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Development of an Improved Open Graded Premix Carpet for Single Laying By Cold Mix Design

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ABSTRACT
Open graded premix carpet is an important wearing course for low to medium volume traffic roads in India. But due to poor mechanisation, permeability or water penetration, it has been unsuccessful in giving expected results in some cases. And in this study, PC has been made by cold mix technology instead of making it by the conventional method of HMA. This investigation was performed to study the effect on permeability property of this wearing course when PC mix for single laying with seal coat by cold mix design. The volumetric property and permeability property were studied and compared with convention PC with seal coat on top.

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I. INTRODUCTION

In India, 80 percent of total road network consisted by rural roads and other roads network. In these rural roads, generally low to medium traffic is present, that is why the bituminous wearing course used in these roads is also different from the high traffic volume road. Government of India provides limited budget for construction of rural roads and other roads compared to NH, Expressway. So, it is an important matter for the bituminous wearing course to be economically good. In India, generally premix carpet is used for rural roads and other road network. This is because it is a 20 mm thick wearing course and it is good, economical, bituminous wearing course mix to be placed directly on water bound macadam (WBM) of low volume rural roads. Sometimes the quality of WBM may not be consistent. The 20 mm thick open graded premix carpet is flexible enough to adapt to any uneven consolidation of WBM. Open graded premix carpet is very porous due to the use of Nominal max aggregate size 13.2 mm and 11.2 mm. The premix carpet is also provided with a bituminous sand seal coat to minimise direct penetration of rainwater into it. But, it is not suitable for those roads where surface drainage is usually inadequate. If it rains even for half an hour, flooding of roads and streets is a common sight in India. Under such situation use of premix carpet is not any solution. Also a sand seal coat is provided on the surface of the premix carpet, it is not completely effective in making the PC waterproof at the surface. Even for a small patch where PC has lost its sand seal coat, the water on roads can penetrate it at the spot, then flow sideward like an open graded friction course and flood entire premix carpet below the seal coat. Once the premix carpet is saturated with water, the hydraulic pressure resulting from traffic above can loosen up the sand seal in other areas of PC and it also causes stripping in the PC and as well as in the underlying bituminous course. For a solution to all these problems, research is carried out on the development of improved open graded premix carpet by single laying with seal coat by cold mix technology. In this study, cold mix technology has been used to overcome the disadvantages of hot mix asphalt (HMA). The benefits of emulsion based cold mixes are

- Environment friendly and energy efficient.
- Construction feasible in rains/wet and cold.
- Extends construction period during a year.
- Fast production of cold mix.
- The cold mix is economical than HMA.
- Contains in built anti stripping agent.
- Labour friendly technology.

II. LITERATURE REVIEW

There is no standard cold mix design method for open graded premix carpet. Some investigators made their investigations on different properties e.g. use of different emulsion grades, influence of curing on cold mix mechanical performance, performance of cold mixes in service life, properties of open graded friction course [Michael et al. (1978); Serfass et al. (2004); Pundhir et al. (2012); Kandhal&Mallick (1999); Watson & Johnson

(1998);]. Some researchers made their work on permeability of pavement wearing course [Zube (1962); Mullen (1967); Westerman (1998) ; Waters (1990, 1993, 1998); Cooley et al. (2001); Brown et al. (2004);].

Table 1: Categorization of permeability levels for asphalt concrete from Waters (1990, 1993 & 1998).

k (mm/s)	**Classifications from Waters (1990, 1993, 1998)**
1×10^{-8} to 1×10^{-5}	Impervious
1×10^{-5} to 1×10^{-4}	Very low permeability
1×10^{-4} to 1×10^{-3}	Low permeability
1×10^{-3} to 1×10^{-2}	Moderate permeability, some water infiltrating under traffic
1×10^{-2} to 1×10^{-1}	Permeable: substantial water entering under traffic
1×10^{-1} to 1	Moderately free draining: permeates freely under traffic or raindrop Impact. Pumping of fines
1 to 10	Free draining

III. EXPERIMENTAL PROGRAMME AND RESULT ANALYSIS

Premix carpet is generally used as wearing course of low traffic volume and medium traffic volume road. Open graded premix carpet is made mainly in two steps. Firstly coarse aggregate i.e., mixture of NMAS 13.2 mm and NMAS 11.2 mm is laid as per IRC: 14-2004 and MoRTH specifications and then seal coat is given on top of it and made water tight surface. By learning from different drawbacks of this method and to overcome the main drawback due to permeability property, main objective of this study is to develop an improved open graded premix carpet mix for single laying. The grading and quantity (volume) of materials (aggregate and emulsion) are taken from MoRTH and IRC: 14-2004 specifications.

The following properties were studied on samples of premix carpet

(i) Permeability property.

(ii) Density-voids property.

3.1 Material Selection and properties.

The properties of cold mix depend on the properties of materials. Aggregate and emulsion are the major components of cold mix asphalt. The materials are tested to determine the properties of emulsion. The choice of materials depends on the application of mix. Open graded premix carpet is used as wearing course. So it requires highest quality material to get environment and vehicle exposers. In the present study, following materials were used to prepare different types of mixes.

- Coarse aggregate – Crushed stone and rock (19 mm – 2.36 mm)
- Fine aggregate – Natural sand (2.36 mm – 180 micron)
- Filler – Marble dust, stone dust
- Binder – Bitumen Emulsion Medium Setting (MS)

3.2 Aggregates

There are two types of aggregate according to the size. They are coarse aggregate and fine aggregate. Performance of pavement mixes highly influenced by the properties of aggregates. The important aggregate properties are size and grading, shape and texture, affinity for emulsion, absorption, toughness and weathering resistance and cleanliness. Aggregate covers 90 to 95 percent weight of cold mix asphalt. Aggregates are collected from a crusher plant near IIT Guwahati. The quality tests on aggregates have been carried out at Laboratory of IIT Guwahati. The physical properties are shown in Table-2. The grading and quantity of aggregate used in this study is given in Table-

Table 2: Physical requirement of aggregates for open graded premix carpet

Property	Test	Requirement	Result	Relevant Standard
Cleanliness	Grain size analysis	Max 5% passing 0.075 micron	0.12%	IS 2386 Part 1
Particle Shape	Flakiness and elongation Index (combined)	Max 30%	29.88%	IS 2386 Part 1
Strength	Los Angeles abrasion Value	Max 40%	35.44%	IS 2386 Part 4
Strength	Aggregate Impact test	Max 30%	29.69%	IS 2386 Part 4
Water absorption	Water absorption	Max 2%	1%	IS 2386 Part 3

Stripping	Coating and Stripping of Bitumen aggregate mixtures	Minimum retained coating 95%	>95%	IS 6241
Specific Gravity	Specific Gravity Test	2.47-2.62	2.57	IS 2386 Part 3

Table 3 : Quantity of aggregate of premix carpet for NMAS 13.2mm and 11.2mm

Aggregate size	Quantity per 10 m^2 of road surface
NMAS : 13.2 mm NMAS : 11.2 mm	0.18 m^3 0.09 m^3
Total	0.27 m^3

Required weight of NMAS: 13.2 mm for 10m^2 of road surface. (0.18 m^3 volume).
NMAS 13.2 mm : total volume = 0.18 m^3

Table 4 : Required weight of NMAS: 13.2 mm

Gradation	% Retain	Volume (in m^3)	Bulk Density (in kg/cum)	Weight (kg)
22.4	0%	0		
13.2	10%	0.018	1680	30.06
11.2	90%	0.162	1740	281.88
Total weight : 311.94 kg				

Required quantity of NMAS : 11.2 mm for 10m^2 of road surface.
NMAS 11.2 mm : total volume = 0.09 m^3

Table 5 : Required weight of NMAS 11.2 mm

Gradation	% Retain	Volume (in m^3)	Bulk Density (in kg/cum)	Weight (in kg)
13.2	0	0		0
11.2	10%	0.009	1740	15.66
5.6	90%	0.081	1780	144.18
			Total weight:	159.84 kg

Table 6: Total weight of aggregate required for premix carpet

Size	NMAS 13.2 (kg)	NMAS 11.2 (kg)
22.4	0	0
13.2	30.06	0
11.2	281.88	20.61
5.6	0	185.76
	311.94 kg	159.84kg
Total weight = 471.78 kg/ 10m^2		

Table 7: Quantity of aggregate for seal coat

Seal Coat	Aggregate Size	Quantity per 10 m^2 of road surface
Type A	NMAS 6.7 mm	0.09 m^3

Type B	Fine aggregates (2.36 mm Passing 180 micron Retain)	0.06 m^3

Required weight of seal coat Type A, for 10m^2 of road surface. (0.09 m^3).

Table 8: Quantity of seal coat type A

Gradation	% Retain	Volume (in m^3)	Bulk Density (in kg/cum)	Weight (kg)
11.2	0	0		
6.7	10	0.009	1780	16.02
2.8	90	0.081	1863.23	150.92
			Total:	166.94 kg / 10 m^2

Required weight of seal coat Type B, for 10m^2 of road surface.(0.06 m^3).

Table 9: Quantity of seal coat type B

Size	Volume	Bulk Density	Weight
Passing 2.36 mm Retain 180 micron	0.06 m^3	1842.41 kg/cum	110.55 kg/ 10 m^2

3.3 Binder

Generally emulsified asphalt is used as binder in cold mixes. Emulsified asphalt contains emulsifying agent, asphalt and water. It may be anionic or cationic depending upon the emulsifying agent. Type of emulsion depends on the charges of aggregate. Cationic emulsion will make good bond with siliceous aggregate (negatively charged). Laboratory tests are strongly recommended for selection of emulsions. According to IS 8887:2004, emulsion is classified into CRS-1, CRS-2, CMS, CSS-1 and CSS-2. Cationic Medium Setting (CMS) emulsion is used for this which was collected from Om Infraconpvt ltd. This type of emulsion is selected for this study on the basis of aggregate gradation and compatibility with aggregate.

The physical requirements of properties of MS emulsion is in Table 10 and the quantity of binder are in Table 10 and Table 11.

Table 10: Quantity of binder for premix carpet

Item	Quantity as per 10 m^2 area	Type
For 13.2 NMAS	13-15 kg	MS
For 11.2 NMAS	6-7 kg	MS
Total	19-22 kg	

Table 11: Quantity of binder for seal coat as per IRC-14:2004

Type of seal coat	Quantity per 10 m^2 area
Type A (liquid seal coat)	12 to 14 kg
Type B (premixed seal coat)	10 to 12 kg

3.4 Estimation of trial emulsion content

The main step of cold mix design is estimation of trial emulsion content. As per IRC: 14-2004 the quantity of binder as per 10 m^2 area is given as Table 10 and 11. Total emulsion content per 10 m^2 area for trial mixes is taken as 20.5 kg. Mid value of given binder quantity as per IRC: 14-2004 is taken as trial emulsion content.

Table 12: Quantity of trial emulsion for trial mixes.

Item	Quantity as per 10 m^2 area	Type
13.2 mm NMAS	14 kg	MS
11.2 mm NMAS	6.5 kg	MS
Total	20.5 kg	

In the open graded premix carpet, the seal coat is provided to minimize the direct penetration of rainwater into it. Main strength is taken by the molecular structure of coarse aggregate. The trial emulsion content for seal coat is taken as the maximum quantity of binder content as per IRC: 14-2004. (Table 11).

3.5 Estimation of pre-mix water content at mixing (coating test).

In order to find the emulsified asphalt ability to coat aggregate with respect to pre-mix water content, coating test is performed on the selected gradation according to test procedure of coating test which is specified in Article F.07 of MS-14. An emulsion's ability to coat an aggregate is usually sensitive to premix water content of the aggregate. The coating test is very effective for aggregate containing high percentage of materials passing a 75 µm sieve, where insufficient pre mixing water results in balling of the asphalt with the fines and insufficient coating. The coating test is performed at varying aggregate water contents. Emulsions which do not pass the coating test are not considered.

According to MS-14, coating test of Medium Setting (MS) emulsion is started at direct mixing of emulsions with oven dried aggregates without the addition of any water content because this emulsion requires lower water content to produce satisfactory mixes. New trial mixtures are prepared with new batch with an additional increment of 1 percent water by weight of dry aggregate up to 3 percent water by weight of dry aggregate.

The coating test result for different trial mixes in table considering minimum 90 percent of coating at premix water content. All mixing shall be done at the minimum premix water content that produces maximum coating without stripping.

Fig 1: Coating Test with 0%, 0.5%, 1%, 2%, 3% pre-mix water by weight of dry aggregate.

Table 13: Typical coating test result of premix carpet.

% of premix water content to Aggregate	Estimate percentage of coating (visual)
0	84
0.5	90
1	94
2	96
3	96

Table 14: Coating test results of seal coat materials.

Name of seal coat	Aggregate gradation	Premix water content percentage
Type A (liquid seal coat)	As per IRC:14-2004, quantity premix carpet.	1
Type B (premixed seal coat)	As per IRC:14-2004, quantity premix carpet	1

3.6 Finding out optimum water content at compaction

Third step of cold mix design is estimation of water content at compaction if coating of aggregate is sensitive to water content at mixing. Mixture properties are closely related to the density of compacted specimens. It is necessary to optimize the water content at compaction to maximize the desired mixture properties. According to MS-14, Article-F, if the coating of the aggregate is not sensitive to water content at mixing as determined in the coating test, the mixture can be compacted immediately. In this study, coating of aggregate is not sensitive to water content at mixing, the mix is compacted immediately.

3.7 Required quantity of materials to produce 20 mm thick open graded premix carpet with trial emulsion content

The design thickness of open graded premix carpet is 20 mm. This step of cold mix design is to determine the required materials quantity to produce 20 mm thick premix carpet with trial emulsion content.

Quantity of materials are prepared according to the IRC:14-2004 and Marshall Method of mix design of MS-14, Article F.08.

Six Marshall Specimens at trial emulsion content and with same aggregate gradation are prepared. The weight of mix is different in this study for every specimen and the thickness of each sample is different. Main objective of making such specimens with different weight is to determine the quantity of mix for 20 mm thick premix carpet.

Fig 2:- Premix Carpets with different thickness or height to find out the required quantity of materials to produce 20 mm thick Premix Carpet.

Table 15 : Quantity of materials to produce 20 mm thick premix carpe with trial emulsion content

Aggregate size	Weight/Quantity	Thickness of specimen
13.2 mm NMAS	189.26 g	20 mm
11.2 mm NMAS	96.98 g	
Emulsion	12.44 g	
Total	298.68 g	

3.8 Finding out optimum emulsion content

In determining the optimum emulsion content (or residual asphalt content) for a particular aggregate and emulsion, a series of test specimens are prepared over a range of emulsion content, using previously established optimum water content at mixing and compaction and the required quantity of aggregates and emulsion to produce 20 mm thick premix carpet.

According to IRC:14-2004 the required quantity of binder is :

Table 16: Required quantity of binderfor different NMAS in premix carpet

Item	Quantity for 10 m^2 area
NMAS – 13.2 mm	13-15 kg
NMAS – 11.2 mm	6-7 kg
Total : 19-22 kg	

So, the optimum emulsion content lies between 19 to 22 kg.
Combination of different binder quantity required for NMAS 13.2 mm and NMAS 11.2 mm to determine the optimum emulsion content according to IRC:14-2004.

Table 17 : Trial combination of emulsion content for coarse aggregate and seal coat

	Binder quantity required for NMAS 13.2mm			
Binder quantity required for NMAS 11.2mm		A	B	C
	1	13+6*	14+6	15+6
	2	13+7	14+7	15+7

* 13+6 (13 is for 13 kg of emulsion for 13.2 NMAS and 6 is for 6 kg of emulsion for 11.2 NMAS)
In this combination matrix A, B, C and 1, 2 are varying with different binder required for NMAS 13.2 mm and NMAS 11.2 mm and it gives six samples A_1, A_2, B_1, B_2, C_1, C_2 .

Table 18 : Details of different samples with different binder quantity.

Sample Name	Quantity of binder for NMAS 13.2 mm (kg)	Quantity of binder for NMAS 11.2 mm (kg)	Total (kg)
A_1	13	6	19
A_2	13	7	20
B_1	14	6	20
B_2	14	7	21
C_1	15	6	21
C_2	15	7	22

These six different samples with different binder quantity have tested with their Bulk specific gravity, Voids in mineral aggregate, Total voids and Air voids properties to find out the optimum emulsion content.

Fig. 3 :- Six different samples with different binder quantity to find out optimum emulsion content

Sample Name	Aggregate weight (gm)	Emulsion weight (for 13.2 & 11.2 NMAS(gm)	Dry weight (gm)	Wt in water (gm)	SSD wt (gm)	Bulk sp gravity G_{mb}	VMA (%)	V (%)	AV (%)
A_1	286.24	11.53 =(7.88+ 3.65)	297.74	183.39	329.34	2.040	32.54%	26.68%	22.35%
A_2	286.24	12.13 =(7.88+ 4.25)	298.33	182.95	328.76	2.046	31.77%	26.33%	21.87%
B_1	286.24	12.13 =(8.49+3.64)	298.34	182.87	329.19	2.039	32.01%	26.59%	22.15%
B_2	286.24	12.74 =(8.49+ 4.25)	298.96	181.93	327.69	2.051	31.74%	26.02%	21.42%
C_1	286.24	12.74 =(9.1+3.34)	298.96	182.20	328.68	2.041	32.08%	26.39%	21.96%
C_2	286.24	13.35 =(9.1+ 4.25)	299.57	181.44	328.07	2.043	32.14%	26.19%	21.49%

Table 19 : Design data of different samples

It is found from the result , sample B_2 is giving the best result out of six samples. Sample B_2 has minimum air voids and maximum bulk specific gravity. Also this sample gives best result on voids in mineral aggregate (VMA), total voids (V) percentage and Air Voids Percentage (AV).

In the case of premix carpet the gradation is different from any other type of wearing course. Quantity of aggregate is given for 10 m^2 area of road surface. The emulsion quantity is also given. In order to determine their optimum emulsion content, the previous properties have been checked based on the quantity as per IRC: 14-2004 and MoRTH 2001 specifications. Out of six different combination of binder quantity B_2 is giving best result. So, optimum emulsion content is (14+7) = 21 kg for 10 m^2 area. Here 14 kg emulsion for 13.2 mm NMAS and 7 kg for NMAS 11.2 mm.

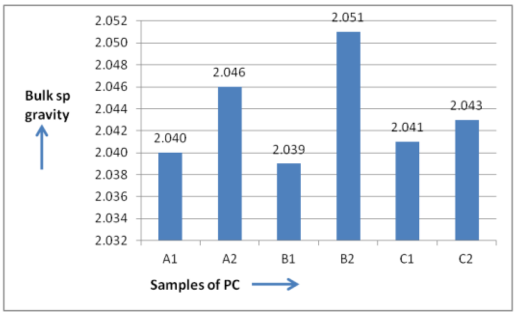

Fig. 4 : Bulk specific gravity of different samples of PC

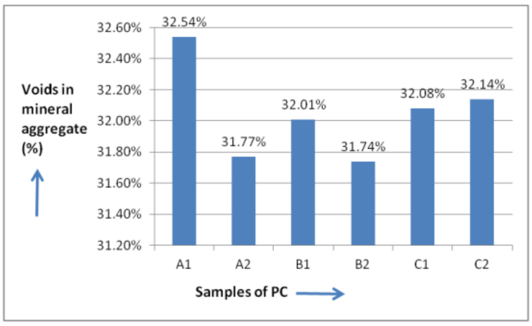

Fig. 5 : Voids in mineral aggregate (VMA%) of different samples of PC

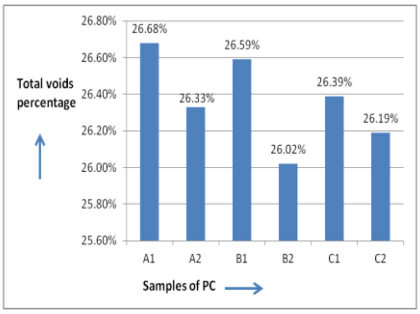

Fig. 6: Total voids in percentage(V) of different samples of PC

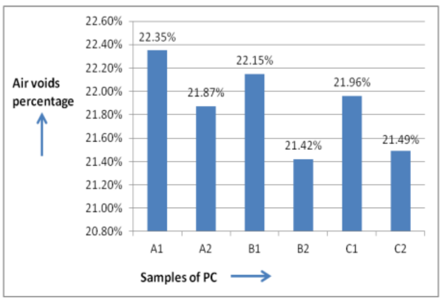

Fig. 7: Air voids percentage (AV) of different samples of PC

3.9 Required quantity of different materials to produce 20 mm thick open graded premix carpet
Quantity of materials to produce 20 mm thick premix carpet with seal coat on the top.
3.9.1 For premix carpet

Table 20: Quantity of materials for premix carpet

Aggregate Size	Quantity (gm)	
	For Type A Seal Coat	For Type B Seal Coat
13.2 mm NMAS	189.26	189.26
11.2 mm NMAS	96.98	96.98
Emulsion	12.74	12.74
Total	298.98gm	298.98gm

3.9.2 For Type A seal coat

Table 21: Quantity of materials for Type A seal coat

Aggregate Size	Quantity (gm)
11.2	00
6.7	8.25
2.8	74.3
Emulsion	5.43
Total	109.78

3.9.3 For Type B seal coat

Table 22: Quantity of materials for Type B seal coat

Aggregate Size	Quantity (gm)
Passing 2.36 mm and Retain 180 microns	67.07
Emulsion	7.28
Total	74.35

3.10 Curing of Cold Mixes

Hot mix asphalt reaches its mature state after a very short period of time. Their characteristics are therefore measured almost after manufacturing. But the same method cannot be applied to cold mix asphalt. The aggregates for cold mixes probably reduced gradually as the mix is curing with respect to time. Cold mixes have lower structural coefficient in the initial period and it may take up to 1-2 years to achieve its full strength. Emulsified cold mixes behave in a peculiar way especially in their early life. This peculiar behavior results from the combination of several factors like curing temperature, humidity and curing time. In this study cold mix specimens are allowed to cure for 1 day in mould at room temperature and 3 days in oven at 40^{o}C.

3.10.1 Parallel method to accelerate the curing of specimen :

In this study another process is used due to the structural inadequacy of the material in early life and to accelerate the curing process.

In this method cold mixes are placed in the oven after mixing the aggregate with emulsified asphalt for a specific time period and at specific temperature before compaction. Trial tests are done to determine the specific temperature and time period of heating. Then bulk density and air voids are checked. The temperature with specific time period giving maximum bulk density and minimum air voids is taken as compaction temperature and heating time of the mix.

The main objective of this method is to accelerate the evaporation process or curing and to help the mix for reaching its mature state after a very short period of time.

Different cold mixes are prepared with same quantity of materials and binder but the heating time and temperature is different before compaction.

Table 23: Details of different cold mixes used in this method.

Cold mixes	Temp (^oC)	Time (h)	Bulk sp gravity	Air Voids (%)
80 CH1	80	1	2.0503	21.524
80 CH2	80	2	2.0505	21.497
80 CH3	80	3	2.0506	21.493
90 CH1	90	1	2.0498	21.464
90 CH2	90	2	2.0505	21.497
90 CH3	90	3	2.0510	21.478
100 CH1	100	1	2.0506	21.493
100 CH2	100	2	2.0507	21.489
100 CH3	100	3	2.0509	21.482
110 CH1	110	1	2.0510	21.478
110 CH2	110	2	2.0509	21.482
110 CH3	110	3	2.0510	21.477
120 CH1	120	1	2.0515	21.458
120 CH2	120	2	2.0513	21.466
120 CH3	120	3	2.0511	21.474
130 CH1	130	1	2.0506	21.493
130 CH2	130	2	2.0512	21.47
130 CH3	130	3	2.0513	21.466

80 CH1 means the sample is heated at 80^oC for 1 hour before compaction.
G_{mm} or theoritical max sp gravity = 2.612
Compaction temperature 120 ^oC and heating periods one hour is taken as result because it produces maximum bulk specific gravity and minimum air voids after 1 day of mixing.

3.11 Design data of premix carpet with seal coat on top.

Different design data have been given in the table below. As per MoRTH specification and IRC: 14-2004 open graded premix carpet with seal coat on top produced. Different design data of conventional open graded premix carpet like quantity of materials ro produce 20 mm thick premix carpet, air voids in the premix carpet and bulk density of the premix carpet etc. are given below.

Table 24: Design data of conventional open graded premix carpet.(PC + Seal coat on top)

Cold mixes premix carpet	Quantity of material required for PC (gm)	Quantity of material required for seal coat (gm)	Bulk Density G	Voids in Mineral aggregate VMA	Total voids (%) V	Air voids (%) AV
PC+Seal coat Type A (20 mm) on top	13.2 mm NMAS→189.26 11.2 mm NMAS→ 96.98 Wt of Emulsion→ 12.74 Total → 298.98 gm	Aggregate size 11.2 – 00 6.7 – 9.72 2.8 – 91.57 Wt of Emulsion – 8.49 Total – 109.78 gm	2.26	25.46%	17.78%	12.1%
PC+Seal coat Type B on top (20 mm)	13.2 mm NMAS→189.26 11.2 mm NMAS→96.98 Wt of Emulsion→ 12.74 Total → 298.98 gm	Passing 2.36 mm and Retain 180 microns 67.07 E – 7.28 Total – 74.35gm	2.35	22.61%	14.37%	8.37%

3.12 Design of open graded premix carpet for single laying with different seal coat materials

Main objective of this study is to develop improved open graded premix carpet for single laying with seal coat by cold mix design

3.12.1 Different types of materials used as single layng seal coat with premix carpet:

Different types of materials are used as single laying seal coat with premix carpet to fill the voids between stone to stone molecular structure of premix carpet to decrease the quantity of voids and reduce the permeability. In this method, three types of seal coat have been used :

1. Seal coat type A for open graded PC.
2. Seal coat type B for open graded PC.
3. Slurry Seal Type II.

3.12.2 Gradation for these three types of materials are given below respectively

3.12.2.1 Seal Coat Type A and Type B for open graded PC.

Table 25: Gradation for Seal coat Type A and Type B

Seal Coat	Aggregate Size	Quantity per 10 m^2 of road surface
Type A	NMAS 6.7 mm	0.09 m^3
Type B	Fine aggregates (2.36 mm passing 180 micron retain)	0.06 m^3

3.12.2.2 Slurry Seal Gradation

Table 26 : Gradation used for the Slurry Seal Type II as per the ISSA Method Mix Design

Seive Size		Percentage Passing by Weight of Aggregate						Amount of the material mix for the design
in.	Mm	Type II		mid value	Cumulative Percentage retained (%)	Individual % Retained	Weight to be taken for test of 200 gm	
		Higher Limit	Lower Limit					
3by 8	9.5	100	100	100	0	0	0	
No. 4	4.75	100	90	95	5	5	10	
No. 8	2.36	90	65	77.5	22.5	17.5	35	
No. 16	1.18	70	45	57.5	42.5	20	40	
No. 30	0.6	50	30	40	60	17.5	35	
No. 50	0.3	30	18	24	76	16	32	
No. 100	0.15	20	10	15.5	84.5	8.5	17	
No. 200	0.075	15	5	10	90	5.5	11	
Pan		0	0		100	10	20	
							200	

As per the gradation of these three types of seal coat, single laying premix carpet has been designed by mixing seal coat which is respectively 10%, 20%, 30%, 40%, 50%, 60% and 70%. by weight of premix carpet (without any seal coat on top of premix carpet).

3.13 Design data of premix carpet with single laying seal coat :

As different materials are used as in build seal coat, their various design data such as air voids, bulk density etc. are given below

Table 27 : Design data of Premix Carpet with seal coat Type A by single laying

Cold mixes premix carpet	Quantity of material required for PC (gm)	Quantity of material required for seal coat (gm)	Bulk Density G	Voids in Mineral aggregate VMA	Total voids (%) V	Air voids (%) AV
PC+ seal coat A, 10% weight of PC by single laying	13.2 NMAS→189.26 11.2 NMAS→96.98 Emulsion→ 12.74 Total → 298.98	Aggregate size 11.2 – 00 6.7 – 2.86 2.8 – 25.76 Emulsion – 2.16 Total – 30.78	2.081	30.87%	24.72%	19.9%
PC+ seal coat A, 20% weight of PC by single laying	13.2 NMAS→189.26 11.2 NMAS→96.98 Emulsion→ 12.74 Total → 298.98	11.2 – 00 6.7 – 5.72 2.8 – 51.52 E – 4.32 Total – 61.56	2.128	29.45%	22.88%	17.84%
PC+ seal coat A,30% weight of PC by	13.2 NMAS→189.26	11.2 – 00 6.7 – 8.58				

single laying	11.2 NMAS→96.98 Emulsion→ 12.74 Total → 298.98	2.8 – 77.28 E – 6.48 Total – 92.34	2.199	27.23%	20.17%	14.85%
PC+ seal coat A, 40% weight of PC by single laying	13.2 NMAS→189.26 11.2 NMAS→96.98 Emulsion→ 12.74 Total → 298.98	11.2 – 00 6.7 – 11.44 2.8 – 103.04 E – 8.64 Total – 123.12	2.25	25.68%	18.22%	12.65%

Table 28 : Design data of Premix Carpet with seal coat Type B by single laying

Cold mixes premix carpet	Quantity of material required for PC (gm)	Quantity of material required for seal coat (gm)	Bulk Density G	Voids in Mineral aggregate VMA	Total voids (%) V	Air voids (%) AV
PC+ seal coat B, 10% weight of PC by single laying	13.2 NMAS→189.26 11.2 NMAS→96.98 Emulsion→ 12.74 Total → 298.98	Aggregare size Passing 2.36 mm Retain 180 micron 28.62 E – 3.11 Total – 31.73	2.118	29.83%	23.2%	18.13%
PC+ seal coat B, 20% weight of PC by single laying	13.2 NMAS→189.26 11.2 NMAS→96.98 Emulsion→ 12.74 Total → 298.98	P 2.36 mm 57.24 R 180 micron Emulsion – 6.22 Total – 63.46	2.148	29.17%	21.82%	16.39%
PC+ seal coat B, 30% weight of PC by single laying	13.2 NMAS→189.26 11.2 NMAS→96.98 Emulsion → 12.74 Total → 298.98	P 2.36 mm 85.86 R 180 micron Emulsion 9.33 Total – 95.19	2.213	27.31%	19.19%	13.38%
PC+ seal coat B, 40% weight of PC by single laying	13.2 NMAS→189.26 11.2 NMAS→96.98 Emulsion → 12.74 Total → 298.98	P 2.36 mm 114.48 R 180 micron 12.44 Total – 126.92	2.29	25.01%	16.45%	10.22%

Fig. 8 : premix carpets, coarse aggregates and slurry seal type II mixed together

3.14 Design data of premix carpet with slurry seal Type II

Table 29: Different types of slurry sealing table no 1 IRC:SP:81-2008

Item	Type I (2-3 mm)	Type II (4-6 mm)	Type III (6-8 mm)
Quantity of slurry (kg/m^2)	4.3 to 6.5	8.4 to 9.8	10.1 to 12
Residual Binder (percent by weight of dry aggregate)	10 to 16	7.5 to 13.5	6.5 to 12

Here Type II slurry seal has been used and Residual Binder content is 7.5 to 13.5 percent by weight of dry aggregate. In this study, residual binder content of the used emulsion is 69.4%. So, emulsion content for Type II is 10.81 to 19.45 percent by weight of dry aggregate.

In this study 12 percent and 15 percent emulsion content is used for determining the property of premix carpet.

Table 30: Design data of Premix Carpet with slurry seal type II (12% emulsion content) by single laying

Cold mixes premix carpet	Quantity of material required for PC (gm)	Quantity of material required	Bulk Density	Voids in Mineral	Total voids (%)	Air voids (%)

		for seal coat (gm)	G	aggregate VMA	V	AV
PC+ slurry seal type II, 10% wt of PC by single laying	13.2 NMAS→189.26 11.2 NMAS→96.98 Emulsion → 12.74 Total → 298.98	Slurry seal type II – 28.62 E – 3.43 Total – 32.05	2.098	30.55%	23.85%	18.77%
PC+ slurry seal type II, 20% wt of PC by single laying	13.2 NMAS→189.26 11.2 NMAS→96.98 Emulsion → 12.74 Total → 298.98	Slurry seal type II – 57.24 E – 6.86 Total – 64.10	2.131	29.83%	22.32%	17.84%
PC+ slurry seal type II, 30% wt of PC by single laying	13.2 NMAS→189.26 11.2 NMAS→96.98 Emulsion → 12.74 Total → 298.98	Slurry seal type II – 85.86 E – 10.29 Total – 96.15	2.171	28.85%	20.57%	14.71%
PC+ slurry seal type II, 40% wt of PC by single laying	13.2 NMAS→189.26 11.2 NMAS→96.98 Emulsion → 12.74 Total → 298.98	Slurry seal type II – 114.48 E – 13.72 Total – 128.20	2.294	24.77%	15.42%	10.22%
PC+ slurry seal type II, 50% wt of PC by single laying	13.2 NMAS→189.26 11.2 NMAS→96.98 Emulsion → 12.74 Total → 298.98	Slurry seal type II – 143.1 E – 17.15 Total – 160.25	2.3	25.77%	15.37%	9.7%
PC+ slurry seal type II, 60% wt of PC by single laying	13.2 NMAS→189.26 11.2 NMAS→96.98 Emulsion → 12.74 Total → 298.98	Slurry seal type II – 171.72 E – 20.58 Total – 192.30	2.299	25.41%	15.22%	8.88%
PC+ slurry seal type II, 70% wt of PC by single laying	13.2 NMAS→189.26 11.2 NMAS→96.98 Emulsion → 12.74 Total → 298.98	Slurry seal type II – 200.34 E – 24.01 Total – 224.35	2.33	24.61%	13.9%	7.79%

Table 31 : Design data of Premix Carpet with slurry seal type II (15% emulsion content) by single laying

Cold mixes premix carpet	Quantity of material required for PC (gm)	Quantity of material required for seal coat (gm)	Bulk Density G	Voids in Mineral aggregate VMA	Total voids (%) V	Air voids (%) AV
PC+ slurry seal type II, 10% wt of PC by single laying	13.2 NMAS→189.26 11.2 NMAS→96.98 Emulsion → 12.74 Total → 298.98	Slurry seal type II – 28.62 E – 4.29 Total – 32.91	2.113	30.26%	23.21%	17.94%
PC+ slurry seal type II, 20% wt of PC by single laying	13.2 NMAS→189.26 11.2 NMAS→96.98 Emulsion → 12.74 Total → 298.98	Slurry seal type II – 57.24 E – 8.58 Total – 65.82	2.130	30.2%	22.58%	16.86%
PC+ slurry seal type II, 30% wt of PC by single laying	13.2 NMAS→189.26 11.2 NMAS→96.98 Emulsion → 12.74 Total → 298.98	Slurry seal type II – 85.86 E – 12.87 Total – 98.73	2.208	28.1%	19.79%	13.44%
PC+ slurry seal type II, 40% wt of PC by single laying	13.2 NMAS→189.26 11.2 NMAS→96.98 Emulsion → 12.74 Total → 298.98	Slurry seal type II – 114.48 E – 17.16 Total –131.64	2.223	27.95%	18%	11.72%
PC+ slurry seal type II, 50% wt of PC by single laying	13.2 NMAS→189.26 11.2 NMAS→96.98 Emulsion → 12.74 Total → 298.98	Slurry seal type II – 143.1 E – 21.45 Total – 164.55	2.269	26.85%	16.9%	9.76%
PC+ slurry seal type II, 60% wt of PC by single laying	13.2 NMAS→189.26 11.2 NMAS→96.98 Emulsion → 12.74 Total → 298.98	Slurry seal type II – 171.72 E – 25.74 Total – 197.46	2.279	26.82%	15.25%	8.81%
PC+ slurry seal type II, 70% wt of PC by single laying	13.2 NMAS→189.26 11.2 NMAS→96.98 Emulsion → 12.74 Total → 298.98	Slurry seal type II – 200.34 E – 30.03 Total – 230.37	2.3	26.36%	14.21%	6.74%

3.15 Comparison of emulsion content (percentage) by weight of dry aggregate between premix carpet with seal coat on top and premix carpet single laying with different seal coats (Seal Coat Type A. Seal Coat Type B, Slurry Seal Type II).

The quality and lifetime of asphalt roads with cold mix technique depend strongly on the residual bitumen content or emulsion content. Low bitumen content in the pavement makes the surface hungry and high bitumen content makes the pavement surface fatty. In the mix design method improvements should finally aim to achieve long-lasting perpetual pavements for which emulsion is one of the properties. But as excessive emulsion content makes pavement surface fatty, it damages the coarse aggregate structure and increases distance between two aggregates through excessive film thickness, and makes the pavement costly. Whereas less emulsion content makes the cold mix surface hungry and bonding between aggregates is affected for not having standard film thickness. As a result, different types of failure are observed in asphalt pavement. Main objective here is to discuss emulsion content of the premix carpet (PC+ Seal Coat type A, Type B, slurry seal Type II) have been compared and their effect on pavement.

3.16 Emulsion content in premix carpet

Emulsion content in premix carpet (coarse aggregate) is same for every premix carpet, which is made by seal coat on top and seal coat with single laying. Emulsion content of seal coat is varying here and the combined emulsion content of total mix is also varying.

3.16.1 For PC with seal coat Type A on top and seal coat type B on top

Table 32 :Combined emulsion content of Premix carpet with seal coat type A and B on top

Type of PMC	Wt of CA in PMC (gm)	Wt of seal coat aggregate as % by dry wt of aggregate		Wt of emulsion for CA(gm)	Wt of emulsion for Seal Coat	Combined emulsion content (%)
PC with seal coat type A on top	286.24	36.46 %	104.35	12.74	5.43	4.65%
PC with seal coat type B on top	286.24	23.43%	67.07	12.74	7.28	5.67%

3.16.2 Emulsion content in premix carpet with single laying seal coat (seal coat Type A and Type B)

Table 33 :combined emulsion content of Premix carpet with seal coat type A and B by single laying.

Type of PMC	Wt of CA in PMC (gm)	Wt of seal coat aggregate as % by dry wt of aggregate		Wt of emulsion for CA(gm)	Wt of emulsion for Seal Coat	Combined emulsion content (%)
PC with seal coat type A by single laying	286.24	10%	28.62	12.74	2.16	4.73
		20%	57.24	12.74	4.32	4.97
		30%	85.86	12.74	6.48	5.17
		40%	114.48	12.74	8.64	5.33
PC with seal coat type B by single laying	286.24	10%	28.62	12.74	3.11	5.03
		20%	57.24	12.74	6.22	5.52
		30%	85.86	12.74	9.33	5.93
		40%	114.48	12.74	12.44	6.28

3.16.3 Emulsion content in premix carpet with single laying seal coat (slurry seal type II)

Table 34: Type II slurry sealing table no 1, IRC: SP: 81-2008.

Quantity of slurry (kg/m^2)	Residual binder (percent by wt of dry aggregate)	Emulsion content (percent by wt of dry aggregate)
8.4 to 9.8	7.5 to 13.5	* 10.81 to 19.46

*Residual bitumen in emulsion = 69.4%

In this study, 12 percent and 15 percent emulsion content is used for determining the property of premix carpet. 10%, 20%, 30%, 40%, 50%, 60% and 70% slurry seal type II has been used with PC for single laying. The emulsion content in slurry seal type II by weight of aggregate in slurry seal is 12% and 15% in this study.

Table 35: Combined emulsion content of Premix carpet with slurry seal type II by single laying

Type of PMC	Wt of CA in PMC (gm)	Wt of slurry seal aggregate as % by dry wt of aggregate		Wt of emulsion for CA(gm)	Wt of emulsion at 12% & 15% by wt of aggregate	Combined emulsion content (%)
PC with Slurry seal type II (12% emulsion content) by single laying	286.24	10%	28.62	12.74	3.43	5.13
		20%	57.24	12.74	6.86	5.7
		30%	85.86	12.74	10.29	5.75
		40%	114.48	12.74	13.72	6.6
		50%	143.1	12.74	17.15	6.96
		60%	171.72	12.74	20.58	7.27
		70%	200.34	12.74	24.01	7.55
PC with Slurry seal type II (15% emulsion content) by single laying	286.24	10%	28.62	12.74	4.29	5.4
		20%	57.24	12.74	8.58	6.21
		30%	85.86	12.74	12.87	6.88
		40%	114.48	12.74	17.16	7.46
		50%	143.1	12.74	21.45	7.96
		60%	171.72	12.74	25.74	8.4
		70%	200.34	12.74	30.03	8.79

IV. Effect of different types and quantity of seal coat on the permeability of open graded premix carpet

Permeability of asphalt pavement is related to the pavement's durability. Main objective here is to determine the permeability of premix carpet mixed with seal coat materials on top of compacted coarse aggregate and by mixing together. If on considering permeability as the key characteristic, pavement wearing course is categorized into various types, it is possible to analyze the permeability of premix carpet from each of the categories. These categories are respectively practically impervious, low permeability and high permeability. Main objective in this chapter is an attempt towards giving a new form to the premix carpet by using different materials. Also, permeability has been considered as a measure of capability of each premix carpet.of each premix carpet.

4.1 Permeability

Permeability is the state or quality of being permeable. Permeability of asphalt pavement is a property that is important to the pavement's durability. Measuring permeability along with density will give a better indication of a pavement's durability than density alone. The presence of water for extended periods of time in the pavement is directly linked to early deterioration. Permeability or the hydraulic conductivity of the pavement, defined as the rate of flow of a fluid through a material, is usually based on Darcy's Law.

4.2 Darcy's Law

Darcy established the fundamental ideas of permeability in 1856 and focused on a term called co-efficient of permeability.

Darcy's Law can be written as

$$Q = k \cdot i \cdot A = k \cdot \frac{\Delta H}{L} \cdot A$$

where Q = rate of flow.
k = co-efficient of permeability.
i = hydraulic gradient.

A = Cross sectional area of specimen perpendicular to the direction of flow.
ΔH = head loss across the specimen.
L = Length of specimen.
The method for measuring permeability is the falling head test. This method measures the head loss over time. The co-efficient of permeability can be represented as :

$$k = \frac{a.L}{A.\Delta t} . \log\left(\frac{h1}{h2}\right)$$

k = co-efficient of permeability.
a = area of stand pipe.
L = Length of specimen.
h_1 = Water head at beginning of test.
h_2 = Water head at end of test
A = Cross sectional area of specimen
t = time between reading h_1 and h_2.

4.3 Coefficient of permeability of different premix carpets prepared with seal coat on top and seal coat by single laying.

In this study different numbers of premix carpets are prepared as per MoRTH and IRC: 14-(2004) specifications and made by mixed together the coarse aggregate with seal coat. Mainly, the objective is to determine the coefficient of permeability of premix carpet changes on keeping its coarse aggregate structure constant and by applying seal coat on top of coarse aggregate and by mixing together with different quantities or percentage of seal coat.

Fig 9: Photographs of conducted permeability test of different premix carpet samples

4.4 Test results of sample PC, PCAT and PCBT

PC means only premix carpet (20 mm) without any seal coat, only coarse aggregate structures are there. PCAT means premix carpet with seal coat Type A on top as per IRC: 14-2004 specifications. PCBT means premix carpet with seal coat Type B on top as per IRC: 14-2004 specifications.

Table 36: Co-efficient of permeability of different PC samples

Type of PC	Co-efficient of permeability
PC	1.3437 mm/s
PCAT	0.1167 mm/s
PCBT	0.1987 mm/s

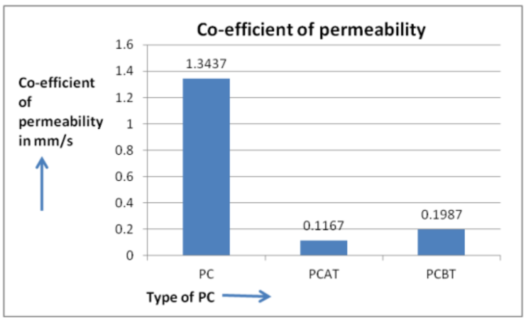

Fig. 10: Co-efficient of permeability of different PC samples

4.5 Test results of sample PCASL 10 to PCASL 40

Here PCASL 10 means premix carpet with seal coat Type A by single laying and weight of seal coat type A is 10% weight of premix carpet.

PCASL 20, PCASL 30, PCASL 40 mean premix carpet with seal coat Type A by single laying and weight of seal coat type A is respectively 20%, 30%, 40% weight of premix carpet.

Table 37: Co-efficient of permeability of different PC samples

Type of PC	Co-efficient of permeability
PCASL 10	1.0156 mm/s
PCASL 20	0.7324 mm/s
PCASL 30	0.5959 mm/s
PCASL 40	0.4934 mm/s

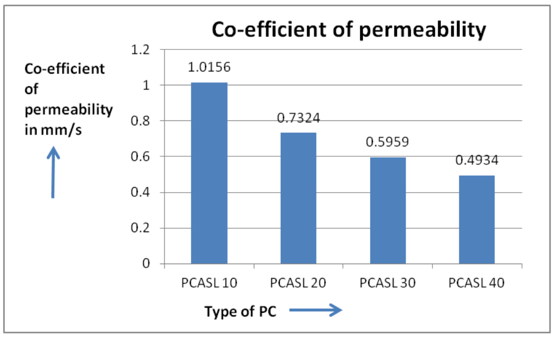

Fig. 11: Co-efficient of permeability of different PC samples

4.6 Test results of sample PCBSL 10 to PCBSL 40

Here PCBSL 10 means premix carpet with seal coat Type B by single laying and weight of seal coat type B is 10% weight of premix carpet.

PCBSL 20, PCBSL 30, PCBSL 40 mean premix carpet with seal coat Type B by single laying and weight of seal coat type B is respectively 20%, 30%, 40% weight of premix carpet.

Table 38: Co-efficient of permeability of different PC samples

Type of PC	Co-efficient of permeability
PCBSL 10	0.8924 mm/s
PCBSL 20	0.6905 mm/s
PCBSL 30	0.4850 mm/s
PCBSL 40	0.4179 mm/s

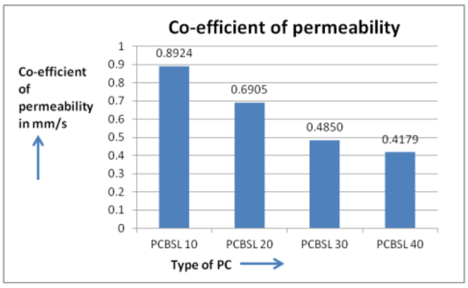

Fig. 12 : Co-efficient of permeability of different PC samples

4.7 Test results of samples PCSSA 10 to PCSSA 70 *(at 12% emulsion content)*

Here PCSSA 10 means premix carpet with slurry seal type II as seal coat by single laying and weight of slurry seal type II mixed with premix carpet is 10% weight of premix carpet.

PCSSA 20 to PCSSA 70 mean premix carpet with slurry seal type II as seal coat by single laying and weight of slurry seal type II mixed with premix carpet is respectively 20%, 30%, 40%, 50%, 60%, 70% weight of premix carpet.Emulsion content in the slurry seal coat is 12%.

Table 39 : Co-efficient of permeability of different PC samples

Type of PC	Co-efficient of permeability
PCSSA 10	0.5873 mm/s
PCSSA 20	0.4699 mm/s
PCSSA 30	0.3553 mm/s
PCSSA 40	0.3154 mm/s
PCSSA 50	0.2362 mm/s
PCSSA 60	0.1957 mm/s
PCSSA 70	0.1508 mm/s

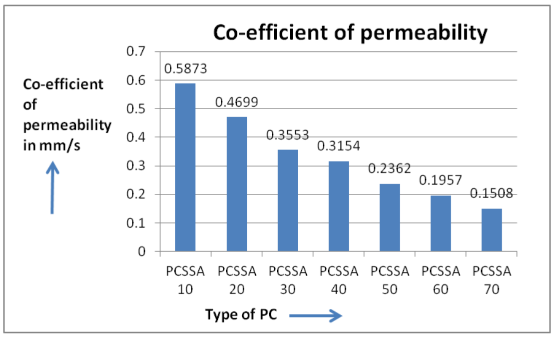

Fig. 13: Co-efficient of permeability of different PC samples

4.8 Test results of samples PCSSB 10 to PCSSB 70 *(at 15% emulsion content)*

Here PCSSB 10 means premix carpet with slurry seal type II as seal coat by single laying and weight of slurry seal type II mixed with premix carpet is 10% weight of premix carpet. PCSSB 20 to PCSSB 70 mean premix carpet with slurry seal type II as seal coat by single laying and weight of slurry seal type II mixed with premix carpet is respectively 20%, 30%, 40%, 50%, 60%, 70% weight of premix carpet.
Emulsion content in the slurry seal coat is 15%.

Table 40: Co-efficient of permeability of different PC samples

Type of PC	Co-efficient of permeability
PCSSB 10	0.5631 mm/s
PCSSB 20	0.4078 mm/s
PCSSB 30	0.3269 mm/s
PCSSB 40	0.3009 mm/s
PCSSB 50	0.2102 mm/s
PCSSB 60	0.1721 mm/s
PCSSB 70	0.1320 mm/s

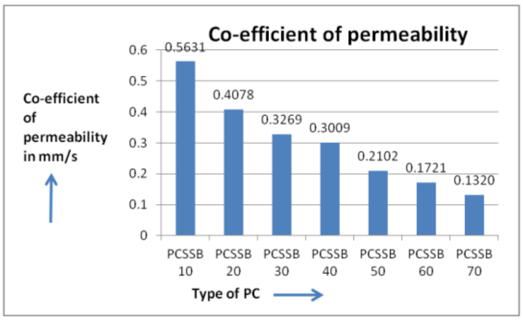

Fig. 14: Co-efficient of permeability of different PC samples

V. Summary :

Use of different types of seal coat by different quantity and different method is found very effective in the laboratory prepared cold mix premix carpet. The rate of permeability of premix carpet by single laying with seal coat is decreased with increase of seal coat quantity. The study shows that after some level the premix carpet by single laying with seal coat is giving better co-efficient of permeability value than premix carpet with seal coat on top.

VI. Comparison between premix carpet with seal coat on top and premix carpet for single laying with seal coat

Premix carpet with seal coat on top of compacted coarse aggregates is used as conventional wearing course in the road construction. It has many drawbacks. Like it is not suitable for roads in cities where surface drainage is inadequate. A sand seal coat is provided on the surface of premix carpet, it is not completely effective in making the premix carpet waterproof at the surface. Even if there is a small patch where the premix carpet has lost its sand seal, the water on roads can penetrate it at that spot, flow sideward like an open graded friction course (OGFC), and flood the entire premix carpet below the sand seal. Once the premix carpet is saturated with water, the hydraulic pressure resulting from traffic above can loosen up the sand seal in other areas of the premix carpet. The hydraulic pressure also causes stripping in the premix carpet as well as in the underlying bituminous course (Kandhal&Mallick 1999).

In this aspect, premix carpet for single laying with seal coat is able to overcome those drawbacks which can be alternative of premix carpet with seal coat on top. Main objective here is to compare premix carpet with seal coat on top and with single laying. The structural compound of premix carpet with seal coat on top and with single laying is shown in figure to have a basic difference between these two mixes.

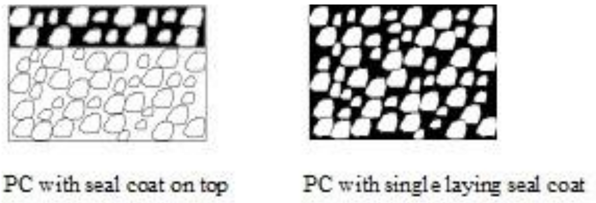

Fig 15: compound of premix carpet with seal coat on top and with single laying

VII. Comparison of properties

As per objectives of this study, permeability and air voids properties are compared between different premix carpet samples.

7.1 Comparison of properties between PC+ seal coat Type A on top and PC+ seal coat Type A by single laying.

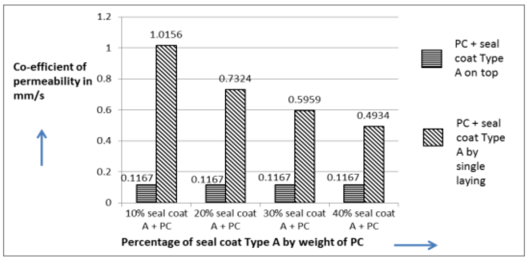

Fig. 16: Comparison of co-efficient of permeability between PC+ SC Type A on top and PC+ SC Type A by single laying.

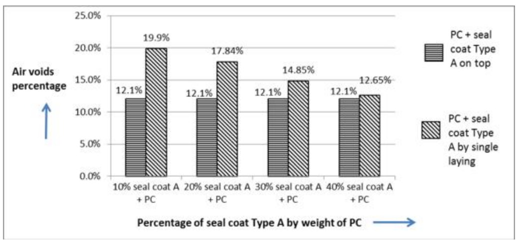

Fig. 17: Comparison of percentage of air voids between PC+ SC Type A on top and PC+ SC Type A by single laying.

7.2 Comparison of properties between PC+ seal coat Type B on top and PC+ seal coat Type B by single laying.

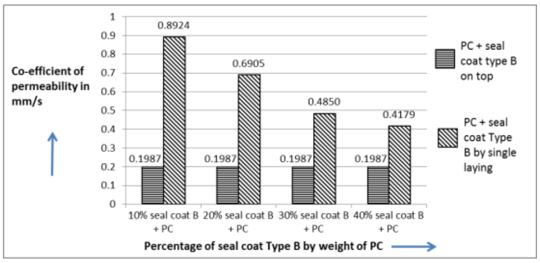

Fig. 18: Comparison of co-efficient of permeability between PC+ SC Type B on top and PC+ SC Type B by single laying.

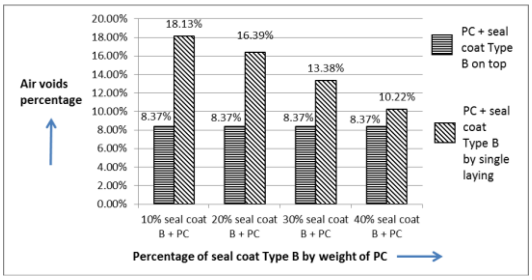

Fig. 19: Comparison of percentage of air voids between PC+ SC Type B on top and PC+ SC Type B by single laying**.**

7.3 Comparison of properties between PC+ Seal coat Type A& B by single layingwith PC+ Slurry seal Type II (emulsion content 12%) as single laying.

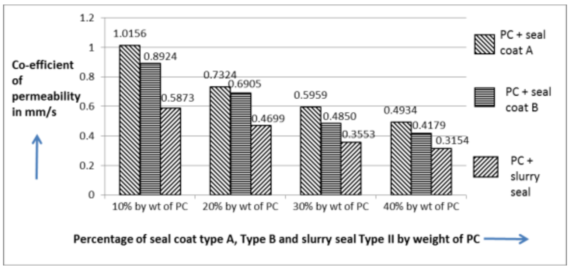

Fig. 20:Comparison of co-efficient of permeability between PC+ SC Type A& B by single laying with PC+ Slurry seal Type II (emulsion content 12%) as single laying.

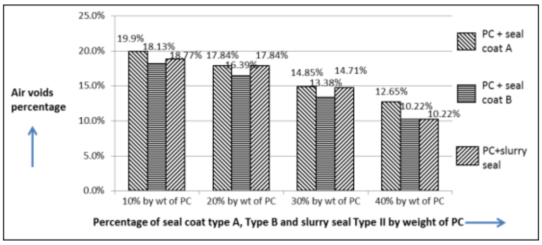

Fig. 21: Comparison of percentage of air voids between PC+ SC Type A& B by single laying with PC+ Slurry seal Type II (emulsion content 12%) as single laying.

7.4 Comparison of properties between PC+ Seal coat Type A& B by single layingwith PC+ Slurry seal Type II (emulsion content 15%) as single laying.

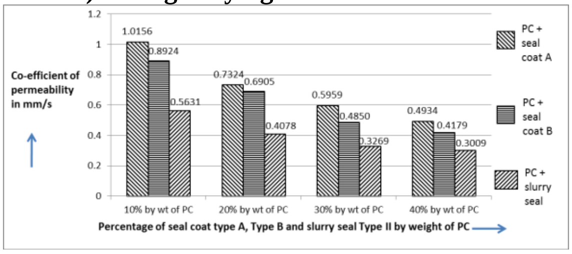

Fig. 22:Comparison of co-efficient of permeability between PC+ Seal coat Type A& B by single laying with PC+ Slurry seal Type II (emulsion content 15%) as single laying.

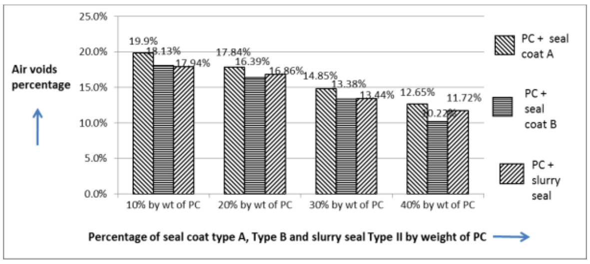

Fig. 23: Comparison of percentage of air voids between PC+ SC Type A& B by single laying with PC+ Slurry seal Type II (emulsion content 15%) as single laying.

7.5 Comparison of properties between PC+ Slurry Seal type II (12% emulsion content) as single laying seal coat and PC+ seal coat A on top and PC+ seal coat B on top.

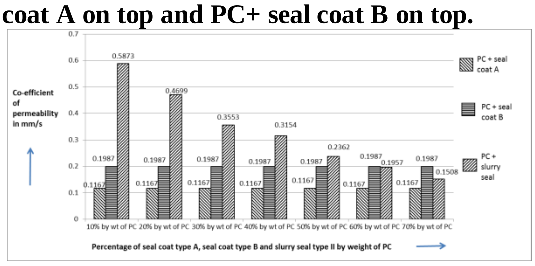

Fig. 24: Comparison of co-efficient of permeability between PC+ Slurry Seal type II (12% emulsion content) as single laying seal coat and PC+ SC type A on top and PC+ SC type B on top.

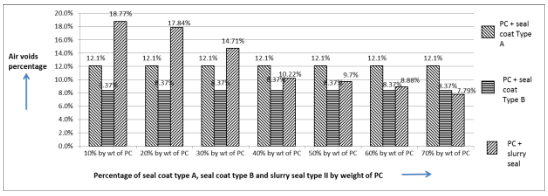

Fig. 25: Comparison of percentage of air voids between PC+ Slurry Seal type II (12% emulsion content) as single laying seal coat and PC+ SC type A on top and PC+ SC type B on top.

7.6 Comparison of properties between PC+ Slurry Seal type II (15% emulsion content) as single laying seal coat and PC+ seal coat A on top and PC+ seal coat B on top.

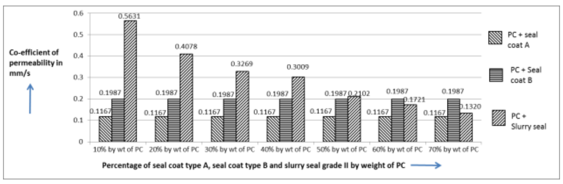

Fig. 26: Comparison of co-efficient of permeability between PC+ Slurry Seal type II (15% emulsion content) as single laying seal coat and PC+ SC type A on top and PC+ SC type B on top.

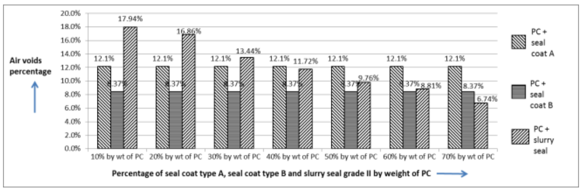

Fig. 27: Comparison of percentage of air voids between PC+ Slurry Seal type II (15% emulsion content) as single laying seal coat and PC+ SC type at A on top and PC+ SC type B on top.
[SC : Seal coat, PC : Premix carpet]

VIII. CONCLUSIONS

Based on this study, following conclusions are drawn.

(i) The basic requirement of permeability and air voids properties premix carpet with seal coat Type A by single laying upto 40% seal coat A by weight of premix carpet is not satisfied with the standard properties of premix carpet with seal coat on top which is given in MoRTH specification (2001). Upto 40% PC with single laying seal coat Type A cannot be used as paving mix in road construction. But there is a tendency to give better result after 50% weight of seal coat Type A when mixed with PC by single laying.

(ii) The basic requirements of PC+seal coat Type B by single laying upto 40% weight of seal coat by weight of PC is not satisfied the properties on PC+seal coat B on top which is given in MoRTH specification (2001). So it cannot be used as paving mix in road construction.

(iii) When premix carpet with seal coat Type A & B by single laying is compared with PC with slurry seal Type II (Emulsion content 12% and 15%), then it is observed that premix carpet+slurry seal by single laying (Emulsion content 12% and 15%) is giving better permeability property than PC+seal coat Type A & B by single laying. But while comparing air voids properties, it is seen that PC with seal coat Type B is giving lower percentage of air voids in some cases. Therefore it can be said here that although percentage of air voids is less, the co-efficient of permeability is high because here quantity of interconnected air voids is high. Due to the presence of interconnected air voids, water easily penetrates and co-efficient of permeability increases.

(iv) When premix carpet with seal coat on top (seal coat A & B) and PC with slurry seal type II (Emulsion content 12%) are compared, it is observed upto 70% slurry seal type II by weight of premix carpet when used by single laying with premix carpet, premix carpet with seal coat A on top is giving better result and upto 50%, PC with seal coat Type B is giving better result than PC with slurry seal type II by single laying. But after 50%, from 60%, PC with slurry seal type II is giving better result. When PC with slurry seal type II (Emulsion content 15%) is compared with PC+seal coat Type A & B on top, it is seen that PC+seal coat Type A on top is giving better result but difference of co-efficient of permeability is very less. If weight of slurry seal is increased by small amount or emulsion content is increased, good result can be expected from PC with seal coat Type A on top. But in the case of PC with seal coat Type B, upto 50% slurry seal when mixed with PC is giving good result but at 60% and 70%, slurry seal type II is giving better result. As per IRC: SP: 81-2008 for slurry seal type II emulsion content upto 19% (Residual bitumen content 7.5% to 13.5%), that means there is scope to increase emulsion content and in that case better result will be obtained and it can be expected that it will give better result and it is possible to fix the drawbacks of conventional premix carpet.

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