Course Type	Course Code	Name of the Course	L	T	P	Credits
DC	NMNC522	Excavation Methods for Tunnels and Caverns	3	1	0	4

Course Objective
• The students will learn theoretical aspects of tunnel and cavern excavation methods. The subject will help in understanding the applicability of excavation techniques with respect to ground conditions and its cost benefits.

Learning Outcomes
• The students will learn about various techniques of tunnel excavation and will be able to translate the knowledge in the field.

Units	Course Content	L+T	Learning Outcomes
Unit 1	**Introduction to Tunnel and underground space:** Scope and application, art of tunnelling, future tunnelling considerations, size, shape, purpose, geological aspects	(2L + 1T)	Introduction and scope of tunnels in various conditions
Unit 2	**Excavation Methods:** Types and purpose of tunnels; factors affecting choice of excavation technique; Methods: soft ground tunnelling, hard rock tunnelling, shallow tunnelling, deep tunnelling; Shallow tunnels – cut and cover, cover and cut, pipe jacking, jacked box excavation techniques, methods of muck disposal, supporting, problems encountered and remedial measures.	(9L + 3T)	Excavation methods for tunnelling and their applications
Unit 3	**Excavation by Drilling and Blasting:** Unit operations in conventional tunnelling; Drilling - drilling principles, drilling equipment, drilling tools, drill selection, specific drilling, rock drillability factors; Blasting - explosives, initiators, blasting mechanics, blast holes nomenclature; types of cuts- fan, wedge and others; blast design, tunnel blast performance - powder factor, parameters influencing, models for prediction; mucking and transportation equipment selection. Controlled blasting techniques, over break estimation and control, problems of drilling and blasting for large tunnels and caverns, cost calculations.	(9L + 4T)	Drilling and blasting for tunnel excavation
Unit 4	**Mechanized excavation Techniques:** Introduction and advantages of shield tunnelling; classification; different types of shields tunnelling techniques- Conventional shields, EPBS, segmental lining, cost calculations ***Tunnelling by Roadheaders and Impact Hammers***: Cutting principles, method of excavation, selection, performance, limitations and problems.	(10L + 2T)	Mechanized excavation for tunneling

	Tunnelling by Tunnel Boring Machines: Boring principles, method of excavation, selection, performance, limitations and problems; TBM applications.		
Unit 5	**Excavation of large and deep tunnels and Caverns:** Introduction; purpose and use; excavation issues; excavation methods- unit operations, different equipment, types of rock pressure and methods to deal, roof and wall supports, case studies from hydel, road and rail tunnels, ground treatment for adverse conditions.	(5L + 2T)	Excavation methods for deep tunnels and caverns with case studies
Unit 6	**Miscellaneous:** **Twin tunnels:** Excavation process, case study of a twin tunnel project **Services:** Ventilation, drainage and pumping. **Methods of Sinking Shafts:** Vertical and inclined, decline; shaft/raise boring machines and their application.	(7L + 2T)	
	Total	**56** **(42 L + 14T)**	

Textbooks:

1) Design and construction of tunnels by Pietro Lunardi, Springer-Verlag Berlin Heidelberg 2008.

Reference Books:

1) Tunnelling design, stability and construction by Barry N. Whittaker, Russell C. Frith, 1990, Technology & Engineering, 460 pages.
2) Drilling and Blasting of Rocks by C. Lopez Jimeno, E. Lopez Jimeno, Francisco Javier Ayala Carcedo (1995).