Bitumen Emulsion Based Low Energy Mild Warm Mixes for Maintenance of Roads

Presentation by:
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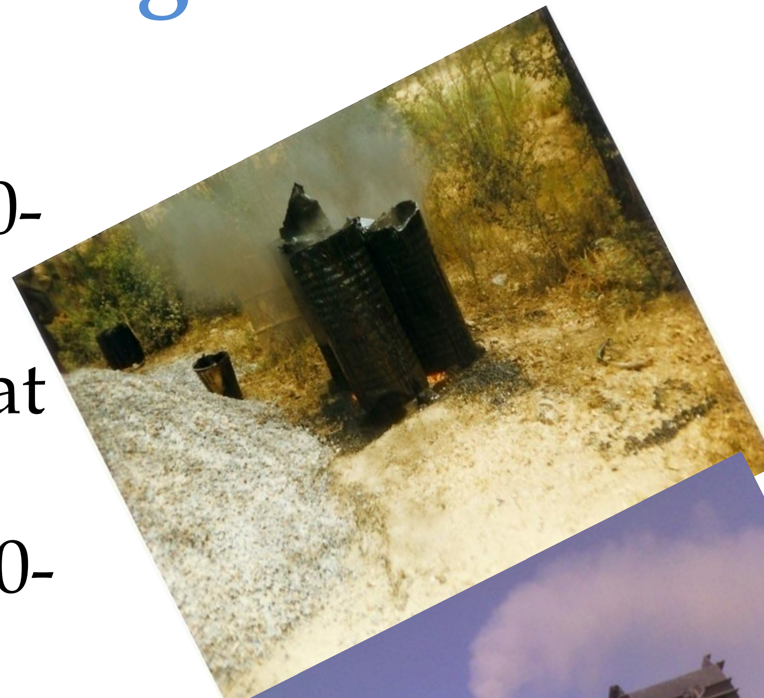
Indian Road Transport Scenario

- Road transport is in great demand
- Second largest road network in the world with more than 4.7 million road kilometers
- To meet the increasing demands, road construction activity is at its all time high
- Focus is on connectivity of villages and development of rural roads
- Need of green and pollution free roads

Hot Mix Technologies-Shortfalls

- Heating of binder at 160-170°C
- Heating of aggregates at 155-170°C
- Production of mix at 150-160°C
- Environmental pollution
- High energy consumption
- Harmful to health of construction of workers



Solution: Low Energy Asphalt Mixes

A way out to reduce the amount of energy required to manufacture hot mix asphalt (HMA) in order to combine both energy savings and environmental benefits.

Advantages:

1. Reduce energy consumption.
2. Reduce Green House Gas Emissions.
3. Equal or improved mix performance.
4. Minimize equipment costs/plant modifications.
5. Labor friendly.

Low Energy Asphalt Mixes

- **Warm Mixes (120-130^{0}C)**
  - Using partially heated aggregate and partially heated binder containing additive
- **Half Warm Mixes (80-900C)**
  - Using half warm aggregate and warm binder
- **Cold Mix (Ambient Temperature)**
  - Using unheated aggregate and cold emulsion binder
  - Foaming Process

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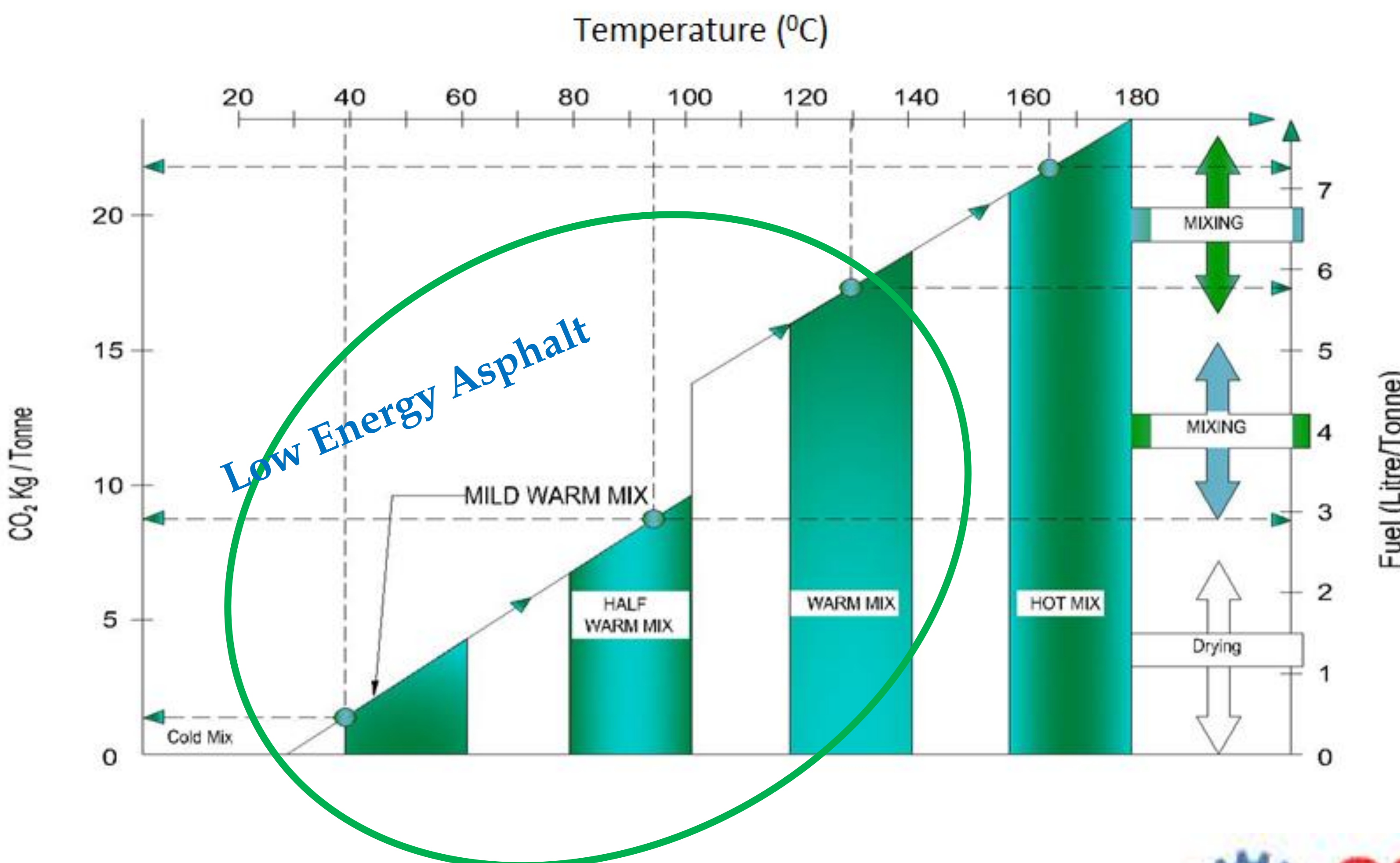
Objectives

- Introduction of Mild Warm Asphalt Mix (MWMA)
- A comparative study of the performance of Cold Mix Asphalt (CMA), Mild Warm Mix Asphalt (MWMA) and Half Warm Mix Asphalt (HWMA) for roads using Bitumen Emulsion

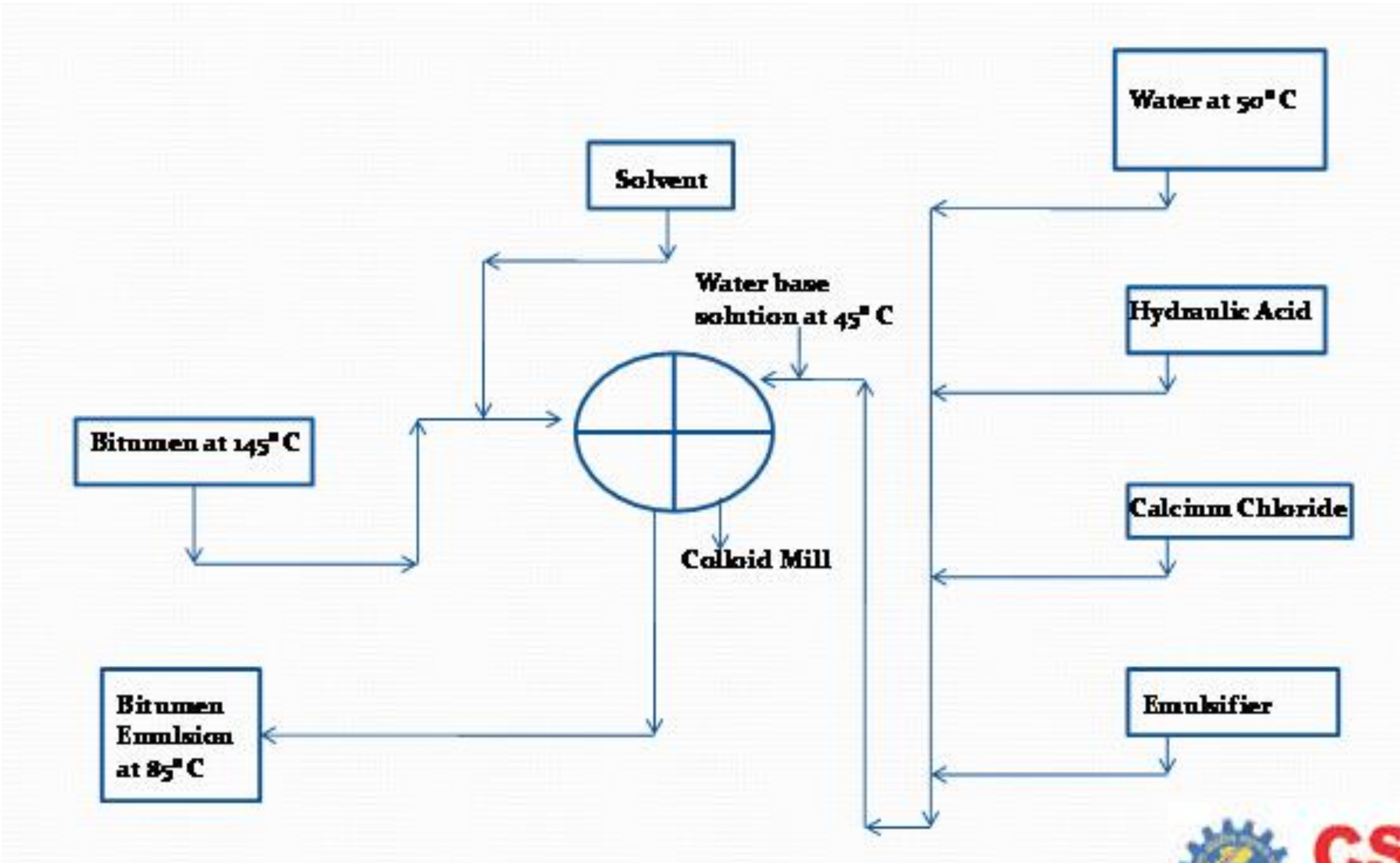
Energy and Emission Chart



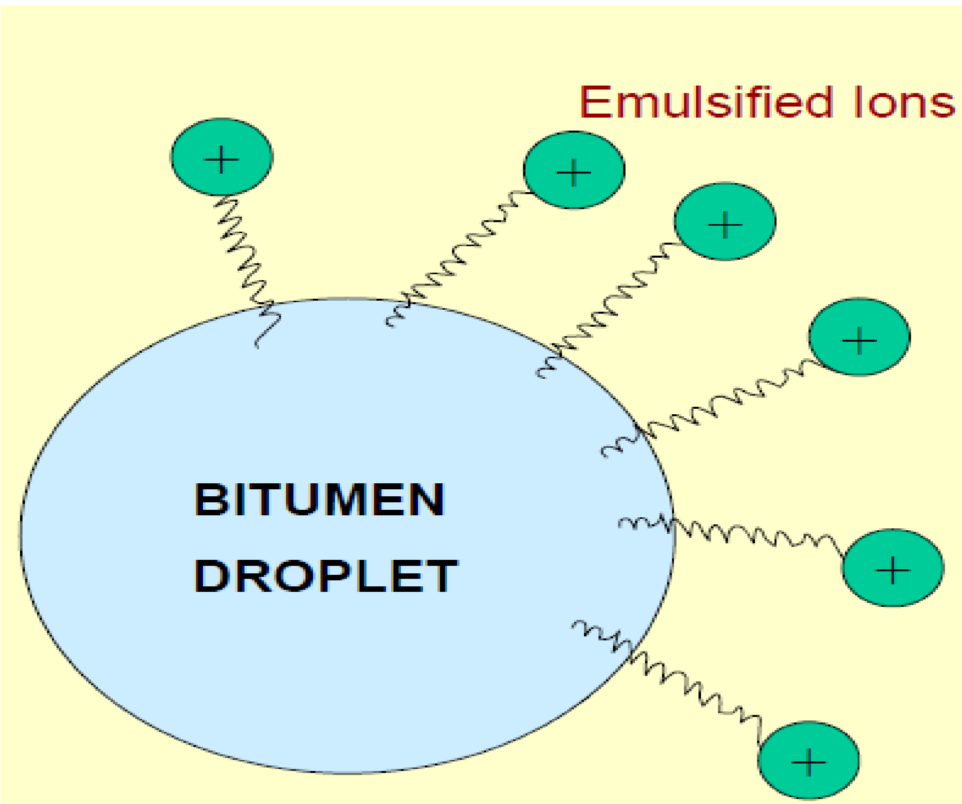
Bitumen emulsion

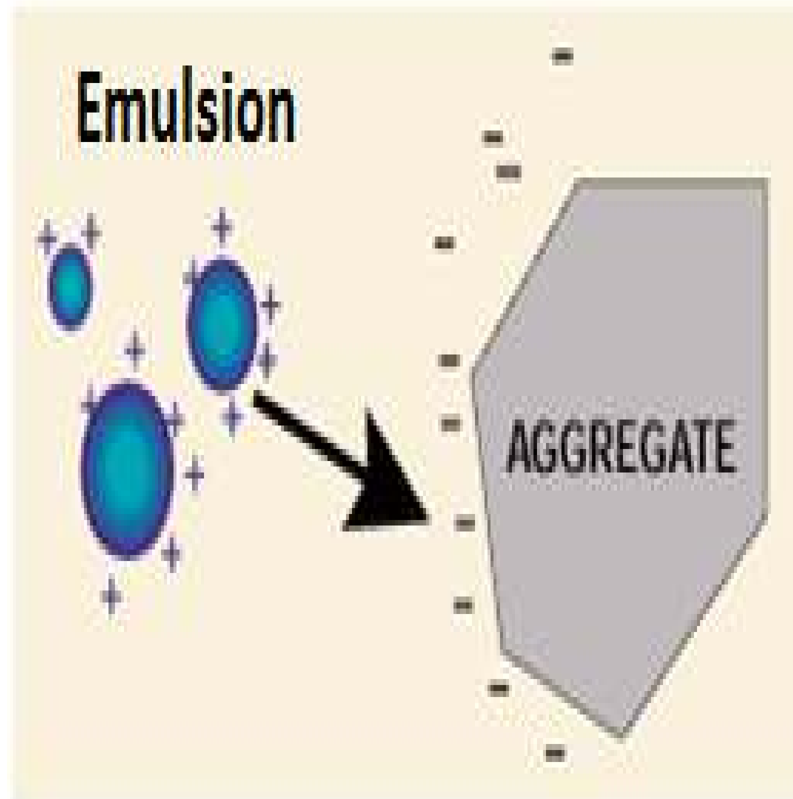
An emulsion a mixture of two immiscible liquids, one of which is dispersed in the other in the form of very fine droplets, using an emulsifier.

Manufacturing of Emulsion



Mechanism of Interaction of Aggregate and Emulsion





Bitumen Emulsion (SS2) Properties

S.No	Characteristics	Test Results	Recommend values as per IS: 8887-2004
1.	Viscosity by sayboltfurol viscometer, seconds at 25°C	67	30-150
2.	Storage stability after 24h, percent, Max.	1.4	2
3.	Residue by Evaporation percent, Min.	64	60
4.	Ductility, 25°C/cm, Min.	70+	50
5.	Penetration, 25o C/100g/5sec	91	60-120
6.	Particle Charge	Positive	Positive

Aggregate Properties

Properties Tested	Test Method	Test Results	MoRTH, 2012 Specifications
Aggregate Impact Value	IS 2386 (Part IV)	8.0372 %	30% max
Combined (EI + FI) Index	IS 2386 (Part I)	24.8 %	30% max
Water Absorption	IS 2386 (Part III)	0.70 %	2% max
Specific Gravity	IS 2386 (Part II)	2.785	-
Stripping	IS :6241	95 % retained coating	> 95 % retained coating

Gradation of Aggregate in Dense Bituminous Macadam Mixtures

Sieve Size mm	% Passing	
	Grading of blend	Specified Grading
37.5	100	100
26.5	100	90-100
19	83	71-95
13.2	68	56-80
4.75	46	38-54
2.36	36	28-44
0.3	14	7-21
0.075	5	2-8

Mix Design of Bituminous Emulsion Mix

(a)Aggregate form site

(b) Required grade of emulsion is added

(c) Cold mix is prepared

(d) Cold mix is kept in tray

(e) determination of breaking time, coating and setting time

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Low Energy Mixtures with Bitumen Emulsion

Mixing temperature of different aggregate

Type of Mix	Temperature (^{0}C)			
	Aggregate	Emulsion	Water	Mix
CMA	25	25	25	25
MWMA	70	60	60	50
HWMA	110	60	60	90

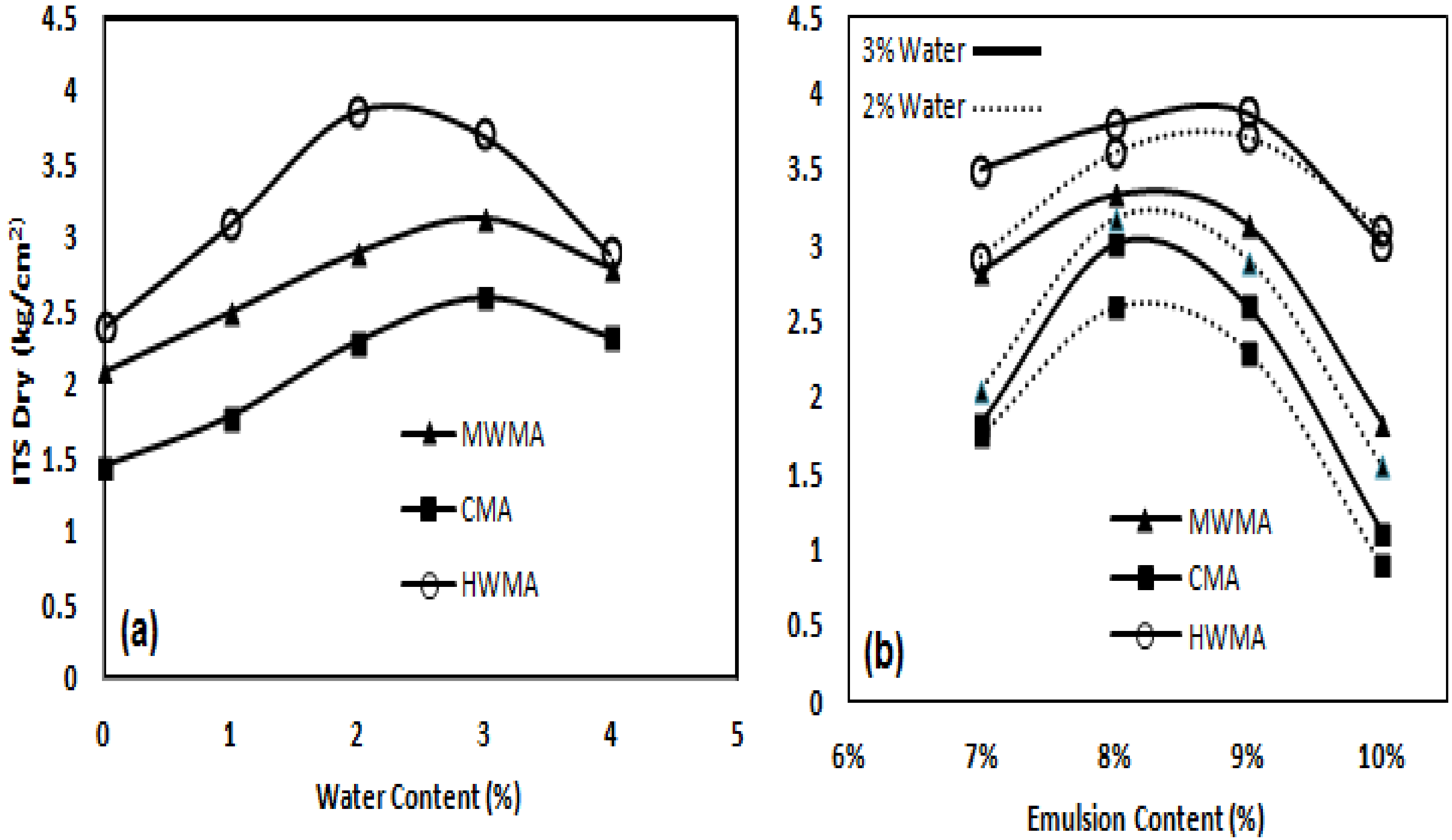
Minimum Emulsion Content

$$P = [(0.05 \times A) + (0.1 \times B) + (0.5 \times C)] \times 0.7$$

P = The approximate total bitumen demand
A =The percent of mineral aggregate retained on 2.36 mm sieve
B =The percent of mineral aggregate passing the 2.36 mm sieve and retained on the 75µ sieve
C =The percent of mineral aggregate passing on 75µ sieve

Optimum Water Content (From Dry ITS)
Optimum Emulsion Content (From Dry ITS)

Optimum Water and Emulsion Content



Optimization of CMA, MWMA & HWMA (a) Effect of mixing water on ITS (b) Effect of mixing emulsion on ITS

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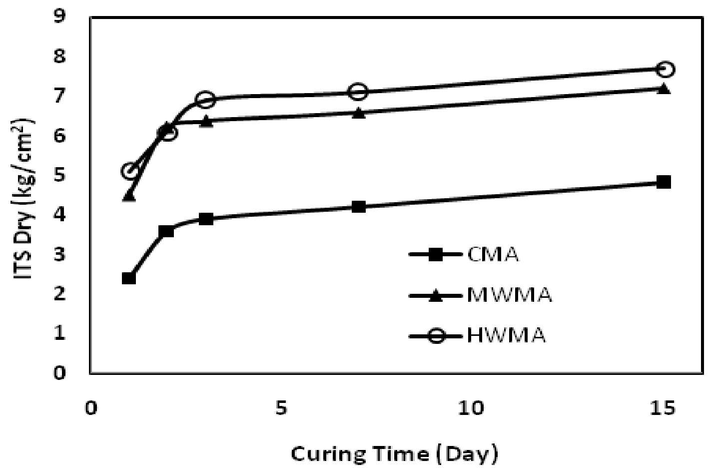
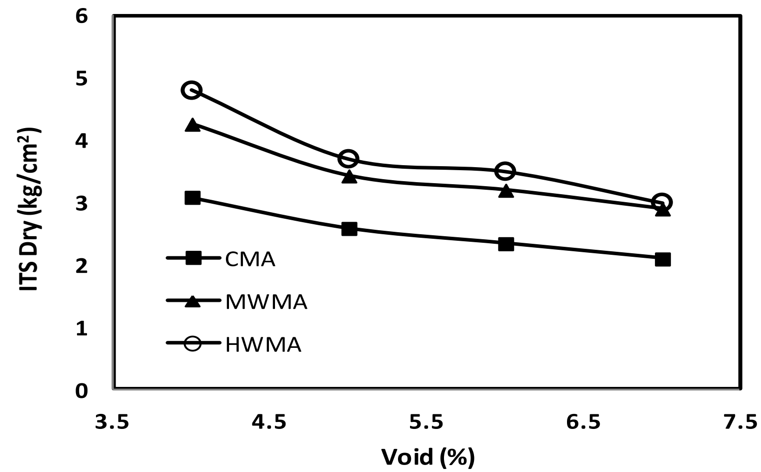
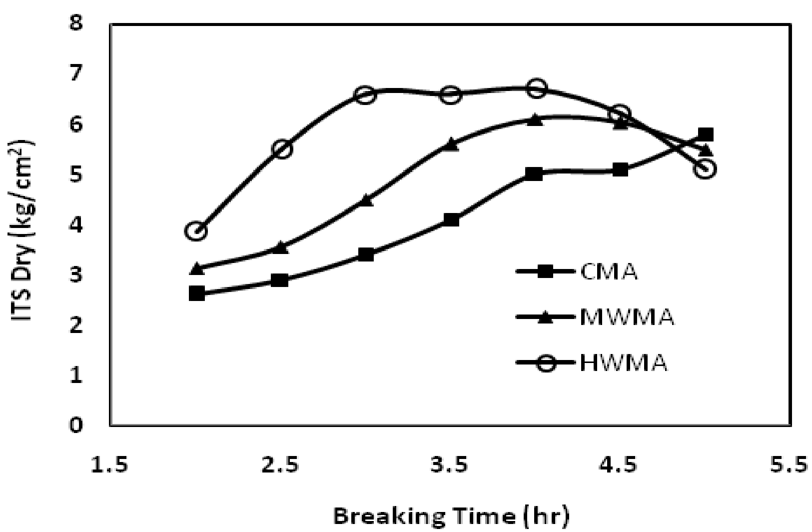
Optimization of Mixture



Variation of ITS values with respect to Curing time.



Variation of ITS values with respect to Void



Variation of ITS values with respect to breaking time.

Optimum Condition:

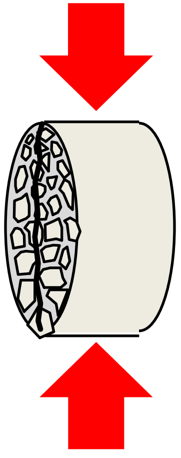
- 2.5% Water
- 8.5% Emulsion
- 3 Day Curing
- 4 hr Breaking time
- 5% Void

Performance Testing

PARAMETER	LAB TEST	TEST METHOD
Moisture Susceptibility	Tensile Strength Ratio	ASTM D 4867
Deformation Resistance	Dynamic Creep Test	NCHRP 9-19
	Wheel-Tracking Test	AASHTO T 324
Fatigue Life	Flexural Test	AASHTO T 321
Stiffness	Indirect Tension Test for Resilient Modulus	ASTM D 7369

Moisture Susceptibility: TSR

$$TSR = \frac{\text{Avg. wet tensile strength}}{\text{Avg. dry tensile strength}}$$



Tensile Strength Ratio

Mix.	Dry ITS (kg/sq.cm)	Wet ITS (kg/sq.cm)	Tensile Strength Ratio (%)
CMA	5.03	4.02	80.96
MWMA	6.37	5.76	93.18
HWMA	6.90	6.45	93.02

Resilient Modulus (MR) Testing

- The elastic modulus based on the recoverable strain under repeated loads is called the **Resilient Modulus**.
- Resilient modulus correlates stress-strain for rapidly applied loads – like those experienced by pavements.
- Measure of stiffness.
- **Test Parameters**

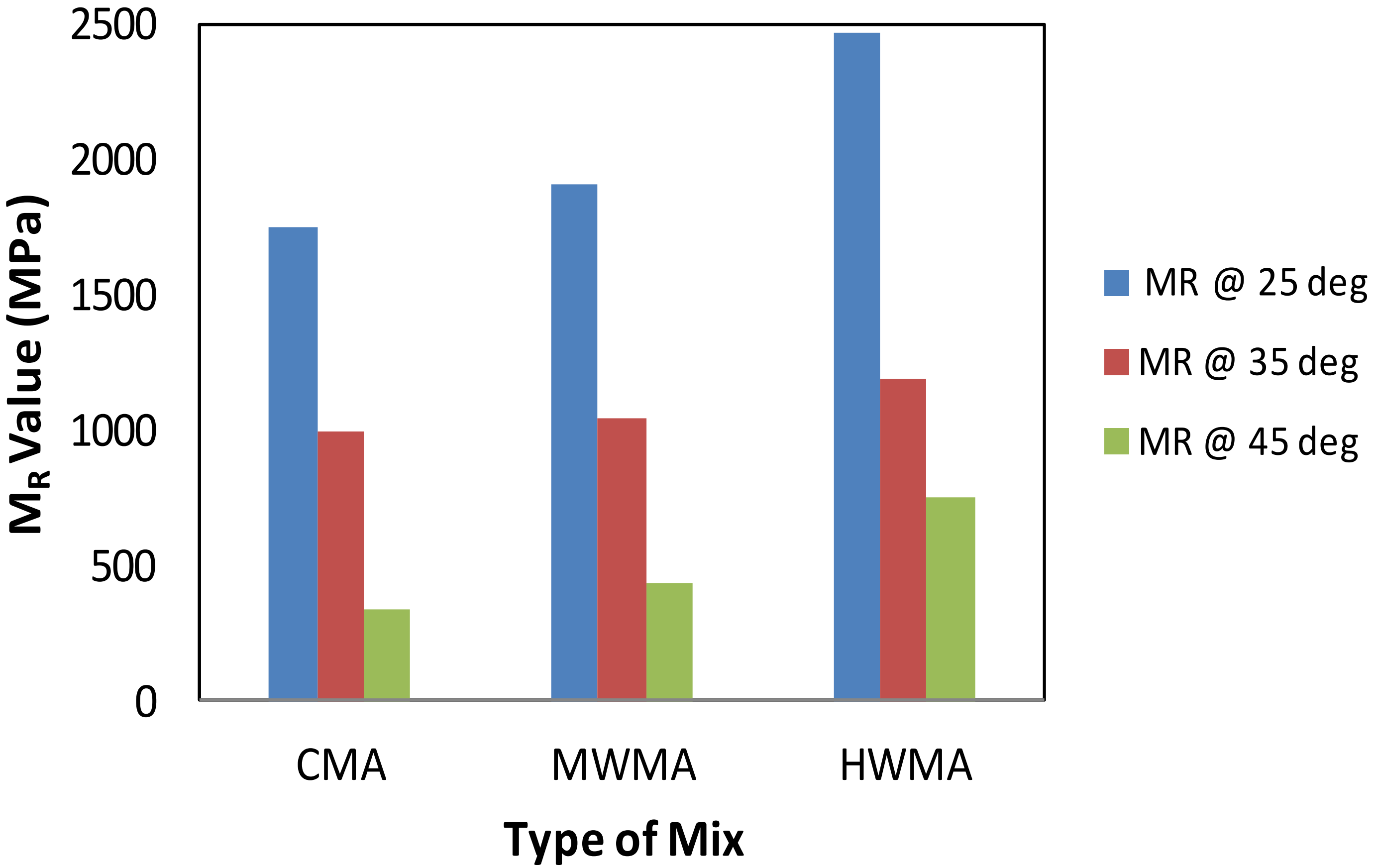
Type of Load Pulse = Haversine

Pulse Width = 250 msec

Pulse Repetition Period = 3000 msec

Peak Load Produced = 1000 N

Resilient Modulus

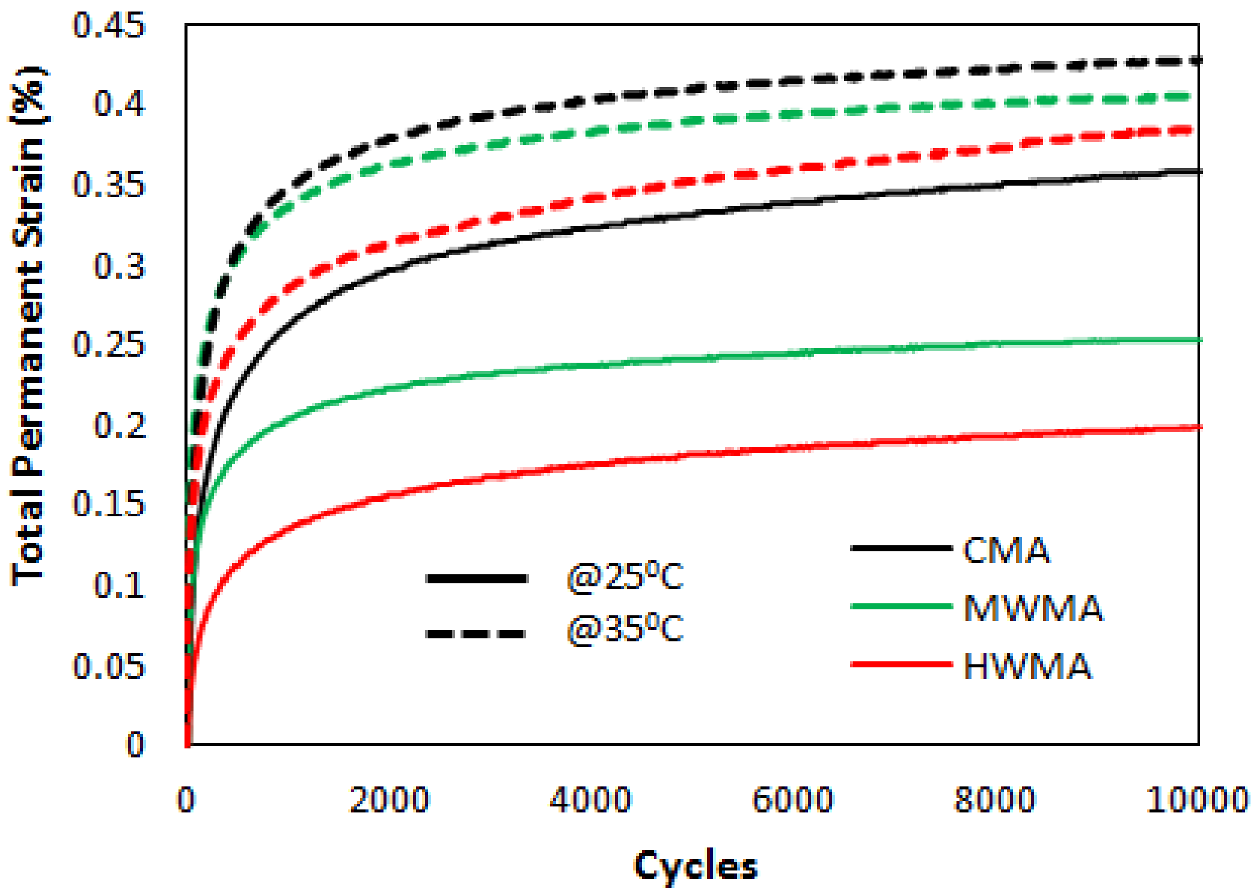


Dynamic Creep Test

- Property that describes visco-elastic materials.
- Creep testing is a simple version of a controlled stress test.
- The total permanent strain - indicator for the resistance to rutting.
- Test Parameters

Loading function	Haversine
Cyclic stress (kPa)	69
Seating stress (kPa)	11
Load cycle width (ms)	100
Load cycle repeat time (ms)	1000

Dynamic Creep Test



Flexural Test

- Fatigue cracking is one of the key reason of distress/ failure.
- An accurate prediction of fatigue properties would be useful in predicting overall pavement life.
- Beam dimensions - 400 mm long x 50 mm thick x 63 mm wide
- Constant strain – 300 & 400 microstrain
- Haversine loading at frequency of 10 Hz
- Controlled Strain Mode
- Failure criteria is taken as 50% reduction in the initial Flexural stiffness of the beam sample.

Fatigue Beam Test

Types of Mix	Temp (°C)	Initial Flexural Stiffness (Mpa)	Number of Cycles to failure	Strain (μ)	Poisson Ratio
CMA	20	300	66000	400	0.35
MWMA		349	76000		
HWMA		436	78000		
CMA		770.33	1,35,440	300	
MWMA		892	9,60,350		
HWMA		1244	15,67,670		

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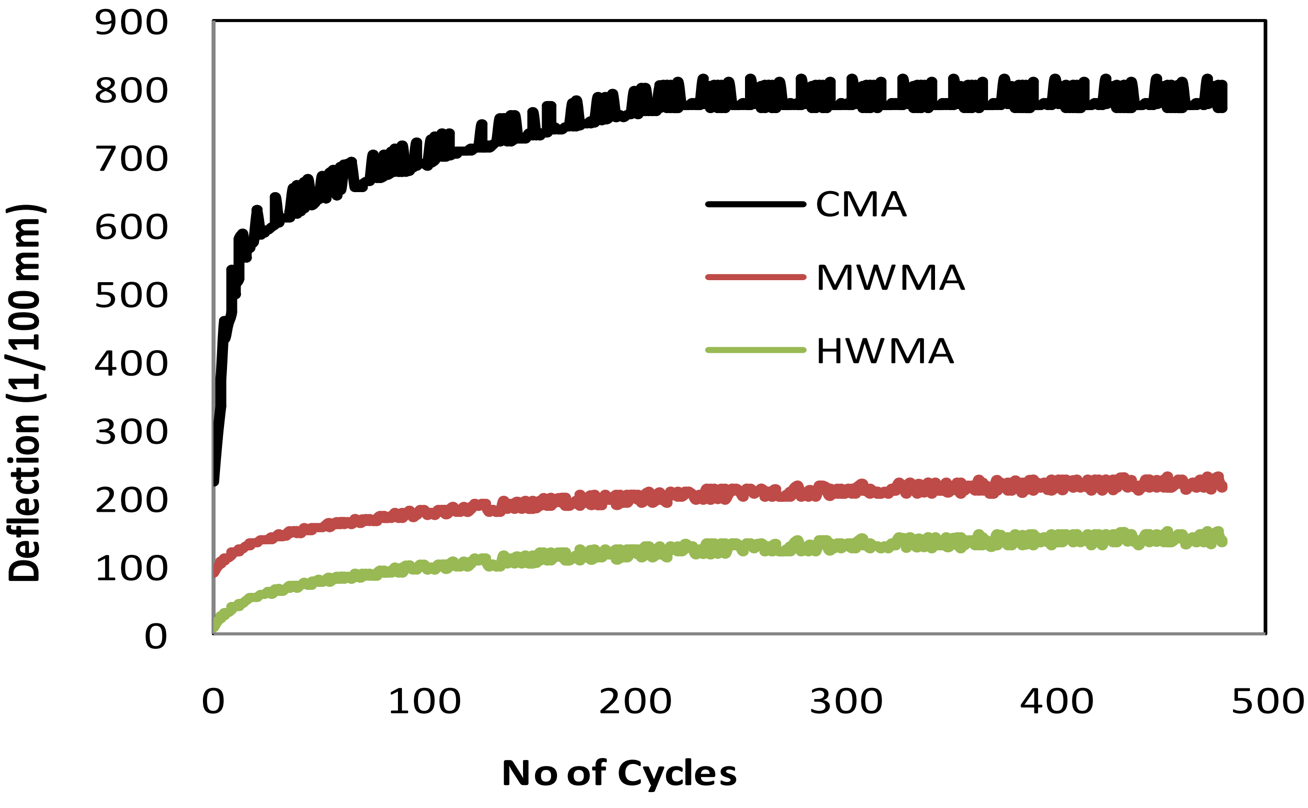
Wheel Tracking Test

- This test involves direct contact between the loaded wheels and the fabricated test specimens.
- Rut depth after 20,000 passes is compared for conventional mix and low energy mixes .
- Slab dimensions -300 mm × 300 mm × 50 mm
- Tyre load of 31 kg with a mean normal pressure of 5.6 kg/cm2.
- Loading rate of 42 passes per minute along the length of the slab.
- Temperature - 45°C.
- Test data is presented in the form of plot between Rut depth vs. Number of passes.

Wheel Tracking Test



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Conclusion

A new type of Mild Warm Mix (MWMA) of low energy mix has been developed and its performance properties are compared with cold mix as well as half warm mix, which shows better energy efficient mixture for road construction in adverse climate condition such as low temperature and high rainfall.

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Thank You