

**Faculty of Science and Technology
Savitribai Phule Pune University
Maharashtra, India**



<http://unipune.ac.in>

Honors* in Metro Construction

**Board of Studies
(Civil Engineering)
(with effect from A.Y. 2021-22)**

http://unipune.ac.in/university_files/syllabi.htm

Dear Students

It gives me an immense pleasure to introduce a state-of-the-art course on Metro-construction as an Honors Program under Civil Engineering Curriculum starting from June 2021. The honors courses will start from TE civil and will continue in BE as well. Students are referred to

http://collegecirculars.unipune.ac.in/sites/documents/Syllabus2020/Rules%20and%20Regulations%20of%20Honors%20and%20Minors_17.02.2021.pdf

for details about the honors program.

Metro rail system is about to become a major transportation medium in India in Metro cities and two-tire cities as well. The Metro having different names as Tube, Subway, Metro, Ubahn, Sbahn is already a popular means of transportation in all the major cities of the world. It's a high time that we at the University level should include this as a part of our curriculum. We the Board of Civil of Engineering are introducing the honors course on Metro-construction from June 2021 starting at TE. In our opinion it would give another opening to students pursuing their BE (Civil) under the aegis of Savitribai Phule University. I thank all the faculty members involved in framing the syllabus of this honors program. I would like to thank all the Board of Studies members for unanimously approving this honors program. Finally I would like to thank the faculty of Science and Technology, Dean faculty of Science and Technology, Hon. members of the academic council and Hon. Vice Chancellor for giving the necessary approval to start this program.

Prof. Shreenivas Londhe
Chairman BOS (Civil Engineering)
SPPU Pune

Savitribai Phule Pune University
With effect from 2021-22

Honors* in Metro Construction

Year & Semester	Course Code	Course Title	Teaching scheme Hours/week			Examination Scheme and Marks						Credit Scheme		
			Theory	Tutorial	Practical	Mid-Semester	End-Semester	Term work	Practical	Presentation	Total Marks	Theory / Tutorial	Practical	Total Credit
T E & V	301301	Surveying in Metro construction	4	--	--	30	70	--	--	--	100	04	--	04
	301302	Surveying in Metro construction -Lab	--	--	02	--	--	50	--	--	50	--	01	01
		Total	4	--	02	100		50	-	-	150	04	01	05
Total Credits = 05														
TE &VI	301303	Planning and Quantity estimation for metro construction	4	--	--	30	70	--	--	--	100	04	--	04
		Total	4	--	--	100		--	--	--	100	04	--	04
Total Credits = 04														
BE & VII	401301	Work Method Statement Making	4	--	--	30	70	--	--	--	100	04	--	04
	401302	Work Method Statement Making-Lab	--	--	02	--	--	50	--	--	50	--	01	01
		Total	4	--	02	100		50	--	--	150	04	01	05
Total Credits = 05														
BE & VIII	401303	Tunnel Engineering	4	--	--	30	70	--	--	--	100	04	--	04
	401304	Seminar	--	2	--	--	--	--	--	50	50	02	--	02
		Total	4	2	--	100		--	--	50	150	06	-	06
Total Credits = 06														
Total Credit for Semester V+VI+VII+VIII = 20														
* <u>To be offered as Honours for Major Disciplines as-</u>														
1. Civil Engineering														
<u>For any other Major Disciplines which is not mentioned above, it may be offered as Minor Degree.</u>														

SEMESTER V

Savitribai Phule Pune University, Pune
TE Civil (2019 Pattern) w. e. f. June 2021

Honors in* Metro Construction

301301: Surveying in Metro construction

Teaching scheme	Credit	Examination scheme
Lectures: 04 Hours/week	04	In semester exam: 30 Marks End semester exam: 70 Marks

Course Contents

Unit I: History and General Features of Indian Metro Railway (08 Hours)

Developments in Indian Metro Railway in India. The first rapid transits system in India was Kolkata Metro. Kolkata Metro, Delhi Metro, Bengaluru Metro, Mumbai Metro, Jaipur Metro

Unit II: Developments in Indian Metro (08 Hours)

Developments in Indian Metro Railways, Different Modes of Transport, Organization of Indian Metro Railways, Indian Metro Railway Finances and their Control, Commission of Metro Railway Safety, Long-term Corporate Plan of Indian Metro Railways, General Features of Indian Metro Railways, Important Statistics of Indian Metro Railways.

Unit III: Alignment of Metro Railway Lines (08 Hours)

Importance of Good Alignment, Basic Requirements of an Ideal Alignment, Selection of a Good Alignment. Engineering Surveys and Construction of Metro Railway Need for Construction of a New Metro Railway Lines, Preliminary Investigations for a Metro Railway, Traffic Survey, Reconnaissance Survey, Preliminary Survey, Preliminary Engineering-cum-traffic Survey, Final Location Survey, Modern Surveying Techniques for Difficult Terrain, Construction of New Lines of Metro Railway

Unit IV: Track and Track Stresses (08 Hours)

Requirements of a Good Track, Maintenance of Permanent Way, Track as an Elastic Structure, Forces Acting on the Track Tunnel Railways

Unit V: Requirements for Metro -Station (08 Hours)

Metro Railway Stations and Yards, Purpose of a Metro Railway Station, Selection of Site for a Metro Railway Station, Facilities Required at Metro Railway Stations, Requirements of a Passenger Metro Railway Yard, Classification of Metro Railway Stations, Station Platforms, Main Building Areas for different Types of Metro Stations.

Unit VI: Construction of New Metro Railway Lines and Track Linking of Metro Railway Tunnelling (08 Hours)

Necessity/Advantages of a Tunnel, Tunnel Alignment and Gradient, Size and Shape of a Tunnel, Methods of Tunnelling, Ventilation of Tunnels, Lighting of Tunnels, Drainage of Tunnels , Shaft of Tunnels , Lining of Tunnels , Maintenance of Railway Tunnels, Safety in Tunnel Construction.

Text Books

- 01 Metro Rail Projects in India: A Study in Project Planning Book by M. Ramachandran
- 02 Urban rail transit construction technology demonstration project: Guangzhou Metro Line Paperback – January 1, 2000 by LU GUANG LIN. CHEN SHAO ZHANG (Author)
- 03 The Metro Railway Corporation and Maintenance ACT 2002

PART A – Act

Indian Railway Board Act, 1905

The Railways Act, 1989

Railway Protection Force Act, 1957

PART B – Codes

Indian Railways Administration and Finance an Introduction

Indian Railways Code for the Accounts Department Part - I

Indian Railways Code for the Accounts Department Part – II

Indian Railways Establishment Manual Volume-I

Indian Railways Establishment Manual Volume-II

Indian Railway Commercial Manual Volume-I



SEMESTER V

Savitribai Phule Pune University, Pune
TE Civil (2019 Pattern) w. e. f. June 2021
Honors in* Metro Construction

301302: Surveying in Metro construction: Lab

Teaching scheme	Credit	Examination scheme
Practical: 02 Hours/week	01	TW: 50 Marks

Any Eight experiments

1. To transfer level from permanent benchmark to different location of metro project.
2. Setting out curve of metro alignment.
3. Setting out closed traverse as a reference line for metro construction.
4. Setting out of foundation for metro line.
5. Transfer of Centre line on Pile cap.
6. Metro alignment details on AutoCAD sheet.
7. Visit to completed metro project.
8. Hydrographic survey on riverbed for metro alignment.
9. GIS analysis for metro alignment.
10. Visit to ongoing Metro construction project

SEMESTER VI

Savitribai Phule Pune University, Pune

TE Civil (2019 Pattern) w. e. f. June 2021

Honors in* Metro Construction

301303: Planning and Quantity estimation for metro construction

Teaching scheme	Credit	Examination scheme
Lectures: 04 Hours/week	04	In semester exam: 30 Marks End semester exam: 70 Marks

Course Contents

Unit I: Preparation of plans and estimates of Metro Railway (08 Hours)

Metro railway of infrastructure; Typical Metro railway planning steps; Planning and appraisal of major Metro railway projects; Screening of project ideas; Life cycle analysis of Metro railway; Multi-criteria analysis for comparison of Metro railway construction alternatives; Procurement strategies; Scheduling and management of planning activities of construction.

Preparation of plans and estimates: Preparation of Plans General procedure; preparation of plans, sizes of drawings; titles and numbering of drawings; scale of drawings; details on drawings; symbols and colours of drawings. Preparation of Estimates - Preparations of estimates – Code rules; technical details, rates and quantities; schedule of rates and price, special features of estimates; Supplementary Estimates.

Unit II: Economic Analysis of Metro Railway Project (08 Hours)

Economic Analysis of Metro Railway Project– Concepts and Applications, Principles of methodologies for economic analysis of public works, Social welfare function, indifference curves and tradeoffs, Demand curves and price elasticity's; Benefit-cost ratio and internal rate of return; Shadow pricing; Accounting for risk and uncertainty;

Unit III: Acquisition of Land ACT of Metro Railway (08 Hours)

ACT and Policies relevant of Project, Right of Fair Compensation and Transparency in Land Acquisition and resettlement and rehabilitation ACT 2013, Maharashtra guidelines and Rules for Land Acquisition.

Unit IV: Details Estimate of Metro construction projects (08 Hours)

Elevated section (viaduct), Underground section by Tunnel Boring Machine (TBM) excluding station box, Underground section by Cut and Cover, Station Buildings, Elevated Station excluding viaduct (Civil work), Elevated station (E&M work including lift and escalator), Underground station (Civil work), Underground station (E&M work including ECS, TVS, Lift and Escalator), Permanent way

Unit V: Financial Evaluation of Metro Railway (08 Hours)

Financial Evaluation - Time value of money, Investment criteria, Project cash flows – elements and basic principles of estimation, Financial estimates and projections, Cost of capital, Rate of return; Project risk analysis; Political and social perspectives of infrastructure planning; Case studies

Unit VI: Construction Contracts (08 Hours)

Construction Contracts of Metro Railway Project - Contract Specifications, types of contract documents used for construction, Contract Procurement - selecting a contractor, Introduction to BOT and BOOT projects, EPC contracts

Text Books

- 01 Projects: Planning, analysis, selection, financing, implementation, and review, P. Chandra, Tata McGraw-Hill, New Delhi, 2009.
- 02 Project financing - Asset-based financial engineering, J. D. Finnerty, John Wiley & Sons, New York, 1996.
- 03 Infrastructure planning handbook: Planning, engineering, and economics, A. S. Goodman and M. Hastak, McGraw-Hill, New York, 2006
- 04 Infrastructure planning, J. Parkin and D. Sharma, Thomas Telford, London, 1999.
- 05 Laws Relating to Building and Engineering Contracts in India, Gajaria G.T., M.M. Tripathi Private Ltd., Bombay, 1982.
- 06 Computer-based construction project management, T. Hegazy, Prentice Hall, New Jersey, 2002.
- 07 Project management in construction, 5th ed., S. M. Levy, McGraw Hill, New York, 2007.
- 08 A guide to the project management body of knowledge, PMI, 3rd ed., Project Management Institute, Pennsylvania, 1996.
- 09 Planning and controlling construction projects, M. Mawdesley, W. Askew and M. O'Reilly, Addison Wesley Longman Limited, Essex, 1997.
- 10 Value management of construction projects, J. Kelly, S. Male and D. Graham, Blackwell Publishing, Oxford, 2003.
- 11 Handbook of Construction Management, Joy P.K, Mac Millan Publications, 1991

SEMESTER VII

Savitribai Phule Pune University, Pune
BE Civil (2019 Pattern) w. e. f. June 2022
Honors in* Metro Construction
401301: Work Method Statement Making

Teaching scheme	Credits	Examination scheme
Lectures: 04 Hours/week	04	In semester exam: 30 Marks End semester exam: 70 Marks

Course Contents

Unit – 1: Introduction

(08 Hours)

Brief on activities involved for construction of Metro, sequence / order of its execution. **Survey:** Preliminary survey – establishing route alignment, identification of hindrances and its diversion, traverse closing, setting up of Temporary Bench Marks & control points. **Barricading:** Erection of hard barricades and utility trenching, diversion of underground utilities. **Geotechnical investigations:** RQD, core recovery, Unconfined compressive strength, determining type of foundation, point load test, RMR values, SPT & N-values. **Type of Bearings:** Elastomeric, POT PTFE (free, guided fixed), spherical, etc. **Construction chemicals:** for grouting of bearings / PT ducts, segmental bonding agents, anchorage protection, old to new concrete, corrosion inhibitors, low viscosity injection grouts.

Unit – 2: Pile Foundations

(08 Hours)

Method statement for Pile Foundation

Roles & Responsibility, Project In charge, Site Engineer, QA/QC Engineer, Safety Officer, Supervisor/Foreman, Charge hand, Inspection & Testing, Work Permits, Health, Safety And Environmental Procedures, Quality Assurance & Control, Materials, Manpower, Equipment & Tools, Work Procedure, Placing of concrete, Compacting / vibrating of concrete. Termination criteria, applicable codes and standards.

Method Statement for Low Strain Integrity Test on Pile, Cross Hole Sonic Logging and dynamic load test

Understanding Pile Integrity, cross hole sonic logging Testing and dynamic load test's scope of Work and Application, Test Equipment's, Site Arrangements, Test Procedures, Roles and responsibilities of Project Manager, Deputy Project Manager, Engineers, Survey Engineer/Surveyor, QA/QC Manager/ QC Engineer, Chief SHE Manager, Data Processing, Materials, Environment, Health & Safety, Weather Limitations, Post Casting Activities, Formats & Checklist, Preamble & Scope, Reference Documents, applicable codes and standards.

Method Statement for Initial Vertical load test, Routine vertical load test and Lateral Pile Load Test

Responsibilities, Project Manager, Deputy Project Manager Engineers, Survey, Engineer/Surveyor, QA/QC Manager/ QC Engineer, Chief SHE Manager, machinery and equipment's, methodology, Design & drawings, Inspection plan, Test pile information, Method of Loading, Determination of pile capacity, Determination of lateral capacity of file, Load test Equipment, Recording observation / settlement, applicable codes and standards.

Unit – 3: Pile cap and Open foundations

(08 Hours)

Method statement for Excavation

Method of excavation, safety measures, Construction Drags, Levels/Co-ordinates, Barricading, Workers Training, Proper Access, Lighting, Excavation protection, Machinery condition, Pumps availability, Silt traps, Sedimentation tanks, Dumper speeding, Competency of operators, Prevent mud water pumping into drains, approval, safety, quality. Ground levels, co-ordinates marked and recorded, Average depth of excavation recorded, Surveyor certified the co-ordinates and levels, Soil samples collected at 0.5m intervals, Soil is stacked away from the edge of excavation, Soil is reaching the proper dumping yard, Protection of the excavation sides is met, Strutting is at right levels, Strutting details are as per the approved drawings, The stacking soil is covered, Excavation bottom level is correct as per drawings, applicable codes and standards.

Method Statement for Pile Cap

Purpose, Scope, Reference Documents, Responsibilities, Project Manager, Deputy Project Manager, Engineers, Survey Engineer/Surveyor, QA/QC Manager/ QC Engineer, Chief She Manager, Organization Chart, Equipment's & Materials, Methodology, Rebar Works, Transportations of Reinforcement and Placing at Site, Excavation, Pile Cap Casting, Surveying and Marking, Preparation of Access, Concrete Placing, Pile Chipping, Setting Out, Testing & Records, Quality Assurance & Quality Control, Health, Safety & Environment, Inspection Plan, Test Plan, Risk Assessment, applicable codes and standards.

Method statement for Open Foundation

Responsibilities, Project Manager, Deputy Project Manager, Engineers, Survey Engineer/Surveyor, QA/QC Manager/ QC Engineer, Chief SHE Manager, Machinery And Equipment's, Materials, Methodology, Setting Out Of Open Foundation, Excavation Of Open Foundation, Laying Of PCC For Open Foundation, Reinforcement Fabrication And Placing, Shuttering Of Open Foundation, Concreting, De-Shuttering, Curing, Design & drawings, quality assurance Plate Load Test : Responsibilities, Project Manager, Deputy Project Manager Engineers, Survey, Engineer/Surveyor, QA/QC Manager/ QC Engineer, Chief SHE Manager, machinery and equipment's, methodology, Design & drawings, Inspection plan, Method of Loading, Determination of safe bearing capacity of strata, Load test Equipment, Recording observation / settlement, applicable codes and standards

Unit – 4: Pier, pier arms and pier cap

(08 Hours)

Method Statement for Pier, Purpose, Sequence of construction of Pier, Responsibilities, Project Manager, Deputy Project Manager, Engineers, Survey Engineer/Surveyor, QA/QC Manager/ QC Engineer, Chief SHE Manager, Organization Chart, Procedure for Construction of Pier, Survey, Reinforcement, Rebar Fixing of Pier starter , Fixing of drainage pipes and other fittings, Pier Shuttering, Pier Concreting, Curing, Machinery, Materials and Manpower, Materials, Safety, applicable codes and standards.

Method Statement for Pier caps, Concourse Pier arm Platform Pier arm with integrated pier cap, Normal pier cap, cantilever pier cap and portal beams.

Responsibilities and Authorities, Precast Yard Manager, Precast Yard Superintendent, Reinforcement fabrication In-charge, The Quality Assurance Manager , The Field QC Engineers, The Safety & Environment Coordinator ,The Manager of Survey ,The Survey Crews, The Shift-in-Charge, Casting yard, Sequence of Work, cast-in-situ or Pre cast, Surveying At Precast Yard, Concrete Pouring Sequence For Pier Arm Segments, Casting Time Cycle, Post Casting Activities, Handling Precast Units, Weather Limitations, Safety, Health and Environment, requirement of temporary staging / supporting and its design.

Unit – 5: Launching Girder

(08 Hours)

Method Statement for Overhead Launching Girder

Responsibility & Authority, Enabling Structures, Launching Girder type – box or truss, Assembly of launching girder, erection of launching girder, hoisting mechanism of segments, Segment trolleys / sliding beams, Arrangement for temporary stressing, supporting, system for launching girder, Front support, Middle support, Rear support, Rear Trolley, erection of First, second and third span, Auto-launching mechanism, negotiation of curves, limitations and advantages of OHLG, HSFG/HT bolts, torque requirements, High tensile strength bars, hydraulics involved, Hazard identification and risk assessment

Method Statement for Underslung Segment Launcher

Introduction, Purpose, Project Manager, Launching Manager, Site Engineer, Safety Manager, Quality Manager, Organization Chart, Equipment's, Machineries And Manpower, Methodology, Ground Supported Staging System, End Supports, Main Support Towers, Steel Grid, Segment Trolleys, Job Break Down, Staging erection, EOT track laying, EOT / crane shifting and positioning, Removal of staging, EOT Track Laying, EOT / crane Shifting And Positioning negotiation of curves, limitations and advantages of USLG / GSS-LG, HSFG/HT bolts, torque requirements, High tensile strength bars, hydraulics involved, Hazard identification and risk assessment.

Method Statement for Load Testing of Launching Girder

Objective, Purpose, Equipment used for construction, Project Manager, Launching In-Charge, Site Engineer, QA/QC Manager, Chief Safety Manager, Surveyor, Execution of Work, Methodology (temperature correction, loading and unloading sequence, support settlement, residual deflection and recovery), Risk and Hazard Assessment, applicable codes and standards.

Unit – 6: Casting and Erection / launching of precast segmental spans or full spans (08 Hours)

Method Statement for Segment Casting / full span at Casting Yard

Responsibilities and Authorities, Construction Manager, Precast Yard Manager, Quality Assurance Manager, The Field QC Engineers, The Safety Coordinator, Environmental Coordinator, Manager of Survey, The Survey Crews, The Shift-in-Charge, construction Drawing, Bar bending schedule, Project Quality plan, Safety, Health & Environment plan, Casting Yard, Casting Bed, Sequence of Casting, Time Cycle For Casting, Rebar Jig, Rebar Cage, Cover Blocks, Concreting, Debonding Agent, Embedded Items, Geometry, Control, Marking of Segments / full spans, Curing of Segments / full spans, Strength Requirements, De-Shuttering, Lifting of Segments / full spans, Post Pour Inspection, Sand Blasting, Handling and Stacking of Units, Casting of Curved Span, Safety, Health and Environment, Inspection Plan, Test Plan

Method statement for erection / launching of precast spans

Purpose, Scope, Roles & Responsibility, Project Manager, Deputy Project Manager, Engineers, Survey Engineer/Surveyor, QA/QC Manager/ QC Engineer, Chief SHE Manager, Organization Chart, Documents/Codes/Drawings, transportation of precast segments / spans, vertical temporary stressing, hoisting of segment / spans, dry matching, application of epoxy, Horizontal temporary stressing, Permanent pre-stressing (as dealt separately), lowering of span to pier cap on temporary supports.

Procedure for Pre-stressing of Segment and Tendon Grouting

Purpose, Scope, Roles & Responsibility, Project Manager, Deputy Project Manager, Engineers, Survey Engineer/Surveyor, QA/QC Manager/ QC Engineer, Chief SHE Manager, Organization Chart, Documents/Codes/Drawings, Pre-stressing Materials & Procedure, High Tensile Strands, Sheathing Pipes, Anchor Cone, Anchor Head, Wedges, Storage and Transportation of Pre-Stressing Materials, Preparatory Works for Stressing, Stressing Operation, Fixing of Anchorages, General Operation, The Following Steps Should Be Preferred For Jack Mounting, Stage Pre-Stressing, Acceptance Criteria, Calibration and Maintenance, Grouting, Grouting Equipment Details, Grouting Materials, Preparatory Works For Grouting, End Protection of Anchorages, Safety, applicable codes and standards.

Unit – 7: Bearing installation and span load test

(08 Hours)

Method Statement for Span Alignment

Purpose, Scope of Work, Materials, Quality, survey, Assurance/Quality Control, Major Tools and Machineries, Work Procedure, Precautions Safety.

Method Statement for Horizontal Bearing Installation

Project Manager, Deputy Project Manager, Engineers, Survey Engineer/Surveyor, QA/QC Manager/ QC Engineer, Chief SHE Manager, Organisation Chart, Machinery And Equipment's, Type of Bearings, Inspection, Surface Preparation, Setting Out and Marking Bearing Location, Span Alignment, Installation of Bearing, installation of bearing shutters, grouting, Load Transfer, Design & drawings, Inspection Plan, Test Plan, Safety, Health and Environment, Testing & Records, Safe Operation Procedure for Open Foundation Excavation

Method Statement for Vertical Bearing Installation

Purpose, Scope, Reference Documents, Responsibilities, Project Manager, Deputy Project Manager, Engineers, Survey Engineer/Surveyor, QA/QC Manager/ QC Engineer, Chief She Manager, Organisation Chart, Materials, Methodology, Elastomeric Bearings, Inspection, Surface Preparation, Installation of Bearing, Installation of Bearing Shutters, Grouting, Load Transfer, Design & Drawings, Inspection Plan, Test Plan, Safety, Health and Environment.

Method Statement for Span load test

Objective, Purpose, Equipment used for construction, Project Manager, Launching In-Charge, Site Engineer, QA/QC Manager, Chief Safety Manager, Surveyor, Execution of Work, Methodology (temperature correction, loading and unloading sequence, support settlement, residual deflection and recovery, Risk and Hazard Assessment, applicable codes and standards.

Unit-8: Other important miscellaneous activities

(08 Hours)

Method Statement for Pier Protection and Kerb Median Fixing

Purpose, Scope, Reference Documents, Approved Drawings, IS456 Form Reinforcement Cement Concrete, IS1786 For Reinforcement, SHE Condition of Contract, Project SHE Plan, Project Quality Management Plan, Responsibilities, Project Manager, Deputy Project Manager, Engineers, Survey Engineer/Surveyor, QA/QC Manager/ QC Engineer, Chief She Manager, Organisation Chart, Machinery and Equipment's, Materials, Methodology, Pier Protection, Kerb Median Fixing, Design & Drawings, Inspection Plan, Safety, Health and Environment

Method Statement for Pier Protection and Kerb Median Fixing

Purpose, Scope, Reference Documents, Approved Drawings, IS456 Form Reinforcement Cement Concrete, IS1786 For Reinforcement, SHE Condition of Contract, Project SHE Plan, Project Quality Management Plan, Responsibilities, Project Manager, Deputy Project Manager, Engineers, Survey Engineer/Surveyor, QA/QC Manager/ QC Engineer, Chief She Manager, Organisation Chart, Machinery and Equipment's, Materials, Methodology, Pier Protection, Kerb Median Fixing, Design & Drawings, Inspection Plan, Safety, Health and Environment

Method Statement for Concrete Repair Works

Purpose, Scope, Responsibilities, References, Classification Details of Defects, Equipment's and Materials Methodology, Honeycomb Repair Method Depth <25 mm, Honeycomb Repair Method Depth >25 mm Edge Repair, Bug Holes, Rough Surface Repair Cracks Patch Repair, Patch Repair, Exposed Reinforcement, Inspection Plan, Health, Safety & Environment

Method Statement for Road Widening Work

Purpose, Responsibility, Project Manager, Deputy Project Manager, Engineers, Survey Engineer/Surveyor, QA/QC Manager/ QC Engineer, Chief SHE Manager, Equipment and Materials Used for Construction, Organisation Chart, Execution of Work, Sequence of Construction, Compaction and Consolidation, Placing of Concrete, Curing, Safety Precautions, Inspection Plan

Method Statement for Road Restoration

Purpose Responsibilities, Project Manager, Dy. Project Manager, Site Engineers, QA/QC Engineer, Reference Documents, Methodology, PCC, Pavement Quality Concrete, Joints, Inspection Plan, Test Plan, Safety Precautions

Reference Books:

1. Metro Rail in India for Urban Mobility Hardcover – 1 January 2021 by M. M. Agarwal (Author), Sudhir Chandra (Author), K. K. Miglani (Author)
2. Metro Railways (Operation and Maintenance) Act, 2002 Bare Act
3. METRO RAIL PROJECTS IN INDIA Hardcover – 21 October 2011 by M. Ramachandran
4. Concrete bridges – V.K.Raina

SEMESTER VII

Savitribai Phule Pune University, Pune
BE Civil (2019 Pattern) w. e. f. June 2022
Honors in* Metro Construction

401302: Work Method Statement Making - Lab

Teaching scheme	Credits	Examination scheme
Practical: 02 Hours/week	01	TW: 50 Marks

Any ten Experiments with drawings and Figures

1. Visit to Metro Construction Site and Details Report
2. Visit to Metro Construction Segment Casting at Casting Yard
3. Assignment on Metro Rail Project Report
4. Assignment on Method Statement for Lateral Pile Load Test
5. Assignment on Method Statement for Open Foundation
6. Assignment on Method Statement for Pier
7. Assignment on Method Statement for Launching Girder & Span Erection
8. Assignment on Method Statement for Fixed Support Single Box Launching Girder & Span Erection
9. Assignment on Method Statement for Pier Protection and Kerb Median Fixing
10. Assignment on Method Statement for Low Strain Integrity Test on Pile
11. Assignment on Method Statement for Concourse Pier Cap and Platform Pier Cap
12. Assignment on Method Statement for Underslung Segment Launcher
13. Assignment on Method Statement for Horizontal Bearing Installation
14. Assignment on Method Statement for Vertical Bearing Installation
15. Assignment on Procedure for Pre-Stressing of Segment and Tendon Grouting
16. Assignment on Method Statement for Load Testing of Launching Girder
17. Assignment on Method Statement for Segment Casting at Casting Yard
18. Assignment on Method Statement for Road Widening Work
19. Assignment on Method Statement for Concrete Repair Works
20. Assignment on Method Statement for Span Alignment & Horizontal Bearing Installation

SEMESTER VIII

Savitribai Phule Pune University, Pune

BE Civil (2019 Pattern) w. e. f. June 2022

Honors in* Metro Construction

401303: Tunnel Engineering

Teaching scheme	Credits	Examination scheme
Lectures: 04 Hours/week	04	In semester exam: 30 Marks End semester exam: 70 Marks

Course Contents

Unit 1

(08 Hours)

Introduction: Scope and application, historical developments, art of tunnelling, tunnel engineering, future tunnelling considerations.

Types of Underground Excavations: Tunnel, adit, decline, shaft parameters influencing location, Shape and size, geological aspects, planning and site investigations.

Tunnelling Methods: Types and purpose of tunnels; factors affecting choice of excavation technique, Methods - soft ground tunnelling, soft rock tunneling techniques, hard rock tunnelling (Drilling and Blasting), shallow tunnelling, deep tunnelling; Shallow tunnels – cut and cover (Bottom-up construction & Top -Down construction), pipe jacking, jacked box excavation techniques, methods of muck disposal, supporting Deep Tunneling: New Austrian tunneling method (NATM), Tunneling by TBM (Tunnel boring machine) for Metro rails, Under water tunneling methods (Tube rails) and rehabilitation/ retrofitting of damaged tunnels. Problems encountered and remedial measures.

Shallow tunnels: Cut and cover tunneling method : Bottom-up construction & Top -Down construction. Pipe jacking, jacked box excavation techniques, methods of muck disposal, supporting

Deep Tunneling: New Austrian tunneling method (NATM), Tunneling by TBM (Tunnel boring machine) for Metro rails, Under water tunneling methods (Tube rails)

Soft ground tunnelling: Heading & Benching Method, Pilot tunnel method, Fore poling method, Needle beam method, Shield tunneling method.

Soft rock tunneling techniques : Shotcreting and guniting, rock bolting/rock anchoring, Concrete lining.

Hard rock tunnelling: Drilling and Blasting, Road headers and Impact Hammers and by TBMs
Tunnelling by Drilling and Blasting: Unit operations in conventional tunnelling; Drilling – drilling principles, drilling equipment, drilling tools, drill selection, specific drilling, rock drill ability 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.

Unit 2

(08 Hours)

Tunnelling by Road headers and Impact Hammers:

Cutting principles, method of excavation, selection, performance, limitations and problems. Tunnelling by Tunnel Boring Machines: Boring principles, method of excavation, selection, performance, limitations and problems;

TBM applications. Supports in Tunnels: Principal types of supports and applicability.

Ground Treatment in Tunnelling: Adverse ground conditions and its effect on tunnelling; introduction to ground control.

Tunnel Services: Ventilation, Lighting, drainage and pumping.

Methods of Sinking Shafts: Vertical and inclined, decline; shaft/raise boring machines and their Application.

Tunnelling Hazards: Explosion, flooding, chimney formation, squeezing ground, failures of temporary support structure and collapse of tunnel, hazardous gases due to poor ventilation, poor visibility, electrocution, water ingress & drowning. Hazardous gases (CO & CO₂) and low oxygen level in tunnels. Heart rate & blood pressure variation in Caissons, Compressed-Air work and Deep Tunnelling.

Unit 3

(08 Hours)

Underground space - types, location, size, shape, purpose; excavation process of large tunnels. Advanced Excavation Techniques: Advanced drilling techniques - measure while drilling, drilling machines for longer drill holes, automation in drilling machines, drilling patterns; Advances in road- header.

Controlled blasting techniques- line drilling, pre-splitting, smooth blasting, cushion blasting, Factors responsible for over break, over break estimation and control, problems of drilling and blasting for large tunnels and caverns; New Austrian Tunnelling Method (NATM).

Tunnel Boring Machine - Cut ability / bore ability assessment, performance prediction in tunnelling with machine selection methodology. Shield Tunnelling: Introduction; advantages of shield tunnelling; classification; different types of shield tunnelling techniques – open shield, close shield, half shield; conventional shields, special features in shield tunnelling; factors affecting selection of a shield; slurry shield, earth pressure balance shield, slime shields, other shield development methods, problems encountered with possible remedies. Water sealant & dewatering measures. Application in Metro rail, lowering of TBM (assembling & dismantling) Precast concrete liners, casting yard set up, transportation & erection. TBM operation, safety hazards, precautionary measures to be taken. Structural health monitoring system like Strain gauges and vibration monitoring equipment etc.

Twin tunnels: excavation process, case study of a twin tunnel project and stacking tunnel projects. Excavation of large and deep tunnels: Introduction; purpose and use of large and deep tunnels; excavation issues governing large and deep tunnels; excavation methods of large and deep tunnels - unit operations, different equipment, types of rock pressure and methods to deal, roof and wall supports, case studies from hydel, road and rail tunnels.

Unit 4

(08 Hours)

Excavation of large and deep caverns: Introduction; purpose and use of large and deep caverns; excavation issues governing large and deep caverns; excavation methods of large and deep caverns - unit operations, different equipment, types of rock pressure and methods to deal, roof and wall supports, case studies from hydel, LPG and storage caverns.

Monitoring and control in tunnel construction: Ground deformation monitoring in tunnelling, Vibrating wire displacement sensor, Strain gauges, Potentiometric displacement sensor, inclinometer/in place inclinometer, Wireless tilt meter etc.

Underground environment: Composition of atmospheric air, O₂ deficiency – causes, effects & detection, Underground environment: Composition, Underground gases- CO₂, CO, H₂S, NO_x, CH₄, Radon gas – properties, physiological effects on man, occurrence & detection, Assessment, monitoring and remedial measures- Sampling and analysis of air –Gas chromatography, IR gas analyser.

Heat and Humidity: Sources of heat in underground space, Metabolism and heat balance in human body, physiological effects of heat and humidity, Psychometric, Cooling power of air, Air conditioning – basic principles.

Dust: Sources, measurement equipment & techniques, control measures Air flow through underground openings: Introduction, general energy balance equation, flow of viscous fluids, laminar and turbulent flow, resistance of smooth walled pipes, flow through ducts, shock resistance, pressure losses, determination of resistance in air ways (pressure drop and quantity of flow through field measurement)

Methods of Ventilation and Equipment: Natural ventilation – Causes, Natural Ventilation Pressure (NVP)- Calculation of NVP from air density, Motive column, other methods of determining NVP, Numerical problems, Mechanical ventilation- Types of fans, Centrifugal fan –theoretical head developed, theoretical characteristic curves, fan losses, actual characteristics curves of CF fan, fan efficiency, Axial-flow fan – drag and lift, characteristic curves, variable pitch fan., Fan laws, Selection of fan, installation of fan – forcing & exhaust, Fan drift, diffuser, series and parallel operation of fans, fan control, Booster fan – function of booster fan, installation, pressure gradient diagram and positioning, Auxiliary ventilation, Forcing and exhaust ventilation systems, Numerical problems. Standard Ventilations are made of different purposes Planning and Design of ventilation system for tunnels

Unit 5

(08 Hours)

Lighting systems and fixtures in tunnels: specifications, maintenance, emergency lighting

Underground space - types, location, size, shape, purpose; excavation process of large tunnels and caverns for hydel, LPG and storage caverns Advanced Excavation Techniques: Advanced drilling techniques - measure while drilling, drilling machines for longer drill holes, automation in drilling machines, drilling patterns; Controlled blasting techniques - line drilling, pre-splitting, smooth blasting, cushion blasting, Factors responsible for over break, over break estimation and control, problems of drilling and blasting for large tunnels and caverns; Advances in road heading and TBM technologies, cut ability/bore ability assessment, performance prediction in tunnelling with machine selection methodology. Shield Tunnelling: Introduction; advantages of shield tunnelling; classification; different types of shield tunnelling techniques – open shield, close shield, half shield; conventional shields, special features in shield tunnelling; factors affecting selection of a shield; slurry shield, earth pressure balance shield, slime shields, other shield development methods, problems encountered with possible remedies.

Twin tunnels: excavation process, case study of a twin tunnel project Excavation of large and deep tunnels: Introduction; purpose and use of large and deep tunnels; excavation issues governing large and deep tunnels; excavation methods of large and deep tunnels - unit operations, different equipment, types of rock pressure and methods to deal, roof and wall supports, case studies from hydel, road and rail tunnels. Excavation of large and deep caverns: Introduction; purpose and use of large and deep caverns; excavation issues governing large and deep caverns; excavation methods of large and deep caverns - unit operations, different equipment, types of rock pressure and methods to deal, roof and wall supports, case studies from hydel, LPG and storage caverns.

Unit 6

(08 Hours)

Submerged and Floating Tunnels: Micro-tunnelling; Trenchless excavation Novel Excavation Techniques: Penetrating Cone Fracture, Bottom-hole pressurization, expanding cements, Diamond wire saw

History of Safety movement – HIRA (Hazard Identification and Risk assessment), OSHA standards, Risk registers, Material safety data sheet (MSDS) and First Aid knowledge etc.

Evolution of modern safety concept- general concepts of management– planning for safety for optimization of productivity -productivity, quality and safety-line and staff functions for safety-budgeting for safety-safety policy. Incident Recall Technique (IRT), disaster control, job safety analysis, safety survey, safety inspection, safety sampling, evaluation of performance of supervisors on safety.

Safety Audit – Introduction: Components of safety audit, types of audit, audit methodology, nonconformity reporting (NCR), audit checklist and report – review of inspection, remarks by government agencies, consultants, experts – perusal of accident and safety records, formats –implementation of audit indication - liaison with departments to ensure co-ordination – check list – identification of unsafe acts of workers and unsafe conditions in the shop floor.

Tunnel Safety: To promote safety for those who work in underground construction, the Occupational Safety and Health Administration requires that employees receive extensive training in: Air monitoring and ventilation, Illumination, Communications, Flood control, Personal protective equipment, Emergency procedures, including evacuation plans, Check-in/check-out procedures, Explosives, Fire prevention and protection, Mechanical equipment.

Tunnel Construction Hazards: Hard physical labour bodily injuries, roof falls or cave-ins, head injuries, crush injuries, suffocation or death. Exposure to crystalline silica dust and cement dust, respiratory, lung or skin problems. Exposure to chemical vapours, lung problems, including chemical pneumonitis, respiratory failure and death if left unchecked. Exposure to radon can cause lung cancer. Oxygen-deficient atmospheres can contribute to breathing problems, such as asthma.

Reference Books:

1. Engineering Geology & Tunnels Engineering, Jaafar Mohammed. Open source.
2. Underground Infrastructures Planning, Design, and Construction, R.K. Goel, Bhavani Singh, JianZhao, Butterworth-Heinemann Publishers.
3. Handbook of Tunnel Engineering Volume I: Structures and Methods B. Maidl, M. Thewes, U. Maidl, Ernst & Sohn Publishers.
4. 4 Tunnel Engineering Handbook John O. Bickel, Thomas R. Kuesel, Elwyn H. King, Kluwer Academic Publishers.
5. Underground Infrastructures Planning, Design, and Construction R.K. Goel, Bhavani Singh, JianZhao, Butterworth-Heinemann Publishers.
6. Rock Mechanics Design in Mining and Tunneling by Z.T. Bieniawski. Supplementary Reading:
7. Technical Manual for Design and Construction of Road Tunnels - Civil Elements U.S. Department of Transportation Federal Highway Administration
8. Introduction to Tunnel Construction David Chapman, Nicole Metje and Alfred Stark, Spon Press
9. Practical Tunnel Construction, Gary B. Hemphill, Wiley Publication Supplementary Reading:
10. Tunnel Engineering Handbook, Authors: Kuesel, Thomas R., King, Elwyn H., Bickel, John
11. OSHA Standards

SEMESTER VIII

Savitribai Phule Pune University, Pune
BE Civil (2019 Pattern) w. e. f. June 2022
Honors in* Metro Construction
401304: Seminar

Teaching scheme	Credits	Examination scheme
Tutorial: 02 Hours/week	02	Presentation: 50 Marks

Course Contents

A Seminar Report should be made which should contain the following topics (not limited to):

1. Introduction of the topic, its relevance to Metro Construction, need of the study, aims and objective, limitations.
2. Latest Literature review on the topic chosen.
3. Theoretical contents related to the chosen topic and case studies if applicable.
4. Concluding remarks or summary.

Examination: The students must prepare presentation on seminar topic and present in presence of examiners through a viva-voce examination.

Suggested topics:

1. Critical Issues Related to Metro Rail Projects in India
2. Hurdles in Design and Construction of Metro-Rail Projects in India
3. Benchmarking for Cost Estimation of Metro Rail Projects
3. Delhi Metro Rail Project Management
4. Case Study of Metro Rails in Indian Cities
5. "Performance audit of phase I of Delhi Mass Rapid Transit System by Delhi Metro Rail Corporation", Comptroller and Auditor General of India,
6. Detailed Project Report for Pune Metro", Delhi Metro Rail Corporation
7. Traffic forecast for the proposed metro rail project in Pune metropolitan area, Transportation systems engineering group"
8. Mythologies, metro rail systems and future urban transport", Economic and Political Weekly 10 Mass Rapid Transit System for Pune Metropolitan Area, RITES Ltd.
9. Comprehensive Mobility Plan for Pune City, Wilbur Smith Associates", IL&FS Urban Infrastructure Services Ltd
10. "Study on traffic and transportation policies and strategies in urban areas in India commissioned by the Ministry of Urban Development (Government of India)", Wilbur Smith Associates,
11. Contributions of Metro-Rail Project in Bangalore's Urban Fabric
12. Constructability & Cost Feasibility Analysis of Pune Metro Rail Project Including Planning & Design Specifications
13. Draft Development Plan & Development Control Rules for Old Pune City 16 Understanding the Metro Rail Demand',
14. The dual mode TBM (Tunnel Boring Machine) having double shield using a case study
15. Purpose & uses of the Underground Caverns
16. Floating tunnels
17. Different type trenchless technology methods