TABLE OF CONTENTS
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Acknowledgements</th>
<th>(i)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>(iii)</td>
</tr>
<tr>
<td>Table of Contents</td>
<td>(vii)</td>
</tr>
<tr>
<td>List of Figures</td>
<td>(xv)</td>
</tr>
<tr>
<td>List of Tables</td>
<td>(xviii)</td>
</tr>
<tr>
<td>List of Abbreviations</td>
<td>(xx)</td>
</tr>
<tr>
<td>List of Symbols</td>
<td>(xxi)</td>
</tr>
</tbody>
</table>

## CHAPTER 1 - TRANSPORTATION AND ROAD DEVELOPMENT IN RURAL AREAS

1.1 Introduction

1.2 Problems in Rural Development and Importance of Rural Transportation

1.3 Rural Transportation in Developing and Developed Countries

1.4 Rural Transportation in India
   1.4.1 Present Scenario on Indian Roads
   1.4.2 An Over View of Rural Road Development Programmes in India
      1.4.2.1 The National Road Plans
      1.4.2.2 Study on Indian Roads Planning by Planning Commission
      1.4.2.3 Efforts by Other Agencies
      1.4.2.4 Some Advances in Rural Road Planning

Page

1
2
4
12
13
14
17
17
18
19
1.5 STRATEGIES IN RURAL TRANSPORTATION - NEED FOR SPATIAL PLANNING

1.5.1 Current Status of Planning

1.6 SEARCH FOR APPROPRIATE SOLUTION

1.7 OBJECTIVES OF STUDY

1.8 SUGGESTED APPROACH

1.9 PRESENTATION OF THESIS WORK

CHAPTER 2 - PLANNING OF RURAL ROAD NETWORKS – A REVIEW

2.1 INTRODUCTION

2.2 TRANSPORT AND SPATIAL STRUCTURE

2.3 RURAL TRANSPORT PROBLEMS, POLICIES AND PLANS

2.3.1 Mobility and Accessibility in Rural Areas

2.3.2 Rural Transport Deprivation

2.3.3 Rural Transport in Developing Countries

2.3.4 Policy and Planning Responses in Developed Countries

2.3.5 Rural Transport Planning and Policy in Developing Countries

2.4 ROAD NETWORK DEVELOPMENTS IN RURAL AREAS

2.4.1 The Dutch Road Network

2.4.2 West Germany Rural Road Network

2.4.3 Rural Road Network in Belgium

2.4.4 Rural Transportation in Devon, U.K.

2.4.5 Rural Road Planning in Switzerland
2.5 MODELLING CONCEPTS IN RURAL ROAD NETWORK

2.5.1 Recent Developments in Rural Road Network Planning 52
2.5.2 Features of Rural Road Network Models 55

2.6 MODELLING FRAMEWORK FOR THE FUTURE 59

2.7 ELEMENTS OF SUCCESSFUL RURAL ROAD NETWORK 60

2.8 SPECIFIC SCOPE OF THE STUDY 62

CHAPTER 3 - AN APPROACH TO DEVELOP ROAD NETWORK IN
RELATION TO SERVICE CENTRES IN RURAL AREAS

3.1 GENERAL 64

3.2 TRENDS IN RURAL TRANSPORTATION 65

3.3 EXISTING PRACTICES, RECOMMENDATIONS, FINDINGS OF EXPERTS/RESEARCHERS 66

3.3.1 Indian Road Congress (IRC) Recommendations 66
3.3.2 Drawbacks in Existing Practices 68

3.4 RURAL CONFIGURATIONS, STRUCTURES AND SERVICE CENTRE LOCATIONS 68

3.5 CHARACTERISTICS OF POLICIES TO BE FORMULATED TO ORIENT RURAL TRANSPORTATION NETWORK 69

3.6 MECHANISM AND THEORIES ASSOCIATED WITH RURAL TRANSPORTATION 71

3.7 RELEVANCE OF SPATIAL PARAMETERS ON RURAL ROAD NETWORKS 74

3.7.1 Service Centres as Nuclei in Spatial Entity 74
3.7.2 Road Linkages with Nodes in a Spatial Entity

3.8 LOCATIONAL ANALYSIS ON RURAL POTENTIAL CENTRES
   3.8.1 Location Analysis Models

3.9 DEMAND POTENTIAL AS A PROXY OF TRAVEL DEMAND

3.10 PROPOSED SPATIAL PLANNING METHODOLOGY
   3.10.1 Policy Formulation
   3.10.2 Demand Potential

3.11 MODELING PROCEDURES SUGGESTED IN NETWORK DEVELOPMENT
   3.11.1 Locational Analysis of Service Centres
   3.11.2 Development of Network Oriented to Wider Coverage Approach
   3.11.3 Inter Area Road Network Planning
   3.11.4 Development of Uniform Coverage Road Network
   3.11.5 Development of Hierarchical Road Network Configuration with Minimum Cost Approach
   3.11.6 Identification of Link Configuration with Minimisation of Gap Between Direct and Indirect Cost

3.12 POLICY EVALUATION

3.13 POLICY SELECTION

3.14 DETAILS OF SUGGESTED METHODOLOGY IN TO A WORKING PROCESS.
CHAPTER 4 - DEVELOPMENT OF RURAL ROAD NETWORK BASED ON SPATIAL PARAMETERS - A CASE STUDY

4.1 GENERAL CONCEPT

4.2 STUDY AREA DESCRIPTION

4.2.1 Study Area Characteristics

4.2.1.1 Location of Study Area

4.2.1.2 Existing Road Infrastructure

4.3 SURVEYS

4.3.1 Field Surveys

4.3.2 Survey Organisation

4.4 COLLECTION OF DATA FROM SECONDARY SOURCES

4.5 DATA PROCESSING AND PRESENTATION

4.5.1 Division of Study Area

4.5.2 Processing of Travel Data

4.6 DATA INTERPRETATION

4.7 IDENTIFICATION OF DEMAND POTENTIAL

4.8 IDENTIFICATION OF POTENTIAL CENTRES

4.9 DEVELOPMENT OF GENERAL USER BASED ROAD NETWORK CONFIGURATION

4.9.1 Development of Intra Area Network Configuration

4.10 DEVELOPMENT OF INTER AREA ROAD NETWORK

4.10.1 Assumptions in Formulating the Methodology

4.10.2 Algorithm
4.11 DEVELOPMENT OF HIERARCHICAL BASED SYSTEM CONSTRAINED NETWORK

4.11.1 Concept Development and Model Building for Primary and Secondary Roads

4.11.2 Assumptions

4.11.3 Network Development

4.11.4 Assessment of Construction Cost

4.11.5 Assessment of Travel Cost

4.11.5.1 Inter Mandal Travel Cost

4.11.5.2 Intra Mandal Travel Cost

4.11.5.3 Calculation of Travel Cost for the Out of Path Villages

4.11.6 Graph Construction

4.12 DEVELOPMENT OF UNIFORM COVERAGE ROAD NETWORK CONFIGURATION

4.12.1 Calculation for Accessibility Model

4.13 MINIMISATION APPROACH ON IDENTIFICATION OF NETWORK CONFIGURATION

4.13.1 Working Methodology

4.13.2 Application of Methodology

4.13.2.1 Calculation of Demand Potentials

4.13.2.2 Development of an Algorithm
CHAPTER 5 – VALIDATION AND EVALUATION OF MODELS DEVELOPED ON RURAL ROAD NETWORK IN MEDAK DISTRICT OF ANDHRA PRADESH

5.0 INTRODUCTION

5.1 VALIDATION

5.1.1 Intra - Area Road Network

5.1.2 Inter - Area Road Network

5.1.3 Policy Constraining Hierarchical Road Network

5.1.4 Uniform Coverage Road Network

5.1.5 Minimisation of Gap Approach

5.2 EVALUATION

5.2.1 Intra Road Network

5.2.2 Inter Area Road Network

5.2.3 Policy Constrained Hierarchical Network

5.2.4 Uniform Coverage Network Configuration

5.2.5 Minimisation Approach on Identification of Network Configuration

CHAPTER 6 - SUMMARY AND CONCLUSIONS

6.1 INTRODUCTION

6.2 SUMMARY

6.2.1 Identification of Proxy to Travel Demand

6.2.2 Identification of Potential Service Centres

6.2.3 Development of Road Network Configuration for Intra Area Travel

6.2.4 Development of Inter Area Road Network
6.2.5 Development of Uniform Coverage Based Road Network Configuration.

6.2.6 Development of Hierarchical Road Network Configuration

6.2.7 Development of Road Network Configuration with Minimisation of Gap Between Direct and Indirect User Cost

6.3 FINDINGS AND FEATURES OF RECOMMENDED STRATEGY

6.4 CONCLUSIONS

6.5 LIMITATIONS OF THE STUDY AND SCOPE FOR FURTHER WORK

REFERENCES

APPENDIX – I

APPENDIX – II

APPENDIX – III
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure No.</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Transport Sector Investment in Total Public Sector Investment in Different Countries</td>
<td>6</td>
</tr>
<tr>
<td>1.2</td>
<td>Suggested Approach in Identification of Road Network Configurations</td>
<td>32</td>
</tr>
<tr>
<td>2.1</td>
<td>Road Network Development Analyzed in T.M.G Approach on Rural Roads</td>
<td>36</td>
</tr>
<tr>
<td>2.2</td>
<td>Gould’s Simulation of Spatial Exploration in Time periods</td>
<td>38</td>
</tr>
<tr>
<td>2.3</td>
<td>Road Densities and Percentages of Total Road Length</td>
<td>45</td>
</tr>
<tr>
<td>3.1</td>
<td>Flow chart for Intra Area Road Network Configuration</td>
<td>89</td>
</tr>
<tr>
<td>3.2</td>
<td>Flow chart for Inter Area Road Network Configuration</td>
<td>92</td>
</tr>
<tr>
<td>3.3</td>
<td>Flow chart for Uniform Coverage Road Network Configuration</td>
<td>94</td>
</tr>
<tr>
<td>3.4</td>
<td>Flowchart for Hierarchical Road Network Configuration</td>
<td>100</td>
</tr>
<tr>
<td>3.5</td>
<td>Flow chart for Network Configuration by Minimisation of Gap between Direct and Indirect Cost</td>
<td>104</td>
</tr>
<tr>
<td>4.1</td>
<td>Location of Study Area</td>
<td>111</td>
</tr>
<tr>
<td>4.2</td>
<td>Mandal Wise Division Map of Study Area.</td>
<td>112</td>
</tr>
<tr>
<td>4.3</td>
<td>Study Area Showing the Villages</td>
<td>113</td>
</tr>
<tr>
<td>4.4</td>
<td>Existing Road Infrastructure of Study Area</td>
<td>115</td>
</tr>
<tr>
<td>4.5</td>
<td>Travel Desires in Administrative Units of Study Area</td>
<td>124</td>
</tr>
<tr>
<td>4.6</td>
<td>Intra Area Road Network Configuration from Demand Potential And Travel Demand as Criteria on Mandal wise Units</td>
<td>138</td>
</tr>
<tr>
<td>4.7</td>
<td>Intra Area Road Network Configuration from Population and Workers Combinations as Criteria on Mandal wise Units</td>
<td>139</td>
</tr>
</tbody>
</table>
4.8 Intra Area Road network Configuration from Travel Demand
And Demand Potential as Criteria on Composatory Units 140

4.9 Intra Area Road network Configuration from Population and
Workers Combinations as Criteria on Composatory Units 141

4.10 Coordinated Intra Area Road Network from Travel Demand and
Demand Potential – Mandal wise 143

4.11 Coordinated Intra Area Road Network from Population and
Workers Combination – Mandal wise 144

4.12 Coordinated Intra Area Road Network from Travel Demand and
Demand Potential on Composatory Unit Base 145

4.13 Coordinated Intra Area Road Network from Population and
Workers Combinations on Composatory Unit Base 146

4.14 Intra Area Road Network – Population as Criteria 147

4.15 Intra Area Road Network – Employment as Criteria 148

4.16 Final Intra Area Road Network Configuration 149

4.17 Inter Area Road Network for M1 Unit 154

4.18 SST Network for Inter Area - Mandal wise 165

4.19 SST Network for Grid Based Inter Area 166

4.20 Selected SST Network for Inter Area – Mandal wise 167

4.21 Selected SST Network for Inter Area – Grid wise 168

4.22 Coordinated Inter Area Road Network Configuration for Mandal wise Unit 170

4.23 Coordinated Inter Area Road Network Configuration for Grid wise Unit 171

4.24 Optimal Value for Spacing of Road 179
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.25</td>
<td>Optimal Network Configuration</td>
<td>179</td>
</tr>
<tr>
<td>4.26</td>
<td>Skim Trees of a Study Area</td>
<td>183</td>
</tr>
<tr>
<td>4.27</td>
<td>Identification of Optimal Spacing of Network Configuration with Grid Base Reference</td>
<td>194</td>
</tr>
<tr>
<td>4.28</td>
<td>Identification of Optimal Spacing of Network Configuration with Radial Base Reference</td>
<td>195</td>
</tr>
<tr>
<td>4.29</td>
<td>Policy Constrained Hierarchical Road Network Configuration</td>
<td>196</td>
</tr>
<tr>
<td>4.30</td>
<td>Coordinated Policy Constrained Hierarchical Road Network Configuration</td>
<td>197</td>
</tr>
<tr>
<td>4.31</td>
<td>Uniform Coverage Road Network Configuration of Study Area</td>
<td>200</td>
</tr>
<tr>
<td>4.32</td>
<td>Uniform Coverage Road Network Configuration in Serilingampally Municipality</td>
<td>203</td>
</tr>
<tr>
<td>4.33</td>
<td>Coordinated Uniform Coverage Road Network Configuration</td>
<td>204</td>
</tr>
<tr>
<td>4.34</td>
<td>Minimum Impedance Network</td>
<td>206</td>
</tr>
<tr>
<td>4.35</td>
<td>Skim Trees from Different Home Nodes</td>
<td>210</td>
</tr>
<tr>
<td>4.36</td>
<td>Optimal Route Using Minimisation Approach</td>
<td>206</td>
</tr>
<tr>
<td>4.37</td>
<td>Road Network Configuration for Minimisation of Gap Approach</td>
<td>215</td>
</tr>
<tr>
<td>4.38</td>
<td>Coordinated Road Network Configuration of Minimisation Approach</td>
<td>217</td>
</tr>
<tr>
<td>5.1</td>
<td>Comparision for Road Length Identity</td>
<td>220</td>
</tr>
<tr>
<td>5.2</td>
<td>Comparision for Population Served Identity</td>
<td>221</td>
</tr>
<tr>
<td>5.3</td>
<td>Comparision for Villages Connected Identity</td>
<td>222</td>
</tr>
<tr>
<td>5.4</td>
<td>Comparision for Maximum Road Distance Identity</td>
<td>222</td>
</tr>
<tr>
<td>5.5</td>
<td>Correlation of Travel Desire and Network Configuration</td>
<td>233</td>
</tr>
</tbody>
</table>
LIST OF TABLES

Table No. | Description                                                                 | Page |
----------|------------------------------------------------------------------------------|------|
2.1       | Rural Transport Trips by Lengths and Loads                                   | 43   |
4.1       | Number of Villages Unconnected by Pucca Road Out of Total Number of Villages for Each Mandal | 116  |
4.2       | Details of Survey on Study Area                                             | 120  |
4.3       | Classification of Compository Units                                         | 122  |
4.4       | Primary and Secondary Sources of Data for Andole Mandal                      | 126  |
4.5       | Primary and Secondary Sources of Data for Grid – B1                         | 127  |
4.6       | Output of p-Median Method of Medak Mandal                                    | 131  |
4.7       | Optimal Locations of Service Centres Mandal wise                            | 135  |
4.8       | Optimal Locations of Service Centres Grid wise                              | 136  |
4.9       | Performance Figures for Shortest Spanning Tree Network – Mandal (M1)         | 155  |
4.10      | Performance Figures for Selected Shortest Spanning Tree Network – Mandal (M1) | 157  |
4.11      | General Evaluation and Performance Figures of Mandal (M1)                   | 159  |
4.12      | Combined Performance Evaluation Figures (Mandal wise)                       | 160  |
4.13      | Combined Performance Evaluation Figures (Grid wise)                         | 161  |
4.14      | Combined Performance Evaluation Figures (Mandal & Grid wise)                | 162  |
4.15      | Comparative Performance Evaluation Figures of Compository base/ Grid Unit with Reference to Mandal wise | 163  |
4.16      | Demographic Characteristics of Mandal Based Interchange Units               | 164  |
4.17      | Demographic Characteristics of Grid Based Interchange Units                 | 164  |
4.18      | Travel Demand of Eight Mandals                                              | 178  |
4.19 Construction, Travel Cost and Total Cost for Different values of Z  178
4.20 Construction Cost  189
4.21 Travel Cost  191
4.22 Total Cost  193
4.23 Accessibility Index Values for Raikodur Mandal  201
4.24 Accessibility Index Values at Village and Zonal Level  202
4.25 Shortest Travel Time Matrix  207
4.26 Maximum Travel Time Matrix  207
4.27 Calculation of Demand Weights  208
4.28 Demand Weight Matrix  208
4.29 Direct – Demand Potential Hour Matrix  209
4.30 Feasible Linkages using Minimisation Approach  209
5.1 Values on Identities for Different Networks  223
5.2 Indices Evaluation  227
5.3 Operational Evaluation  228
5.4 Comparision of Connectivity between Administrative Unit
And Compository Unit  231
5.5 Correlation of Travel Desire and Network Orientation  234
# LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMG</td>
<td>Taaffe, Morrill and Gould</td>
</tr>
<tr>
<td>L.C</td>
<td>A Conversion Factor</td>
</tr>
<tr>
<td>SST</td>
<td>Shortest Spanning Tree</td>
</tr>
<tr>
<td>C.L</td>
<td>Circuity Limit</td>
</tr>
<tr>
<td>I.R.C.</td>
<td>Indian Roads Congress</td>
</tr>
<tr>
<td>D.P</td>
<td>Demand Potential</td>
</tr>
<tr>
<td>POP</td>
<td>Population</td>
</tr>
<tr>
<td>Kms</td>
<td>Kilometres</td>
</tr>
<tr>
<td>Sq. Kms</td>
<td>Square Kilometres</td>
</tr>
<tr>
<td>NE-SE</td>
<td>North East – South East</td>
</tr>
<tr>
<td>NW-SW</td>
<td>North West – South West</td>
</tr>
<tr>
<td>S-W</td>
<td>South – West</td>
</tr>
<tr>
<td>Sqrt</td>
<td>Square Root</td>
</tr>
<tr>
<td>TC</td>
<td>Total Cost</td>
</tr>
<tr>
<td>Fig</td>
<td>Figure</td>
</tr>
<tr>
<td>Tab</td>
<td>Table</td>
</tr>
<tr>
<td>NTPC</td>
<td>National Transport Policy Committee</td>
</tr>
<tr>
<td>RUTEX</td>
<td>Rural Transport Experiments</td>
</tr>
<tr>
<td>Ha</td>
<td>hectares of area</td>
</tr>
<tr>
<td>TD</td>
<td>Travel Demand</td>
</tr>
<tr>
<td>SC</td>
<td>Service Centre</td>
</tr>
<tr>
<td>ΔPH</td>
<td>Difference in Passenger Hours</td>
</tr>
</tbody>
</table>
LIST OF SYMBOLS

\( \alpha \)  \hspace{1cm} \text{Alpha}  \\
\( \beta \) \hspace{1cm} \text{Beta}  \\
\( \gamma \) \hspace{1cm} \text{Gama}  \\
\( \eta \) \hspace{1cm} \text{Eta}  \\
\( \Sigma \) \hspace{1cm} \text{Sum of}  \\
\( \leq \) \hspace{1cm} \text{Less than}  \\
\( \geq \) \hspace{1cm} \text{Greater than}  \\
\( \varepsilon \) \hspace{1cm} \text{Belongs to}  \\
\( \Delta \) \hspace{1cm} \text{Delta}  \\
\( \sigma \) \hspace{1cm} \text{Sigma}  \\
\% \hspace{1cm} \text{Percentage}  \\
\circ \hspace{1cm} \text{Degrees}