This book aims at presenting the topics of Railway, Bridge and Tunnel Engineering written in a simple manner. The subject-matter is characterized by comprehension as well as methodical and easy-to-follow style.

The Section I: Railway Engineering is well divided in to Thirteen chapters including Introduction; Railway track gauges; Surveys and alignment of railway lines; Railway traction; Rails; Sleepers; Ballast; Track fittings; Geometric design of a track; Resistance to traction; Points and crossings; Railway stations and yards; Signalling and Interlocking; etc.

The Section II: Bridge Engineering is well divided in to Nine chapters including Introduction; Bridge foundations; Sub-structures; Classification of bridges; Bridge flooring; Bridge bearings; Design of bridges; Construction and erection methods of bridge super-structure; Maintenance of the bridges; etc.

The Section III: Tunnel Engineering is well divided in to Nine chapters including General aspects of tunnelling; Alignment of a tunnel; Shafts and portals; Tunnelling in hard rock; Tunnelling in soft ground; Tunnel lining; Lighting, ventilation and dust control in tunnels; Drainage of tunnels; Safety in tunnel construction; etc.

The Appendix I gives Abbreviated Terms and Appendix II gives five solved examination papers of GTU.

Salient features of this book are:

* 346 Self-explanatory and neatly drawn sketches;
* 32 Illustrative problems;
* 40 Important useful tables;
* 590 Typical questions at the end of the chapters.

The text-matter has been arranged systematically according to the curriculum developed by the Gujarat Technological University (G.T.U.) for the Sixth Semester students of Civil Engineering (Subject code: 160603) and also it should prove to be extremely useful to the Civil Engineering students preparing for the Degree Examinations of all the Indian Universities, Diploma Examinations conducted by various Boards of Technical Education, Certificate Courses as well as for the A.M.I.E., U.P.S.C., G.A.T.E., I.E.S. and other similar competitive and professional examinations. It should also prove great of interest and practical use to the practising professionals.
Section 1: RAILWAY ENGINEERING

Chapter 1 INTRODUCTION
1-1. Brief history of railways
1-2. Importance of railways
1-3. Trends in modern railways
1-4. Trains of tomorrow (Maglev Trains)
1-5. Automatic train operation
1-6. Indian railways
1-7. Development of the Indian railway
1-8. Classification of Indian Railways
1-9. Achievements of Indian Railways
1-10. Future plan of indian railways

Chapter 2 RAILWAY TRACK GAUGES
2-1. Definition of gauge of track
2-2. Factors affecting the choice of a gauge
2-3. Types of gauges
2-4. Uniformity in gauges
2-5. Loading gauge
2-6. Construction gauge
2-7. Track capacity
2-8. Electrification on the Indian railways

Chapter 3 SURVEYS AND ALIGNMENT OF RAILWAY LINES
3-1. Reasons for laying a new railway line
3-2. Factors influencing the proposed route
3-3-1. Reconnaissance survey
3-3-2. Preliminary survey
3-3-3. Location survey
3-3-4. Railway Electrification Survey
3-4. Project report and drawings
3-5. Construction of new lines

Chapter 4 RAILWAY TRACTION
4-1. Tractive effort of a locomotive
4-2. Track stresses

Chapter 5 RAILS
5-1. Permanent way and its requirements
5-2. Functions of rails
5-3. Requirements of an ideal rail
5-4. Types of rails
5-5. Steel for rails
5-6. Weight and section of rails
5-7. Marking on rails
5-8. Corrugated or roaring rails
5-9. Corrosion of rails
5-10. Length of rail
5-11. Welding of rails
5-12. Wear of rails
5-13. Methods adopted to reduce wear of rails
5-14. Measuring wear of rails
5-15. Renewal of rails
5-16. Failure of rails
5-17. Coning of wheels
5-18. Hogged rails
5-19. Buckling
5-20. Creep of rails
5-20-1. Causes of creep
5-20-2. Factors determining magnitude of creep
5-20-3. Results of creep
5-20-4. Method of measuring the creep
5-20-5. Methods of correcting the creep

Chapter 6 SLEEPERS
6-1. Functions of sleepers
6-2. Types of sleepers
6-3. Requirements of an ideal material for sleeper
6-4. Materials for cross-sleepers
6-5. Sleeper density

Chapter 7 BALLAST
7-1. Functions of ballast
7-2. Requirements of an ideal material for ballast
7-3. Materials used as ballast
7-4. Size and quantity of ballast
7-5. Screening of ballast

Chapter 8 TRACK FITTINGS
8-1. Rail joints
8-2. Avoidance of rail joints
8-3. Types of rail joints
8-4. Requirements of an ideal fastening
8-5. Fastenings for rails
8-6. Fish-plates
8-7. Spikes, fang-bolts and hook-bolts
8-7-1. Spikes
8-7-2. Fang-bolts
8-7-3. Hook-bolts
8-8. Chairs and keys
8-9. Bearing-plates

Chapter 9 GEOMETRIC DESIGN OF A TRACK
9-1. Objections to curvature of track
9-2. Designation of a curve
9-3. Types of curves and limiting radius or degree of curvature
9-4. Transition curves
9-5. Super-elevation or cant
9-6. Factors affecting super-elevation
9-7. Speed of trains on curves
9-8. Cant Deficiency and Negative super-elevation
9-9. Cant Excess
9-10. Grade compensation on curves
9-11. Bending of rails on curves
9-12. Cutting of rails on curves
9-13. Widening gauge on curves
9-14. Spirals for mountain railways
9-15. Switch-backs
9-16. Rack railways
9-17. String-lining of curves
9-18. Tilting train

Chapter 10 RESISTANCE TO TRACTION
10-1. Train resistances
10-2. Rolling stock
10-2-1. Locomotives
10-2-2. Coaches
10-2-3. Wagons
10-3. Train-brakes
10-4. Dynamometer car

Chapter 11 POINTS AND CROSSINGS
11-1. Purpose
11-2. Some definitions
11-3. Sleepers laid for points and crossings
11-4. Steel for points and crossings
**RAILWAY, BRIDGE AND TUNNEL ENGINEERING**

**DETAILED CONTENTS**

<table>
<thead>
<tr>
<th>Section 11:</th>
<th>Switches</th>
</tr>
</thead>
<tbody>
<tr>
<td>11-5.</td>
<td>Switches</td>
</tr>
<tr>
<td>11-6.</td>
<td>Shapes of switches</td>
</tr>
<tr>
<td>11-7.</td>
<td>Length of stock rails and tongue rails</td>
</tr>
<tr>
<td>11-8.</td>
<td>Heel divergence or heel clearance</td>
</tr>
<tr>
<td>11-9.</td>
<td>Switch angle</td>
</tr>
<tr>
<td>11-10.</td>
<td>Throw of switch</td>
</tr>
<tr>
<td>11-11.</td>
<td>Crossings</td>
</tr>
<tr>
<td>11-12.</td>
<td>Types of crossings</td>
</tr>
<tr>
<td>11-13.</td>
<td>Theoretical nose of crossing (T.N.C.) and actual nose of crossing (A.N.C.)</td>
</tr>
<tr>
<td>11-14.</td>
<td>Crossing clearance</td>
</tr>
<tr>
<td>11-15.</td>
<td>Crossing number</td>
</tr>
<tr>
<td>11-16.</td>
<td>Crossing angle</td>
</tr>
<tr>
<td>11-17.</td>
<td>Different types of leads and their calculations</td>
</tr>
<tr>
<td>11-18.</td>
<td>Laying of points and crossings</td>
</tr>
<tr>
<td>11-19.</td>
<td>Maintenance of points and crossings</td>
</tr>
<tr>
<td>11-20.</td>
<td>Combinations of points and crossings</td>
</tr>
<tr>
<td>11-20-1.</td>
<td>Cross-overs</td>
</tr>
<tr>
<td>11-20-2.</td>
<td>Scissors cross-overs</td>
</tr>
<tr>
<td>11-20-3.</td>
<td>Slips</td>
</tr>
<tr>
<td>11-20-4.</td>
<td>Fixed point</td>
</tr>
<tr>
<td>11-20-5.</td>
<td>Three throws</td>
</tr>
<tr>
<td>11-20-6.</td>
<td>Tandems or double turnouts</td>
</tr>
<tr>
<td>11-20-7.</td>
<td>Gathering lines or ladder tracks</td>
</tr>
<tr>
<td>11-20-8.</td>
<td>Gauntlet tracks</td>
</tr>
<tr>
<td>11-20-9.</td>
<td>Double junctions</td>
</tr>
</tbody>
</table>

**QUESTIONS 11**

<table>
<thead>
<tr>
<th>Chapter 12:</th>
<th>RAILWAY STATIONS AND YARDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-1.</td>
<td>General</td>
</tr>
<tr>
<td>12-2.</td>
<td>Definition of a station</td>
</tr>
<tr>
<td>12-3.</td>
<td>Purposes of a railway station</td>
</tr>
<tr>
<td>12-4.</td>
<td>Selection of site for a railway station</td>
</tr>
<tr>
<td>12-5.</td>
<td>Facilities required at railway stations</td>
</tr>
<tr>
<td>12-6.</td>
<td>Classification of stations</td>
</tr>
<tr>
<td>12-6-1.</td>
<td>Operational classification</td>
</tr>
<tr>
<td>12-6-2.</td>
<td>Functional classification</td>
</tr>
<tr>
<td>12-7.</td>
<td>Platforms</td>
</tr>
<tr>
<td>12-8.</td>
<td>Staff quarters</td>
</tr>
<tr>
<td>12-9.</td>
<td>Goods traffic at wayside stations</td>
</tr>
<tr>
<td>12-10.</td>
<td>Catch sidings</td>
</tr>
<tr>
<td>12-11.</td>
<td>Definition of a yard</td>
</tr>
<tr>
<td>12-12.</td>
<td>Types of yards</td>
</tr>
<tr>
<td>12-12-1.</td>
<td>Passenger yards</td>
</tr>
<tr>
<td>12-12-2.</td>
<td>Goods yards</td>
</tr>
<tr>
<td>12-12-3.</td>
<td>Marshalling yards</td>
</tr>
<tr>
<td>12-12-4.</td>
<td>Locomotive yards</td>
</tr>
<tr>
<td>12-13.</td>
<td>Level-crossing</td>
</tr>
<tr>
<td>12-14.</td>
<td>Ash-pits, ash-panns and examination pits</td>
</tr>
<tr>
<td>12-15.</td>
<td>Drop pits</td>
</tr>
<tr>
<td>12-16.</td>
<td>Water columns</td>
</tr>
<tr>
<td>12-17.</td>
<td>Triangles</td>
</tr>
<tr>
<td>12-18.</td>
<td>Turntables</td>
</tr>
</tbody>
</table>

**QUESTIONS 12**

<table>
<thead>
<tr>
<th>Chapter 13:</th>
<th>SIGNALLING AND INTERLOCKING</th>
</tr>
</thead>
<tbody>
<tr>
<td>13-1.</td>
<td>Objects of signalling</td>
</tr>
<tr>
<td>13-2.</td>
<td>Classification of signals</td>
</tr>
<tr>
<td>13-2-1.</td>
<td>Classification according to function</td>
</tr>
<tr>
<td>13-2-2.</td>
<td>Classification according to location</td>
</tr>
<tr>
<td>13-2-3.</td>
<td>Special signals</td>
</tr>
<tr>
<td>13-3.</td>
<td>Typical layouts</td>
</tr>
<tr>
<td>13-4.</td>
<td>Interlocking</td>
</tr>
<tr>
<td>13-4-1.</td>
<td>Essential principles of interlocking</td>
</tr>
<tr>
<td>13-4-2.</td>
<td>Methods of interlocking</td>
</tr>
<tr>
<td>13-4-3.</td>
<td>Slotting of signals</td>
</tr>
<tr>
<td>13-4-4.</td>
<td>Detectors</td>
</tr>
<tr>
<td>13-4-5.</td>
<td>Point lock and treadle or lock bar</td>
</tr>
<tr>
<td>13-4-6.</td>
<td>Interlocking of level-crossings</td>
</tr>
<tr>
<td>13-4-7.</td>
<td>Interlocking standards</td>
</tr>
<tr>
<td>13-4-8.</td>
<td>Improvements in interlocking and signalling</td>
</tr>
</tbody>
</table>

**QUESTIONS 13**

<table>
<thead>
<tr>
<th>Section II:</th>
<th>BRIDGE ENGINEERING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 14:</td>
<td>INTRODUCTION</td>
</tr>
<tr>
<td>14-1.</td>
<td>General</td>
</tr>
<tr>
<td>14-2.</td>
<td>Importance of bridges</td>
</tr>
<tr>
<td>14-3.</td>
<td>Identification of bridges</td>
</tr>
<tr>
<td>14-4.</td>
<td>Requirements of an Ideal Bridge</td>
</tr>
<tr>
<td>14-5.</td>
<td>Selection of bridge site</td>
</tr>
<tr>
<td>14-6.</td>
<td>Preliminary data to be collected for bridge project</td>
</tr>
<tr>
<td>14-7.</td>
<td>Stages of investigation</td>
</tr>
<tr>
<td>14-8.</td>
<td>Preliminary and final project drawings</td>
</tr>
<tr>
<td>14-9.</td>
<td>Choice of bridge type</td>
</tr>
<tr>
<td>14-10.</td>
<td>Components of a bridge</td>
</tr>
<tr>
<td>14-11.</td>
<td>Approaches of bridge</td>
</tr>
<tr>
<td>14-12.</td>
<td>Economic span of a bridge</td>
</tr>
<tr>
<td>14-13.</td>
<td>Number of spans of a bridge</td>
</tr>
<tr>
<td>14-14.</td>
<td>Afflux</td>
</tr>
<tr>
<td>14-15.</td>
<td>Clearance and freeboard</td>
</tr>
<tr>
<td>14-16.</td>
<td>Maximum flood discharge or High flood level (H.F.L.)</td>
</tr>
<tr>
<td>14-17.</td>
<td>Length of a bridge</td>
</tr>
<tr>
<td>14-18.</td>
<td>Grip length</td>
</tr>
<tr>
<td>14-19.</td>
<td>Linear waterway of a bridge</td>
</tr>
<tr>
<td>14-20.</td>
<td>Bridge alignment</td>
</tr>
<tr>
<td>14-21.</td>
<td>Joints of bridge</td>
</tr>
<tr>
<td>14-22.</td>
<td>Handrails</td>
</tr>
<tr>
<td>14-23.</td>
<td>River training works</td>
</tr>
</tbody>
</table>

**QUESTIONS 14**

<table>
<thead>
<tr>
<th>Chapter 15:</th>
<th>BRIDGE FOUNDATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-1.</td>
<td>General</td>
</tr>
<tr>
<td>15-2.</td>
<td>Essential requirements of a good foundation</td>
</tr>
<tr>
<td>15-3.</td>
<td>General principles of design of bridge foundations</td>
</tr>
<tr>
<td>15-4.</td>
<td>Subsoil exploration</td>
</tr>
<tr>
<td>15-5.</td>
<td>Testing of soil samples</td>
</tr>
<tr>
<td>15-6.</td>
<td>Types of foundations</td>
</tr>
<tr>
<td>15-7.</td>
<td>Spread foundations</td>
</tr>
<tr>
<td>15-8.</td>
<td>Pile foundations</td>
</tr>
<tr>
<td>15-9.</td>
<td>Caissons and Cofferdams</td>
</tr>
<tr>
<td>15-9-1.</td>
<td>Classification of caissons</td>
</tr>
<tr>
<td>15-9-2.</td>
<td>Materials used for the construction of caissons</td>
</tr>
<tr>
<td>15-9-3.</td>
<td>Requirements of a cofferdam</td>
</tr>
<tr>
<td>15-9-4.</td>
<td>Uses of caissons</td>
</tr>
<tr>
<td>15-9-5.</td>
<td>Uses of cofferdams</td>
</tr>
<tr>
<td>15-9-6.</td>
<td>Types of cofferdams</td>
</tr>
<tr>
<td>15-9-7.</td>
<td>Prevention of leakage in cofferdams</td>
</tr>
<tr>
<td>15-9-8.</td>
<td>Factors affecting design of a cofferdam</td>
</tr>
</tbody>
</table>

**QUESTIONS 15**

<table>
<thead>
<tr>
<th>Chapter 16:</th>
<th>SUB-STRUCTURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>16-1.</td>
<td>General</td>
</tr>
<tr>
<td>16-2.</td>
<td>Abutments</td>
</tr>
<tr>
<td>16-3.</td>
<td>Piers</td>
</tr>
<tr>
<td>16-4.</td>
<td>Wing walls</td>
</tr>
<tr>
<td>16-5.</td>
<td>Setting out for piers and abutments</td>
</tr>
<tr>
<td>16-6.</td>
<td>Materials for sub-structures</td>
</tr>
<tr>
<td>16-7.</td>
<td>Bridge inspection</td>
</tr>
</tbody>
</table>

**QUESTIONS 16**
Chapter 17 CLASSIFICATION OF BRIDGES
17-1. Introduction
17-2. Classification of bridges
17-3. Classification of bridges according to material used
17-4. Classification of bridges according to the position of bridge floor
17-5. Classification of bridges according to the inter span relations
17-6. Classification of bridges according to the form or type of super-structure
17-7. Classification of bridges according to the method of clearance for navigation (Movable bridges)
17-8. Classification of bridges according to the length of span or as per linear waterway
17-9. Classification of bridges according to the road level relative to highest flood level (H.F.L.)
17-10. Classification of bridges according to life or expected period of service of super-structure
17-10-1. Bridges with intermediate supports
17-10-2. Bridges without intermediate supports
17-10-3. Floating bridges
17-11. Classification of bridges according to flexibility of super-structure
17-12. Classification of bridges according to the alignment
17-13. Classification of bridges according to level of crossing of highways and railways
17-14. Classification of bridges according to method of connections adopted for different parts of super-structure
17-15. Classification of bridges according to the function of a bridge
17-16. Classification of bridges according to the degree of redundancy
17-17. Classification of bridges according to the loading

QUESTIONS 17

Chapter 18 BRIDGE FLOORING
18-1. General
18-2. Factors affecting the choice of flooring material
18-3. Requirements of a good flooring material
18-4. Types of floors
18-5. Flooring materials
18-6. Drainage of floors

QUESTIONS 18

Chapter 19 BRIDGE BEARINGS
19-1. Definition
19-2. Purposes or functions of bearings
19-3. Importance of bearings
19-4. Free and fixed bearings
19-5. Types of bearings
19-6. Materials for bearings
19-7. Bed blocks
19-8. Maintenance of bearings

QUESTIONS 19

Chapter 20 DESIGN OF BRIDGES
20-1. General
20-2. Buoyancy pressure
20-3. Centrifugal forces
20-4. Dead load
20-5. Deformation stresses
20-6. Earth pressure
20-7. Erection stresses
20-8. Impact load
20-9. Live load
20-10. Longitudinal forces
20-11. Secondary stresses
20-12. Seismic load
20-13. Temperature variation forces
20-14. Water pressure
20-15. Wind load
20-16. Design of bridge foundations
20-17. Forces acting on different components of a bridge

QUESTIONS 20

Chapter 21 CONSTRUCTION AND ERECTION METHODS OF BRIDGE SUPER-STRUCTURE
21-1. General
21-2. Erection of steel girders
21-3. Erection of steel truss bridges
21-4. Erection of suspension bridges
21-5. Construction of pre-stressed concrete super-structure
21-6. Erection of R.C.C. and pre-stressed girder bridges
21-7. Formwork for arch bridges

QUESTIONS 21

Chapter 22 MAINTENANCE OF THE BRIDGES
22-1. General
22-2. Deterioration of bridges
22-3. Bridge Failures
22-4. Defects of bridges and their rectification
22-5. Inspection of bridges
22-6. Posting of bridges
22-7. Rating of existing bridges
22-8. Rebuilding of bridges
22-9. Testing and strengthening of bridges
22-10. Maintenance of the bridges

QUESTIONS 22

Section III: TUNNEL ENGINEERING

Chapter 23 GENERAL ASPECTS OF TUNNELLING
23-1. General
23-2. Advantages and disadvantages of tunnelling
23-3. Advantages and disadvantages of open cuts
23-4. Alignment of a tunnel
23-5. Classification of tunnels
23-6. Shape of tunnels
23-7. Size of tunnels
23-8. Problems in tunnelling

QUESTIONS 23

Chapter 24 ALIGNMENT OF A TUNNEL
24-1. Investigations for tunnel site
24-2. Setting out or alignment of tunnel
24-3. Excavation
24-4. Excavation of tunnels in rock with machines
24-5. Blasting

QUESTIONS 24

Chapter 25 SHAFTS AND PORTALS
25-1. General
25-2. Advantages of shafts
25-3. Size of shafts
25-4. Location of shafts
25-5. Classification of shafts
25-6. Construction of shafts in rock
25-7. Construction of shaft in soft ground
25-8. Precautions for shaft sinking work in soft soil
25-9. Protection round the shaft opening
25-10. Portals
25-11. Twin tunnels

QUESTIONS 25
Chapter 26 TUNNELLING IN HARD ROCK
26-1. General
26-2. Sequence of operations for tunnelling in rock
26-3. Faces of attack for tunnelling in rock
26-4. Methods of tunnelling in rock
26-5. Mucking
26-6. Hauling
26-7. Safety precautions in rock tunnelling

Chapter 27 TUNNELLING IN SOFT GROUND
27-1. Soil classification
27-2. Choice of method
27-3. Methods of tunnelling in soft ground
27-4. Forepoling method
27-5. Needle beam method
27-6. Army method or case method
27-7. American method
27-8. English method
27-9. Belgian method
27-10. German method
27-11. Austrian method
27-12. Liner plates method
27-13. Shield tunnelling
  27-13-1. Dimensions of shield
  27-13-2. Parts of shield
  27-13-3. Terms used with shield
  27-13-4. Primary lining
  27-13-5. General steps of tunnelling with shield
  27-13-6. Shield tunnelling in different types of soils
  27-13-7. Common Equipments with shield
  27-13-8. Stages of using the shield
27-14. Timbering in soft soil tunnelling

Chapter 28 TUNNEL LINING
28-1. Necessity of lining
28-2. Objects of lining
28-3. Materials for lining
28-4. Sequence of lining a tunnel

Chapter 29 LIGHTING, VENTILATION AND DUST CONTROL IN TUNNELS
29-1. Tunnel lighting
  29-1-1. Spacing of lights
  29-1-2. Types of tunnel lights
29-2. Ventilation in tunnels
  29-2-1. Objects of tunnel ventilation
  29-2-2. Requirements of tunnel ventilation
  29-2-3. Volume of air required
  29-2-4. Methods of ventilation
  29-2-5. Equipments for ventilation
  29-2-6. Permanent ventilation
29-3. Dust control

Chapter 30 DRAINAGE OF TUNNELS
30-1. General
30-2. Pré-drainage
30-3. Dewatering (Temporary drainage)
30-4. Pumping (Temporary drainage)
30-5. Permanent drainage

Chapter 31 SAFETY IN TUNNEL CONSTRUCTION
31-1. General
31-2. Safety precautions in tunnelling
31-3. Health protection

APPENDICES
Appendix I ABBREVIATED TERMS
Appendix II GTU EXAMINATION PAPERS
Index