DEPARTMENT OF MINING ENGINEERING

Course Book for
Master of Technology (M.Tech)

in

Excavation and Tunnel Engineering

For
ACADEMIC YEAR
2026-27 onwards

Visvesvaraya National Institute of Technology
Nagpur – 440 010 (Maharashtra)

Department of Mining Engineering, VNIT, Nagpur

Scheme of Examination for M.Tech.(Excavation and Tunnel Engineering)

Four Semester Course: Two Years

1. **Objectives:**

-Establishment of a national-level postgraduate education and research center in the area of Excavation and Tunnel Engineering with mining, construction, and civil applications.

-To train students at the postgraduate level in the area of rock excavation and tunnel engineering and produce professionals to serve the challenges of the huge rock excavation and tunnel industry in the country.

- To generate new knowledge and enhance the economy, productivity and safety of the excavation industry, including mining, tunneling, building materials production, and underground space technology.

2. **Need :**

The excavation industry has seen an exponential growth in India in the last decade with respect to rock excavations for slopes, tunnels, surface mines, underground mines, underground caverns for power houses, storage for the army, foundations for high-rise buildings, railways, metros, etc. Some of the challenging problems facing the industry are in the areas of deep excavations, excavations in fragile and mountainous regions, excavations and tunneling in urban areas, utilization of underground space in urban areas for storage, waste disposal, and habitats, reduction in excavation costs, management of excavations, and making mining ores and building materials profitable and sustainable. Professionals trained in the above areas are essential to meet the challenges and contribute effectively in this nation-building activity. This course is intended to provide input to mining and civil engineers to enhance their engineering knowledge in the field of excavation and tunnel engineering, which would be useful to serve the construction and mining industry in the most technically effective way.

3. **Eligibility**: The students having UG degrees in BE/B. Tech or equivalent in Mining, Construction, Civil Engg or related areas will be eligible to seek admission to this course and as per **CCMT guidelines**. GATE qualified/ Institute Test in case of vacancy.

4. **Intake:** As per institution norms. :

Department of Mining Engineering, VNIT, Nagpur
M.Tech (Excavation & Tunnel Engineering)

Four Semester Course: Two Years
Scheme and Credits

Postgraduate Core (PC)		**Postgraduate Elective (PE)**	
Category/Courses	**Credit**	**Category**	**Credit**
Departmental Core(DC)	25	Departmental Electives(DE)	12
Engineering Arts and Sciences (BS)	3		
D-type Course	12		
Sub Total	**40**	**Sub Total**	**12**
Grand Total PC + PE			**52**

Department of Mining Engineering, VNIT, Nagpur
M.Tech (Excavation & Tunnel Engineering)
Four Semester Course: Two Years

(Semester-wise Mapping)

I Semester (Odd)				II Semester(Even)			
PG CORE				**PG CORE**			
Code	Course	L-T-P	Credits	Code	Course	L-T-P	Credits
	Engineering Arts and Sciences (BS)						
MAL 505	Mathematical Elements for Engineers	3-0-0	3	MNL525	Blasting Technology in Excavations	3-0-0	3
	Departmental Core (DC)			MNP 525	Blasting Technology in Excavations- Pract	0-0-2	1
MNL 522	Geo-mechanics in Excavations	3-0-0	3	MNL527	Geo-Environmental Engineering	3-0-0	3
MNP 522	Geo-mechanics in Excavations - Pract	0-0-2	1	MNL528	Modeling Techniques and Computer Applications	3-1-0	4
MNL 526	Tunnel and Cavern Engineering	3-1-0	4	MNL5XX	Tunnels–Design-Planning & Construction	3-0-0	3
MNL 5XX	Excavation Equipment & Technology	3-0-0	3	MND525	Field visit and demonstrations		Audit
	Sub Total(DC)		14		Sub Total(DC)		14
PG Electives (Any Two) DE-6 credits				**PG Electives (Any Two) DE-6 credits**			
MNL 529	Contract and Construction Management	3-0-0	3	MNL 530	Slope Engineering	3-0-0	3
MNL 532	Advanced Engineering Geology	3-0-0	3	MNL 531	Ground Improvement Engineering	3-0-0	3
MNL 533	Instrumentation in Excavation	3-0-0	3	MNL5XX	Concrete and Shotcrete Technology	3-0-0	3
MNL 534	Grouting Technology	3-0-0	3	MNL 5XX	AI/ML applications and robotics in tunnels	3-0-0	3
MNLXXX	Principles and Concepts of Mining *	3-0-0	3	MNL 535	Tunnel Ventilation, Safety & Services	3-0-0	3
	Open Course				Open Course		
	Sub Total (DC+DE)		**20**		Sub Total		**20**

III Semester(Odd)				VI Semester(Even)			
PG CORE				**PG CORE**			
Code	Course	L-T-P	Credits	Code	Course	L-T-P	Credits
MND 540	Project Phase -I Seminar :		6	MND 541	Project Phase -II Dissertation – Seminar_Viva		6
Total DC: 40 and DE :12							

***This elective Course is offered for non-mining students**

ENGINEERING ARTS AND SCIENCE COURSES (BS)

Course Code & Course Title	MAL 505 MATHEMATICAL ELEMENTS FOR ENGINEERS
Course Type	DC
Name of the Programme	M.Tech (Excavation & Tunnel Engineering)
L – T – P	3-0-0
No. of Credits	3
Pre-requisites	NIL
Course Equivalence	NIL

1. Course Objectives:

• To provide advanced domain knowledge in the subject area.

• To develop analytical and design capability in excavation engineering.

2. Course Outcomes (COs):

2.	Course Outcomes (Min. 3 & Max. 5):
CO1	Students will be able to apply principles of linear algebra, vector spaces, and matrix transformations.
CO2	Students will be able to construct and utilize approximate integration formulae using numerical techniques.
CO3	Students will demonstrate the ability to solve ordinary and partial boundary value problems using finite difference methods.
CO4	Students will be able to formulate and study mathematical models using linear and differential equations.

Topics	CO(s) Addressed	Duration in weeks
Linear Algebra & Matrices: Linear Vector Spaces, Linear dependence, basis and dimensions, Four fundamental subspaces, Linear transformations, Transformation from one linear space to another, Inner product space and applications, Eigen values and Eigen vectors, diagonalization, complex matrices, similarity transformations, matrix norms & condition number, iterative methods for solving AX=b	CO1	Four weeks
Numerical Techniques: Review of the topics in elementary numerical analysis, Basic Principles, Construction of approximate integration formulae using method of undetermined weights & nodes, Gauss- Legendre formula, Gauss-Chebyshev formula, Gauss-Hermite formula, Errors in numerical integration.	CO2	Three weeks
Finite Difference Methods: Approximation of derivatives (Ordinary & Partial) in terms of pivotal values: Application to solve Boundary value problems in ordinary differential equations, Boundary value problems in partial differential equations: Laplace equation, one-dimensional heat equation, and one-dimensional wave equation.	CO3	Four weeks
Introduction to Mathematical Modeling: Study of cases of modeling through linear equations and differential equations.	CO4	Three weeks

4. Text Books:

1. R.K. Jain and S.R.K. Iyengar, Advanced Engineering Mathematics, 3rd ed., Narosa, 2002.
2. Gilbert Strang, Introduction to Linear Algebra, 5th ed., Wellesley-Cambridge Press, 2016.
3. Steven C. Chapra and Raymond P. Canale, Numerical Methods for Engineers, 7th ed., McGraw-Hill, 2015.2.

5. Reference Books:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 10th ed., Wiley, 2011.
2. Richard L. Burden and J. Douglas Faires, Numerical Analysis, 10th ed., Cengage, 2015.

6	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Code	Type	Structure L+T+P	Credits	Evaluation Weightage (%)	
				Method	**Range**
L	Lecture	L: 3 T: 0 P: 0	L	Mid-Semester Exam.	20-30
				Teacher-Defined Assessment	20
				End-Semester Exam.	50-60

7	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)
High - 3; Medium – 2; Low – 1;

CO / PO	PO1	PO2	PO3
CO1	1	3	3
CO2	2	1	3
CO3	1	2	3
CO4	2	1	3

8	**List of Indicative Laboratory Experiment (if applicable):**

NIL

DEPARTMENTAL CORE
(DC)

Course Code & Course Title:	**MNL 522 GEO-MECHANICS IN EXCAVATIONS**
Course Type:	DC
Name of the programme(s):	M.Tech. (Excavation and Tunnel Engg)
L-T-P	3-0-2
No. of Credits	4 (Theory: 3, Practical: 1)
Pre-requisites: Course Code(s) & Name(s)	NIL
Course Equivalence: Course Code(s) & Name(s)	NIL

1. **Course Objective:** To provide advanced knowledge of geo-technical aspects of excavation engineering and to make students aware of the design considerations with regard to geo-mechanics

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Students will be able to analyze the mechanical behaviour of soils and earth pressures for embankments and foundations.
CO2	Students will be able to characterize rockmass and understand the influence of anisotropy on rock behavior.
CO3	Students will demonstrate the ability to determine the pre-mining state of stress and analyze stress distributions around openings.
CO4	Students will be able to conduct geological investigations and select appropriate opening shapes and sizes.

3. Detailed Description of the Course:

Topics	**CO(s) Addressed**	**Duration in weeks**
Soil mechanics: Advanced soil properties, Mechanical behaviour of soil, Analysis and constitutive models, Basic dynamics and analysis of strong motion data, Earth pressures, Earthquake geotechnical engineering, Embankments and earthworks, Engineering seismology, Foundations, Ground profiles and ground investigation, Strength and deformation.	CO1	Three weeks
Geological structures in rockmass: Objective and methods of rockmass characterization. Rock Mass Classification, Methods of determination of strength and deformability of rock and rockmass. Failure criteria for rock and rockmass, Mechanics of rock fracture, Failure mechanism of excavation in rock, Influence of anisotropy and discontinuity on rock behaviour.	CO2	Four weeks
Pre-mining state of stress: sources, methods of determination and presentation, Stress distributions around single and multiple openings in rocks: methods of estimation factors, Propagation of elastic waves in rock medium and dynamic behaviour of rocks influencing stress concentration; zone of influence of an excavation: effect of planes of weaknesses and shape of excavations; delineation of zone of failure.	CO3	Four weeks

Investigation & Mechanics: Investigation of Rock Condition, Selection of opening shape and size, geological and geophysical investigations, 3D geological logs, and preparation of Stereo-nets. Introduction to the mechanics of rock cutting and drilling.	CO4	Three weeks

4. Textbooks:

1. Karl Terzaghi, Ralph B. Peck and Gholamreza Mesri, *Soil Mechanics in Engineering Practice*, 3rd ed., Wiley, 1996.
2. J. A. Hudson and J. P. Harrison, *Engineering Rock Mechanics: An Introduction to the Principles*, Elsevier, 1997.
3. R. E. Goodman, *Introduction to Rock Mechanics*, 2nd ed., John Wiley & Sons, 1989

4. **Reference Books:**

1. Evert Hoek and J. Bray, *Rock Slope Engineering*, 3rd ed., Institution of Mining and Metallurgy, 1981.
2. B. H. G. Brady and E. T. Brown, *Rock Mechanics for Underground Mining*, Springer, 2004.

6	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Code	Type	Structure L+T+P	Credits	Evaluation Weightage (%)	
				Method	**Range**
L	Lecture	L: 3 T: 0 P: 1	L + P	Mid-Semester Exam.	20-30
				Teacher-Defined Assessment	20
				End-Semester Exam.	50-60

7	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

High - 3; Medium – 2; Low – 1;

	PO1	PO2	PO3
CO1	3	2	1
CO2	3	2	2
CO3	3	2	2
CO4	3	3	1

8	**List of Indicative Laboratory Experiment (if applicable):**

1. Sample collection and preparation of the specimen.
2. To determine the density of a given rock sample.
3. To determine the uniaxial compressive strength (unconfined) of a given rock specimen.
4. To determine the uniaxial tensile strength of the given rock specimen by the Brazilian method (Indirect method).
5. To determine the shear strength of the given rock by the double shear method.
6. To determine the Protodyakonov index of a given rock sample.
7. To determine Young's modulus and Poisson's ratio of a given rock sample.
8. To determine the point load strength index of the given rock sample.
9. To determine the slake durability index of the given rock specimen.
10. To determine triaxial compression strength of given mass and draw Mohr's circle.

Course Code & Course Title:	**MNL 526 TUNNEL AND CAVERN ENGINEERING**
Course Type:	DC (Departmental Core)
Name of the programme(s):	M.Tech. (Excavation and Tunnel Engg)
L-T-P	3-1-0
No. of Credits	4
Pre-requisites: Course Code(s) & Name(s)	NIL
Course Equivalence: Course Code(s) & Name(s)	NIL

1. **Course Objective:** To make students aware of tunneling technology and its latest development, and to develop tunnel and cavern design capability.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Students will be able to understand the parameters influencing tunnel location, planning, and site investigation.
CO2	Students will analyze tunneling methods in soft ground and rock using road heading machines.
CO3	Students will evaluate the applications of TBMs, micro-tunneling, and the excavation of large caverns.
CO4	Students will understand specialized tunneling techniques like NATM, NTM, cut and cover, and tunneling hazards.
CO5	Students will be able to select tunnel supports and manage tunnel services like ventilation and drainage.

3. Detailed Description of the Course

Topics	**CO(s) Addressed**	**Duration in weeks**
Types & Planning: Types of underground excavations: tunnel, shaft, cavern, etc. Parameters influencing location of a tunnel and its design, planning and site -investigation for tunneling, methods of tunneling; selection of method of excavation.	CO1	Three weeks
Soft Ground & Roadheaders: Tunneling in soft ground, Tunneling in rock by road heading machines: cutting principles, method of excavation, performance limitations and problems.	CO2	Three weeks
TBMs & Caverns: Tunneling in rock by tunnel boring machines: method of excavation, performance, limitations and problems, TBM application, TBM for soft formations, micro-tunneling. Excavation of large tunnels, special storage and underground space, caverns for hydro-electric projects.	CO3	Three weeks
Special Methods & Hazards: No-Dig technology, NATM & NTM methods, short life excavations, tunneling under water bodies. Cut and cover tunnels, metro tunnels Hazards in tunneling.	CO4	Three weeks
Supports & Services: Supports in tunnels_Tunnel services: ventilation, drainage and lighting and maintenance.	CO5	Two weeks

4. Textbooks

1. J. O. Bickel, T. R. Kuesel and E. H. King, Tunnel Engineering Handbook, 2nd ed., Chapman & Hall, 1996.
2. Z. T. Bieniawski, Design Methodology in Rock Engineering, A.A. Balkema, 1992.
3. B. N. Whittaker and R. C. Frith, Tunneling: Design, Stability and Construction, Institution of Mining and Metallurgy, 1990.

5. Reference Books:

1. Evert Hoek and E. T. Brown, Underground Excavation in Rock, Institution of Mining and Metallurgy, 1980.
2. Bhawani Singh and D. K. Yadav, Design and Construction of Tunnels: Analysis of Controlled Convergence Pressure Tunnel Boring Machines, CRC Press, 2010.

6	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Code	Type	Structure L+T+P	Credits	Evaluation Weightage (%)	
				Method	**Range**
L	Lecture	L: 3 T: 1 P: 0	L + T	Mid-Semester Exam.	20-30
				Teacher-Defined Assessment	20
				End-Semester Exam.	50-60

7	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

High - 3; Medium – 2; Low – 1;

CO / PO	PO1	PO2	PO3
CO1	3	2	1
CO2	3	3	1
CO3	3	3	2
CO4	3	3	2
CO5	2	3	1

8	**List of Indicative Laboratory Experiment (if applicable):**

NIL

Course Code & Course Title:	**MNL XXX EXCAVATION EQUIPMENT & TECHNOLOGY**
Course Type:	DC (Departmental Core)
Name of the programme(s):	M.Tech. (Excavation and Tunnel Engg)
L-T-P	3-0-0
No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	NIL
Course Equivalence: Course Code(s) & Name(s)	NIL

1. Course Objective: To give a detailed idea about the equipment used in excavation and tunnels, including their construction, selection, limitations, and capacity calculation. To make students aware of modern techniques and introduce various maintenance systems.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Students will be able to understand various drilling equipment and surface excavating machines, including their capacities and applications.
CO2	Students will be able to select and evaluate underground excavating machines like roadheaders and TBMs.
CO3	Students will demonstrate an understanding of shaft and raise boring machines, as well as modern automation and robotics in excavation.
CO4	Students will understand equipment maintenance, performance optimization, and cost management.

3. Detailed Description of the Course

Topics	**CO(s) Addressed**	**Duration in weeks**
Drilling & Surface Equipment: Introduction to various types of drilling equipment in excavations; Introduction to Surface excavating machines: Various machines like Dozers, rippers, shovels, draglines, scrapers, Surface miners, etc., their construction, application, and capacity.	CO1	Four weeks
Underground Excavating Machines: Roadheading machines - road headers, dintheaders, and Tunnel Boring Machines; their selection, construction & operation for underground excavation.	CO2	Four weeks
Specialized Boring & Automation: Shaft drills and mucking system; shaft boring machines, raise boring machines. Introduction to automation, robotics, and radio control operations in excavation equipment.	CO3	Three weeks
Equipment Management: Housekeeping of equipment, performance optimization, Cost and downtime management, optimization of equipment utilization, and workshop equipment management.	CO4	Three weeks

4. Textbooks

1. Ratan Raj Tatiya, Surface and Underground Excavations: Methods, Techniques and Equipment, A.A. Balkema, 2005.
2. Howard L. Hartman, SME Mining Engineering Handbook, 3rd ed., Society for Mining, Metallurgy & Exploration, 2011.
3. William A. Hustrulid, Blasting Principles for Open Pit Mining, CRC Press, 1999.

5. Reference Books:

1. William A. Hustrulid, Open Pit Mine Planning and Design, 3rd ed., CRC Press, 2013.

6	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Code	Type	Structure L+T+P	Credits	Evaluation Weightage (%)	
				Method	**Range**
L	Lecture	L: 3 T: 0 P: 0	L	Mid-Semester Exam.	20-30
				Teacher-Defined Assessment	20
				End-Semester Exam.	50-60

7	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

High - 3; Medium – 2; Low – 1;

CO / PO	PO1	PO2	PO3
CO1	2	3	1
CO2	2	3	1
CO3	1	2	3
CO4	2	3	1

8	**List of Indicative Laboratory Experiment (if applicable):**

NIL

Course Code & Course Title:	**MNL 525 BLASTING TECHNOLOGY IN EXCAVATIONS**
Course Type:	DC (Departmental Core)
Name of the programme(s):	M.Tech. (Excavation and Tunnel Engg)
L-T-P	3-0-2
No. of Credits	4 (Theory: 3, Practical: 1)
Pre-requisites: Course Code(s) & Name(s)	NIL
Course Equivalence: Course Code(s) & Name(s)	NIL

1. **Course Objective:** To provide advanced knowledge of blasting and to develop design capability for blasting in excavation.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Students will be able to understand the chemistry, physics, and selection of explosives and priming systems.
CO2	Students will analyze rock breakage theories and comminution laws.
CO3	Students will be capable of designing blasting rounds for surface and underground excavations, including special techniques.
CO4	Students will be able to manage environmental considerations, control fly rock, and optimize blasting economics.

3. Detailed Description of the Course

Topics	**CO(s) Addressed**	**Duration in weeks**
Explosives & Initiation: Chemistry and physics of explosives; properties of explosives. Explosives and blasting agents; initiation and priming systems, bulk explosives, and explosive selection.	CO1	Three weeks
Rock Breakage: Rock breakage by explosives theories, laws of comminution, methods for prediction and assessment of fragmentation.	CO2	Three weeks
Blast Design: Design of blasting rounds for surface and underground excavation, special blasting techniques- including secondary breakage, pre-splitting, destress blast technique, Lake tap design. Profiling, trenching, casting, and demolition.	CO3	Four weeks
Environment & Optimization: Environmental considerations, handling and storage of explosives, control of noise, vibration, air blast, and fly rock. Blasting optimization, intelligent blast design, blast economics, and computer applications in blasting.	CO4	Four weeks

4. Textbooks

1. Calvin J. Konya, Rock Blasting and Overbreak Control, National Highway Institute, USA, 1995.
2. Stig Olofsson, Applied Explosives Technology for Construction and Mining, Applex, 1990.
3. N. R. Thote and G. K. Pradhan, Surface Mine Blast Design and Evaluation, Mintech Publications, 2011.

5. Reference Books:

1. J. W. Wyllie and C. W. Mah, Rock Slope Engineering, 4th ed., CRC Press, 2004.
2. William A. Hustrulid, Blasting Principles for Open Pit Mining, CRC Press, 1999.

6	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

3.

Code	Type	Structure L+T+P	Credits	Evaluation Weightage (%)	
				Method	**Range**
L	Lecture	L: 3 T: 0 P: 1	L + P	Mid-Semester Exam.	20-30
				Teacher-Defined Assessment	20
				End-Semester Exam.	50-60

7	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference) *High - 3; Medium – 2; Low – 1;*

CO / PO	PO1	PO2	PO3
CO1	2	3	1
CO2	2	2	2
CO3	3	3	2
CO4	3	3	3

4.

8	**List of Indicative Laboratory Experiment (if applicable):**

1. To understand the properties of explosives.
2. Study the types of explosives and storage safety.
3. To study the blasting initiation system.
4. Blasting tools and accessories.
5. Measurement of ground vibration and other external effects.
6. To study optimum glass design for surface excavation.
7. To study various patterns of holes for underground surface mines.
8. To study optimum blouse design for tunnels and caverns.
9. To study various blast design software.
10. Techniques of controlled blasting.

Course Code & Course Title:	**MNL 527 GEO-ENVIRONMENTAL ENGINEERING**
Course Type:	DC
Name of the programme(s):	M.Tech. (Excavation and Tunnel Engg)
L-T-P	3-0-0
No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	NIL
Course Equivalence: Course Code(s) & Name(s)	NIL

1. **Course Objective:** To make students aware of the environmental concerns of excavation and to develop the skill of environmental documentation.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Students will understand environmental management, lighting, and emergency management in excavation.
CO2	Students will assess land, water, and air pollution issues and evaluate soil properties.
CO3	Students will analyze major pollutants, gas detection, and manage waste disposal.
CO4	Students will be able to develop EIA, ERA, EMP, and disaster management plans for excavations.

3. Detailed Description of the Course

Topics	**CO(s) Addressed**	**Duration in weeks**
Environmental Management: Environmental management in excavation, design of ventilation, lighting, and emergency management.	CO1	Three weeks
Pollution & Land Environments: Land, water and air pollution issues due to excavations. Contaminated Land, Ground Contamination due to excavations, The Land Environment, Land Environment Sensitivity and Tolerance. Land Suitability and Use. Wastes and Waste Streams. Nature of Soils: Soil Materials in the Land Environment, Soil Materials Physical Properties, Soil-Water Systems.	CO2	Four weeks
Pollutants & Debris: Pollutants of Major Concern, Gas Detection, Water contamination or loss due to excavation Dust, SPM. Disposal of debris and its management.	CO3	Four weeks
Assessments & Planning: EIA, ERA, EMP, emergency & disaster management in excavations.	CO4	Three weeks

4. Textbooks

1. N. R. Lakshmi and Hilary I. Inyang, Geoenvironmental Engineering: Principles and Applications, Marcel Dekker, 2000.
2. Jacob Bear and Arnold Verruijt, Modeling Groundwater Flow and Pollution, Reidel Publishing, 1990.
3. P. B. Bedient, H. S. Rifai and C. H. Newell, Groundwater Contamination: Transport and Remediation, Prentice Hall, 1994.

5. Reference Books:

1. D. E. Daniel, Geotechnical Practice for Waste Disposal, Chapman & Hall, 1993.
2. F. H. Chen and M. Ahmedna, Geoenvironmental Engineering: Contaminated Soils, Pollutant Fate, and Mitigation, CRC Press, 2004.

6	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Code	Type	Structure L+T+P	Credits	Evaluation Weightage (%)	
				Method	**Range**
L	Lecture	L: 3 T: 0 P: 0	L	Mid-Semester Exam.	20-30
				Teacher-Defined Assessment	20
				End-Semester Exam.	50-60

7	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

High - 3; Medium – 2; Low – 1;

CO / PO	PO1	PO2	PO3
CO1	3	3	1
CO2	2	2	1
CO3	2	3	1
CO4	3	3	1

8	**List of Indicative Laboratory Experiment (if applicable):**

NIL

Course Code & Course Title:	**MNL 528 MODELING TECHNIQUES AND COMPUTER APPLICATIONS**
Course Type:	DC
Name of the programme(s):	M.Tech. (Excavation and Tunnel Engg)
L-T-P	3-1-0
No. of Credits	4
Pre-requisites: Course Code(s) & Name(s)	NIL
Course Equivalence: Course Code(s) & Name(s)	NIL

1. **Course Objective:** To make students aware of modeling techniques and to provide training in computer modeling.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Students will be able to understand the basics of physical, mathematical, and computer modeling.
CO2	Students will be able to perform excavation modeling using DTM and block models.
CO3	Students will understand numerical methods like Finite Element, Boundary Element, and Finite Difference methods.
CO4	Students will apply simulation and software tools for planning, scheduling, and design of excavations.

3. Detailed Description of the Course

Topics	**CO(s) Addressed**	**Duration in weeks**
Basics of Modeling: Introduction to modeling, physical. Mathematical and computer modeling. Mathematical modeling, methods with different techniques.	CO1	Three weeks
Excavation Models: Excavation modelling with DTM and block models.	CO2	Three weeks
Numerical Methods: Introduction to the use of the finite element method, boundary element method, and finite difference method in modelling.	CO3	Four weeks
Software Applications: Simulation, Virtual reality in excavation, study of excavation design software. Application of software in the design, planning and scheduling of excavations. Preparation of computer models using available software for excavations.	CO4	Four weeks

4. Textbooks

1. C. Detournay and R. Hart (Eds.), FLAC and Numerical Modeling in Geomechanics, Balkema, 2001.
2. Evert Hoek and E. T. Brown, Underground Excavation in Rock, Institution of Mining and Metallurgy, 1980.
3. Z. T. Bieniawski, Rock Mechanics Design in Mining and Tunneling, Balkema, 1984.

5. Reference Books:

1. Jaan Kiusalaas, Numerical Methods in Engineering with Python, Cambridge University Press, 2013.
2. Klaus-Jürgen Bathe, Finite Element Procedures, Prentice Hall, 1996.

6	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Code	Type	Structure L+T+P	Credits	Evaluation Weightage (%)	
				Method	**Range**
L	Lecture	L: 3 T: 1 P: 0	L + T	Mid-Semester Exam.	20-30
				Teacher-Defined Assessment	20
				End-Semester Exam.	50-60

7	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

High - 3; Medium – 2; Low – 1;

CO / PO	PO1	PO2	PO3
CO1	2	1	3
CO2	3	2	3
CO3	2	1	3
CO4	3	2	3

8	**List of Indicative Laboratory Experiment (if applicable):**

NIL

Course Code & Course Title:	**MNL 5XX TUNNELS: DESIGN, PLANNING & CONSTRUCTION**
Course Type:	DC
Name of the programme(s):	M.Tech. (Excavation and Tunnel Engg)
L-T-P	3-0-0
No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	NIL
Course Equivalence: Course Code(s) & Name(s)	NIL

1. Course Objective:

- To train the students in the planning and design of tunnels in different conditions
- To expose the students for designing and construction methodology for various tunnels.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Students will understand the planning and design process, route selection, and choice of tunnel systems.
CO2	Students will be able to evaluate and design tunnels in soft ground and hard rock formations.
CO3	Students will evaluate tunnel support systems and lining requirements based on empirical methods.
CO4	Students will manage tunnel construction operations, structural monitoring, and safety planning.

3. Detailed Description of the Course

Topics	**CO(s) Addressed**	**Duration in weeks**
Planning & Tunnel Systems: Planning and Design Process for Tunnels: Approaches to tunnel design, Route Selection, location, and alignment; Geometric Parameters; design of underground space in rock. Choice of Tunnel System: Escape Distance, Lateral Exits / Access, Parallel Service, Pipe Jacking and Micro-tunneling. Tunnel; Shape and Size of Cross-Section: Serviceability Requirements, Geological/Geotechnical Conditions, Shapes: D Shape, Horseshoe Shape, Elliptical / Circular Shape.	CO1	Four weeks
Soft Ground & Hard Rock Design: Tunnels in soft ground: design considerations, lining type, short term and long-term behavior, subsidence, instrumentation and monitoring, case study. Tunnels and caverns in hard rock: design considerations, design approaches, estimation of support pressures, ground behavior, instrumentation and monitoring, case study.	CO2	Three weeks
Support Systems & Lining: Tunnel Support Systems: Wooden, Steel, Rock Bolt, Wire Mesh, Fore-polling, Grouting, and Freezing. Lining: Requirements, Types of Lining, Timing, Placement of Lining, Sequence of Lining Operation, Formwork, Concreting, Compaction, Curing, Segmental Lining; Empirical Methods of Tunnel, Fore-poling, Shotcrete, grouting.	CO3	Four weeks

Construction Management: Tunnel construction management: Overall Tunneling Process, its Operation, Scheduling, Construction Aspects, Profile, Gradient, Curvature, Ventilation and Lighting, Clearances, Aerodynamic Problems in tunnels, monitoring. Challenges and Financial Planning; Risk and Safety Management.	CO4	Three weeks

4. Textbooks

1. J. O. Bickel, T. R. Kuesel and E. H. King, Tunnel Engineering Handbook, 2nd ed., Chapman & Hall, 1996.
2. R. K. Goel, Bhawani Singh and Jian Zhao, Underground Infrastructures: Planning, Design and Construction, Butterworth-Heinemann, 2012.
3. B. N. Whittaker and R. C. Frith, Tunneling: Design, Stability and Construction, Institution of Mining and Metallurgy, 1990.

5. Reference Books:

1. Evert Hoek and E. T. Brown, Underground Excavation in Rock, Institution of Mining and Metallurgy, 1980.
2. Bhawani Singh and D. K. Yadav, Design and Construction of Tunnels: Analysis of Controlled Convergence Pressure Tunnel Boring Machines, CRC Press, 2010.

6	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Code	**Type**	**Structure L+T+P**	**Credits**	**Evaluation Weightage (%)**	
				Method	**Range**
L	Lecture	L: 3 T: 0 P: 0	L	Mid-Semester Exam.	20-30
				Teacher-Defined Assessment	20
				End-Semester Exam.	50-60

7	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

High - 3; Medium – 2; Low – 1;

CO / PO	PO1	PO2	PO3
CO1	3	2	1
CO2	3	2	2
CO3	2	3	1
CO4	3	3	2

DEPARTMENTAL ELECTIVES (DE)

Course Code & Course Title:	**MNL 529 CONTRACT AND CONSTRUCTION MANAGEMENT**
Course Type:	DE
Name of the programme(s):	M.Tech. (Excavation and Tunnel Engg)
L-T-P	3-0-0
No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	NIL
Course Equivalence: Course Code(s) & Name(s)	NIL

1. **Course Objective:**
   - To provide knowledge about the legal aspects of contracts.
   - To develop skills regarding contract documentation and management.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Students will understand contract preparation, legal provisions, and bid negotiations.
CO2	Students will be able to apply software tools for contract and construction management and analyze excavation cases.
CO3	Students will demonstrate the ability to develop project schedules, manage time in execution, and allocate resources.
CO4	Students will evaluate financial risks, manage project costing, and understand relevant codes and permissions.

3. Detailed Description of the Course

Topics	**CO(s) Addressed**	**Duration in weeks**
Contracts & Legal Provisions: Introduction to preparation of contract, clauses, Drafting of contracts. Legal provisions of contract, Negotiations, bids preparation.	CO1	Three weeks
Software & Case Studies: Case of excavation and construction contract, Use of software for contract and construction management. Use of software for contract and construction management, work scheduling, resource allocation.	CO2	Three weeks
Project & Construction Management: Project management, schedule preparation, Time management in work execution. Construction management practice.	CO3	Four weeks
Economics & Risk: Relevant Codes for excavations, permissions from various government and other agencies, Finance and economics, Financial risk managements, project scheduling, costing.	CO4	Four weeks

4. Textbooks

1. Dave Roberts, Pipe and Excavation Contracting, Craftsman Book Company, 2003.
2. Caterpillar Inc., Caterpillar Performance Handbook, 48th ed., Caterpillar Inc., 2018.
3. K. K. Chitkara, Construction Project Management: Planning, Scheduling and Controlling, Tata McGraw-Hill, 2014.

2. Reference Books:

1. Ali D. Haidar, Handbook of Contract Management in Construction, Springer, 2011.
2. K. K. Chitkara, Construction Management: Planning, Scheduling and Control, Tata McGraw-Hill, 2008.

6	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Code	Type	Structure L+T+P	Credits	Evaluation Weightage (%)	
				Method	Range
L	Lecture	L: 3 T: 0 P: 0	L	Mid-Semester Exam.	20-30
				Teacher-Defined Assessment	20
				End-Semester Exam.	50-60

7	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

High - 3; Medium – 2; Low – 1;

CO / PO	PO1	PO2	PO3
CO1	3	2	1
CO2	1	3	2
CO3	2	3	1
CO4	3	3	2

8	**List of Indicative Laboratory Experiment (if applicable):**

NIL

Course Code & Course Title:	**MNL 532 ADVANCED ENGINEERING GEOLOGY**
Course Type:	DE
Name of the programme(s):	M.Tech. (Excavation and Tunnel Engg)
L-T-P	3-0-0
No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	NIL
Course Equivalence: Course Code(s) & Name(s)	NIL

1. **Course Objective:** To provide advanced knowledge of geological aspects of surface and underground excavation.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Students will be able to interpret geological maps, ground profiles, and understand the engineering description of soils and rocks.
CO2	Students will be able to analyze neotectonic processes, brittle fracture in rock, and the nature of jointing.
CO3	Students will demonstrate an understanding of hydrogeological principles, groundwater flow, and the application of remote sensing and GIS for engineering design.
CO4	Students will evaluate engineering seismology, physical parameters of earthquakes, and seismic hazard analysis.

3. Detailed Description of the Course

Topics	**CO(s) Addressed**	**Duration in weeks**
Geological Fundamentals & Profiles: Review of basic aspects of applied geology commonly employed in engineering geology, including map construction and interpretation... Ground profiles and ground investigation: Significance of ground profiles to engineering design... Formation and geotechnical character of intrusive and extrusive igneous rocks.	CO1	Four weeks
Neotectonics & Fractures: Neotectonic processes and brittle fracture in rock: The character and origin of neotectonic processes, geological evidence of such processes... Nature of jointing, generation of fractures and their relationship to burial, exhumation and in situ stress.	CO2	Three weeks
Hydrogeology, Remote Sensing & GIS: Hydrogeological principles: The definition, measurement and quantification of head... wells and water supply, the control of groundwater in surface and underground works... Remote sensing and GIS: General character of remotely sensed images... Introduction to Geographical Information System, preparation of GIS for engineering design.	CO3	Four weeks

Engineering Seismology: Introduction. Earth structure and plate tectonics, strain accumulation, elastic rebound and faulting. Energy release and seismic waves. Physical parameters of the earthquake source. Seismic hazard analysis and estimation of design ground motions... Basic concepts of codes for earthquake-resistant design.	CO4	Three weeks

4. Textbooks

1. Walter R. Judd and Paul B. Judd, Engineering Geology and Geotechnics, McGraw-Hill, 1987.
2. F. G. Bell, Engineering Geology, 2nd ed., Butterworth-Heinemann, 2007.
3. K. S. Valdiya, Environmental Geology: Indian Context, Tata McGraw-Hill, 1987.

1. Reference Books:

1. Perry H. Rahn, Engineering Geology: An Environmental Approach, Prentice Hall, 2004.
2. D. P. Krynine and W. R. Judd, Principles of Engineering Geology and Geotechnics, CBS Publishers, 2002.

6	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Code	Type	Structure L+T+P	Credits	Evaluation Weightage (%)	
				Method	**Range**
L	Lecture	L:3 T: 0 P: 0	L	Mid-Semester Exam.	20-30
				Teacher-Defined Assessment	20
				End-Semester Exam.	50-60

7	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

High - 3; Medium – 2; Low – 1;

CO / PO	PO1	PO2	PO3
CO1	3	2	1
CO2	2	1	2
CO3	3	2	3
CO4	3	1	3

8	**List of Indicative Laboratory Experiment (if applicable):**

NIL

Course Code & Course Title:	**MNL 533 INSTRUMENTATION IN EXCAVATION**
Course Type:	DE
Name of the programme(s):	M.Tech. (Excavation and Tunnel Engg)
L-T-P	3-0-0
No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	NIL
Course Equivalence: Course Code(s) & Name(s)	NIL

1. Course Objective: To impart knowledge of various instruments used for measurement and monitoring in surface and underground excavation. To assess the interpretation data and prediction of respective site values.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Students will understand the application of various instruments, including bore hole logging and ground penetrating radars.
CO2	Students will be able to utilize stress, strain, convergence, and seismic measuring instruments.
CO3	Students will evaluate concrete testers and non-destructive instruments for performance monitoring.
CO4	Students will analyze automated data acquisition systems and interpret field investigation data for equipment selection.

3. Detailed Description of the Course

Topics	**CO(s) Addressed**	**Duration in weeks**
Basics & Logging Systems: Introduction to various instruments in excavation, electronic and manual data generation. Bore hole logging system, acoustic/ultrasonic instruments, ground penetrating radars.	CO1	Three weeks
Stress & Deformation Measurement: Stress and strain, deformation, convergence measuring instruments, Seismic instruments.	CO2	Three weeks
Non-Destructive Testing & Monitoring: Concrete testers, non-destructive instruments for excavations, Instrumentation for performance monitoring.	CO3	Four weeks
Data Acquisition & Field Investigations: Instrumentation for investigations: Field investigations for selection and design of mechanical excavators and drilling systems. Data loggers, Automated data acquisition, analysis and interpretation.	CO4	Four weeks

4. Textbooks

1. John Dunnicliff, Geotechnical Instrumentation for Monitoring Field Performance, John Wiley & Sons, 1988.
2. Evert Hoek and E. T. Brown, Underground Excavation in Rock, Institution of Mining and Metallurgy, 1980.
3. Z. T. Bieniawski, *Rock Mechanics Design in Mining and Tunneling*, Balkema, 1984.
4.

5. Reference Books:

1. B. N. Whittaker and R. C. Frith, Tunneling: Design, Stability and Construction, Institution of Mining and Metallurgy, 1990.
2. R. Van Eekelen and J. van Tol, Geotechnical Monitoring: A Review, CRC Press, 2010.

6	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Code	Type	Structure L+T+P	Credits	Evaluation Weightage (%)	
				Method	**Range**
L	Lecture	L: 3 T: 0 P: 0	L	Mid-Semester Exam.	20-30
				Teacher-Defined Assessment	20
				End-Semester Exam.	50-60

7	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)
High - 3; Medium – 2; Low – 1;

CO / PO	PO1	PO2	PO3
CO1	2	3	2
CO2	2	3	2
CO3	1	3	2
CO4	2	3	3

8	**List of Indicative Laboratory Experiment (if applicable):**

NIL

Course Code & Course Title:	**MNL 534 GROUTING TECHNOLOGY**
Course Type:	DE
Name of the programme(s):	M.Tech. (Excavation and Tunnel Engg)
L-T-P	3-0-0
No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	NIL
Course Equivalence: Course Code(s) & Name(s)	NIL

1. **Course Objective:** To make students conversant about the application of different types of grouts and its properties used in excavation.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Students will understand the principles, viscosity, thixotropy, and types of grouts used in rock and soil strengthening.
CO2	Students will apply various grouting injection techniques and assess grout quality and setting durability.
CO3	Students will be able to select grouting equipment and design grouting based on geological site investigations.
CO4	Students will evaluate compaction and remediation grouting practices and testing methods.

3. Detailed Description of the Course

Topics	**CO(s) Addressed**	**Duration in weeks**
Grouting Principles & Types: Principles, purpose and application of grouting, viscosity and thixotropy of grout, flow of grout in cracks, pressures for grouting, utility for control of water movement, strengthening of both soil and rock, and structural applications. Grouts: Types of grout cement, chemical, cellular grout, silica fume modified grouts and microfine cement....	CO1	Three weeks
Grouting Techniques & Assessment: Grouting techniques: injection techniques, jet, displacement, and permeation. Mix preparation, grout quality. Procedure of grouting assessment during and after grouting, Water testing in grout holes, Monitoring and control methods. Grouting in surface and sub-surface excavations.	CO2	Four weeks
Equipment & Design: Grouting equipment: drilling and grouting equipment, grouting mixers, agitators, pumps, valves, pressure gauges, fittings on grout holes, grouting arrangement. Site investigation, geology, permeability and grouting design Grouting in stressed rock, computer aided grouting.	CO3	Three weeks
Compaction & Remediation: Compaction, Remediation, and Testing of grout: field and laboratory studies related to grouting materials, Grouting verification methods and related technologies. Compaction grouting: mechanisms; theories, practice; effect of fines in compaction grouts. Remediation grouting: mine subsidence, cement grouting of dam joints.	CO4	Four weeks

4. Textbooks

1. A. C. Houlsby, Construction and Design of Cement Grouting: A Guide to Grouting in Rock Foundations, John Wiley & Sons, 1990.
2. Robert Bowen, Grouting in Engineering Practice, Applied Science Publishers, 1981.
3. R. K. Goel, Engineering Rock Mechanics: Excavation, Support and Monitoring, Butterworth-Heinemann, 2011.

5. Reference Books:

1. John H. Long and Colin Jenkins, Ground Treatment: Design and Installation, ICE Publishing, 2005.
2. Evert Hoek and E. T. Brown, Underground Excavation in Rock, Institution of Mining and Metallurgy, 1980.

6	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Code	Type	Structure L+T+P	Credits	Evaluation Weightage (%)	
				Method	**Range**
L	Lecture	L: 1/2/3 T: 0 P: 0	L + T	Mid-Semester Exam.	20-30
				Teacher-Defined Assessment	20
				End-Semester Exam.	50-60

7	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

High - 3; Medium – 2; Low – 1;

CO / PO	PO1	PO2	PO3
CO1	2	3	1
CO2	2	3	1
CO3	3	3	2
CO4	2	3	2

8	**List of Indicative Laboratory Experiment (if applicable):**

NIL

Course Code & Course Title:	**MNLXXX PRINCIPLES AND CONCEPTS OF MINING**
Course Type:	DE
Name of the programme(s):	M.Tech. (Excavation and Tunnel Engg)
L-T-P	3-0-0
No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	NIL
Course Equivalence: Course Code(s) & Name(s)	NIL

1. Course Objective:

Non-Mining Background students will be made aware of the concepts of Mining Engineering

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	The students will be able to understand the basic terminology of mining and study different concepts of mining.
CO2	The students will be able to understand the phases of underground and open-cast mining.
CO3	The students will be able to understand the operations involved in drifting and shaft sinking.
CO4	The students will be able to understand the types of explosives and its application in mines

3. Detailed Description of the Course

Topics	**CO(s) Addressed**	**Duration in weeks**
Introduction: Important mineral resources, the importance of Mining and its consequences. Basic terminology: Surface Mining, Underground coal and metal such as Mine, Mining, surface mining, underground mining, mineral, rock, ore, mineral deposit, beds, coal seam, veins, strike and dip, hanging wall, footwall, bench, haul road, bench slope, pit slope, overburden, dump, stripping ratio, shaft, adit, incline, tunnel, cross cut, drift, level, winze, raise, stope, dip and rise, level, face, panel, pillar, gallery, roadway.	CO1	Four weeks
Phases of mining: Prospecting to reclamation, Brief description of elements of an opencast mine; ramp, haul roads, benches, production cycle, dumping of overburden and backfilling. Introduction to underground metal mining methods: Brief description of underhand, overhand, cut and fill, and sub level stoping methods of metal mining.	CO2	Three weeks

Introduction to Mining: Opening of deposits; mode of entry: adit, shaft, decline, and combined model; their applicability and comparison. Drifting: Small and medium-sized tunnelling and drifting; drivage work in varying ground conditions using conventional methods, drilling, blasting, mucking, transportation, supports, services and cycle of operations. Shaft sinking: Site selection, shaft sinking preparatory arrangements, drilling and blasting, mucking, hoisting, ventilation, pumping, lighting, supporting of sides, complete cycle of operations	CO3	Four weeks
Explosives: types of explosives- their composition and properties. Blasting: Brief introduction to blasting accessories, exploders, blasting practices in opencast and underground mines	CO4	Three weeks

4. Textbooks

1. Howard L. Hartman, *Introductory Mining Engineering*, 2nd ed., Wiley, 2002.
2. S. K. Das, *Coal Mining Technology*, Lovely Prakashan, 1994.
3. D. J. Deshmukh, Elements of Mining Technology, Vol. 1, Denett & Company, 2008.
4. R. D. Singh, Principles and Practices of Modern Coal Mining, New Age International, 2005.

3. Reference Books:

1. William A. Hustrulid, *SME Mining Engineering Handbook*, 3rd ed., Society for Mining, Metallurgy & Exploration, 2011.

6	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Code	Type	Structure L+T+P	Credits	Evaluation Weightage (%)	
				Method	**Range**
L	Lecture	L: 3 T: 0 P: 0	L + T	Mid-Semester Exam.	20-30
				Teacher-Defined Assessment	20
				End-Semester Exam.	50-60

7	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

High - 3; Medium – 2; Low – 1;

CO / PO	PO1	PO2	PO3
CO1	3	2	2
CO2	2	3	1
CO3	3	3	2
CO4	3	3	2

8	**List of Indicative Laboratory Experiment (if applicable):**

NIL

Course Code & Course Title:	**MNL 530 GROUND IMPROVEMENT ENGINEERING**
Course Type:	DE
Name of the programme(s):	M.Tech. (Excavation and Tunnel Engg)
L-T-P	3-0-0
No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	NIL
Course Equivalence: Course Code(s) & Name(s)	NIL

1. **Course Objective:** To provide knowledge of ground reinforcement and improvement techniques of surface and underground excavation.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Students will understand basic principles and classify support techniques for surface and subsurface excavations.
CO2	Students will apply soil improvement technologies, geosynthetics, and ground-retaining techniques.
CO3	Students will evaluate grouting, shotcreting methods, and design supports for tunnels and caverns.
CO4	Students will analyze slope stability and design dumps for various rock conditions.

3. Detailed Description of the Course

Topics	**CO(s) Addressed**	**Duration in weeks**
Basics & Supports: Basics, purpose, principles. Ground improvement techniques for excavation, types and application. Support classification for surface and subsurface excavations, Rock bolts, cable bolts, side stitching, rock binding.	CO1	Three weeks
Stabilization & Retaining: Geo-synthetics: geo-textile application, soil improvement technologies, Ground retaining techniques, diaphragm walls, soil stabilization: stone columns, sand piles, dynamic compaction, binding. Piling.	CO2	Four weeks
Grouting & Tunnel Linings: Methods of Grouting, Jet grouting, shotcretting, guniting. Supports in tunnels and caverns, linings, and design.	CO3	Four weeks
Slope & Dump Design: Design of slope in various rock conditions, Slope stability, slope failure analysis. Dump design and management.	CO4	Three weeks

4. Textbooks

1. M. P. Moseley, *Ground Improvement*, 2nd ed., CRC Press, 2004.
2. A. C. Houlsby, *Construction and Design of Cement Grouting: A Guide to Grouting in Rock Foundations*, John Wiley & Sons, 1990.
3. Brajja M. Das, *Principles of Foundation Engineering*, 8th ed., Cengage Learning, 2013.

Reference Books:

1. Jie Han, Principles and Practice of Ground Improvement, Wiley, 2015.
2. Evert Hoek and J. Bray, Rock Slope Engineering, 3rd ed., Institution of Mining and Metallurgy, 1981.

6	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Code	Type	Structure L+T+P	Credits	Evaluation Weightage (%)	
				Method	**Range**
L	Lecture	L: 3 T: 0 P: 0	L	Mid-Semester Exam.	20-30
				Teacher-Defined Assessment	20
				End-Semester Exam.	50-60

7	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

High - 3; Medium – 2; Low – 1;

CO / PO	PO1	PO2	PO3
CO1	3	3	2
CO2	2	3	2
CO3	3	3	1
CO4	3	2	3

8	**List of Indicative Laboratory Experiment (if applicable):**

NIL

Course Code & Course Title:	**MNL 531 SLOPE ENGINEERING**
Course Type:	DE
Name of the programme(s):	M.Tech. (Excavation and Tunnel Engg)
L-T-P	3-0-0
No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	NIL
Course Equivalence: Course Code(s) & Name(s)	NIL

1. **Course Objective:** Students are made aware of the essential parameters required for slope design. Students will study the stability methodology of excavated slopes.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Students will understand slope failure mechanisms, elements, and factors influencing stability.
CO2	Students will analyze geological and geotechnical data to interpret stability for various slopes.
CO3	Students will evaluate the effect of groundwater flow and seepage on slope stability.
CO4	Students will apply limiting equilibrium, numerical modeling, and stabilization techniques for slope design and monitoring.

3. Detailed Description of the Course

Topics	**CO(s) Addressed**	**Duration in weeks**
Slope Fundamentals: Introduction: Types and formation of slopes in surface mines, elements of slope, basic mechanism of slope failure, common modes of slope failure, factors influencing stability of slopes.	CO1	Three weeks
Geological Information: Geological and Geotechnical Information: Site investigation and geological data collection and mapping for Bench slope, highwall pit slope, Waste Dump slope, Tailings Pond Embankment slope and their interpretation for stability analysis, Physico-Mechanical Properties of rock, soil, tailings, fly-ash.	CO2	Three weeks
Groundwater Effects: Groundwater Flow conditions in slope: Basics of water flow through porous material and its permeability; water flow through soil type material, broken spoil material, discontinuity and rock-mass; Slope dewatering, Cone of depression, Graphical Flow Net analysis of seepage, seepage patterns under different conditions; Effect of groundwater on slope stability.	CO3	Four weeks
Stability Analysis & Monitoring: Slope Stability Analysis Methods: Limiting equilibrium method, Kinematics and Limiting equilibrium analysis of Plane Failure, Wedge Failure, Circular Failure and Toppling Failure... Post failure analysis of slopes, Seismic analysis; Numerical modeling for slope design, design of slope using computer software... Stabilization techniques, Earth retaining structures... Slope monitoring techniques and interpretation.	CO4	Four weeks

4. Textbooks

1. Evert Hoek and J. Bray, Rock Slope Engineering, 3rd ed., Institution of Mining and Metallurgy, 1981.
2. Debasis Deb and Abhiram Kumar Verma, Fundamentals and Applications of Rock Mechanics, PHI Learning Pvt. Ltd., 2010.
3. Charles A. Kliche, Rock Slope Stability, Society for Mining, Metallurgy & Exploration (SME), 1999.

5. Reference Books:

1. William A. Hustrulid, Michael K. McCarter and Dirk J. A. Van Zyl, Slope Stability in Surface Mining, Society for Mining, Metallurgy & Exploration, 2000.
2. Lee W. Abramson, Thomas S. Lee and Sunil Sharma, Slope Stability and Stabilization Methods, 2nd ed., Wiley, 2002.

6	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Code	Type	Structure L+T+P	Credits	Evaluation Weightage (%)	
				Method	**Range**
L	Lecture	L: 3 T: 0 P: 0	L	Mid-Semester Exam.	20-30
				Teacher-Defined Assessment	20
				End-Semester Exam.	50-60

7	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)
High - 3; Medium – 2; Low – 1;

CO / PO	PO1	PO2	PO3
CO1	3	2	1
CO2	3	2	2
CO3	3	2	1
CO4	3	3	3

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8	**List of Indicative Laboratory Experiment (if applicable):**

NIL

Course Code & Course Title:	**MNL 535 CONCRETE AND SHOTCRETE TECHNOLOGY**
Course Type:	DE
Name of the programme(s):	M.Tech. (Excavation and Tunnel Engg)
L-T-P	3-0-0
No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	NIL
Course Equivalence: Course Code(s) & Name(s)	NIL

1. **Course Objective:** To provide knowledge of concrete and shortcrete application in excavation. To make students aware of the properties and design of concrete in excavation.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Students will understand concrete-making materials, cement hydration, and mix design principles.
CO2	Students will be able to evaluate properties of fresh and hardened concrete and manage production processes.
CO3	Students will apply special concretes and understand the design philosophy for concrete floors on the ground.
CO4	Students will demonstrate knowledge of shotcrete technology, materials, properties, and quality control.

3. Detailed Description of the Course

Topics	**CO(s) Addressed**	**Duration in weeks**
Materials & Mix Design: Concrete Making Materials: Aggregates classification, IS Specifications, Properties, Grading, Methods of combining aggregates, specified, grading, Testing of aggregates, Fibers. Cement, Grade of cement, Chemical composition, Testing of concrete, Hydration of cement, Structure of hydrated cement, Special cements - Water, Chemical admixtures, Mineral admixture. Mix Design: Principles of concrete mix design, Methods of concrete mix design, Testing of concrete. Aggregates, mixing water and admixtures, Formwork, Reinforcement, Concrete production (including ready-mixed concrete).	CO1	Four weeks
Properties & Production: Concrete: Properties of fresh concrete, Hardened concrete, Strength, Elastic properties, Creep and shrinkage, Variability of concrete strength. Materials for concrete, Receiving and storing materials, Batching, mixing. Transporting, placing, and compacting, finishing and surface preparation, Protection and curing, Formwork and reinforcement, Sand-cement mixes, durability of concrete.	CO2	Three weeks

Special Concrete & Floors: Special Concrete: Light-weight concrete, Fly ash concrete, Fibre reinforced concrete, Polymer Concrete, Super plasticised concrete, Epoxy resins and screeds for rehabilitation. Properties and Applications: High performance, Mass concrete, Hot and cold weather concreting, Defects and repairs, Concrete pavements, Introduction to prestressed concrete, Vacuum dewatering - underwater concrete. Concrete Floors on the Ground: Design philosophy, Subgrades and subbases, Joints.	CO3	Four weeks
Shotcrete Technology: Shotcrete technology: Introducing sprayed concrete, Materials for shotcrete including fibres, Properties of shotcrete (fresh and hardened), Mix design, Batching and mixing, Quality control, Equipment selection and maintenance, Planning and logistics.	CO4	Three weeks

4. Textbooks

1. A. M. Neville, Properties of Concrete, 5th ed., Pearson Education, 2011.
2. M. S. Shetty, Concrete Technology: Theory and Practice, S. Chand & Company Ltd., 2012.
3. M. F. Nuruddin (Ed.), Shotcrete: Theory and Practice, Woodhead Publishing, 2014..

5. Reference Books:

1. G. Rudnai, Lightweight Concrete, Akadémiai Kiadó, 1963.
2. BIS, IS 10262: Concrete Mix Proportioning – Guidelines, BIS, 2019.

6	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Code	Type	Structure L+T+P	Credits	Evaluation Weightage (%)	
				Method	**Range**
L	Lecture	L: 3 T: 0 P: 0	L + T	Mid-Semester Exam.	20-30
				Teacher-Defined Assessment	20
				End-Semester Exam.	50-60

7	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

High - 3; Medium – 2; Low – 1;

CO / PO	PO1	PO2	PO3
CO1	3	2	2
CO2	2	3	1
CO3	3	3	2
CO4	3	3	2

8	**List of Indicative Laboratory Experiment (if applicable):**

NIL

Course Code & Course Title:	**MNL 5XX AI/ML AND ROBOTICS IN TUNNELS**
Course Type:	DE
Name of the programme(s):	M.Tech. (Excavation and Tunnel Engg)
L-T-P	3-0-0
No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	NIL
Course Equivalence: Course Code(s) & Name(s)	NIL

1. Course Objective:

- To give an introduction to the concept and models of AI.
- To make the students aware of the application of AI/ML models in tunnels.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Students will be able to understand intelligent agents and problem-solving search techniques.
CO2	Students will apply First-Order Logic and inference mechanisms for knowledge representation.
CO3	Students will understand machine learning basics, models, and neural network algorithms.
CO4	Students will be able to apply AI/ML models in geological predictions, tunnel monitoring, and robotics.

3. Detailed Description of the Course

Topics	**CO(s) Addressed**	**Duration in weeks**
AI Basics & Search: Introduction to Artificial Intelligence and Machine Learning and its models. Intelligent Agents, Problem-Solving Agents, Searching for Solutions like Breadth-first search, Depth-first search, Hill-climbing search, Simulated annealing search, Local Search in Continuous Spaces.	CO1	Three weeks
Logic & Inference: First-Order Logic - Syntax and Semantics of First-Order Logic, Using First-Order Logic, Knowledge Engineering in First-Order Logic. Inference in First-Order Logic: Propositional vs. First-Order Inference, Unification, Forward Chaining, Backward Chaining, Resolution. Knowledge Representation.	CO2	Four weeks
Machine Learning & Models: Introduction to machine learning, Basics of machine learning - Human Learning - Define machine learning - Types of machine learning -compare supervised, unsupervised and reinforcement learning -Problems not to be solved using machine learning -Applications of machine learning-List the Tools used for ML, Advantages and disadvantages of machine learning. Models and algorithms in AI: Neural Networks, Convolutional Neural Network CNNs (for Vision), Recurrent Neural Network RNNs (for Sequences). Building Information Modeling (BIM), Artificial Neural Network (ANN), K-Nearest Neighbors (KNN), Support Vector	CO3	Four weeks

Machines (SVM) Game theory, Fussy logic concepts in models.		
Tunnel Applications: Al models in geological and geotechnical prediction and interpretations, AIML applications in structural and settlement monitoring of tunnels and inspections, Al applications in robotics machines like TBM, Roadheaders, Drillers etc. Environment monitoring models in tunnels.		

4. Textbooks

1. Saptarsi Goswami, Amit Kumar Das and Amlan Chakrabarti, AI for Everyone: A Beginner's Handbook for Artificial Intelligence, Pearson Education, 2024.
2. Chip Huyen, AI Engineering: Building Applications with Foundation Models, O'Reilly / Shroff Publishers, 2024.
3. J. O. Bickel, T. R. Kuesel and E. H. King, Tunnel Engineering Handbook, 2nd ed., Chapman & Hall, 1996.

5. Reference Books:

1. Amin Gharaibeh, Artificial Intelligence and Machine Learning for Civil Engineers, Wiley, 2021.
2. B. N. Whittaker and R. C. Frith, Tunneling: Design, Stability and Construction, Institution of Mining and Metallurgy, 1990.

6	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Code	Type	Structure L+T+P	Credits	Evaluation Weightage (%)	
				Method	**Range**
L	Lecture	L: 3 T: 0 P: 0	L	Mid-Semester Exam.	20-30
				Teacher-Defined Assessment	20
				End-Semester Exam.	50-60

7	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

High - 3; Medium – 2; Low – 1;

CO / PO	PO1	PO2	PO3
CO1	2	2	3
CO2	1	1	3
CO3	1	1	3
CO4	2	2	3

8	**List of Indicative Laboratory Experiment (if applicable):**

NIL

Course Code & Course Title:	**MNL 5XX TUNNEL VENTILATION, SAFETY AND SERVICES**
Course Type:	DE
Name of the programme(s):	M.Tech. (Excavation and Tunnel Engg)
L-T-P	3-0-0
No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	NIL
Course Equivalence: Course Code(s) & Name(s)	NIL

1. Course Objective:

To give an introduction to the concept and models of AI.

To make the students aware of the application of AIML models in tunnels.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Students will be able to understand the principles and different configurations of tunnel ventilation systems.
CO2	Students will evaluate hazards, safety management, risk analysis, and firefighting strategies in tunnels.
CO3	Students will apply Computational Fluid Dynamics (CFD) approaches to analyze ventilation and safety.
CO4	Students will understand system testing for new tunnels and methods for tunnel refurbishment and upgrades.

3. Detailed Description of the Course

Topics	**CO(s) Addressed**	**Duration in weeks**
Ventilation Principles: Principle of ventilation, Types of ventilation systems in tunnels: primary types of ventilation techniques: natural and artificial. Ventilation principles portal-to-portal, portal-to-shaft, and shaft-to-shaft configurations. longitudinal, transverse, or semi-transverse ventilation systems. Mechanical ventilations.	CO1	Four weeks
Safety & Firefighting: Hazards in tunnels, safety management in tunnels, Risk Analysis & Safety Measures: evaluation of safety-related systems, rescue, safe evacuation strategies and escape routes. Fire-fighting systems in tunnels.	CO2	Four weeks
CFD Approaches: CFD approach to ventilation and fire fighting and safety.	CO3	Three weeks
Testing & Refurbishment: System Testing: Testing for new road and rail tunnels, plus recurring inspections during operation. Tunnel Refurbishment & Upgrades: Modernizing infrastructure without disrupting daily operations.	CO4	Three weeks

4. Textbooks

1. Alan V. Jones, Ventilation of Underground Facilities, CRC Press, 2000.
2. John Dix, Tunnel Safety Handbook, Thomas Telford Publishing, 2001.
3. David Chapman, Nicole Metje and Alfred Stärk, Introduction to Tunnel Construction, CRC Press, 2010.

5. Reference Books:

1. B. D. Keefer and David R. Kirtley, Tunnel Ventilation: A Practical Guide, ASHRAE, 1998.
2. Benedetto Croce and Giulio de Simone, Fire and Smoke Control in Road Tunnels, PIARC / World Road Association, 2007.

6	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Code	Type	Structure L+T+P	Credits	Evaluation Weightage (%)	
				Method	**Range**
L	Lecture	L: 3 T: 0 P: 0	L	Mid-Semester Exam.	20-30
				Teacher-Defined Assessment	20
				End-Semester Exam.	50-60

7	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

High - 3; Medium – 2; Low – 1;

CO / PO	PO1	PO2	PO3
CO1	3	2	2
CO2	3	3	1
CO3	3	1	3
CO4	2	3	2

8	**List of Indicative Laboratory Experiment (if applicable):**

NIL