


|  | TRANSPORTATION ENGINEERING | | |
|---|--|-------------------------|----------------------|
| | Credits (L:T:P) 4:0:0 | Total Contact Hours: 52 | Course Code: 15CE54T |
| | Type of Course: Lecture, Case study, Mini projects | Credit :4 | Core/ Elective: Core |
| CIE- 25 Marks | | SEE- 100 Marks | |

Pre-requisite: Knowledge of Survey, Construction Technology, Building materials.

Course objectives

1. To distinguish between different modes of transportation and importance of bridges and tunnel.
2. To understand the functions of various components of roads, railways, tunnel, and bridges.
3. To understand the importance of surveys, alignment and geometric features of Highways, bridges, Railways and tunnel.
4. To differentiate between types of highway pavements, their construction and advantages.
5. To realize the significance of road safety by incorporating the concepts of Traffic Engineering.
6. To understand the importance of highway drainage and road arboriculture.
7. To classify the types of stations, yards, tunnels, harbour, airport and bridge.
8. To realize the importance of safety in railways by understanding the concepts of track maintenance, points and crossing and signals.

At the end of the course the student should be able to

| Course Outcome | | CL | Linked PO | Teaching Hrs |
|-----------------------|--|--------|-----------------|--------------|
| CO1 | Classify the different modes of transportation and describe highway geometrics. | R/U | 1,2,5,6, | 08 |
| CO2 | Select suitable road materials for the design of different types of pavements and plan proper drainage system. | R/U/Ap | 1,2,5,6,8,10 | 10 |
| CO3 | Identify - types of bridges, components of bridges and select suitable bridge foundations. | R/U/Ap | 1,2,5,6,9 | 08 |
| CO4 | Explain various components of a railway track. | R/U/Ap | 1,2,5,9 | 10 |
| CO5 | Outline the process of railway track construction; classify railway stations, suburban railway system and recognise the importance of railway track maintenance. | R/U/Ap | 1,2,4,5,8,10 | 12 |
| CO6 | Describe various components of tunnel, airport and harbour engineering. | R/U/Ap | 1, 2,5,6,7,9,10 | 04 |
| CO7 | Perform the suggested activities individually or in team and have fundamental knowledge of modes of transportation. | R/U/Ap | 1 to10 | * |
| Total sessions | | | | 52 |

Legend- R; Remember U: Understand Ap: Application Ay: Analysis C:CreationE:Evaluation

*Related to Student activity beyond classroom hours.

Programme outcome Attainment Matrix

| Course | Programme Outcome | | | | | | | | | |
|-----------------------------------|-------------------|----------------------|--------------------------|-------------------|----------------------|------------------------------|--------|--------------------------|---------------|--------------------|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
| | Basic knowledge | Discipline knowledge | Experiments and Practice | Engineering Tools | Engineer and society | Environment & Sustainability | Ethics | Individual and Team work | Communication | Life long learning |
| TRANSPORTATION ENGINEERING | 3 | 3 | 1 | 3 | 3 | 3 | 2 | 2 | 1 | 3 |

Level 3- Highly Addressed, Level 2-Moderately Addressed, Level 1-Low Addressed.

Method is to relate the level of PO with the number of hours devoted to the COs which address the given PO.

If $\geq 40\%$ of classroom sessions addressing a particular PO, it is considered that PO is addressed at Level 3

If 25 to 40% of classroom sessions addressing a particular PO, it is considered that PO is addressed at Level 2

If 5 to 25% of classroom sessions addressing a particular PO, it is considered that PO is addressed at Level 1

If $< 5\%$ of classroom sessions addressing a particular PO, it is considered that PO is considered not-addressed.

| UNIT | COURSE CONTENTS | Hours allotted |
|------|---|----------------|
| 1 | HIGHWAY | 8 |
| | <p>1.1 Introduction: Importance of transportation - different modes of transportation –surface transportation, water transportation and air transportation.</p> <p>1.2 Highways: Highway planning, factors controlling highway alignment, Engineering surveys.Importance and objectives of highway geometric design - highway cross sectional elements. Sight distances, concept of super elevation, widening of roads at horizontal curves, gradients and its types, elements of horizontal and vertical alignments, cross-sections of different types of roads.</p> | |
| 2 | <p>2.1 Highway Materials and Pavements: Types of bitumen, Properties of bitumen, Soil stabilisation principles and methods, Requirements of highway pavements, Types of pavement, Flexible pavements-construction of WBM and WMM roads, , construction of bituminous roads,(Bitumen bound macadam only)Rigid pavements- advantages and disadvantages of CC roads, construction of CC roads, joints in CC roads, comparison between flexible and rigid pavements, Overlays.</p> | 10 |
| | <p>2.2 Road drainage: Significance and requirements of highway drainage, subsurface highway drainage, objects of Road Arboriculture.</p> | |
| 3 | BRIDGE ENGINEERING | 8 |
| | <p>Introduction, component parts of a bridge, terms used in bridge engineering- water way, afflux, economic span of a bridge, scouring, free board, classification of bridges, selection of site for bridge, concept of coffer dams. Bridge sub structure- abutments, piers, wing walls, bearings-functions, requirements, types only. Highway bridges-permanent bridges (Steel, RCC T-Beam Bridge), flyovers.</p> | |

| UNIT | COURSE CONTENTS | Hours allotted |
|------|--|----------------|
| 4 | <p>RAILWAY ENGINEERING</p> <p>4.1 Introduction Role of Indian railways, General features of Indian railways. Gauge, different gauges on IR, Uni-gauge policy and its benefits.</p> <p>4.2 Railway track. Permanentway, Various components and requirements of a good track, factors to be considered while selecting a good alignment, forces acting on the track, concept of coning of wheels and tilting of rails, Gradient and its types.</p> <p>4.3 Track Components Rails - Functions, types and requirements, wear - types and methods to reduce wear, creep, causes, effects and prevention. Sleepers - Functions, requirements, PSC monoblock sleeper with pandrol clips, sleeper density. Ballast - Functions, requirements, broken stone ballast. Track fittings and fastenings - Purpose, fish plates, only elastic fastenings used in concrete sleepers. Rail joints and welding of rails - Types of rail joints, comparison of short welded, long welded and continuous welded rails.</p> | 10 |
| 5 | <p>5.1 Points and crossings Turnout and its necessity, sketch of constituents of a turnout. Track junctions - crossover between two parallel tracks, Diamond crossing, Scissor crossover. Level Crossings- objects of providing level crossings, typical layout of a square level crossing. Track maintenance - Necessity, advantages and essentials of track maintenance, duties of a PWI.</p> <p>5.2 Railway stations and yards Classification of railway stations on operational and functional considerations (explain only A- class block station for double line) wayside station on a single line section, types of yards, explain Marshalling yard. Signalling and interlocking - Objectives, signals required at stations, Interlocking and its essential regulations.</p> <p>5.3 Suburban railways in metro cities Tube railways and elevated railways, typical cross-section of underground railway (tunnel circular section) and elevated railways with dimensions.</p> | 12 |
| 6. | <p>TUNNEL ,AIR PORT AND HARBOURS</p> <p>Tunnels: Terminology, advantages of tunnels, Size and shapes of tunnels- horse shoe, egg shape, segmental roof section, transferring alignment inside the tunnel, mucking, concept of shafts, objects of tunnel lining, ventilation and drainage in tunnels.</p> <p>Airport – Terminology, Aerodrome, Apron, Hanger, Runway, Taxiway, Terminal area, Wind rose. Harbour- Terminology, Dock, Port, Breakwater, Jetties, Quays, Dredging, Light house, Buoys and Beacons.</p> | 4 |

Course Delivery: The course will be delivered through lectures, demonstration, Presentations and suggested activities.



SUGGESTED STUDENT ACTIVITIES

1. Visit a highway construction site and collect cross sectional drawings and topo sheets and prepare a power point presentation with photographs and videos.
2. Prepare a comparative chart showing various types of roads such as WBM, Bituminous roads, Concrete roads.
3. Visit a highway construction site, identify various types of soils, the test procedures as per relevant IS codes and inference based on the test results.
4. Draw the cross sectional details of Village roads, MDR, SH, NH using CADD and prepare a chart.
5. Collect the parameters of road intersection in the locality and prepare a model.
6. Prepare a model showing the cross sectional details of various types of roads such as bituminous and concrete roads.
7. Taking the measurements of an existing box culvert and prepare a model of the same.
8. Prepare a model of a typical bridge structure showing the component parts of bridge.
9. Prepare a presentation on comparison between RCC and PSC bridges with proper photographs and videos.
10. Prepare a chart showing the various road signs used by collecting the information from nearby RTO and prepare report and presentation it.
11. Visit nearest railway station and collect the information regarding railway track such as ballast, sleeper, gauge and signals and prepare a presentation and submit a report.
12. Collect information regarding various types of railway gauges used in India and other countries, prepare a chart and present it.
13. Collect videos showing the various forces acting on a railway track and present in the class.
14. Collect photographs and videos of crossings and prepare a presentation on it.
15. Collect videos related to track laying procedure and give seminar in the class.
16. Give a presentation on production of railway sleepers.
17. Collect information about alternate modes of transport (Mass Rapid Transport system) and make a presentation on it.
18. Explain the airport components in the class with the aid of presentation.
19. Explain the construction of tunnel with the help of video in the class room and submit a report.
20. Explain different types of tunnels with the help of presentation.
21. Prepare a presentation on component parts of Harbour.
22. Collect different IRC codes pertaining to highway geometric design and prepare a chart.
23. Prepare a presentation and report on Maglev Trains.
24. Prepare a presentation and report on Bullet Trains.
25. Give a seminar on the use of eco-toilets in trains.
26. Give a seminar on the use of bio toilets in trains.

27. Prepare a model of a typical railway track.
28. Prepare a presentation on sky bus technology.
29. Seminar on Intelligent Transport System (ITS).
30. Collect the information regarding various railway divisions in India and their functions.
31. Collect the information regarding the functions and importance of the following agencies regarding road projects.
 - National Highway Authority of India
 - Indian Road Congress
 - Karnataka Rural Infrastructure Development Corporation
 - Public Works Department
 - Rural Development and Panchayath Raj Department
32. Collect the information and prepare a presentation on the following topics.
 - Pradhan Mantri Gram Sadak Yojana (PMGSY)
 - Golden Quadrilateral Project
 - National Highway grid
 - Public Private Partnership (PPP) road projects
 - Renumbering of Indian National Highways
 - Use of road reflectors, delineators, and road markings

NOTE

1. Students should select any one of the above or other topics relevant to the subject approved by the concerned faculty, individually or in a group of 3 to 5. Students should mandatorily submit a written report and make a presentation on the topic. The task should not be repeated among students. Report will be evaluated by the faculty as per rubrics. Weightage for 5 marks Internal Assessment shall be as follows: (Unsatisfactory **1**, Developing **2**, Satisfactory **3**, Good **4** and Exemplary **5**)

2. Reports should be made available along with bluebooks to IA verification officer

Example of model of rubrics / criteria for assessing student activity

| Dimension | Students score | | | | |
|---------------------------------|--|-----------|-----------|-----------|-----------|
| | (Group of five students) | | | | |
| | STUDENT 1 | STUDENT 2 | STUDENT 3 | STUDENT 4 | STUDENT 5 |
| Rubric Scale | Unsatisfactory 1 , Developing 2 , Satisfactory 3 , Good 4 , Exemplary 5 | | | | |
| 1.Literature | 5 | | | | |
| 2.Fulfill team's roles & duties | 2 | | | | |
| 3.Conclusion | 3 | | | | |
| 4.Conventions | 4 | | | | |
| Total | 13 | | | | |

Average=(Total /4) | 3.25=4 | | | |

Note: Concerned faculty (Course coordinator) must devise appropriate rubrics/criteria for assessing Student activity for 5 marks One activity to attain last CO (course outcome) may be given to a group of FIVE students

Note: Dimension should be chosen related to activity and evaluated by the course faculty

| Dimension | Rubric Scale | | | | |
|--------------------------------|--------------------------------------|--------------------------------|---------------------------------|---------------------------------|--|
| | 1 Unsatisfactory | 2 Developing | 3 Satisfactory | 4 Good | 5 Exemplary |
| 1.Literature | Has not included relevant info | Has included few relevant info | Has included some relevant info | Has included many relevant info | Has included all relevant info needed |
| 2.Fulfil team's roles & duties | Does not perform any duties assigned | Performs very little duties | Performs partial duties | Performs nearly all duties | Performs all duties of assigned team roles |
| 3.Communication | Poor | Less Effective | Partially effective | Effective | Most Effective |
| 4.Convensions | Frequent Error | More Error | Some Error | Rare Error | No Error |

Course Assessment and Evaluation Scheme:

| | What | | To whom | When/Where (Frequency in the course) | | Max Marks | Evidence collected | Course outcomes |
|--------------------------|----------------------------|----------|----------|--------------------------------------|--------|-----------------------|--------------------|---|
| Direct Assessment method | CIE | IA | Students | Three tests (Average of three tests) | Test-1 | 20 | Blue books | CO1,CO2 |
| | | | | | Test-2 | | | CO3,CO4 |
| | | | | | Test-3 | | | CO5,CO6 |
| | | | | Mini project | 05 | Assignment books | CO1 to CO7 | |
| | SEE | End Exam | | End of the course | 100 | Answer scripts at BTE | CO1 to CO6 | |
| Indirect Assessment | Student Feedback on course | | Students | Middle of the course | | | Feedback forms | CO1,CO2,CO3, Delivery of course |
| | End of Course Survey | | | End of the course | | | Questionnaires | CO1 to CO7 Effectiveness of Delivery of instructions & Assessment Methods |

*CIE – Continuous Internal Evaluation

*SEE – Semester End Examination

Note: I.A. test shall be conducted for 20 marks. Average marks of three tests shall be rounded off to the next higher digit.

Note to IA verifier: The following documents to be verified by CIE verifier at the end of semester

1. Blue books (20 marks)
2. Student suggested activities report for 5 marks evaluated through appropriate rubrics.
3. Student feedback on course regarding Effectiveness of Delivery of instructions & Assessment Methods

Weightage of Marks and blue print of marks for SEE

| Unit | Major Topics | Hours Allotted | Questions to be set for SEE | | | | | | Marks weightage | weightage (%) | A* | B* |
|--------------|---|----------------|-----------------------------|--------|-----|-----|-----|-----|-----------------|---------------|----|----|
| | | | Cognitive Levels | | | | | | | | | |
| | | | R | U | Ap | Ay | C | E | | | | |
| 1 | 1.1 Introduction to Highway Engineering 1.2 Highways | 8 | 25% | 25% | 50% | 0% | 0% | 0% | 20 | 13 | 2 | 1 |
| | | | 5 | 5 | 10 | 0 | 0 | 0 | | | | |
| 2 | 2.1 Highway Materials and Pavements 2.2 Road drainage | 10 | 20% | 40% | 40% | 00% | 00% | 00% | 25 | 18 | 1 | 2 |
| | | | 5 | 10 | 10 | 0 | 0 | 0 | | | | |
| 3 | Introduction to Bridges | 8 | 33.33% | 66.66% | 00% | 0% | 0% | 0% | 30 | 20 | 2 | 2 |
| | | | 10 | 20 | 0 | 0 | 0 | 0 | | | | |
| 4 | 4.1 Introduction 4.2 Railway track. 4.3 Track Components | 10 | 25% | 25% | 25% | 25% | 00% | 00% | 20 | 14 | 2 | 1 |
| | | | 5 | 5 | 5 | 5 | 0 | 0 | | | | |
| 5 | 5.1 Points and crossings 5.2 Railway stations and yards 5.3 Suburban railways in metro cities | 12 | 20% | 80% | 00% | 00% | 0% | 0% | 35 | 25 | 1 | 3 |
| | | | 5 | 20 | 0 | 0 | 0 | 0 | | | | |
| 6 | 6.1 Introduction to Tunnel Engineering 6.2 Terms used in Airport and Harbour | 4 | 60% | 40% | 0% | 0% | 0% | 0% | 15 | 10 | 1 | 1 |
| | | | 15 | 10 | 0 | 0 | 0 | 0 | | | | |
| Total | | 52 | 31% | 48% | 17% | 4% | 0% | 0% | 145 | 100 | 9 | 10 |
| | | | 45 | 70 | 25 | 05 | 0 | 0 | | | | |

A*-SEE QUESTIONS TO BE SET FOR (05MARKS) in PART – A

B*- SEE QUESTIONS TO BE SET FOR (10MARKS) in PART – B

Questions for CIE and SEE will be designed to evaluate the various educational components such as:

| | | |
|---|---|------------------|
| 1 | Remembering and Understanding : | - 79% weightage |
| 2 | Applying the knowledge acquired from the course : | - 17 % weightage |
| 3 | Analysis : | - 04% weightage |
| 4 | Evaluation : | - 0% weightage |
| 5 | Creating new knowledge : | - 0% weightage |

Model Question Paper for CIE

| Test/Date and Time | Semester/year | Course/Course Code | Max Marks | |
|--|---------------|----------------------------|-----------|--------------|
| Ex: I test/6 th week of sem 10-11 Am | V SEM | Transportation Engineering | 20 | |
| | Year: 2015-16 | Course code:15CE54T | | |
| Name of Course coordinator : | | | | |
| Course outcome :CO1, CO2 | | | | |
| Note: Answer all questions | | | | |
| Question | M | CL | CO | PO |
| 1 | 05 | U | 1 | 1,2,5,6, |
| Explain the role and importance of transportation. OR Explain the various factors controlling the alignment of roads. | | | | |
| 2 | 05 | U | 1 | 1,2,5,6, |
| 3 | 05 | R | 2 | 1,2,5,6,8,10 |
| 4 | 05 | U | 2 | 1,2,5,6,8,10 |
| Explain briefly sub surface drainage system with a neat sketch. OR Explain the method of construction of WBM road width a neat sketch. | | | | |

Note: Internal choice may be given in each CO at the same cognitive level (CL).



Text Books:

1. Khanna S.K. and Justo C.E.G, Highway Engineering, Nemchand and Bros, Roorkee.
2. Kadiyali L.R, "Highway Engineering", Khanna Publishers, New Delhi.
3. Satish Chandra and Agarwal M M, Railway Engineering, Oxford university press.

Reference Books:

1. Subramanyam. K.P, "Transportation Engineering", Scitech Publications, Chennai.
2. Khanna SK and Justo CEG, "Highway Material Testing Laboratory Manual", Nemchand and Bros. Roorkee.
3. Dr. S K Sharma, Highway Engineering, S Chand and company, New Delhi.
4. J S Mundrey, Railway track engineering, McGraw Hill education, New Delhi.
5. Paul H Wright and Karen K Dixon, Highway Engineering, Wiley pub, New Delhi.
6. James H Banks, Tata Mcgraw-Hill, New Delhi.

MODEL QUESTION PAPER
DIPLOMA IN CIVIL ENGINEERING
FIFTH SEMESTER
TRANSPORTATION ENGINEERING

Maximum Marks: 100 marks.

Time: 03 hours.

PART-A

Answer any six questions. Each question carries five marks each.

1. Explain the role and importance of transportation.
2. What is meant by super elevation? And list the objects and advantages.
3. What are the necessities of providing Highway drainage?
4. Explain are the component parts of a bridge?
5. What is meant by bridge bearing? and list its functions
6. What are the general features of Indian railways?
7. What are the various forces acting on the track?
8. List the duties of PWI.
9. List the purpose of drainage of tunnel and its types.

PART-B

Answer any seven questions. Each question carries ten marks each.

1. Mention the various surveys to be conducted for road alignment and explain briefly preliminary and final location of survey.
2. Explain the method of construction of WBM road with a neat sketch.
3. Explain briefly sub surface drainage system with a neat sketch.
4. List the classification of bridges according to all the parameters.
5. Explain briefly the sub structure components of a bridge with a sketch.
6. What are the various components and requirements of a good track?
7. What is meant by creep? List the causes, effects and prevention of creep.
8. a) Draw a typical cross-section of an underground railway tunnel circular in section and an elevated railway (Metro rail).
9. a) What are the advantages of tunnelling?
b) List the objects of lining and ventilation in tunnels.
10. Define the terms:- Aerodrome, Hanger, Runway, Brake water, Jetties.

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MODEL QUESTION BANK:-

UNIT-1

Cognitive level- Remembering

1. What are the different modes of transportation?
2. What are the objects of highway planning?
3. What is meant by super elevation? And list the objects and advantages.
4. Define curve and what are its advantages? Also list the type of curves.
5. List the objects and requirements of a transition curve.
6. What is gradient? And list its objects and types.

Cognitive level- Understanding

1. Explain the role and importance of transportation.
2. Explain the various factors controlling the alignment of roads.
3. What are the objects of highway geometrics? And list the factors which affects the design of geometrics.
4. Explain briefly cross-sectional elements of highways.
5. Explain the necessity of widening of roads in curves.
6. Draw a typical cross-section of a national highway.

Cognitive level- Application

1. Mention the various surveys to be conducted for road alignment and explain briefly preliminary and final location of survey.

UNIT-2

Cognitive level- Remembering

1. What is meant by soil stabilisation? And what are its principles?
2. What are requirements of a good highway pavement?
3. Write a short note on Overlays.
4. What are the necessities of providing Highway drainage?
5. What are the requirements of a good drainage system?

Cognitive level- Understanding

1. Explain briefly methods of soil stabilisation.
2. Explain briefly the materials and its qualities which are used in highway pavements.
3. Explain the method of construction of WBM road with a neat sketch.
4. Explain the method of construction of Bitumen bound macadam road.
5. Explain the construction of CC roads.
6. Explain the different types of joints used in CC roads.
7. Explain briefly sub surface drainage system with a neat sketch.

Cognitive level- Application

1. Comparison between flexible pavement and rigid pavement.
2. What are the objects of road Arboriculture?

UNIT-3

Cognitive level- Remembering

1. What are the component parts of a bridge? with examples.
2. List the classification of bridges according to all the parameters.
3. Define the terms: water way, afflux, economic span of a bridge, scouring, free board.
4. What is a coffer dam and list its requirements? .
5. What is meant by bridge bearing? and list its functions
6. What are the types of bridge bearings?

Cognitive level- Understanding

1. What are the points to be considered while selecting a site for bridge.
2. Explain briefly the sub structure components with a sketch.
3. Write a short note on flyovers.

UNIT-4

Cognitive level- Remembering

1. What are the general features of Indian railways?
2. What are the factors to be considered while selecting a good railway alignment?
3. What are the various components and requirements of a good track?
4. What are the various forces acting on the track?
5. What is meant by creep? List the causes, effects and prevention of creep.
6. What are the qualities of broken stone ballast.

Cognitive level- Understanding

1. Explain the role of Indian railways.
2. Define gauge and list the benefits of UNI-GAUGE policy.
3. Differentiate between Conning wheels and Tilting of rails.
4. List the functions and requirements of rails.
5. Explain with a neat sketch a flat footed rail.
6. List the methods to reduce the wear of rails.
7. List the functions and requirements of sleepers.
8. Explain with a neat sketch monoblock PSC sleeper with pandrol clips.
9. List the functions and requirements of ballast.

UNIT-5

Cognitive level- Remembering

1. What are the purpose of providing fittings and fastenings in tracks.

2. What is meant by buckling of track? List its causes and prevention.
3. List the necessities, advantages and essentials of a track maintenance.
4. What are the objects of providing level crossings? List its types and draw a typical layout of a square level crossing.
5. What are the types of yards? And list the functioning of Marshalling yard.
6. List the objects of signalling.
7. What is meant by Inter-locking and list its essential regulations.

Cognitive level- Understanding

1. List the elastic fastenings and explain fish plate.
2. What is meant by turn out? And draw a typical sketch of a turn out and label the components.
3. Draw the layout of track junctions cross over between two parallel tracks.
4. Draw the layout of Diamond crossing and Scissor crossing.
5. List the types of rail joints.
6. Comparison between short welded, long welded and continuous welded rails.
7. List the duties of PWI.
8. Draw the classification chart of railway stations based on operations and functions.
9. Explain A-class block station for a double line section.
10. Explain way side station on a single line section.
11. What are the signals required at railway stations?
12. Draw a typical cross-section of an elevated railway (Metro rail).

Unit-6

Cognitive level- Remembering

1. Define the terms:- tunnel, shaft, mucking
2. What are the advantages of tunnelling?
3. List the shapes of tunnel.
4. List the purpose of drainage of tunnel and its types.
5. List the objects of tunnel lining and ventilation.
6. Define the terms:- Airport, runway, wind rose.
7. Define the terms:-Harbour, dock, Jetties.
8. Define the terms:- Brake water, Quays, Buoys.
9. Define the terms:- Port, light house, Beacons.

Cognitive level- Understanding

1. Draw a typical cross-section of an underground railway tunnel circular in section.
2. Comparison between Horse shoe, egg shape and segmental tunnel sections.