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Master of Technology

In

Tunneling and Underground Space Engineering

Offered by

Department of Civil Engineering, IIT (BHU), Varanasi

Under aegis of

Center of Excellence on "Tunneling and Underground Space Engineering (CETUSE)"

A joint initiative of IIT (BHU) and DMRC New Delhi

Part-A: Vision, Outcome and Resource Persons

1. Prologue:

Construction of tunnels is complex in nature due to multi-dimensional challenges. To name a few, tunneling requires geological and geotechnical investigations to mark the alignment with depth, to identify the suitable tunneling methodology, machineries required and many other related issues. Upon finalizing the alignment, infrastructure financing, assets management and public policies become instrumental in preparation of detailed project report (DPR). Further, quality control and safety measures become essential during construction. During operation and maintenance phase also, infrastructure projects face various technical problems, which are multi-faceted and require multidisciplinary solutions.

Currently, infrastructure projects mainly rely upon imported machinery and experts for planning, construction and implementation. For operation and maintenance, imported scientific solutions are customized for Indian scenarios, which is not a sustainable approach. Therefore, tunneling projects seeks indigenized solutions to their engineering problems through research and specialized training of their employees. The specialized training of the manpower that is handling the tunneling and underground space technology shall drive the growth engine of transport infrastructure of 21st century India, more efficiently.

Upon realizing the need of an institute capacity building of individual and institution, IIT (BHU) and DMRC have joined the hands to establish a tunneling academy, which will cater scientific solution to the problems faced by tunneling industry on a day-to-day basis. Under the umbrella of this center, a two-year M.Tech Course is proposed which aims to train human resources for various advanced technological construction practices in underground space construction.

The two years master's program in "Tunneling and Underground Space Engineering" will provide an interdisciplinary background in underground space construction. The course will be a unique blend of tunneling technology, infrastructure asset management, public policy and financing for infrastructure projects. The proposed course is deep rooted with fundamentals of tunneling and equipped with advanced tunneling methodologies, data analytic for multi-modal transportation system and construction management.

2. Vision:

To impart education and training on innovative indigenized engineering solutions for tunneling and underground space construction.

3. Outcome:

Upon completion of the course, the student will have skill-set essential for tunneling and underground construction industry. Graduates may assist policy makers, governments and agencies involved in the development of metro projects, underground railway tracks, hydrology-structures, tunnels and other allied works. The course aims to train graduates for various technological advanced construction practices in Tunneling and Underground Space. The course also provides a good foundation for research studies in the field of underground construction.

4. Topics covered:

Urban Space: Determination of alignments and construction methodology, Advance Engineering Geology, Rock Mechanics, Design of Underground Structures, Instrumentation and monitoring techniques of underground works, Ground Improvement techniques

5. Resource Persons:

1. **Center of Excellence** on "Tunneling and Underground Space Engineering", a joint initiative of IIT (BHU), Varanasi and DMRC, New Delhi
2. **Dr. Supriya Mohanty**, Associate Professor, Department of Civil Engineering, IIT (BHU), Varanasi
3. **Dr. Abhisek Mudgal**, Assistant Professor, Department of Civil Engineering, IIT (BHU), Varanasi
4. **Dr. Mahendra Kumar Pal**, Assistant Professor, Department of Civil Engineering, IIT (BHU), Varanasi
5. **Dr. Kshitij Kumar Yadav**, Assistant Professor, Department of Civil Engineering, IIT (BHU), Varanasi
6. **Dr. Agnivesh Pani**, Assistant Professor, Department of Civil Engineering, IIT (BHU), Varanasi
7. **Dr. Vishwajit Anand**, Assistant Professor, Department of Civil Engineering, IIT (BHU), Varanasi

Part-B: Intake, Eligibility Criteria and Course Content

1. Proposed Intake:

Categories of Admission	Intake (No. of Students per year)
Full Time Regular	15
Part-Time	05
Full Time Sponsored	10
Total	30

2. Eligibility Criteria for Admission:

2.1 Full Time Regular Registration Category*:*

- ✓ First Class in B.E./ B. Tech in Civil Engineering/Construction Technology and Management/ Allied engineering
- ✓ *GATE Qualified with validity not expired*

  OR
- ✓ B. Tech Degree in relevant discipline from an IIT/NIT with minimum CPI of 8.0 or above in which case GATE score is not mandatory

2.2 Part-Time Registration Category:

- ✓ For Permanent staff of the Institute, Research Assistants working in Externally Funded Project running in Institute with minimum left out duration of two years, Scientists, Engineers, faculty members working in other Institutes
- ✓ Educational qualifications are the same as for regular candidates with GATE exemption.
- ✓ Other Criteria are as laid down in PG Ordinance, IIT (BHU).

2.3 Full Time External Registration Category:

- ✓ For scientists, engineers, professionals working in an external R&D organization or in an industry recognized by the Institute, which is equipped with necessary research and library facilities may be considered for admission to M.Tech.. programs, provided he/she satisfies the eligibility criteria laid down for the program concerned
- ✓ The employer must undertake to pay the full salary to the candidate and relieve him/her from the duty to enable the candidate to stay on the campus and to complete the course work requirements.
- ✓ The candidate should submit a certificate obtained from his/her organization that the research facilities of his/her organization would be made available to him/her for

carrying out research. He/she should also provide the biodata of the prospective supervisor along with his/her consent, who would be supervising the candidate's work at his/her organization.

- ✓ [N.B. Letter of appointment and Form – 16 for two years of service is required from the employer at the time of written test/interview.]
- ✓ Educational qualifications are the same as for regular candidates with GATE exemption.

2.4 Sponsored Registration Category

2.4A Full Time Mode

- ✓ Candidate who is sponsored by a teaching institution or by an R&D organization or by an industry is eligible for admission to MTech. programs, provided he/she satisfies the eligibility criteria laid down for the program.
- ✓ He/she must have been in service of the sponsoring institution/organization for at least two years at the time of admission. The sponsoring organization must specifically undertake to provide full salary to the candidate and to relieve him/her to pursue the program for its full duration.
- ✓ Such candidates must complete the requirements of the program by staying on-campus for the full duration of the program
- ✓ The requirement of qualifying in GATE/GPAT is waived off for such candidates for the purpose of admission to PG programs.
- ✓ Educational qualifications are the same as for regular candidates with GATE exemption.
- ✓ [N.B. Letter of appointment and Form – 16 for two years of service is required from the employer at the time of written test/interview. In addition, the candidate must submit an undertaking that he/she will continue to submit Form – 16 for the subsequent years till he/she completes the program.]

2.4 B Executive Mode:

- ✓ B.Tech/BE with at least 60% marks or at least 6.5/10 Cumulative Performance Index (CPI) or Cumulative Grade Point Average (CGPA). (50% marks or at least 5.5/10 CGPA/CPI for the reserved category candidates).

- ✓ The requirement of qualifying in GATE/GPAT is waived off for such candidates for the purpose of admission.
- ✓ Candidates admitted in this category shall be a full-time employee with minimum two years of work experience and sponsored by Industry, Govt./R&D. organizations, Laboratories, NGOs, and Banking Institutions.
- ✓ The employer must undertake to pay the full salary to the candidate and permit him/her from the duty to enable the candidate to stay on the campus and to complete the course work requirements.
- ✓ The candidate should submit a certificate obtained from his/her organization that the research facilities of his/her organization would be made available to him/her for carrying out research. He/she should also provide the biodata of the prospective supervisor along with his/her consent, who would be supervising the candidate's work at his/her organization.
- ✓ Letter of appointment and Form – 16 for two years of service is required from the employer at the time of written test/interview. In addition, the candidate must submit an undertaking that he/she will continue to submit Form – 16 for the subsequent years till he/she completes the program.

3. Modalities of Executive Mode:

- ✓ The Executive M. Tech Program in Tunneling and Underground Space Engineering will be administered as a hybrid program, incorporating both in-person and online learning modalities. The theoretical components will be delivered through online modules and/or synchronous virtual sessions, while laboratory-based instruction will be conducted through in-person lectures and workshops.
- ✓ Students must adhere to the institute's academic calendar and participate in regular examinations, including mid-term and end-term assessments.
- ✓ As part of the program requirements, students must be present on campus for a minimum of four weeks per semester, inclusive of examinations on campus.
- ✓ Campus Immersion Program: In addition to minimum residential requirement, participants are mandated to engage in a structured 10-days immersion program per semester dedicated to laboratory work and practical learning. The schedule for this program shall be determined upon mutual agreement between students and the

convener.

- ✓ For all intents and purposes, both IIT-BHU and DMRA shall be designated as official campus locations for this program.

4. Fee:

As per institute norm

5. Credit Requirements as per PG Ordinance

Full Time:

Program	Minimum Total Credits	Minimum Credits through coursework	Minimum Credits through Thesis work	Minimum number of courses	Minimum Residence	Maximum Duration
M.Tech.	77	33	44	8	4 Sem	4 years

Part-Time: As per PG ordinance

6. Course Structure

Course Structure: M.Tech. in Tunneling and Underground Space Engineering (2025-2026)					
Cat.	**Deviation**	**Programme Components**		**Recommended**	
				Min	**Max**
DC	0	Department/Programme Core (Includes Stream Courses)	12	12	15
DE	0	Department/Programme Elective (Includes Stream Courses)	18	15	18
DP	0	Practical Component	3	3	3
HU/LM	0	Humanities/Language & Management Course	3	3	5
DT	0	Thesis	44	44	44
		Total	**80**	77	81
		All Semester Total (Hons.)			
L: Lecture hours; T: Tutorial hours; P: Laboratory/ Practical hours; C: Credits					
Area in Civil Engineering					
	Area Code	**Area Title**			
		Tunneling and Underground Space Engineering			

Course Structure: M.Tech. in Tunneling and Underground Space Engineering (2025-2026)						
PG-CRC Code	**Course Code**	**Course Name**	**L–T–P**			**Credits**
I-Semester						
DC-1	CE-581	Advanced Course on Conventional & NATM Tunneling	3	0	0	3
DC-2	CE-582	Design of Tunnel & Tunnel Support Systems	3	0	0	3
	DE-…….	Department Elective#1	3	0	0	3
	DE-…….	Department Elective#2	3	0	0	3
	DE-…….	Department Elective#3	3	0	0	3
	DP-…..	Geological and Geotechnical Investigation* (Lab#1)	0	0	3	1.5
HU/LM	HU/LM	Humanities/Language & Management Course^^	3	0	0	3
		Total				**19.5**
^^ Course to be selected form the list as declared by Academic office.						
Department Elective -DE-1, DE-2 & DE-3						
	CE-534	Advanced Concrete Technology	3	0	0	3
	CE-528	Soil-Structure Interaction	3	0	0	3
	CE-521	Geotechnical Exploration and Measurement Techniques	3	0	0	3
	CE-524	Ground Improvement Technique	3	0	0	3
	CE-515	Surface Water Hydrology	3	0	0	3
	CE-587	Construction Methods and Equipment	3	0	0	3
	CE-502	Computational Methods in Engineering	3	0	0	3
	CE-585	Sub-Surface Investigation & Interpretation Works	3	0	0	3
	CE-584	Soil Retaining Systems in underground Works	3	0	0	3
	CE-583	Design of Underground Structures	3	0	0	3
	CE-586	Instrumentation & Monitoring Techniques for Underground Works	3	0	0	3
II-Semester						
DC-3	MN-521	Underground Space Technology	3	0	0	3
DC-4	CE-623	Applied Rock Mechanics	3	0	0	3
	DE-…….	Department Elective#4	3	0	0	3
	DE-…….	Department Elective#5	3	0	0	3
	DE-……	Department Elective#6	3	0	0	3
	DP……	BIM Modelling of Underground Structures (Lab#2)	0	0	3	1.5

	CE595	Thesis	0	0	8	4
		Total	**15**	**0**	**10**	**22**
Department Elective -DE-4, DE-5 &DE-6						
Department Elective -DE-4, DE-5 &DE-6	CE-632	Plates and Shells	3	0	0	3
	CE-684	Quality Assurance & Quality Control in Underground Works	3	0	0	3
	CE-682	SHE Practices in Underground Space Construction	3	0	0	3
	CE-681	Advanced Course on TBM Tunneling	3	0	0	3
	CE-685	Construction Project Management	3	0	0	3
	CE-686	Infrastructure Assets Management	3	0	0	3
	CE-687	Public Policy and Governance for Infrastructure	3	0	0	3
III-Semester						
DT.CE695.17	CE695	Thesis	0	0	40	20
		Total	**0**	**0**	**40**	**20**
IV-Semester						
DT.CE696.17	CE696	Thesis	0	0	40	20
		Total	**0**	**0**	**40**	**20**
L: Lecture hours; T: Tutorial hours; P: Laboratory/ Practical hours; C: Credits						

Semester-I

CE-581: Advanced Course on Conventional & NATM Tunneling

1. General Information

1.1 Course Title: Advanced Course on Conventional & NATM Tunneling

1.2 Course Number: CE-581

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-I (DC-1)

1.5 Pre-Requisite: None

2. Course Objective

3. Course Content

Unit 1. Importance of Preliminary Investigation Details while finalizing the Construction Methodology, Importance of Building Condition Survey & Real Time Instrumentation Monitoring System, Conventional Method of Tunneling: Cut & Cover (Top Down), Cut & Cover (Bottom Up).

Unit 2. Soil Stabilization & Soil Retention Techniques in Cut & Cover Tunneling.

Unit 3. Excavation Methods & Techniques, Drilling & Blasting in Rocks, Various types of Machinery Involved in the Execution Works., New Austrian Tunnelling Method (NATM): Introduction & Historical Evolution of NATM, Factors affecting selection of NATM as execution method, Soil Stabilization & Soil Retention Techniques in NATM Tunneling, Caution during NATM Progression, Planning of an Efficient Contingency Plan.

Unit 4. Introduction to Box Pushing Technique, Pros & Cons of Box Pushing Method, Design Considerations.

Unit 5. Safety, Health & Environment (SHE) Measures in Conventional Tunnelling Works.

Unit 6. Water Proofing & General Repair Works.

4. Textbooks/ Reference Book

5. Assessment

6. Course Outcome

7. Other Information

CE-582: Design of tunnel & tunnel Support Systems

1. General Information

1.1 Course Title: Design of tunnel & tunnel Support Systems

1.2 Course Number: CE-582

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-I (DC-2)

1.5 Pre-Requisite: None

2. Course Objective

3. Course Content

·**Unit 1.** Factors affecting the Design of Tunnel & Underground Spaces.

·**Unit 2.** Design Philosophy of Tunnel & Underground Spaces.

·**Unit 3.** Design of Temporary Ground Stabilization & Ground Retention Works

·**Unit 4.** Design of Tunneling & Underground Space through Cut & Cover Techniques, NATM Techniques, TBM Technique and Box Pushing Technique.

·**Unit 5.** Tunnel Support Systems for Construction of Tunnels.

4. Textbooks/ Reference Book

a) Design of Tunnel Liners and Support Systems by Deere, D. U.; Peck, R. B.; Monsees, J. E.; Schmidt, B (Technical Report)

b) Guidelines for Design & Construction of Tunnels by RDSO, (Report No- RDSO/2012/GE: G-0017)

c) Guidelines for the Design of Tunnels by International Tunneling Association

5. Assessment

6. Course Outcome

7. Other Information

CE-534 Advanced Concrete Technology

1. General Information

1.1 Course Title: Advanced Concrete Technology

1.2 Course Number: CE 534

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-I (DE-)

1.5 Pre-Requisite: None

2. **Course Objective**

This course aims to provide comprehensive understanding of concrete, its basic constituents, quality control, and durability and time dependent proprieties. Course also aims to train students on how to do nominal mix design of concrete following the codal provisions to obtain the desired compressive strength. The study of this subject will develop analytical abilities related to concrete construction in terms of mix-design, quality control, and testing methodology for concrete used in construction.

3. Course Content

Unit 1: Constituent materials and their properties, types of cement, fresh concrete, workability **(9 Lectures)**

Unit 2: Strength, elasticity and fracture of hardened concrete **(6 Lectures)**

Unit 3: Time dependent properties of concrete, Durability of concrete (**6 Lectures)**

Unit 4: Concrete admixtures, mix design methods; Manufacture and processes; Codal provisions **(9 Lectures)**

Unit 5: Special concrete: Self Compacting Concrete, Self-healing Concrete, 3-D Printing of Concrete (**6 Lectures**)

4. Textbooks/ Reference Books

1. Concrete Technology: Theory and Practice by M.S. Shetty.
2. Concrete Technology by S.S. Bhavikatti
3. Concrete Technology by J.J. Brooks A. M. Neville
4. IS 456 -2009 PLAIN AND REINFORCED CONCRETE – CODE OF PRACTICE .
5. IS 10262: 2009 CONCRETE MIX PROPORTIONING -GUIDELINES.

5. Assessment

6. Course Outcome

7. Other Information

CE-528: Soil Structure Interaction

1. General Information

1.1 Course Title: Soil Structure Interaction

1.2 Course Number: CE-528

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-I (DE-)

1.5 Pre-Requisite: None

2. Course Objective

3. Course Content

Unit 1: Introduction to Soil-Structure interaction: Contact pressure distribution: rigid footings on flexible and rigid base, flexible footings on rigid and flexible base, Ground response analysis, critical aspects of SSI, free field motion, foundation input motion, Method of analysis of SSI problems: Direct approach, Substructure approach, Analysis using response spectrum and response functions

Inertial interaction: system identification, period lengthening ratio and foundation damping, impedance functions, non uniform soil profiles, foundation embedment, foundation shape, foundation flexibility

Kinematic interaction: Base slab averaging, embedment, wave scattering, transfer function, transmissibility, effect of foundation flexibility **(7 Lectures)**

Unit 2: Constitutive Models for Soil-Structure Analysis

Constitutive equations for elasticity, Plasticity, Viscoelasticity, Elastic Models: Winkler Model, Filonenko Borodich Model, Hetenyi Model, Pasternak Model, Kerr Model, Determination of modulus of subgrade reaction and factors affecting it, Non-linear models: Elasto-plastic representation of nonlinear response, Bilinear representation

Viscoelastic Models: Maxwell's model, Kelvin model, Burger's model **(7 Lectures)**

Unit 3: Beams on Elastic Foundations

Basic Concepts, Classification of beams according to their stiffness: Infinite beams, semi-infinite beams and finite beams, Differential equation of equilibrium of a beam on elastic foundations Solution of homogeneous differential equation

Derivation of particular integrals corresponding to concentrated vertical force, concentrated moment, uniformly distributed loads and uniformly varying load

Infinite, semi-infinite and finite beams on elastic foundations, Numerical examples **(7 Lectures)**

Unit 4: Buried Structures

Types of buried structures and their classification on the basis of stiffness Arching in Soils

Conduits: classes of underground conduits, factors affecting the interaction of conduit and soil, ditch conduits, positive

projecting conduits, negative projecting conduits, special conduits, loading behaviour of ditch conduits and projecting conduits **(7 Lectures)**

Unit 5: Analysis of Soil-Pile-Structure Interaction

Deep Foundations, Single pile/shaft behavior under axial loading: boundary conditions, tip behavior of a pile, soil resistance at the tip and introduction to Q-z curves, skin friction resistance and t-z curves. Laterally loaded piles: Resistance-Displacement representation, One dimensional response, determination of P-y curves **(6 Lectures)**

Unit 6: Modern trends in design of earth retaining structures **(5 Lectures)**

4. Textbooks/ Reference Book

1.1 TEXT BOOKS

1. Geotechnical Earthquake Engineering by Steven L. Kramer, Publisher: Pearson.
2. Elastic Analysis of Soil-Foundation Interaction by A.P.S. Selvadurai, Elsevier Science
3. Dynamic Soil-Structure Interaction by Jhon F. Wolf, Prentice-Hall Inc.

REFERENCE BOOKS:

1. Fundamental Concepts of Earthquake Engineering by Roberto Villaverde, CRC Press.
2. A report on Soil Structure Interaction in Practice by Constantine C. Spyrakos

5. Assessment

6. Course Outcome

7. Other Information

CE-524: Ground Improvement Techniques

1. General Information

1.1 Course Title: Ground Improvement Techniques

1.2 Course Number: CE-524

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-I (DE-1)

1.5 Pre-Requisite: None

2. Course Objective

3. Course Content

Unit- I Need of ground improvement.

Unit- II Shallow compaction, Deep Compaction, Preloading, Drainage, Vibrofloatation, Sand drains and geosynthetic drains.

Unit- III Mechanical stabilization, Chemical stabilization, Thermal improvement methods, Stone columns and Grouting.

Unit- IV Geosynthetics and other soil reinforcement methods, Soil nailing and Improvement by Confinement.

Unit- V Effect of environment on soil properties and Case Histories.

4. Textbooks/ Reference Book

1. Manfred R. Haussmann, “Engineering principles of ground modification”, Pearson Education Inc. New Delhi, 2008.

2. Robert M. Koerner- Construction and Geotechnical Methods in Foundation Engineering, Mc Graw Hill

3. F. G. Bell- Foundation Engineering in Difficult Ground, Butterworth, London, 1983

4. Purushothama Raj P.- Ground Improvement Techniques, Laxmi Publications (P) Ltd., New Delhi

5. Shashi K. Gulhati & Manoj Datta- Geotechnical Engineering, Tata Mc Graw Hill

6. G. L. Sivakumar Babu- An Introduction to Soil Reinforcement and Geosynthetics- 2007

5. Assessment

6. Course Outcome

7. Other Information

CE-515: Surface Water Hydrology

1. General Information

1.1 Course Title:Surface Water Hydrology

1.2 Course Number: CE-515

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-I (DE-1)

1.5 Pre-Requisite: None

2. Course Objective

3. Course Content

Unit 1: Description and classification of Hydrologic systems and processes: surface, sub-surface andchannel processes. **(10Lectures)**

Unit 2: Conceptual models, formulation of their structures and applications inHydrologic planning and design. **(10Lectures)**

Unit 3: Probabilistic and Statistical analyses of hydrologic dataincluding frequency analysis and Regional statistical analysis. **(10Lectures)**

Unit 4: Design Storms and designfloods. Stochastic processes and models, time series analysis, synthetic data generation and their application to stream flow situation. **(9 Lectures)**

4. Textbooks/ Reference Book

1. R.K. Linsley& J.L.H. Paulhus, 'Water Resource Engineering', McGraw Hill Book Co.

2. K. Subramaniya, 'Engineering Hydrology', Tata MacGraw Hill, New Delhi.

3. H.M. Raghunath, 'Ground Water', Wiley Eastern Ltd.

4. Todd, 'Groundwater Hydrology', John Wiley & Sons, New York.

5. Kevin Hiscock, 'Hydrology : Principle and Practices', Black-bell Publication.

6. Chow, V.T., Maidment, D.R. and Mays, L.W. (1988), "applied Hydrology", McGraw Hill Inc. N York

7. Singh, V.P. (1986), "Hydrologic Systems,", Prentice Hall Inc., N York

8. Haan C.T., (1995), "Statistical Methods in Hydrology", East West Press, New Delhi

9. Viessman, W., Lewis, G.L. and Knapp, J.W. (1989), "Introduction to Hydrology", Harper & Row Publications Inc., Singapore.

10. McCueen R.H. and Snyder, W.M. (1985), Hydrologic Modelling – Statistical Methods and Applications", Prentice Hall Inc. N York.

11. Ponce, W.F. (1987), “Engineering Hydrology”, Prentice Hll Inc. N York.

12. Kottegoda (1982), “Stochastic Processes in Hydrology”, Prentice Hall, Inc., N Jersey

13. Patra, K.C. Hydrology and Water resources Engineering, Narosa Publishing House, New Delhi

5. Assessment

6. Course Outcome

7. Other Information

CE-587: Construction Methods and Equipment

1. General Information

1.1 Course Title: Construction Methods and Equipment

1.2 Course Number: CE-587

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-I (DE-1)

1.5 Pre-Requisite: None

2. Course Objective

This course provides comprehensive information on guidelines for selection of equipment, estimation of cost and productivity of various equipment and determination of optimum replacement time of equipment.

3. Course Content

The emphasis of the course is on the construction equipment and the construction methods as relevant for infrastructure creation. Initially, the course introduces different types of infrastructure viz, transportation, irrigation and water supply, power and buildings. Subsequently the course delves into various components of infrastructure along with their specific requirements will be explained. The common elements across the infrastructure types will be introduced. Building on the knowledge from the general civil engineering courses, the course focuses on recent developments, equipment, practices and issues in Surveying, Earthwork in Excavation, Slope Stabilization, Ground Improvement, Earthwork in Embankment, Concrete – Production, Transportation and Placement, and formwork design. Besides the broad principles involved, specifications and quality requirements, and productivity and cost issues will also be addressed.

4. Textbooks/ Reference Book

Texts:

1. Peurifoy, R., Schexnayder, C., Shapira, A., & Schmitt, R. (2011). “Construction Planning, Equipment, and Methods” (8th ed.). McGraw-Hill.
2. Gransberg, D. D., Popescu, C. M., & Ryan, R. C. (2006). “Construction equipment management for engineers, estimators, and owners” (2nd ed.). CRC Press.

References:

1. Day, D. A., & Benjamin, N. B. H. (1991). “Construction equipment guide” (2nd ed.). John Wiley & Sons.
2. Harris, F. (1994). “Modern construction and ground engineering equipment and methods” (2nd ed.). Pearson Longman.
3. Nunnally, S. W. (2011). “Construction methods and management” (8th ed.). Prentice Hall.

5. Assessment

6. Course Outcome

7. Other Information

CE-502 Computational Methods in Engineering

1. General Information

1.1 Course Title: Computational Methods in Engineering

1.2 Course Number: CE 502

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-I (DE-3)

1.5 Pre-Requisite: None

2. Course Objective

This course provides an overview of the numerical techniques used to solve engineering problems in civil engineering. Topics include numerical analysis, numerical differentiation and integration, linear and nonlinear systems of equations, optimization, finite difference and finite element methods, and numerical solutions to differential equations. The course emphasizes applications to civil engineering problems, including structural analysis, soil mechanics, and fluid mechanics. The course is expected to lay foundation for students beginning to engage in research projects that involve numerical methods. Students will use MATLAB as a tool in the course. Experience with MATLAB is not required.

3. Course Content

Module 1: Introduction to Numerical Methods – Overview of numerical methods and their importance in civil engineering, general MATLAB commands and features, numerical errors and their impact on solution accuracy. [**7 lectures**]

Module 2: Solutions of linear and nonlinear equations – Bracketing methods, open methods, roots of polynomials, Gauss elimination, LU decomposition, matrix inversion, direct and iterative methods for solving linear systems of equations, Newton-Raphson method and other iterative methods for solving nonlinear systems of equations, applications of linear and nonlinear systems of equations in civil engineering problems case studies, and optimization. [7 **lectures**]

Module 3: Curve fitting – Least squares regression: linear regression, polynomial regression, multiple linear regression, nonlinear regression, Interpolation: Newton's method, Lagrange's method, inverse interpolation, spline interpolation, Fourier approximation: curve fitting with sinusoidal functions, continuous Fourier series, frequency and time domains, Fourier integral and transform, discrete and fast Fourier transform (DFT & FFT). [**7 lectures**]

Module 4: Numerical differentiation and integration – Newton Cotes formula: Trapezoidal rule, Simpson's rules, Integration: Newton-Cotes formula, adaptive quadrative, Gauss quadrature, Numerical Differentiation: Richardson extrapolation, derivatives of unequally spaced data, derivatives and integrals for data with errors, partial derivatives. [**7 lectures**]

Module 5: Ordinary Differential Equations – Runge-Kutta methods: Euler's method and its improvement, RK methods, system of equations, adaptive RK methods, Stiffness and Multistep methods, Boundary value and eigenvalue problems: general approaches, ODEs and software packages, stiff systems with applications in environmental engineering, boundary value problems in structural and environmental engineering. [7 **lectures**]

4. Textbooks/ Reference Book

Textbooks:

1. Numerical Methods for Engineers by Steven C. Chapra and Raymond P. Canale
2. Applied Numerical Methods with MATLAB for Engineers and Scientists by Steven C. Chapra
3. Numerical Analysis by Richard L. Burden and J. Douglas Faires

References:

1. Numerical Recipes: The Art of Scientific Computing by William H. Press, Saul A. Teukolsky, William T. Vetterling, and Brian P. Flannery
2. Finite Element Analysis: Theory and Application with ANSYS by Saeed Moaveni
3. The Finite Element Method: Its Basis and Fundamentals by O. C. Zienkiewicz and R. L. Taylor

5. Assessment

6. Course Outcome

7. Other Information

CE-585: Sub-Surface Investigation & Interpretation Works

1. General Information

1.1 Course Title: Sub-Surface Investigation & Interpretation Works

1.2 Course Number: CE-585

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-I (DE-1)

1.5 Pre-Requisite: None

2. Course Objective

3. Course Content

Unit 1. Subsurface Investigation Works: Introduction & its necessity in Underground Works, Contractual & Legal provisions pertaining to Subsurface investigation Works, Types of Subsurface Investigation Works, Budgeting for Geological Investigation Works.

Unit 2. Sub-surface exploration: Steps in geological studies of project site, engineering consideration of structural features, exploratory drilling, preservation of cores, core logging, graphical representation of core log, limitations of exploratory drilling method, numerical problems on core drilling, introduction to geological map Sub-surface water: Runoff, fly off and percolation of surface water, juvenile, connate and meteoric water, water table, zones of subsurface water, perched water table, aquifer theory.

Unit 3. Geophysical Exploration: Magnetic, Seismic, Gravitational and Electrical Resistivity methods, Real Time Probing/electrical conductivity monitoring systems, applications of electrical resistivity method using Wenner configuration in civil engineering problems such as: finding thickness of over burden and depth of hard rock, locating the spot for ground water well, seepage of water finding.

Unit 4. Geology of soil formations: Soil genesis, geological classification of soils, residual and transported soils, soil components, characteristics of soils derived from different types of rocks, nature of alluvium and sand from rivers of Deccan trap region, scarcity of sand.

Unit 5. Physico-Mechanical Properties of Rocks: Specific Gravity, Hardness, Porosity, Moisture Content, Permeability, Thermal Conductivity. Compressive, Tensile and Shear Strengths. Modulus of Elasticity. Poisson's Ratio and Triaxial Strength, Swell Index, Slake Durability, Point Load Index.

Rockmass Classification Systems: Rock Quality Designation (Rqd), Rock Mass Rating (Rmr) and Q-System- Their Applications in Structure Support

Unit 6. Rheological Models and Time Dependent Properties of Rocks.

Theories of Rock Failure and Post Failure Behaviour: Griffith, Mohr-Coulomb, Hoek and Brown Failure Criteria. Post-Failure Behaviour of Rock

Unit 7. Sub-Surface Utility Engineering (SUE): Pilot Tunneling, Latest Approaches & Recommendations to deal with variations & claims due to encounterance of unexpected geological strata

4. Textbooks/ Reference Book

5. Assessment

6. Course Outcome

7. Other Information

CE-584: Soil Retaining Systems in underground Works

1. General Information

1.1 Course Title: Soil Retaining Systems in underground Works

1.2 Course Number: CE-584

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-I (DE-1)

1.5 Pre-Requisite: None

2. Course Objective

3. Course Content

·**Unit 1. Soil Types & their Properties**, Principle of Soil Retention, Concept of Active/Passive Pressure.

·**Unit 2. Various Soil Retention Techniques**.

·**Unit 3. Design & Construction Methodology :** Soldier Piling, Secant Piling, Sheet Piling, Gabion Wall, Diaphragm Wall.

·**Unit 4** Applications, Advantages & Disadvantages of each type of retaining structures.

4. Textbooks/ Reference Book

5. Assessment

6. Course Outcome

7. Other Information

CE-583: Design of Underground Structures

1. General Information

1.1 Course Title: Design of Underground Structures

1.2 Course Number: CE-583

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-I (DE-1)

1.5 Pre-Requisite: None

2. Course Objective

The students would learn analysis of underground structures in rock and soil using elastic and elastoplastic stress-strain behavior of rock and soil, respectively. design of underground structure using empirical, analytical and numerical approaches use of codes and standards in design of underground structures

3. Course Content

Introduction. Types and classification of underground openings. Factors affecting design.

Design methodology. Functional aspects. Size and shapes. Support systems. Codal provisions.

Analysis: Stresses and deformations around openings, Stresses and deformations around tunnels and galleries with composite lining due to internal pressure, Closed form solutions, BEM, FEM.

Design: Design based on analytical methods; Empirical methods based on RSR, RMR, Q systems; Design based on Rock support interaction analysis; Observational method- NATM, Convergence-confinement method. Design based on Wedge failure and key block analysis. Design of Shafts and hydraulic tunnels.

Stability of excavation face and Tunnel portals.

Use of appropriate software packages.

4. Textbooks/ Reference Book

1. Hoek, E., Brown, E. Underground excavations in rock, CRC Press, 1980.

2. Leonard Obert, Wilbur I. Duvall, Rock mechanics and the design of structures in rock, Wiley, 1967.

3. Poulos, H.G. and Davis, E.H.: Elastic Solutions for soil and rock mechanics. John Wiley & Sons, 1974.

4. Bieniawski, Z.T. Rock mechanics in mining & tunnelling. A.A. Balkema, 1984.

5. Szechy, K. The art of tunnelling, Akadémiai Kiadó, 1973.

6. Goodman, R.E. Introduction to Rock Mechanics. John Wiley, 1980.

5. Assessment

6. Course Outcome

7. Other Information

CE-583: Instrumentation & Monitoring Techniques for Underground Works

1. General Information

1.1 Course Title: Instrumentation & Monitoring Techniques for Underground Works

1.2 Course Number: CE-583

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-I (DE-1)

1.5 Pre-Requisite: None

2. Course Objective

3. Course Content

Unit 1.·Building Condition Survey (BCS) : Introduction & its necessity in Underground Works, Contractual & Legal provisions pertaining to BCS, Types of BCS, Generation of BCS Report, Equipment Used in BCS and their Application.

Unit 2. Investigation Required during BCS: Detailed Investigations while conducting BCS, Important locations of distress & distress signs to be observed in a building during BCS, Sit Visit.

Unit 3 Instrumentation & monitoring (I&M) : Necessity of I&M in Underground Works, Contractual Provisions related to I&M scheme, Types of Instruments used in I&M Techniques

Unit 4. Real Time I&M Systems

Unit 5. Analysis of I&M Data : Relevant of Alert, Alarm & Action (AAA) Values, Common Complaints leading to litigation between the building owner and the client/contractor

Unit 6·Case Studies

4. Textbooks/ Reference Book

5. Assessment

6. Course Outcome

7. Other Information

Semester-II

MN-521: Underground Space Technology

1. General Information

1.1 Course Title: Underground Space Technology

1.2 Course Number: MN-521

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-II (DC-3)

1.5 Pre-Requisite: None

2. Course Objective

3. Course Content

Unit 1. Tunnel Driving Techniques: Drilling and blasting. Tunnel boring machines. Tunnel shield supports, remote control and automation of supports. Tunneling shield system with road headers. Tunnel lining – design, reinforcement and adhesives, changes of curvature, strain and stress measurement. Rock anchoring and bolting.

Unit 2. Design and Construction of Large Underground Excavations: Rock conditions and initial state of stress. Dimensions, shape, structural behaviour, methods and sequence of excavations.

Unit 3. Nature of Underground Works: Power stations. Storage caverns. Metro railways. Large diameter trenches for communication, radioactive disposal and excavation for defence purposes.

Unit 4. Stability Analysis: Structurally controlled instability, influence of size and in-situ stresses.

Unit 5. Instrumentation, monitoring and analysis.

4. Textbooks/ Reference Book

5. Assessment

6. Course Outcome

7. Other Information

CE-623: Applied Rock Mechanics

1. General Information

1.1 Course Title: Rock Mechanics

1.2 Course Number: CE-623

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-II (DC-4)

1.5 Pre-Requisite: None

2. Course Objective

3. Course Content

Unit 1. In-situ stresses: In-situ stresses in the earth's crust, methods of in-situ stress measurement

Unit 2 Stress Around Mine Opening: Distribution of Stresses around mine openings of various shapes

Unit 3. Design of Mine Openings and Pillars

Unit 4. Design of Supports: Roof bolting, Cable bolting, Roof stitching, Shotcreting, Support for Bord and Pillar and Longwall working Goaf Support, Mechanics of Caving and Filling

Unit 5. Rock Bursts and Bumps: Mechanism, Prediction and Control

Unit 6. Subsidence: Mechanism, Prediction and Control

Unit 7. Design of Shaft pillars

4. Textbooks/ Reference Book

5. Assessment

6. Course Outcome

7. Other Information

CE-680: BUILDING INFORMATION MODELLING (BIM) FOR UNDERGROUND PROJECTS

1. General Information

1.1 Course Title: BUILDING INFORMATION MODELLING (BIM) FOR UNDERGROUND PROJECTS

1.2 Course Number: CE-680

1.3 Contact Hours: 0-0-2, Credit 1

1.4 Semester offered: Semester-II (DP-2)

1.5 Pre-Requisite: None

2. Course Objective

3. Course Content

·**Module 1. BIM Management:** Information Management, Open BIM and Collaboration Practice.

·**Module 2. BIM for Design:** Coordination, Design Authoring with REVIT, Design Authoring with ArchiCAD, Analysis Tools Interoperability.

·**Module 3. BIM for Construction:** Pre Construction, Construction & Handover with BIM authoring Software, Coordination and Site Management.

·**Module 4. BIM for Asset Management:** Information Exchange in Asset Management.

·**Module 5. BIM Implementation:** Implementation of BIM in Underground Projects

4. Textbooks/ Reference Book

5. Assessment

6. Course Outcome

7. Other Information

CE-601 Structural Optimization and Reliability

1. General Information

1.1 Course Title: Structural Optimization and Reliability

1.2 Course Number: CE 601

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-II (DE-4)

1.5 Pre-Requisite: None

2. Course Objective

This course aims to provide comprehensive understanding of concepts and applications of structural reliability and design optimization with their computational aspects. The study of this subject will develop analytical abilities related to failure probability and structural optimization.

3. Course Content

Unit#1: (**6 Lectures**): Introduction to Design Optimization; Optimal Design Problem Formulation; Graphical Optimization and Basic Concepts, Optimum Design Concepts: Optimality Conditions; Optimal Design with MATLAB

Unit#2: (**4 Lectures**) Numerical Methods for Unconstrained Design Optimization; Numerical Methods for Constrained Design Optimization; Practical Applications of Optimization

Unit#3: (**4 Lectures**): Genetic Algorithm for Optimum Design; Multi-objective Optimum Design, Concepts and Methods

Unit#4: (**4 Lectures**) Fundamentals of probability theory; Common probabilistic models, General component reliability; First-order second-moment methods; First and Second-order reliability method

Unit#5: Importance measures and parameter uncertainty; Sampling techniques; Surrogate

Modelling, Development of reliability based design codes; System reliability

4. Textbooks/ Reference Book

1. Jasbir S. Arora, “Introduction to Optimum Design”, 3rd Ed., Academic Press
2. chintya Halder and Sankaran Mahadevan, “Probability, Reliability, and Statistical Methods in Engineering Design”, John Wiley.
3. O. Ditlevsen, and H. O. Madsen, “Structural Reliability Methods”, Internet Edition 2.3.7, John Wiley
4. A.H.S. Ang and W. H. Tang, “Probability Concepts in Engineering Planning and Design”, Vol. I : Basic Principles, Wiley.
5. R. E. Melchers, “Structural Reliability Analysis and Prediction”, 2nd Ed., Wiley.

5. Assessment

6. Course Outcome

(a) Compute first- and second-order estimates of failure probabilities of engineered systems;

(b) Compute sensitivities of failure probabilities to assumed parameter values;

(c) Measure the relative importance of the random variables associated with a system;

(d) Update reliability estimates based on new observational data;

(e) Identify the relative advantages and disadvantages of various analytical reliability methods, as well as Monte Carlo simulation;

(f) Use reliability tools to calibrate simplified building codes

7. Other Information

CE-631 Finite Element Method

1. General Information

1.1 Course Title: Finite Element Method

1.2 Course Number: CE 631

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-II (DE-3)

1.5 Pre-Requisite: None

2. Course Objective

3. Course Content

UNIT I: Approximate Solution Of Boundary Value Problems: Methods of weighted residuals, Ritz Methods, Approximate solution using variation method, Modified Galerkin Method, Boundary conditions and general comments, Two dimensional example **(5 Lectures)**

UNIT II: Basic Finite Element Concepts: Basic concepts of Calculus of Variation, Hamilton's Principle, Governing Equation, Weak Form, Derivation of Stiffness Equation **(5 Lectures)**

UNIT III: Isoparametric FE Approximation: Truss Element**,** Natural coordinates for triangles, quadrilateral, tetrahedral and hexahedron elements, Shape functions for elements, Natural coordinate mapping, Numerical integration.**(5 Lectures)**

UNIT IV: Two & Three Dimesnional Problems: Plane stress, Plane strain and axisymmetric problems, Discretization, Imposing Boundary Condition: Constraint Equations: Direct Approach and Penalty Approach . **(5 Lectures)**

UNIT V: Scalar Field Problems: Steady state heat transfer, Torsion, Potential flow and Seepage, Electrical and magnetic field problems. **(7 Lectures)**

UNIT VI: Computer Application of FEM: Algorithm of FEM Programming, Development of MATLAB FEM modules, Application of FEM software to various field problems discussed above and validation. **(7 Lectures)**

UNIT VII: Advances in FEM: Meshless Method, eXtended Finite Element Method (XFEM), Iso-Geometric Analysis (IGA), Particle Methods . **(7 Lectures)**

4. Textbooks/ Reference Book

1. Chandrupatla T . R., and Belegundu, A. D., Introduction to Finite Elements in Engineering, Prentice Hall, 2003.

2. Krishnamoorthy C.S., Finite Element Analysis: Theory & Programming, TMH, New Delhi, 1994.

3. Zienkiewicz, O.C. and Taylor, R.L., The Finite Element Method, 6th Ed., Vol. 1, Elsevier, 2005.

4. Reddy J.N., An Introduction to FEM, McGraw Hill Book Company,

5. Bathe K.J., Finite element procedures, Prentice Hall, 1996

6. Daryl L. Logan, A first course in finite element method (3rdEdition), Thomson, India Edition

7. Cook R.D., Malkus and Plesha, Concepts and applications of Finite element analysis: John Wiley and Sons, 2003

8. Kenneth Heubner et.al., The Finite Element Method foe Engineers, John iley & Sons, 2004.

5. Assessment

6. Course Outcome

7. Other Information

CE-632 Theory of Plates and Shells

1. General Information

1.1 Course Title: Theory of Plates and Shells

1.2 Course Number: CE 632

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-II (DE-4)

1.5 Pre-Requisite: None

2. Course Objective

This course covers a range of topics including the derivation of elastic and plastic stress-strain relations for plate and shell elements, bending and buckling of rectangular plates, non-linear geometric effects, post-buckling and ultimate strength of cold formed sections and typical stiffened panels in naval architecture, general theory of elastic and axis-symmetric shell, buckling, crushing, and bending strength of cylindrical shells with application to offshore structures.

3. Course Content

1. Strain-Displacement Relation for Plates [3 Lectures]: 1-D Strain Measure, Engineering Strain, Green-Lagrangian Strain, 3-D Strain Measure, Derivation of Green-Lagrangian Strain Tensor for Plates, Specification of Strain-Displacement Relation for Plate

2. Derivation of Constitutive Equation for Plates [3 Lectures]: Definition of Bending Moment and Axial Forces, Bending Energy, Bending Moment, Bending Energy Density, Total Bending, Membrane Energy, Axial Force, Membrane Energy Density, Totally Membrane Energy

3. Development of Equation of Equilibrium and Boundary Conditions Using Variational Approach [6 Lectures]: Bending Theory of Plates, Total Potential Energy, First Variation of the Total Potential Energy, Equilibrium Equation and Boundary Conditions, Specification of Equation for Rectangular Plate

4. General Theories of Plate [8 Lectures]: Bending Theory of Plates, Membrane Theory of Plates, Mindlin Plate Buckling Theory of Plates, General Equation of Plate Buckling, Linearized Buckling Equation of Rectangular Plate, Analysis of Rectangular Plate Buckling, Derivation of Rayleigh-Ritz Quotient, Large Deflection Theory

5. Buckling of Shell [8 Lectures]: Governing Equations for Buckling of Cylindrical Shells, Derivation of Linearized Buckling Equation, Buckling under Axial Compression, Buckling under Lateral Pressure, Buckling under Hydro-static Pressure, Buckling under Torsion, Influence of Imperfection and Comparison with Experiments.

4. Textbooks

1. Don. O. Brush and Bo. O. Almroth: Buckling of Bars, Plates and Shells, McGraw-Hill Inc, 1975, ISBN-10:0070085935
2. Timoshenko, Stephen P., and Woinowsky Krieger, Theory of Plates and Shells, 2nd ed. New York, NY, McGraw-Hill Companies, 1959, ISBN:0070647798

Reference Book

1. Eduard Ventsel, Theodor Krauthammer, Thin Plates and Shell, Theory, Analysis and Application, CRC Press, 2001
2. Timoshenko, Stephen P., and Gere James M., Theory of Elastic Stability, 2nd ed McGraw Hill Education, 2017, ISBN-10:9780070702417

5. Assessment

6. Course Outcome

Upon completion of the course, students should be able to

1. Analyze the deformation and stress states of plates and shells under various loading using appropriate mathematical techniques and numerical methods
2. Analyze the buckling and stability of plates and shells and predict their failure modes
3. Design thin plates and shells to meet the desired specifications and safety requirements.
4. Understand and application of modern computation tools and software for analysis and design of thin, plates, and Apply the knowledge gained in the course to real-world engineering problems related to thin plates and shells.

7. Other Information

CE-684: Quality Assurance & Quality Control in Underground Works

1. General Information

1.1 Course Title: Quality Assurance & Quality Control in Underground Works

1.2 Course Number: CE-684

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-II (DE-4)

1.5 Pre-Requisite: None

2. Course Objective

3. Course Content

Unit 1 Diverse nature of construction projects, definitions, stakeholders, specifications, compliance, acceptance, relating quality of materials, components and system, factors influencing quality and safety, contracts, inspection, cost of quality and safety, processes and products, archiving records;

Unit 2. Concepts of quality control: Objectives, definitions, systems, ISO 9000 family of standards, third-party certification, QC in construction and large projects (aircraft, ship building);

Unit 3. Basic construction safety: Hazards, human factors in construction safety, introduction to occupational health and safety, problem areas in construction safety, elements of an effective safety program, job-site safety assessment, safety planning, safety audit;

Unit 4. Legal issues in quality: Regulatory framework, Third-party certification Process

Unit 5. Case studies and examples: Quality and safety issues in steel construction, concrete construction (including pre-cast, pre-stressed), tunnelling, bridges (not all need be covered)

4. Textbooks/ Reference Book

5. Assessment

6. Course Outcome

7. Other Information

CE-682: SHE Practices in Underground Space Construction

1. General Information

1.1 Course Title: SHE Practices in Underground Space Construction

1.2 Course Number: CE-682

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-II (DE-4)

1.5 Pre-Requisite: None

2. Course Objective

3. Course Content

Unit 1. Factors affecting safety in Underground Works: Contract Conditions, Location, Social Awareness, Literacy Rate etc.

Unit 2. Introduction to Occupational Health, Safety & Environment (HSE), problem areas in construction safety, elements of an effective safety program, job-site safety assessment, Safety Planning, HSE Audit.

Unit 3 Safety Challenges in tunneling Works: Introduction to BS6164, Fire Hazard & Fire Mitigation in Tunneling Works, Emergency Planning & Preparedness, Material Handling at Site, Safe Practices during Cut & cover Works, TBM Launching, Operations & Retrieval works, Cross Passage Construction & other NATM Works, Setting up and operation of Casting Yard & Batching Plants.

Unit 4. Global Advancements in Underground Safety Practices: Health Assurance in Underground Construction Works, Best Environmental Conservation Practices for Sustainable Underground Space Engineering Works.

Unit 5. Budgeting for HSE Assurance at Sites: Legal issues in quality and safety: Regulatory framework, labour laws, compensation.

Unit 6. Safety engineering: Training, audit, management practices, safety planning, PPE, construction accidents: nature, causes, investigation and reporting accidents.

Unit 7. Case studies and Site Visits.

4. Textbooks/ Reference Book

5. Assessment

6. Course Outcome

7. Other Information

CE-681: Advanced Course on TBM Tunneling

1. General Information

1.1 Course Title: Advanced Course on TBM Tunneling

1.2 Course Number: CE-681

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-II (DE-4)

1.5 Pre-Requisite: None

2. Course Objective

3. Course Content

Unit 1. Introduction to TBM Tunneling, Advent of Tunnel Boring Machines & their Evolution over Time, Types of TBMs & their Components, Function of each Component of TBM.

Unit 2. Principle of working of various types of TBM, Selection of TBM based upon the site conditions.

Unit 3. TBM testing Procedure (FAT & SAT), Site Assembly of TBM.

Unit 4. TBM Launching & TBM Retrieval: Commencement of Initial Drive of TBM, Main Drive of TBM and its advancement, Construction of Mid Shafts & Cross Passages.

Unit 5. Set Up of Casting Yard, Casting of Tunnel Segments.

Unit 6. Safety, Health & Environmental Issues Related to Tunneling by TBM

Unit 7. Design Principle for Design of Tunneling by TBM.

4. Textbooks/ Reference Book

5. Assessment

6. Course Outcome

7. Other Information

CE-685: Construction Project Management

1. General Information

1.1 Course Title: Construction Project Management

1.2 Course Number: CE-685

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-II (DE-4)

1.5 Pre-Requisite: None

2. Course Objective

3. Course Content

Unit 1. Fundamentals: Overview of project management, project, stakeholders, role of project manager, stages in planning a project, developing an objective or goal for the project, project risk plan, work breakdown or organizational structure,

Unit 2 Scheduling project work: workable schedule, project control and evaluation, managing the project team.

Unit 3. Project Management: Scope Management, Integration Management, Time Management, Cost Management, Quality Management, Human resource Management, Communication Management, Risk and safety Management, Procurement Management, Stakeholders Management

Unit 4. Dispute Litigation

4. Textbooks/ Reference Book

5. Assessment

6. Course Outcome

7. Other Information

CE-686: Infrastructure Assets Management

1. General Information

1.1 Course Title: Infrastructure Assets Management

1.2 Course Number: CE-686

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-II (DE-4)

1.5 Pre-Requisite: None

2. Course Objective

3. Course Content

Unit 1. Basic discussion of concepts of infrastructure assets and their management, performance of infrastructure assets, stakeholders involved, along with factors affecting the demand and supply of public works services; relating infrastructure and economic development;

Unit 2. Strategies for financing public works; performance indicators and measures;

Unit 3. Framework for Infrastructure Management: Design for reliability, maintainability, support-ability, and service life; Inventory and database management; Condition assessment; Performance modelling and failure analysis; Maintenance strategies, Life-cycle cost and benefits analysis;

Unit 4. Introduction to the basic policies and initiatives of the Government in the area of infrastructure asset creation and management (JNNURM, Smart cities, etc.);

Unit 5. Case studies including Bridge Management Systems, Pavement Management System, Pipeline management, Hydro- system Asset Management

4. Textbooks/ Reference Book

5. Assessment

6. Course Outcome

7. Other Information

CE-687: Public Policy and Governance for Infrastructure

1. General Information

1.1 Course Title: Public Policy and Governance for Infrastructure

1.2 Course Number: CE-687

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-II (DE-4)

1.5 Pre-Requisite: None

2. Course Objective

.

Help government officials from developing countries in Asia and other experts develop critical thinking, problem-solving, and leadership skills essential for designing and implementing policy reforms that facilitate private investment in infrastructure projects

Provide lessons that empower participants to advance infrastructure investment- friendly reforms under unfavourable economic, financial, political, and cultural conditions

3. Course Content

The course will feature case studies and group exercises on providing public goods, bypassing bureaucratic obstacles, facilitating investment, and the state as an economic catalyst. Through interactive lectures, the program will explore how to effectively set priorities, sequence actions, and build coalitions to achieve policy changes, even under adverse domestic conditions

4. Textbooks/ Reference Book

5. Assessment

6. Course Outcome

- ·Enhanced capacity of government officials from developing Asia and experts to address the public policy challenges of infrastructure growth
- ·Network development and greater impetus for innovative policy dialogue and collaboration among participating government officials and experts

7. Other Information

CE-683: Safety and Disaster Management in Tunneling

1. General Information

1.1 Course Title: Disaster Management and Planning in Tunneling

1.2 Course Number: CE-683

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-II (DE-4)

1.5 Pre-Requisite: None

2. Course Objective

3. Course Content

Unit 1. Introduction to Safety: Concept of Safety, Importance of industrial safety, Safety scenario in Indian mines

Unit 2 Accident Analysis and Control: Concept of an accident, accident classification, Causes of accidents; Domino sequence, Unsafe acts and conditions; Safety performance measures, Documentation of accidents, Accident investigation and analysis; Role of supervisory staff and safety committee for accident prevention.

Unit 3. Hazard, Risk Issues and Hazard Assessment: Concept of hazard, hazard monitoring, assessment; Risk management, Stochastic models for accident prediction, Consequence modeling, Preliminary hazard analysis (PHA), Hazard operability studies (HAZOP), Safety warning systems, Safety Management Plan

Unit 4. Behavioural Safety: Human behavioural study; Human error analysis

Unit 5. Safety Audit: Components of safety audit, Audit methodology, Non conformity reporting (NCR), Audit Checklist and report.

Unit 6. Safety Management: Principles of safety management – Workplace design, Development of safety culture, Safety Barrier; Promoting Safety at workplace

Unit 7. Systems Safety: Systems engineering approach to safety management.

4. Textbooks/ Reference Book

5. Assessment

6. Course Outcome

7. Other Information

CE-688: CONTRACT MANAGEMENT OF UNDERGROUND WORKS

1. General Information

1.1 Course Title: CONTRACT MANAGEMENT OF UNDERGROUND WORKS

1.2 Course Number: CE-688

1.3 Contact Hours: 3-0-0, Credit 3

1.4 Semester offered: Semester-II (DE-4)

1.5 Pre-Requisite: None

2. Course Objective

3. Course Content

Unit 1. Introduction to Conditions of Contract : Definition & Characteristic of a legal Contract, Types of Construction contracts, Features of EPC Contract, Tendering Process, General Obligations of the Client, Contractor & Designer in an EPC Contract, Indian Conditions of Contract, FIDIC Conditions of Contract, JICA Conditions of Contract, ADB Conditions of Contract.

Unit 2. Claims & Variations: Difference between Variation & claims, Frequent Reason for variation & claims.

Unit 3. Mitigation of Claims: Mitigation measures at Planning Stage to avoid occurrence of variations & claims, Mitigation measures at Tendering Stage to avoid occurrence of variations & claims, Mitigation measures during Execution Stage to avoid occurrence of variations & claims, Record Maintenance at Worksites to mitigate claims and variations.

Unit 4. Delays, suspension & Termination of Works: Possible reasons for delys, Dealing with contractual delays, Responsibility sharing between client and contractor for delays in underground works, Suspension of the works and conditions leading to suspension, Termination of the works and conditions leading to termination, Suspension/Termination Proceedings to avoid legal disputes.

Unit 5. Conciliation & Arbitration Proceedings : Introduction to Conciliation & Arbitration Proceedings, Frequent Reasons for Occurrence of Disputes in Underground Works, Ambit of Conciliation & Arbitration Processes and further Avenues, Merits & Demerits of Conciliation & Arbitration Proceedings.

Unit 6. New Approaches for Amicable Dispute Resolution Process.

4. Textbooks/ Reference Book

5. Assessment

6. Course Outcome

7. **Other Information**