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**EFFECT OF WARM MIX ADDITIVE ON
THE PERFORMANCE OF CRUMB
RUBBER MODIFIED ASPHALT:
A CASE STUDY**

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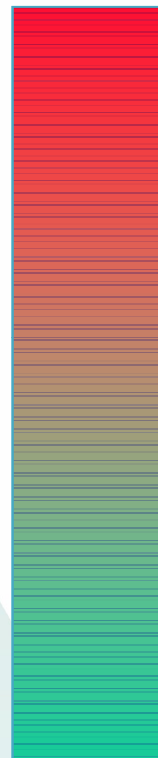
AGENDA

- Warm Mix Asphalt (WMA)
- Principal Issue
- Crumb Rubber Modified Bitumen (CRMB)
- Combination of WMA with CRMB
- Laboratory Study done at CSIR-CRRI, India
- Test section using WMA-CRMB
- Conclusion

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WHAT IS WARM MIX ASPHALT



HOT MIX ASPHALT 135-160°C

- Cost Effective
- Renewable
- Sustainable

WARM MIX ASPHALT 100-130°C



COLD MIX ASPHALT 15-30°C

ASPHALT

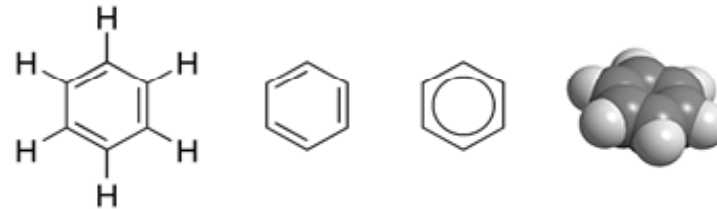
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Principal Issue

Can we and our children get sick from continual exposure to hot asphalt fumes and smoke stack discharge?

Fumes consists of :



H₂S, Benzene, polycyclic aromatic hydrocarbons, Arsenic, Cadmium, Mercury, Nickel, Chromium and Beryllium

Chemicals cause cancer by damaging DNA and inducing chromosomal aberrations : [American Cancer Society](#)

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Crumb Rubber Modified Bitumen Waste Tire



Recycling of Waste Tire



CRMB Technology

The addition of crumb rubber in mixture

- 5-25% by weight of bitumen binder
- Mixing temperature from 163 –205 C
- Compacting temperature 149 –191 C

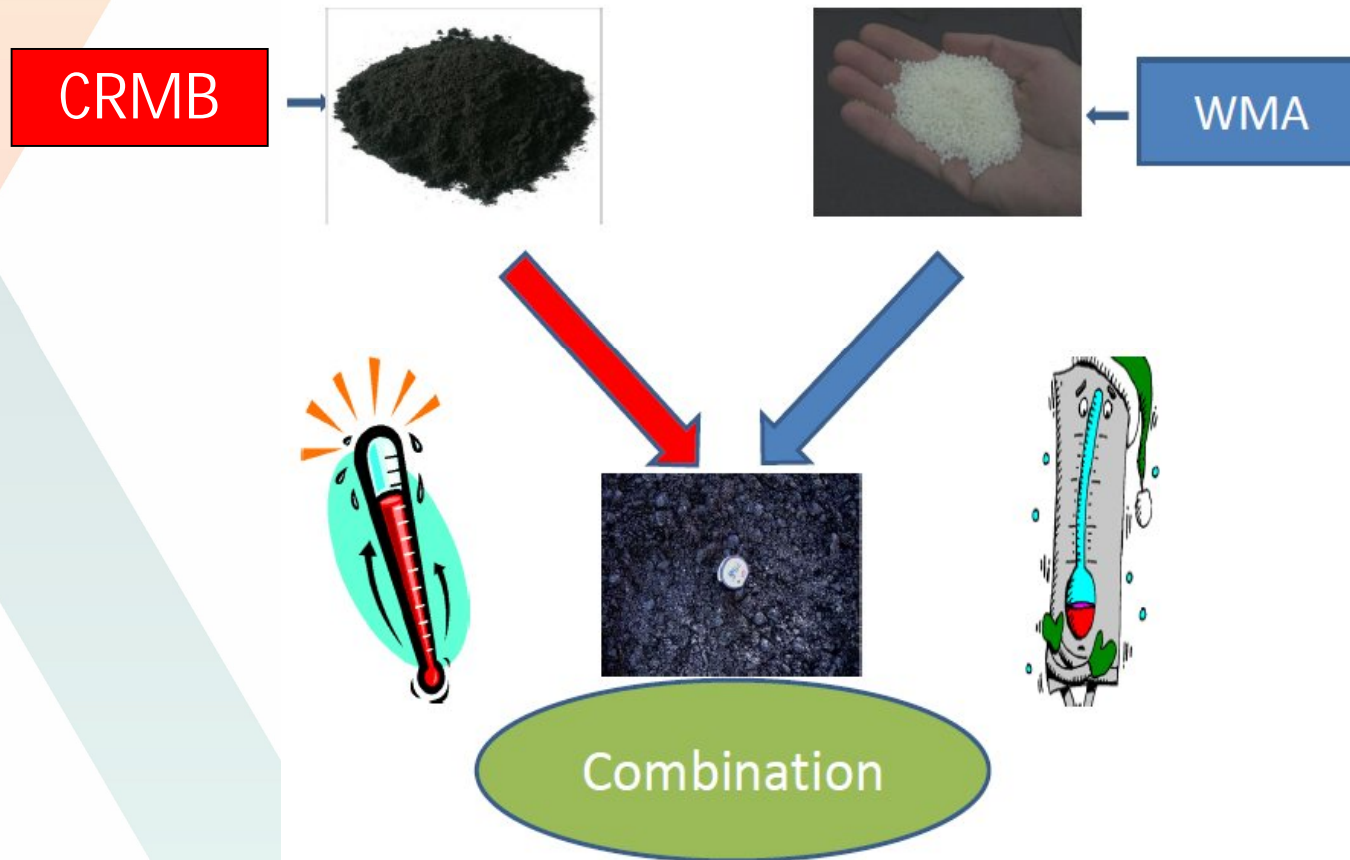
CRMB mixtures have been proven to increase the durability of pavements and to decrease pavement noise in addition to keeping scrap tires out of landfills.

However, CRMB mixtures generally require higher mixing and compaction temperatures compared to conventional asphalt mixtures.

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WMA With CRMB



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Laboratory Study At CRRI

The objective of the study is to evaluate the chemical additive for its ability to bring down the mixing and compaction temperature of Crumb Rubber Modified Bitumen as compared to the Hot mix and check whether it affects the properties like:

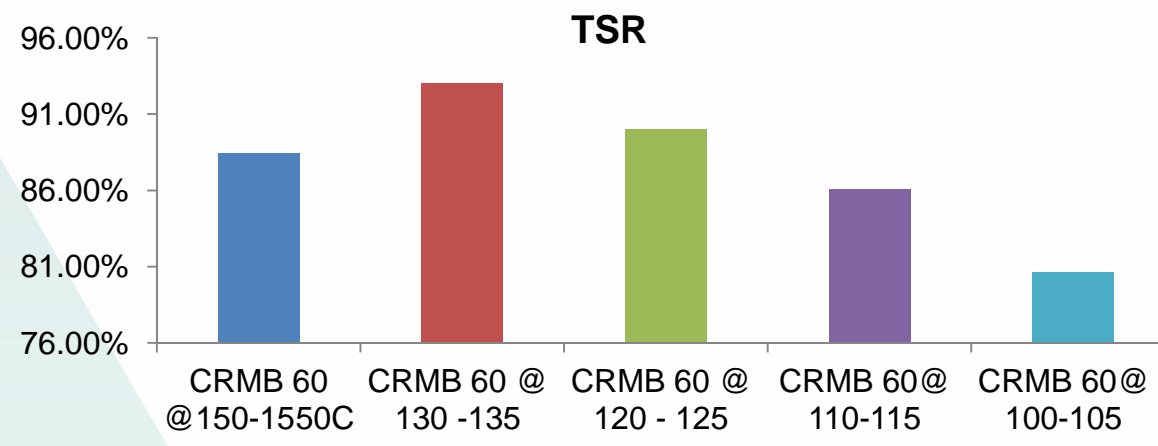
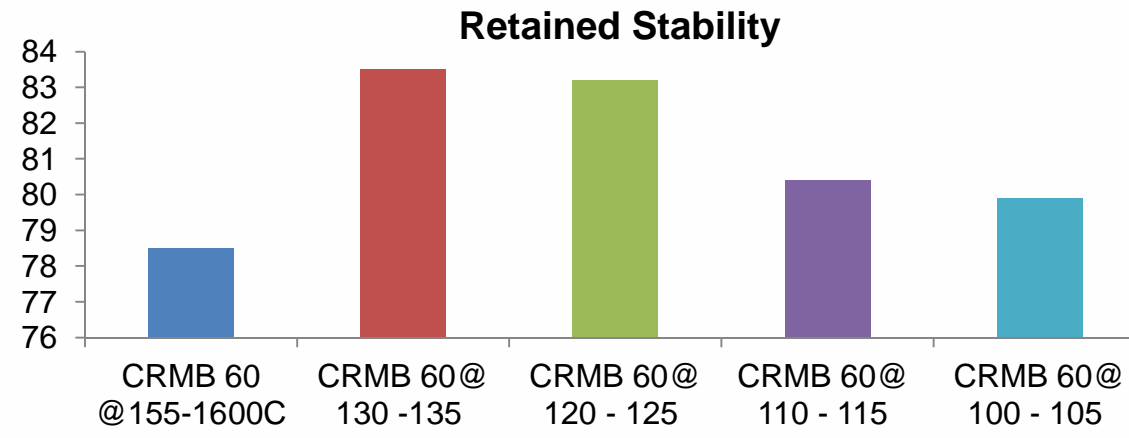
- ❖ Compactability of the bituminous mix
- ❖ Marshall Stability and Flow
- ❖ Retained Stability
- ❖ Indirect Tensile Strength & TSR
- ❖ Rutting Potential

Samples were prepared at OBC and with 0.5% chemical additive at various temperature ranges. Four temperature ranges were considered in this study viz 100-105C, 110-115C, 120-125C and 130-135C to determine the various performance characteristics.

Type of Mix at Various temperatures	Avg. stability after half an hour in water at 60°C (kg)	Avg. stability after 24 hours in water at 60°C (kg)	Avg. Retained Stability %	Design Requirement
CRMB 60 @ 160-165°C without chemical additive	1127	885	78.5	Minimum 75% (as per MORTH 4 th Revision Table 500-17)
Chemical additive Modified CRMB 60@ 130 -135	1196	999	83.5	
Chemical additive Modified CRMB 60@ 120 - 125	1156	962	83.2	
Chemical additive Modified CRMB 60@ 110 - 115	1128	908	80.4	
Chemical additive Modified CRMB 60@ 100 - 105	1119	895	79.9	

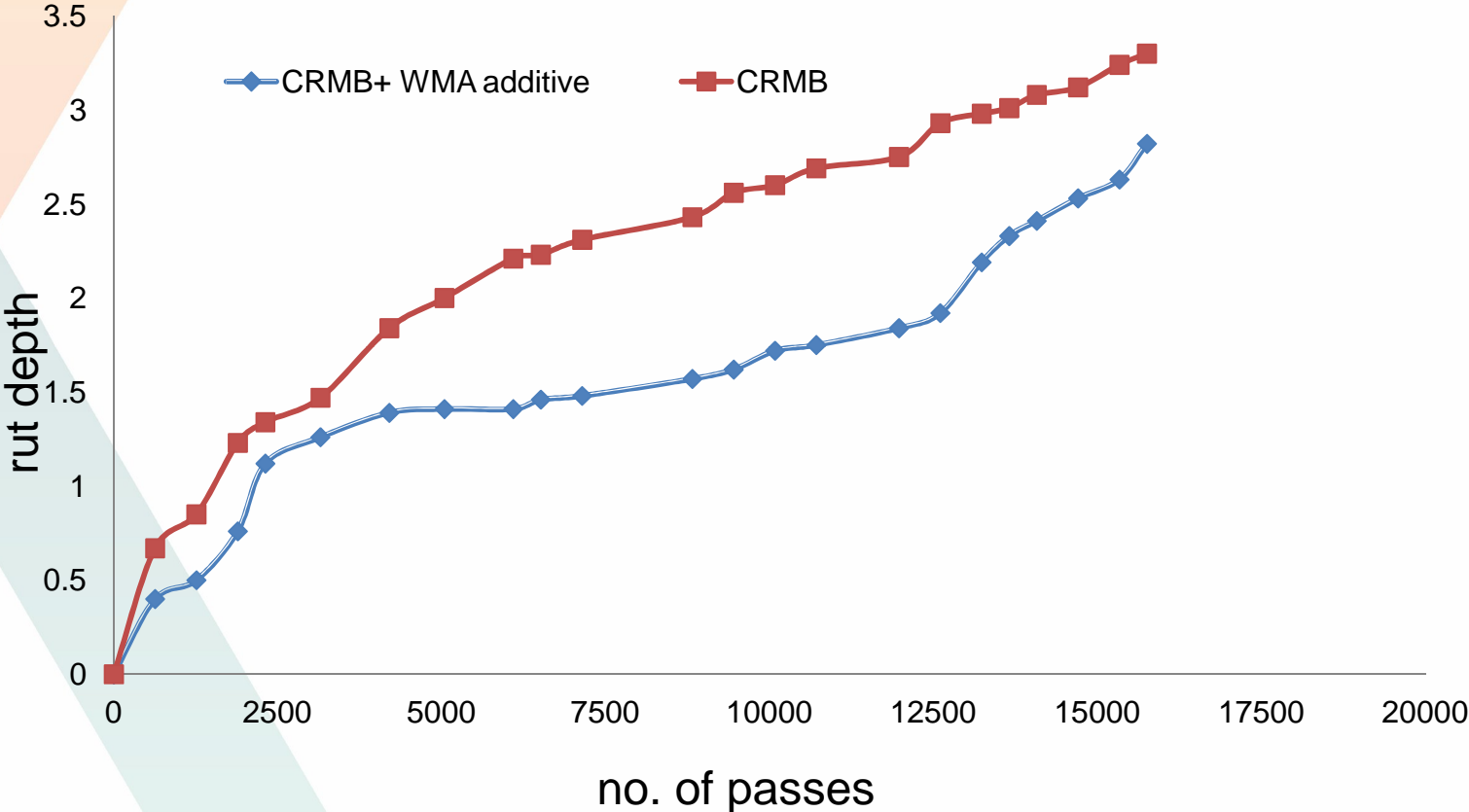
ITS & TSR

Type of Mix at Various temperatures	Avg. Dry ITS (Kg/cm ²)	Avg. Wet ITS (Kg/cm ²)	Tensile Strength Ratio (%)	Design Requirement
CRMB 60 @ 160-165°C without Chemical additive	9.5	8.4	88.4%	Minimum 80% (as per Morth 4 th Revision Table 500-17)
Chemical additive Modified CRMB 60 @ 130-135	10.3	9.6	93%	
Chemical additive Modified CRMB 60 @ 120-125	10.2	9.2	90%	
Chemical additive Modified CRMB 60 @ 110-115	9.4	8.1	86.1%	
Chemical additive Modified CRMB 60 @ 100-105	9.3	7.5	80.6%	



Rutting graph with CRMB 60

Rutting Chart



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Field Trial

After laboratory evaluation of warm mix additive, a test section was laid in Delhi



Field Trial Observations

	Conventional CRMB	CRMB WMA
Production Temperature (°C)	160	130
Mix Delivery Temperature (°C)	140-150	125-130
Mix Temperature Behind Paver (°C)	130-145	120-125
Break-down Compaction Temperature (°C)	130-135	110-115
Finishing Compaction Temperature (°C)	90-100	70-80
Mix Haul Time (min)	30	30

- A significant drop of 30 °C was achieved.
- Indicating substantially lower fuel consumption.
- Density of the pavement was found to be slightly better with the WMA technology, the number of roller passes can be reduced to increase the rate of production.
- Elimination of Anti-Stripping Agents

WMA- CRMB

Mix Temperature at the rear end of the hauler



WMA- CRMB Mix Placement



**Mat temperatures just behind the screed
were measured at roughly 117°C**

Performance Monitoring

The evaluation process consisted of tests like:

- ❖ Benkelman beam deflection (BBD) test (IRC 81:1997),
- ❖ Coring of field samples for laboratory evaluation. The cores were then subjected to the following tests.
 - Marshall stability
 - Static creep test
 - Resilient modulus test

DSIDC Road, Bawana : After 31 months



BBD results

	Final Deflection (mm)	Mean Deflection (mm)	Std. Dev. (mm)
Control Hot Mix	1.08	0.7	0.19
Warm Mix	1.04	0.63	0.205

The BBD results clearly indicate similar performance of the mat in terms of resisting deformation. All the pavement stretches were found to be structurally adequate.

Field Core Testing Results

Marshall stability values

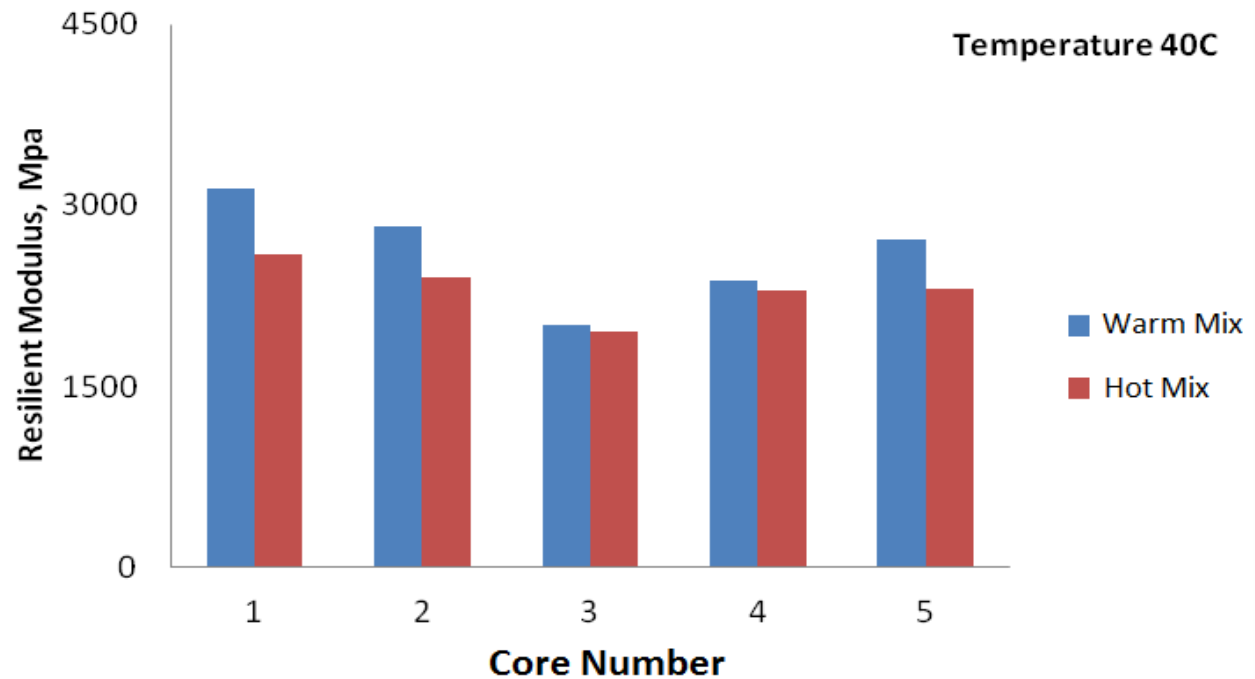
Type of Mix	Avg. stability after 1/2hour in water at 60°C (kg)
Warm Mix	1032
Control Section	727

- The results clearly indicate improved Marshall stability values of the warm mix section cores. This suggests better resistance of the mix to distortion, displacement, rutting and shearing stresses.
- This improved performance of the warm mix in the Marshall stability test is possibly as a result of improved compaction and slightly better densities during the construction of the warm mix pavement.

Resilient Modulus Test

- Repeated loading indirect tensile test on cores extracted from the trial stretches was performed by applying a compressive load in the form of haversine wave at 40 °C for warm mix and control hot mix section cores.
- The specimens were conditioned for 24 hours in an environmental chamber at the given temperature and then subjected to repeated loading pulse width of 100 ms, and pulse repetition period of 1000 ms.





Results showed that warm mix has a higher resilient modulus, indicating a stiffer mix that can resist resistance to deformation and rutting better. It is hypothesised that the improved compaction and better densities during the construction of the warm mix section was the reason for the improved resilient modulus of the mix.

Static Creep Test

Static creep test is conducted by applying a uniaxial static load to a specimen and then measuring the permanent deformation of the specimen and the elastic recovery after the load was removed. A 100 kPa uniaxial load was applied for 3600 seconds at a test temperature of 40°C.

Mix Type	Permanent Deformation(mm)	Percentage Recovery	Creep Modulus (MPa)
Warm Mix 1	0.248	22.7	9.67
Warm Mix 2	0.20	34.5	10.78
Control Mix 1	0.26	20.7	10.02
Control Mix 2	0.69	10.06	5.69

The data shows improved performance of the warm mix section relative to the control hot mix section against creep loading and improved percentage recovery. The increase in the percentage recovery can be attributed to the reduced oxidation of the bitumen due to lower mixing and compaction temperatures during construction.

CO₂ Emission from NH Site (HMA and WMA)

Total road area (paved): 1,798,000 m²
 Road length: 62 km
 Width: 3.5 (4Lane)

WMA		HMA	
Consolidated results:	tCO ₂ -eq	Consolidated results:	tCO ₂ -eq
Pre-construction	0	Pre-construction	0
On-site impacts	0	On-site impacts	0
Construction materials:	17390.0	Construction materials:	17980.0
Material transport:	9482.8	Material transport:	9482.8
Construction machines:	6.1	Construction machines:	6.1
Total CO₂ equivalent emissions:	26,878.70	Total CO₂ equivalent emissions:	27,469.14

590 tonne equivalent CO₂ is saved for 1,798,000 m² paving area i.e 32g per 1 m² paving area

Conclusions

- The addition of warm mix additive of 0.5% by weight of bitumen helps in substantially lowering down the mixing and compaction temperatures.
- Warm Mix CRMB showed better resistance to moisture damage when compared to control hot mix CRMB.
- The use of WMA technology in conjunction with CRMB mixtures has the potential to decrease the temperature requirements while maintaining the high-performance characteristics of CRMB HMA.
- Warm mix CRMB have indicated improved resistance to permanent deformation as compared to the conventional hot mix.
- The Warm mix could be compacted well in field using conventional equipment and rolling patterns, and there was no evidence of the mix agglomerating due to the lower temperature involved.
- Due to reduced mixing and compaction temperatures, 590 tonne equivalent CO₂ is saved for 1,798,000 m² paving area i.e 32g per 1 m² paving area.



... thanks for your kind attention