CONSTRUCTION OF RURAL ROADS WITH CATIONIC BITUMEN EMULSION BASED COLD MIX MIX TECHNOLOGY

Dr. N.K.S. Pundhir
Senior Principal Scientist
E-mail: pundhir.crri@nic.in

CSIR- Central Road Research Institute, New Delhi-110025
CONVENTIONAL METHOD FOR ROAD CONSTRUCTION

- HOT MIX TECHNOLOGY

Hot Applications

- Heating of Binder at 165°C
- Heating of Aggregate at 150°C
- Production of mix at 155°C
- Tack coating at 160°C
- Laying of mix at 130°C
- Compaction of mix at 120°C
DRAW BACKS OF HOT MIX TECHNOLOGY

- Environmental Degradation
- High Energy Consumption
- Increase in Carbon Footprint
- Low Output for Mix Production
- Low Laying Work in rains / cold
- Limited Construction Period in a yr.
- Oxidative Hardening of Binder
- Heath / Safety Hazard to Labour
Emulsion Based Cold Mixes
Overcome
Hot Mix Problems
BITUMEN EMULSION

A liquid product in which a substantial amount of bitumen is suspended in a finely divided form of the size 4-10 microns in water in presence of emulsifiers

TYPES OF EMULSIFIER

- **Anionic Emulsifier**
  - $\text{RCOOH} + \text{NaOH} = \text{RCOO}^- + \text{Na}^+ + \text{H}_2\text{O}$

- **Cationic Emulsifier**
  - $\text{RNH}_2 + \text{HCl} = \text{RNH}_3^+ + \text{Cl}^-$
**TYPES OF EMULSION**

- Anionic Emulsion
- Cationic Emulsion
- Non Ionic Emulsion
GRADES OF BITUMEN EMULSION

- **Rapid Set** - RS-1 & RS-2
- **Medium Set** - MS
- **Slow Set** - SS-1 & SS-2

- RS-1: Tack-Coating, Penetration Grouting
- RS-2: Surface Dressing,
- MS: Premix carpet, Patch Repair
- SS-1: Priming
- SS-2: SDBC, BC, BM, Slurry Seal,
- PMB/Latex Emulsion: Micro-surfacing
Bitumen Emulsion Production

Bitumen + 2% K.oil

Water + emulsifier

Bitumen Emulsion

dosage pump

colloid mill

dosage pump

emulsion
TESTING OF EMULSIONS (IS: 8887-2004)

- Residue on 600 micron IS sieve
- Viscosity by Saybolt Furol viscometer
- Coagulation at low temperature
- Storage stability after 24 hrs.,
- Particle charge
- Stability to mixing with cement,
- Coating ability and water resistance
- Residue Test
  - Penetration
  - Ductility
  - Solubility in Trichloroethylene
<table>
<thead>
<tr>
<th>S.No.</th>
<th>Properties of Bitumen Emulsion</th>
<th>Requirement of IS:8887-2004</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>RS-1</td>
</tr>
<tr>
<td>(i)</td>
<td>Residue on 600 micron IS sieve (% mass)</td>
<td>0.05 max.</td>
</tr>
<tr>
<td>(ii)</td>
<td>Viscosity by Saybolt Furol Viscometer, seconds</td>
<td>20-100</td>
</tr>
<tr>
<td></td>
<td>At 25°C</td>
<td>20-100</td>
</tr>
<tr>
<td></td>
<td>At 50°C</td>
<td>20-100</td>
</tr>
<tr>
<td>(iii)</td>
<td>Coagulation of emulsion at low temperature</td>
<td>Nil</td>
</tr>
<tr>
<td>(iv)</td>
<td>Storage stability after 24 hrs., %, max.</td>
<td>2.0</td>
</tr>
<tr>
<td>(v)</td>
<td>Particle charge</td>
<td>+ve</td>
</tr>
<tr>
<td>(vi)</td>
<td>Coating ability and water resistance</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(a) Coating, dry aggregates</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(b) Coating after spraying water</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(c) Coating, wet aggregates</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(d) Coating after spraying water</td>
<td>-</td>
</tr>
<tr>
<td>(vii)</td>
<td>Stability to mixing cement, %coagulation</td>
<td>Nil</td>
</tr>
<tr>
<td>(viii)</td>
<td>Miscibility with water (coagulation)</td>
<td>No Coagulation</td>
</tr>
<tr>
<td>(ix)</td>
<td>Test on residue:</td>
<td>60 min.</td>
</tr>
<tr>
<td></td>
<td>(a) Residue by evaporation, %</td>
<td>80-150</td>
</tr>
<tr>
<td></td>
<td>(b) Penetration, 25°C/100 gm/5 sec.</td>
<td>50 min.</td>
</tr>
<tr>
<td></td>
<td>(c) Ductility, 27°C/cm.,</td>
<td>98 min.</td>
</tr>
<tr>
<td></td>
<td>(d) Solubility In Trichloroethylene, %</td>
<td>98 min.</td>
</tr>
</tbody>
</table>
APPLICATION OF COLD MIX TECHNOLOGY

- Construction of BM, PMC, MSS & SDBC
- Surface Dressing
- Grouting-Penetration Macadam
- Priming GSB/WMM & Tack coating
- Crack Sealing (Black Seals)
- Repair of Pot- Holes & Depression
- Repair of Utility Cuts & Bomb Crater
- Sub-Base & Base Courses (Sealing)
- Slurry Seal Treatment / Micro surfacing
COLD MIX DESIGN

Cold mix design of MSS, SDBC / BM :

- Evaluation of Bitumen Emulsion
- Gradation and Properties of Aggregates
- Premixing Optimum Water Content
- Preparation of Marshall Specimens
- Testing of Marshall Specimens
**Determination of Premix Water Content**

- Quantity of emulsion (P) is determined as:
  \[ P = 0.05A + 0.1B + 0.5C \]
  
  Where,
  - A = Percent aggregate retained on 2.8 mm sieve
  - B = Percent aggregate retained on 90 micron sieve
  - C = Percent aggregate passing on 90 micron sieve

- Fix quantity of emulsion, P,
- Prepare cold mix with varying water contents (2,3,4,5 %) and visually examined for coating value and workability
- Premix water content is determined as water content at which coating and workability is maximum
Preparation of Marshall Specimens

1100g Blended Aggregates → Mix for wetting
4% water content → Addition of emulsion 7,8,9% into aggregates → Mixing for uniform coating → Cold mix in mould

Compaction with 75 Blows on each face Specimens → Marshall Specimen → Curing for 3 days at 40°C → Testing for Bulk Density, Stability, flow, Retained Stab. at 25°C
TESTING OF COLD MIX
## PROPERTIES OF COLD MIX WITH EMULSION (SS-2)

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Properties</th>
<th>Bitumen emulsion Content, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>6.0</td>
</tr>
<tr>
<td>i</td>
<td>Bitumen residue, %</td>
<td>3.8</td>
</tr>
<tr>
<td>ii</td>
<td>Bulk density, gm/cc</td>
<td>2.26</td>
</tr>
<tr>
<td>iii</td>
<td>Air Voids, %</td>
<td>9.1</td>
</tr>
<tr>
<td>iv</td>
<td>Stability, kg. at 25°C</td>
<td>480</td>
</tr>
<tr>
<td>v</td>
<td>Flow, mm</td>
<td>6</td>
</tr>
</tbody>
</table>
OPTIMIZATION OF EMULSION CONTENT

- **Dry Bulk Density (g/cc.):**
  - 3 day curing (40C oven) shows a peak at around 9% bitumen emulsion content.

- **Marshall Stability (kg.):**
  - 3 day curing (40C oven) has a peak stability at around 9% bitumen emulsion content.

- **Air Voids (%):**
  - 3 day curing (40C oven) indicates a decrease in air voids with increasing bitumen emulsion content, reaching a minimum at around 9% content.

- **Marshall Stability (kg.):**
  - Similar pattern as Marshall Stability, peaking at around 9% bitumen emulsion content.
FIELD TRIALS IN DIFFERENT CLIMATES
Available Specifications for Cold Mixes

- IRC: 14-2004  Recommended Practice for Open Graded Premix Carpets (Third Revision)
- IRC: 82-1982  Code of Practice for Maintenance of Bituminous Surfaces of Highways

- No Specifications for MSS, SDBC, BC & BM with cold mixes
TEST LOCATIONS OF BRO / LOCAL PWDs

- On NH-1A Jammu-Srinagar National Highway in J&K under snow bound area
- On NH-44 near Silchar on Jowai - Badarpur Road in Assam under high rainfall area
- On Hanumangarh-Sangeria Road in Rajasthan in desert climate
- On NH-2 near Agra from km-228-230 in hot climate
- On Approach Road to Secratariat, Aizwal in wet climate
- Dantaur-Khajuwala Road in Rajasthan-desert climate
- By-pass Aizawl, High rainfall (June, 2007)
- NH-1A Jammu-Srinagar Road (Sept., 2007)
- Rural Roads in Assam (Feb. 2012)
CONSTRUCTION OF ROAD WITH COLD MIX

Tack Coating

- Bitumen Emulsion of RS-1
- Quantity @ 2.5 – 3.5 kg per 10 M² area
- Pressure distributor / or manually
- Cleaning of holes with water when tack coating discontinued
- Spread Cold Mix when Tack coat turns black from brown
- Wetting of road surface required, in Summer
PREPARATION OF COLD MIX IN MIXER

1. Charging of Aggregates
2. Wetting of Aggregates
3. Bitumen Emulsion for Cold Mix
4. Discharging of Cold Mix
PREPARATION OF COLD MIX IN TRAY

1. Spreading gravel and aggregates in the tray.
2. Pouring the binder into the tray.
3. Mixing the mixture in the tray.
4. Resulting cold mix ready for application.
LAYING OF COLD MIX FOR MSS / PMC

1. Tack coating with emulsion
2. Ferrying of cold mix
3. Spreading of cold mix
4. Laying of cold mix in rains
INEXPENSIVE SURFACE DRESSING WITH EMULSION

Preparation of road surface
• Pavement surface cleaned of dirt, dust
• Pot-holes and minor irregularity ratified
• Half width taken for surface dressing
• The road was divided into segment of 10 m² area.

Tack coat
• Bitumen emulsion (RS-2) with quantity @ 17 kg per 10m² area was applied with perforated cans at 3mm hole apart

Spreading of Aggregate
• The first layer of aggregate of 19 mm size was spread over the tack coated area
• The aggregate was compacted with 8-10 ton road roller
• The newly laid road surface was allowed to traffic after 4-5 hours.
CONSTRUCTION OF RURAL ROADS WITH COLD MIX TECHNOLOGY IN NORTH EAST REGION
CONSTRUCTION DEMO IN AGARTALA (5.2.2012)
CONSTRUCTION OF RURAL ROAD IN ASSAM- Feb. 6, 2012
PERFORMANCE OF RURAL ROADS WITH COLD MIX--
Under PMGSY IN BONGAGAON (2012)
PERFORMANCE OBSERVATIONS
CONDUCTED IN ASSAM

A. Rajkhowapara Road to NH-52
B. Bongshar to Solalkuche Road.
C. Kayajan to Patkata Road.
D. Bezera-Mandakta Road.
ANNEXURE-1

(PHOTOGRAPHS OF M.B. ROAD ON DATED 22/03/2010)

2010/03/22 23:00

2010/03/22 23:03
MECHANISED CONSTRUCTION IN VARYING CLIMATES

- Desert (Rajasthan)
- High Rainfall (High Rainfall)
- Cold & Snow Bound (J&K)
PRODUCTION OF COLD MIXES WITH HMP

1. Adding Pre-mix Water
2. Adding Emulsion in Drum Mixer
3. Cold Mix on Conveyer Belt
4. Discharge of Cold Mix to Dumper
LAYING ROAD WITH COLD MIX IN RAJASTHAN
LAYING OF ROAD WITH COLD MIX IN J & K

1. 

2. 

3. 

21-9-07
SDBC
NH-1A

4. 

21-9-07
NH-1A
Laying of Road with Cold Mix in Mizoram
<table>
<thead>
<tr>
<th>Specification</th>
<th>Aggregate (cu.m.)</th>
<th>Bitumen (Kg.)</th>
<th>Energy (Kilo /Cal×10^8)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hot</td>
<td>Cold</td>
<td>Hot</td>
</tr>
<tr>
<td>Two Coat Surface Dressing</td>
<td>85</td>
<td>70</td>
<td>9800</td>
</tr>
<tr>
<td>Premix Carpet + Seal Coat</td>
<td>116</td>
<td>116</td>
<td>9100</td>
</tr>
<tr>
<td>Mix Seal Surfacing</td>
<td>95</td>
<td>95</td>
<td>8700</td>
</tr>
<tr>
<td>Semi-Dense Bituminous Concrete</td>
<td>134</td>
<td>134</td>
<td>11000</td>
</tr>
</tbody>
</table>
## Comparative Cost of Bituminous Surfacings With Emulsion vis-a-vis Hot Bitumen

<table>
<thead>
<tr>
<th>S. N.</th>
<th>Specification</th>
<th>Thickness, mm</th>
<th>Binder</th>
<th>Cost / m², Rs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SDBC</td>
<td>25</td>
<td>Bitumen</td>
<td>324.08</td>
</tr>
<tr>
<td>2</td>
<td>SDBC</td>
<td>25</td>
<td>Emulsion</td>
<td>276.21</td>
</tr>
<tr>
<td>3</td>
<td>PMC</td>
<td>20</td>
<td>Bitumen</td>
<td>168.84</td>
</tr>
<tr>
<td>4</td>
<td>PMC</td>
<td>20</td>
<td>Emulsion</td>
<td>104.76</td>
</tr>
</tbody>
</table>
FIELD PERFORMANCE EVALUATION

METHODOLOGY

- VISUAL INSPECTION
- DISTRESS MEASUREMENTS
- BINDER’s AGING
- FUNCTIONAL CHARACTERISTICS
  - UNEVENNESS OF SURFACING
  - BENKELMAN BEAM DEFLECTION
PERFORMANCE OF MSS WITH EMULSION ON NH-2

- 10% Binder economy is achieved in MSS, PMC and TCSD

1. MSS with Bitumen after 4 yrs
2. Mix Seal Surfacing with 20% reduced emulsion after 5 yrs
Service Life of Mix Seal Surfacings with Emulsion and Bitumen
Pavement Distress with Time in Mix Seal Surfacings

Service Life, Years

Pavement Distress, %
PERFORMANCE OF PMC WITH EMULSION ON NH-2

Premix Carpet with 10% reduced emulsion after 5 yrs service life

PMC with 5% reduced emulsion after 5 yrs service life

Premix Carpet with bitumen after 4 yrs service life
Performance of Premix Carpet with Bitumen and different Emulsion Content

![Graph showing performance points over service life for different emulsion contents.](attachment:image.png)
PERFORMANCE OF COLD TCSD ON NH-2

TCSD with emulsion After 5 Years

TCSD with emulsion After 5 Years

TCSD with Bitumen after 4 years
Performance of Two Coat Surface Dressing with Emulsion and Bitumen
PERFORMANCE OF ROADS WITH EMULSION ON NH-44

1. SDBC with emulsion after 4 yrs

2. PMC emulsion after 4 yrs

3. PMC with emulsion after 5 yrs
PERFORMANCE OF PMC ON H-S ROADS (RAJASTHAN)

1. PMC with emulsion on H-S Rd after 2 yrs

2. PMC with emulsion after 5 yrs
PERFORMANCE OF SDBC ON NH-1A (J&K)

SDBC with emulsion after 5 yrs

SDBC with emulsion after 5 yrs
PERFORMANCE OF BM + PMC AFTER 5 yrs ON NEW APPROACH ROAD AIZAWL
• There is chemical interaction between emulsion / aggregate

• The Cationic Emulsion is positively charged

• Surface of Siliceous aggregates is having Negative Charge

• The strong bond formed between emulsion-Aggregate

• Emulsion contain Anti - stripping agent which reduces water damages
Benefits of Emulsions Based Cold Mixes

- Environment Friendly and Energy Efficient
- Construction feasible in rains/wet and cold weather
- Extends construction period During a year
- Fast Production of Cold Mix
- 4-5 times Faster Construction by Cold Mix
- 15-20 % Cheaper Roads
- Contain in built ant-stripping agent
- Prevent oxidative hardening
- Consume targeted Budget in time
- Labour Intensive - Creates Jobs for Villagers - MNREGA
- Labour Friendly Technology- Health, Safety
GHG Emission Per Ton Laid Material

- Bituminous concrete
- Road base asphalt concrete
- High modulus asphalt concrete
- Warm mix asphalt concrete
- Emulsion bound aggregate
- Cold mix asphalt
- Cement-bound aggregate
- Cement-bound aggregate & "AU"
- Aggregate with hydraulic road binders & "AU"
- Aggregate with hydraulic road slabs without dowels
- Continuous reinforced concrete
- Untreated in-situ with lime + cement
- Thermorecycles with 0% RAP
- Concrete asphalt concrete with 10% RAP
- Concrete asphalt concrete with 20% RAP
- Concrete asphalt concrete with 30% RAP
- Concrete asphalt concrete with 50% RAP
- Emulsion in-situ recycling

GHG emissions (kg/t)
Energy Consumption Per Ton Laid Material

- **Laying**
- **Transport**
- **Manufacture**
- **Aggregates**
- **Binders**
REPAIR OF POT- HOLE

- Make rectangular shape
- Clean the pot- hole area
- Track coating the edge and area
- Prepare cold mix
- Charge the aggregate 11 mm down in concrete mixer
- Add 2 % Water and mix
- Add 5-6% emulsion & mix uniformly
- Pour mix in pot hole/depression
- Compact with road roller
PREPARATION OF COLD MIX FOR REPAIR
PROCESS OF REPAIR WITH COLD MIX

1. 19.03.08
   AIZAWL

2. 

3. 

4. 20.03.08
   AIZAWL
REPAIR DEMO IN MUMBAI (Jan. 9, 2012)
REPAIR DEMO IN AGARTALA (Feb. 5, 2012)
APPLICATION OF SLURRY SEAL ON

- DISTRESS ROADS- CRACKED
- VIP ROADS
What is Slurry Seal
The slurry seal shall consist of:

- cationic bitumen emulsion (SS-2)
- mineral aggregate
- water

Grading of Aggregates

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>% Passing (Minimum Layer Thickness)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Type I (2-3 mm)</td>
</tr>
<tr>
<td>9.5 mm</td>
<td></td>
</tr>
<tr>
<td>6.3 mm</td>
<td>100</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>100</td>
</tr>
<tr>
<td>2.36 mm</td>
<td>90-100</td>
</tr>
<tr>
<td>1.18 mm</td>
<td>65-90</td>
</tr>
<tr>
<td>600 micron</td>
<td>40-65</td>
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<tr>
<td>300 micron</td>
<td>25-42</td>
</tr>
<tr>
<td>150 micron</td>
<td>15-30</td>
</tr>
<tr>
<td>75 micron</td>
<td>10-20</td>
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</tbody>
</table>
APPLICATION OF SLURRY SEAL
PERFORMANCE OF SLURRY SEAL

6 MONTHS

6 MONTHS
Drafted Specifications for Development of Cold Mix Technology and under IRC consideration

- Proposed Tentative Specification For Semi-dense Bituminous Concrete Using Cationic Bitumen Emulsion
- Proposed Tentative Specification of Mix Seal Surfacing (Dense-Graded Premix Carpet) With Cationic Bitumen Emulsion
- Proposed Specification for Bituminous Macadam (Base & Binder Course) with Cationic Bitumen Emulsion
- Guidelines for Construction of Roads with Emulsion Based Cold Mix Technology
- Guidelines for Patch and Pot hole Repair with Emulsion Based Cold Mix Technology
THANK YOU