

Research Article

Evaluating the repercussion of Evotherm J1 as Warm Mix Bond Booster with VG 10 in Mix Design

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Abstract

Traditional hot-mix bitumen (HMA) has been the essential material utilized as a part of bitumen paving in past decades. Then again, contrasted with customary HMA mix, warm-mix bitumen (WMA) mix have indicated incredible potential, and offer advantages not given by HMA mix, subsequent to the WMA mix can deliver bitumen layers at lower temperatures, without compromising pavement performance thereby keeping up its structural integrity all through its normal expected service life when presented to the harming impacts of the environment and repeated traffic axle loads. In this paper, at first the examinations are finished to focus engineering properties of for the most part available aggregates, fillers and VG 10 assessment bitumen for mix design. Marshall Method of mix outline for DBM (Grade II) was gotten to make sense of the perfect bitumen content. For VG 10 bituminous mix perfect bitumen substance is considered for Marshall Mix diagram by addition of 0.25%, 0.5% and 0.75% estimation of warm blend added substance Evotherm J1 chemical is arranged and attempted to focus the key properties as per the codal acquirement. The lab study indicates that Marshall Mix design using WMA blend by the addition of the added substance can be carried out at reduced temperatures at 120°C. Also Moisture susceptibility test is surveyed using boiling point test.

Keywords: Air Voids (VA), Marshall Stability, Voids in Mineral Aggregates (VMA), Evotherm J1 chemical.

1. Introduction

At the beginning of 21st century there have been rising attentiveness toward environment all around the globe. Huge endeavours have been made all around the globe to diminish the emanation of this gas to evade its unsafe impact on nature later on. Consistent investigations for mechanical enhancements are being finished by the hot bituminous mix industry that would monitor assets and would progress natural stewardship. A legitimate way to deal with perform these objectives is by diminishing the creation temperature of Hot Mix Bitumen is by utilizing warm Mix Bitumen (WMA) which is a quick rising new innovation with capability of changing the generation of bitumen mixtures and compaction at 30°C to 40°C lower temperatures which brings about less energy utilization, decreased emissions, augmented paving seasons and lessened worker exposure contrasted with HMA. Evotherm J1 is an added substance, created by MeadWestvaco Bitumen Innovations, USA. It

incorporates a blend of emulsification agents, surfactants, polymers, and adhesion promoters to coating, workability, and compaction at lower temperatures. It lessens the inside rubbing between total particles amid the compaction of bituminous mix. Keeping these facts in minds it was felt that endeavours can be made to use some Evotherm J1 chemical added substance in suitable measurements as a part of VG 10 assessment bitumen and study the diverse parameters of bitumen and bituminous mix.

2. Literature Review

Presently a day's Warm Mix Bitumen (WMA) is broadly utilized everywhere throughout the world as a result of its quantities of points of interest when contrasted with Hot Mix Bitumen (HMA). In later past numerous scientists studied and developed different conventional methods for WMA. Some of these procedures are:

MeadWestvaco (2003) performed research centre study to decide relevance of Evotherm for typical paving operation utilizing total size PG 64-22. He found that expansion of Evotherm as an added substance reduce air pollution at 46% decrease in CO₂, 81% in SO_x and 63% in CO.

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Brian D Prowell, Graham C. Hurley, Everett crews (2007), predefined that warm mix added substance conveyed by an emulsion methodology were surveyed under animated stacking in three total territories of the National Center for Bitumen Technology Test Track and used as the surface mix for two of the segments. Evotherm was combined into the same mix used heretofore on the track. Set up densities of the WMA surface layers were proportional to or superior to the hot-mix dark top (HMA) surface layers, despite when compaction temperatures were diminished by 8 to 42 °C. Research facility rutting-weakness tests coordinated operating at a profit top black-top analyzer showed practically identical execution for the WMA and HMA surface blend with the PG 67-22 base dark top. In any case, research office tests showed an extended potential for dampness harm with the WMA mix.

Zun jhang (2010) concentrated on the impacts of warm mix bitumen's added substances on black-top blend attributes and bitumen execution. The essential goal of this examination is to assess the plausibility of a few WMA blends as potential bitumen paving mixtures furthermore; three surely understood WMA added substances (i.e. Sasobit, Evotherm, and Advera manufactured zeolite) were assessed.

Yu Kuang (2012) assessed the execution of Evotherm 3G as WMA innovation and as an anti-strip added substance. There are two principle targets through this examination. His first target is to assess execution of the Evotherm-J1 and the Evotherm-M1 as a compaction innovation added substance. His second goal is to concentrate on the impact of dampness anti-strip to segment of the Evotherm-J1 and the Evotherm-M1

3. Materials and Methods

Aggregates

Overwhelming outlining and mechanical properties of coarse totals are of most compelling crucial to the thoroughfare engineers for accomplishing long life pavements and overseeing significant movement loads. Predominant designing and mechanical properties of coarse aggregates are of most extreme essential to the thruway engineers for attaining to long life bitumen and managing substantial activity loads. The crushed stones (coarse and fine) picked for the research facility examinations satisfy the criteria's as set down in MoRTH. (Table 1 & 2)

Aggregate Gradation Adopted

Aggregate presents real portion of bitumen concrete. The attributes are the essential material quality variable impacting rut susceptibility. This implies coarser degrees are required to perform superior to anything better gradation. According to the failure mechanisms (Rutting), the gradations ought to be restricted between upper limit and lower limit in light of the nominal maximum aggregate size and ought to that fulfil the necessity of the Ministry of Road

Transport and Highways (MoRTH, 2004) specification for midpoint value DBM gradation for Grading-II am chosen for mix design as shown in Fig 1.

Viscosity Grade – 10 (VG-10) Plus Warm Mix Additive (Evotherm J1)

Bitumen is a non-crystalline viscous material dark/dim cocoa in shading, which is generously solvent in carbon disulphide (CS₂), having adhesive and water-sealing qualities. Bitumen is a thermoplastic material and its immovability is liable to temperature. Higher is the assessment of bitumen, the stiffer the bitumen. The pavement designers and specialists can benefit the benefit of such covers as demonstrated in MoRTH. For the study VG-10 assessment bitumen is obtained from Tiki Tar Company, Halol, Vadodara.

Warm Mix Additive Evotherm J1:

Evotherm J1 is a low viscosity dark liquid having density 0.99 gm/cm³, particular specific gravity 0.999 at 25°C. It consolidates a mix of emulsification agents, surfactants, polymers, and adhesion promoters to coating, workability, and compaction at lower temperatures which causes less energy usage, diminished emissions, enlarged paving seasons and decreased laborers exposure. The science of Evotherm J1 is custom-made to meet the broadly changing requests of WMA mixtures and paving operations. Suitable estimations of 0.25%, 0.50% and 0.75% of Evotherm J1 are incorporated particularly by weight of bitumen and blending to fitting mixing at 175°C, Table 3 shows the summary of test results of VG10 grade bitumen with and without Evotherm J1.

Outline of Dense Bituminous Macadam (Grading 2) Mix

Marshall's Method of mix design as indicated by Dense Bituminous Macadam grade - II was gotten for this study. The Marshall Test examples were masterminded by including 3.5, 4.0, 4.5, 5.0 and 5.5 each percent of bitumen by weight of total at 160°C for HMA. Compaction is completed by giving 75 blows each side as indicated by DBM-2 of the specimen. Fulfilling the standard criteria's the specimens are arranged and had a go at as indicated by the acquisitions of codal practice to center Marshall stability, flow value, voids loaded with bitumen, air voids and voids in mineral aggregate the test property for DBM mix design data is tabulated in Table 4.

The obtained bitumen content for VG bituminous mix is worked out as $(4.2\% + 4.8\%)/2 = 4.5\%$ for which volumetric properties is resolved as shown in Fig 2.

To the obtained VG 10 bituminous mix with 4.50% ideal bitumen substance is mulled over for Marshall mix design by expansion of 0.25%, 0.50% and 0.75% measurement of Evotherm J1 warm mix additive chemical at temperature 110°C, 120°C & 130°C. The summary of test results are shown in Table 5 and correspondingly the figures for Marshall Mix design curves for VG10 bituminous mix with Evotherm J1 warm mix additive are shown in Fig 3.

Table 1: Laboratory Tests

| Physical Requirements for Coarse Aggregate for Dense Bituminous Macadam grade - II (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.30.-Ret.24mm-0.33% |
| | | | | Pas.24-Ret.14 mm-0.45% |
| | | | | Pas. 14 -Ret. 6 mm-0.79% |
| 2 | Particle shape | Flakiness & Elongation Indices (Combined) | 35% Max | 25.98% |
| 3 | Strength | Aggregate Impact Value(AIV) | 27 % Max | 10.47% |
| 4 | Durability | Soundness | | |
| | | Magnesium Sulphate | Max 18 % | 0.59% |
| | | Sodium sulphate | Max 12 % | 0.29% |
| 5 | Stripping | Coating and Stripping Bitumen Aggregate Mixtures | Min. Retained Coating 95 % | >95% |
| 6 | Atterberg's Limit (As per 507.2.3) | Plasticity Index | 4 %Max | Non-Plastic |
| 7 | Water absorption value | Water absorption value | 2 % Max | 1.11% |

Table 2: Properties of Aggregates

| Size of Aggregate | Aggregate Proportions | Bulk Sp. Gravity | Apparent Sp. Gravity | Water Absorption |
|-------------------|-----------------------|------------------|----------------------|------------------|
| 30.0-24.0 mm | 12% | 2.865 | 2.952 | 1.03 |
| 24.0-14.0 mm | 22% | 2.861 | 2.956 | 1.13 |
| 14.0-6.0 mm | 22% | 2.852 | 2.952 | 1.18 |
| 6.0-0.0 mm | 44% | 2.790 | 2.914 | 1.523 |

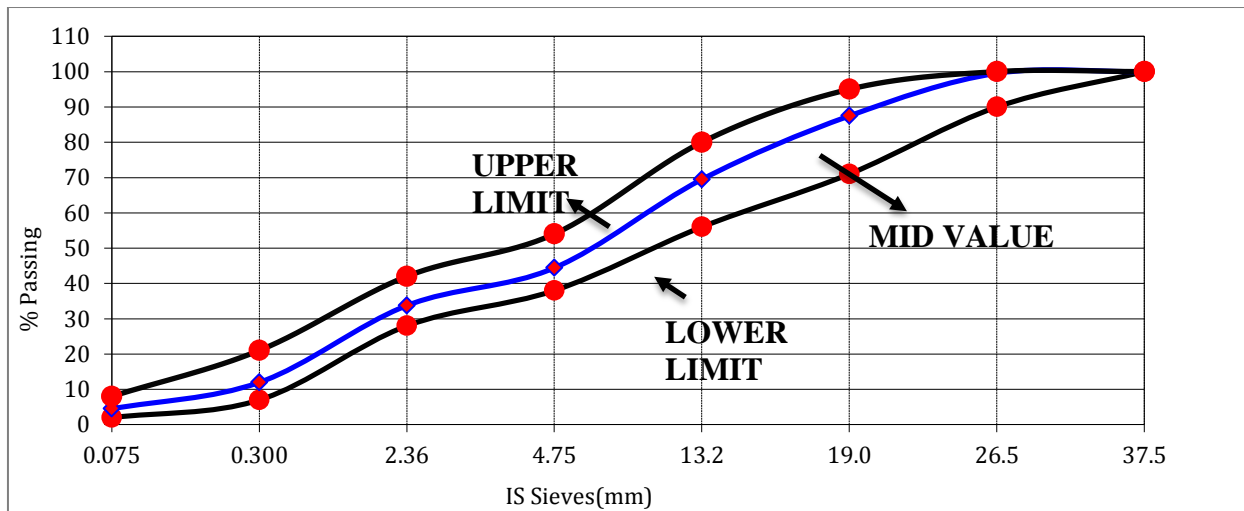


FIG 1: Gradation Curve Chart of DBM GR II (12:22:22:44)

Table 3: Summary of test results of VG 10 grade bitumen with and without Evotherm J1

| Characteristics of tests: | VG-10 | VG-10 + 0.25 % Evotherm J1 | VG-10 + 0.50 % Evotherm J1 | VG-10 + 0.75 % Evotherm J1 | Min. Limit | Code |
|-------------------------------|-------|----------------------------|----------------------------|----------------------------|---------------|------------------|
| Penetration (mm) | 81 | 54.1 | 55.4 | 55.6 | 80-100 | IS 1203 |
| Softening point (C°) | 47 | 48 | 48 | 47 | 40 | IS 1205 |
| Ductility (cm) | 98 | 82.3 | 82 | 85.5 | 75 | IS 1208 |
| Absolute Viscosity at 60 (C°) | 976 | 1740 | 1800 | 2100 | Min 800 Poise | IS 1206 (part 2) |

Table 4: Test property for DBM mix design data by Marshall Method

| % Bit. By Weight of Mix | Bulk Sp. Gr. (Gmb) | Stability (KN) | Voids in Mineral Agg. VMA (%) | Voids Filled with Bitumen VFB (%) | Flow (mm) | Air Voids VA (%) | Parameters | Binder Content 4.5 (%) |
|-------------------------|--------------------|----------------|-------------------------------|-----------------------------------|-----------|------------------|----------------|------------------------|
| 3.5 | 2.523 | 11.14 | 13.92 | 48.62 | 1.8 | 7.15 | Stability (KN) | 13.97 |
| 4.0 | 2.553 | 13.02 | 13.32 | 62.96 | 2.47 | 4.93 | Bulk Sp. Gr. | 2.577 |
| 4.5 | 2.577 | 13.97 | 12.98 | 70.37 | 3.17 | 3.84 | VA % | 3.84 |
| 5.0 | 2.574 | 11.91 | 13.53 | 75.61 | 4.37 | 3.30 | VFB % | 70.37 |
| 5.5 | 2.559 | 11.22 | 14.03 | 77.13 | 5.07 | 3.21 | VMA% | 12.98 |
| Limits | | Min 9 | 12-15 | 65-75 | 2-4 | 3-5 | Flow | 3.17 |

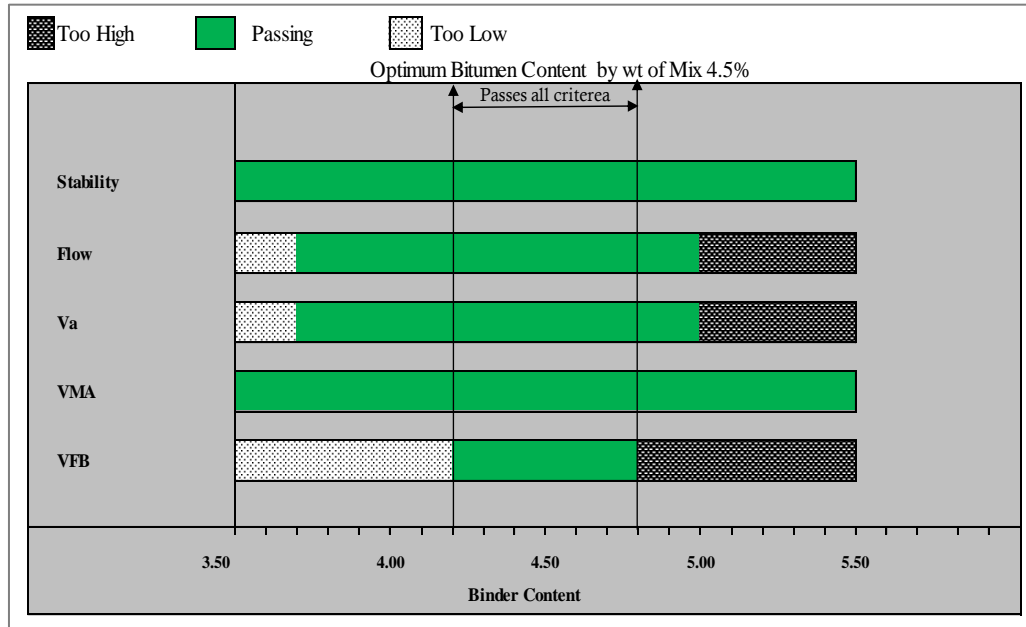
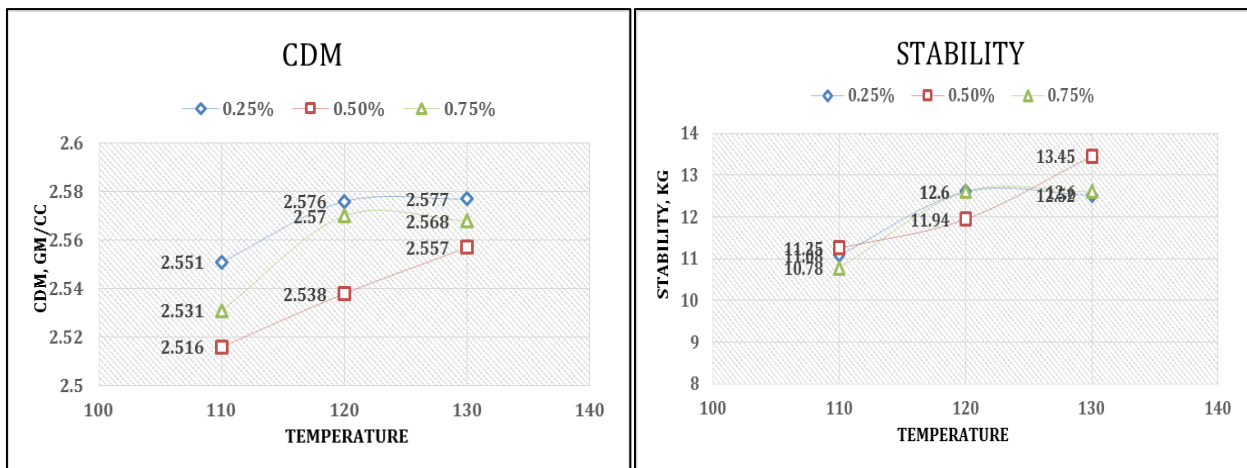


Fig.2 Narrow range of acceptable binder content for DBM mix grading-II

Table 5: Summary of test results for VG 10 + Evotherm J1 for DBM Mix Design Grading II

| Evotherm | 0.25% | | | 0.50% | | | 0.75% | | | Limits |
|---------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| Temp. | 110°C | 120°C | 130°C | 110°C | 120°C | 130°C | 110°C | 120°C | 130°C | |
| CDM,gm/cc | 2.551 | 2.576 | 2.577 | 2.516 | 2.538 | 2.557 | 2.531 | 2.57 | 2.568 | |
| Air Voids % | 4.98 | 4.14 | 4.15 | 5.62 | 5.11 | 4.67 | 4.61 | 3.31 | 3.56 | 3-5 |
| VMA, % | 13.85 | 13.01 | 12.96 | 15.03 | 14.29 | 13.66 | 14.54 | 13.21 | 13.27 | 12-15 |
| VFB, % | 64.01 | 68.22 | 67.99 | 62.61 | 64.2 | 65.83 | 68.3 | 74.97 | 73.18 | 65-75 |
| Stability, kg | 11.08 | 12.6 | 12.52 | 11.25 | 11.94 | 13.45 | 10.78 | 12.6 | 12.6 | Min 9 |
| Flow, mm | 3.5 | 3.5 | 3.50 | 2.5 | 2.07 | 2.77 | 2.8 | 2.2 | 2.17 | 2-4 |



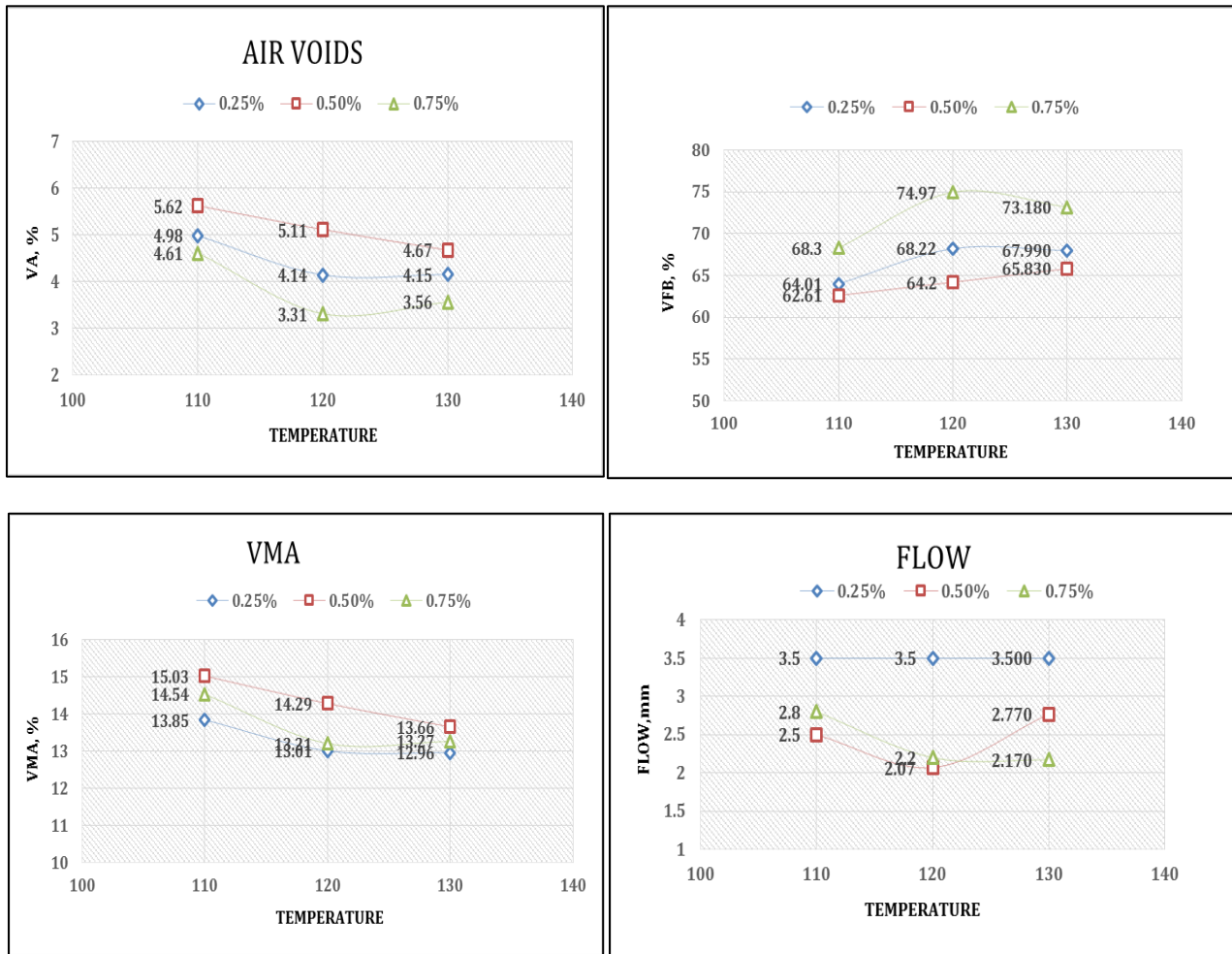


Fig 3: Marshall Mix Design Curves for VG10 Bituminous mix with Evotherm J1 Warm Mix Additive

Table 6: Boiling test showing level of stripping

| Test Sample | 10 min | 30 min | 1 hour | 6 hour |
|---|--------|--------|--------|---------------|
| 4.5% VG 10 bitumen binder by weight of mix(without Evotherm J1) | 92% | 87% | 83% | Total Failure |
| 4.5% VG 10 bitumen binder containing Evotherm J1 (0.25%) by weight of mix | 100% | 99% | 99% | 98% |
| 4.5% VG 10 bitumen binder containing Evotherm J1 (0.50%) by weight of mix | 100% | 99% | 98% | 97% |
| 4.5% VG 10 bitumen binder containing Evotherm J1 (0.75%) by weight of mix | 100% | 98% | 98% | 96% |

Specification : <95% Fails

ASTM 3625 Boiling Test

Adhesion at the interface in the middle of bitumen and aggregate is one of the main practical properties to ensure sturdiness of bituminous mix design. In any case, the adhesion can be decreased by the cohesion within bitumen lost through the vicinity of water at the bitumen/stone interface. Subjective dampness powerlessness ASTM boiling test evaluates for quick assessment of different bitumen–aggregate mixes as a relative measure of the bond quality and stripping resistance.

Boiling test is done at 100°C for 10 min, 30 min, 1 hr. and 6 hr. on free HMA samples and WMA samples

with 0.25%, 0.50% and 0.75% Evotherm J1 chemical added substance.

After the suitable brief period stress of the specimens, the sample is permitted to cool while the stripped bitumen is skimmed away. The water is depleted, and the wet samples is put on a paper towel and permitted to dry. Visual rating is directed to survey the level of stripping as shown in Table 6. This test technique is a fast system for assessing the dampness affectability of a bitumen– aggregate mixture. Be that as it may, it doesn't represent mechanical properties of the mix, and it does exclude the impacts of movement traffic action.

Conclusions

The results of the trial study show that execution of WMA balanced bituminous mix is better than that of HMA mix. Taking after key conclusions can be drawn from this study:

- 1) Looking at the scientifically evaluated test reports on aggregates for dense bituminous macadam grade – II, it shows that engineering properties are fulfilled as per MoRTH. Moreover the ideal gradation curve also indicates the fulfilment of the Ministry of Road Transport and Highways (MoRTH, 2004) specification for midpoint value DBM gradation for Grading-II is chosen for mix design. The summary of test results of VG 10 grade bitumen with and without evotherm J1 indicates that penetration quality decreases fundamentally at 0.25% rate of Evotherm J1 showing the increase in softening point temperature. Also the movements on account of Evotherm J1 substance are satisfying the properties as set down in codal provisions.
- 2) Test property curves for DBM grading - II by Marshall Method is exhibiting volumetric properties of VG 10 bituminous mix design ideally suited at 4.5% satisfying the criteria's set down in MoRTH determination. Also to obtained OBC of 4.5% required dosages of WMA Evotherm J1 0.25%, 0.50% and 0.75% for carrying Marshall Mix design, it shows that VG 10 level bitumen with 0.25% Evotherm J1 additive shows no compromise with quality thereby following the ideal requirements of MoRTH. But the reduction in temperature is noted in the mix design at 120°C which results in reduced CO₂ emissions, increased sustainability, improved working conditions for construction and maintenance crews, extended paving season and financial benefits derived through lower production costs.
- 3) The boiling point test delayed consequences of VG 10 assessment bitumen with and without Evotherm J1 shows that coating is seen to be found appealing and stayed held fast to the aggregate surface considerably following six hours which is obviously seen for VG-10 + 0.25% Evotherm J1 for stripping test. The essential objective of Evotherm J1 substance is to eliminate the moisture sensitivity of the DBM grading - II mixture by improving the bond between the bitumen binder and the aggregate so as to ensure good long term performance and the total to guarantee great long haul execution.

- 4) Hence it can be proposed for adaptable asphalts in colder districts as well, where dampness is constantly clear. It is recommended that the designers, highway contractors and the related to road advancement can profit the utilization of such added substance (VG-10 + 0.25% Evotherm J1) to upgrade the long haul execution quality while keeping up the economy for the country like our own.

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