ROAD INFRASTRUCTURE DEVELOPMENT IN INDIA
ROAD DEVELOPMENT SCENARIO
“...IT IS NOT WEALTH THAT BUILT THE ROADS BUT, ROADS THAT BUILT OUR WEALTH”

- John F. Kennedy
<table>
<thead>
<tr>
<th>Road Type</th>
<th>Length (in km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Highway (NH)</td>
<td>58,112</td>
</tr>
<tr>
<td>State Highways (SH)</td>
<td>1,37,119</td>
</tr>
<tr>
<td>Major District Roads (MDR)</td>
<td>4,70,000</td>
</tr>
<tr>
<td>Village and Other Roads (ODR &amp; VR)</td>
<td>26,50,000</td>
</tr>
<tr>
<td><strong>Total Road Length</strong></td>
<td><strong>33,15,231</strong></td>
</tr>
</tbody>
</table>

NHs are less than 2% of network but carry 40% of total traffic.
## STATUS OF MAIN HIGHWAYS

<table>
<thead>
<tr>
<th>Carriageway</th>
<th>National Highways</th>
<th></th>
<th>State Highways</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Length KM</td>
<td>Percent</td>
<td>Length KM</td>
<td>Percent</td>
</tr>
<tr>
<td>Four-lane</td>
<td>1800</td>
<td>4</td>
<td>1200</td>
<td>1</td>
</tr>
<tr>
<td>Two-lane</td>
<td>23700</td>
<td>66</td>
<td>238800</td>
<td>19</td>
</tr>
<tr>
<td>One-lane</td>
<td>15000</td>
<td>30</td>
<td>100500</td>
<td>80</td>
</tr>
<tr>
<td>Total</td>
<td>49500</td>
<td>100</td>
<td>125500</td>
<td>100</td>
</tr>
</tbody>
</table>
NATIONAL HIGHWAY DEVELOPMENT PROJECTS

- Country’s most ambitious Highways Development Project
- Highways with International Standard and facilities for uninterrupted traffic flow
  - Divided carriageways & Service roads
  - Grade separators, over bridges & underpasses
  - Bypasses
  - Wayside amenities
  - Enhanced safety features
NATIONAL HIGHWAYS DEVELOPMENT PROJECTS

<table>
<thead>
<tr>
<th>Description</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Length of NHDP</td>
<td>13,151</td>
</tr>
<tr>
<td>Golden Quadrilateral</td>
<td>5,851*</td>
</tr>
<tr>
<td>High Density Traffic Corridors linking Delhi, Mumbai, Chennai &amp; Kolkata</td>
<td></td>
</tr>
<tr>
<td>Completion by 2003</td>
<td></td>
</tr>
<tr>
<td>North-South &amp; East-West Corridors</td>
<td>7,300</td>
</tr>
<tr>
<td>N-S: Kashmir to Kanyakumari including Kochi-Salem</td>
<td>4,000</td>
</tr>
<tr>
<td>E-W: Silchar to Saurashtra</td>
<td>3,300</td>
</tr>
<tr>
<td>Completion by 2007</td>
<td></td>
</tr>
<tr>
<td>Road connectivity to Major Ports</td>
<td>400 km</td>
</tr>
<tr>
<td>400 km and other projects involve about 600 km road development</td>
<td></td>
</tr>
</tbody>
</table>
NATIONAL HIGHWAY DEVELOPMENT PROJECT
State-wise Break-up of the Golden Quadrilateral and North-South and East-West Corridor Projects

<table>
<thead>
<tr>
<th>States</th>
<th>Golden Quadrilateral</th>
<th>North-South Corridor(km)</th>
<th>East-West Corridor (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andhra Pradesh</td>
<td>1000</td>
<td>753</td>
<td>-</td>
</tr>
<tr>
<td>Assam</td>
<td>-</td>
<td>-</td>
<td>758</td>
</tr>
<tr>
<td>Bihar</td>
<td>200</td>
<td>-</td>
<td>517</td>
</tr>
<tr>
<td>Delhi</td>
<td>25</td>
<td>34</td>
<td>-</td>
</tr>
<tr>
<td>Gujarat</td>
<td>498</td>
<td>-</td>
<td>654</td>
</tr>
<tr>
<td>Haryana</td>
<td>175</td>
<td>254</td>
<td>-</td>
</tr>
<tr>
<td>Himachal Pradesh</td>
<td>-</td>
<td>14</td>
<td>-</td>
</tr>
<tr>
<td>Jammu &amp; Kashmir</td>
<td>-</td>
<td>405</td>
<td>-</td>
</tr>
<tr>
<td>Jharkhand</td>
<td>192</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Karnataka</td>
<td>686</td>
<td>125</td>
<td>-</td>
</tr>
<tr>
<td>Kerala</td>
<td>-</td>
<td>160</td>
<td>-</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>-</td>
<td>524</td>
<td>142</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>487</td>
<td>232</td>
<td>-</td>
</tr>
<tr>
<td>Orissa</td>
<td>437</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Punjab</td>
<td>-</td>
<td>296</td>
<td>-</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>688</td>
<td>32</td>
<td>480</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>275</td>
<td>851</td>
<td>-</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>752</td>
<td>268</td>
<td>548</td>
</tr>
<tr>
<td>West Bengal</td>
<td>471</td>
<td>-</td>
<td>366</td>
</tr>
<tr>
<td>Interstate roads/Bypasses</td>
<td>66</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5952</strong></td>
<td><strong>7413</strong></td>
<td></td>
</tr>
</tbody>
</table>
FUNDING OF NHDP

CESS 37%

PRIVATE SECTOR 7.5%

MARKET BORROWINGS 18.5%

ASSISTANCE FROM WORLD BANK/ADB 37%

TOTAL AMOUNT Rs. 540 BILLION COVERING 14,000 km
POLICY INCENTIVES FOR ATTRACTING PRIVATE INVESTMENT

• 100 % FDI permitted in Road sector
• Government to carry out all preparatory work including land acquisition
• Government to provide land at no cost and free from all encumbrances
• NHAI to provide capital grants upto 40%
• Ten year tax holiday for road, bridge and highway projects
• Concession period allowed upto 30 years
• Housing and real estate development
• Duty free import allowed of specified modern high capacity equipments for highway construction
PRIVATE PARTICIPATION IN EXECUTION OF NHDP

INDIAN FIRMS 65%

FOREIGNERS 8%

JOINT VENTURES 27%

TOTAL No. OF CONTRACTS = 118
NATIONAL HIGHWAYS

- Length has increased to 58,112 km
- Around 13,250 km for four/six lane by NHAI
- 8000 km identified for four laning by MoRTH - (Improving about 4000 km to four lane and the balance to be made all-weather two lane roads)
- Additional lane to be added to about 8000 km in the NH network.
STATE HIGHWAYS

• About 5,000 km need upgradation to four lane and the entire balance length needs quality improvement to be made to fit as potential future NHs.

• Being improved through enhanced Budget, external loan, 15% part receipt from cess on diesel.

• Private sector participation for bridges, bypasses and maintenance works.
URBAN ROADS

• 30 % of the 100 crore population lives in urban areas expected to grow 40 % of 140 crores in 2025

• Severe pressure on the existing 2 lakh km of Urban Roads

• Need for augmentation of quality, capacity through construction of flyovers and underpassess etc.
RURAL ROADS

• Other District Roads and Villages roads

• Only 50 percent of habitations are provided with all-weather roads

• Massive rural road programme under PMGSY
  
  ➢ Aim to connect all the habitations with 500 and above by the year 2007 with all-weather roads.
  ➢ Separate fund has been created by allocating 50 % of cess on diesel (Dedicated Fund)
PRADHAN MANTRI GRAM SADAK YOJANA

- A Centrally sponsored programme
- Rs. 60,000 crores required upto 2007
- Rs. 2500 crores available per year from 50% of diesel cess
## STATUS OF UNCONNECTED VILLAGES

<table>
<thead>
<tr>
<th>Population Range</th>
<th>Number of Villages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 1000</td>
<td>51,163</td>
</tr>
<tr>
<td>Between 1000 - 500</td>
<td>76,150</td>
</tr>
<tr>
<td>Below 500</td>
<td>1,74,954</td>
</tr>
</tbody>
</table>

**Total Number of Unconnected Villages**: 3,02,267

**Total Number Of Villages In India**: About 6,84,620
P.M.’S RURAL ROAD PROJECT

Aims to provide all-weather road

- To link all villages with more than 1000 population by 2003 and those with over 500 population by 2007.

All-Weather Road

A road, which is negotiable during all weathers, except at major river crossings. This implies that the road bed is drained effectively by adequate Cross Drainage structures such as culverts, minor bridges and causeways. Interruption to traffic as per permitted frequency and duration are, however, allowed.

The pavement should be negotiable during all-weathers, but this does not necessarily imply that it should be paved or surfaced or black topped. An earthen road with gravely soil or an earthen road with a gravel or WBM layer on top permits all-weather use, depending upon rainfall and soil type.
Rural Roads With Specifications

CARRIAGEWAY WIDTH 3.75 m
FORMATION WIDTH 7.50 m
LAND WIDTH 12.00 m

* There will be variation in hilly & other difficult terrain

To provide gravel/black top/semi-rigid or rigid pavement with all-weather access
TECHNICAL INPUTS

- THE PROGRAMME (PMGSY) IS DESIGNED WITH REQUIRED TECHNICAL INPUTS
- CONCEPT OF THE STATES ABOUT RURAL ROAD IS CHANGED
  - RURAL ROAD IS ENGINEERING STRUCTURE
  - IT IS TO BE DESIGNED FOR TRAFFIC AND SOIL STRENGTH
- PROJECT BASED PROGRAMME IMPLEMENTATION FOR REALISTIC OUTPUT
- UNIFORM STANDARDS AND SPECIFICATION ADOPTED FROM INDIAN ROAD CONGRESS
- ONLY ALL-WEATHER ROADS TO BE BUILT
DESIGN SPECIFICATIONS

- Good and properly evaluated materials conforming to respective IRC or BIS specifications shall be used.

- Use of waste materials e.g. fly ash, slag, sludge etc. to be explored, maintaining requirements of design & performance.

- Special efforts to be made for use of locally available materials without compromising quality.
<table>
<thead>
<tr>
<th>Material</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kankar</td>
<td>U.P., Rajasthan</td>
</tr>
<tr>
<td>Dhandla</td>
<td>Part of Rajasthan</td>
</tr>
<tr>
<td>Gravel</td>
<td>NE, J&amp;K, Himachal, Punjab, Bihar, MP, Orissa, Gujarat, Maharashtra, &amp; Tamilnadu</td>
</tr>
<tr>
<td>Laterite</td>
<td>Parts of NE, Maharashtra, AP, TN, Karnataka, &amp; Kerala</td>
</tr>
<tr>
<td>Moorum</td>
<td>MP, Orissa, Maharashtra, AP, Karnataka &amp; TN</td>
</tr>
<tr>
<td>Fly ash</td>
<td>In vicinity of Thermal Power plants</td>
</tr>
<tr>
<td>Slag</td>
<td>In vicinity of Steel plants</td>
</tr>
<tr>
<td>Marble waste</td>
<td>Rajasthan, Gujarat etc.</td>
</tr>
</tbody>
</table>
- Soil Type: Black Cotton (CBR 2)
- Rainfall: 1000-2000 mm per annum
- Traffic: 15-45 commercial vehicles per day
- Design Crust Thickness: 475 mm
- Example States: Gujarat, Madhya Pradesh, Maharashtra, A.P. etc

Case I

Two coat surface dressing / mix seal surfacing / open graded premix with sand seal

- WBM Gr. II: 75 mm
- WBM Gr. I: 100 mm
- Subbase GSB/Stabilized soil: 300 mm
- Sand drainage layer: 200 mm
- Subgrade CBR 2: 475 mm

Approximate Cost of Construction Rs. 12 to 14 lakh per km
Soil Type: Silty Clay (CBR 3 to 4)
Rainfall: >1000 mm per annum
Traffic: 15-45 commercial vehicles per day
Design Crust Thickness: 300 mm
Example States: West Bengal, Bihar and North East

20 mm Mix seal surfacing / open graded premix with sand seal or liquid seal

 approximate Cost of Construction Rs. 10 to 12 lakh per km
20 mm Mix seal surfacing/ open graded premix with sand seal or liquid seal

Approximate Cost of Upgradation Rs. 7 to 8 lakh per km
RIGID PAVEMENT DESIGN (RCCP)  
(IRC:58-2002)

Based on:
Traffic, 
Flexural Strength 
Soil CBR

<table>
<thead>
<tr>
<th>PQC, M-35 Grade, 200mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>DLC, M-10 Grade, 100mm</td>
</tr>
<tr>
<td>Drainage Layer</td>
</tr>
<tr>
<td>Gravel/graded sand, 150 mm</td>
</tr>
<tr>
<td>Subgrade CBR 2-5</td>
</tr>
</tbody>
</table>

X- Section of Cement Concrete Road
Cost Rs. 18-20 lakh per lane km
CAPACITY REQUIRED
DEMAND PROJECTION FOR HEAVY ROAD MACHINERY (15-20 YRS.)

<table>
<thead>
<tr>
<th>Product Group</th>
<th>2010-11</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excavator</td>
<td>9700</td>
<td>18500</td>
</tr>
<tr>
<td>Excavator Loaders</td>
<td>1033</td>
<td>20750</td>
</tr>
<tr>
<td>Front end Loaders</td>
<td>4800</td>
<td>9600</td>
</tr>
<tr>
<td>Crawler Tractor &amp; Dozers</td>
<td>2690</td>
<td>5400</td>
</tr>
<tr>
<td>Cranes</td>
<td>4100</td>
<td>6500</td>
</tr>
<tr>
<td>Vibrator Rollers</td>
<td>1300</td>
<td>2100</td>
</tr>
<tr>
<td>Static Rollers</td>
<td>1200</td>
<td>1400</td>
</tr>
<tr>
<td>Asphalt Pavers</td>
<td>300</td>
<td>400</td>
</tr>
<tr>
<td>Hydrostatic</td>
<td>225</td>
<td>340</td>
</tr>
<tr>
<td>Motor graders</td>
<td>340</td>
<td>650</td>
</tr>
<tr>
<td>Hot Mix Plants 15T to 20T</td>
<td>970</td>
<td>1050</td>
</tr>
</tbody>
</table>
## OTHER MACHINERY ITEMS REQUIRED IN THE NEXT 15 TO 20 YEARS

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy Concrete Batch Mix Plants</td>
<td>100</td>
</tr>
<tr>
<td>Concrete Pavers</td>
<td>100</td>
</tr>
<tr>
<td>Computerized Crushers</td>
<td>300</td>
</tr>
<tr>
<td>Heavy Duty Tippers</td>
<td>50,000</td>
</tr>
<tr>
<td>Road Maintenance Units</td>
<td>3,000</td>
</tr>
<tr>
<td>Bridge Inspection Units</td>
<td>100</td>
</tr>
<tr>
<td>Piling Machines Shuttering</td>
<td>150</td>
</tr>
<tr>
<td>Pre-casting Yards</td>
<td>100</td>
</tr>
</tbody>
</table>
BROADLY ESTIMATED MANPOWER NEEDS (15-20 YRS.)

<table>
<thead>
<tr>
<th>Position</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Civil Engineers</td>
<td>27,000</td>
</tr>
<tr>
<td>Mechanical Engineers</td>
<td>2,000</td>
</tr>
<tr>
<td>Environmental Experts</td>
<td>200</td>
</tr>
<tr>
<td>Economists</td>
<td>200</td>
</tr>
<tr>
<td>Financial Experts</td>
<td>200</td>
</tr>
<tr>
<td>Geologists</td>
<td>100</td>
</tr>
<tr>
<td>Estate Managers</td>
<td>200</td>
</tr>
<tr>
<td>Resettlements and Rehabilitation Experts</td>
<td>100</td>
</tr>
<tr>
<td>Skilled Workers</td>
<td>4,00,000</td>
</tr>
<tr>
<td>Semi Skilled Workers</td>
<td>16,00,000</td>
</tr>
<tr>
<td>Unskilled Workers</td>
<td>50,00,000</td>
</tr>
</tbody>
</table>
ROAD CONSTRUCTION

- Road Construction Industry in India is about Rs.150 billion size

- The contracting industry consist of

  - Large scale contractors (Rs.500 million & above) about 20 large contractors accounting 40% of construction activities

  - Medium scale contractors (Rs.100 – 500 million) is involved about 20% of construction activities

  - Small scale contractors (Rs.5-100 millions) is involved about remaining 40%.
ROAD CONSTRUCTION EQUIPMENT

- Earlier labour-based method
- In 1960s Mechanisation introduced.
- Govt. Bodies are the main buyers of the road construction equipment, market is limited
- During 1980s, transformation took place. Project became much larger size – external agency funding – mandatory to use appropriate equipment
- Pre-qualification criteria: based on ownership of equipment for selection of contractors. In large projects 10% advance were given, as a result contractors began purchasing their own equipment.
- Half of Indian manufactures producing equipment in India have tie-up with foreign partners to improve their products.
CONSTRUCTION MATERIALS
MATERIALS FOR ROAD CONSTRUCTION

- Embankment
- Subgrade
- Pavement structure
  - base course
  - surface course
- Special materials for
  - drainage
  - maintenance
FLY ASH FOR ROAD EMBANKMENT

- Ideally suited as back fill material
- Higher shear strength leads to greater stability
- Design by conventional method
- Intermediate soil layers to provide confinement
- Slope erosion controlled by soil cover
- Can be compacted under adverse weather
- Guidelines approved by IRC
Approach Embankment for Second Nizamuddin Bridge at Delhi

- Length of embankment - 1.8 km, height 6 to 9 m
- Fly ash utilized - 1,50,000 cubic metre
- Savings Rs.1.00 crore
Laying of geotextile over soil subgrade (as separator)

Use of geotextiles for construction of embankment with steep slope
REINFORCED FLY ASH EMBANKMENT

- Fly ash - better backfill material for reinforced embankments
- Polymeric reinforcing materials - Geogrids, friction ties, geotextiles
- Construction sequence - similar to reinforced earth structures

GEOSYNTHETICS FOR EMBANKMENT

- Reinforcement, erosion control and drainage
- Coir and woven jute netting can be used for erosion control
SARITA VIHAR FLYOVER REINFORCED APPROACH EMBANKMENT

ARRANGEMENT OF FRICTION TIES BEFORE LAYING POND ASH

LENGTH - 90 M,
MAX. HEIGHT - 5.25 M
ASH UTILIZED - 15,000 CUBIC METRE

LAYING OF FRICTION TIES
MATERIALS FOR ROAD PAVEMENTS

- Subgrade upgradation (stabilisation)
  Improvement in CBR and reduction in pavement thickness by stabilisation (use of foamed bitumen-cement, enzymes, resins etc.)

- Sub-base/base courses
  Use of waste materials like fly ash, Blast furnace slag, Aircooled slags, municipal wastes, etc

- Wearing courses
  Modified bitumens, multigrade bitumens and improved emulsions
Lime stabilisation of (Orissa)

View of finished road surface
USE OF PROCESSED MUNICIPAL WASTES (PMW)

- Construction of stabilised base/sub-base courses (PMW-lime-fly ash, PMW-soil-cement)
- Material available in about 25 cities in our country

Construction of test track using municipal wastes
MATERIALS FOR BITUMINOUS CONSTRUCTION

- High performance bitumen
  - Rubber modified bitumen
  - Polymer modified bitumen
  - Antioxidant modified bitumen
  - Antistripping agent modified bitumen
  - Multigrade bitumen

- Bituminous emulsion
  - Unmodified
  - Polymer modified
  - Rubber latex modified
HIGH PERFORMANCE BITUMEN

- Acts as multi-grade
- Withstand higher resistance to deformation and cracking
- Demonstrate better adhesion, higher fatigue life under heavy axle load, and better resistance to ageing
- Improved road performance
## EXTENSION OF LIFE BY USE OF PMB (R-54)

<table>
<thead>
<tr>
<th>SPECIFICATION</th>
<th>COST (Rs)/m²</th>
<th>LIFE (Years)</th>
<th>EXTRA LIFE (Years)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 mm Thick SDBC – 60/70</td>
<td>70</td>
<td>3-4</td>
<td>-1</td>
</tr>
<tr>
<td>25 mm Thick BC – 60/70*</td>
<td>80</td>
<td>4 –5</td>
<td>--</td>
</tr>
<tr>
<td>25 mm Thick BC – 80/100*</td>
<td>74</td>
<td>4 –5</td>
<td>--</td>
</tr>
<tr>
<td>25 mm Thick BC – 60/70</td>
<td>96</td>
<td>5-6</td>
<td>+1</td>
</tr>
<tr>
<td>SAMI-CRMB</td>
<td>28</td>
<td>4-5</td>
<td>--</td>
</tr>
<tr>
<td>SAMI+25 mm Thick BC – 80/100</td>
<td>102</td>
<td>6-7</td>
<td>+2</td>
</tr>
<tr>
<td>SAMI+25 mm Thick BC – 60/70</td>
<td>108</td>
<td>6-7</td>
<td>+2</td>
</tr>
<tr>
<td>SAMI+40 mm Thick BC – 80/100</td>
<td>110</td>
<td>7-8</td>
<td>+3</td>
</tr>
<tr>
<td>SAMI+40 mm Thick BC – 60/70</td>
<td>116</td>
<td>7-8</td>
<td>+3</td>
</tr>
<tr>
<td>SAMI+25 mm Thick BC (CRMB)</td>
<td>116</td>
<td>7-8</td>
<td>+3</td>
</tr>
<tr>
<td>25 mm Thick BC (EVA+LDPE)</td>
<td>90</td>
<td>7-8</td>
<td>+3</td>
</tr>
<tr>
<td>25 mm Thick SDBC (SBS)</td>
<td>88</td>
<td>7-8</td>
<td>+3</td>
</tr>
<tr>
<td>25 mm Thick SDBC (EVA+LDPE)</td>
<td>84</td>
<td>6-7</td>
<td>+2</td>
</tr>
<tr>
<td>25 mm Thick BC (CRMB)</td>
<td>84</td>
<td>6-7</td>
<td>+2</td>
</tr>
</tbody>
</table>

* with reference to 25 mm thick BC of conventional bitumen
# EXTENSION IN LIFE BY USE OF PMB IN SNOW BOUND AREA AND COASTAL AREA

<table>
<thead>
<tr>
<th>SPECIFICATION</th>
<th>COST (Rs)/m²</th>
<th>LIFE (Years)</th>
<th>EXTRA LIFE (Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(Snow Bound Areas)</strong>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 mm Thick OGPC – 80/100</td>
<td>45-50</td>
<td>2-4</td>
<td>--</td>
</tr>
<tr>
<td>25 mm Thick –EVA</td>
<td>50-55</td>
<td>4-6</td>
<td>+2</td>
</tr>
<tr>
<td>25 mm Thick –SBS</td>
<td>55-60</td>
<td>4-7</td>
<td>+3</td>
</tr>
<tr>
<td><strong>(Coastal Areas)</strong> **</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 mm Thick BC – 60/70 or 80/100</td>
<td>94-98</td>
<td>4</td>
<td>--</td>
</tr>
<tr>
<td>40 mm Thick BC –EVA+LDPE</td>
<td>112-116</td>
<td>7</td>
<td>+3</td>
</tr>
<tr>
<td>40 mm Thick BC -SBS</td>
<td>120-124</td>
<td>7</td>
<td>+3</td>
</tr>
<tr>
<td>25 mm Thick SDBC –60/70</td>
<td>58-60</td>
<td>3</td>
<td>-1</td>
</tr>
<tr>
<td>25 mm Thick SDBC (EVA+LDPE)</td>
<td>84-88</td>
<td>6</td>
<td>+2</td>
</tr>
<tr>
<td>25 mm Thick SDBC-SBS</td>
<td>88-92</td>
<td>6</td>
<td>+3</td>
</tr>
<tr>
<td>25 mm Thick BC –60/70</td>
<td>80-84</td>
<td>3</td>
<td>-1</td>
</tr>
<tr>
<td>25 mm Thick BC (LDPE+ EVA)</td>
<td>90-94</td>
<td>4</td>
<td>+1</td>
</tr>
<tr>
<td>25 mm Thick BC -SBS</td>
<td>98-102</td>
<td>6</td>
<td>+3</td>
</tr>
</tbody>
</table>

* with reference to 20 mm OGPC-80/100
** with reference to 40 mm BC-60/70
CRITERIA FOR SELECTION OF MODIFIERS AND GRADE OF MODIFIED BITUMEN

- Traffic
- Climate
- Cost effectiveness
- Performance reports
- Constructability
- Availability
**SUGGESTED SELECTION CRITERIA OF MODIFIERS IN DIFFERENT CLIMATIC CONDITIONS AND TRAFFIC IN INDIA**

<table>
<thead>
<tr>
<th>CLIMATE</th>
<th>Traffic ESALs Per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,000 to 10,000</td>
</tr>
<tr>
<td>COLD AND SNOW BOUND</td>
<td></td>
</tr>
<tr>
<td>SBS (+++), SBR (+++), EVA (++)</td>
<td>SBS (++)</td>
</tr>
<tr>
<td>CR, NR (++)</td>
<td>CR, NR (+)</td>
</tr>
<tr>
<td>MODERATE COLD</td>
<td></td>
</tr>
<tr>
<td>SBS (+++), SBR (+++), EVA (++)</td>
<td>SBS (+++), SBR (+++), EVA (+++), CR (+++), NR (++)</td>
</tr>
<tr>
<td>MODERATE HOT AND MODERATE COLD</td>
<td></td>
</tr>
<tr>
<td>SBS (+++), CR (+++), SBR (+++), EVA (++)</td>
<td>SBS (+++), CR (+++), EVA (++)</td>
</tr>
<tr>
<td>MODERATE HOT AND COASTAL</td>
<td></td>
</tr>
<tr>
<td>SBS (+++), SBR (+++), EVA (+++), NR (+++), CR (++)</td>
<td>SBS (+++), SBR (+++), EVA (+++), CR (++)</td>
</tr>
</tbody>
</table>

+++ Very good; ++ Good; + Satisfactory
# Selection Criteria for PMB and CRMB Grade Based on Atmospheric Temperature

<table>
<thead>
<tr>
<th>Minimum Atmospheric Temperature °C</th>
<th>Maximum Atmospheric Temperature °C</th>
<th>PMB</th>
<th>CRMB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; -15</td>
<td>PMB -120</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CRMB-50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 to -15</td>
<td>PMB -120</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CRMB-55</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PMB -70</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CRMB-55</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PMB -70</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CRMB-60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 15</td>
<td>PMB -70</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CRMB-55</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PMB -40</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CRMB-60</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PMB -40</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CRMB-60</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PMB: Polymer Modified Bitumen  
CRMB: Crumb Rubber Modified Bitumen
MATERIALS FOR RIGID PAVEMENTS

- Roller compacted concrete (RCCP)
  - Faster and economical
  - Can be used for base course and for wearing course
  - Saving of cement by using fly ash and GBFS

Construction of roller compacted concrete
Use of waste materials like Marble slurry dust, Slag, Fly ash, etc

- Use of waste materials to replace aggregates (DLC)
- Use of pozzolanic waste materials to replace part of cement (CC and RCC pavements)

Magnesium oxychloride cement

- As a substitute to OPC in CC pavements
- Used for stabilisation of sand
MATERIALS FOR RIGID PAVEMENTS

- High performance concrete
  - Improved resistance to environmental influences (Durability)
  - Low water/cement ratio leads to high strength
  - Supplimentary cementing materials – silica fume, fly ash, slag
  - High ability to protect embedded steel from corrosion
FULLY INTERLOCKING CONCRETE BLOCK PAVEMENTS (ICBP)

- Fully interlocking blocks for road with traffic (medium/heavy)
- Non-interlocking / partially interlocking blocks for pedestrian / light traffic
- Preferred optimum strength & thickness:
  - 25-35 MPa for light / medium traffic; 60 mm thick
  - 40-50 MPa for heavy traffic; 80 to 100 mm thick
  - Above 50 MPa for heavy punching loads; 100 mm
- Edge restraint to be provided for optimum performance
- Strong Subgrade and Base – Pre-requisite and Essential
Different shapes of Interlocking Paving Blocks

Use of ICBP for paving
PREPARATION OF DETAILED PROJECT REPORT FOR NHDP WORKS
OBJECTIVES

- Establish Technical, Economical and Financial Viability of the Project
- DPR for Rehabilitation and Upgradation of Existing 2-lane to 4-lane or 6-lane Depending upon the Requirements
- Designed as Partially Access Controlled
- Detailed Design of Pavement duly considering the options, Bridges, CDs, Grade-Separated Structures, Service Roads
- Economic and Financial Viability Analysis
SCOPE OF SERVICES

- Widening Within Right of Way, if Possible
- Feasibility of Toll Collection - Location for Toll Plaza, wayside amenities, service roads
- Financing Options like BOT, Annuity
- EIA, EMP etc
SURVEYS

- Classified Volume Count – 3 locations/100 km
- O-D Commodity Movement – 2/ 200 km
- Axle Load Survey – 2 / 100 km
- Intersection Volume Count – All major Junctions
- Speed and Delay Studies – Project Road Section
- Pedestrian and Animal Cross Traffic Count
TRAFFIC VOLUME COUNT SURVEYS

- 7 days – Continuous, Direction-wise
- Vehicle Classification
  - Motorised - New Technology, Old Technology, 2 W, 3 W, Utility Vehicles, MCV, HCV, MAV
  - Non-Motorised – Bicycle, Cycle Rickshaw, ADV, HC, others
ENGINEERING SURVEYS

- Reconnaissance and Alignment
- Topographic Surveys
- L/S and C/S
- Details of Utility Services and other Physical Features
- Road Inventory Surveys
PAVEMENT INVESTIGATIONS

- Pavement Composition
- Road and Pavement Condition Surveys
- Pavement Roughness
- Pavement Structural Strength
- Subgrade Characteristics and Strength
INVESTIGATIONS FOR BRIDGES AND STRUCTURES

- Inventory for Bridges and Structures
- Hydraulic and Hydrological Investigations
- Condition Surveys for Bridges, Culverts and Structures
- Geotechnical Investigations and Sub-Soil Exploration
- Material Investigations
DETAILED DESIGN OF ROAD AND PAVEMENTS

- Design Standards
- Geometric Design
- Pavement Design
- Design of Embankments
- Drainage System
- Traffic Safety Features, Road Furniture and Road Markings
- Toll Plaze
ECONOMIC ANALYSIS

- Assess Capacity of Existing Roads and Effect of Capacity on VOC
- Quantify Benefits viz., due to Reduced Congestion, Travel Distance, Road Maintenance Cost Saving, Reduced Incidence of Accidents
- Estimate Economic Internal Rate of Return
- Saving in Travel Time
## REDUCTION IN VOC DUE TO ROAD SURFACE IMPROVEMENTS ON ROADS OF DIFFERENT WIDTHS

<table>
<thead>
<tr>
<th>VEHICLE TYPE</th>
<th>VOC CONSIDERING FUEL, TYRES AND SPARES, RS.</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SINGLE LANE UI=8000 mm/km</td>
<td>UI=3000 mm/km</td>
<td>INTERMEDIATE UI=8000 mm/km</td>
<td>UI=3000 mm/km</td>
<td>TWO LANE UI=8000 mm/km</td>
</tr>
<tr>
<td>Bus</td>
<td>5.18</td>
<td>4.84</td>
<td>5.10</td>
<td>4.78</td>
<td>3.78</td>
</tr>
<tr>
<td>Truck</td>
<td>6.78</td>
<td>6.04</td>
<td>5.93</td>
<td>5.48</td>
<td>4.01</td>
</tr>
<tr>
<td>MAV</td>
<td>15.81</td>
<td>14.46</td>
<td>14.39</td>
<td>13.52</td>
<td>11.00</td>
</tr>
<tr>
<td>Jeep &amp; Maxi Cab</td>
<td>3.47</td>
<td>2.87</td>
<td>3.22</td>
<td>2.71</td>
<td>2.55</td>
</tr>
<tr>
<td>Car</td>
<td>3.99</td>
<td>2.81</td>
<td>2.98</td>
<td>2.79</td>
<td>2.81</td>
</tr>
<tr>
<td>T/W</td>
<td>1.27</td>
<td>0.97</td>
<td>1.01</td>
<td>0.96</td>
<td>0.98</td>
</tr>
<tr>
<td>A/R</td>
<td>2.02</td>
<td>1.56</td>
<td>1.65</td>
<td>1.34</td>
<td>1.25</td>
</tr>
</tbody>
</table>
PERCENTAGE SAVING IN VOC DUE TO ROAD IMPROVEMENT VIZ., UI 8000 TO 3000 MM/KM AND WIDENING OF CARRIAGEWAY

<table>
<thead>
<tr>
<th>VEHICLE CLASS</th>
<th>PERCENTAGE SAVING IN VOC DUE TO ROAD IMPROVEMENT</th>
<th>PERCENTAGE SAVING IN VOC DUE TO ROAD IMPROVEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single, UI = 8000</td>
<td>Single, UI = 8000</td>
</tr>
<tr>
<td></td>
<td>Single, UI = 3000</td>
<td>Two lane, UI = 3000</td>
</tr>
<tr>
<td>Bus</td>
<td>6.56</td>
<td>29.73</td>
</tr>
<tr>
<td>Truck</td>
<td>10.91</td>
<td>42.92</td>
</tr>
<tr>
<td>MAV</td>
<td>8.54</td>
<td>32.51</td>
</tr>
<tr>
<td>Maxi Cab/ Jeep</td>
<td>17.29</td>
<td>37.18</td>
</tr>
<tr>
<td>Car</td>
<td>29.70</td>
<td>32.46</td>
</tr>
<tr>
<td>Two-Wheeler</td>
<td>23.62</td>
<td>25.98</td>
</tr>
<tr>
<td>Auto-rickshaw</td>
<td>22.77</td>
<td>48.51</td>
</tr>
</tbody>
</table>

Note: UI Values are in mm/km
HDM-4 TECHNICAL IMPROVEMENTS

🌟 Pavements
- Wider range of flexible pavements
- Rigid pavements
- More maintenance types
- Drainage effects
- Freezing climates effects

🌟 Road Users
- New vehicle types
- Characteristics of Modern Vehicles
- Non-motorized traffic
- Congestion effects
- Accidents
- Emissions & Energy consumption
THE HDM-4 MODEL

- Analytical tool for engineering and economic assessment of
  - road investments and maintenance
  - transport pricing and regulation

- Physical and economic relationships derived from extensive research on road deterioration, the effects of maintenance activities, and vehicle operation and user costs
ROAD AGENCY ALTERNATIVES

- Standards / Alternatives
- Policies / Strategies
- Norms / Options

- 4 cm overlay every 8 years
- 6 cm overlay every 15 years
- reseal the road and postpone the overlay
- reconstruct the road when IRI = 10
- do nothing

- grading every 180 days
- upgrade unpaved road to a paved standard
EVALUATION OF ALTERNATIVES

- Economic evaluation
- Technical evaluation
- Institutional evaluation
- Financial evaluation
- Commercial evaluation
- Social evaluation
- Environmental evaluation
TRANSPORT BENEFITS

- Reduce vehicle operating cost
- Savings in time of passengers and cargo
- Reduction of accidents
- Stimulate regional development
- Increase the comfort and convenience
- Better national integration
- National security
- Greater self-sufficiency
- Equal distribution of income
- Prestige of the country
TECHNICAL-ECONOMIC EFFICIENCY

- Current Condition
- Deterioration Prediction
- Maintenance Effects
- Vehicle Operating Costs

Benefits to Society

Ride m/km
Distress %
Rut mm
Structural #
Safety #

Condition

Index Rating

90 Poor

Composed Index
Overall Index

Remaining Service Life

Terminal Life

R.L.

Current Condition

Current Condition

- Current Condition
TOTAL SOCIETY COSTS

= ROAD AGENCY COSTS
  - Construction
  - Maintenance

+ ROAD USER COSTS
  - Vehicle operation
  - Passenger and cargo time
  - Accidents
MINIMIZING CONSUMPTION OF RESOURCES

Consumption of Resources

Unit Costs

Total Society Costs

litres

m³

hours

X

Costs

= 

XUnit
ROAD USER COSTS MODEL

- Road Geometry, Condition
- Driver, Traffic Flow

Vehicle Characteristics

- Speed

Fuel & Lubricants
- Tire
- Maintenance Parts & Labor
- Crew Time
- Depreciation & Interest
- Passenger & cargo time

CONSUMPTION
PAVED ROAD DETERIORATION MODEL

Moisture, Temperature, Aging

Traffic, Loading

Pavement Materials, Thickness

Cracking

Ravelling

Potholing

Rutting

Roughness
COSTS-SHARES UNDER OPTIMAL MAINTENANCE

50 veh/day  300 veh/day  5000 veh/day

User Costs

Agency Costs

User Costs

Agency Costs

User Costs

Agency Costs
PRIMARY FEATURES OF HDM-4

• Simulates deterioration and maintenance of paved and unpaved roads, in physical condition and quantities, for strategies defined by the user

• Simulates road user costs (speeds and consumption of physical components)

• Determines time-streams of road agency, road user costs, and net benefits

• Computes economic indicators
IMPORTANT USES OF HDM-4

Planning and Programming
- Analytical support to justify funding
  - Forecasting financial and physical needs for preserving road network

Technical Applications
- Optimal maintenance strategies
- Economic thresholds for road improvements
- Tradeoffs between design and maintenance standards or options
- Simulating type and extent of deterioration

Economic Applications
- Road use cost and damage attribution, in road transport pricing and taxation (user charges, fuel tax, etc.)
- Optimal axle loading and configuration
- Fleet modernization
**COMPARISON OF ALTERNATIVES**

- **Evaluation Period = 20 years**
- **Discount rate = 12.00 %**

<table>
<thead>
<tr>
<th>Length (km)</th>
<th>Construction Costs</th>
<th>Road Maintenance Costs</th>
<th>Internal Rate of Return (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.0</td>
<td>BASE 2.71</td>
<td>26.7</td>
<td>17.1</td>
</tr>
<tr>
<td></td>
<td>PROJ 9.28</td>
<td>17.0</td>
<td>3.2</td>
</tr>
</tbody>
</table>

**Is the project economically justified?**
MAINTENANCE NEEDS FORECASTING

- Routine Maintenance
  Reconstruction when IRI > 11.0

- Routine Maintenance
  Patching 100% of potholes
  Reconstruction when IRI > 11.0

- Routine Maintenance
  Patching 100% of potholes
  12 mm Resealing when damage is > 30%
  Reconstruction when IRI > 11.0

- Routine Maintenance
  Patching 100% of potholes
  4 cm overlay when IRI is > 4.0

- Routine Maintenance
  Patching 100% of potholes
  8 cm overlay when IRI is > 4.0
ROUGHNESS PROGRESSION

![Graph showing roughness progression over years for different pavement conditions.](image-url)
A Road Network

- What are the resources needed to maintain the network?

- How should the agency allocate the resources needed for an optimal maintenance program?

- What maintenance program should be implemented in case of budgetary constraints?
BUDGETARY CONSTRAINTS

A Road Network

Resource Constraints

Optimal Strategy under Budgetary Constraints

Optimisation Module

Strategy without Budget Constraint
VEHICLE POLICIES

How much road damage is caused by trucks?
ROLE OF HDM-4 IN ROAD MANAGEMENT

INPUTS
- Road Inventory
- Road Condition
- Traffic Data
- Bridges Inventory
- Bridges Condition

OUTPUTS
- Long Term Strategic Road Plan
- Multi-Year Rolling Work Program
- Detailed Project Level Appraisal
- Policies Standards Research Design

HDM-4 DATABASES
PROCUREMENT

ISSUES
• Dedicated organisation for road infrastructure development

• Tremendous pressure on the project preparation and construction

• Involvement of consultants/contractors and technical experts in road development
Tender criteria:

• Cost/technical capability/ both criteria to follow?

• Highest level of technical as well as economy

• Qualifying score and weightages for technical and financial scores?

• Uniform procedure for this similar projects
SCOPE OF THE WORK

• Incomplete and inadequate TOR invites assumptions and variations in both technical and financial proposals
• Standardization of TOR: A major shift in the procedural aspects of technical proposal
KEY PERSONNEL

• Detailed requirements or eligibility criteria for evaluation of CVs
• Enhance the transparency in the process
• Realistic Requirements?
• Age limit: 65 yrs./70 yrs.
• Non-availability of key personnel at time of execution?
RULES AND PROCEDURES

• Need to change the rules and regulations to support progressive work plan

• MSRDC has shown the way by pioneering the modern way of planning and execution of the road projects

• Changes are possible by substantial upgradation of organisational skill and culture
STUDY DURATION AND DATABASE

- Inadequate time for project preparation
- Inadequate database for project preparation/execution
- Major time and resources for creating workable database
- Lack of time for innovative methodology/solution
COST LIMIT

• If the client’s estimate is based on rational data, why the same cannot be the basis for selection?

• Abnormally low quotation may severely affect the quality of work

• Provision for rejecting abnormally low quotations?

• Analysis of causes and effects of variations in financial proposals for already awarded projects to offer a remedial measure
UNCERTAINTIES

• Uncertainties be minimized and clearly mentioned in the TOR

• Remove uncertainties before appointing consultant/ contractor to minimize time and cost overruns

• Tendencies to transfer uncertainties to consultants to be eliminated
CLOSURE

• The targeted road infrastructure development substantially higher. Very few countries in the world ever had undertaken similar ambitious programmes.

• If the jobs done in the first decade are not carried out with extreme seriousness and caution in all fronts, it will have serious setback and people of the country will loose faith in the gigantic programmes undertaken.
• For the sake of targets there must not be short cuts in planning and designing of the projects

• A wrongly planned and designed project may damage the network operations as well as both physical and social environment for many decades to come before the facility is completely use up
• Procurement of the services of the right and competent consultants and contractors is important and critical

• All unhealthy competitions and corruption must be eliminated using efficient, transparent and properly documented system for procurement
Thank you