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"A STUDY ON WARM MIX DESIGN OF BITUMINOUS MIXES (VG-30)"

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Abstract - *The purpose of this study is mainly to find out the optimum temperature by which the bituminous concrete mix temperature is reduced through the warm mix asphalt technology. Warm mixing with additive is becoming popular because of mixing at lower temperature which reduces the fuel usage and emission of hazardous gases consequently decreases the mixing as well as compaction temperature of mix. Reduction of 20º C to 40º C have documented, such reduction have the obvious benefits of cutting fuel consumption and decreasing the production of green house gases. Also, there will improvement on performance of pavement.*

In present study, warm mix design of Bituminous Concrete, Rediset-organic additive is used as adhesion with used as a binder viscosity grade-30(VG-30). The Optimum Bitumen Content (OBC) using a binder will obtained by the Marshall Test. Then after Optimum dosage of Rediset and Temperature are found i.e., the temperature at which Rediset perform effectively. Also, comparative study is making to know the stability of Rediset with Binder. The Warm mix with VG-30 satisfied all the Marshall Stability test of bituminous mixes and well suited for construction of road with heavily traffic. Also, Laboratory testing is carried out to find the physical properties of Aggregate and bitumen test for VG-30 with and without Rediset.

Key Words: **optimum temperature, Rediset, VG-30, Bituminous, aggregate, Marshall Stability Test, asphalt technology**

1.INTRODUCTION *(Size 11 , cambria font)*

1.1 General

The area of work of this study covers laboratory study **on bitumen, bituminous mixes and bituminous mixes with additive.**

The purpose of this study is mainly concentrated to find out the optimum temperature by which the bituminous concrete mixing temperature is reduced through the **warm mix asphalt technology.**

The use of **Warm mix additive - Rediset** in bitumen VG-30 is to reduce the mixing and compaction temperature of Bituminous Concrete. The warm mix asphalt (**WMA**) is an asphalt mixture which is mixed at temperature lower than conventional hot mix asphalt (**HMA**).

Bituminous mixes prepare with conventional temperature (160°C) emit lots of fumes, odor, CO_2 and other obnoxious gases which are hazardous for Environment as well as Human Being. Also, there will be requirement of fuel to prepare mix at 160°C which is key issue due to rising of fuel cost. Also, there will be need of improve performance in bituminous pavement using modified binders.

1.2 Objectives

The main objective of the study is to focus on lowering the mixing temperature of bituminous mix by warm mix asphalt technology.

This study has carried out to meet the following Objectives:

- To improve cohesive strength of the mix thereby reduces rutting.
- To reduce mixing and compaction temperature of BC mixture.
- To check the suitability of Binders (VG-30) in Warm mix design of BC.

2. Study Methodology

2.1 Methodology

In this study Bituminous concrete mix is design for 19 mm nominal size of aggregate. The Aggregate use in the study is crusher Aggregate from Quarry and VG-30 used as binder. First, Laboratory testing is carried out to find the physical properties of Aggregate by conducting tests like Grain size

analysis, Aggregate Impact value, Abrasion Test, Crushing value test, Flakiness and elongation Index (combined), Water absorption, Specific Gravity etc. Also, by sieve analysis the Gradation of Aggregate has been decided which satisfied the requirement of Gradation of 19 mm nominal size of aggregate for BC design as per MORTH section 500 clause 509.

Similarly, The Bitumen test for VG-30 with and without Rediset has been done including Penetration test, Softening Point test, Elastic Recovery Test, Viscosity, Specific Gravity etc which satisfied the requirement of IS: 73-2006 "VG-30 Bitumen- Specification".

Secondly, prepared samples for Marshall Mix design and determine the Optimum bitumen content for mix using VG-30. After determining the OBC prepare sample at 110°C, 120°C, 130°C temperature and different dose of Rediset like 1.5%, 2.0%, and 2.5%. Based on this the Optimum Temperature and Optimum Dose of Rediset has been determined for both binders.

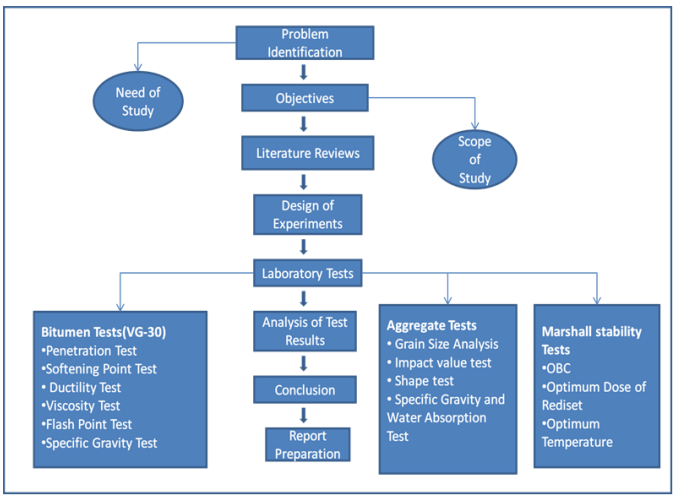

Fig - 1: shows the Study Methodology

3. LITERATURE REVIEW

3.1 MATERIALS

Rediset WMX

Warm mix asphalt is a modified hot mix asphalt mixture that is produced, placed and compacted at 10°C to 40°C lower temperature than the conventional hot mix asphalt mixture.

Warm mix is technology which gives you space to prepare bituminous mixes at lower temperature than conventional hot mix. This technology is classified in category like use of water or organic additives or Chemical additives. In this study use of Rediset WMX which is organic additives in the pellet form and does not contain water. Rediset is a combination of organic additives and surfactants that is developed to enhance the adhesion between asphalt and aggregates. The manufacturer of Rediset, AkzoNobel India Chemistry Ltd. claims that the surfactants improve the wetting ability of the asphalt binder for better coating with the aggregates, and the organic additives provide a reduction of the viscosity of the binder and a lubricating effect for easier coating and compaction. It is supplied in a pellet form that can be added at a dose rate of 1.5% to 2.5% by weight of binder. According to the recommendation of the manufacturer, a dosage of 2% by weight of asphalt is used for preparing the specimens.

Fig - 2: Photograph of Rediset Additive

Viscosity Grade-30(VG-30)

VG-30 is primarily used to construct extra heavy duty Bitumen pavements that need to endure substantial traffic loads. It can be used in lieu of 60/70 Penetration grade.

4. LABORATORY TESTS

Warm mix design of bituminous mixes start with Laboratory tests commence by finding Physical properties of Aggregate and Bitumen which must satisfied the requirement as per relevant IS codes. After that Marshall Stability test for Mix Design has been carried to determine the OBC as well as Optimum Temperature and Optimum doses of Rediset for making Warm mix design of BC.

4.1 AGGREGATE TESTS

Aggregate used in the design of BC is crusher aggregate collected from quarry. Before use of aggregate in design mix it has been tested for their physical properties consist of Hardness,

Toughness, Cleanliness, Particle shape, Water absorption, Stripping etc. All these test should be performed as per procedure in relevant IS codes. The test to be performed is enlisted as follows:

- Grain size analysis, IS: 2386 (Part 1)-1963
- Impact value test, IS: 2386 (Part 4)-1963
- Abrasion test IS: 2386 (Part 4)-1963
- Shape test, IS: 2386 (Part 1)-1963
- Water absorption and Specific Gravity test, IS: 2386 (Part 3)-1963

4.2 BITUMEN TESTS

Bitumen used in the warm as well as control design of BC is VG-30. Bitumen is used to bind the material together. Before use of bitumen in design mix it has been tested for their physical properties. All these test should be performed as per procedure in relevant IS codes. The tests to be performed are enlisted as follows:

- Penetration test, IS: 1203-1978
- Softening Point test, IS: 1205-1978
- Ductility test, IS: 1208-1978
- Viscosity test, IS: 1206-1978
- Specific Gravity test, IS: 1202-1978

4.3. GRADATION OF AGGREGATE

Grading of aggregate is carried out before mix design. For this purpose sieve analysis of aggregate is done having size 19mm, 6mm and stone dust. Grading requirement of BC for this study should satisfy the MORTH section 500 clauses 509 Table 500-18 for 19 mm nominal size of aggregate. The aggregate is sieved and final blend of aggregate has to be obtained by Heat and Trial. Grading requirement of aggregate shown in Table.

Grading	1	2
Nominal aggregate size	19mm	6mm
Layer Thickness	50-65mm	30-45mm
IS Sieve (mm)	**Cumulative % by weight of total aggregate passing**	
45	-	-
37.5	-	-
26.5	100	-
19	79-100	-
13.2	59-79	100
9.5	52-72	90-100
4.75	35-55	35-51
2.36	28-44	24-39
1.18	20-34	15-30
0.6	15-27	-
0.3	10-20	9-19
0.15	5-13	-
0.075	2-8	3-8
Bitumen content % by mass of total mix	5.0-6.0	5.0-7.0
Bitumen grade (pen)	65	65

4.4. MARSHALL TEST

4.4.1. . Marshall Stability Test

This test has been carried out to determine the Optimum Binder content for BC mixes. The properties incorporate with the test are stability, flow value, Bulk specific gravity, Air voids, Voids filled with bitumen and Voids in mineral aggregate. Marshall Requirement of bituminous mixes shown in Table 2. The Voids in mineral aggregate must satisfied the requirement as shown in Table 3.

Minimum stability (kN at 600C)	9.0
Minimum flow (mm)	2
Maximum flow (mm)	4
Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
Percent air voids	3 – 6
Percent voids filled with bitumen (VFB)	65 – 75
Loss of stability on immersion in water at 600C (ASTM D 1075)	Min. 75 percent retained strength

TABLE -2 : Marshall Requirements of Bituminous concrete

Nominal Maximum Particle size (mm)	Minimum VMA, Percent Related to Design Air Voids, (%)		
	3.0	4.0	5.0
9.50	14.0	15.0	16.0
12.5	13.0	14.0	15.0
19.0	12.0	13.0	14.0
25.0	11.0	12.0	13.0
37.5	10.0	11.0	12.0

TABLE – 3: Requirement of Voids in Mineral Aggregate

5.ANALYSIS OF TEST RESULTS

Laboratory test results has been evaluated to predict the behavior of warm mix as well as control mix and to investigate the use of Rediset in bituminous mixes has superior over control mix. Analysis of test results start from the analysis of aggregate and bitumen test results, which satisfied all the recommendation of MoRTH section 500 clause 509.

Secondly, a volumetric property of Marshall Mix design has been analyzed. Also, results of optimum temperature and optimum dose of Rediset has been analyzed while comparing with stability, bulk density and air voids.

5.1. AGGREGATE TESTS

Aggregate used in the study has been tested as per the procedure given in relevant IS codes.

All these tests should satisfy the requirement given in MORTH section 500 clauses 509 Table 500-17. Test results of aggregate shown in Table 4.

Sr. No.	Test	Result	Recommended Value as per MORTH
1	Grain size analysis	2.11%	Max 5% passing 0.075 mm IS Sieve
2	Impact Value Test	15.35%	24% MAX
3	Shape Test	29.47%	30% MAX
4	Water Absorption Test	1.47 %(20 mm) 1.83 %(6 mm) 2.04 %(Stone Dust)	2% MAX
5	Specific Gravity	2.63(20 mm) 1.75(6 mm) 1.29(Stone Dust)	---

TABLE – 4 : Aggregate Test Results

5.2. BITUMEN TESTS

Bitumen used in the study is VG-30 which has been tested as per procedure given in relevant IS codes. All the tests must satisfy the requirement of physical properties of Binders as per IS: 73-2013.
A test result of binder clearly shows that they satisfied all the requirement of binder for with and without Rediset. The testing results of plain bitumen show significant values which fulfill the requirements of relevant IS limits, hence the bitumen is appropriate to use for the Marshall mix design of bituminous concrete.

6. CONCLUSIONS

Objective: Lowering the bituminous mixing temperature through warm mix asphalt technology.

Fulfillment: The aim of the study including the experiments and the results observed here fulfill the objective of the reduction in mixing temperature of bituminous concrete by adding the warm mix adhesion additive. The temperature reduction (about 40°C**)** is observed through the laboratory experiments.

The results of Marshall Test to determine the optimum temperature represents the most suitable temperature are 120°C. The tests satisfied the Marshall properties notably at this temperature. The mixing temperature of bituminous mix is lowered from 160°C to 120°C in this study. The results of Marshall Properties for both, bituminous mix without Rediset and with Rediset, fulfilled the requirements, hence this technology is acceptable for bituminous concrete production. The results from comparative analysis represent the acceptance of bituminous concrete production at 120°C temperature by warm mix asphalt technology.

The results from bitumen penetration and viscosity tests in both the cases show that, the bitumen added with Rediset is less viscous than the plain bitumen. So, it provides better coating to the aggregate surface thoroughly. It also gives better bonding by its viscous property; hence, the adhesion is improved. It reduces the mixing efforts of bituminous mix in comparison to the bituminous mix with plain bitumen. Also, some amount of fumes is observed during mixing of hot bituminous concrete mix while in warm bituminous mix, there is no such fumes observed. It proves that this technology of warm mix asphalt production by adding Rediset is way better than the conventional production technology for hot mix asphalt in terms of energy savings and ambient working exposure. Therefore, it justified the use of this warm mix technology is appropriate.

Hence, the conclusion summarize that, the warm mix asphalt technology by Rediset can reduce the energy consumption (fuel) during the bituminous concrete production. Also, the environmental degradation by emission of toxic gases and fume generation can be decreased by this technology. And as the overall results are positive, the advantages of this technology have been cemented.

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