Tailor made Cold Mix Technology for construction and maintenance of roads using Hot Mix Plant

Abstract Id: 106

Abstract: Tailor-made Bitumen emulsion based cold mix technologies using existing Hot Mix Equipment are green and alternative to traditional hot mix technology which serve the intended purpose. In current practice, the conventional bitumen emulsion-based cold mix technologies are used which pose different limitations and problems in the execution for different reasons.

To overcome these challenges of emulsion-based mixes technique, started laboratory experiments and field-based trials in different climatic conditions to develop the Tailor-made Cold Mix technology using existing Hot Mix Plant and other equipment and in present time, it is possible to construct roads in rural roads, district roads and state roads by required applications. 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 and 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 (Semi Dense Bituminous Concrete) by using tailor made cold mix binders without jamming the plants.

Keywords: Tailor-made, cold mix technology, hot mix, emulsion-based, conventional, binder, aggregate, compatibility, pre-wetting, workability, cost-effective

1. Introduction:

Tailor Made Cold Mix technique is the field application of mix design based tailor-made bitumen emulsion binders with the available or recommended aggregates through modified Hot Mix Plant or site mixing and to eliminate the need of any pre-wetting of aggregates or heating of aggregate-binder mix in an environment friendly manner to construct and maintenance of roads. The said technique helps in production of dense/ semi-dense mixes like seal coat & Semi Dense Bituminous Concrete (SDBC) as well.

2. 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.

3. Use of Hot mix plant/Hot mix equipment for Tailor made cold mix technology:

Hot Mix Equipment required for the technology is as under –

1. Hot Mix Plant (HMP) for cold mix production
2. Shelf-propelled Mechanical Paver for laying & spreading of the cold mix
3. Roller for compaction of the mix on the surface, Rollers are –
   a. 8-12 tones three-wheel steel roller for initial break down rolling
   b. 15-30 tones smooth wheel pneumatic roller for intermediate rolling
   c. 8-10 tones tandem roller for final rolling

3.1 Hot Mix Plant: Drum Mix Plant being used for hot mix technology can be used for cold mix technology by little more modification in the plant setup. It is a modified HMP by installing suitable conversion kits with adequate heat tracing tap to eliminate the need of heating and burning with heat tracing assembly. All parts of the Hot Mix Plant will be used in the cold mix operation, but burner section will be switch off. For storage of cold mix binder, either clean bitumen storage tank or other clean tank (MS tank or HDPE tank) may be used capacity of which will be minimum five tons. As per recommended cold mix design for the required application, aggregate and binder are selected, put the recipe in PLC (Programmable logic control) and produced the cold mix in minimum 40-50 ton/hr. to construct road.

Fig 1: Existing hot mix plant

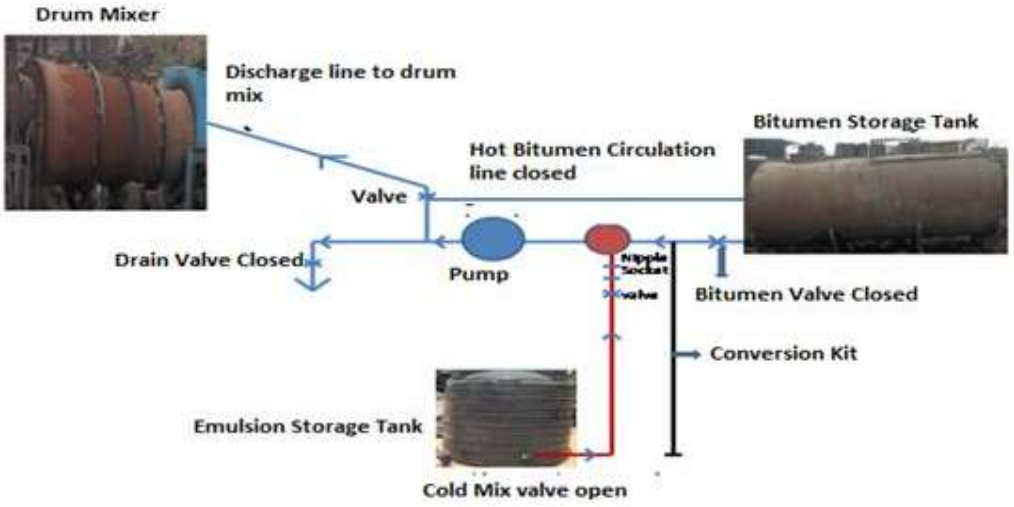
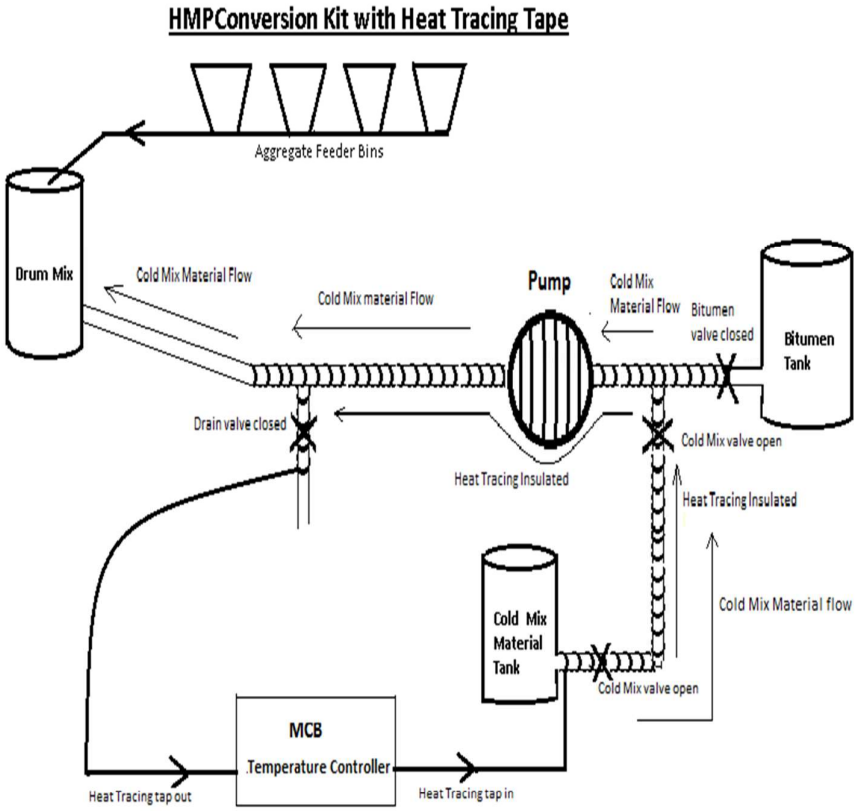


Fig. 2: Modification of HMP by conversion kits



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.

Fig. 3: HMP conversion kits with heat tracing assembly

3.1.1 Conversion Kits for Hot Mix Plant:

Table 1: Conversion kits for hot mix plant

SL NO	Name of conversion kits	Size and requirement	Use
1	MS Nipple	As per plant site requirement	To connect with the socket for further connection with MS Pipe
2	MS socket	Do	To connect with the nipple for further connection with MS Pipe
3	MS pipe	Do	Suction pipe of Cold mix binder from the binder tank to the pump
4	MS Bend	Do	To connect two MS pipe to the opposite direction.
5	MS three way valve	Do	To connect three pipes in different direction.
6	Teflon tap	Do	To use in the valve, socket or nipple to keep in air tight for preventing leakage.
7	Gun metal valve	Do	To open and close the flow of binder

3.1.2 Operational procedure for cold mix production through converted Hot Mix Plant:

Table 2: Operational procedure for cold mix production

Step	Procedure
1	Check all the sections of the plant by running
2	Fill the aggregates in the feeder bins
3	Cold mix binder filling in the tank
4	Setting of recipe in the control room panel (PLC) as per design of the application
5	Placement of clean tipper at the ramp
6	Start power supply
7	Switch on the main power supply of the control room &supply of PLC system
8	Start the exhauster
9	Start loader conveyor belt
10	Start drum mix
11	Start aggregate vibrating screen
12	Open aggregate feeder bin valve
13	Start aggregate feeding
14	Start the binder pump to dose binder
14	Check outlet of produced mix, it should be clean and clear
16	Produced cold mix is carrying through conveyor belt
17	Check the mix to know the coating and workability
18	Start loading at the tipper and transport to the concern site

3.1.3 Control room of the plant:

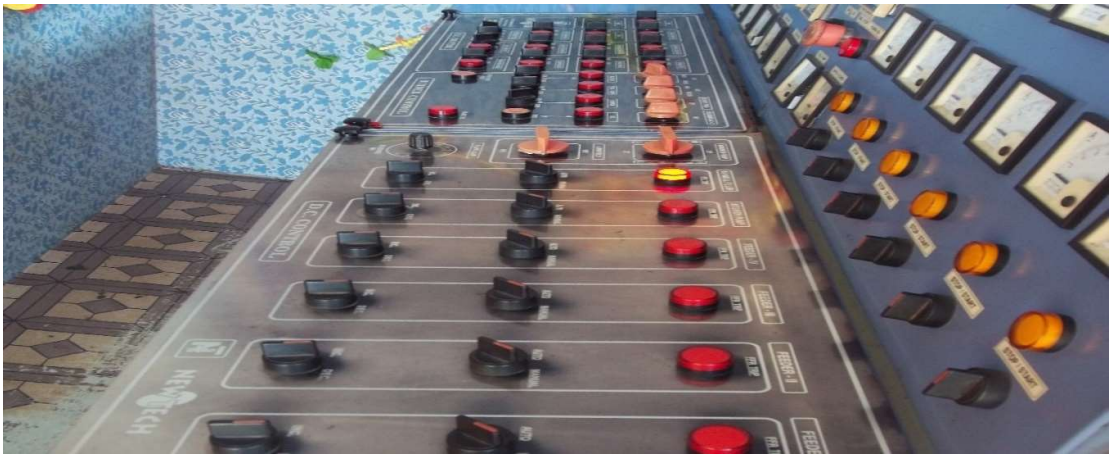


Fig. 4: Control panel of Hot mix plant

3.2 Shelf-propelled Mechanical Paver: Self-propelled mechanical paver is used with an appropriate speed capable of spreading, tamping and finishing the mix true to proper grade, line and cross-section. The mix shall be spread in such a manner that after compaction, the required thickness of layer is laid uniformly for desired thickness. It is advisable to maintain minimum loose thickness to get desired compacted surface as per design. Compacted thickness of the road surface is varied application to application.

3.3 Roller: After change of colour from brown to black of the mix already laid, shall be thoroughly and uniformly compacted through a set of rollers at a speed not more than 5 km per hour. The initial or break down rolling shall be done with 8-12 tons three-wheel steel roller followed by final rolling with 8-10 tons' tandem rollers. Before finishing with tandem roller, break down rolling shall preferably be followed by smooth wheel pneumatic roller15-30 tons having a tyre pressure of 7 kg/sq.cm.All the compactions i.e. breakdown rolling, intermediate rolling and final rolling shall be accomplice by using a vibrating roller (Vibratory system shall be switch off) of 8-10 tons' weight. Rolling activity shall exercise by cleaning the wheels of the roller and by moistening it to prevent the mix from sticking to the wheel. Rolling shall continue until all voids are filled up and to get desired compaction and to achieve the required density of not less than 97 % of the laboratory design density. Compaction shall enable the specified thickness, surface level & regulatory requirements. Traffic may be allowed from 1-2 hour after completion of the construction depending on the site condition.

Adequate quality control at every stage of work is essential as per norms and standard.

4. Other key elements of tailor-made cold mix technology:

1. Aggregate
2. Cold mix binder (Tailor made)
3. RCMD (Recommended Cold Mix Design) Process – Simulation of Site Condition
4. Application type

4.1 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 is done as per the desired physical properties or determining the actual properties of aggregates to be used.

4.2 Cold mix binder (Tailor- made)

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 Cal carious (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.

4.2.1: Test parameter, specification and test result of tailor-made cold mix binder:

Followed 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.

Table 3: Test parameter, specification and actual result of Tailor-made cold mix binder

SL NO	Properties of Cold Mix Binder	Specification	Actual
1	Residue on 600 micron IS sieve (% mass)	0.05 max	0.031
2	Viscosity by Say bolt Furol Viscometer (second)	30 – 100	37
3	Coagulation of emulsion at low temperature	NIL	NIL
4	Storage stability after 24 hrs (% mass)	1	0.58
5	Particle charge	+ ve	+ve
6	Stability to mixing with cement (% coagulation)	Less than 2	1.58
7	Miscibility with water (coagulation)	NIL	NIL
8	Test on residue (a) Residue by evaporation, % (b) Penetration at 25º C/100 GM/5 Sec (c) Ductility at 27º C, cm (d) Solubility in Trichloroethylene, %	60 min 60 – 120 75 min 97.5 min	65.21 97 100 + 99.2

4.2.2 Manufacturing of cold mix binder:

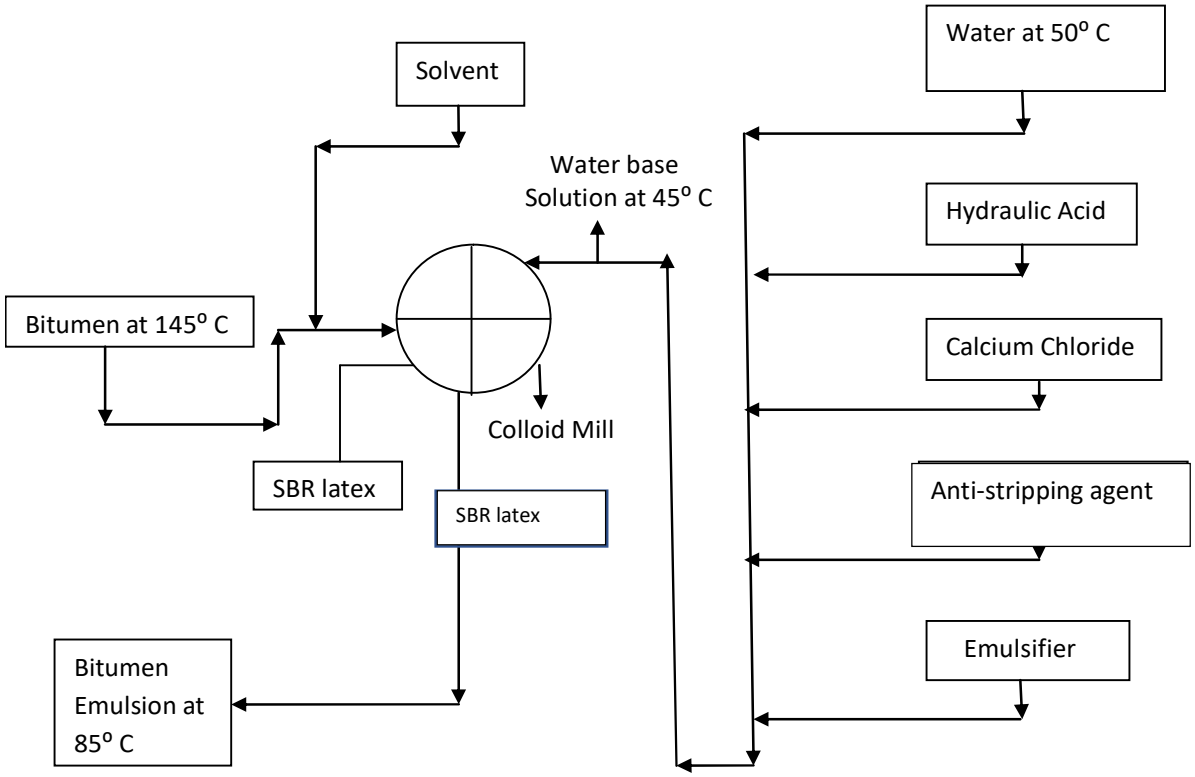


Fig. 5: Manufacturing of cold mix binder

4.3 Recommended Cold Mix Design (RCMD) process–simulation to site condition

RCMD process is conducted looking at the following site conditions -

1.Aggregate gradation & physical test
2.Aggregate fines content
3.Mixing equipment
4.Lead time from plant to site

5.Weather condition
6.Moisture in aggregates at site level
7.Different types of aggregates like granite, Cal Carious type etc.

4.3.1 Gradation of aggregates: IRC: SP:100-2014 & MORTH specification

Table 4: Gradation of aggregates

IS Sieve (mm)	Applications											
	OGPC (20 mm)						BM		SDBC		MSS	
	13.2 mm	11.2 mm	Seal coat-B	Seal coat-C	Liquid seal coat	Sand seal coat	Grade-1 (80-100 mm) Passing %	Grade-2 (50-75 mm) Passing %	Grade 1 (50-75 mm) Passing %	Grade 2 (25-30 mm) Passing %	Type A Passing %	Type B Passing %
45						Clean and dry sand	100					
37.5							90-100					
26.5							75-100	100				
24												
22.4	Passing											
19								90-100	100			
13.2		Passing					35-61	56-88	90-100	100		100
11.2	Retained										100	88-100
9.5				Passing					70-90	90-100		
6.3					Passing							
5.6		Retained									52-88	31-52
4.75							13-22	16-36	35-51	35-51		
2.8											14-38	5-25
2.36			Passing	Retained			4-19	4-19	24-39	24-39		
1.18									15-30	15-30		
0.6												
0.3							2-10	2-10	9-19	9-19		
0.180			Retained									
0.150												
0.090											0-5	0-5
0.075							0-8	0-8	3.8	3.8		

4.3.2: The permissible variation of the individual ingredients in the actual mix from the job mix formula:

Table 5: The permissible variation of the individual ingredients in the mix

SL NO	Description of the Ingredient	Permissible variations by wt. of total mix (%)
1	Aggregate passing 13.2 mm or larger size	± 8
2	Aggregate passing 11.2 mm sieve and 5.6 mm sieve	± 7
3	Aggregate passing 2.8 mm sieve and 1.4 mm sieve	± 6

4	Aggregate passing 710 micron sieve and 355 micron sieve	± 5
5	Aggregate passing 180 micron sieve	± 4
6	Aggregate passing 90 micron sieve	± 3
7	Binder content	± 0.3

4.3.1 Specification of physical tests of aggregate for different applications - As per Ministry of Road Transport & Highways, IRC: SP:100-2014 and Hand Book on Quality Control: Road Works of Pradhan Mantri Gram Sadak Yojana specification:

Table 6: Physical test of aggregates

Test parameter	Specification			
	SDBC (semi-Dense Bituminous Concrete)	**BM (Bituminous Macadam)**	**MSS (Mixed Seal Surfacing)**	**OGPC (Open-Graded Premix Carpeting)**
Flakiness & Elongation Index	Max. 30 %	Max. 30 %	Max. 35 %	Max. 35 %
Aggregate Impact Value	Max. 27 %	Max. 30 %	Max. 30 %	Max. 30 %
Water Absorption	Max. 2 %	Max. 2 %	Max. 2 %	Max. 2 %
Coating & Stripping of Bitumen Aggregate Mixtures	Min. Retained Coating 95 %	Min. Retained Coating 95 %	Min. Retained Coating 85 %	Min. Retained Coating 85 %
Sand equivalent value test	Minimum 50	Minimum 50	Minimum 50	Minimum 50
Methylene blue test	NA	Maximum 10	Maximum 10	Maximum 10

5: Requirement of cold mix binder and aggregates for different types of applications:
As per IRC: SP:100-2014 & MORTH specification

Table 7: Requirement of cold mix binder and aggregates

SL NO	Particulars	Required quantity per sq.m
A	**Cold Mix (OGPC, 20 mm)**	
1	Aggregate (13.2 & 11.2 mm)	0.027 Cu.m
2	Cold Mix Binder	2.1 kg
B	**Liquid Seal Coat**	
1	Stone chips	0.009 Cu.m
2	Cold mix binder	1.2 kg
C	**Seal coat- C**	
1	Stone chips	0.009 Cu.m
2	Cold mix binder	1 kg
D	**Seal coat-B**	
1	Stone chips	0.006 Cu.m
2	Cold mix binder	1.1 kg
E	**Cold Mix MSS**	
1	Aggregate	0.027 Cu.m
2	Cold mix binder	3 kg

F	Cold mix SDBC	
1	Aggregate	0.03 Cu.m
2	Cold Mix binder	7-8 % by wt. of aggregate
G	**Cold Mix BM**	
1	Aggregate	0.06-0.075 Cu.m
2	Cold mix binder	5 % by wt. of aggregate

4.3 Cold mix design activity & recommendation:

Table 8: Cold 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 Recommended Cold Mix Design (RCMD) report

4.3.2 Properties of cold mix semi dense bituminous concrete (SDBC) with cold mix binder

Table 9: Properties of cold mix SDBC with cold mix binder and test result

Sl No	Properties	Cold mix binder content		
		7 %	8 %	9 %
1	Bitumen residue %	4.2	4.8	5.4
2	Bulk density, gm/cc	2.33	2.37	2.34
3	Voids %	9	8	11
4	Stability, kg at 25°C	470	600	535
5	Flow, mm	8.2	7.2	9

4.3.3 Mix design for cold mix SDBC using Marshall Equipment:

Fig. 6: Marshall equipment

Fig. 7: SDBC mould with 10 mm, 6 mm, fines aggregates and required binder

4.3.3 Properties of Marshall test, specification and test result:

Table 10: Marshal test properties, specification and test result

SL NO	Properties	Specification	Test result
1	No of compaction blows on each side of Marshall Specimen.	50	50
2	Marshall Stability at 25ºC in Kg after curing the	500	600

	specimen in air for 72 hours, min.		
3	Marshall Flow (mm) at 25ºC, max.	8	7.2
4	Per cent voids in mixture	6-10	8
5	Binder content (residual bitumen), by weight of total mix(%),min.	4.5	4.8

4.3.4: Other Cold Mix Test:

Table 11: Other cold mix test

Test	Recommendation
Coating	Min 95 %
Breaking time	5 – 20 min as per site condition
Curing time	1-3 hrs as per site condition
Lead time during transportation	Min 3-4 hrs
Adhesion	Very good adhesion for good binding between the aggregates
Run-off	Mix should not be run-off

4.3.4 Cold Mix execution procedure for SDBC application

Table 11: Cold mix execution procedure

Step	Activities
1	**Compliance of Pre-RCMD report by site engineer**
	Inspection of the site to be executed to know about the site condition before execution is as under -
	Surface condition, availability of equipment and condition, workman force, availability of aggregates and quality, distance from the plant site to execution site, climatic condition etc.
	Mix design at site to know gradation of aggregate, consumption of binder, quality of mix design to know adhesion, breaking time-setting time-lead time and report through standard format
2	Arranging necessary requirements
	Apply Tack Coat on cleaning BM or Bituminous surface as per standard
	Let the tack coated surface break or convert into black before laying the mix
	Be ready with necessary team with required setup at the site
3	Laying of Cold mix SDBC
	Receive the Tipper loaded with Cold mix SDBC at site
	Unload the cold mix at the paver from the tipper
	Lay the mix by self-propelled mechanical paver with suitable speed capable of spreading, tamping and finishing the mix true to proper grade, line and cross-section. Maintain minimum loose thickness to get compacted surface as per design

	Longitudinal joints and edges shall be constructed true to the line marking parallel to the center line of road
3	Rolling & Compaction
	After breaking the cold mix surface, roll the surface first by Pneumatic Tyred Roller followed by Static Roller (8-10 ton) at a speed of not more than 5 km/hr.
	Rolling activity shall exercise by cleaning of wheels/tyres of the roller and by moistening it to prevent the mix from sticking to them.
	Rolling shall continue until all voids are filled up and to get required compaction and to achieve the required density of not less than 97 % of the laboratory design density
	Compaction shall enable the specified thickness (25 mm), surface level & regulatory requirements
	Allow traffic 1 hour after completion of the construction
4	**Post-RCMD report**
	After streamline construction of the road, need to highlight the following status
	Per day construction, binder consumption, aggregate quality, quality of road surface, troubleshooting if any etc.
5	**Submission of project report**
	After completion of the project, project report is submitted within 7-10 days stating all details as under
	Site name, road name, package no, total km constructed, quality of construction, binder consumption, comment of department engineer- contractor, details of aggregate gradation and quality and all photos step by step. Followed by credential certificate from department engineer within one month

4.4 Application type:

1. Open Graded Premix Carpeting and Seal Coat (OGPC-SC) for rural roads and PMGSY schemes
2. Close Graded Premix Carpeting (CGPC) for rural roads and PMGSY schemes
3. Bituminous macadam (BM) for state road, town road, district roads
4. Semi dense bituminous concrete (SDBC) for state road, town road, district roads
5. Micro-surfacing for maintenance in highways, express highways etc
6. Patching and pot hole repairing

4.4.2 Application: Close Graded Premix Carpeting (Cold Mix CGPC) in Anantapuram, Andhra Pradesh

Fig 8: Cold mix CGPC production through converted Hot Mix Plant

Fig. 9: Laying and spreading of cold mix CGPC by paver

Fig. 10: Compaction of cold mix CGPC by roller

4.4.4 Application of Cold Mix SDBC at Kendukana to Panitema road, Rangia, Assam in 2016:

Fig 11: Cold Mix SDBC Production through converted Hot Mix Plant

Fig 12 Cold Mix SDBC laying by paver and compaction by roller

Fig 13: Completed Cold Mix SDBC Road.

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

Table 12: Condition of Cold Mix Treatment

Title of treatment	Traffic (CVPD)	Climate	
		Temperature	Rainfall
OGPC	< 1500	Moderate & cold climate (maximum temperature around 45°C)	Medium
Seal Coat	< 1500	No limit	No limit
MSS	< 1500	Moderate & cold climate (maximum temperature around 45°C)	Low
BM	< 1500	Moderate & cold climate (maximum temperature around 45°C)	Low
SDBC	< 3000	Moderate & cold climate (maximum temperature around 45°C)	Low

7: Cold Mix Road construction in India using converted Hot Mix Plant and other Hot Mix Equipment

Table 13: Cold Mix Road Construction in India using converted hot mix plant

SL NO	Name of state	Total km constructed	Year of construction
	Assam	30	2013-2017
	Maharashtra	45	2013-2016
	Karnataka	60	2016-2018
	Andhra	44	2016-2018
	Telangana	74	2016-2018
	Madhya Pradesh	10	2017-2018
	Himachal Pradesh	15	2016-2018
	Chhattisgarh	50	2016-2018
	Bihar	1	2014
Total		**329**	

8: Performance evaluation of five yrs. cold mix road conducted by CSIR-NEIST in 2013

North-East Institute of Science & Technology (A Constituent Establishment of CSIR) conducted performance evaluation of 5 yrs. cold mix and hot mix road and made a comparative statement vide its Report No: QSP/MR/19/ACED/BTCM/214/2013. They had conducted evaluation of 21 no cold mix roads and 13 no hot mix roads age of which were 4-5 yrs. and constructed at the same time in 2008-2009.

In the report, it is revealed that all cold mix roads are in good conditions whereas more than 95 % hot mix roads are very poor condition

8:1 Details of Road Sections taken for Performance Observation:

Table 14: Details of road section for performance evaluation

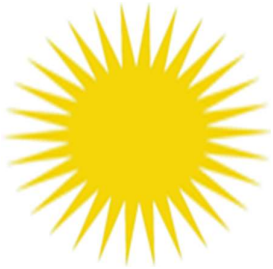
	Road Name	Contractor Name	Scheme/ Pkg. No	Year of Construction	Date of Evaluation	Type of Mix used /Road Length	Present Condition
1.	Gar Ali to Medalujan Road Titabar, Jorhat	Rajesh Agarwal	MPNA	2009	15th May2013	Cold Mix Surfacing Length = 3kms	Good condition as a 4 years old road
2.	Aanapurna Titabar Road, Titabar, Jorhat	Manik Dutta	PMGSY As-10-15	2009	15th May2013	Hot Mix Surfacing Length = 5.44kms	Poor
3.	J.B. Road to Nij-Baligaon Road, Jorhat	Rameswar Bora	PMGSY AS-10-33	2009	15th May2013	Cold Mix Surfacing Length = 2.5kms	Good condition as a 4 years old road
4.	Naichuck to Lakhimikhat Road, Baligaon,Jorhat	Dipen Ch.Bora	MPNA	2009	15th May2013	Hot Mix Surfacing Length = 1.5 kms	Poor
5.	Sariamukh to Thuramukh Road, Rangajan Golaghat	Pronab Jyoti Baruah	PMGSY AS-08-55	2009	16th May2013	Cold Mix Surfacing Length = 3kms	Good condition as a 4 years old road
6.	Bokial To Purabangla Road,	Sagar Gohain	PMGSY	2009	16th May2013	Hot Mix Surfacing Length = 9.0kms	Poor

	Bokial, Golaghat						
7.	Lakhminath Phukan Road, Near D.K.D.College, Dergaon, Golaghat	Pranjal Bora	MPNA	2009	16th May2013	Cold Mix Surfacing Length = 3.9kms	Good condition as a 4 years old road
8.	NH-37 to Khonikar Road, Dergaon, Golaghat	Padum Gogoi	PMGSY (ADB)	2008	16th May2013	Hot Mix Surfacing Length = 5.558kms	Good condition as a 4 years old road
9.	Rajmai to Rajabari Road Rajmai, Sibsagar	Pragati Construction	PMGSY (ADB)	2009	17th May2013	Cold Mix Surfacing Length = 7.96kms	Good condition as a 4 years old road
10.	Rajuar to Balijan Road Sonari, Sibsagar	BB Enterprise	PMGSY	2009	17th May2013	Cold Mix Surfacing Length = 3.80kms	Good condition as a 4 years old road
11.	P.G.J.H. to Chapari Gaon Road, Majuli, Jorhat	Bani Hazarika	PMGSY AS-10-59	2009	22th June 2013	Cold Mix Surfacing Length = 3.214kms	Good condition as a 4 years old road
12.	P.G.J.H. to Ratanpur Miri Gaon Road, Majuli, Jorhat	Bani Hazarika	PMGSY AS-10-59	2009	22th June 2013	Cold Mix Surfacing Length = 2.2 kms	Good condition as a 4 years old road

9: Guideline for Execution of Cold Mix Technology (Do's & Don't)

Do's -

✓ **Execute cold mix work in Dry Spell of Rainy Season.**



✓ • Surface of the road should be dry and there should be no accumulation of water on the surface.

- Use dry & standard aggregate.

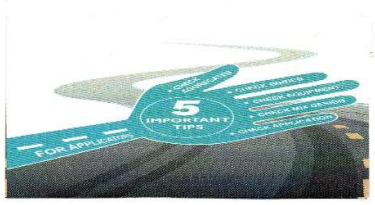

- May use damp aggregate


- Cover the site aggregate/plant site aggregate by the tarpaulin to protect from rain

Do's

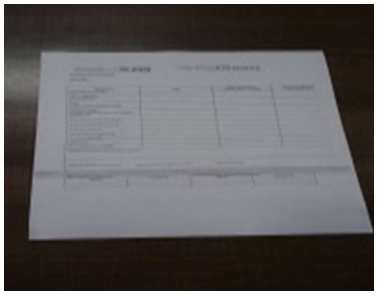
- Reshuffle wet aggregate by manually or JCB to remove moisture from aggregate before use

- Check five finger tips before execution.



- **Follow SOP of Pre-RCMD mentioning clearly weather report and submit it to get**

✓ **green signal for the execution**



- **Stop execution if it rains before and during execution and wait for necessary**

✓ **instruction to be given from PD.**

Don't

☒

- **Don't execute in rainy day.**

☒

- **Don't execute in wet surface or**

☒ Where there is water logging.

☒

- Don’t use wet aggregate.

- Don’t execute if there is rain during operation, inform to the concern for necessary

☒ correction to be taken.

☒

- Don’t execute on loose surface.

10: Savings of fuel in per km cold mix road construction and comparison with hot mix road for fuel consumption based on site construction data.

Table 15: Savings of fuel in cold mix road construction

Particulars	Rural Roads	State Roads	State Highway/City Roads
Specifications of Bituminous Black-topping	3.75 mtr width 2 cm thickness	5.5 mtr width 2.5 cm thickness	7mtr- 10 mtr width 5cm - structural bituminous layer 2.5 cm- wearing coat
Fuel Needs in Blacktopping in hot mix	1500 lit/km	2500 lit/km	5500 lit/km
Fuel needs in Blacktopping in Cold Mix	NIL	NIL	NIL

11: Energy consumption in hot mix and cold mix technology

Source: http://www.i-cema/past_event/P.K.Jain.pdf

Table 16: Energy consumption in cold mix and hot mix road

Specification	Energy Kilo cal x 108	
	Hot Mix Technology	**Cold Mix Technology**
Mix Seal Surfacing (20 mm)	1.16	0.92
Premix with seal coat	1.02	0.88

12: Comparison of GHG Emission for Cold Mix and Hot Mix Technology (1 Km rural road construction) (Using Changer)

Detail of changer can be found on the IRF web site: http://www.irfghg.org/index.php.

Table 17: Comparison of GHG Emission for Cold Mix & Hot Mix Technology

Input Materials	CO2 Emitted (in Tonne CO2 eq)			
	Premix Carpeting		Seal Coat	
	Hot Mix	Cold Mix	Hot Mix	Cold Mix
Bitumen/Cold Mix Binder	40.2	21.4	43.5	18.2
Crushed Aggregates	8.2		2.7	
During construction	141.5	7.5	141.5	7.5
Total	189.9	37.1	187.7	28.4

12.1: GHG Emission per km per lane Roads using (a) 20 mm MSS (b) 40 mm SDBC and (c) 50 mm BM:

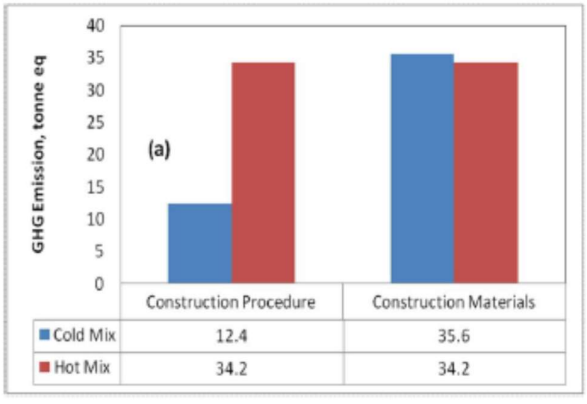


Fig 14: Comparison of GHS Emission for 20 mm MSS

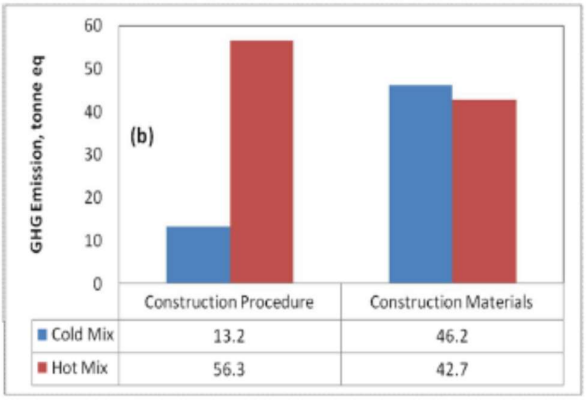


Fig 15: Comparison of GHS Emission for 40 mm SDBC

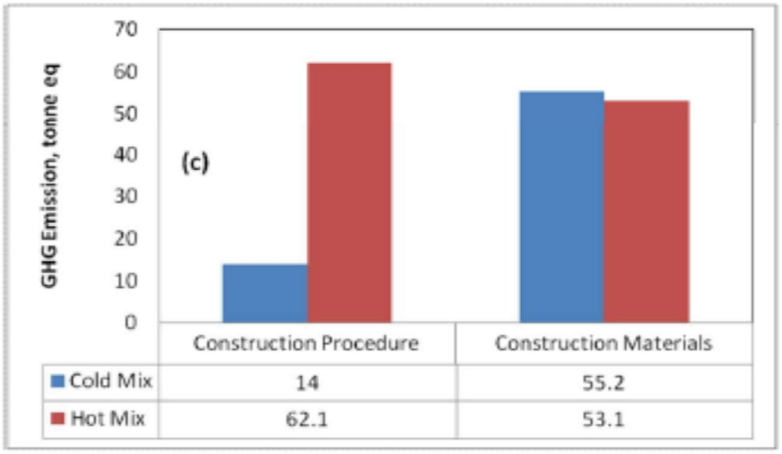


Fig 16: Comparison of GHS Emission 50 mm BM

13: Advantages:

- Ready to Use – Simple to Use
- Energy Efficient
- Controls pollution– Highly Environment Friendly – User Friendly
- Safe – Non – Hazardous due to elimination of heating and burning
- Continuous construction in Rainy Season – Damp aggregates are utilized for this method of construction which is naturally available in rainy season – Double utilization of Hot Mix Plant for both hot mix and cold mix.
- Extends construction period in a year
- Inbuilt property of anti-stripping agent provides better mix quality

14: Challenges:

The technology after field trials and demonstrations conducted at different states of India, even in difficult terrain has come out successful as per comment given, credentials provided and evaluated by the engineers and scientists. Still, it has some challenges like –

1. The setting and curing time of cold mix in cold regions and high thickness applications on roads above 25 mm is very slow which increases the traffic releasing time. Further, it makes the mix unstable due to presence of water in the mix.
2. The existing cold mix binder does not work with clay and soil coated aggregates. Results in high consumption, poor workability, poor coating, poor adhesion and high stripping.
3. In some particular cases, observed de-coating of aggregates during laying of the mix by paver in mechanized operation.
4. Deterioration of the quality due to adulteration of cold mix binder at site.

15: Comparative cost analysis of Cold Mix close graded premix carpeting (CGPC-single layer) and Cold Mix open graded premix carpeting and seal coat (double layer) based on site construction data

Table 18: Comparison of cost analysis

Particulars	**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 manpower for per km construction (standard rate)	INR 3915	INR 4639 (18.5 % high)
Cost for equipment for per km construction (standard rate)	INR 58398 (standard rate)	INR 67426 (15.4 % high)
Layer in wearing course	Single	Double
Total cost for per km construction (3750 sqm), standard rate	INR 7,43,074	INR 9,71,824 (30.7 % high)

15: Conclusion:

Development of Modified Hot Mix Plant used for different types of cold mix applications is now in streamline operation after successful year to year lab evaluation, filed study and outcome of site execution with the support and guidance of Central Road Research Institute (CRRI) New Delhi. This development has definitely up-charged the knowledge of road construction agencies for their future course of road construction. This will provide opportunity to the department and the contractors to construct roads having wide ramification for the benefit of the society at large. This in turn will encourage and benefit young engineers and the contractors of the region and enable them to contribute their efforts in development with green technologies.

References:

[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 October 2013 vide Report No: QSP/MR/19/ACED/BTCM/214/2013.

[3] Collaborative project with CSIR-CRRI & BitChem on Up-gradation and modification of Cold Mix Technology, March 2016.

[4] Patent of the technology – it is filed, published for comment.

[5] CRRI: SP:1-2011 on Design and Construction of Bituminous Surfacing Using Cationic Emulsion Based Cold Mixes.

[6] Report on Field Performance Study of Structural Layers of Flexible Pavement with Bitumen Emulsion in Different Conditions conducted by Flexible Pavement Division of CSIR-CRRI in October 2010.

[7] Specifications for Road and Bridge, Ministry of Road Transport & Highways.

[8] Hand Book on Quality Control : Road Works, Pradhan Mantri Gram Sadak Yojana.