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INFLUENCE OF ZYCOSIL IN COLD MIX DESIGN OF DBM (Dense Bituminous Macadam)

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Abstract - *Rapid increase of urban population in India with rapid rise in industrialization needs high demand of vehicles. Road sectors are very important for the growth of economy, employments and empowerment of a country. Approximately 40% roads are unpaved of total road lengths. The natural bitumen shows failure and serious problems during rainy seasons. The treatment and strengthening of bitumen is required to keep the pavement surface serviceable. Zycosil a Nano material recently used as an additive to strengthen the pavement.*

In this study, we are looking forward to use zycosil as additives in DBM mix along with cement as filler. Various cold mix samples were prepared at different percentages of binder content (7%, 8%, 9% and 10%).These samples were tested for Marshall Values. These Marshall values were used to compute the optimum bitumen content of the mix. The optimum bitumen content was found to be 8% for DBM mix. Zycosil additive was added at varying percentage (0.02%, 0.03% and 0.04%) to this optimum bitumen content. Upon addition of zycosil to the optimum bitumen content, the Marshall stability values of the mix increases significantly. Hence it is suggested to use it in the flexible pavement construction.

Key Words: **Marshal Stability & flow characteristics, DBM, Zycosil, Cold mix.**

1. INTRODUCTION

Road networks are the main element of transportation system which acts as a key element of economy of the country. Roads should be capable to take heavy loads and meets the demand of road user with enhanced performance of pavement. Researchers are continuously trying to improve the pavement with appropriate quality, better life time and stability. Bituminous mixes are most commonly used all over world in the construction of pavement. Because of rapid increase in population, modernization, urbanization and industrial revolution the number of vehicle with higher axle load which are responsible for putting high stresses over limiting available roads causes greater distress resulting in decreasing serviceability and it directly increases the resource consumption and maintenance cost. In order to overcome these problems the modification of binder is a choice to meet the increasing traffic demand with appropriate pavement quality. The material used as modifier is capable to resist the variation in temperature. The road industries are therefore looking forward for a modifier which is helpful to design a suitable Marshall Mix for flexible pavement as per MORTH guideline to meet the requirement of long life pavement with less distress and should be eco-friendly. In order to meet the above requirement the waste and chemical are used as a modifier or additives [4]. There are many studies carried out on zycosil chemical as additives in the pavement design [5]. Various studies have been conducted to study the effect of zycosil on the optimum bitumen content for different pavements.it showed favourable results upon addition of zycosil to the mix. Effect of Zycosil with cold mix emulsion binder content on Marshall Properties of dense bituminous macadam (DBM) design to improve the strength of pavement As per Indian specifications {MORTH (5th Revision)}[7]

2. Literature review:

Bala Raju Teppala, C.B. Mishra and Dinesh Kumar (2015): In this paper the authors have first examined the engineering properties assessable for pulverized stone, fillers, and VG10 evaluation bitumen for blend outline. Marshall Method for DBM received to figure out the ideal bitumen content. For VG10 bitumen blend ideal bitumen substance is mulled over for modified Marshall Mix outline by addition of 0.03%, 0.04% and 0.06% measurement of zycosil chemical and tried to focus on the key properties according to the code provision that VG10 grade bitumen with 0.06% zycosil chemical can be suggested for flexible pavement in colder

Sarkar et al., (2014) stated that the weak materials like over burnt bricks are used as a coarse aggregate in bituminous concrete pavement construction when it is treated with Zycosil. The optimum bitumen content is high in case of over burnt brick as compared to conventional mix because of higher porosity and roughness of over burnt brick. Stability value is increased by 30% in case of over burnt brick aggregates when it is treated by Zycosil.

Daxesh Makwana, Sanjay Jadav,Prof. C.B. Mishra (2015): New Creative Material needs to be used in research facility before it can be proposed for thruway development .the present paper hence edifies the technique to figure out ideal bitumen content by Marshall mix outline strategy for BC blend acquired in research centre examination obliged doses of zycosil compound in 0.02%, 0.03% and 0.04% is includes and changes in properties are recorded.

Abhijit Mondal and Prof. Rajan Choudhary: (2012): Paper presents the mix design of cold mixes for use in different course of pavement such as BC Mix DBM Mix. The paper

provides information on the different additives which are usually used to increase the performance of cold mix .it also gives the result of same earlier studies on cold mix. It also highlights the scope of using cold mix. Cold mix is used in a colder regions and these eco-friendly environment. Cold mix give batter results with the some additives.

3. Materials used

The following section covers the description of the coarse aggregate, fine aggregate, bitumen and additives used in the study.

Aggregates:

For preparation of cold mixes, test of aggregates and gradations of aggregate for dense bituminous gradation macadam (DBM) was taken as per MORTH (Table 500-36) and IRC: SP: 79 specifications given in table 1 and table 2 respectively.

Coarse Aggregates:

Raw materials consist of stone chips were collected from a local source. Aggregates up to 4.75 mm are IS sieve size was used as coarse aggregate. Its specific gravity was found to be (19, mm) are 2.78, and (6, mm) are 2.87 as per IS: 2386 (Part-III) procedures. Standard test was conducted to determine some other physical properties and is summarized in table 1.

Fine Aggregates:

Raw materials consisted of stone crusher dusts were collected from a local crusher. Aggregates with fractions passing 4.75 mm and retained on 0.075 mm IS sieve was used as fine aggregates. Its specific gravity was found to be (dusts) is 2.74 as per IS: 2386 (Part-III) procedures.

Filler:

Raw materials for stone crusher dusts were collected from a local crusher while fly ash, lime and Portland slag cement (Grade 43) were collected from local market. Stone dust, slag dust, hydraulic cement, hydrated lime, fly ash and some other mineral materials can be used as filler. Filler should passing 100% through 0.06 mm sieve, 95-100 % through 0.30 mm, 70% through 0.075 mm sieve size. It should be sufficiently dried to flow freely at the time of sample preparation. Here in this study cement is used as mineral filler.

Binder Content:

Cationic slow setting (CSS) Bitumen emulsion collected from the reliable source was used in this investigation to prepare the samples.

Zycosil as modifier-

The chemical additive used as modifier in this study is zycosil. It is Nano material (size 50-100 nm) water soluble compound that forms water clear solution. Zycosil reaction leads to the permanent Nano siliconization of the surfaces by converting the water loving silanol groups to water repellent siloxane bonds. The Si-O-Si siloxane bond is nature's strongest bond and lasts longer .Zycosil's reactive bonding ability with the aggregates and asphalt helps to almost eliminate stripping of aggregates.

4. Methodology-

Different materials are such as aggregates, Cement, zycosil an additives and bituminous emulsions are collected from their quarry and different tests on aggregates are being conducted such as Impact Test, Crushing Test, Los Angeles Abrasion Test and Specific Gravity and Water Absorption Test. Further with trial and error method gradation is obtained and Marshall Specimen is prepared and Marshall Stability Test is conducted and graphical and theoretical analysis is done.

Table 1: Aggregates Properties and Test Results

Property	Test Method	Test Result
Aggregate Impact Value (%)	IS: 2386 (P IV)	14.3
Aggregate Crushing Value (%)	IS: 2386 (P IV)	13.02
Los Angeles Abrasion Value (%)	IS: 2386 (P IV)	18
Flakiness Index (%)	IS: 2386 (P I)	18.83
ngation Index (%)	IS: 2386 (P I)	21.5
er Absorption (%)	IS: 2386 (P III)	0.1

Table 2: gradations of aggregates by trial and error method for cold mix DBM

DBM JOB MIX FORMULA						
SIEVE MM	% BY WEIGHT PASSING				COMBINED GRADING	MORTH SPECIFICATION
	26.5 MM	13.2 MM	DUST	FILLER	.35A+.33B +0.30C+0.02D	
45	-	-	-	-	-	-
37.5	100	100	100	100	100	100
26.5	83	100	100	100	94.05	90-100
13.2	0	92	100	100	62.36	56-80
4.75	0	9	100	100	34.97	29-59
2.36	0	0	83.5	100	27.05	19-45
0.3	0	0	21.5	100	8.45	5-17
0.075	0	0	4.5	95	3.25	1-7

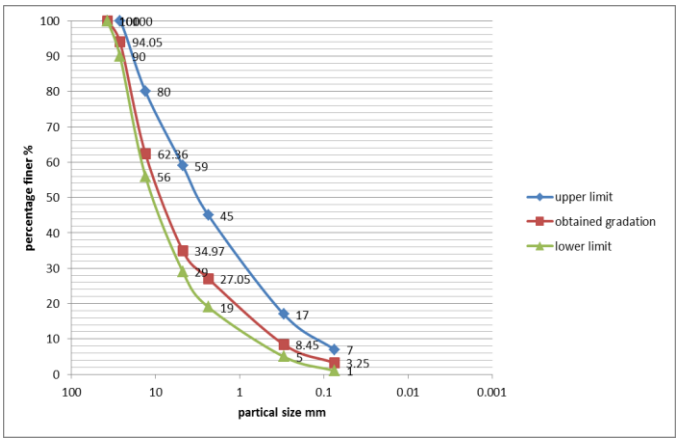

Figure: 1 Gradation Curve of aggregates for Dense Bituminous Macadam

Preparation of Marshall Samples for DBM mixes and there testing's:

The samples were cast according to standard method of casting according to Marshall Mix design. The mix proportion for each and every sample was selected according to MORTH specifications **[7].** The bitumen percentage was varied from 7% to 10% from the total weight of the mix, varying in 1% intervals. The standard number of 75 blows per each side was applied to compact the samples under the required traffic load. To average the properties, several samples were cast from each category.
A sample was cast to compare the results. The sample includes no zycosil materials. Three samples each were cast for each bitumen percentage used. The total weight of aggregates used in the mix was 1200g.the aggregate was used cold at room temperature .the moisture content was added 3% to the aggregate and mixed thoroughly. The mix was left for 10-15 minute at room temperature before adding bitumen emulsion. The emulsion was added cold to the wet aggregate and mixed thoroughly for about 2 minutes. The suitability of the mix and degree of coating was then evaluated. After mixing the mixture was kept for curing at room temperatures for 72 hours. In their study has done the compaction of the mixture by the Marshall Compaction hammer on each side of specimen 75blows. The prepared samples were extruded after 24 hours. This sample is ready for testing and found optimum bitumen binder content (OBC).

Again sample casting for optimum bitumen binder content percent of bitumen emulsion and add 2%cement filler with different proportion of zycosil additive (0.02%, 0.03%, and 0.04%) to all percentage of bitumen emulsion.

Testing the samples, all the samples were kept in a constant temperature bath for 30 minutes at the room temperature. It allows both the surface and the core of the sample to be of same temperature. The room temperature was selected in order to allow the natural condition faced in the India context. Apart from the Marshall properties, the bulk properties of the samples were determined.

Fig.2: Marshall Apparatus for Sample testing.

Table 3 :(TABLE: 500-16): Requirements for Dense Bituminous macadam Pavement Design According MORTH Specification.

Properties	Values
Marshall Stability	2.2 KN
Minimum flow	2 mm
Air voids	4 to 6 %
Voids Filled Bituminous% (VFB %)	70 -80 %
Level of compaction	75 blows
Emulsion content	7 to 10 %
Voids in mineral aggregate	DBM: 13 %

5. RESULTS

This test has been carried out to determine the Optimum Binder content for DBM mixes. Initially for DBM, gradation of aggregates is carried out as per MORTH specification and specimens are prepared with varying bitumen content. The properties incorporated with the tests which are stability, flow value, bulk specific gravity, air voids, voids filled with bitumen and voids in mineral aggregate are evaluated. The optimum binder content is worked out as 8% for DBM Mix Design.

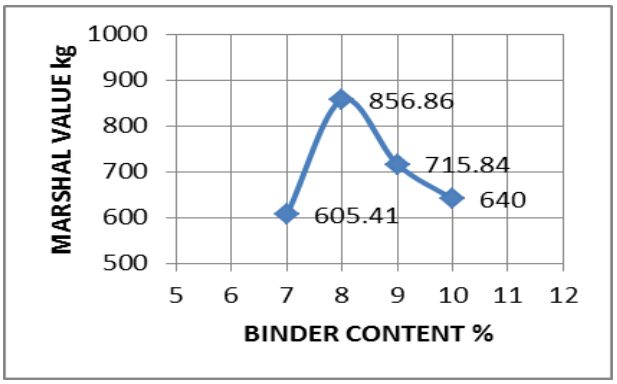

Fig.3: Variation of Marshal Stability with Bitumen

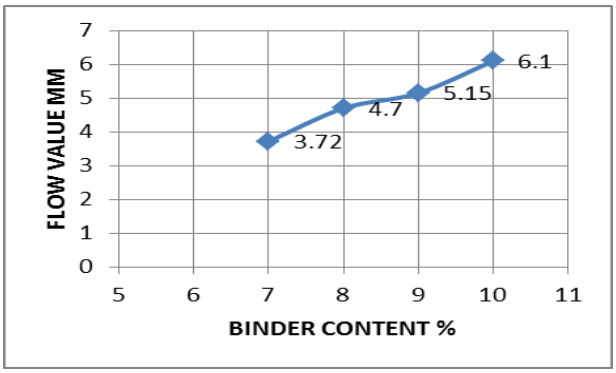

Fig.4: Variation of Flow Value with Bitumen.

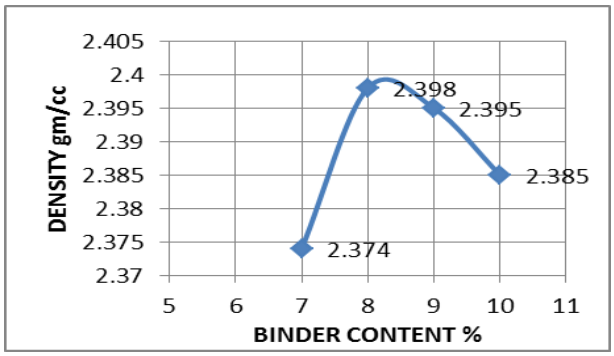

Fig.5: Variation of Density of Mix with Bitumen.

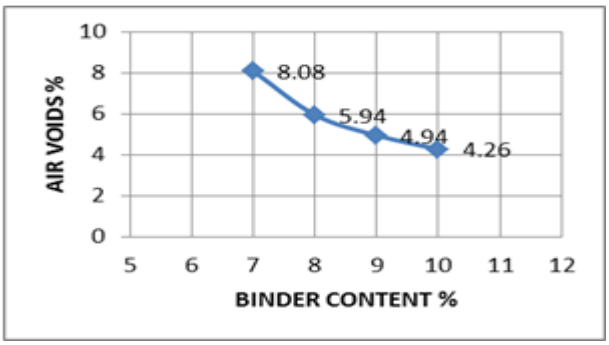

Fig.6: Variation of air voids of mix with Bitumen.

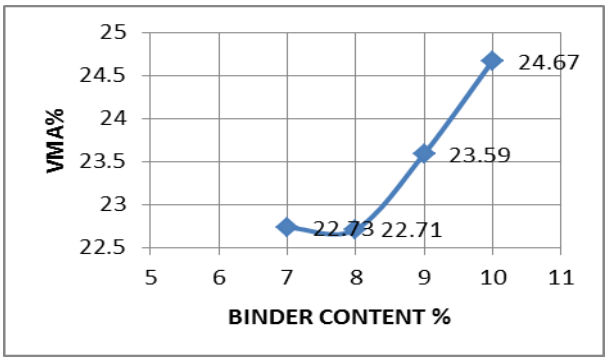

Fig.7: Variation of VMA% Value with Bitumen.

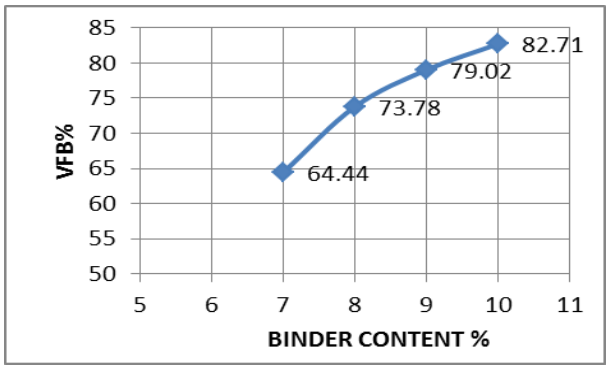

Fig.8: Variation of VFB% of mix with Bitumen.

Table 4: Comparisons of properties of mix at optimum bitumen content with Zycosil as additives at varying percentage i.e., 0.02%, 0.03% and 0.04%.

bitumen content by weight of total mix	stability (Kg)	Unit weight (gm/cc)	FLOW, mm	AIR VOIDS %	VMA %	VFB %
8.0% optimum	856.86	2.398	4.7	5.94	22.71	73.78
0.02% zycosil content	872.11	2.402	4.45	5.82	22.52	74.12
0.03% zycosil content	979.9	2.410	4.18	5.57	22.18	74.86
0.04% zycosil content	961.46	2.415	3.95	5.3	21.89	75.78
specification limit by MORTH	Min^{m}, 220 kg		min^{m} 2, mm	4 to 6	min^{m} 13 % (size 26.5mm)	70 to 80

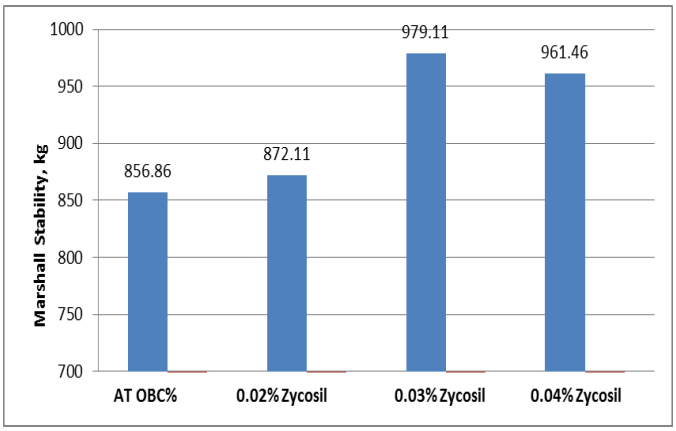

Fig.9: Variation of Marshall Stability of optimum bitumen content with zycosil content at varying percentages (0.02%, 0.03%, and 0.04%)

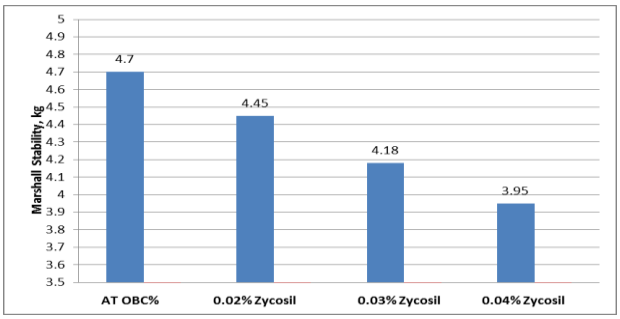

Fig.10: Variation of flow value of optimum bitumen content with zycosil content at varying percentages (0.02%, 0.03%, and 0.04%)

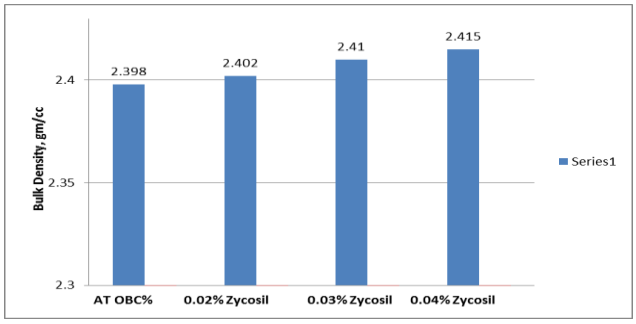

Fig.11: Variation of bulk density of optimum bitumen content with zycosil content at varying percentages (0.02%, 0.03%, and 0.04%)

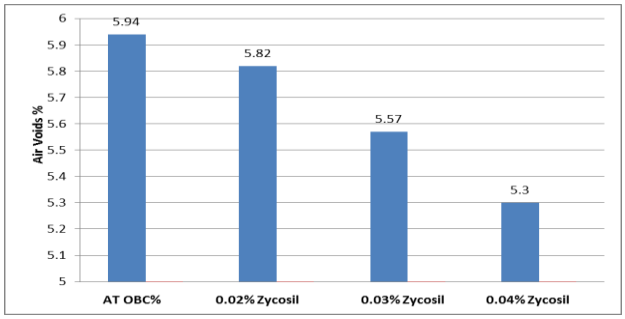

Fig.12: Variation of air voids of optimum bitumen content with zycosil content at varying percentages (0.02%, 0.03%, and 0.04%)

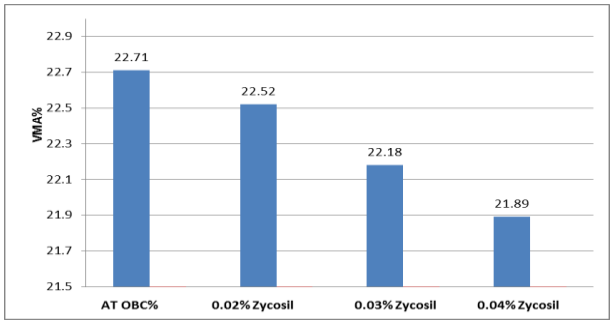

Fig.13: Variation of VMA% of optimum bitumen content with zycosil content at varying percentages (0.02%, 0.03%, and 0.04%)

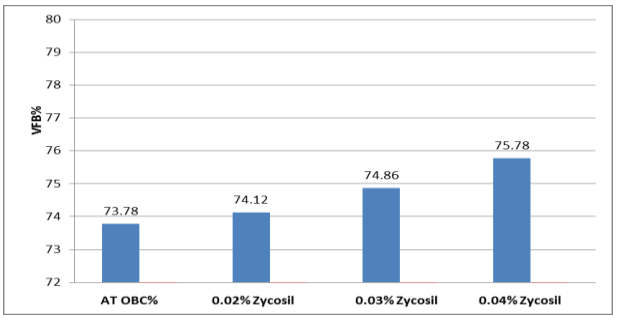

Fig.14: Variation of VFB% of optimum bitumen content with zycosil content at varying percentages (0.02%, 0.03%, and 0.04%)

Discussion:

1. The optimum bitumen content percentage obtained from the above results is 8%
2. The mix design value such as Marshall stability (856.86kg), flow value (4.7 mm), bulk density (2.398, gm/cc), air voids (5.94%) , voids filled with bitumen VFB%, (73.78%), voids in mineral aggregates VMA%(22.71%) value were found corresponding to the above optimum bitumen content percentage.
3. Varying percentages of zycosil (0.02%, 0.03% and 0.04%) is added to this optimum bitumen content percentage. The Marshall Stability values for these percentages of zycosil are 872.11, kg, 979.11 kg, and 961.46 kg respectively.
4. Obtained Marshall Value at 0.03% zycosil as additives is found to be 14.26 % which is higher than that of normal mix without additives
5. Flow value of DBM mix samples gradually increases with increase in bitumen content. The increase is initially slow, but later the rate increases with the increase in bitumen content. After mixing the zycosil content of 0.02%, 0.03%, and 0.04% the flow value continuously decreases due cohesive bonding of zycosil chemical. . These values are well within the ranges specified in MORTH specification.
6. The value of Maximum bulk Density Obtained is 2.398, gm/cc. After mixing the zycosil content of 0.02%, 0.03%, and 0.04%. Corresponding to these varying percentages of zycosil, the bulk density is found to be 2.402 gm/cc, 2.410 gm/cc and 2.415
7. The Air Voids (VA) decrease as we go on increasing the bitumen content. This is because with an increase in bitumen content. The bitumen continuously fills the air voids. After mixing the zycosil content of 0.02%, 0.03%, and 0.04%, VA value continuously decreases but rate of air voids slowly decreases because of the very low zycosil content mix such as 0.02%, 0.03% and 0.04%. These values are well within the ranges specified in MORTH specification.

8. Theoretically VMA should remain constant for a given aggregate gradation with respect to binder content. But practically, it is observed that at low bitumen content, VMA slowly decreases with increase in bitumen content and then increases. After mixing the zycosil content of 0.02%, 0.03%, and 0.04% the VMA value continuously decreases. . These values are well within the ranges specified in MORTH specification.
9. The Voids Filled with bitumen % (VFB %) increase as we go on increasing the bitumen content. This is because with an increase in bitumen content. bitumen continuously fills the air voids. After mixing the zycosil content of 0.02%, 0.03%, and 0.04% the VFB% value continuously increases but rate of voids filled with bitumen% slowly increases because zycosil content mixes in very low quantities such as 0.02%, 0.03% and 0.04%. These values are well within the ranges specified in MORTH specification

CONCLUSION:

It can be concluded from the present investigation that for specimen prepared by mixing cold mix binder content with different percentages of zycosil additive, the stability becomes maximum which is 979.11 kg for DBM. . These results also indicate that the cold mix binder content with zycosil as additive, in bituminous mix shows much stronger value of 14.26% increase in stability value than that of conventional mix without additive. Thus it meant that Cold Mix Dense Bituminous Macadam (CMDBM) along with zycosil additives had higher Marshall Stability values. It indicates a high stiffness mix with a greater ability to spread the applied load and the pavement being more resistant to pavement deformation. So from the present study it may be concluded that a highly stable road with eco- friendly environment service may be provided in a cost effective way by using zycosil additive with cold mix emulsion. On the other hand the problem of emission of harmful gases can be solved.

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