

Jharkhand University of Technology Ranchi

Master of Technology Course Structure & Syllabus



Department of Civil Engineering

December 2021

Specialization – Geotechnical Engineering

(With effect from Academic Year 2021-22)

Model Curriculum for

**Postgraduate Degree Courses of Civil
Engineering Department of JUT 2021
Onwards**

December 2021

Specialization – Geotechnical Engineering

**Specialization: GEOTECHNICAL
ENGINEERING**

Semester I				
Sr. No.	Course Type	Code	Course Name & Course code	Credits
1.	Core-I	CESM1101	Advanced Soil Mechanics (CESM1101)	3
2.	Core-II	CESM1102	Advanced Foundation Engineering (CESM1102)	3
3.	Program Elective-I	CESM1103	1. Soil Structure Interaction	3
		CESM1104	2. Ground Improvement Techniques	
		CESM1105	3. Pavement Analysis and Design	
		CESM1106	4. Shear strength of soil	
		CESM1107	5. Unsaturated soil Mechanics	
4.	Program Elective-II	CESM1108	1. Numerical methods in civil engineering	3
		CESM1109	2. Geo-Environmental Engineering	
		CESM1110	3. Critical Soil Mechanics	
		CESM1111	4. Limit state design of structure	
		CESM1112	5. Offshore Geotechnical Engineering	
5.	Program Elective-III	CESM1113	1. Stability analysis of slopes	3
		CESM1114	2. Foundations on weak rocks	
		CESM1115	3. Geotechnical earthquake engineering	
		CESM1116	4. Subsoil exploration	
		CESM1117	5. Geotechnics in Practice	
6.	Core	CESM1201	Core Lab I	2
7.	Core	CESM1202	Core Lab II	2
8.	Compulsory Paper	RMC1101	Research Methodology & IPR	2
9.	A10001	Audit I	English for research paper writing	0
	A10002		Professional ethics	
	A10003		Constitution of India	
	A10004		Stress management by yoga	
Total Credit				21

**Specialization: GEOTECHNICAL
ENGINEERING**

		Semester II		
Sr. No.	Course Type	Code	Course Name	Credits
1.	Core-III	CESM2101	Dynamics of soils and foundations	3
2.	Core-IV	CESM2102	Subsurface investigations and Instrumentation	3
3.	Program Elective-IV	CESM2103	1. Marine Geotechniques	3
		CESM2104	2. FEM in civil engineering	
		CESM2105	3. Engineering rock mechanics	
		CESM2106	4. Flow through porous media	
		CESM2107	5. Soil Properties and Behavior	
4.	Program Elective-V	CESM2108	1. Earth Retaining Structures	3
		CESM2109	2. Design of underground excavations	
		CESM2110	3. Physical and Constitutive Modelling on Geomechanics	
		CESM2111	4. Advance soil testing	
		CESM2112	5. Geosynthetics Engineering	
5.	Open Elective-I	CESM2113	1. Business Analytics	3
		CESM2114	2. Industrial Safety	
		CESM2115	3. Operations Research	
		CESM2116	4. Cost Management of Engineering Projects	
		CESM2117	5. Composite Materials	
		CESM2118	6. Waste to Energy	
6.	Core	CESM2201	Core Lab III	2
7.	Core	CESM2202	Core Lab IV	2
8.	Core	CESM2203	Mini Project	2
9.	A20001	Audit II	Disaster management	0
	A20002		Value education	
	A20003		Soft skills	
	A20004		Personality development through life enlightenment skills	
Total Credit				21

Semester III

Sr. No	Course Type	Code	Course Name	Credit
1.	Dissertation	CESM3201	Dissertation Phase – I	10
			Total credit	10

Semester IV

Sr. No.	Course Type	Code	Course Name	Credit
1.	Dissertation	CESM4201	Dissertation Phase – II	16
			Total credit	16

Core-I: ADVANCED SOIL MECHANICS (CESM1101)

S. No.	Contents	Contact hours
1	Introduction to advancement in soil mechanics, stress equilibrium in one-dimension, two-dimension and three- dimension. Elastic and plastic deformations: elastic wall; introduction to yielding and hardening; yield curve and yield surface.	14
2	Compressibility of soils: consolidation theory (one and two dimensional consolidation theories), consolidation in layered soil and consolidation for time dependent loading, determination of coefficient of consolidation (Casagrande method and Taylors method)	12
3	Strength behavior of soils; Mohr Circle of Stress; UU, CU, CD tests, drained and undrained behavior of sand and clay, significance of pore pressure parameters; determination of shear strength of soil; Interpretation of triaxial test results.	5
4	Stress path Drained and undrained stress path; Stress path with respect to different initial state of the soil; Stress path for different practical situations.	5
5	Critical state soil mechanics; Critical state parameters; Critical state for normally consolidated and over consolidated soil; Significance of Hvorslev state boundary surface; drained and undrained plane. critical void ratio; effect of dilation in sands.	6
Total		42

Suggested Books

1. B.M. Das, Advanced Soil Mechanics, Taylor and Francis, 2018
2. Purushotham Raj, Ground Improvement Techniques, Laxmi Publications, New Delhi, 1996.

Core –II :ADVANCED FOUNDATION ENGINEERING (CESM1102)

S. No.	Contents	Contact hours
1	Planning of soil exploration for different projects, methods of subsurface exploration, methods of borings along with various penetration tests	8
2	Shallow foundations , requirements for satisfactory performance of foundations, methods of estimating bearing capacity, settlements of footings and rafts, proportioning of foundations using field test data, IS codes.	12
3	Pile foundations , methods of estimating load transfer of piles, settlements of pile foundations, pile group capacity and settlement, negative skin friction of piles, laterally loaded piles, pile load tests, analytical estimation of load- settlement behavior of piles, proportioning of pile foundations, lateral and uplift capacity of piles.	5
4	Well foundation , IS and IRC codal provisions, elastic theory and ultimate resistance methods	5
5	Foundations on problematic soils: Foundations for collapsible and expansive soil. Cofferdams- various types, analysis and design.	12
Total		42

Suggested Books

1. Bowles. J.E., Foundation Analysis and Design, Tata McGraw-Hill International Edition, 5th Edn, 1997.
2. Purushotham Raj, Ground Improvement Techniques, Laxmi Publications, New Delhi, 1996.
3. Das B.M., Shallow Foundations: Bearing capacity and settlement, CRC Press, 1999
4. Tomlinson M.J., Pile design and construction Practice, Chapman and Hall Publication, 1994.
5. Poulos, H. G. and Davis, F. H., "Pile Foundation Analysis and Design", Wiley and Sons. 1980

Program Elective – I:SOIL STRUCTURE INTERACTIONS (CESM1103)

S. No.	Contents	Contact hours
1	Soil-Foundation Interaction: Introduction to soil-foundation interaction problems, Soil behavior, Foundation behavior, Interface behavior, Scope of soil foundation interaction analysis, soil response models, Winkler, Elastic continuum, Two parameter elastic models, Elastic plastic behavior, Time dependent behavior.	8
2	Beam on Elastic Foundation- Soil Models: Infinite beam, Two parameters, Isotropic elastic half space, Analysis of beams of finite length, Classification of finite beams in relation to their stiffness.	12
3	Plate on Elastic Medium: Thin and thick plates, Analysis of finite plates, Numerical analysis of finite plates, simple solutions.	5
4	Elastic Analysis of Pile: Elastic analysis of single pile, Theoretical solutions for settlement and load distributions, Analysis of pile group, Interaction analysis, Load distribution in groups with rigid cap.	5
5	Laterally Loaded Pile: Load deflection prediction for laterally loaded piles, Subgrade reaction and elastic analysis, Interaction analysis, Pile-raft system, Solutions through influence charts. An introduction to soil-foundation interaction under dynamic loads.	6
Total		36

Suggested Books

1. Selvadurai, A.P.S, Elastic Analysis of Soil-Foundation Interaction, Elsevier, 1979.
2. Poulos, H.G., and Davis, E.H., Pile Foundation Analysis and Design, John Wiley,1980.
3. Scott, R.F., Foundation Analysis, Prentice Hall, 1981
4. Structure Soil Interaction - State of Art Report, Institution of Structural Engineers, 1978.
5. ACI 336. (1988), Suggested Analysis and Design Procedures for combined footings and Mats, American Concrete Institut

Program Elective – I GROUND IMPROVEMENT TECHNIQUES (CESM1104)

S. No.	Contents	Contact hours
1	Introduction - Engineering properties of soft-weak and compressible deposits – problems associated with weak deposit	5
2	Requirements of ground improvements – introduction to engineering ground modification, need, objectives and outcomes. Soil Stabilization - Science of soil stabilization – Mechanical modification – Hydraulic modification – Dewatering systems – Chemical modification – Modification by admixtures like lime, Cement, Bitumen etc – Grouting – Deep jet mixing methods.	8
3	Recent Ground improvement techniques - stabilization using industrial waste – modification by inclusion and confinement – soil nailing – stone column – compaction piles – dynamic compaction – prefabricated vertical drains – preloading – electro-osmosis – soil freezing vacuum consolidation – deep explosion – dry powdered polymers – enzymes. Soil reinforcement - Historical background, RCC – Vidalean concept of reinforced earth – Mechanisms – Types of reinforcements	12
4	Soil– Reinforcement – Interaction studies – Internal and External stability criteria – Design Principles of steep reinforced soil slopes – pavements – Embankments on soft soils. Geo-Synthetics - Geo-synthetic clay liner – Construction details	5
5	Geo Synthetic Materials – Functions – Property characterization – Testing Methods for Geo-Synthetics – Recent research and Developments - Control of Improvement – Field Instrumentation – design and analysis for bearing capacity and settlement of improved deposits.	6
Total		36

Suggested Books

1. Hausmann, M. R., Engineering Principles of Ground Modification, McGraw – Hill International Editions, 1990. Poulos, H.G., and Davis, E.H., Pile Foundation Analysis and Design, John Wiley, 1980.
2. Purushotham Raj, Ground Improvement Techniques, Laxmi Publications, New Delhi, 1996.
3. Klaus Krisch, Alan Bell, Ground Improvement (3rd Edition), CRC Press, London, 2012.
4. Jones C. J. F. P, Earth Reinforcement and Soil Structures, Butterworths, London, 1988.
5. Moseley M. P., Ground Improvement, Blackie Academic and Professional, Chapman and Hall, Glasgow, 1993

Program Elective – I :PAVEMENT ANALYSIS AND DESIGN (CESM1105)

S. No.	Contents	Contact hours
1	Philosophy of design of flexible and rigid pavements. Analysis of pavements using different analytical methods	11
2	Selection of pavement design input parameters – traffic loading and volume	8
3	Material characterization, drainage, failure criteria, reliability	6
4	Design of flexible and rigid pavements using different methods,	5
5	Comparison of different pavement design approaches, design of overlays and drainage system.	6
Total		36

Suggested Books

1. Hausmann, M. R., Engineering Principles of Ground Modification, McGraw – Hill International Editions, 1990. Poulos, H.G., and Davis, E.H., Pile Foundation Analysis and Design, John Wiley, 1980.
2. Jones C. J. F. P, Earth Reinforcement and Soil Structures, Butterworths, London, 1988.
3. Scott, R.F., Foundation Analysis, Prentice Hall, 1981
4. B.M. Das, Advanced Soil Mechanics, Taylor and Francis, 2018

Program Elective – I :SHEAR STRENGTH OF SOIL (CESM1106)

S. No.	Contents	Contact hours
1	Concept of stress and strain in octahedral plane. Theories of failure criteria in soils, Bishops modification Mohr's theory in three dimensions. Shear strength of cohesionless soils, critical void ratio, and volume change. Stress dilatancy, factors affecting; failure criteria by maximum stress ratio and maximum deviator stress.	5
2	Shear Strength of saturated cohesive soils, Principles of undrained shear strength, effective stress principles .pore pressure parameters, Skempton's and Henkel's equation, normally and over-consolidated clays, factors affecting strength.	8
3	Total and effective stress parameters. Hvorslev's parameters, concept of stress path, Henkel's and Roscoe's concepts of yield surface principles of critical state soil mechanics. Shear tests, unconfined, direct shear, vane shear, Ring shear and drained tests, compressor and extensive tests, Back pressure techniques of saturation. Pore pressure measurements and constant volume tests.	6
4	Residual strength of soils. Factor affecting residual factor, methods of measurement.Rheological models and time dependent behavior of clays. Constitutive relationship in sand and clays, factors affecting Kondner's stress-strain relationship and determination of coefficient and flow rule.	11
5	Shear strength of partially saturated soils, principle of effective stress and its limitations, factors affecting determination of CHI factor. Shear strength of compacted soils- multi stage. Influence of anisotropy on strength of clays.	6
Total		36

Suggested Books

1. B.M. Das, Advanced Soil Mechanics, Taylor and Francis, 2018
2. RamondNen Yong, Laboratory Shear Strength of Soils, ASTM International

Program Elective – I :UNSATURATED SOIL MECHANICS (CESM1107)

S. No.	Contents	Contact hours
1	Stresses and strains in soils - stress, strain paths invariants - one-dimensional and isotropic compression of soils and idealization; state boundary of compression of soils; stress paths and soil tests; critical state line and Roscoe surface	5
2	Drained and undrained planes; Critical state line for sands; Behavior of over-consolidated soils and Hvorslev's surface; Behavior of soils before failure.	8
3	Interpretation of index tests in the light of critical state concepts; Cam-clay models, Determination of critical state parameters.	6
4	Identification and classification of expansive and collapsing soils, effective stress concepts, matric and osmotic suction	5
5	Collapse, heave and strength characteristics of unsaturated soils Flow through unsaturated soils. Laboratory evaluation of swell pressure and swell potential, tests to evaluate collapse potential. Measurements of soil suction	12
Total		36

Suggested Books

1. Jean-Louis Briaud, Geotechnical Engineering: Unsaturated and Saturated Soils, John Wiley & Sons, Inc., New Jersey, 2013
2. Murray E.J, Sivakumar V., Unsaturated Soils: A fundamental interpretation of Soil behaviour, Wiley-Blackwell, 2010.
3. Ng C.W.W and Menzies B, Advanced unsaturated soil mechanics and engineering, CRC Press, 2019
4. Lu, N. and Likos, W.J., Unsaturated soil mechanics, Wiley, 2004 (2)
5. Fredlund, D. J., Rahardjo, R., and Fredlund, M.D. Unsaturated Soil Mechanics in Engineering Practice, Wiley, 2012.

Program Elective – II NUMERICAL METHODS IN CIVIL ENGINEERING (CESM1108)

S. No.	Contents	Contact hours
1	Fundamentals of Numerical Methods: Error Analysis, Polynomial Approximations and Interpolations, and extrapolation.	5
2	Solution of Nonlinear Algebraic and Transcendental Equations: Bisection, False Position, Newton-Raphson, Successive approximation method, Iterative methods	8
3	Elements of Matrix Algebra: Solution of Systems of Linear Equations, Eigen Value Problems, Jacobi's method, Gauss-seidal method, successive over relaxation method.	6
4	Numerical Differentiation & Integration: Solution of Ordinary and Partial Differential Equations.	5
5	Correlation and Regression Analysis: Correlation - Scatter diagram, Karl Pearson coefficient of correlation, Limits of correlation coefficient; Regression –Lines of regression, Regression curves, Regression coefficient, Differences between correlation and regression analysis.	12
Total		36

Suggested Books

1. An Introduction to Numerical Analysis, Atkinson K.E., J. Wiley and Sons, 1989
2. Theory and Problems of Numerical Analysis, Scheid F, McGraw Hill Book Company, (Shaum Series), 1988.
3. Introductory Methods of Numerical Analysis, Sastry S. S, Prentice Hall of India, 1998.

Program Elective – II GEO-ENVIRONMENTAL ENGINEERING (CESM1109)

S. No.	Contents	Contact hours
1	Soil as a multiphase system; Soil-environment interaction; Properties of water in relation to the porous media; Water cycle with special reference to soil medium.	5
2	Soil mineralogy; significance of mineralogy in determining soil behavior; Mineralogical characterization. Mechanisms of soil-water interaction: Diffuse double layer models; Force of attraction and repulsion; Soil-water-contaminant interaction; Theories of ion exchange; Influence of organic and inorganic chemical interaction.	14
3	Concepts of waste containment; Sources, production and classification of wastes, Environmental laws and regulations, physio-chemical properties of soil, ground water flow and contaminant transport, desirable properties of soil; contaminant transport and retention; contaminated site remediation.	6
4	Soil characterization techniques; volumetric water content; contaminant analysis. contaminated site characterization, estimation of landfill quantities, landfill site location, design of various landfill components such as liners, covers, leachate collection and removal	5
5	Soil characterization techniques : ground water monitoring, end uses of landfill sites, slurry walls and barrier systems, design and construction, stability, compatibility and performance, remediation technologies, stabilization of contaminated soils and risk assessment approaches.	6
Total		36

Suggested Books

1. Mitchell, J.K and Soga, K., Fundamentals of Soil Behavior, John Wiley and Sons Inc., 2005
2. Fang, H-Y., Introduction to Environmental Geotechnology, CRC Press, 1997
3. Rowe, R.K., Quigley, R.M. and Booker, J.R., Clay Barrier Systems for Waste Disposal Facilities, E & FN Spon, 1995.
4. Sharma, H.D. and Lewis, S.P, Waste Containment Systems, Waste Stabilization and Landfills: Design and Evaluation, John Wiley & Sons Inc., 1994.
5. Reddi, L.N. and Inyang, H.F, Geoenvironmental Engineering - Principles and Applications, Marcel Dekker Inc, 2000.

Program Elective – II CRITICAL SOIL MECHANICS (CESM1110)

S. No.	Contents	Contact hours
1	Soil Behavior: State of stress and strain in soils, Stress and strain paths and invariants, behavior of soils under different laboratory experiments	5
2	The Critical state line: Families of undrained tests, Families of drained tests, the critical state line, drained and undrained surfaces	8
3	Behavior of Over consolidated samples: The Hvorslev surface: Behavior of over consolidated samples, drained and undrained tests, The Hvorslev surface, complete State Boundary Surface, Volume changes and pore water pressure changes	6
4	Behaviour of Sands: The critical state line for sands, Normalized plots, the effect of dilation.	5
5	Behaviour of Soils before Failure: Elastic and plastic deformations, Plasticity theory Development of elastic-plastic model based on critical state soil mechanics, The Cam-clay model, The modified Cam-clay model	12
Total		36

Suggested Books

1. M J. H. Atkinson and P. L. Bransby, “The mechanics of soils: An introduction to critical state soil mechanics”, McGraw Hill, 1978
2. D. M. Wood, “Soil behaviour and critical state soil mechanics”, Cambridge University Press, 1990
3. B. M. Das, “Fundamental of geotechnical engineering”, Cengage Learning, 2013

Program Elective – II LIMIT STATE DESIGN OF STRUCTURE (CESM1111)

S. No.	Contents	Contact hours
1	Introduction: Stress-Strain relationship; Fully Plastic moment and Plastic hinge, Simple cases of Plastic collapse: Simply supported and Fixed beams, Portal frames	5
2	Basic theorems: Principle of virtual work; Partial, Complete and Over-complete collapses. Upper bound, lower bound and uniqueness theorems	8
3	Design: Trial and Error method, combined mechanisms, plastic moment distribution Deflection: Moment-curvature relations, simple beams and portal frames. Deflection at collapse Minimum weight design: characteristic strength, partial factor of safety	6
4	Shear and Torsion, simply reinforced, doubly reinforced and Tee beam	5
5	Serviceability requirements: Deflection – long and short term deflections Compression members: Axially loaded, short columns, slender columns, combined bending and axial forces, biaxial bending, use of SP-16 Design of slabs in flexure failure: Yield line theory, work method, equilibrium method, strip method	12
Total		36

Suggested Books

1. M NEAL B. G.: Plastic method of Structural Analysis
2. PUNMIA B. C.: Limit State Design

Program Elective – II: OFFSHORE GEOTECHNICAL ENGINEERING (CESM1112)

S. No.	Contents	Contact hours
1	Identify and describe key challenges of offshore engineering design – describe the aspects of the marine environment that feed into offshore engineering design.	5
2	Describe the main components of an offshore site investigation; Interpret selected geotechnical site investigation data	8
3	Identify the main types of offshore foundation systems and describe the drivers during foundation design	6
4	Perform selected foundation design calculations to illustrate the interplaying mechanisms.	5
5	Identify key aspects of geotechnical pipeline design and perform selected design calculations to illustrate the interplaying mechanisms. Determine the loads acting on the offshore structures	12
Total		36

Suggested Books

1. M Randolph M and Gourvene S, Offshore Geotechnical Engineering, CRC Press, 2017.
2. Ben C. Gerwick, “Construction of Marine and Offshore Structures”, CRC Press, 1999.
3. B. Gou, S. Song, J. Chacko and A. Ghalambor, “Offshore Pipelines”, GPP Publishers, 2006.
4. S. K. Hakrabarti, “Handook of Offshore Engineering”, Elsevier, 2005.
5. M. J. Tomlinson, “Pile Design and Construction”, E and F Spon, 1994

Program Elective – III: STABILITY ANALYSIS OF SLOPES (CESM1113)

S. No.	Contents	Contact hours
1	Slopes: Types and causes of slope failures, mechanics of slope failure, failure modes.	5
2	Stability analysis: infinite and finite slopes with or without water pressures; concept of factor of safety, pore pressure coefficients, Wedge methods, friction circle method ; Method of slices, Bishop’s method, Janbu’s method, Morgenstern and Price, Spencer’s method	8
3	Stability analysis in the presence of seepage: two dimensional flow – Laplace equation and it’s solution, graphical method, determination of phreatic line, flow nets in homogeneous and zoned earth dams under steady seepage and draw-down conditions, seepage control in earth dams,	11
4	Strengthening measures (a): Stabilization of slopes by drainage methods, surface and subsurface drainage, use of synthetic filters, retaining walls,	6
5	Strengthening measures (b): Stabilization and strengthening of slopes, shotcreting, rock bolting and rock anchoring, slope movements, warning devices, maintenance of slopes	6
Total		36

Suggested Books

1. Chowdhary R and Chowdhary , "Geotechnical Slope Analysis", CRC Press.
2. Harr M.E., " Ground Water and Seepage", McGraw Hill. 1962

Program Elective – III: FOUNDATION ON WEAK ROCKS (CESM1114)

S. No.	Contents	Contact hours
1	Engineering properties of weak rocks, different rock mass classification systems, relative merits and demerits	5
2	Failure criteria for weak rocks, bi-linear Mohr-Coulomb failure criterion, Hoek and Brown criterion and modified Hoek and Brown failure criterion etc.	3
3	Effect of structural planes on rock foundations, possible modes of failure of foundations on rocks/ rock masses, determination of in-situ shear strength of rocks and rock masses	5
4	Requirements for satisfactory performance of foundations, bearing capacity of foundations on rocks and rock masses, allowable bearing pressure of rock foundations using a nonlinear failure criterion, monotonic and cyclic plate load tests. - Piles in weak rocks, bearing capacity and settlement of piles, piles in stratified rock masses, field load tests on piles in weak rocks, behavior of bored / driven piles in soft / weathered rocks	11
5	Pressure-settlement characteristics, effect of layering, anisotropy, heterogeneity and in-elasticity Shallow foundations, shallow foundations on sloping ground, raft foundations, stilt foundations, foundations for suspension bridges, transmission line towers, framed buildings etc, treatment of foundations - open joints, solution cavities, weak seams	12
Total		36

Suggested Books

1. Wyllie Duncan C.,” Foundations on Rock: Engineering Practice”, E&FN Spon, Taylor and Francis.
2. Hudson J.A. and J.P. Harrison. Engineering Rock Mechanics: an Introduction to the Principles, 1997. Elsevier, Oxford
3. Singh, B. and Goel, R.K.,”Rock Mass Classification- A Practical Engineering Approach”, Elsevier
4. Ramamurthy, T., “Engineering in Rocks”, PHI Learning Pvt. Ltd.
5. Hoek, E., “Practical Rock Engineering”, Rock science.

Program Elective – III GEOTECHNICAL EARTHQUAKE ENGINEERING (CESM1115)

S. No.	Contents	Contact hours
1	Earthquake seismology – Causes of earthquake, Plate tectonics, Earthquake fault sources, Seismic waves, Elastic rebound theory, Quantification of earthquake, Intensity and magnitudes, Earthquake source models.	7
2	Earthquake ground motion – Seismograph, Characteristics of ground motion, Effect of local site conditions on ground motions, Design earthquake, Design spectra, Development of site specification and code-based design.	7
3	Ground response analysis – One-dimensional ground response analysis: Linear approaches, Equivalent linear approximation of non-linear approaches, Computer code “SHAKE”.	7
4	Liquefaction and lateral spreading - Liquefaction related phenomena, Liquefaction susceptibility: Historical, Geological, Compositional and State criteria. Evaluation of liquefaction by cyclic stress and cyclic strain approaches, Lateral deformation and spreading, Criteria for mapping liquefaction hazard zones.	7
5	Seismic design of foundations , Seismic slope stability analysis: Internal stability and weakening instability and Seismic design of retaining walls	8
Total		36

Suggested Books

1. Steven Kramer, “Geotechnical Earthquake Engineering”, Pearson, 2008.
2. Seco e Pinto, P., Seismic behaviour of ground and Geotechnical structure, A. A.
3. Ferrito, J.M, Seismic design criteria for soil liquefaction, Tech. Report of Naval Facilities service centre, Port Hueneme, 1997.

Program Elective – III : SUBSOIL EXPLORATION(CESM1116)

S. No.	Contents	Contact hours
1	Planning of Geotechnical exploration, methods of boring, type of samples & sampling	8
2	Non-destructive testing, field tests, standard penetration, plate load, static and dynamic cone penetration, field vane shear and pressure meter tests	8
3	Electrical resistivity and seismic refraction tests,	8
4	Location of ground water table, processing of exploration data and its interpretation	8
5	Piezometers and Slope Inclometers. Offshore exploration	4
Total		36

Suggested Books

1. HVORSLEV M. J.: Subsurface Exploration and Sampling of Soils for Civil Engineering Purposes US Waterways Experiment Station, Vicksburg, Miss., USA (1949)
2. TERZAGHI K. and PECK R. B. : Soil Mechanics in Engineering Practice John Wiley and Sons, NY, USA (1967) Instruction Manuals

Program Elective – III GEOTECHNICS IN PRACTICE (CESM1117)

S. No.	Contents	Contact hours
1	Course Content Geotechnical Interpretation Report (GIR) – deriving design parameters for a particular site – data analysis. Back analysis of field data - soft ground – application of ground improvement techniques	8
2	Considerations - short term effects such as slope stability - long term effects such as settlement and creep – Liquefaction potential. Stepwise analysis of underground structures	8
3	Damage assessment of structures due to tunnelling - Empirical methods.	8
4	IS and IRC Codal recommendations – application of design procedures. Estimation of fee for design projects – work breakdown structure – Budgets – Gross and Net margins – Work-in-progress	8
5	Elevated structures – foundation design – Shallow, Pile and Pile-raft – Geological considerations	4
Total		36

Suggested Books

1. All relevant IS and IRC codes.
2. ISO 9001:2015.
3. All relevant ASTM and Euro codes

RM 1101	Compulsory paper	Research Methodology & IPR	2
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Course Content

Unit-1: Research Problem and Scope for Solution: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.

Unit-2: Format: Effective literature studies approaches, analysis, Plagiarism, Research ethics. Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

Unit-3: Process And Development: Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, patenting under PCT.

Unit-4: Patent Rights: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit-5: New Developments In IPR: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Text Books:

1. Stuart Melville and Wayne Goddard, “*Research methodology: an introduction for science & engineering students*”
2. Wayne Goddard and Stuart Melville, “*Research Methodology: An Introduction*”
3. Ranjit Kumar, 2nd Edition, “*Research Methodology: A Stepby Step Guide for beginners*”

Reference Books:

1. Halbert, “*Resisting Intellectual Property*”, Taylor & Francis Ltd ,2007.
2. Mayall, “*Industrial Design*”, McGraw Hill, 1992.
3. Niebel, “*Product Design*”, McGraw Hill, 1974.
4. Asimov, “*Introduction to Design*”, Prentice Hall, 1962.
5. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ *Intellectual Property in New Technological Age*”, 2016.
6. T. Ramappa, “*Intellectual Property Rights Under WTO*”, S. Chand, 2008

Core –III : DYNAMICS OF SOILS AND FOUNDATIONS(CESM2101)

Unit	Course Content	Contact Hours
1.	Fundamentals of vibrations: single, two and multiple degree of freedom systems, vibration isolation, vibration absorbers.	4
2.	Wave propagation: elastic continuum medium, semi-infinite elastic continuum medium, soil behavior under dynamic loading. Liquefaction of soils: liquefaction mechanism, factors affecting liquefaction, studies by Dynamic tri-axial testing, oscillatory shear box, shake table, assessment of liquefaction potential.	16
3.	Dynamic elastic constants of soil: determination of dynamic elastic constants, various methods including block resonance tests, cyclic plate load tests, wave propagation tests, oscillatory shear box test.	10
4.	Machine foundations: Design criteria for machine foundations; Elastic homogeneous half space and lumped parameter solutions, analysis and design of foundations for reciprocating and impact type machines, turbines, effect of machine foundation on adjoining structures.	8
5.	Bearing capacity of foundations: Introduction to bearing capacity of dynamically loaded foundations, such as those of water towers, chimneys and high rise buildings, response of pile foundations.	6

References:

1. Das, B.M., “Fundamentals of Soil Dynamics”, Elsevier, 1983.
2. Steven Kramer, “Geotechnical Earthquake Engineering”, Pearson, 2008.
3. Prakash, S., Soil Dynamics, McGraw Hill, 1981.
4. Kameswara Rao, N.S.V., Vibration analysis and foundation dynamics, Wheeler Publication Ltd., 1998.
5. Prakash, S. and Puri, V.K., Foundation for machines: Analysis and Design, John Wiley & Sons, 1998

Core-IV: SUBSURFACE INVESTIGATION AND INSTRUMENTATION
(CESM2102)

Unit	Course Content	Contact Hours
1	Introduction: Necessity and Importance of soil exploration, Method of sub surface exploration Test pits, Trenches, Caissons, Tunnels and drifts, Wash boring, Percussion drilling , Rotary drilling, Factors affecting the selection of a suitable method of boring	4
2	Extent of boring, Factors controlling spacing and depth of bore holes, Spacing and depth of various Civil engineering structures. Indirect method of exploration, Seismic method, Electrical resistivity, Resistivity sounding and profiling, Qualitative and quantitative interpretation of test results, Comparison of resistivity and seismic surveys, Shortcomings	8
3	Stabilization of bore holes, Different method of stabilization of the bore holes, their relative merits and demerits. Ground water Observation: Different method of ground water observation: Time lag in observation, sampling of ground water.	9
4	Sampling: Source of disturbance and their influence. Type of sampler, Principle of design of sampler, Representative and undisturbed sampling in various types of soils. Surface sampling, Amount of sampling, Boring and sampling record, Preservation and shipment of sample preparation of bore log.	10
5	Penetration tests, Standard penetration tests, Dynamic cone penetration tests with and without bentonite slurry, Static cone penetration tests, factor affecting the penetration tests. Various corrections in the test results. Interpretation of test result for design and determination of modulus of deformation. Small size penetrometers. Correlation among various test results.	16

References:

1. Bowles, J.E., Foundation Analysis and Design, McGraw-Hill International Edition, 1997.
2. Schnaid, F., “ In Situ Testing in Geomechanics”, Taylor and Francis.

A. Program Elective-IV: Marine Geo-Techniques (CESM 2103)

Unit	Course Content	Contact Hours
1	Marine soil deposits: Offshore environment, Offshore structures and foundations, Specific problems related to marine soil deposits, Physical and engineering properties of marine soils	8
2	Behaviour of soils subjected to repeated loading: Effect of wave loading on offshore foundations, Behavior of sands and clays under cyclic loading, Laboratory experiments including repeated loading, Cyclic behavior of soils based on fundamental theory of mechanics, Approximate engineering methods which can be used for practical cases	8
3	Site Investigation in the case of marine soil deposits: Challenges of site investigation in marine environment, Different site investigation techniques, sampling techniques, Geophysical methods, Recent advancements in site investigation and sampling used for marine soil deposits	8
4	Foundations in marine soil deposits: Different offshore and nearshore foundations, Gravity platforms, Jack-up rigs, pile foundations, caissons, spudcans	8
5	Numerical modeling of marine foundations subjected to wave loading: Numerical modeling of cyclic behavior of soils, empirical models, elastic-plastic models, FEM analysis of marine foundations subjected to wave loading	8

Reference:

1. Offshore Geotechnical Engineering, Mark Randolph and Susan Gourvenec, 2011
2. SP -2209-OCN Handbook for Marine Geotechnical Engineering, David Thompson and Diane Jarrah Beasley;2012.
3. Coastal Engineering: Process , theory and Design, Reeve D and Chadwick A. ,2004, Taylor and Francis.

B. Program Elective-IV:FEM IN GEOTECHNICAL ENGINEERING (CESM2104)

Unit	Course Content	Contact Hours
1.	Introduction: History and Applications. Spring and Bar Elements, Minimum Potential Energy Principle, Direct Stiffness Method, Nodal Equilibrium equations, Assembly of Global StiffnessMatrix, Element Strain and Stress.	10
2.	Types: Triangular Elements, Rectangular Elements, Three-Dimensional Elements, Iso-parametricFormulation, Axi-Symmetric Elements, Numerical Integration, Gaussian Quadrature	8
3.	Method of Weighted Residuals: Galerkin, Finite Element Method, Application to Structural Elements, Interpolation Functions, Compatibility and Completeness Requirements, Polynomial Forms, Applications.	8
4.	Application of FEM : i) Solid Mechanics ii) Seepage Analysis	6
5	Application of FEM : iii) Foundation Analysis	2

Reference:

1. Finite Element Analysis in Geotechnical Engineering:Applications by David M. Potts and LidijiaZdravkovic, 2001.
2. Finite Elements in Geotechnical Engineering by David John Naylor and G. N. Pande. Pine ridge Press, 1981.

C. Program Elective-IV: ENGINEERING ROCK MECHANICS. (CESM2105)

Unit	Course Content	Contact Hours
1	Rock: Formation of rocks, Physical properties, Classification of rocks and rock masses, Elastic constants of rock; In-situ stresses in rock	6
2.	Rock Testing: Laboratory and Field tests. Discontinuities in Rock Masses: Discontinuity orientation, Effect of discontinuities on strength of rock	16
3	Strength Behaviour: Compression, Tension and Shear, Stress-Strain relationships, Rheological behavior	8
4	Strength/ Failure Criterion: Mohr-Coulomb, Griffith theory, Hoek and Brown, strength and other strength criteria. Stresses in rock near underground openings	8
5.	Application of rock mechanics in Civil Engineering: Rock tunneling, rock slope stability, bolting, blasting, grouting and rock foundation design. Modern modelling techniques & analyses in rocks.	8

References:

1. Hudson J.A. and J.P. Harrison. Engineering Rock Mechanics: an Introduction to the Principles, 1997. Elsevier, Oxford
2. Goodman, R.E. Introduction to Rock Mechanics, John Wiley & Sons.
3. Ramamurthy, T., "Engineering in Rocks", PHI Learning Pvt. Ltd Jaeger, J.C. and Cook, N.G.W,
4. Fundamentals of Rock Mechanics, Chapman and Hall, 1976. Wyllie, D.C., Foundations on Rock, E & FN Spon. 2nd Edition, 1992.

D. Program Elective-IV:Flows through Porous Media (CESM2106)

Unit	Course Content	Contact Hours
1.	Introduction, Occurrence of ground water flow and storage characteristics of aquifers, Darcy's law; Anisotropy and heterogeneity, Governing equations for ground water flow, Dupuit-Forchheimer assumptions, general differential equations governing ground water flow, Analytical solutions	8
2.	Dupuit's theory for unconfined flow, Two-dimensional flow in horizontal impervious boundaries; Free surface subject to infiltration / evaporation; Pavlovsky solution	7
3.	Flow Nets solution by conformal transformation, reciprocal function, velocity hodograph, Zhokovsky function, Schwarz-Christoffel transformation	10
4.	Confined flow : beneath weirs; Khosla's solution; weirs on permeable soils with sheet piles. Approximate solution – method of fragments; seepage through earth dams on porous base with toe filter and tail water; solution by inversion	8
5.	Electrical Analogy; Sketching flownets for various cases Ground water conservation, artificial recharge, Ground water pollution: remedy and prevention; Ground Water flow modeling	7

References:

1. HARR M. E. : Ground Water and Seepage
2. SPANGLER M. G. : Soil Engineering

E. Program Elective-IV: Soil Properties and Behaviour (CESM2107)

Unit	Course Content	Contact Hours
1.	Introduction – formation of soils – different soil deposits and their engineering properties – Genesis of clay minerals –identification and classification – Anion and cation exchange capacity of clays – specific surface area – bonding in clays.	8
2.	Physical and physio-chemical behaviour of soils – diffused double layer theory – computation of double layer distance – effect of ion concentration, ionic valency, pH, dielectric constant, temperature on double layer – stern layer – attractive and repulsive forces in clays – types of soil water – mechanism of soil – water interactions - soil structure.	7
3.	Problems associated with swelling and shrinkage behaviour of soils –Causes, consequences and mechanisms – factors influencing swell – shrink characteristics – swell potential – osmotic swell pressure – soil fabric and measurement – sensitivity, thixotrophy of soils – soil suction	10
4.	soil compaction – factors affecting soil compaction. Compressibility, shear strength and permeability behaviour of fine and coarse grained soils – mechanisms and factors influencing engineering properties – liquefaction potential – causes and consequences	8
5.	Conduction in soils – hydraulic, electrical, chemical and thermal flows in soils – applications - coupled flows – Electro-kinetic process – thermo osmosis - electro osmosis – prediction of engineering behaviour of soils using index properties – empirical equations and their applicability.	7

References:

1. Mitchell, J.K., Fundamentals of Soil Behaviour, John Wiley, New York, 1993.
2. Yong, R.N. and Warkentin, B.P., Introduction to Soil Behaviour, Macmillan, Limited, London, 1979.
3. Coduto, D.P., Geotechnical Engineering – Principles and practices, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.
4. Das, B.M., Principles of Geotechnical Engg, PWS Publishing Comp, Boston, 1998

**A. PROGRAM ELECTIVE-V: EARTH RETAINING
STRUCTURES(CESM2108)**

Syllabus Contents:

Unit	Course Content	Contact Hours
1.	Earth Pressure: Rankine and Coulomb theories, active, passive and pressure at rest; concentrated surcharge above the back fill, earth pressure due to uniform surcharge, earth pressure of stratified backfills, saturated and partially saturated backfill.	8
2.	Retaining walls: Proportioning of retaining walls, stability of retaining walls, mechanically stabilized retaining walls/reinforced earth retaining walls	7
3.	Sheet Pile wall: free earth system, fixed earth system	8
4.	Bulkheads: bulkheads with free and fixed earth supports, equivalent beam method, Anchorage of bulkheads and resistance of anchor walls, spacing between bulkheads and anchor walls, resistance of anchor plates	8
5.	Tunnel and Conduit: Types of conduits, Load on projecting conduits; Arching and Open Cuts: Arching in soils, Braced excavations: Earth pressure against bracings in cuts, Heave of the bottom of cut in soft clays	13

References:

1. Das, Braja M., "Principles of Foundation Engineering", PWS Publishing. 1998
2. Bowles. J.E., Foundation Analysis and Design, Tata McGraw-Hill International Edition, 5th Edn, 1997.

B.PROGRAM ELECTIVE-V: Design of underground excavation (CESM2109)

Syllabus Contents:

Unit	Course Content	Contact Hours
1.	Introduction, planning of and exploration for various underground construction projects, stereographic projection method, principle and its application in underground excavation design.	8
2.	Elastic stress distribution around tunnels, stress distribution for different shapes and under different in-situ stress conditions, Greenspan method, design principles, multiple openings, openings in laminated rocks, elasto-plastic analysis of tunnels, Daemen's theory	7
3.	Application of rock mass classification systems, ground conditions in tunneling, analysis of underground openings in squeezing and swelling ground, empirical methods, estimation of elastic modulus and modulus of deformation of rocks; uniaxial jacking / plate jacking tests, radial jacking and Goodman jacking tests, long term behaviour of tunnels and caverns, New Austrian Tunneling Method (NATM), Norwegian Tunneling Method (NTM), construction dewatering.	10
4.	Rock mass-tunnel support interaction analysis, ground response and support reaction curves, Ladanyi's elasto-plastic analysis of tunnels, design of various support systems including concrete and shotcrete linings, steel sets, rock bolting and rock anchoring, combined support systems, estimation of load carrying capacity of rock bolts	8
5.	In-situ stress, flat jack, hydraulic fracturing and over coring techniques and USBM type drill hole deformation gauge, single and multi-point bore hole extensometers, load cells, pressure cells, etc. Instrumentation and monitoring of underground excavations, during and after construction, various case studies	7

References:

1. Hoek, E and and Brown, E. T.,” Underground Excavations in Rocks”, Institute of MiningEngineering.Obert, L. and Duvall, W.I.,
2. Rock Mechanics and Design of Structures in Rocks”, John Wiley. Singh, B. and Goel, R.K.,”
3. Rock Mass Classification- A Practical Engineering Approach”, Elsevier.Singh, B. and Goel, R.K., “Tunnelling in Weak Rocks”, Elsevier

C. PROGRAM ELECTIVE-V: Physical and Constitutive Modeling On Geomechanics.(CESM2110)

Unit	Course Content	Contact Hours
1.	Role of constitutive modeling; Importance of laboratory testing with relation to constitutive modeling; Elasticity: linear, quasi linear, anisotropic;	8
2.	Plasticity basics: yield criteria, flow rule, plastic potential, hardening/softening; Rate Independent Plasticity: mohr-coulomb, nonlinear failure criteria, Drucker Prager, and cap models;	7
3.	Critical state soil mechanics: critical state concept, cam clay models, simulation of single element test using cam clay,	10
4.	Consolidation, drained and undrained triaxial test; Stress dilatancy theory;	8
5.	Work hardening plasticity theory: formulation and implementation; Applications of elasto-plastic models; Special Topics: hypoelasticity-plasticity, disturbed state concept.	7

References:

1. Hicher and Shao, “Constitutive Modeling of Soils and Rocks”, John Wiley. 2008
C.S. Desai and H. J. Siriwardane,
2. “Constitutive Laws for Engineering Materials with Emphasis on Geologic Materials”, Prentice-Hall, Inc., New Jersey. 198 David M Potts and Lidiya Zdravkovic,
3. “Finite Element Analysis in Geotechnical Engineering Theory and Application”, Thomas Telford. 1999 C.S. Desai,
4. Mechanics of Materials and Interfaces: The Disturbed State Concept”, CRC Press LLC. 2000
A.P.S. Selvadurai, M.J. Boulon, “Mechanics of Geomaterial Interfaces, Elsevier

D. PROGRAM ELECTIVE-V: ADVANCED SOIL TESTING (CESM2111)

Unit	Course Content	Contact Hours
1	Importance of soil testing and analysis. Sample collection and processing, Purpose of soil testing and analysis.	6
2	Methods of soil sample processing, precautions during soil collection and processing, preservation labelling and storage of soil sample.	8
3	Study of instruments : PH meter, conductivity meter, spectrometer, UV spectrophotometer, Use of soil testing kit and mobile soil testing van, Assesmbly for determination of nitrogen in soil	8
4	Study of laboratory setup : Laboratory Layout, Built up area, Laboratory requirements,working pattern, budget requirement, trained manpower, variousfunding schemes and agencies.	8
5	Soil Test Report & Fertilizer Recommendation : Preparation of Soil analysis and test report, Fertilizerrecommmendation, preparation of soil test summaries and fertilitymaps.	8

References:

1. Soil Sampling, Preparation and analysis, Marcell Dekker, Inc, New York.
2. Soil Sampling and methods of analysis, carter M.R. and E.G.Gregorich, 2007, 2ndEd..
3. Methods of soil analysis, Part, American society of Agronomy Inc., Kuete,A.Et.al., 1986.

E. PROGRAM ELECTIVE-V: Geo-Synthetics Engineering (CESM2112)

Unit	Course Content	Contact Hours
1.	Background of reinforced earth, mechanism and concepts, Basics of reinforced earth wall design – Geo-synthetics - classifications, functions, applications, raw materials used. Different types of Geosynthetics, manufacturing, system,	8
2.	Design and sustainability - Various properties of Geo-synthetics, physical properties, mechanical properties, hydraulic properties & endurance properties.	7
3.	Nano material - Different types of facing elements, construction procedure, cost, design of Geo-synthetics wrap around faced wall, geogrid reinforced soil walls, geocell wall, gabion wall - Model for single and multi-layer reinforced slopes, guidelines for design of reinforced slopes,	10
4.	Design of basal reinforced embankment, placement of Geo-synthetics, construction procedure, widening of existing road embankments. Consolidation techniques	8
5.	Development of design chart for preUNSATfabricated vertical drains, ground instrumentation and monitoring, Design of encased stone columns, geocell/geofoam systems. Bearing capacity of Geosynthetics reinforced soil system; geocell reinforced sand overlaying soft clay.	7

References:

1. P. T. Sherwood, Alternative Materials in Road Construction, Thomas Telford Publication, London, 1997.
2. RRL, DSIR, Soil Mechanics for Road Engineers, HMSO, London, 1995
3. Koerner, R. M. Designing with Geosynthetics, Prentice Hall, Englewood Cliffs, New Jersey, U.S.A.

A. OPEN ELECTIVES-I: Business Analytic (CESM2113)

Unit	Course Content	Contact Hours
1.	Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and Organization, competitive advantages of Business Analytics. Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of Probability distribution and data modeling, sampling and estimation methods overview.	9
2.	Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.	8
3.	Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predictive Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.	9
4.	Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models. Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.	10
5.	Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making. Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.	12

Reference:

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

B. OPEN ELECTIVES-I: Industrial Safety (CESM2114)

Unit	Course Content	Contact Hours
1.	Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.	9
2.	Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.	8
3.	Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.	9
4.	Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.	10
5.	Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance	8

Reference:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

C. Open Elective: Operation Research (CESM2115)

Unit	Course Content	Contact Hours
1.	Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models	9
2.	Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming	8
3.	Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT	9
4.	Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.	10
5.	Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation	8

3. References:

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

D. Open Elective: Cost Management of Engineering Projects(CESM2116)

Unit	Course Content	Contact Hours
1.	Introduction and Overview of the Strategic Cost Management Process	4
2.	Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.	8
3.	Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as a conglomeration of technical and non- technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process	9
4.	Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.	10
5.	Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.	8

References:

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

E. Open Elective: Composite Material (CESM2117)

Unit	Course Content	Contact Hours
1.	INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.	4
2.	REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Iso-strain and Iso-stress conditions.	8
3.	Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.	9
4.	Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.	10
5.	Strength: Lamina Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hydrothermal failure. Laminate first ply failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.	8

References:

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.
3. Handbook of Composite Materials-ed-Lubin.
4. Composite Materials – K.K.Chawla.
5. Composite Materials Science and Applications – Deborah D.L. Chung.
6. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

F. Open Elective: Waste of Energy (CESM2118)

Unit	Course Content	Contact Hours
1	Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors	4
2	Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.	8
3	Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.	9
4	Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.	10
5	Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.	8

References:

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996. Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, WestGermany.

Core Lab-III: Soil Dynamics Lab (CESM2203)

S. No.	Contents	Contact hours
1	Spectral analysis of surface waves (SASW) Test / Multi-channel analysis of surface waves(MASW)test	4
2	Seismic cross-hole test	4
3	Seismic down-hole / up-hole test	4
4	Seismic dilatometer test	4
5	Resonant column test	4
6	Piezoelectric bender element test	4
7	Cyclic triaxialtest	4
8	Cyclic direct shear test	4
Total		32

Suggested Books

1. B.M. Das, Principle of Soil Dynamics, Wadsworth Publishing Co Inc; 2nd ed. edition (1 January 2010)
2. B.M. Das, Dynamics of Soils and Foundations. Wadsworth Publishing Co Inc

Core Lab-IV: Sub-Soil Exploration Lab (CESM2204)

S. No.	Contents	Contact hours
1	Exploratory borings by different methods including auger boring, wash boring, percussion drilling and rotary drilling.	4
2	Standard penetration test	4
3	Dynamic cone penetration test	4
4	Static cone penetration test	4
5	Plate load test	4
6	Pressure meter test	4
7	Geophysical exploration tests	4
8	Site Visit	4
Total		32

Suggested Books

1. Fu Hua Chen, Soil Engineering and Subsoil Exploration, CRC Press, 1st Edition
2. Robert W. Day, Foundation Engineering handbook, Tata McGraw Hill, 2nd Edition