. Plasticity and yielding: yielding of clays, yielding of sands, slip line fields, introduction to upper and lower bounds, selected boundary value problems. Elastic-plastic model for soils: elastic volumetric strains, plastic volumetric strains, plastic hardening, plastic shear strains, plastic potentials, flow rule. Cam clay model: critical state line, shear strength, stress-dilatancy, index properties, prediction of conventional soil tests. Applications.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction: fundamental relations, models and soil mechanics.	6
2	Elasticity: Isotropic, anisotropic, soil elasticity.	8
3	Plasticity and yielding: yielding of clays, yielding of sands, slip line fields, introduction to upper and lower bounds, selected boundary value problems.	7
4	Elastic-plastic model for soils: elastic volumetric strains, plastic volumetric strains, plastic hardening, plastic shear strains, plastic potentials, flow rule.	7
5	Cam clay model: critical state line, shear strength, stress-dilatancy, index properties, prediction of conventional soil tests.	9
6	Applications.	5
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12		
COURSE TOTAL *(14 times 'L')*		42

16. Brief description of tutorial activities

NIL

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
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7		
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10		
COURSE TOTAL *(14 times 'P')*		

18. Suggested texts and reference materials

STYLE: Sonntag, R. E., Borgnakke, C., and Van Wylen, G. J., *Fundamentals of Thermodynamics*, 5th Ed., John Wiley, 2000.

1. Soil Behaviour and critical state soil mechanics by D.M. Wood
2. The mechanics of soils - An introduction to critical state soil mechanics by Atkinson and Bransby
3. Foundations of theoretical soil Mechanics by M.E. Harr
4. Desai, C.S. and Siriwardane, H.J., Constitutive laws for engineering materials with emphasis on geologic materials, Prentice Hall, 1984.
5. Chan, W.K. and Saleeb, A.F., Constitutive equations for engineering materials, Volume

1: Elasticity and modelling, Elsevier, 1994.
6. Chan, W.K. and Saleeb, A.F., Constitutive equations for engineering materials, Volume 2: Plasticity and modelling, Elsevier, 1994.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Available
19.2	Hardware	Available
19.3	Teaching aides (videos, etc.)	Black board, OHP, PPT, Videos and site visits
19.4	Laboratory	NA
19.5	Equipment	NA
19.6	Classroom infrastructure	Black board and PPT Projector required
19.7	Site visits	YES

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Upto 20%
20.2	Open-ended problems	Upto 20%
20.3	Project-type activity	Upto 10%
20.4	Open-ended laboratory work	Upto 10%
20.5	Others (please specify)	Selfstudy component: Upto 20%

Date: (Signature of the Head of the Department)