

TAILOR MADE COLD MIX TECHNOLOGY

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ABSTRACT

In current practice, conventional bitumen emulsions grades (MS and SS-2) conforming to IS: 8887 are used to prepare bitumen emulsion based mixes for road construction and maintenance as per IRC SP: 100: 2014. This is not found to be always consistent in quality due to the variable aggregate quality and improper gradation available in sites in different regions in India, different weather conditions at different sites even within single State, requirement of pre-wetting of aggregates prior to mixing with bitumen emulsion as per IRC SP:100:2014 is mandatory, inability to measure the presence of existing moisture in aggregates in sites, non-standard mixing equipment available with contractors in different regions, inability to use mechanized HMP plant for dense/ semi-dense cold mixes and the inability to cover larger distances to sites with varied lead time and desired workability of the produced mix.

To overcome these challenges of emulsion based mixes technique, BitChem and CSIR-CRRI started laboratory experiments and field-based trials in different climatic conditions to develop the Tailor made Cold Mix technology. The first development was the use of a diagnostic procedure to determine the best aggregate-binder compatibility in the laboratory using a Bio-incubator by simulating site conditions as per the expected aggregate quality (including marginal materials) and site conditions during execution of work, the second step was to develop a portfolio of tailor made cold mix binders and select the best suitable to avoid pre-wetting of aggregates and provide the necessary lead time and workability to the mix, which shall be found appropriate to the above diagnosis, and lastly to develop & install a proven cost-effective and simple conversion kit in existing Hot-mix plants to eliminate the need of heating the aggregates as well as to prepare dense/semi-dense mixes like seal coat or SDBC by using tailor made binders without jamming the plants.

KEYWORDS

Bitumen Emulsion, Cold Mix, Tailor Made Binder, Recommended Cold Mix Design, Conversion Kit, hot mix, HMP, Mechanization, Open Graded Premix Carpeting, Seal Coat, Mix Seal Surfacing, Bituminous Macadam, Semi Dense Bituminous Concrete.

INTRODUCTION

Tailor Made Cold Mix technique is the field application of mix design based tailor-made CRRI-BitChem bitumen emulsion binders with the available or recommended aggregates through modified HMP plant or site mixing and to eliminate the need of any pre-wetting of aggregates or heating of aggregate-binder mix. The said technique helps in production of dense/ semi-dense mixes like seal coat & SDBC as well.

Key Challenges of Conventional Bitumen Emulsion Based Mixes

1. Pre-wetting of Aggregates Prior to mixing - As per IRC specifications, it needs pre-wetting of aggregate before cold mix production resulting in nonperformance of mix quality as there is no limitation of adding of water with the aggregates by the site people and needs increased vigilance on quality control.
2. Presence of existing moisture in aggregates- Post-rains the dampness and presence of moisture in aggregates becomes an additional factor of poor quality due to run-off of bitumen emulsion from the mix when pre-wetting of aggregates is done prior to mixing operations.
3. Need of IRC specification of aggregates at sites - Conventional Bitumen Emulsion based mixes needs standardized recommended aggregates as per IRC specifications, which is practically not found throughout the country. It needs clean aggregate to perform the mixing operations and achieve the necessary coating and anti-stripping properties, which is not possible as per site condition. Only Open Graded Pre-mix carpeting is possible with such clean aggregates. Other applications like Seal Coat, MSS, BM, and SDBC are not possible for the chemical combination is standardized in conventional Bitumen Emulsion and varied quality of site aggregates.
4. Need of mechanization for all types of Cold Mix operations - Cannot utilize existing hot mix equipment to prepare dense/ semi-dense mixes for inadequate design properties of conventional bitumen Emulsion.
5. Adequate binding and performance of the mix - Performance of Emulsion based cold mixes in road construction does not provide the enhanced anti-stripping properties due to very low use of the necessary chemicals and hence gets easily worn out during rains etc., especially when mix design based approach with varied aggregates is not undertaken.

The Key Elements Of Tailor Made Cold Mix Technology

- (a) Aggregate
- (b) CRRI- BitChem Cold Mix Binder (Tailor made)
- (c) RCMD (Recommended Cold Mix Design) Process – Simulation of Site Condition
- (d) Equipment
- (e) Application type

(a) Aggregate

The coarse aggregate or fines shall consist of crushed rock, crushed gravel or other hard material as per specification. They shall be clean, hard, and durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious matter. The aggregate gradation differs largely in all sites either being under-graded or over-graded and mostly not adhered to IRC specifications especially in rural areas in difficult geographies. Soil coated aggregates which are generally unacceptable for such paving operations are also found to be used in practice in States like Himachal Pradesh, Uttarakhand, and various States of NE region as marginal materials.

The testing of aggregates are done as per the desired physical properties or determining the actual properties of aggregates to be used.

(b) CRRI- Bitchem Tailor Made Cold Mix Binder

It is a mix design based tailor made bitumen emulsion with enhanced binder characteristics using certain performance additives and anti-stripping agent along with the regular emulsifiers to provide medium or medium and slow characteristics within the single grade of binder in cold mix technology in various applications of road construction. The main feature of this cold mix binder is that this binder has been customized to use with the aggregates available from any source in India i.e. dusty Aggregates, soil coated Aggregates, clean Aggregates, damp Aggregates, pea gravel Aggregates or the Calcareous (lime mix) Aggregates. As well as the varied gradation of aggregates, in case it cannot be supplied as per the IRC recommended specifications.

The tailor made cold mix binder exceeds the specifications of IS 8887:2004 and is a step ahead of IRC SP: 100:2014.

(b)1: Test parameter & specification of tailor made cold mix binder

We follow IS 8887 and IRC standard to meet the desired workability, adhesion, breaking & curing time, lead time, coating, stripping and compatibility of the cold mixes when mixed with aggregates

(c) RCMD Process –Simulation Of Site Condition

RCMD process is conducted looking at the following site conditions -

- a) Aggregate gradation
- b) Aggregate fines content
- c) Mixing equipment also need different binder
- d) Lead time from plant to site
- e) Weather condition
- f) Moisture in aggregates at site level
- g) Different types of aggregates like granite, Cal Careous type etc

(c)1: Cold mix design activities and Recommended Cold Mix Design Report (RCMD)

TABLE1 Mix design activity & recommendation

Step	Activity
Step 1	Aggregate sample collection from sites
Step 2	Gradation of aggregate using standard IS Sieve to meet the specification
	Physical Property Test of the aggregate
Step 3	Mix Design with Graded Aggregate and Cold Mix Binder
	Test to know the breaking, setting & lead time; coating & adhesion
	Test to know the coating of the mix design in wet and dry condition
	Stripping & compatibility Test
	Marshall test for flow, stability, air voids, density, ITS etc.
Step 4	Recommendation of the mixing proportion of course and fine aggregate
	Recommendation of consumption of cold mix binder of the mix to be produced
Step 5	Issue of RCMD report

(c)2: Recommended Cold Mix Design (RCMD) for OGPC and Seal Coat at BitChem Knowledge Centre

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TECHNOLOGY LICENSE OF  **CSIR**
CRRRI
OVER 4000 KMS OF GREEN ROADS COMPLETED

 **BitChem**®
Greener Roads. The Smarter Way.

RECOMMENDED COLD MIX DESIGN REPORT WITH CRRRI-BitChem COLD MIX BINDER

CRRRI- Bitchem Knowledge Centre

Report No: 003-06-17	Date: 13-06-2017
Customer Name: M/s S.C Jain Construction Company	Site: Bamouri to Umarchedi, Hoshangabad, MP
Package No: MP-16100	Project Reference: PMGSY

A. Aggregate analysis:

Aggregate Size	Aggregate gradation (IS 2386)		Requirements as per IRC:SP:100-2014						Weight of 1 m ³ Aggregate
	Over graded, percent	Under graded, percent	Water absorption, Max, 2% (IS:2386 Part III)	AIV, Max, 27% (IS:2386 Part IV)	Stripping, Max, 5% (IS:6241)	Combined Flakiness and Elongation Index, Max, 35% (IS:2386 Part I)	Sand Equivalent Value, Min, 50 (IS:2720 Part 37)	Methylene Blue Value, Max, 10 (ISSA)	
Carpeting (13.2mm)	14.0	1.3							
Carpeting (11.2mm)	4.0	1.5	0.22	23.6	NIL	37.5	N/A	N/A	1398 Kg
Seal Coat (Type-C)	NIL	26.5	0.20	-	NIL	-	80.0	9.0	1403 Kg

B. Recommended Cold Mix® Design Report:

Recommended Mix Process (Road mix/ Plant mix)	Application	Recommended CRRRI-Bitchem Cold Mix Binder	Aggregate condition at the time of mixing	Binder consumption (As per IRC:SP:100-2014)			
				Percent	Per m ³ (Kg)	Per m ² (kg)	Per KM for 3.75m width (MT)
Plant Mix	OGPC	PLANT MIX	As is where is basis	5.5	76.89	2.07	7.7
	Seal Coat (Type-C)	PLANT MIX	As is where is basis	12.0	168.36	1.5	5.6

Remarks: 1. The validity of this RCMD report is two month from the date of issue considering the quality of aggregate remains the same.
3. The Seal Coat aggregates are slightly dusty. If the aggregate can be screened to remove the dust particles, the consumption of binder would come down to 1.01 Kg/m², i.e. 8% by weight of aggregate.

Consumption may vary depending on the nature of aggregates at site.

CRRRI-Bitchem Cold Mix Technology: The Cold Mix technology is a field application of mix design based tailor-made CRRRI-Bitchem cold mix emulsion binders with the available IRC recommended aggregates through modified HMP plant or site mixing without need of any heating in an environment-friendly manner. The specification of the Cold mix binder is as per IRC: SP: 100-2014.

Checked & Issued by

I/C QCQA 

An

Enterprise

(c)3: Mix design for cold mix SDBC



IMAGE 1 mixing of 10 mm, 6 mm & fines



IMAGE 2 adding cold mix binder as per gradation



IMAGE3 preparing cold mix SDBC



IMAGE 4 prepared mix is kept on to a tray



IMAGE5 the mix is kept under Sun light to know the breaking- setting-lead time, Coating & adhesion

(c).4 Mix design test through Marshall Equipment



IMAGE 6 Marshall Equipment



IMAGE 7 mould of cold mix SDBC prepared for Marshall test

(c) 5 Properties of Marshall Test for Cold Mix SDBC and Test Result

TABLE 2 Properties of Marshall Test for Cold Mix SDBC

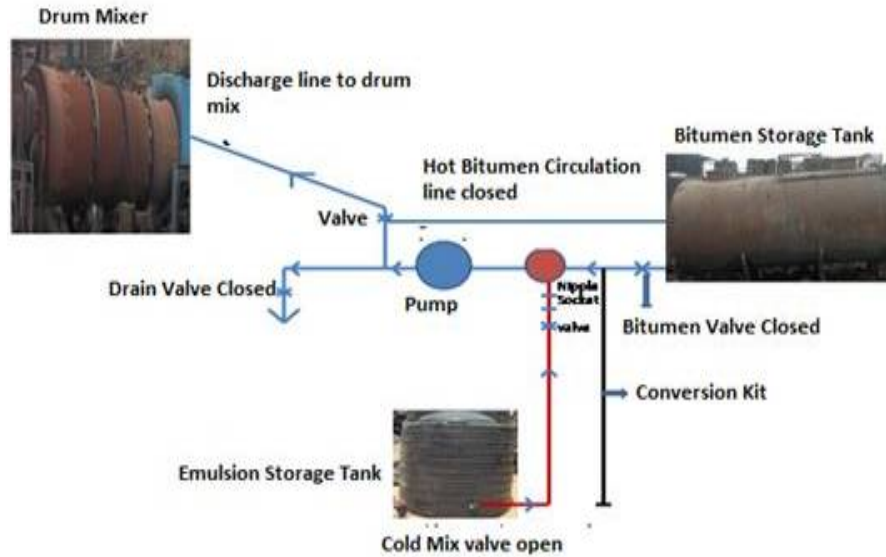
Sl. No	Properties	Requirement	Test result
1	No of compaction blows on each side of Marshall Specimen.	50	50
2	Marshall Stability at 25 ⁰ C in Kg after curing the specimen in air for 72 hours ,min.	500	900-1000
3	Marshall Flow (mm) at 25 ⁰ C, max.	8	4 - 7
4	Per cent voids in mixture	6-10	6-10
5	Binder content (residual bitumen),by weight of total mix(%),min.	4.5	> 4.5
6	Retained indirect tensile strength at 25 ⁰ C after conditioning for 72 h in air and 24 h at 40 ⁰ C in water, %	75	>75

(d) Equipment

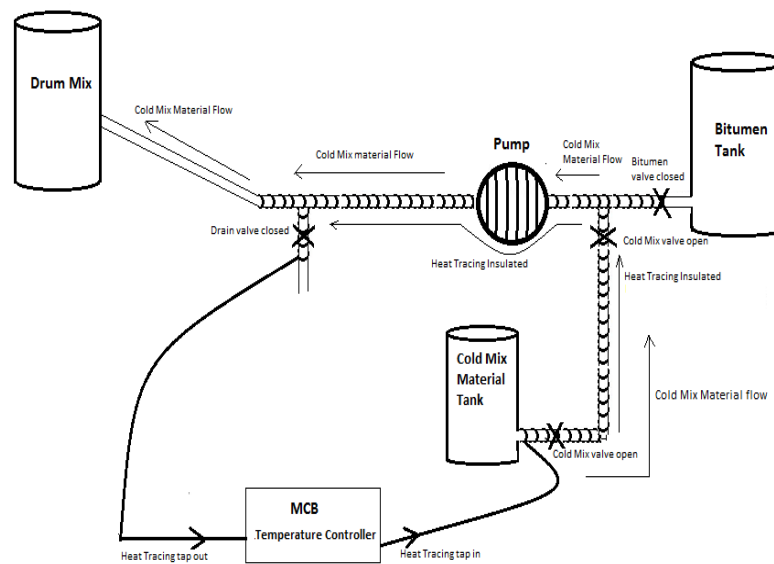
It is a modified HMP through suitable conversion kits with adequate heat tracing tap to eliminate the need of heating and burning with heat tracing assembly.



(d) 1 IMAGE 8 existing HMP



(d) 2 IMAGE9 Modification of HMP with conversion kit



Remarks: The binder suction line, the pump and the binder discharge line should be connected with a fully insulated heat tracing tape 30 Mtr long along with automatic temperature controlled Panel with MCB, input and output terminal and temperature sensor to eliminate heating before and during cold mix production. Temperature of heat tracing tap is to set at 150-160 Degree Centigrade, when pump is freed after 2-3 hrs, then temperature is set at 60-70 Degree Centigrade and arrange to start the plant maintaining this temperature.

(d) 3 IMAGE 10 modification of HMP with heat tracing tap for cold mix production

(e) Application of tailor made cold mix technology

(e)1 Five important tips need to be checked before and during cold mix execution.



IMAGE 11 five finger tips of cold mix application

(e).2 Application of cold mix MSS (Mix Seal Surfacing)



IMAGE 12 laying of cold mix MSS



IMAGE 13 compaction of cold mix MSS

(e).3 Application of cold mix SDBC (Semi Dense Bituminous Concrete)

It has no specification of Cold Mix SDBC in MORTH 2013. But the specification is available in IRC: SP: 100-2014 in the pages from 46 – 48 and page 81 except adding water in aggregate. Also, required reference on it is available in the page no 67 and 70, SL NO 7.

Cold Mix SDBC was first developed in 2011 by CSIR-CRRI Guidelines - “Design and Construction of Bituminous Surfacing Using Cationic Emulsion Based Cold Mixes” vide CRRI:SP: 1 – 2011. In the guidelines, it is well exemplified on “Guidelines for Design and Construction of Semi-Dense Bituminous Concrete (SDBC) Using Cationic Bitumen Emulsion” - Pages 17 – 26.

CRRI-BitChem Cold Mix SDBC specification with rate analysis was appeared in the SOR of Arunachal Pradesh Public Works Department in 2014. Page 68. The specification and rate analysis are appeared in the SOR of Assam Public Works Roads Department (APWRD) for Rural Roads for the year 2016 – 17, pages 97 & 98.

It is also important to note as mentioned in the paper that we are developing and promoting CRRI-BitChem Tailor made cold mix technology which is based on the development by CRRI and BitChem jointly and the detail technology specification is available in IRC : SP : 100 – 2014.

Execution of Cold Mix SDBC is being implemented to meet the specification of IRC: SP : 100 – 2014 only with satisfactory result. No other emulsion based cold mix company is so far able to execute Cold Mix SDBC in India. It is viable only for Tailor made cold mix technology.



IMAGE 14 laying & compaction cold mix SDBC



IMAGE15 completed cold mix SDBC road

(e)4 Application of Seal Coat (Dense Cold Mix)



IMAGE16 laying of cold mix seal coat



IMAGE17 completed seal coat surface

(e)5 Total km constructed by mechanized cold mix operation in different states.

TABLE 3 Total km constructed by cold mix mechanization

Sl. No	Name of state	Total km constructed
	Assam	30
	Maharashtra	36
	Karnataka	25
	Andhra - Telangana	34
	Madhya Pradesh	5
	Himachal Pradesh	4
	Bihar	1
	Total	135

BENEFITS OF THE TAILOR MADE COLD MIX TECHNOLOGY

- 2-3 times faster progress without need of capital expenditure in new equipment for execution of field works.
- Due to increased adhesion properties, 50% higher life than conventional cold-mix as found in field performance evaluation by CSIR-NEIST, Jorhat.
- Use of marginal materials as well as laboratory level diagnostic services helps improve quality of materials to be used at site by contractors.
- By removing the need of pre-wetting of aggregates by at least 2% of the total mix weight, we save around 3000 liters of water which is estimated at Rupees 1500/- per km as compared to conventional cold mix.
- Eliminating chances of increased adulteration and quality control vigilance by removal of on-site water use in pre-wetting operations
- Simple and ready to use- No open firewood, tyreheating arrangements required for heating the pipelines, tank, pumps etc.
- Production of dense/ semi-dense mixes like seal coat, MSS, SDBC allows complete elimination of hot mix process.
- Works 12 months a year in all climatic zones except rainy or snowy days and when water or snow is accumulated on the surface.

Environmental consideration of CRRI-BitChemCold Mix® Technology

TABLE 4 Environmental consideration of Cold Mix® Technology

Particulars	Rural Road	State Road	State Highway/City Road
Specification of Bituminous Black Topping	Application – OGPC-SC Width – 3.75 m Thickness – 2 cm	Application – SDBC Width – 5.5 m Thickness – 2.5 cm	Application- BM/SDBC Width , 7-10 m Structural bituminous layer – 5 cm Wearing coat – 2.5 cm
Fuel consumption in Black topping in hot mix	1500 litres per KM	2500 litres per KM	5500 litres per KM
CO2 Emissions in hot mix	4000 kg	6500 kg	14,300 kg

CONCLUSION

Field execution of this novel technology in difficult terrains as well as where there is need of mechanisation for complete elimination of hot mix process with the proper design of tailor made cold mix binder using varieties of aggregates available from any region of India and at any weather condition, using of existing HMP to provide faster construction with dense graded cold mix and performance evaluation on CRRI-BitChem cold mix road conducted by CSIR-NEIST has helped NRRDA to declare this technology as 100 % main stream technology. Therefore, this technology can stand as complete replacement of conventional hot mix technology looking at the negative impacts of hot mix technology like huge energy consumption, pollution of environment, CO2 emission, limitation to work throughout the year, risky – hazardous – accident prone.

ACKNOWLEDGEMENT

1. DG, NRRDA, Ministry of Rural Development, Govt. of India, New Delhi, 110066
2. CSIR-CRRI, New Delhi, 110025
3. State PWD of NE States of India, North India, East India, West India & South India
4. CSIR-NEIST, Jorhat, Assam India
5. IIT, Guwahati, Assam
6. Assam Science Technology & Environment Council, Guwahati, Assam
7. University of Science & Technology, Meghalaya
8. NIT, Warangal, Andhra Pradesh

REFERENCE

1. IRC:SP:100 – 2014 on Use of Cold Mix Technology in Construction and Maintenance of Roads using Bitumen Emulsion.
2. Performance Evaluation Report on Rural Roads constructed using CRRI-BitChem Cold Mix Technology by CSIR-NEIST, Jorhat, Assam, India in 2013 vide Report No : QSP/MR/19/ACED/BTCM/214/2013.
3. Collaborative project with CSIR-CRRI on Up-gradation and modification of Cold Mix Technology.
4. Patent of the technology – it is filed, published for comment.