MAINTENANCE OF INFRASTRUCTURE – CASE STUDY OF HIGHWAY SECTOR
Road Composition

- **Base Black Topping**
- **Road Crust**
- **Vehicle**
- **Sub Grade 300mm**
- **Sub Base**
- **Sub Grade 300mm**
- **Sub Base**
- **Embankment**
- **Ground Level**
GRAVEL ROAD OR ASPHALTED ROAD?
POT HOLES IN ROADS OR ROADS IN POT HOLES?
PONDS AND LAKES IN ROADS - RAIN WATER HARVESTING?
TRAVEL SAFE ON BUNDS!!
Beaten, battered and bruised
Clockwise from top left: Pools of water on Ponniamman Koil road near Sayeenager Annex near Chinmaya Nagar; yawning craters at Kanagasabai street, Nesappakkam, K. K. Nagar; and inches of slush on Alandur Road, Saidapet. PHOTOS: K.N. MURALIDHARAN, R. RAGU AND S. THANTHONI
NEED FOR MAINTENANCE

- Deterioration with Passage of Time due to
  - Action of traffic – HCV
  - Environmental Factors – Ingress of water, oxidation of Binder, loss of volatiles
  - Inadequacies in the initial design, specifications and construction standards
  - Lack of adequate support from lower pavement layers
FUNCTIONAL REQUIREMENTS

- Adequate Skid Resistance
- Good Riding Quality
- Adequate Transverse Profile without Ruts
- No Cracks
- No Potholes
- No Surface Integration
STRUCTURAL REQUIREMENTS

- Adequate Thickness
- Stresses and Strain within Limit
- Withstand Repeated Application of Wheel Loads
- Without Excessive Permanent Deformation – Ruts
- No Cracks in Bituminous Surface
CLASSIFICATION OF MAINTENANCE OPERATIONS

- Routine Maintenance - day to day work necessary like pot hole patching, crack sealing etc.,
- Periodic Maintenance – work carried out periodically once few years to prevent deterioration
- Rehabilitation and Strengthening – work intended to restore or upgrade the pavement

ASSESSED EVERY YEAR AS PART OF PLANNING OF MAINTENANCE
DETERIORATION OF PAVEMENTS

- Pavements Deteriorate with Time
- Rate of Deterioration Depends on Traffic, Climate, Drainage, Environmental Factors and Structural Adequacy
- Failure to do Routine Maintenance Requires Premature Periodic Maintenance - 20 times Costlier than RM
- Failure to Carryout Periodic Maintenance Requires Strengthening with Overlay – 3 times costlier than PM
- Failure to Strengthen at the Appropriate Time Requires Rehabilitation - 15 times costlier than PM or 5 times costlier than strengthening
VEHICLE OPERATION COST

- Neglect of Maintenance – Appearance of Cracks and Potholes – VOC increases by 15%
- Neglect of Further Maintenance – Disintegration of Pavement – VOC increases by 50% = twice the cost of construction of the road
- During the Design Life, Total VOC is 4 times initial construction cost Whereas Maintenance is only 1 to 2 % of Total Transportation Cost
# REDUCTION IN VOC DUE TO ROAD SURFACE IMPROVEMENTS

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>VOC Considering fuel, tyres and spares, Rs.</th>
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<tbody>
<tr>
<td></td>
<td>Single Lane</td>
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<td></td>
<td>UI= 8000 mm/km</td>
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<tr>
<td>Bus</td>
<td>5.18</td>
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<tr>
<td>Truck</td>
<td>6.78</td>
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<tr>
<td>MAV</td>
<td>15.81</td>
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<tr>
<td>Jeep &amp; Maxi Cab</td>
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<tr>
<td>Car</td>
<td>3.99</td>
</tr>
<tr>
<td>T/W</td>
<td>1.27</td>
</tr>
<tr>
<td>A/R</td>
<td>2.02</td>
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</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>
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<tbody>
<tr>
<td></td>
<td>Single, UI = 8000 to 3000</td>
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<tr>
<td>Bus</td>
<td>6.56</td>
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<tr>
<td>Truck</td>
<td>10.91</td>
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<tr>
<td>MAV</td>
<td>8.54</td>
</tr>
<tr>
<td>Maxi Cab/ Jeep</td>
<td>17.29</td>
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<tr>
<td>Car</td>
<td>29.70</td>
</tr>
<tr>
<td>Two-Wheeler</td>
<td>23.62</td>
</tr>
<tr>
<td>Auto-rickshaw</td>
<td>22.77</td>
</tr>
</tbody>
</table>

Note: UI Values are in mm/km
BASIC REQUIREMENTS

- Drainage, drainage, drainage

- Sufficient thickness and internal strength to carry expected traffic loads

- Adequately dense to prevent penetration of moisture from underneath, sides, and surface

- Top surface which is smooth; waterproof; skid resistant; resistant to wear, distortion, and deterioration by weather and deicing chemicals
TYPES OF DEFECTS IN BITUMINOUS SURFACEINGS

- Surface Defect – Fatty Surface, Smooth Surface, Streaking, Hungry Surface
- Cracks – Hairline Cracks, Alligator Cracks, Longitudinal Cracks, Edge Cracks, Shrinkage Cracks and Reflection Cracks
- Deformation – Slippage, Rutting, Corrugations, Shoving, Shallow Depressions, Settlements and Upheavels
- Disintegration – Stripping, Loss of Aggregates, Ravelling, Potholes and Edge Breaking
BASE PATCHING

This is the treatment that is used to repair:

- mesh cracking (Page III - 11),
- ruts and depressions (Page III - 15),
- edge subsidence and rutting (Page III - 17),
- edge surface failure (Page III - 19),
- potholes (Page III - 23),
- shoving (Page III - 25).

Four steps are involved:

1 **Marking out the area to be repaired**

   The area to be treated is marked out with chalk by drawing a rectangle around the defects.
SURFACING PATCHING

This treatment is used to repair local aggregate loss (Page III - 21) and is carried out in the following steps:

1. **Sweep the area**
   
The area must be swept out by hand. The surface must be clean and dry.

2. **Mark out the area to be repaired**
   
The surfacing that is to be repaired is outlined in chalk.

**OPTION 1: SEAL**

Use cold emulsion or hot cut back bitumen to seal the area to be repaired and provide a tack coat at the following rates:

- 1.5 kg/m² for bitumen emulsion
- 1.0 kg/m² for cut back bitumen.

Apply the chippings (such as 6-10 mm size) and ensure a complete coverage. Lightly roll the chippings into the bitumen using a roller or vehicle tyres.
Commonly Used Surface Patching Equipment

Single drum walk behind roller

Double drum walk behind roller
BLEEDING

Causes: too much binder, unsuitable binder
Remedies: spread fine sand or metal chips and roll or apply surface dressing
TACK COAT APPLICATION USING MECHANICAL SPRAYER
GOOD TACK COAT
Applying Tack Coat Over CRMB
Bleeding
Ripples (shoving) of mix under construction traffic after compaction
DEFECT: EDGE SUBSIDENCE AND RUTTING

Location
Usually along the edges of the pavement where it borders unsealed shoulders.

Main Causes
- inadequate or badly maintained shoulder,
- penetration of water into the pavement structure or foundation and resulting loss of bearing strength,
- poor drainage,
- narrow carriageway.

Development, if neglected
- rapid during the rainy season leading to the disintegration of the edges of the pavement.

Remedies
- slight subsidence (less than 5 cm): filling in of ruts and depressions (Page III - 63) and restoration of shoulder (see Volume I),
- deep subsidence: local restoration of the pavement structure (Page III - 71) and restoration of the shoulder (see Volume I),

Also consider improvements to the drainage (see Volume I), or sealing of the shoulder (Part B or C) to help prevent the problem recurring.
RUTS AND DEPRESSIONS

Causes: Insufficient foundation/pavement strength, inadequate stability of bituminous mix.

Remedy: Fill up depressions (< 5cm) local restoration of pavement structure.
EDGE DAMAGE
EDGE DAMAGE

Inadequate support from shoulder; Impervious material used for shoulders.
Replace worn out material and construct layer by layer
SHOVING
RECTIFICATION OF DEFORMATIONS

- **DEPRESSIONS**
  - Scarify the affected area
  - Cut the sides of depressions vertically
  - Apply tack Coat using emulsion with a sprayer
  - Fill the depression with premix
  - Roll with a power roller
  - Apply liquid seal coat

- **INCASE OF LARGE DEPRESSIONS**
  - Strengthen the base or sub-base
  - Provide proper drainage layer,
RECTIFICATION OF DEFORMATIONS

HUMPS OR HEAVING

- Due to high temperature, bitumen from top layer flows to sides because of pressure of wheels
- Resultant formation of humps at edges and depressions at centre
- Remove humps and depressions by pick axe
- Treat the exposed surface with premix material
RECTIFICATION OF DEFORMATIONS

CAMBER CORRECTION

- Thickness of layer depends on extent of correction
- Provision should be made in the estimate for PCC
- Avoid stagnation of water
- Fill with suitable bituminous levelling course
GLAZING

Causes: wear and tear
Solution: apply surface dressing/thin overlay
Loss of Surface Aggregate

Poor adhesion of surface dressing, dirty aggregates, poor premix Insufficient binder, insufficient penetration of aggregate
STREAKING

Faulty Spraying Equipment
CRACKS

Poor quality materials, poor workmanship, insufficient thickness, shrinkage, (CTB), pavement edge
LONGITUDINAL CRACKS
TRANSVERSE CRACKS
LONGITUDINAL CRACKS
BLOCK CRACKING
SEVERE FATIGUE CRACKS WITH PERMANENT DEFORMATIONS
OVER LOADED TRUCK
## COMMON DEFECTS, CAUSES AND MAINTENANCE MEASURES IN SURFACED ROADS

<table>
<thead>
<tr>
<th>BLEEDING</th>
<th>EXCESS/UNSUITABLE BINDER</th>
<th>SPREADING OF AGGREGATE CHIPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>Excess/Unsuitable binder</td>
<td>Spreading of aggregate chips</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SURFACE AND PAVEMENT STRUCTURE CRACKS</th>
<th>POOR QUALITY OF MATERIAL/WORKMANSHIP</th>
<th>LOCAL SEALING OF FILLING IN OF CRACKS STRENGTHENING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient pavement crust excessive loads</td>
<td>Insufficient pavement crust excessive loads</td>
<td>Insufficient pavement crust excessive loads</td>
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</table>

<table>
<thead>
<tr>
<th>EDGE SUBSIDENCE</th>
<th>INADEQUATE OR BADLY MAINTAINED SHOULDERS</th>
<th>SLIGHT SUBSIDENCE: FILLING OF RUTS AND DEPRESSIONS AND RESTORATION OF SHOULDERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inadequate or badly maintained shoulders</td>
<td>Inadequate or badly maintained shoulders</td>
<td>Inadequate or badly maintained shoulders</td>
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</table>

<table>
<thead>
<tr>
<th>RUTS AND DEPRESSIONS</th>
<th>POOR QUALITY OF MATERIAL INADEQUATE PAVEMENT OR SUBGRADE STRENGTH</th>
<th>SLIGHT RUTTING: FILLING DEEP RUTTING: LOCAL RESTORATION OF PAVEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inadequate or badly maintained shoulders</td>
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</table>
# COMMON DEFECTS, CAUSES AND MAINTENANCE MEASURES IN SURFACED ROADS

<table>
<thead>
<tr>
<th>Rutting</th>
<th>Loss of strength due to water penetration</th>
<th>Deep subsidence: Local restoration of pavement, improvement of drainage</th>
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<tbody>
<tr>
<td>Edge damage</td>
<td>Poor drainage Narrow road Shoulder damage due to action of water</td>
<td>Local restoration of pavement Repair of shoulder</td>
</tr>
<tr>
<td>Potholes</td>
<td>Degradation of pavement structure, Poor quality of material, Infiltration of water Traffic</td>
<td>Cutting and removal of material upto affected depth, filling and compaction by ramming</td>
</tr>
<tr>
<td>Shoving</td>
<td>Failure of subgrade/sub-base, Water ingress, Poor materials, Poor workmanship, Heavy traffic</td>
<td>Cutting and removal of material upto full depth of affected area and refilling with appropriate materials in layers and compacting</td>
</tr>
</tbody>
</table>
Techniques for AC-Surfaced Pavements
Techniques for AC-Surfaced Pavements

- Maintenance of drainage features
- Crack filling/sealing
- Fog seals
- Slurry seals
- Microsurfacing
- Chip seals
- Cold in-place recycling
- Hot in-place recycling
- Milling
- Thin HMA overlays
Crack Treatments

- Crack Filling
  - Lower level operation with lower quality sealant and little preparation
  - Applicable only to non-working cracks

- Crack Sealing
  - Higher level operation with higher quality sealant and more preparation
  - Working cracks
Surface Treatments

- Fog Seals
- Slurry Seals
- Microsurfacing
- Chip Seals
Fog Seals

- Light application of diluted, slow-setting asphalt emulsion without aggregate cover

- Purpose
  - Seal the pavement
  - Inhibit raveling
  - Enrich hardened/oxidized asphalt
  - Provide delineation with shoulder

- For pavements in good condition
- Not recommended on high-speed roadways
FOG SEAL

- Light application of low viscosity bituminous emulsion
- For sealing of cracks less than 3 mm wide; incipient fretting or disintegration of bituminous surfacing
- Material – Slow setting emulsion
- Construction – to be sprayed using a mechanical sprayer @ 0.5 – 1.0 litre/sq.m
- Traffic to be allowed after 24 hours
Slurry Seals

- Mixture of materials
  - Well-graded fine aggregate
  - Mineral filler (if needed)
  - Slow-setting asphalt emulsion
- Thicknesses of 3 to 12 mm (0.12 to 0.5 in)

- Purpose
  - Stop raveling and loss of matrix
  - Reduce potential for stripping
  - Improve surface friction
Slurry Seal

- Mixture of fine aggregate, portland cement / lime filler, bitumen emulsion and water
- Thickness – 1.5 to 5 mm
- To seal cracks, arrest fretting and fill voids and minor depressions
- Tack coat – 0.15 to 0.30 litres/sq.m
- Mixing, transportation and applications
- Rolling using a pneumatic roller – 0.75 to 1.50 t
<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>% by mass passing finished thickness of sealing</th>
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<tr>
<td></td>
<td>5 mm</td>
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<tr>
<td>9.5</td>
<td>100</td>
</tr>
<tr>
<td>4.75</td>
<td>90-100</td>
</tr>
<tr>
<td>3.35</td>
<td>-</td>
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<tr>
<td>2.36</td>
<td>65-90</td>
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<tr>
<td>1.18</td>
<td>45-70</td>
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<tr>
<td>0.600</td>
<td>30-50</td>
</tr>
<tr>
<td>0.300</td>
<td>18-30</td>
</tr>
<tr>
<td>0.150</td>
<td>10-21</td>
</tr>
<tr>
<td>0.075</td>
<td>5-15</td>
</tr>
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</table>
## SLURRYY SEAL

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>% by mass passing finished thickness of sealing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 mm</td>
</tr>
<tr>
<td>Quantity of Binder, % by mass of aggregate</td>
<td>7.5-13.5</td>
</tr>
<tr>
<td>Approx. Coverage (kg/sq.m)</td>
<td>8-15</td>
</tr>
</tbody>
</table>
Slurry Seal Operation
Surface Dressing

- Application of asphalt and aggregate chips rolled into pavement

- Purpose
  - Seal the pavement
  - Improve surface friction
  - Wearing course

- Some recent application on high-volume roads
Application of Surface Dressing

- Application of Aggregate
- Application of Asphalt or Emulsion

Pneumatic-Tired Rolling
Application of Aggregate
Application of Asphalt or Emulsion
Existing AC Pavement

Single Chip Seal
Double Chip Seal
Surface Dressing Operation
CURRENT CONSTRUCTION PRACTICES
Tack Coat Without Crack Sealing
Overlay Over Severely Cracked Surface
PREVENTIVE MAINTENANCE – AN EFFECTIVE TECHNIQUE FOR LONG LASTING HIGHWAY PAVEMENTS
Typical Variation of Pavement Condition as a Function of Time

- **EXC**: PM Cost Here is a Fraction of $1.00
- **GOOD**: 40% Drop in Quality
- **FAIR**: 75% of Life
- **POOR**: 40% Drop in Quality
- **V. POOR**: 12% of Life
- **FAILED**: $1.00 for Rehab Here
- **FAILED**: Will Cost $4.00 to $5.00 Here
TREATMENT TYPES

☐ AC Pavements
  ▪ Crack Sealing
  ▪ Fog Seal
  ▪ Slurry Seal
  ▪ Thin overlay
  ▪ Mill and overlay
  ▪ Surface Dressing
  ▪ Microsurfacing
  ▪ Shoulder

☐ PCC Pavements
  ▪ Joint resealing
  ▪ Spall repair
  ▪ Crack sealing
  ▪ Diamond grinding
  ▪ Shoulder maintenance
  ▪ Drain cleanout
  ▪ Dowel retrofit
Quantifying Benefits

- Current Pavement Deterioration
- Preventive Maintenance Trigger
- Rehabilitation Trigger

Benefits:
- Benefit of Preventive Maintenance
- Benefit of Rehabilitation
<table>
<thead>
<tr>
<th>Strategy</th>
<th>Benefit</th>
<th>ADT</th>
<th>Cost</th>
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<tbody>
<tr>
<td>Preventive Maint.</td>
<td>250</td>
<td>7000</td>
<td>Rs.5,00,000</td>
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<tr>
<td>Rehabilitation</td>
<td>1000</td>
<td>7000</td>
<td>Rs.35,00,000</td>
</tr>
</tbody>
</table>

PM Strategy: \[ B/C = \frac{250 \times 7000}{500,000} = 3.5 \]

Rehab Strategy: \[ B/C = \frac{1000 \times 7000}{35,00,000} = 2.0 \]
## Primary benefits of different maintenance treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Roughness</th>
<th>Friction</th>
<th>Noise</th>
<th>Life Extension</th>
<th>Moisture Reduction</th>
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<tr>
<td><strong>Bituminous – Surfaced Pavements</strong></td>
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<tr>
<td>Crack Sealing</td>
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<td>Scrub Seals</td>
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<tr>
<td>Micro surfacing</td>
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<td>Ultra thin Friction Course</td>
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<td><strong>PCC Pavements</strong></td>
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<tr>
<td>Joint and Crack Sealing</td>
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<tr>
<td>Diamond Grinding</td>
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</tbody>
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THANK YOU