



## Table of Contents

<b>1</b>	<b>Roads as a Metric of Development</b>	<b>1</b>
1.1	Understanding the Basics	1
1.2	Road Development in the Post-Independence Countries	3
1.3	Roads and Economic Development: How are they related?	4
1.4	Roads and Poverty: How are they related?	5
1.5	Roads and the Market-Based Economy: How are they related?	6
1.6	Reference	7
<b>2</b>	<b>Understanding the Role of Policy</b>	<b>8</b>
2.1	What is Policy?	8
2.2	Understanding Governmental and Organizational Policies	9
2.3	Policy Integration	12

2.4	Propagating a Policy	16
2.5	Performance Index of a Policy	16
2.5.1	Monitoring the Policy	16
2.5.2	Presentation	17
2.6	Policy Design	18
2.6.1	Some Key Issues in Policy Design Process	19
2.7	Reference	20

### 3 Traffic 21

3.1	Introduction	21
3.2	Composition of the Traffic	22
3.2.1	Various Modes of Transport	22
3.2.2	Commercial Transportation	23
3.2.3	Cycle Commuters and Pedestrian Commuters	24
3.2.4	Design Models and their Application	24
3.3	Growth and Flow of Traffic	25
3.3.1	Traffic	25
3.3.2	Axle Loading	26
3.4	Speed Flow and Capacity	27
3.4.1	Capacity	27
3.4.2	Flow Variation	29
3.4.3	Volume of Service	29
3.5	Capacity Increment	30
3.5.1	Improvement in Terms of Geometry	30
3.5.2	Commercial Transport	30
3.6	Various Information and Data on the Traffic Systems	31
3.7	Reference	35

### 4 Road Safety 36

4.1	Introduction	36
4.2	Trends and Safety Measurements	37
4.3	Patterns of Road Accidents	40
4.4	Factors Contributing to Accidents	41
4.5	Road Safety Improvements	42
4.5.1	Training and Education	45
4.6	Reference	46

<b>5</b>	<b>Roads and Environments</b>	<b>47</b>
5.1	Introduction	47
5.2	Consequences on the Environment and their Mitigation	48
5.2.1	Flora and Fauna	48
5.2.2	Air Quality	49
5.2.3	WaterResources	50
5.2.4	Soil	52
5.2.5	Noise	52
5.2.6	CulturalHeritage	54
5.2.7	Socio-economicConcerns	54
5.3	Assessment of the Environmental Impact	55
5.3.1	Background	55
5.3.2	Screening	55
5.3.3	Scoping	56
5.3.4	AssessmentMethods and Techniques	56
5.3.5	Valuation of Environmental Impacts	57
5.3.6	Public Consultation	57
5.3.7	EnvironmentalControls and Monitoring	58
5.3.8	Strategic Assessment of Environment	59
5.4	Reference	59
<b>6</b>	<b>Methods of Planning</b>	<b>60</b>
6.1	Nature of Planning	60
6.1.1	Plan in Road Design	61
6.2	Elements used in Designing	63
6.3	Demand Forecasting of Transportation	66
6.4	Planning Application	68
6.5	Development of Plans and its Implementation	69
6.6	Rural Transport Infrastructure Planning	70
6.6.1	Elements of Rural Transport	71
6.6.2	Integrated Rural Accessibility Planning Methodology (IRAP)	72
6.7	Reference	74
<b>7</b>	<b>Economic Evaluation of Roads and Highways</b>	<b>75</b>
7.1	Introduction	75
7.2	Purpose of Economic Assessment in Constructing a Road	77
7.3	Estimation of Costs in Construction of Roads	79

7.4	Estimation of Benefits in Construction of Roads	84
7.5	Economic Assessment for Major and Minor Roads	86
7.6	Restrictions of Economic Assessment	87
7.7	Cost-benefit Assessment for Roads	89
7.8	Reference	93
<b>8</b>	<b>Investigation of Soil</b>	<b>94</b>
8.1	Introduction	94
8.2	Types of Soil Investigations for the Construction of Road	96
8.2.1	Determination of Moisture Content in Soil	96
8.2.2	Determination of Soil's Specific Gravity	96
8.2.3	Determination and Distribution of Particle Size	96
8.2.4	Compaction Test	97
8.2.5	The California Bearing Ratio Test	97
8.3	Evaluation of Obtained Information	98
8.3.1	Map Interpretation	98
8.3.2	Interpretation of Air Photo	99
8.3.3	Interpretation of Satellite Image	101
8.3.4	Terrain Classification	102
8.4	Investigation of Field	102
8.4.1	Geophysical Exploration	102
8.4.2	Sampling	104
8.5	Laboratory Testing	105
8.5.1	How to Approach	105
8.5.2	Distributed Soil Testing	105
8.5.3	California Bearing Ratio	108
8.6	Classification of Soil	110
8.7	Reference	111
<b>9</b>	<b>Tropical Soils and Rocks</b>	<b>112</b>
9.1	Introduction	112
9.2	Rocks and Their Types	114
9.2.1	Igneous Rocks	114
9.2.2	Sedimentary Rocks	116
9.2.3	Metamorphic Rocks	118
9.3	Soil	118
9.3.1	Laterite	119
9.3.2	Desert Soils	122

9.3.3	Clays	125
9.3.4	Volcanic Soils	126
9.3.5	Alluvial Soils	127
9.4	Reference	127
<b>10 Hydrological Engineering and Drainage</b>		<b>128</b>
10.1	Introduction	128
10.2	Precipitation	131
10.3	Flood Discharge Estimation	134
10.4	Information on Direct Streamflow	137
10.5	Representation Technique of the Runoffs	138
10.6	Design of Hydrologic Structures	139
10.6.1	Hazards	139
10.7	Various Components of the Drainage System	140
10.8	Erosion	141
10.9	Conclusion	142
10.10	Reference	143
<b>11 Geometric Design</b>		<b>144</b>
11.1	Important Elements for Designing of Roads	144
11.2	Horizontal Alignment	147
11.2.1	Horizontal Tangent	148
11.3	Vertical Alignment	149
11.3.1	Vertical Curvature	150
11.3.2	Vertical Curves of Minimum Lengths	151
11.4	Phasing	152
11.4.1	Mis-phasing and its Types	152
11.5	Alignment Co-ordination	153
11.6	Intersections	155
11.7	AutoCAD Civil 3D (Computer-aided Design)	156
11.8	Reference	158
<b>12 Earthworks, Unbound and Stabilized Pavements</b>		<b>159</b>
12.1	Introduction	159
12.2	Clearance and Burrowing	160
12.3	Excavation	160
12.4	Embankment Construction	162
12.5	Compaction	163

12.6	Finishing Operations	165
12.7	Structuring of the Pavements	165
12.8	Unbound Pavement Layers	166
12.8.1	Constituents	166
12.8.2	Topping Layer	166
12.8.3	Sub-base	167
12.8.4	Base	167
12.9	Designing of the Pavements Made Out of the Gravel	170
12.10	Stabilized Pavement Layers	170
12.11	Stabilized Layer Constructions	175
12.12	Reference	176

### 13 Asphalt Pavements 177

13.1	Introduction	177
13.2	Design of Asphalt Pavements	179
13.3	Overseas Road Note 31	180
13.3.1	Design Process of ORN31	180
13.3.2	Traffic	181
13.3.3	Strength of the Subgrade	182
13.3.4	CBR Tests	183
13.3.5	Designing the Pavement	184
13.4	The AASHTO Method	186
13.5	Theoretical and Mechanistic Designs	190
13.5.1	Linear Elastic Theory	191
13.5.2	Criteria of Failures	192
13.6	Materials Required in Construction of Pavements	193
13.7	Reference	194

### 14 Road Construction Contracts and Securing Construction Tasks 195

14.1	Introduction	195
14.2	Types of Construction Contracts	197
14.3	Methods of Project Execution in Road Construction Contracts	200
14.4	Agency in Road Construction	201
14.5	Project Management in Road Construction	202
14.6	Works and Supervision Contracts	203
14.7	Concessions	205

14.7.1	Terminology for Concessions	206
14.7.2	Advantages and Disadvantages of Concessions	206
14.8	External Financing	207
14.9	Procurement of Works Through Civil Engineering Contracts	208
14.9.1	Partnering: An Innovative Approach to the Procurement of Works	209
14.10	Steps Involved in the Selection of Administration Engineers	210
14.11	Selection of Contractor: Basic Approaches	212
14.11.1	Prequalification	213
14.11.2	The Tender	213
14.12	Reference	215
<b>15</b>	<b>The Importance of Supervising a Contract</b>	<b>216</b>
15.1	Introduction	216
15.2	Different Aspects of a Supervision Organization	217
15.2.1	Staff and Responsibilities	217
15.2.2	Supervision Practices	219
15.3	Maintainance of the Quality	220
15.4	How to Measure the Work?	223
15.5	Monitoring the Progress of Work	229
15.6	Necessity for Time Extension	230
15.7	Claiming Expenses	231
15.7.1	Types of Claims	231
15.7.2	Procedure to Make a Claim	232
15.8	The Contractor's Default	233
15.9	Procedure for Supervising a Project	234
15.10	Reference	236
<b>16</b>	<b>Appropriate Technology</b>	<b>237</b>
16.1	Introduction	237
16.2	Technology Choices	238
16.2.1	Aptness of Technology	238
16.2.2	Technological Appropriateness	239
16.2.3	Cost-effectiveness	240
16.2.4	Labor and Equipment Availability	240
16.2.5	Domestic Resources	241

16.3	Intermediate Methods	242
16.3.1	Institutional Framework	242
16.3.2	Contractors	243
16.3.3	Labour Issues	244
16.3.4	Technical Issues	244
16.3.5	Tools and Experiment	245
16.3.6	Organization of Work	246
16.4	Equipment Management	247
16.4.1	Basic Principles	247
16.4.2	Organizational Arrangements	247
16.5	Reference	248

## 17 Management of Road Networks 249

17.1	Introduction	249
17.2	Concept of Road Network	250
17.3	Operations of Road Network	253
17.4	The Network of Road: An Asset or a Liability	256
17.5	Management of Road Networks	258
17.6	Auditing and Monitoring	263
17.7	Information System	264
17.8	Reference	267

## 18 Operations Done for Maintenance 268

18.1	Introduction	268
18.2	Categorization of Activities Related to Maintenance	269
18.3	Required Precautionary Measures	270
18.4	Role of Asphalt Pavement	271
18.4.1	Process of Sanding	272
18.4.2	Technique of Local Sealing	272
18.4.3	Techniques for Sealing a Crack	274
18.4.4	Methods to Fill Depression	274
18.4.5	Role of Surface Patching	276
18.4.6	Need for the Base Patching Technique	276
18.4.7	Importance of Surface Dressing	277
18.4.8	Usage of Slurry Seal and Fog Spray	277
18.4.9	What is an Asphalt Overlay?	278
18.4.10	Prime Causes for Pavement Deterioration	278
18.5	Creation of the Unpaved Roads	279



18.6	Maintenance of the Roadside Areas	281
18.6.1	Maintaining the Shoulders	281
18.7	Maintenance of Shoulders	283
18.8	The Importance of Maintaining the Drainage System	284
18.9	Implementation of the Road Maintenance Tasks	285
18.10	Reference	286
<b>19</b>	<b>Road Investment Model: HDM – 4</b>	<b>287</b>
19.1	Introduction	287
19.2	Classification of Analysis	289
19.2.1	Project Analysis	289
19.2.2	Program Analysis	290
19.2.3	Strategy Analysis	291
19.3	Highway Management and Role of HDM – 4	291
19.3.1	Highways and their Management	291
19.3.2	Management Cycle	294
19.4	Structure of HDM – 4	295
19.4.1	HDM – 4 Modules	295
19.4.2	Data Required	297
19.5	Reference	299
<b>20</b>	<b>Institutional Development</b>	<b>300</b>
20.1	The Scenario at Present	300
20.2	Basis of an Approach	303
20.3	Finance	304
20.3.1	Recovery of Expenses	306
20.3.2	Finances in Road Networks	307
20.3.3	Major Roads being Financed by Public Sector	307
20.3.4	Minor Roads being Financed by Public Sector	308
20.3.5	Major Roads being Financed by Private Sector	310
20.4	Financing Mechanisms	311
20.5	Reference	311
<b>21</b>	<b>Training of Staff</b>	<b>312</b>
21.1	Introduction	312
21.2	Road Organizations and Training	314
21.3	Institutional Issues	316
21.4	Types of Training	318

21.4.1	Types of Internal Training	318
21.5	Analyzing the Need for Training	322
21.5.1	Identifying the Needs	322
21.5.2	Training Priorities	322
21.5.3	Corresponding Requirements	323
21.6	Planning for the Training	323
21.6.1	A Base for Preparation	323
21.6.2	The Training Environment	323
21.6.3	Trainees	324
21.6.4	The Training Programs	325
21.6.5	Contracts and Consultancies for Training of Employees	326
21.7	Implementation	327
21.7.1	Communicating with Trainees	327
21.7.2	Monitoring and Feedback	327
21.8	Reference	328
<b>22</b>	<b>Development Aid</b>	<b>329</b>
22.1	Introduction	329
22.2	Resource Transfer	331
22.3	Aid to the Road and Transport Sector	333
22.4	Modern Techniques used for Managing Financial Aid	333
22.5	Reference	336
	<b>Index</b>	<b>337</b>