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Experimental Assessment of Properties of Crumb Rubber Modified Bitumen Mix (CRMB 55) With and Without Application of Nanotechnology Additive

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ABSTRACT: In the post globalization era, India is witnessing significant growth in every sector which is evident by rapid growth in infrastructure developments. The country is building a huge network of expressways, national highways and rural roads and improvement programs involving large investments. The durability of the road surfaces depends largely on the type and quality of bitumen used and quality control exercised in the production, transportation, mixing, and compaction, to cope up with ever changing rapid growth of laden vehicles with time posing heavy stresses on roads. It is the prime responsibility of researchers, contractors to use such material which modifies the properties of Bitumen and imparts additional strength, elasticity and other beneficial properties to make it better able to withstand high traffic loads, extreme weather conditions and other forms of stresses. Previous studies on CRMB 55 for moderate climatic areas suggest that use of it leads to excellent pavement life, driving comfort and low maintenance.

In this present study, initially paper deals with scientific analyses physical properties for crushed stone aggregate for Dense Bituminous Macadam (As Per MoRTH Table: 500-8). Properties are carefully accessed of CRMB 55 with and without addition in small doses of Chemical Zycosoil to fulfill the basic requirements of standard codes. Different mix design characteristics were determined out using Marshall Method for Dense Bituminous Macadam using CRMB 55 with and without addition in small doses of Chemical Zycosoil.

KEYWORDS: CRMB 55, Dense Bituminous Macadam, Marshall Mix Design, Zycosoil.

I. INTRODUCTION

The growth rate of vehicles is the backbone of economic development of any country. India is the second fastest growing automobile industry in the world. These have brought excitement amongst business leader over the potential enormous vehicle industry and have drawn attention of likely future course of environmentalists and pavement engineers too. Here lies the utmost important responsibility of highway engineer in world to implement sustainable solutions in the road construction industry which is paramount as one of the major research topics. The road needs to be updated to meet the quality and quantity of performance to sustain repeated vehicle loadings, climatic changes and riding quality. Bitumen modification is needed to sustain the stresses of vehicles with other changes in properties. CRMB 55 is a special type of bitumen obtained from HINCOL, Savli, Vadodara which is prepared for improving the properties by blending with crumb rubber and special type of additives to make the material resistant to temperature variations, weathering and high traffic loads. CRMB 55 for dense bituminous macadam design is taken into consideration and careful analysis of necessary properties of it, moisture susceptibility and DBM mixes with and without Zycosoil chemical additive in suitable doses is carried out.

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II. LITERATURE REVIEW

Prof. Justo et al (2002), at the Centre for Transportation Engineering of Bangalore University compare the properties of the modified bitumen with ordinary bitumen. It was observed that the penetration and ductility values of the modified bitumen decreased with the increase in proportion of the plastic additive, up to 12 percent by weight. Therefore the life of the pavement surfacing using the modified bitumen is also expected to increase substantially in comparison to the use of ordinary bitumen.

Shankar et al (2009), crumb rubber modified bitumen (CRMB 55) was blended at specified temperatures. Marshall's mix design was carried out by changing the modified bitumen content at constant optimum rubber content and subsequent tests have been performed to determine the different mix design characteristics and for conventional bitumen (60/70) also. This has resulted in much improved characteristics when compared with straight run bitumen and that too at reduced optimum modified binder content (5.67 %).

S.D.Katara, C.S.Modhiya, N.G.Raval (2014) stated that fly ash and waste tyre of vehicles is one of the most industrial waste residues in India. Fly ash is the main solid waste discharged by coal-fired power plant. In India, the annual emission of fly ash is more than 0.3 billion tons, and it is one of the main industrial waste residue. The use of four wheeler, two wheeler vehicles etc. is increasing day by day. As a result amount of waste tyres also increasing. Waste tyres in India are categorized as solid or hazardous waste. It is estimated that about 60 per cent of waste tyres are disposed via unknown routes in the urban as well as rural areas. This leads to various environmental problems which include air pollution associated with open burning of tyres and aesthetic pollution. Therefore, it is necessary to utilize the wastes effectively with technical development in each field. A good design of Modify bituminous mix is expected to result in a mix which is adequately strong, durable and resistive to fatigue and permanent deformation and at the same time environment friendly and economical. A mix designer tries to achieve these requirements through a number of tests on the mix with varied proportions of material combinations and finalizes the best one. The research result shows that the Marshal method of bituminous mix design was carried out for varying percentages of Fly ash to determine the different mix design characteristics.

III. MATERIALS AND METHODS

Recognition of physical properties and characteristics assists the engineers in evaluating the different aggregates to be used in highway construction. In this paper crushed stone aggregate (coarse, fine and filler) obtained from Timba Quarry village Panchamahal, Godhra was used to prepare the dense bituminous macadam mix specimens. The material needs to correspond to best performance parameter fulfilling the ideal conditions of mix as specified in Ministry of Road Transport and Highways specifications in India. Physical Requirements for Coarse Aggregate for Dense Bituminous Macadam is shown in Table 1 and Table 2 represents various properties of Aggregates.

Table 1: Physical Requirements for Coarse Aggregate for Dense Bituminous Macadam (As Per MoRTH Table: 500-8)

Sr. No.	Property	Test	Specification	Test Result
1	Cleanliness (dust)	Grain size analysis	Max 5 % passing 0.075 IS-Sieve	Pas.37.5-Ret.24mm- 0.48
				Pas.24-Ret.14 mm- 0.78
				Pas. 14 -Ret. 7 mm- 0.88
2	Particle shape	Flakiness & Elongation Indices (Combined)	30% Max	25.65
3	Strength	Aggregate Impact Value(AIV)	27 % Max	11.50
4	Durability	Soundness		
		Magnesium Sulphate	Max 18 %	0.70%
		Sodium sulphate	Max 12 %	0.59%
5	Stripping	Coating and Stripping Bitumen Aggregate Mixtures	Min. Retained Coating 95 %	100.00
6	Atterberg's Limit	Plasticity Index	4 %Max	Non-Plastic

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Sr. No.	Property	Test	Specification	Test Result
	(As per 507.2.3)			
7	Water absorption value	Water absorption value	2 % Max	1.080

Table 2: Properties of Aggregates

Size of Aggregate	Aggregate Proportions	Bulk Sp.Gravity	Apparent Sp.Gravity	Water Absorption
50 - 28 mm	16%	2.853	2.928	0.90
28 - 22 mm	8%	2.849	2.930	0.97
22 - 14 mm	23%	2.861	2.955	1.11
14 - 8 mm	4%	2.854	2.956	1.21
8 mm down	46%	2.850	2.963	1.33
Filler	3%	2.650	-	-

Figure 1 shows graph of blended aggregate gradation of DBM mix with upper limit, mid value and lower limit. Mix proportions are also shown in the figure 1. Upper limit and lower limit are as per MoRTH Table 500-10. They are very useful to determine volumetric properties of the DBM mix.

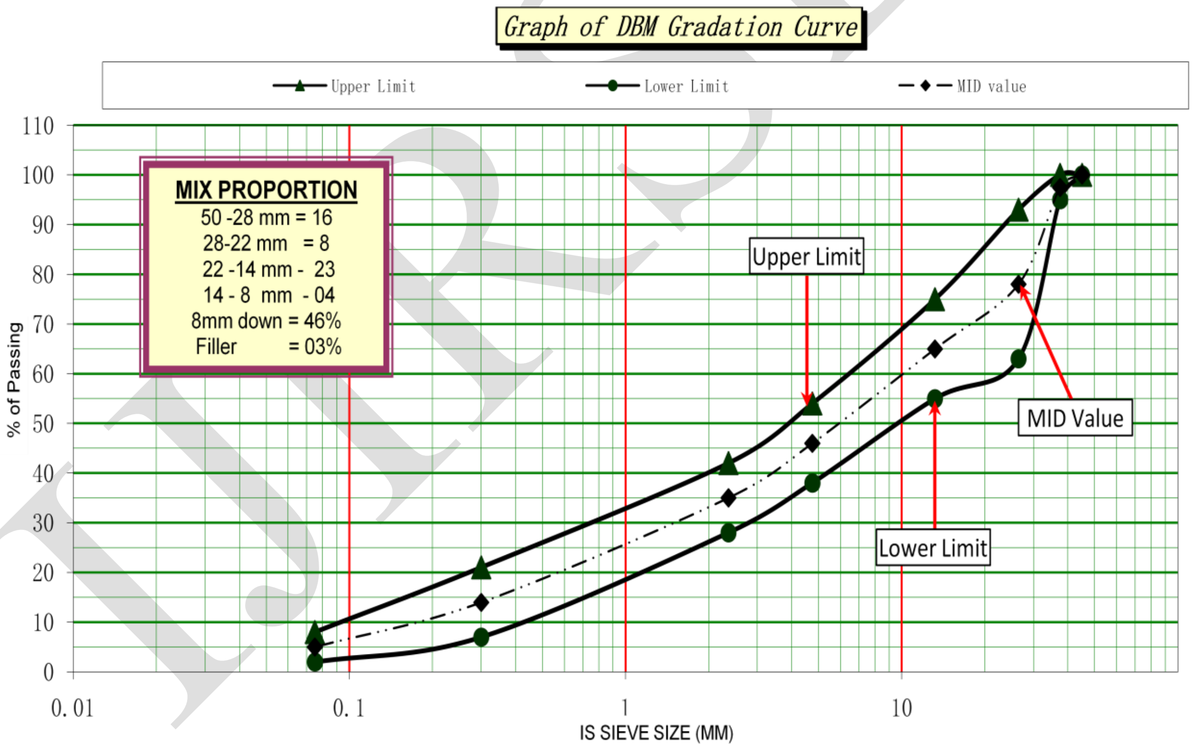

Figure 1:- Graph of DBM Gradation Curve

IV. POLYMER MODIFIED BITUMEN (CRMB 55) PLUS MODIFIER

Crumb rubber Modified Bitumen (CRMB 55) is obtained from Hincol Industry, Savli, Vadodara district, Gujarat. It is a special type of value added bitumen where the properties of are enhanced by blending with crumb rubber and

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special additives as per the provisions of IRC: SP: 53-2002 and IS 15462:2004. CRMB 55 is recommended for moderate climate areas. It has the advantage of lower susceptibility, skid resistance, better adhesion with aggregates and binder increasing the life of pavement and enhancing water resistance.

V. ZYCOSOIL AS MODIFIER

The zycosoil nanotechnology chemical is super 21st century new generation material. Zycosoil additive converts aggregate polar silanol group to non polar siloxanes i.e. water repellant alkyl siloxane surface thereby eliminating debonding of asphalt binder. Zycosoil in suitable dosages of 0.03%, 0.04% and 0.06% be added directly by weight of binder and blending to proper mixing at 175°C. Laboratory tests were conducted using CRMB 55 grade bitumen with & without Zycosoil and the test results are tabulated in Table 3.

Table 3: Summary of test results of CRMB 55 grade bitumen with and without Zycosoil

Characteristics of tests	CRMB 55	CRMB 55 + 0.03 % Zycosoil	CRMB 55 + 0.04 % Zycosoil	CRMB 55 + 0.06 % Zycosoil	Limit	Code
Penetration (mm)	54.76	50.66	49.55	49.00	< 60	IS 1203
Softening point (C°)	63.50	62.50	62.50	61.50	Min 55	IS 1205
Elastic recovery 25 (C°)	74.36	73.22	69.00	69.00	Min 50	IS 15462
Stripping Test	97	98	100	100	Min 95%	IS 6241

VI. DBM MIX DESIGN PROCEDURE

This test procedure is used in designing and evaluating DBM mixes and is extensively used in routine test programmed for the paving jobs. Suitably designed bituminous mix will withstand heavy traffic loads under adverse climatic conditions and also fulfill the requirement of structural and pavement surface characteristics. Initially the Marshall Test specimens are prepared in accordance to the standard procedure for MS-2, with selected aggregate grading and varying bitumen content are prepared and tested for evaluating Marshall Properties. Figure 2-7 shows Test property curves for hot mix design data by the Marshall method. These graphs are used to determine the Optimum design asphalt content of the mix. The optimum binder content is worked out as 4.17% for DBM Mix Design grading – 1 for which on test property curves the design parameters fitting the design Criteria's as laid down in MoRTH are determined.

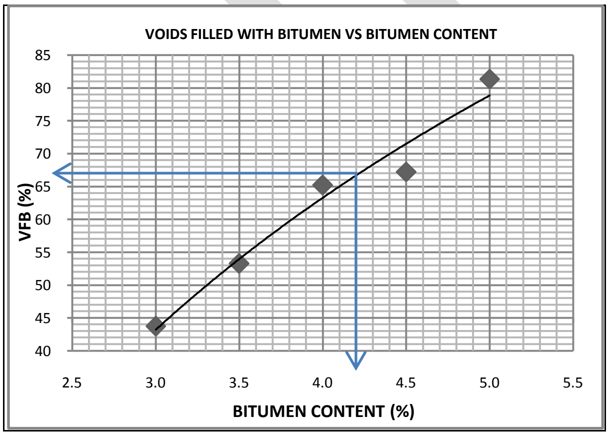

Figure 2:- Voids Filled with Bitumen V/s. Bitumen Content

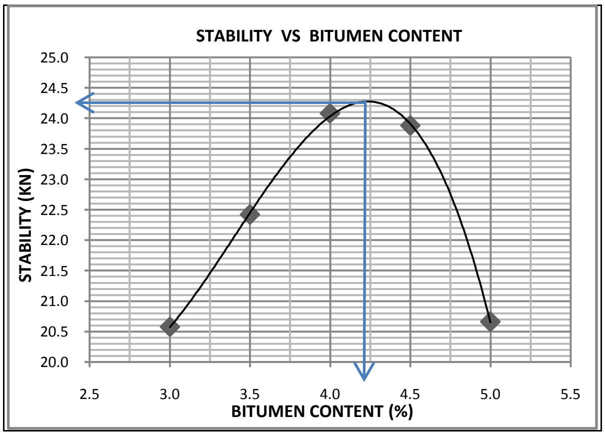

Figure 3:- Stability V/s. Bitumen Content

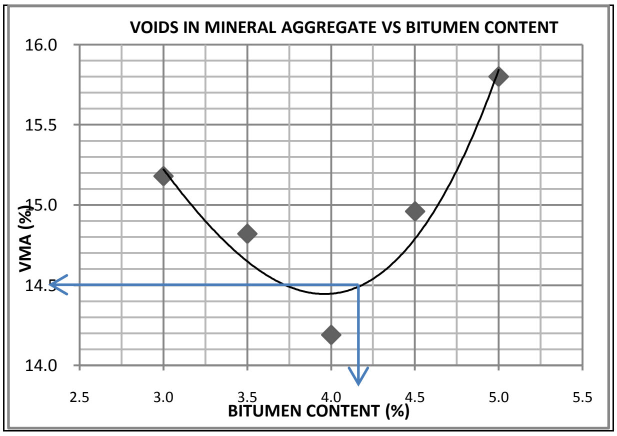

Figure 4:- Voids in Mineral Aggregate V/s. Bitumen Content

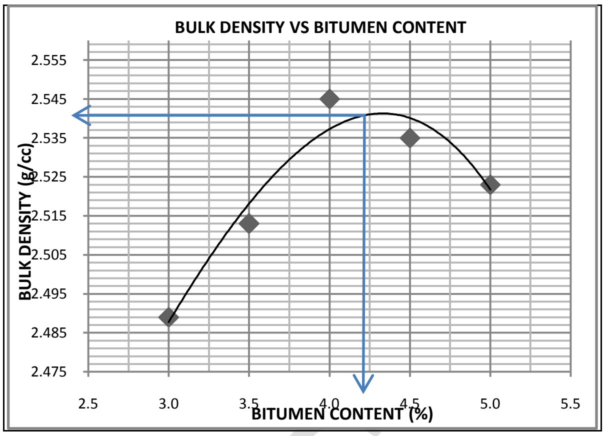

Figure 6:- Bulk Density V/s. Bitumen Content

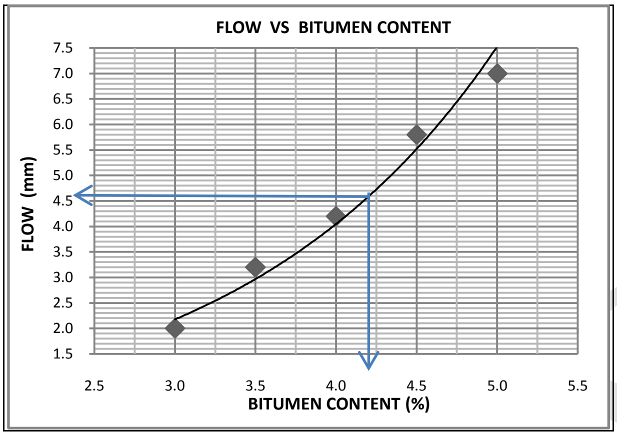

Figure 5:- Flow V/s. Bitumen Content

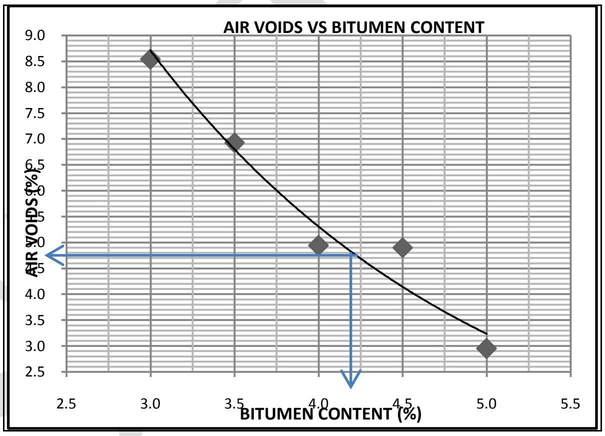

Figure 7:- Air Voids V/s. Bitumen Content

CRMB 55 bituminous mix with 4.17% optimum bitumen content is taken into consideration for following the same procedure of Modified Marshall mix design with and without addition of 0.03%, 0.04% and 0.06% dosage of Zycosoil chemical as an additive at temperature 175°C to compare properties by confirmatory test. The results are shown in Table 4.

Table 4: Abstract of Marshal Mix Design Test Values (confirmatory test)

Bitumen content by wt. of total mix %	Stability (KN)	Unit Wight in gm/cc	Flow in mm	Air Voids in %	VMA in %	VFB in %
4.17%	27.94	2.525	3.1	5.0	15.11	66.91
0.03% Zycosoil	26.88	2.528	3.4	5.0	14.80	66.22
0.04% Zycosoil	28.91	2.535	4.0	4.51	14.26	68.37
0.06% Zycosoil	27.00	2.517	4.80	5.5	15.86	65.32
Specification Limits	20.25 KN	-----	3 - 6	3 - 6	Min.11.5	65 – 75%

VII. ASTM 3625 BOILING TEST

Both the cohesive properties of the CRMB 55 and the adhesion of it to the aggregate surfaces may affect as a result of exposing the bituminous mixtures to moisture. Moisture may damage the pavement causing premature failure of pavement owing to de-bonding of bitumen film from aggregate. The test samples (Regular & with Zycosoil) are prepared as per standard procedure and are kept at room temperature condition. Rapid boiling test method was carried out to determine moisture sensitivity on prepared samples (regular & with Zycosoil) done at 100°C for 10 min, 30 min, 1 hr and 6 hr and the results are shown in Table 5. The results are judged on the basis of a visual rating.

Table 5: Test Sample at 100°C

Test Sample at 100°C	10 min	30 min	1 hour	6 hour
4.17% asphalt binder by weight of mix(without Zycosoil)	97%	97%	96%	95%
4.17% asphalt binder containing Zycosoil (0.03%) by weight of mix	98%	98%	98%	97%
4.17% asphalt binder containing Zycosoil (0.04%) by weight of mix	100%	100%	99%	99%

4.17% asphalt binder containing Zycosoil (0.06%) by weight of mix	100%	100%	99%	98%

Specification : <95% Fails

VIII. CONCLUSIONS

The key indicators of the study after careful assessment of critical laboratory studies within the design criteria's of codal provisions indicates the improvement of performance of DBM crumb rubber modified bituminous mix 55 grade is increased with the addition of Zycosoil nanotechnology chemical as an additive compared to only CRMB 55 mix is as shown:

1. The penetration is a measure of hardness or softness of material. The study reflects that the properties of CRMB 55 changes with the addition of Zycosoil chemical in required doses, as value of penetration decreases material becomes stiff. Also condition of temperature susceptible to increase the workability of bituminous mix is enhanced. With 0.04 % dosage of Zycosoil chemical the change with elastic recovery is also noted indicating more flexibility to the binder and to increase the life of pavement at low temperature.
2. Role of volumetric parameters are utmost important and is associated with careful gradation of aggregates for proper interlocking to increase shear resistance of mix for long life of pavement. Due care of small compaction under traffic loads can be taken up by adequate voids in without causing bleeding and decrease in stability. Looking to the data after scientific investigation in laboratory regarding the confirmatory test of Marshall mix design using CRMB 55 with 0.04 % Zycosoil chemical reflects the significant rise in stability, unit weight and flow values for better compaction and enhancing the workability conditions.
3. Boiling test showed at 0.04% Zycosoil additive incorporation into DBM mixtures helps to resolve the high level of moisture damage that was noted in the control mix.

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