

Use of Cold Mix Technology in Construction and Maintenance of Roads Using Bitumen Emulsion

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Introduction

- ✓ **Flexible (bituminous) pavements constitute over 90% of the total road network including airfield pavements**
- ✓ **Hot mixed bituminous materials and mixes are generally used for the construction of base course, binder course and wearing course of flexible pavement**
- ✓ **The paving bitumen (VG-10, VG-20, VG-30 and VG-40; as per IS:73), is used as a bituminous binder**
- ✓ **Modified bitumen, cutback and bitumen emulsions are alternate binders**

Hot Mix Technologies - Overview

- ✓ Heating of binder at 165°C
- ✓ Heating of aggregates at 155°C for hot mix
- ✓ Production of hot mix at 150°C
- ✓ Laying of hot mix at 135°C
- ✓ Compaction of hot mix at 135°C

Disadvantages of hot mix technologies

- ✓ Noise and air pollution
- ✓ Emission of green house gases
- ✓ Compromise with the durability of bitumen due to aging
- ✓ High energy consumption
- ✓ Unsafe for maintenance crew

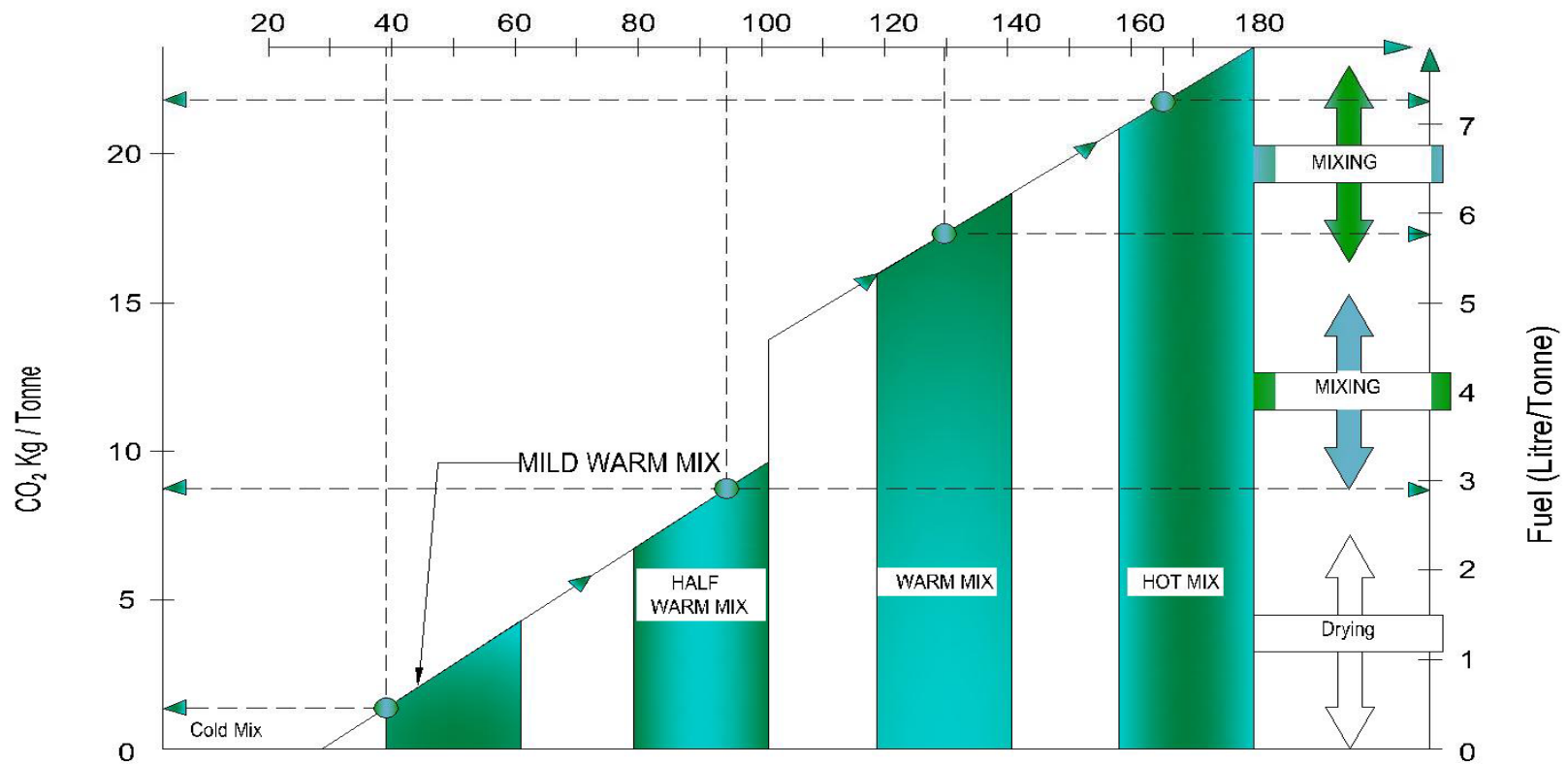


Technical Solutions

- ✓ **Cold mix technologies (mixes produced using unheated aggregate and cold emulsion binder)**
- ✓ **Mild warm mix technologies (mixes produced using mild warm aggregate and mild warm binder)**
- ✓ **Half warm mix technologies (mixes produced using half warm aggregate and warm binder)**
- ✓ **Warm mix technologies (mixes produced using partially heated aggregate and partially heated binder containing additive)**

Energy Input Chart

Energy Input and Emission Chart



Emulsion Based Technologies (IRC Guidelines)

Surface Treatment Including Preventive and Corrective Maintenance	Maintenance Including Periodic Treatments		Other Applications
	Cold Mixes	Half Warm and Mild Warm Mixes	
<ul style="list-style-type: none"> ➤ Fog Seal ➤ Sand Seal ➤ Slurry Seal ➤ Microsurfacing ➤ Cape Seal ➤ Chip Seal 	<ul style="list-style-type: none"> ➤ Patching ➤ Pothole Repair ➤ Cold Recycling ➤ Bituminous Macadam ➤ Premix Carpet ➤ Mix Seal Surfacing ➤ Semi-Dense Bituminous Concrete 	<ul style="list-style-type: none"> ➤ Semi-Dense Mixes ➤ Dense Mixes 	<ul style="list-style-type: none"> ➤ Prime Coat ➤ Tack Coat ➤ Crack Sealing ➤ Soil Stabilization

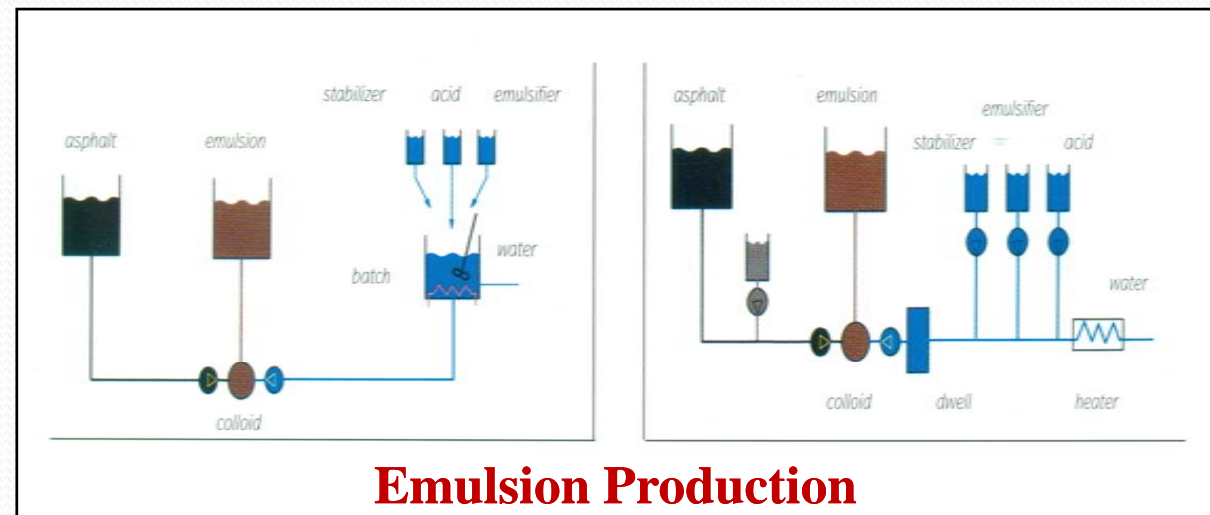
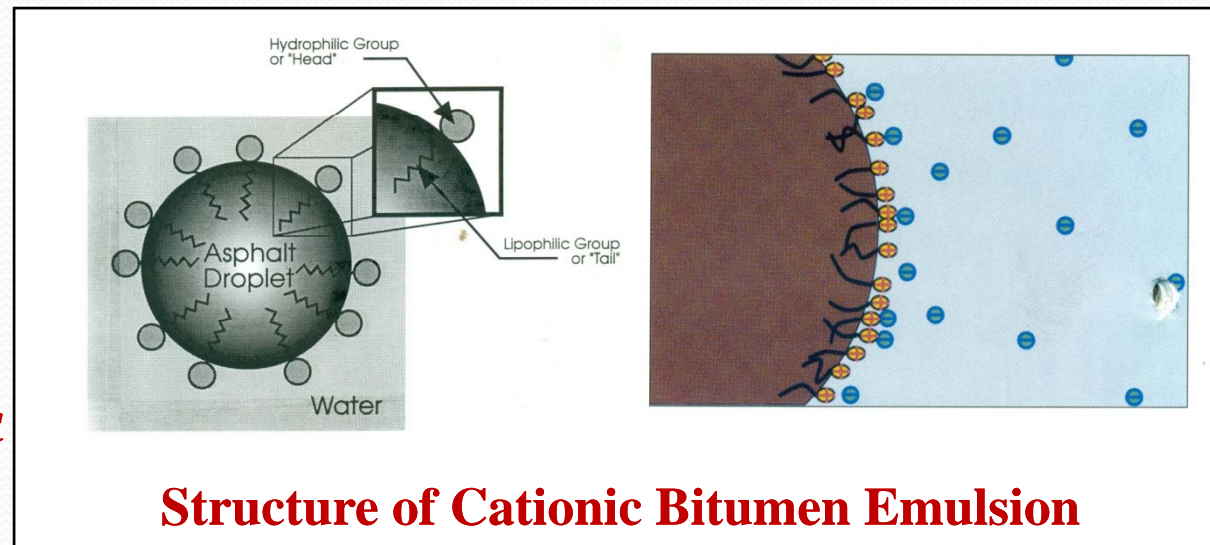
Bitumen Emulsion

An emulsion is defined as a mixture of two immiscible liquids, one of which is dispersed in the other in the form of very fine droplets. The process of emulsification is accomplished by the use of an emulsifier. A colloid mill is generally used for the preparation of an emulsion by dispersion of bitumen in water.

Bitumen emulsion is a heterogeneous two phase systems consisting of two immiscible liquids such as bitumen and water. Bitumen is dispersed throughout the continuous water phase in the form of discrete globules, typically 0.1 micron to 50 micron in diameter, which are held in suspension by electrostatic charges stabilised by an emulsifier

Production and Handling of Bitumen Emulsion

- ✓ Bitumen
- ✓ Water
- ✓ Emulsifier
- ✓ Acid or Caustic
- ✓ Polymers
- ✓ Solvents
- ✓ Additives
- ✓ Stabilizers
- ✓ Buffers



Advantages of bitumen emulsion in road construction

- ✓ **Cold application**
- ✓ **Eliminates heating**
- ✓ **Environment friendly technology**
- ✓ **Energy conservation due to elimination of heating**
- ✓ **Coats damp aggregates**
- ✓ **Non polluting process**
- ✓ **Construction in all weathers**
- ✓ **contains anti-stripping agents**
- ✓ **Lesser manpower**
- ✓ **Increased work year**

Recommended Uses for Different Types of Emulsion

Type	Recommended Uses
RS-1	A quick setting emulsion used for tack coat
RS-2	A quick setting emulsion used for Surface treatment, Surface dressing, Penetration Macadam, Penetration Grouting
MS	A medium setting emulsion used for plant or road mixes with coarse aggregate for premix carpet and surface dressing
SS-1	A slow setting emulsion used for priming
SS-2	A slow setting emulsion used for plant mixes with graded fine aggregate in SDBC, MSS, BM, DBM and BC. This emulsion is also used for slurry seal treatment and tack coat
Modified	Modified emulsion is used for microsurfacing

Cold Mixed Open Graded Premix Carpet

S. No.	Premix Carpet	
(a)	Coarse aggregate of nominal 13.2 mm size: passing IS 22.4 mm sieve and retained on IS 11.2 mm sieve	0.18 m ³
(b)	Coarse aggregate of nominal 11.2 mm size; passing IS 13.2 mm sieve and retained on IS 5.6 mm sieve	0.09 m ³

(A)	For Premix Carpet (MS)	20 to 23 kg
(B)	For Seal Coat	
(i)	For Liquid seal coat (RS-2)	12 to 14 kg
(ii)	For Premix seal coat (SS-2)	10 to 12 kg

Preparation of Cold Mix (OGPC)

- ✓ Charge 13.2 mm and 9.5 mm size aggregates in 2:1 ratio in a concrete mixer
- ✓ Add optimum water content about 2 % by wt. of aggregate
- ✓ Add bitumen emulsion of medium setting (M.S.) @ 5% by wt. of aggregates
- ✓ Mix for uniform coating of aggregate
- ✓ Mixing beyond 2 minutes to be avoided



Transportation of cold mix

- ✓ Cold mix discharged in trolleys/wheel barrow
- ✓ Cold mix transported to site by wheel barrow
- ✓ Avoid newly laid surface or tacky road surface while ferrying

Spreading of cold mix

- ✓ Spread cold mix in half the road-width
- ✓ Required thickness with spreader
- ✓ Cold mix turned black from brown
- ✓ Cold mix aerated for about 2 hours



Compaction

- ✓ Compacted with 8-10 ton road roller
- ✓ Wetting of wheels



Sand seal coat

- ✓ Cold mix of fine aggregates mixture with emulsion (SS)
- ✓ Spread the mix on open graded surface
- ✓ Compact with 8-10 tonne roller

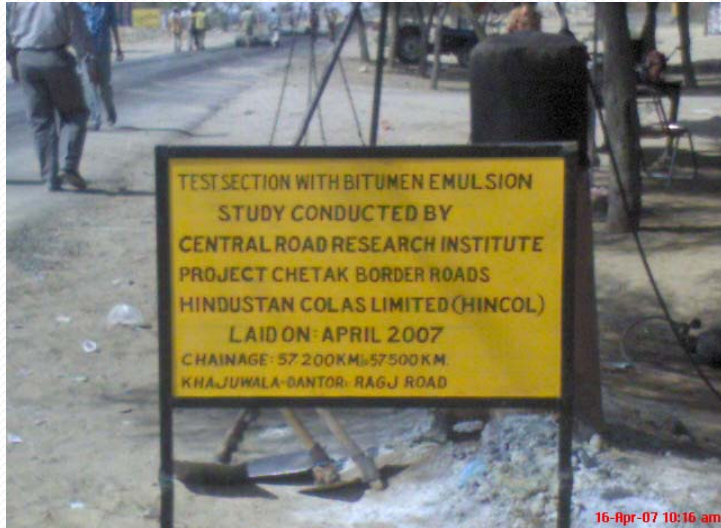
Liquid seal coat

- ✓ Tack coat with emulsion (RS Grade) @ 12-13kg / 10 m²
- ✓ Aggregates 6.3 mm(passing)- 180 micron (Retained)
- ✓ Compact with 8-10 tonne road roller



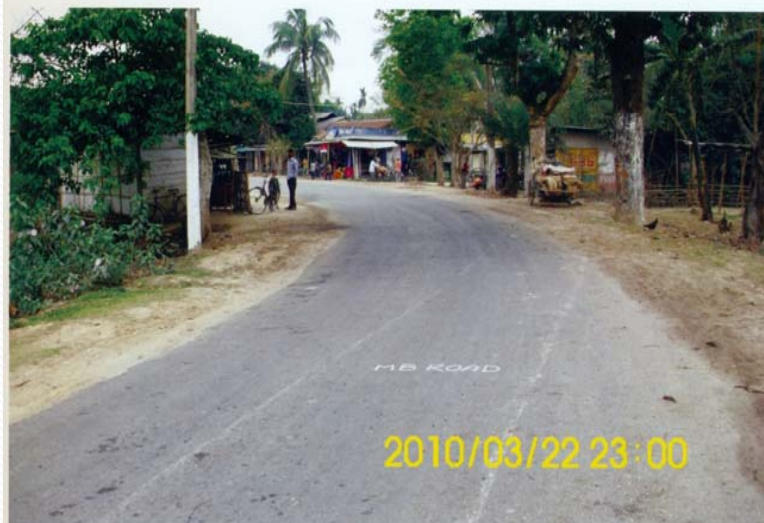


Laying & Compaction of Cold Mix



Performance of Rural Roads with Cold Mix Technologies

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



(PHOTOGRAPHS OF M.B. ROAD)



Performance of Rural Roads with Cold Mix Technologies

(PHOTOGRAPHS OF M.B. ROAD)



(PHOTOGRAPHS OF M.B. ROAD)



Performance of Rural Roads with Cold Mix Technologies

(PATKATA KAJAJAN ROAD, NALBARI)



(PATKATA KAJAJAN ROAD, NALBARI)



Performance of Rural Roads with Cold Mix Technologies

(Rajmai to Rajabari Road, Sibsagar, Assam)



(Rajmai to Rajabari Road, Sibsagar, Assam)



Performance of Rural Roads with Cold Mix Technologies

(Koibarta Village to Maloibari , Maloipathar, Jorhat)



(Koibarta Village to Maloibari , Maloipathar, Jorhat)



Performance of Rural Roads with Cold Mix Technologies

(NH-52 to RAJKHOWAPARA , BEJERA , KAMRUP, ASSAM)



(NH-52 to RAJKHOWAPARA , BEJERA , KAMRUP, ASSAM)



Performance of Rural Roads with Cold Mix Technologies

(NH-52 to RAJKHOWAPARA , BEJERA , KAMRUP, ASSAM)



(NH-52 to RAJKHOWAPARA , BEJERA , KAMRUP, ASSAM)



Performance of Rural Roads with Cold Mix Technologies

(Bongshor to Suwalkushi Road, Suwalkushi, kamrup, Assam)



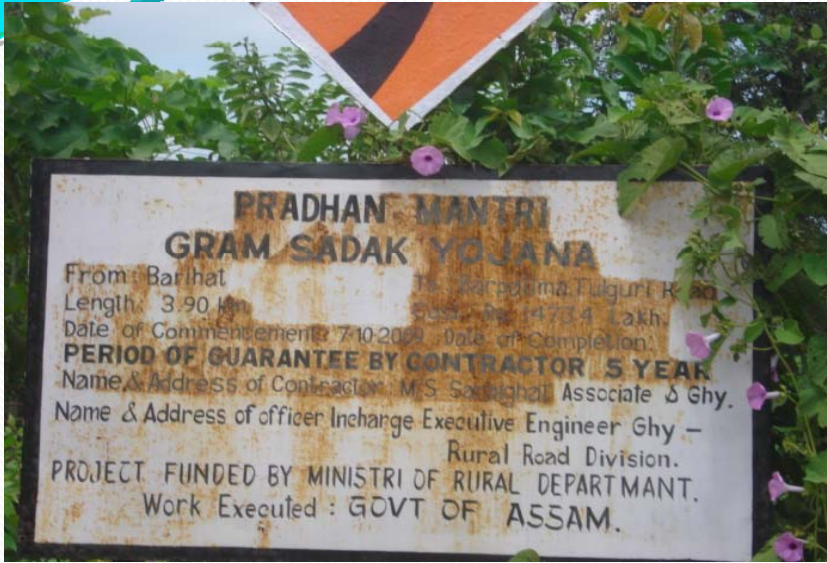
(Bongshor to Suwalkushi Road, Suwalkushi, kamrup, Assam)



2 yrs old road PMGSY package No – As -01-62



3 yrs old road location : Mirza, Kamrup



Cold Mixed Bituminous Macadam (CMBM)

Bituminous Macadam (BM) is a graded bituminous mixture suitable for moderate traffic roads used for construction of bituminous base course as well as for strengthening of flexible pavements

Cold Mixed Bituminous Macadam(CMBM) shall involve construction of one or more courses of 50mm thick compacted mixture prepared with bitumen emulsion and mineral aggregate, laid immediately after mixing to required grade and camber using appropriate machinery

Recommended emulsion is SS-2 grade (IS: 8887)

Grading of Aggregates for Compacted Thickness of 50 mm CMBM

Sieve size, mm	Percent passing by weight
26.5	100
19.0	90-100
13.2	56-88
9.5	20-55
4.75	16-36
2.36	4-19
0.30	2-10
0.075	1 - 4
Sand Equivalent Value (ASTM D2419)	50 Minimum
Percent Crushed Faces	75% Minimum
Bitumen Emulsion (SS2) % by Weight of Mix	5% Minimum

Cold Mixed Semi Dense Bituminous Concrete (CMSDBC)

Semi dense bituminous concrete (SDBC) is a continuously graded mix, which can be used as binder course or wearing course in a flexible pavement. This section deals with the design and construction of 40 mm thick Cold Mixed SDBC using cationic bitumen emulsion. Recommended Emulsion is SS-2

Mixture Design of CM BM

(i)	Number of compaction blows on each side of Marshall specimen	50
(ii)	Marshall Stability at 25°C in kg (minimum), after curing the specimen in air and at 40°C for 3 days	350
(iii)	Marshall flow (mm) at 25°C	Max. 8
(iv)	Per cent voids in mixture	10 - 14
(v)	Binder content (residual bitumen) by weight of total mix (%),min	3.5
(vi)	Retained indirect tensile strength at 25°C after conditioning for 48 hours at 40 °C, %	50

Gradation of Aggregate in CMSDBC

Sieve Size (mm)	Percent Passing by Weight
13.2	100
9.5	90-100
4.75	35 -51
2.36	24-39
1.18	15-30
0.300	9-19
0.075	2-8
Sand Equivalent Value (ASTM D2419)	50 Min.
Percent Crushed Faces	75 Min.
Bitumen Emulsion(SS-2 or tailor made) by Weight of Mix	8-10%

Requirements of Cold Mixed SDBC

(i)	Number of compaction blows on each side of Marshall specimen	50
(ii)	Marshall Stability at 25°C in kg (minimum), after curing the specimen at 50°C for 3 days	500
(iii)	Marshall flow (mm)	Max. 8
(iv)	Per cent voids in mixture	6 – 10
(v)	Binder content (residual bitumen) by weight of total mix (%),min	4.5
(vi)	Retained indirect tensile strength at 25°C after conditioning for 48 hours at 40 °C, %	75

Comparative cost of bituminous surfacing with emulsion and bitumen

S. No.	Specification	Thickness, mm	Binder	Cost / m ² , Rs.
1	SDBC	25	Bitumen	254
2	SDBC	25	Emulsion	276
3	OGPC	20	Bitumen	155
4	OGPC	20	Emulsion	160
5	CMBM	50	Emulsion	350
6	BM	50	Bitumen	325

Production of cold mixes with HMP



Adding Pre-mix Water



**Adding Emulsion in Drum
Mixer**



Cold Mix on Conveyer Belt



Discharge of Cold Mix to Dumper



Production of cold mix for SDBC



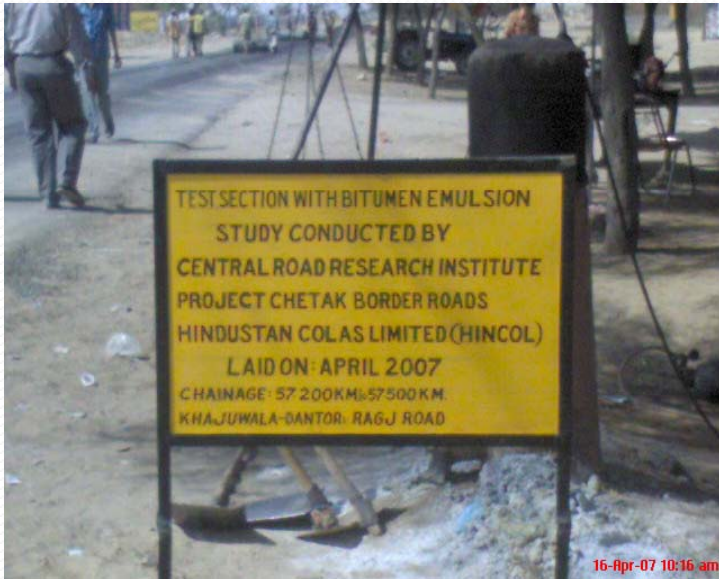
Laying of cold BM with emulsion at Aizawl



Compacting cold mixed SDBC



A 5 year old Surface of cold BM +SDBC



16-Apr-07 10:16 am





Workshop on Non-conventional Materials/Technologies- 18.02.2012



Half Warm Mixes Using Bitumen Emulsion

Half warm mixes are those mixes in which the bituminous binder is either a bitumen emulsion or foamed bitumen, which is manufactured and mixed with warm aggregates (100 ± 10 °C), laid and compacted a temperature between 75 – 85 °C.

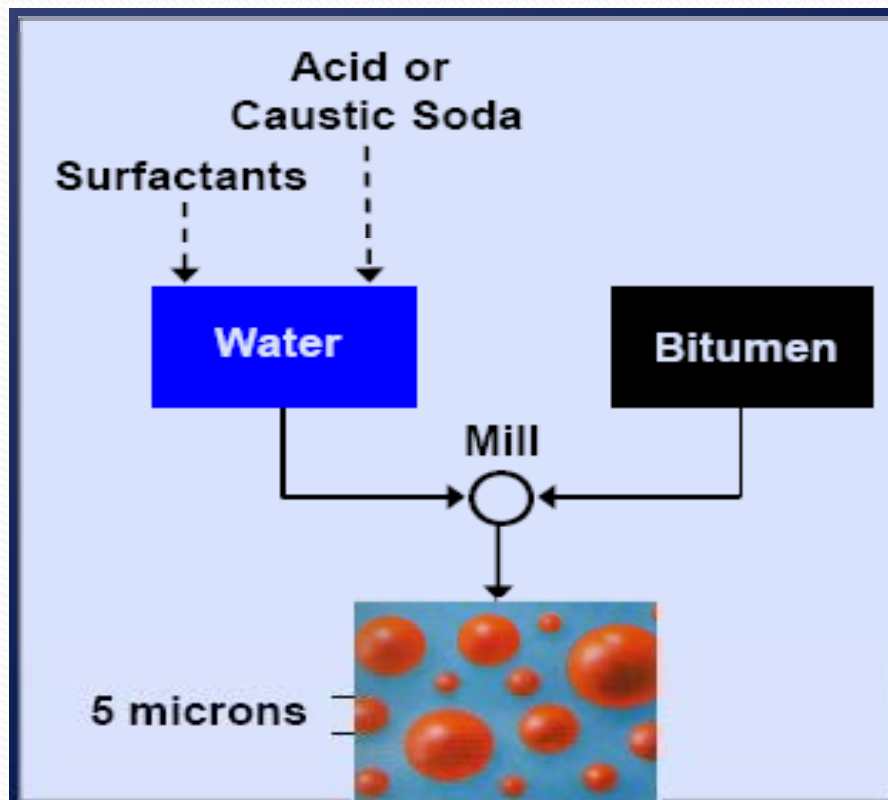
Requirements of the warm mix prepared with bitumen emulsion

(i)	Number of compaction blows on each side of Marshall Specimen	75
(ii)	Marshall Stability at 60°C in kg (minimum), after curing the Marshall Specimen for 24 h	900
(iii)	Marshall flow (mm)	Max. 5
(iv)	Per cent Voids in Mix	3 – 6
(v)	Binder content (Residual Bitumen) by weight of total mix (%),min	4.5
(vi)	Retained Marshall Stability, ratio	80

BINDERS

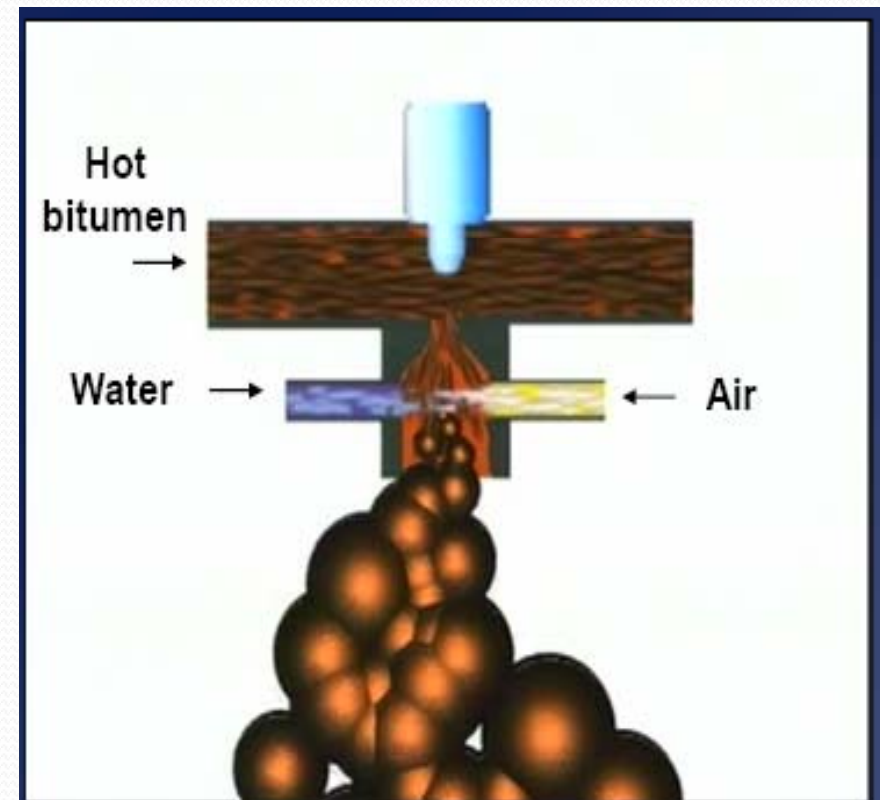
BITUMEN EMULSION

Colloidal Mill



FOAMED BITUMEN

Expansion Chamber



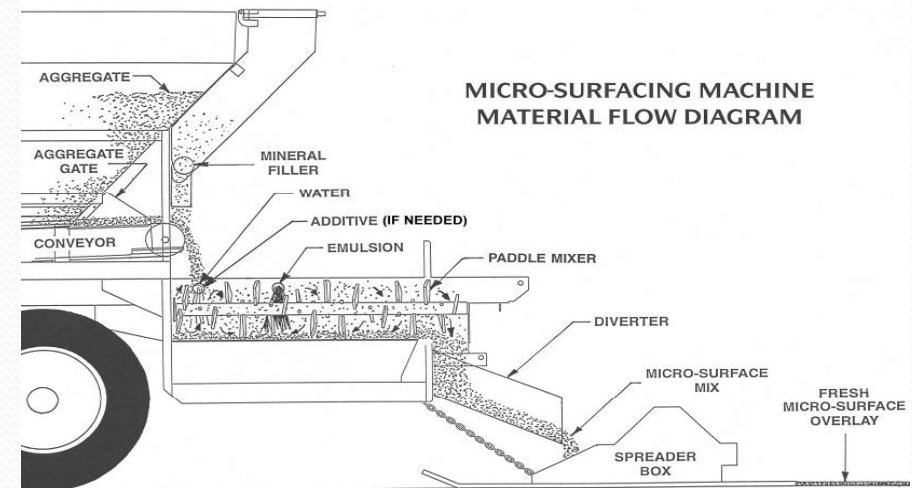


- ✓ **Half warm bituminous mixtures are manufactured using cationic bitumen emulsion and have properties identical to hot bituminous mixture**
- ✓ **Performance properties like rutting resistance, indirect tensile strength ratio, resilient modulus and static creep test results are acceptable.**

- ✓ The half warm bituminous mixture appears to have good coating, and workability at a temperature of 80 -90 °C
- ✓ Half warm bituminous mixture can be manufactured and laid with conventional construction equipments
- ✓ The energy saving due to reduced fuel consumption is high
- ✓ Half warm bituminous mix can be stored if laying is not feasible due to adverse weather
- ✓ Paving window is wider and reduces global warming

Microsurfacing for Maintenance of Roads

- ✓ A mixture consisting of :
- Dense-graded crushed aggregates
 - Polymer / latex modified bitumen emulsion
 - Water
 - Mineral filler (cement)
 - Chemical additive



✓ cold slurry paving system

Advantages of Microsurfacing

- ✓ Dose not increase the pavement height (an advantage for city roads)
- ✓ Does not require heating of mix and compaction
- ✓ Does not affect the environment as well as human health
- ✓ Does not require too excessive manpower, machinery and equipments.
- ✓ Can be constructed during day and even night time
- ✓ Faster construction

Roads Laid with Microsurfacing in Delhi



Brigadiar Hoshiar Singh Marg
(DBM + Microsurfacing) , March 2007



Janpath
(Double Microsurfacing) , June'07



Rajaji Marg
(SDBC + Microsurfacing) , Jan'08



Kamal Attaurk Marg
(Single Microsurfacing) , March'09

Reduction of Greenhouse Gas Emissions and Energy Consumption

Treatments	Environmental Effects			
	Energy (MJ)	CO ₂ (ton)	NO _x (kg)	SO _x (kg)
Milling 50mm and Paving 50mm Recycled Hot Mix	369,79,237	1918	16,821	5,24,944
Milling 50mm and Paving 50mm with Warm Mix Asphalt	261,79,936	1096	8821	3,67,532
50mm Hot In-place Recycled mix	310,62,559	1479	13,095	4,09,447
10 mm Microsurfacing	30,92,958	110	2466	1,07,937

Comparison of Hot Mix and Cold Mix Technology

Item	Microsurfacing	Hot Mixed Bituminous Concrete
Noise Level	Low	High
Production of Toxic Fumes	None	High
Dust	Low	High
Worker Hazard	None	High
Energy Consumption	Low	High
Ease of Application	Very Easy	Not so
Ability to Resist Weathering	High	Low
Flexibility of Product	High	Low
Ability to Apply in Damp Condition	Yes	No
Thickness of Layer	4-16 mm	25-50 mm
Cost per m²	Rs. 140-175	Rs. 250-300
Life Time Expectancy	3-5 Years	4-6 Years

Sustainable repair of potholes and patching

- ✓ Potholes are bowl shaped formation
- ✓ Grow wider and deeper, if not attended
- ✓ Potholes on the road is a matter of critics
- ✓ Cause of accidents on road
- ✓ People dies falling in deep potholes
- ✓ Cost of repair high with passage of time
- ✓ Repair by hot mix emit fumes
- ✓ Repairs do not last long

Sustainable repair techniques

- ✓ Infrared recycling patcher
- ✓ Cold mixes jet patcher
- ✓ Stock piled cold mix using cut back
- ✓ Ready to use patching mixes
- ✓ Emulsion based cold mixes
- ✓ Freshly prepared cold mixes

A view of Pothole



Infrared Recycling Patcher

Surface with pothole and raveling



Preparation of fresh mix



Heating of existing surface



Compacted surface by plate vibrator



A view of Jetpatcher



Surface repaired by Jetpatcher



Cold mix in rectangular raveled surface



Potholes repaired by ready mix



Ready to Use Cold Patching Mixes

- ✓ **Quality of mix is consistent and uniform**
- ✓ **Needs little time for application at sites**
- ✓ **Needs very less manpower during execution**
- ✓ **Reparation of surface for repairs is minimal**
- ✓ **Repair is possible in all adverse climatic conditions**
- ✓ **Zero wastage of material during execution**
- ✓ **Repair does not cause any health and environmental hazard**

Porthole Repair by Jet Patcher



Choice/Selection of Cold Mix Treatments for Different Climate/ Traffic Conditions (Warrants)

Title of Treatment	Traffic (CVPD)	Climate		Choice of Emulsion
		Temperature	Rainfall	
Prime Coat	No Limit	No Limit	No Limit	SS-1
Tack Coat	No Limit	No Limit	No Limit	RS-1
Seal Coat	<1500	No Limit	No Limit	SS-2
Sand Seal	<1500	No Limit	No Limit	SS-2
Cap Seal	<3000	No Limit	No Limit	RS-2 , SS-2 and Modified
Chip Seal	<1500	Avoid in Cold Climate	No Limit	RS-2, Modified
Slurry Seal	<1500	No Limit	No Limit	SS-2
Microsurfacing	No Limit	No Limit	No Limit	Modified
OGPC	<1500	Moderate & cold climate	Medium	MS /SS-2
MSS	<1500	Moderate & cold climate	Low	MS /SS-2

BM	<1500	Moderate & cold climate	Low	MS/SS-2/ Tailor Made
SDBC	<3000	Moderate & cold climate	Low	SS-2/ Tailor Made
Half Warm Mix (DBM. SDBC. BC)	<4500	Moderate & cold climate	No limit	SS-2/ Tailor Made
Cold Recycling	<4500	Moderate & cold climate	No limit	SS-2/ Tailor Made
Patching	No Limit	No Limit	No limit	MS/SS-2/ Tailor Made

Safer construction and good health using cold mix technologies

THANK YOU