CLOSE GRADED COLD MIX FOR CONSTRUCTION AND MAINTENANCE OF RURAL ROADS

Rajeev Agarwal
BitChem Asphalt Technologies Ltd.
G.S.Road, Anil Plaza-3rd Floor, Guwahati, Assam, India
rajeev@smgrp.net

ABSTRACT

Rural Roads connectivity promotes access to economic and social service and thereby increases agricultural income and employment opportunity in rural areas. Construction of good quality, all weather rural roads is the focus of rural road development programs in India. Therefore, development of cost effective and environment friendly materials is the aim of researchers. Closely graded Premix Carpet popularly known as mix seal surfacing containing graded aggregate and hot melted paving bitumen is a cost effective wearing coat specification used in India. The thickness of this specification is restricted to 20 mm with two different grading for low and high rainfall areas. Hot mixed closely graded premix is prepared and laid at fairly high temperature requiring high energy input and lead to higher carbon footprint. Therefore, a laboratory investigation was undertaken to develop and design cold mix containing tailor made bitumen emulsion as a cold mix binder and closely graded mineral aggregate. This new specification has advantages over available specifications of close mixed open graded premix with seal coat as it does not need seal coat. A mix design procedure has been developed based upon Indirect Tensile Strength values. Here, the heating process is completely eliminated and use of existing hot mix plant is encouraged through a conversion kit installed along with heat tracing tap to eliminate completely heating and burning which also increases work progress by more than 2 times.

In current practice, Bitumen Emulsion based cold mixes are being used in the application of Open Graded Premix Carpeting (OGPC) and Seal Coat, 20 mm thick in rural road sector which is difficult to continue the construction and has the challengesto work with varied quality of aggregates available at different sites, different climatic condition, lack of proper chemical combination in bitumen emulsion, need of pre-wetting of aggregate before mix production, not to able to utilize existing hot mix equipment in the operation, high cost in construction for very low progress of work etc. To overcome all these challenges, Close Graded Premix Carpeting (CGPC) may stand complete replacement of conventional Bitumen Emulsion based Cold Mixes (OGPC-SC) for its different types of advantages and benefit as mentioned below.

KEY WORDS

Aggregate gradation, Bitumen Emulsion, single layer treatment, semi-dense graded, dense graded, Cold Mix, Tailor Made Cold Mix Binder, Recommended Cold Mix Design, Close Graded Premix Carpeting, Hot Mix, conversion kit, mechanization

OBJECTIVE

- Innovative mix design to have adequate strength and void fill up in one single layer thereby saving overall cost compared to conventional OGPC & Seal Coat treatment
- Utilize existing equipment to increase productivity
- Utilizebitumen emulsions which are tailor made to adjust marginal aggregates, workability and equipment to achieve acceptable results
- To work in environment friendly condition to reduce GHG emissions.
- To work without needing of heating and burning for safety, health and environment to the workers in particular and to the society in general.

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 CHALLENGESOF OGPC – SEAL COAT

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. Achievement of very low progress and high cost in construction for application of double layers which needs only excess man power but also excess quantities aggregates with high transportation cost.
4. Cannot utilize existing hot mix equipment to prepare cold mixes for inadequate design properties of conventional bitumen Emulsion to be used in application of OGPC-SC.
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.

KEY ELEMENTS OF COLD MIX CLOSE GRADED PREMIX CARPETING

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

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 coted 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.

(a).1 Gradation of aggregate

TABLE 1Gradation of aggregate

Sieve size (mm)	Cumulative % passing by Weight
13.2	100
11.2	100
5.6	40-60
2.8	10-20
0.090	2-5

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 Calcarious (lime mix) Aggregates. As well as the varied gradation of aggregates, incase 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 -

- Aggregate gradation
- Aggregate fines content
- Mixing equipment also need different binder

- Lead time from plant to site
- Weather condition
- Moisture in aggregates at site level
- Different types of aggregates like granite, Cal Cerious type etc.

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

TABLE 2 Mix design activities

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 ITS value
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.2Recommended cold mix design report (RCMD)

UNDER COLDMIX® TECHNOLOGY LICENSE OF CSIR CRRI

OVER 4000 KMS OF GREEN ROADS COMPLETED

BitChem®
Greener Roads. The Smarter Way.

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

CRRI- Bitchem Knowledge Centre

Report No: 001-12-16	Date: 21-12-2016
Customer Name: M/s Mahavir Construction Co.	Site: Dilapahari to Singhpur, Rajnandgaon, Chhattisgarh
Package No: CG 15-64M-01	Project Reference: PMGSY

A. Aggregate analysis:

Aggregate Gradation for CGPC			Physical requirements of aggregate as per IRC:SP:100-2014						Weight of 1 m^3 Aggregate
Sieve Size (mm)	Cumulative % passing by Wt.	Specification	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)	
13.2	100	100							
11.2	94.6	90-100							
9.5	78.5	72-88							
4.75	32.5	24-44	0.46	25.3	4.0	33.0	94.0	6.5	1450 Kg
2.36	12.3	6-22							
1.18	8.5	3-12							
0.600	6.2	2-8							
0.180	3.1	1-5							
0.075	1.8	0-4							

B. Recommended Cold Mix® Design Report:

Recommended Mix Process (Road mix/ Plant mix)	Application	Recommended CRRI-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	CGPC	Plant Mix	As is where is basis	7.5	108.75	2.93	10.9

Remarks: 1. ***The validity of this RCMD report is Two month from the date of issue considering the quality of aggregate remains the same.***

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

CRRI-Bitchem Cold Mix Technology: The Cold Mix technology is a field application of mix design based tailor-made CRRI-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 SM Enterprise

c.3 Test on ITS through Marshall Equipment

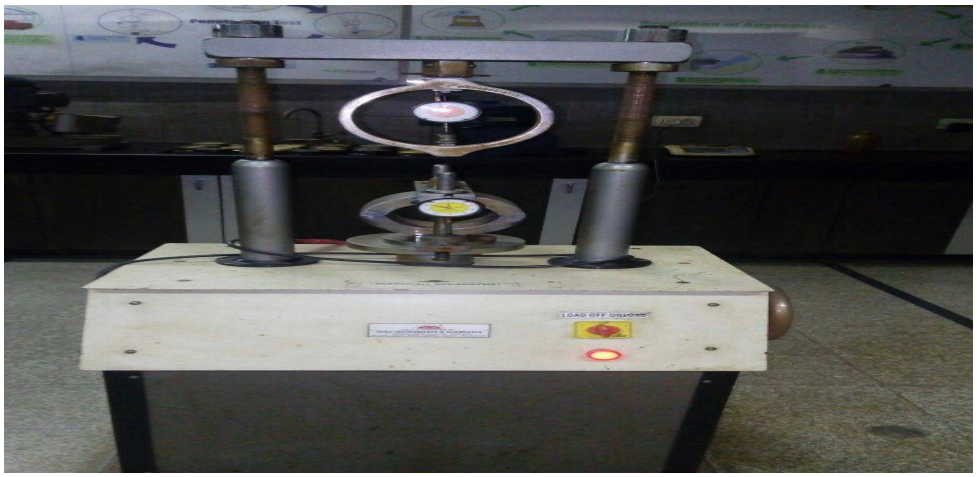
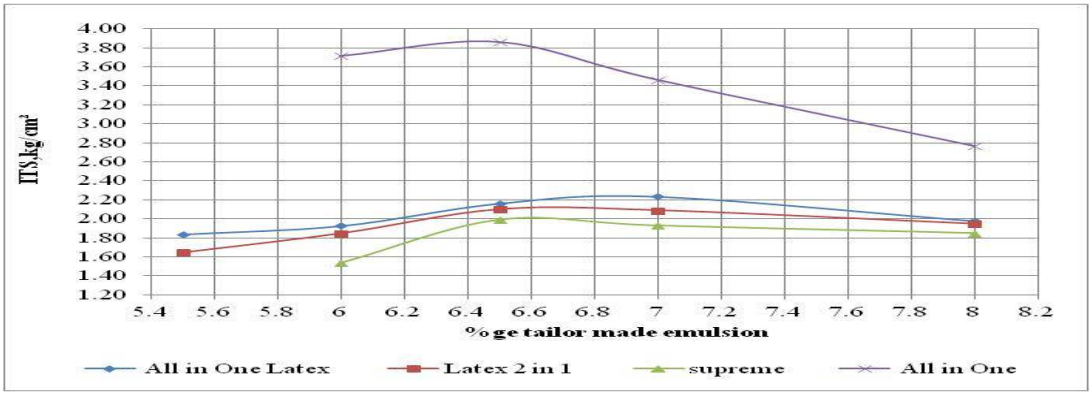


Image-1, Marshall Equipment

Image-2, Marshall CGPC mould

c.4 ITS values of CGPC at different contents with various Tailor Made Cold Mix Binder



c.5 Optimum Residual and Tailor Made Emulsion Content for CGPC with different tailor made binder

TABLE2 Optimum residual content

Type of Tailor Made Emulsion	Optimum Residual Binder (%)	Optimum Tailor Made Emulsion (%)
Rubberized All in One	4.59	7.0
Rubberized Ezee Mix 2 in 1	4.23	6.5
Plant Mix	4.23	6.5

d: Equipment

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

Image-3, Existing HMP

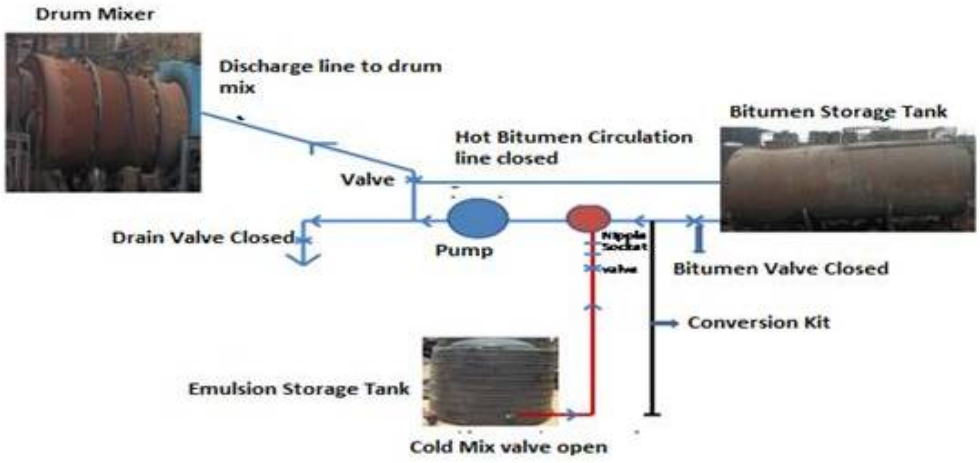
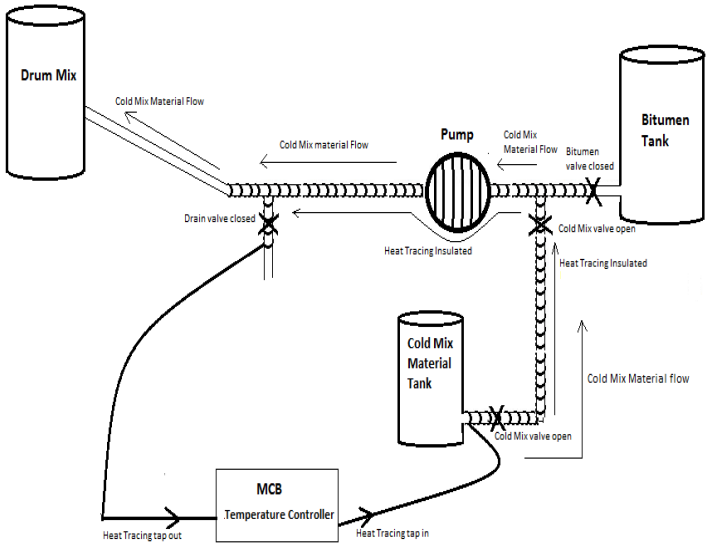


Image-4, Modification of HMP by conversion kit



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.

Image-5, Modified HMP with heat tracing assembly

e. APPLICATION OF CLOSE GRADED PREMIX CRPET(CGPC)

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

Image-6, Five tips to check

CLOSEGRADED PREMIX CARPET (CGPC)

Cold Mix CGPC technology is a highly engineered but simple and effective solution for paving rural roads, farm link roads, low-volume roads requiring a durable all-weather surface measuring 2cm in thickness over the WBM or old bituminous surface with closed graded aggregates instead of Cold Mix OGPC – Seal Coat. This surface is an outcome of Bitchem Cold Mix binder containing certain performance additives pre mixed with graded aggregates through modified HMP, to provide higher volume of construction and speedy completion of road by mechanized process, enhancing the quality of the surface.

15th Nov, 2016

Image-7, application of CGPC

Image-8, completed CGPC road

Road from Atmakur to Perur(6.5 KM), Anantapuram, Andhra Pradesh

20th Nov, 2016

Image-9, application of CGPC

Image-10, completed CGPC road

Road from Velagalapaya to Bommilingam(2.8 KM), Cumbum, Andhra Pradesh

11th Jan, 2017

Image-11, application of CGPC

Image-12, completed CGPC road

Ramakunja to Haleneranke road, Mangalore (Puttur), Karnataka

2nd May, 2016

Image-13, application of CGPC

Image-14, completed CGPC road

Bhandigadi to Niluvagilu Road, Shringeri, Karnataka

TOTALCONSTRUCTION USING COLD MIX CGPC IN INDIA

TABLE 4Road constructions

Name of State	Construction in km
Karnataka	25
Andhra –Telangana	34
Total	**59**

COMPARATIVE STUDYOF ECONOMICSBETWEEN COLD MIX CGPC over COLD MIX OGPC-SEAL COAT WITH PLANT MIX OPERATION

TABLE 5 Comparison of cost& work progress

PARTICULARSS	CGPC	OGPC-Seal Coat
Construction	**Fast progress**	**Slow progress double layer application**
Per day progress	1.5 – 2 km	0.7 – 1 km
Thickness (in mm)	20 mm	20 mm + Seal Coat (no thickness, void fill up)
Consumption of Aggregate (per km)	101 Cum	123 Cum
Consumption of Binder (per km)	10.1 – 11.2 MT	11.2 – 13.0 MT
Savings in aggregate Volume	21.8 %	NIL
Cost Reduction in aggregate consumption	21.8 %	NIL
Savings in Transport Cost / Lead Movement b/w Plant to Site	2.0 % (standard rate)	NIL
Cost for manpowerfor per km construction (standard rate)	Rs 3915	Rs 4639 (18.5 % high)
Cost for equipmentfor per km construction (standard rate)	Rs 58398 (standard rate)	Rs 67426(15.4 % high)
Layer in wearing course	Single	Double

PARTICULARSS	CGPC	OGPC-Seal Coat
Construction	**Fast progress**	**Slow progress double layer application**
Total cost for per km construction (3750 sqm), standard rate	Rs 7,43,074	Rs 9,71,824 (30.7 % high)

CONCLUSION

Cold Mix Close Graded Premix Carpeting (CGPC) is a revolutionary innovation and outcome of the Collaborative Project between CSIR-CRRI and BitChem. From practical site experience, this cold mix road application is found to be appropriate and viable in rural road sector for its speedy completion and construction of roads with single layer application achieving less costing durable roads. Therefore, this application can stand as complete replacement of conventional Open Graded Premix Carpeting & Seal coat which will provide opportunity to the department and the contractors to connect the rural connectivity in fast progress having wide ramification for the benefit of the society at large.

ACKNOWLEDGEMENT

1. DG, NRRDA, Ministry of Rural Development, Govt. of India, New Delhi, 110066
2. CSIR-CRRI, New Delhi, 110025
3. State PWD of Karnataka, Andhra Pradesh &Telangana
4. CSIR-NEIST, Jorhat, Assam India

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