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COURSE CODE	CATE-GORY	COURSE NAME	TEACHING &EVALUATION SCHEME								
			THEORY			PRACTICAL		L	T	P	CREDITS
			END SEM University Exam	Two Term Exam	Teachers Assessment*	END SEM University Exam	Teachers Assessment*				
MTCE 4104(1)	DSE	Engineering Rock Mechanics	60	20	20	0	0	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; C - Credit.
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

Course Educational Objectives (CEOs):
The objectives of the course are for the students to develop an understanding of the engineering properties of rocks, geological and engineering rock classifications, rock failure theories, in-situ stresses in rock, and the fundamental concepts and principles of rock mechanics.

Course Outcomes (COs):
The students will be able to
1. Recall formation of rocks and various properties associated with rocks.
2. Identify discontinuity and strength criteria of rock mass.
3. Understand basic criteria to design structures in rocks.

Syllabus:

UNIT I **08 Hrs.**

Engineering Classification of Rocks: Classification of intact rocks, Rock mass classifications, Rock Quality Designation (RQD), Rock Structure Rating (RSR), Rock Mass Rating (RMR), Norwegian Geotechnical Classification (Q-system), Strength and modulus from classifications, Classification based on strength & modulus and strength and fracture strain, Geoengineering classification.

UNIT II **08 Hrs.**

Laboratory and In-Situ Testing of Rocks: Physical properties, Compressive strength, Tensile strength, Direct shear test, Triaxial shear test, Slake durability test, Schmidt rebound hardness test, Sound velocity test, In-Situ Tests: Seismic methods, Electrical resistivity method, In situ stresses, Plate loading test, Goodman jack test, Plate jacking test, In-situ shear test, Field permeability test.

UNIT III **09 Hrs.**

Strength, Modulus and Stresses-Strain Responses of Rocks: Factors influencing rock response, Strength criteria for isotropic intact rocks, Modulus of intact rocks, effect of confining pressure, Uniaxial Compressive strength, Strength criteria for intact rocks, Strength due to induced anisotropy in rocks, Stress Strain Models: Constitutive relationships, Elastic, Elasto-plastic, Visco-elastic, Elastoviscous plastic stress-strain models.

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MTCE 4104(1)	DSE	Engineering Rock Mechanics	60	20	20	0	0	3	0	0	3

Legends: L - Lecture; T - Tutorial/Teacher Guided Student Activity; P – Practical; C - Credit.
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

UNIT IV **08 Hrs.**

Stability of Rock Slopes and Foundations on Rocks: Rock slopes, Modes of failure, Rotational failure, Plane failure, Design charts, Wedge method of analysis, buckling failure, Toppling failure, Improvement of slope stability and protection. Foundations on Rock: Introduction, Estimation of bearing capacity, Stress distribution, sliding stability of dam foundations, strengthening measures, Settlements in rocks, Bearing capacity of pile/pier in rock, Remedial measures, Foundations located on edge of jointed slope.

UNIT V **08 Hrs.**

Underground and Open Excavations: Blasting operational planning, Explosive products, Blast Design, Underground blast design, Controlled blasting techniques, blasting damage and control, Safe practice with explosives and shots.

Text Books:

1. Deb Debasis and Verma Abhiram Kumar, Fundamentals and Applications of Rock Mechanics, PHI Learning Pvt. Ltd. 2016
2. Richard E. Goodman, Introduction to Rock Mechanics, Wiley India Pvt Ltd; Second edition, 2010

Reference Books:

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

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			END SEM University Exam	Two Term Exam	Teachers Assessment*	END SEM University Exam	Teachers Assessment*				
MTCE 4104(2)	DSE	Earth Retaining Structures	60	20	20	0	0	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; C - Credit.
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

Course Educational Objectives (CEOs):

1. To understand lateral earth pressure theories and pressure theories and design of retaining walls.
2. To understand pressure envelops and design of various components in braced cuts and cofferdams.
3. To understand stability of earth dams and its protection and construction.

Course Outcomes (COs):

Upon successful completion of this course students should be able to:

1. Apply the design philosophy of the foundations and retaining structures
2. Assess and select the geotechnical design parameters
3. Analysis and design of different types of retaining structures

Syllabus:

UNIT I **08 Hrs.**

Earth Pressure: Rankine's 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.

UNIT II **08 Hrs.**

Retaining walls: Proportioning of retaining walls, stability of retaining walls, mechanically stabilized retaining walls/reinforced earth retaining walls; Design of retaining structures; Design of retaining walls with surcharge loads

UNIT III **08 Hrs.**

Sheet Pile wall: Free earth system, fixed earth system; Braced excavations; Earth pressure against bracings in cuts; Heave of the bottom of cut in soft clays

UNIT IV **08 Hrs.**

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

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MTCE 4104(2)	DSE	Earth Retaining Structures	60	20	20	0	0	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; C - Credit.
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

UNIT V **08 Hrs.**

Tunnel and Conduit: Stress distribution around tunnels; Types of conduits; Load on projecting conduits; Arching and open cuts; Arching in soils

Text Books:

1. Muni Budhu, Foundations and Earth Retaining Structures, John Wiley & Sons, 2008
2. Chris R.I. Clayton, Earth Pressure and Earth-Retaining Structures, CRC Press; 3 edition, 2017

Reference Books:

1. Gregory Tschebotarioff, Foundations, Retaining and Earth Structures: The Art of Design and Construction and Its Scientific Basis in Soil Mechanics, McGraw-Hill Education; 2 edition,
2. Hugh Brooks and John P Nielsen, Basics of Retaining Wall Design, H B A Publications; 9 edition, 2012

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MTCE 4205(1)	DSE	Design of Underground Excavations	60	20	20	0	0	3	0	0	3

Legends: L - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; C - Credit.
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

Course Educational Objectives (CEOs):

1. Make theoretical calculations and engineering assessments of in situ and induced stresses before and after opening formation
2. Understand the practical approaches in designing support system for underground openings Analyze the tunnel face stability
3. Learn about the design procedures for dealing with structurally controlled instabilities in underground openings

Course Outcomes (COs):

1. Students can understand the use of elastic and plastic analysis in the design of underground support system.
2. Students will have idea about the field tests generally conducted during and after construction of under structures.
3. Learn the methods to make assessment of the properties of rock and rock masses
4. Learn the design of underground openings in varying ground conditions

Syllabus:

UNIT I **08 Hrs.**

Introduction, planning of land exploration for various underground construction projects; Stereographic projection method, principle, and its application in underground excavation design

UNIT II **08 Hrs.**

Elastic stress distribution around tunnels; Stress distribution for different shapes and under different in-situ stress conditions; Greenspan method, design principles, multiple openings and openings in laminated rocks; elasto-plastic analysis of tunnels, Daemen's theory

UNIT III **08 Hrs.**

Application of rock mass classification systems, ground conditions in tunnelling, 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 Tunnelling Method (NATM), Norwegian Tunnelling Method (NTM), Construction dewatering

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MTCE 4205(1)	DSE	Design of Underground Excavations	60	20	20	0	0	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; C - Credit.
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

UNIT IV **08 Hrs.**

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 shoterete linings, steel sets, rock bolting and rock anchoring, combined support systems; Estimation of load carrying capacity of rock bolts

UNIT V **08 Hrs.**

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

Text Books:

1. Singh, B. and Goel, R.K., Tunnelling in Weak Rocks, Elsevier Science, 2006
2. Singh, B. and Goel, R.K., Rock Mass Classification- A Practical Engineering Approach, Elsevier Science, 1999

References:

1. Hoek, E and Brown, E. T., Underground Excavations in Rocks, Institute of Mining Engineering.
2. Obert, L. and Duvall, W.I., Rock Mechanics and Design of Structures in Rocks, John Wiley.

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MTCE 4205(2)	DSE	Design of Road Pavements	60	20	20	0	0	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; C - Credit.
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

Course Educational Objectives (CEOs):

1. To learn about various factors affecting pavement design.
2. To learn about stress analysis of the pavement.
3. To learn about various methods of flexible pavement design.
4. To learn about various methods of rigid pavement design.

Course Outcomes:

1. To understand the philosophy of design of flexible and rigid pavements.
2. To analysis pavements using different analytical methods.
3. To design of flexible and rigid pavements using different methods.
4. To compare performances of different types of pavements.

Syllabus:

UNIT I **08 Hrs.**

General Consideration: Components of road pavement such as sub grade, subbase, base course and wearing course and their functions; Comparison of flexible and rigid pavements highway and airport pavements

Pavements Materials: Stabilizing base viz., Mechanical, stabilized with admixture like cements, bitumen lime and other chemicals

UNIT II **09 Hrs.**

Factor Affecting the Pavements Design: Traffic factor, moisture and climate factors, soil factor and stress distribution factor

Design of Flexible Pavements: General classification of various methods and their approach; Empirical methods using soil classification; Theoretical and semi theoretical methods; General observation and limitation of various methods.

UNIT III **08 Hrs.**

Design Method of Rigid Pavements: Analysis of stresses in concrete pavements due to various wheel loads; Cyclic changes in temperature; Changes in moisture and volumetric change in subgrade and base course; Comparison of analysis of stress due to wheel loads on liquid and solids subgrade theorem; Thickness design methods such as P.C.A.

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MTCE 4205(2)	DSE	Design of Road Pavements	60	20	20	0	0	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; C - Credit.
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

UNIT IV **08 Hrs.**

Pavement Evaluation and Strengthening: Method of pavement evaluation including LCN method for airport; Design of various types of overlays for flexible and rigid pavements; Mechanics of pumping and blowing; Factor affecting pumping, preventive measures.

UNIT V **09 Hrs.**

Pavements Performance: Pavements performance; Road Mechanic and their applications; The AASTHO road test; Evaluation of performance of the flexible and rigid pavements; Analysis of results from flexible and rigid pavements.

Text Books:

1. S.K.Sharma, Principles, Practice and Design of Highway Engineering, S Chand & Company, 2014.
2. L R Kadyali, Principles and Practices of Highway Engineering, Khanna Publisher, 2005

Reference Books:

1. E.J.Yodar and M.W.Witczac, Principles of Pavement Design, 2nd Edition, John Wiley and Sons, New York,2000
2. Khanna and Justo, Highway Engineering Nem Chand & Sons, Roorkee, 2014

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MTCE 4205(3)	DSE	Geotechnical Earthquake Engineering	60	20	20	0	0	3	0	0	3

Legends: L - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; C - Credit.
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

Course Educational Objectives (CEOs):
Student will able to

1. Understand the behavior of civil engineering structures during earthquake loading.
2. Estimate the earthquake induced ground deformations, such as liquefaction effects, settlement, and lateral spreading, given the characteristics of the earthquake.
3. Design geotechnical structures, such as, shallow and deep foundations, retaining walls, and slope stability.

Course Outcomes (COs):

1. Students will know the causes and quantification of earthquake.
2. Student will be exposed to the effect of earthquake and the design criterions to be followed for the design different geotechnical structures

Syllabus:

UNIT I **08 Hrs.**

Earthquake Seismology: Causes of earthquake; Plate tectonics, earthquake fault sources, seismic waves; Elastic rebound theory; Quantification of earthquake; Intensity and magnitudes; Earthquake source models.

UNIT II **08 Hrs.**

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.

UNIT III **08 Hrs.**

Ground response analysis: One-dimensional ground response analysis: Linear approaches, equivalent linear approximation of non-linear approaches; Computer code "SHAKE".

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MTCE 4205(3)	DSE	Geotechnical Earthquake Engineering	60	20	20	0	0	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; C - Credit.
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

UNIT IV **08 Hrs.**

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

UNIT V **08 Hrs.**

Seismic design of foundations; Seismic slope stability analysis, internal stability and weakening instability and seismic design of retaining walls

Text Books:

1. Steven Kramer, Geotechnical Earthquake Engineering, Pearson Education India, 2008
2. Kumar Kamalesh, Basic Geotechnical Earthquake Engineering, New Age International Private Limited, 2017

Reference Books:

1. Seco e Pinto, P., Seismic behavior of ground and Geotechnical structure, A. A.
2. Ferrito, J.M, Seismic design criteria for soil liquefaction, Tech. Report of Naval Facilities service centre, Port Hueneme, 1997

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MTCE 4104(3)	DSE	**Soil Structure Interaction**	60	20	20	0	0	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; C - Credit.
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

Course Educational Objectives (CEOs):

1. Explain the effects of soil flexibility in the response of the structure
2. Analyse the structure with soil structure interaction effects to obtain the realistic response.

Course Outcomes (COs):

1. Students can apply different soil response models for specific problem based on the requirement.
2. Students can analyze footings/rafts resting on soil as beams/plates on elastic foundation and work out design bending moments/shear and displacements.
3. Student can compute pile response for various loading condition for design purpose.

Syllabus:

UNIT I **08 Hrs.**

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

UNIT II **08 Hrs.**

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

UNIT III **08 Hrs.**

Plate on Elastic Medium: Thin and thick plates; Analysis of finite plates; Numerical analysis of finite plates, simple solutions

UNIT IV **08 Hrs.**

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.

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MTCE 4104(3)	DSE	**Soil Structure Interaction**	60	20	20	0	0	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; C - Credit.
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

UNIT V **08 Hrs.**

Laterally Loaded Pile: Load deflection prediction for laterally loaded piles; Sub-grade reaction and elastic analysis; Interaction analysis; Pile-raft system; Solutions through influence charts.

Text Books:

1. Rolando P. Orense, Nawawi Chouw, Soil-Foundation-Structure Interaction, CRC Press; 1 edition, 2017
2. J.W. Bull, Soil-Structure Interaction: Numerical Analysis and Modeling, CRC Press, 2019

Reference Books:

1. Selvadurai, A.P.S, Elastic Analysis of Soil-Foundation Interaction, Elsevier, 1979.
2. Structure Soil Interaction - State of Art Report, Institution of Structural Engineers, 1978

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