

Module 1

Chapter 1 : Introduction to Transportation systems

1-1 to 1-29

1.1 Introduction to Transportation Engineering : Comparison of various modes of transportation (Roadways, Railways, Airways and Waterways).

1.2 Introduction to Railway Engineering : Cross sectional elements of railway track (Foundation, Ballast, Sleepers and Rail), Introduction to turnout, Super elevation design, Negative Super elevation, Construction and Maintenance of Railway track.

1.3 Introduction to Airport Engineering : Elements of Airport, Site selection of Airport, Design of Runway length, Taxiway and Exit Taxiway design.

1.4 Introduction to Waterways : Definition of Docks, Harbour and Ports. Elements and types of Docks, Harbour and Port

1.1 Introduction to Transportation Engineering ... 1-1

1.1.1 Definition1-1

1.1.2 Role of Transportation.....1-1

1.1.3 Importance of Transportation.....1-1

1.1.4 Comparison of Various Modes of Transportation (Roadways, Railways, Airways and Waterways)1-2

1.2 Introduction to Railway Engineering..... 1-4

1.2.1 Elements of Railway.....1-4

1.2.2 Types of Rails.....1-4

1.2.3 Classification of Railway Sleepers.....1-7

1.2.4 Railway Ballast.....1-9

1.2.5 Introduction to turnout..... 1-12

1.2.6 Super Elevation Design..... 1-13

1.2.7 Negative Super Elevation..... 1-14

1.2.8 Construction of Railways Track..... 1-15

1.2.9 Track Maintenance 1-17

1.3 Introduction to Airport Engineering 1-18

1.3.1 Elements of Airport..... 1-18

1.3.2 Airport Site Selection..... 1-20

1.3.3 Design of Runway Length..... 1-21

1.3.4 Examples on Determination of Actual Runway Length..... 1-21

1.3.5 Taxiway and Exit Taxiway Design 1-24

1.3.6 Geometric Design Standards for Taxiway 1-24

1.4 Introduction to Waterways 1-26

1.4.1 Definition of Docks 1-26

1.4.2 Definition Harbour 1-26

1.4.3 Classification of Harbours 1-27

1.4.4 Ports..... 1-29

Module 2

Chapter 2 : Planning & Geometric Design of Highways

2-1 to 2-39

2.1 Classification of roads based on various criteria : Road development plans, agencies related to highway development, Highway alignment (basic requirement and factors governing), hill roads, Surveys for highway location.

2.2 Terrain Classification : Vehicular Characteristics, Cross section elements of highways (width of carriage way, shoulders, medians, width of road way, right of way, camber & its profile).

2.3 Design speed : Sight distance, perception time, break reaction time, analysis of safe sight distance, analysis of overtaking sight distance, intersection sight distance.

2.4 Horizontal curves : Design of super elevation, its provisions, minimum radius of horizontal curves, widening of pavement, transition curves.

2.5 Gradients : Different types, maximum, minimum, ruling exceptional, grade compensation on curves.

2.1 Classification of Roads Based on Various Criteria 2-1

2.1.1 Traffic Volume2-1

2.1.2 Traffic Tonnage2-1

2.1.3 Location and Function.....2-1



<p>2.1.4 Classification of Roads Based on Width2-2</p> <p>2.1.5 Classification of Roads Based on Economy.....2-2</p> <p>2.1.6 Classification of Roads Based on Traffic2-2</p> <p>2.1.7 Classification Based on Rigidity2-2</p> <p>2.1.8 Classification Based on Topography.....2-3</p> <p>2.1.9 Classification based on Material.....2-3</p> <p>2.1.10 Road Development Plans.....2-3</p> <p>2.1.11 Agencies Related to Highway Development.....2-5</p> <p>2.1.12 Highway Alignment.....2-6</p> <p>2.1.12.1 Requirement of an Ideal Alignment of Road2-6</p> <p>2.1.12.2 Factors Affecting Alignment of Roads.....2-7</p> <p>2.1.13 Different Type of Survey for Highway Location2-8</p> <p>2.1.14 Highway Alignment in Hilly Area2-9</p> <p>2.1.14.1 Alignment Survey2-11</p> <p>2.1.15 Drawing Reports Preparation2-11</p> <p>2.2 Geometric Design of Highway.....2-12</p> <p>2.2.1 Terrain Classification2-12</p> <p>2.2.2 Vehicular Characteristics.....2-13</p> <p>2.2.3 Highway Cross Section Elements and Salient Dimensions2-14</p> <p>2.2.4 Camber2-18</p> <p>2.2.4.1 Purpose of Camber2-18</p> <p>2.2.4.2 Types of Camber.....2-18</p> <p>2.3 Design Speed2-20</p> <p>2.3.1 Factors Affecting Design Speed.....2-20</p> <p>2.3.2 IRC Specification.....2-21</p> <p>2.3.3 Sight Distance2-21</p> <p>2.3.3.1 Factors Affecting Sight Distance2-21</p> <p>2.3.3.2 Types of Sight Distance.....2-21</p> <p>2.3.3.3 Overtaking zone2-25</p> <p>2.4 Horizontal Curves2-26</p> <p>2.4.1 Types of Horizontal Curve.....2-26</p>	<p>2.4.2 Widening of Roads2-28</p> <p>2.4.2.1 Object of Providing Extra Widening of Roads2-28</p> <p>2.4.2.2 Types of a Widening.....2-28</p> <p>2.4.3 Super Elevation2-29</p> <p>2.4.3.1 Object of Providing Super Elevation2-29</p> <p>2.4.3.2 Formula for Calculating Minimum and Maximum Super Elevation2-29</p> <p>2.4.3.3 Maximum Super Elevation2-30</p> <p>2.4.3.4 Minimum Super Elevation.....2-31</p> <p>2.4.3.5 Design of Super Elevation.....2-31</p> <p>2.5 Numericals on Geometric Design of Road2-32</p> <p>2.6 Gradient2-38</p> <p>2.6.1 Purpose of Gradient2-38</p> <p>2.6.2 Types of Gradient.....2-38</p> <p>2.6.3 Factors Affecting Gradient.....2-39</p> <p>2.6.4 Grade Compensation on Curves.....2-39</p>
--	--

Module 3

Chapter 3 : Traffic Engineering

3-1 to 3-34

3.1 Introduction to various traffic studies such as speed study, volume study, parking study, accident study, O&D study etc. Speed study : methods to determine speed, types of speed (Spot speed, Design speed, Upper & lower limit speeds, Mean - Median and Modal speed); Traffic Volume study (flow) : Definition, AADT, ADT, Design volume, methods of determining traffic volume. Traffic density: Definition, importance.

3.2 Introduction to Relationship between speed, density and volume : Capacity : Q-K-V curve, Different types and factors affecting capacity, Concept of PCU and LOS.

3.3 Introduction to traffic control devices Traffic signs, signals (no design), road marking.

3.4 Different types of Intersections - At-grade and Grade Separated ; Grade separated interchanges; rotary intersection.



3.1	Traffic Studies and Analysis 3-1	3.2.2	Basic Capacity 3-20
3.1.1	Different Methods of Conducting Traffic Volume Study 3-1	3.2.3	Possible Capacity 3-20
3.1.2	Traffic Volume Study 3-1	3.2.4	Practical Capacity 3-21
3.1.3	Objects and Use of Traffic Volume Studies 3-2	3.2.5	Factors Affecting Traffic Capacity 3-21
3.1.4	Counting of Traffic Volume 3-2	3.2.6	Q-K-V Curve (Fundamental Diagrams of Traffic Flow) 3-21
3.1.5	Method of Presentation of Traffic Data 3-3	3.2.7	Passenger Car Units (PCU) 3-22
3.1.6	Parking Studies 3-3	3.2.7.1	Factors Affecting PCU Values 3-23
3.1.6.1	Objects of Parking Studies 3-6	3.2.8	Level of Service (LOS) 3-24
3.1.7	Accident Study 3-8	3.3	Introduction to Different Types of Traffic Control Devices 3-24
3.1.7.1	Objective of Accident Studies 3-8	3.3.1	Requirements of Traffic Control Devices 3-24
3.1.7.2	Causes of Accidents 3-8	3.3.2	Type of Traffic Control Devices 3-24
3.1.7.3	Accident Records 3-8	3.3.3	Road Signs 3-24
3.1.8	Origin and Destination Studies 3-9	3.3.3.1	Regulatory Signs 3-24
3.1.8.1	Necessity of Origin and Destination Studies 3-10	3.3.3.2	Types of Regulatory Signs 3-24
3.1.8.2	Methods of Origin and Destination Studies 3-10	3.3.4	Warning Signs 3-26
3.1.9	Speed Study 3-11	3.3.5	Informatory Signs 3-27
3.1.9.1	Spot Speed Studies 3-11	3.3.6	Road Marking 3-27
3.1.9.2	Methods of Conducting Spot Speed Studies 3-12	3.3.6.1	Types of Marking 3-27
3.1.9.3	Methods of Data Representation 3-14	3.3.7	Traffic Signals 3-28
3.1.9.4	Numericals 3-14	3.3.7.1	Advantages of Traffic Signals 3-28
3.1.10	Traffic Volume Study 3-19	3.3.7.2	Disadvantages of Traffic Signals 3-28
3.1.10.1	Definition of Traffic Volume Study 3-19	3.3.8	Types of Traffic Signals 3-29
3.1.10.2	Purpose of Traffic Volume Study 3-19	3.4	Traffic Island 3-29
3.1.11	Traffic Density 3-19	3.4.1	Types of Traffic Island 3-29
3.2	Relationship between Speed, Density and Volume 3-19	3.4.2	Road Intersections 3-31
3.2.1	Capacity 3-20	3.4.2.1	Types of Intersections 3-31
		3.4.3	Interchanges 3-33

Module 4

Chapter 4 : Pavement Material and Design 4-1 to 4-49

4.1 Types of pavements : comparison of flexible and rigid pavements, Requirements of pavement materials, Soil: requirement of soils as subgrade material, CBR test.

Aggregate : Requirements of aggregate as Pavement material, Tests on aggregate with specified values. Bitumen: Requirements of bitumen as pavement material test on bitumen with specified values, variants of bitumen (Modified bitumen) and its uses. Introduction to Bituminous mix design using Marshall Stability test.

4.2 Flexible pavement design : Concepts related to flexible pavement design such as tyre pressure, contact pressure, ESWL, VDF and LDF. IRC approach for design (IRC: 37- 2001, IRC: 37- 2012), also IRC SP 72-2007/2015 and IRC 77 2008.

4.3 Rigid pavement design : Modulus of subgrade reaction, equivalent radius of resisting section, radius of relative stiffness, stresses on rigid pavement, combine loading temperature stress; Design of rigid pavements (IRC: 58- 2002; IRC: 58- 2011, IRC: 58- 2015. IRC: SP- 62- 2004, IRC: SP- 62-2014).

4.1 Pavements..... 4-1

4.1.1 Objects.....4-1

4.1.2 Types of Pavement Structure.....4-1

4.1.3 Components of Pavement and Their Functions.....4-3

4.1.4 Comparison of Flexible and Rigid Pavement.....4-3

4.1.5 Pavement Materials.....4-4

4.1.6 Subgrade Soil.....4-4

4.1.6.1 Characteristic of a Subgrade Soil.....4-4

4.1.6.2 Soil Classification Systems4-4

4.1.7 California Bearing Ratio (CBR) Test.....4-9

4.1.8 Aggregates.....4-11

4.1.8.1 Requirement of Aggregate4-12

4.1.8.2 Test of Road Aggregate.....4-12

4.1.9 Bitumen Materials4-14

4.1.9.1 Requirement.....4-14

4.1.9.2 Test on Bitumen Material4-16

4.1.9.3 Marshall Stability Test4-19

4.2 Flexible Pavement Design.....4-20

4.2.1 Design Factors4-20

4.2.2 Vehicle Damage Factor (VDF).....4-23

4.2.3 Lane Distribution Factor (LDF).....4-23

4.2.4 IRC Approach for Design (IRC 37 – 2001, IRC 37-2012).....4-24

4.2.5 IRC Approach for Design (IRCSP 72-2007/2015).....4-24

4.2.6 Numerical on Flexible Pavement Design4-25

4.3 Rigid Pavement Design4-27

4.3.1 IRC Method of Rigid Pavement Design4-27

4.3.2 Determination of the Thickness of Pavement Slab4-28

4.3.3 Low Traffic-Volume Rigid Pavements for Rural Roads (IRC: SP: 62-2004)4-29

4.3.4 Design of Reinforcements for Pavement Slab.....4-30

4.3.5 Joints in Cement Concrete Pavements4-30

4.3.6 Types of Joints4-30

4.3.7 Spacing of Joints.....4-32

4.3.7.1 Design of Spacing of Joints4-32

4.3.8 Reinforced Cement Concrete Slabs4-33

4.3.9 Design of Dowel Bars.....4-34

4.3.10 Design of Tie-Bars.....4-34

4.3.11 IRC: 58-2011 – Guidelines for the Design of Plain Jointed Rigid Pavements for Highways (Third Revision)4-35

4.3.12 Types of Concrete Pavements.....35

4.3.12.1 Factors Governing Design of Concrete Pavements:.....4-36



4.3.13	Characteristics of Subgrade.....	4-37	5.1.2.2	Bituminous Construction Procedures.....	5-6
4.3.14	Calculations of Flexural Stress	4-37	5.1.2.3	Merits and Demerits of Bituminous Road	5-10
4.3.14.1	Finite Element Method	4-37	5.1.3	Cement Concrete Road.....	5-10
4.3.14.2	Continuously Reinforced Cement Concrete Pavements (CRCP)	4-38	5.1.3.1	Method of Construction of Cement Concrete Road	5-10
4.3.14.3	Recent Developments in Cement Concrete Pavement Design.....	4-38	5.1.3.2	Specifications of Material Used	5-11
4.3.14.4	Factors Governing Design Of Cement Concrete Pavement.....	4-39	5.1.3.3	Plant and Equipment	5-11
4.3.15	Design Of Slab Thickness	4-41	5.1.3.4	Construction Steps for Cement Concrete Pavement Slab	5-11
4.3.16	Concrete Pavement Joints	4-42	5.1.4	Construction of Joints in Cement Concrete Road	5-12
4.3.17	Numerical on Rigid Pavement.....	4-44	5.1.4.1	Reason for Providing Joints	5-12

Module-5

Chapter 5 : Pavement Construction, Soil Stabilization and Drainage **5-1 to 5-23**

5.1 Construction of different types of roads : Water bound macadam (WBM) road, WMM, bituminous pavements, cement concrete pavement. And joint (As per IRC, MORTH specifications) jointed reinforced, continuously reinforced; fiber reinforced; roller compacted concrete pavements.

5.2 Soil Stabilization : Significance, Principle of soil stabilization, different methods of soil Stabilization, use of Geosynthetics in highways and allied structures.

5.3 Highway drainage : Necessity/ Significance, mode of ingress of water in highway structure, Different methods of drainage- surface and subsurface drainage inking for the roads in hilly areas.

5.1	Construction of Different Types of Roads.....	5-1	5.1.5	Joint Filler and Sealer	5-14
5.1.1	Construction of Water Bound Macadam Road.....	5-1	5.1.5.1	Joint Filler	5-14
5.1.1.1	Material Required and its Specifications for WBM Road.....	5-1	5.1.5.2	Joint Sealer	5-15
5.1.1.2	Construction Procedure	5-2	5.1.6	Jointed Reinforced Concrete Pavement.....	5-15
5.1.1.3	Merits and Demerits of WBM Road.....	5-4	5.1.7	Continuously Reinforced Concrete Pavement (CRCP)	5-16
5.1.2	Construction of Bituminous Pavements	5-4	5.1.8	Fibre Reinforced Concrete Pavement	5-16
5.1.2.1	Terms Used in Bituminous Road.....	5-4	5.1.9	Roller Compacted Concrete Pavement	5-16
			5.2	Soil Stabilization.....	5-16
			5.2.1	Definition of Soil Stabilization	5-16
			5.2.2	Significance	5-17
			5.2.3	Principles of Soil Stabilizations	5-17
			5.2.4	Methods of Soil Stabilization	5-17
			5.2.5	Use of Geosynthetics in Highways and Allied Structures	5-18
			5.3	Highway Drainage	5-19
			5.3.1	Necessity Drainage	5-19
			5.3.2	Mode of Ingress of Water in Highway Structure	5-19

5.3.3 Methods of Drainage.....5-19

5.3.4 Surface Drainage.....5-20

5.3.4.1 Function of Surface Drainage.....5-20

5.3.4.2 Types of Surface Drainage.....5-20

5.3.4.3 Surface Drainage System in Urban Roads.....5-20

5.3.4.4 Cross Drainage.....5-20

5.3.5 Sub-Surface Drainage.....5-21

5.3.5.1 Lowering of Water Table5-21

5.3.6 Control of Seepage Flow.....5-22

5.3.6.1 Control of Capillary Rise5-23

Module 6

Chapter 6 : Pavement Evaluation, Failures & Maintenance 6-1 to 6-14

6.1 Evaluation of pavement : Structural and functional evaluation, methods of structural evaluation (working of Benkelman beam, FWD, LWD), methods of functional evaluation (working of Bump indicator, profilometric systems).

6.2 Distress / failure in Rigid and flexible pavement, reasons and measures.

6.3 Strengthening of existing pavement : Overlay and its types, design of overlay (Benkelman beam method).s

6.1 Evaluation of Pavement..... 6-1

6.1.1 Method of Pavement Evaluation.....6-1

6.2 Distress/Failure in Rigid Pavement, Reasons and Measures 6-4

6.2.1 Typical Rigid Pavement Failures6-5

6.2.1.1 Mud Pumping.....6-5

6.3 Highway Maintenance 6-6

6.3.1 Necessity of Highway Maintenance.....6-6

6.3.2 Classification of Maintenance Works6-6

6.3.3 Maintenance of Cement Concrete Roads6-6

6.3.4 Special Repairs of Rigid Pavement (Cement Concrete Pavement).....6-7

6.4 Distress/Failure in Flexible Pavement Reason and Measures 6-7

6.4.1 Maintenance of Bituminous Surfaces.....6-9

6.4.2 Special Repairs in Flexible Pavements.....6-10

6.5 Strength of Existing Pavements6-10

6.5.1 Types of Overlay6-10

6.6 Numericals on Design of Flexible Overlays6-12