DETERMINATION OF BINDER CONTENT FOR OPEN GRADED PREMIX CARPET BY COLD MIX TECHNOLOGY

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Abstract : Open graded premix carpet is an important wearing course for low to medium volume traffic roads in India. It is a type of flexible pavement wearing course. But due to poor mechanism, lack of information regarding binder content and materials, it has been unsuccessful in giving expected results in some cases. In this study open graded premix carpet has been made by cold mix technology instead of making it by conventional and controversial method of hot mix asphalt (HMA). This study was performed to determine the optimum binder content of premix carpet by cold mix technology for better results. The properties of premix carpets were studied and compared. This is made by the range of binder content provided by Indian Road Congress for open graded premix carpet.

Keywords *Cold mix technology, binder content, optimum emulsion*

1. INTRODUCTION

Rural roads network and other road network consists most of the total road network in India. Two types of wearing course is traditionally been used for rural roads and other roads in India. They are 20 mm thick open graded premix carpet and 25 mm dense BC grading 2. Although BC grading 2 is 50% more expensive than the 20 mm thick open graded premix carpet. Government of India provides limited budget for the construction of rural roads and other roads in India. So, open graded premix carpet is the best choice for rural roads. Specifications of materials and this wearing course is standardized by Indian Road Congress. But sometimes or many times it fails to provide expected result due to poor mechanism and lack of technical improvement. The aim of this research is to study the properties of different premix carpets made by the range of binder content provided by IRC and determination of optimum binder content for open graded premix carpet by cold mix technology. As already proved many disadvantages are associated with hot mix asphalt (HMA) like production of greenhouse gases from mix plant, close down of plants during rainy season and when hauling distances are more then problem in maintaining the paving temperature. Some different mixes are being used to overcome these problems.

1.1 Objectives of the study : The main objective of the study is the determination of optimum binder content for open graded premix carpet by cold mix technology to provide technical improvement for rural and other road networks in India.

1.2 Need of the study : 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);]. Presently in India, rural roads are being constructed under PMGSY, and in these roads, use of premix carpet as wearing course is maximum. IRC specification is used for wearing course of these roads. Similarly, IRC:14-2004 is used as specification for open graded premix carpet. In that specification, binder content for open graded premix carpet by cold mix technology is given below :

Table 1: 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	

Although premix carpet is used in India, it is unsuccessful in giving expected results. The reasons held responsible for this are poor mechanism and lack of technical improvement. In this case, binder content as per IRC:14-2004 also needs technical improvement and not only this optimum binder content should be given instead of range of binder content. If binder content is lesser or greater, its inner effect will influence the property of particular wearing course.

2. 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. The main objective of the study is the determination of optimum binder content for open graded premix carpet by cold mix technology to provide technical improvement for rural and other road networks in India. The grading and quantity (volume) of materials (aggregate and emulsion) are taken from MoRTH and IRC: 14-2004 specifications.

Marshall Method of cold mix design is based on the research conducted at the University of Illinois in 1978. The main objective of Cold Mix Design is to find optimum residual asphalt content in the mix.

2.1 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)

2.1.1 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	and elongation Flakiness Index (combined)	Max 30%	29.88%	IS 2386 Part 1
Strength	Los Angeles abrasion Value	Max 40%	35.44%	IS 2386 Part 4
Strength Water absorption	Aggregate Impact test Water absorption	Max 30% Max 2%	29.69% 1%	IS 2386 Part 4 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	0.18 m^3
NMAS : 11.2 mm	0.09 m^3
Total	0.27 m^3

Required weight of NMAS: 13.2 mm for 10 m^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	Percentage retain	Volume	Bulk Density	Weight
22.4	0%	0		
13.2	10%	0.018 m^3	1680 kg/cum	30.06 kg
11.2	90%	0.162 m^3	1740 kg/cum	281.88 kg
			Total weight:	311.94 kg

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

Table 5 : Required weight of NMAS 11.2 mm

Gradation	Percentage Retain	Volume	Bulk Density	Weight
13.2	0	0		
11.2	10%	0.009 m^3	1740 kg/cum	015.66 kg
5.6	90%	0.081 m^3	1780 kg/cum	144.18 kg
			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	
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 Passing180 micron Retain)	0.06 m^3

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

Table 8: Quantity of seal coat type A

Gradation	Percentage Retain	Volume	Bulk Density	Weight (kg)
11.2	0	0		
6.7	10	00.009 m^3	1780 kg/cum	16.02
2.8	90	0.081 m^3	1863.23	150.92
			Total:	166.94 kg / 10 m^2

Required weight of seal coat Type B, for 10 m^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

2.1.2 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. There are various grade of emulsion. 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 Infracon pvt 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

2.2 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 12: 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 13: 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)
Table : Combination of different binder quantity required for NMAS 13.2 mm and NMAS 11.2 mm.

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 14 : 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.

Sample Name	Aggregate weight								
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%

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.

Figure 2 : Bulk specific gravity of different samples of PC

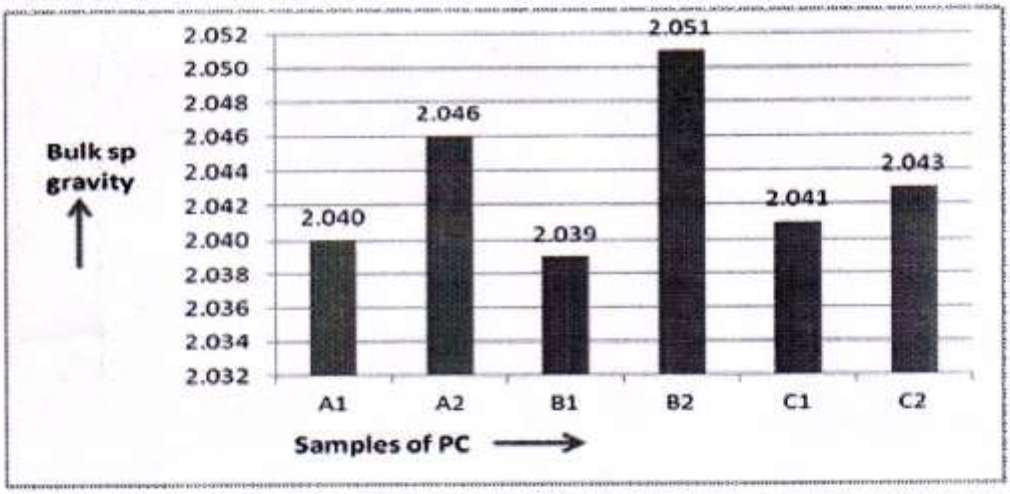


Figure 3 : Voids in mineral aggregate (VMA%) of different samples of PC

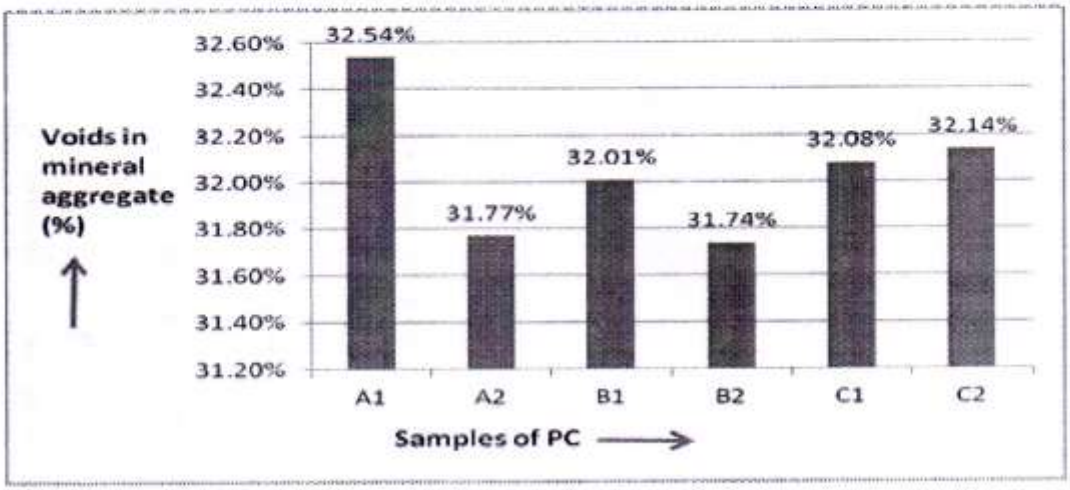


Figure 4: Total voids in percentage(V) of different samples of PC

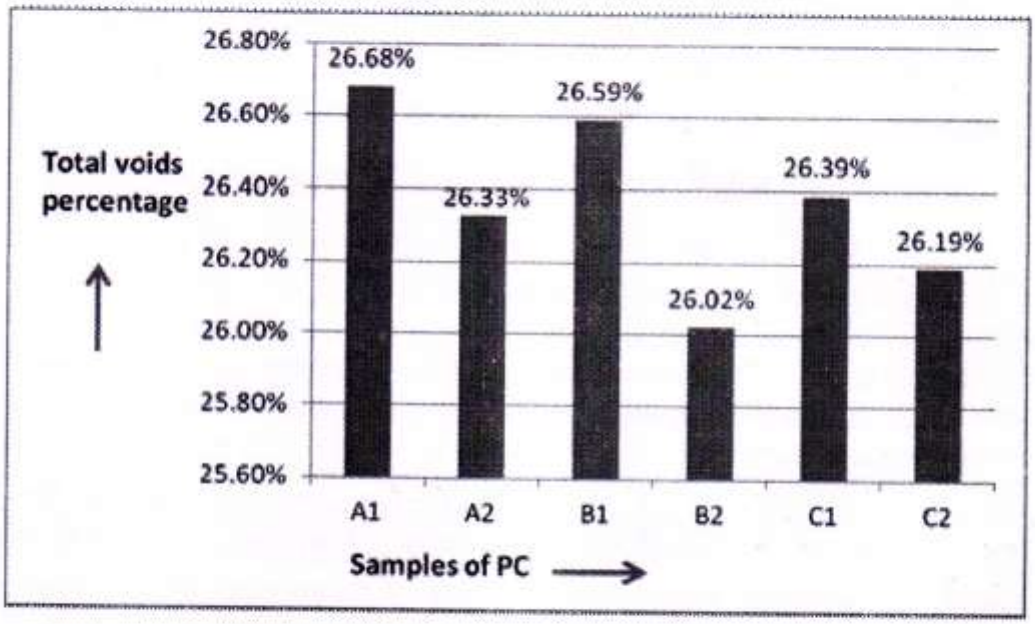
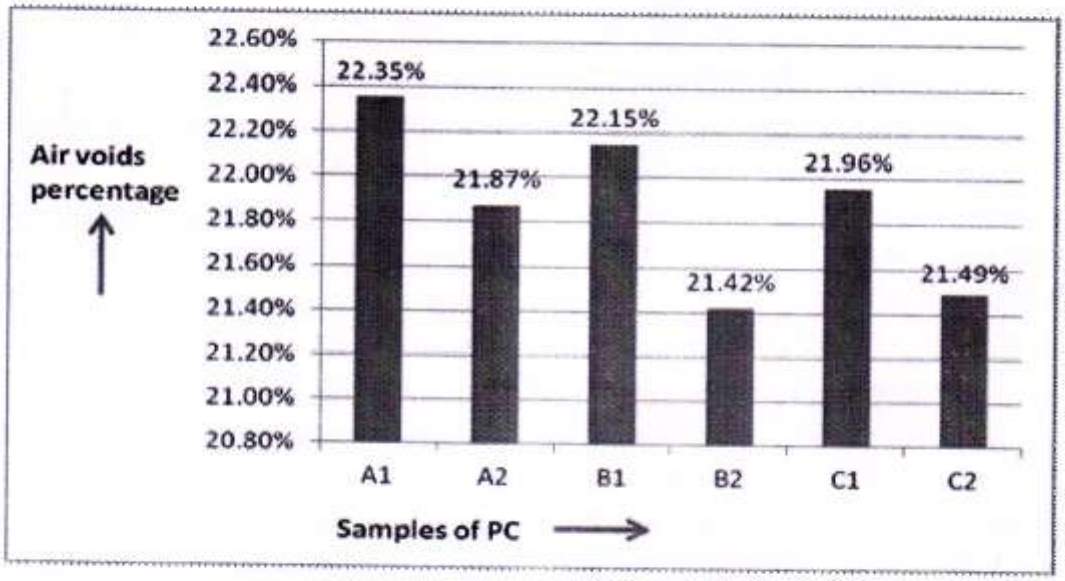


Figure 5: Air voids percentage (AV) of different samples of PC



CONCLUSION

As per IRC:14-2004, the range of binder content is given but with the fluctutation of content of bituminous materials, there are different effects on the properties of asphalt concrete. Before expecting good performance from open graded premix carpet, its mix design should be done properly by analysing its design parameters correctly at

the time of manufacturing. In that case, determination of optimum binder content is a very important part of the mix design. In this study, it has been tried to throw light upon binder content determination which is one of the important parts of mix design of open graded premix carpet by cold mix technology.

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