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Research Article

# Performance Evaluation of VG 30 Paving mix with and without Zycosoil Chemical Additive

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***Abstract***

*The burgeoning urban population of India with rapid rise in industrialization coupled with high increase of road vehicles engaging in rapidly expanding cities to fit the developmental needs of the economy demands good quality of roads to cope up the increasing pressure of road traffic. It becomes the responsibility of researchers, scientists, contractors to improve the riding quality while maintaining the economy for the country like ours. In this paper, initially the investigations are carried out to determine engineering properties of locally available crushed stones, fillers and 60/70 grade bitumen for mix design. Marshall Method of mix design for DBM (grade 1) was adopted to find out the optimum bitumen content. In order to arrive at homogenous mix with required standards, VG 30 bituminous mix with obtained 4.25% optimum bitumen content is taken into consideration for Modified Marshall Mix design by addition of 0.03%, 0.04% and 0.06% dosage of zycosoil chemical is prepared and tested to determine the key properties as per the codal provision. The tests indicated the desire to opt for chemically modified DBM mix is it shows better results as compared to conventional mix hence it is suggested to use for the construction of Flexible pavement.*

***Keywords:*** *Marshall Stability, Air Voids (Vv), Voids in Mineral Aggregates (VMA), Voids filled with bitumen (VFB).*

## 1. Introduction

Growth of good road infrastructure is the backbone of the transportation system and is the key element of economy of country. The significant growth is witnessed owing to strong domestic markets, increasing purchasing power and corporate governance laws. Roads have to meet the ever increasing load carrying capacity to meet the demand of users and should show enhanced performance of pavement. Scientists and researchers are constantly concentrating to improve the pavement with desirable quality, stability and proper lifetime.

Bituminous Mixes are most commonly used all over the world in pavement construction. India has a road network of over 4,689,842 kilometers in 2013, the second largest road network in the world. About 98 % of the paved roads in India have flexible pavements, within which are included surfacing of various types and thickness.

The complicated microstructure of asphalt concrete is related to the gradation of aggregate, the properties of aggregate-binder interface, the void size distribution, and the interconnectivity of voids. For special applications where traffic is extremely heavy, stiffer mixes are required. Keeping these facts in minds it was felt that efforts can be made to use some chemical additive in (60/70) VG 30 grade bitumen and study the various parameters of bitumen and bituminous mixes.

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## 2. Objectives of the present work

The objectives of the present work involves

1. To study basic properties of aggregates and plain bitumen.
2. To evaluate the engineering properties using Marshall Stability, Marshall Flow, Retained Marshall stability index, Density, Voids in mix, Voids filled with bitumen and. The Optimum bitumen Content for the mix with and without Zycosoil chemical is determined.
3. Evaluating the Moisture susceptibility of DBM mix with and without Zycosoil chemical.

## 3. Literature review

**Anil Kumar S (2014)** studied that the development of distresses in the pavements with the conventional mixes reveals the need for use of improved materials and techniques for design specifications based on performance tests. The present investigation was carried out to propose the use of chemical. Chemical were mixed to bituminous concrete by wet process to get modified mix. Marshall Method of mix design was adopted to find out the optimum bitumen content. Marshall specimen were prepared for bitumen content of 5.0,5.5,6.0,6.5 and 7.0 per cent by weight of aggregate with 0.1% of chemical by weight of bitumen. Bulk density, Marshall Stability, Flow, Air Voids (Vv), Voids in Mineral Aggregates (VMA), voids filled with bitumen (VFB), Retained stability,

Indirect Tensile Strength and Tensile Strength Ratio (TSR), Stripping, Fatigue life and deformations were determined and compared with neat bituminous concrete mixes. The Marshall Stability, Retained stability, Indirect Tensile Strength (ITS), Tensile strength ratio, fatigue life values for modified mix was increased, similarly stripping of bitumen and rutting deformation decreased considerably as compared to conventional mix.

**Goutham Sarang (2014)** carried out on Stone Matrix Asphalt (SMA) - a gap graded bituminous mixture with high concentration of coarse aggregates and high mastic content. In this investigation SMA mixtures were prepared by Marshall Compaction (MC) and also in Superpave Gyratory Compactor (SGC) and their performances in laboratory were compared. The mixtures were prepared using Viscosity Graded (VG)–30 bitumen and a chemical named Zycosoil was used as a stabilizing additive. Volumetric properties, Marshall characteristics, behavior to moisture action etc. were determined in laboratory. From the results it is seen that gyratory compaction is the suitable method to prepare SMA mixtures.

**Sangita et al. (2011)** studied the effect of waste polymer modifier (nitrile rubber and polythene) on various mechanical properties of the bituminous concrete mixtures was evaluated. Various test results on 60/70 bitumen and aggregate satisfied the specified limits. Marshall Stability and retained stability tests confirmed the optimum WPM content to be 8%. The WPMB mix containing 8% WPM showed significant improvements in various properties of the bituminous concrete mixture. The higher values of Marshall Stability and retained stability indicated increased strength and low moisture susceptibility.

**Taher M.A. Al-Ani (2009)** studied that adding the Rubber-Silicone to asphalt binder have the following effects on the performance of asphalt mixture: Increasing the Marshal stability, air voids, and reducing the flow and bulk density compared with the original mix. Increasing the flexibility properties of the mix and this appears from reducing the permanent deformation at test temperature (600C), the reduction percentage is about (30% to 70%) compared with the original mix without adding Rubber-Silicone. Study the effect of Rubber-Silicone on the performance of asphalt mixture at low temperature.

**Sandhya Dixit (2013)** showed that the properties of bitumen such as penetration, softening point improved with the addition of the waste fiber. There is a significant decrease in penetration values for modified blends, indicating the improvement in their temperature susceptibility resistant characteristics. From the Marshall Test results, it is concluded that the Marshall Stability value increases with an increase in bitumen content from 5% to 5.5% then it decreases. Also higher value of Marshall Stability was found for a modified mix as compared to an unmodified mix.

## 4. Materials and methods

*Aggregates:* The crushed aggregates are obtained from Timba Quarry village Panchamahal, Godhra district with low water absorption saves fuel when drying the aggregates in the asphalt plant. Superior engineering and mechanical properties of coarse aggregates are of utmost important to the highway engineers for achieving long life pavements and sustaining heavy traffic loads. The laboratory investigations fulfill the criteria's as laid down in MoRTH.

*Mineral Filler:* Mineral dust resulting from the aggregate crushing operation passing the 0.075 mm IS sieve as it plays an important role in engineering properties of bituminous paving mixes to increase the stiffness of the asphalt, improve workability, maintains adequate amount of void in the mix and enhances the life of pavement.

*Aggregate Gradation Adopted:* The grading of aggregate influences the mix proportions for a specified workability and the one satisfying the requirements of MoRTH for mid value DBM gradation 1 is selected for mix design.

*Viscosity Grade – 30 (VG-30) Plus Modifier:* Bitumen is a thermoplastic material and its stiffness is dependent on temperature. Higher is the grade of bitumen, the stiffer the bitumen. VG-30 grade bitumen in lieu of 60/70 penetration grade bitumen is primarily used to construct extra heavy duty bitumen pavements that need to endure substantial traffic loads. Viscosity tests are conducted at $60^{o}$C and $135^{o}$C, which represent the temperature of road surface during summer (hot climate, similar to northern parts of India) and mixing temperature respectively. This gives an edge for greater mix of ease design and better road performance. The pavement engineers, contractors and consultants can avail the benefit of such binders as specified in MoRTH specification. For the study VG-30 grade bitumen is obtained from IOCL, Vadodara.

*Modifier:* The chemical used in the present study is Zycosoil supplied by M/S. Zydex Industries, Vadodara. Chemical nanotechnology allows water proofing of aggregate surfaces permanently and acts as a bonding agent to asphalt. Zycosoil chemically has the property to function as amines and hydrated lime to provide Mother Nature's strongest bond which cannot be displaced by water. 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.

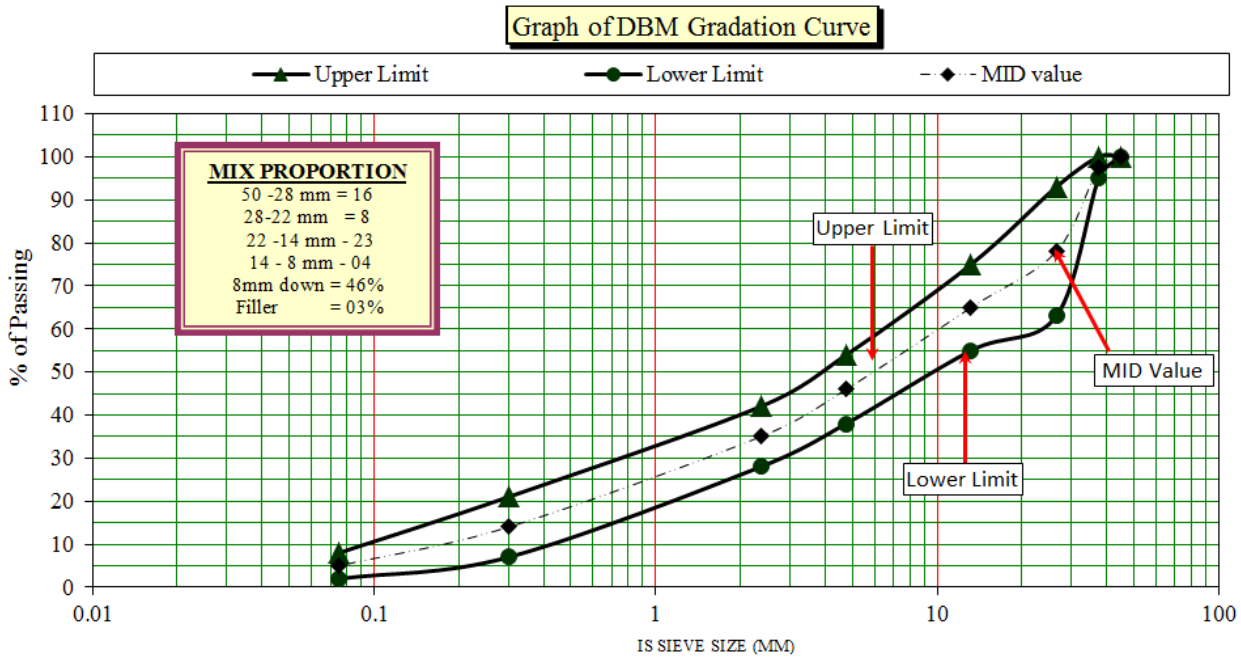
*Design of Dense Bituminous Macadam (Grading 1) MIX:* The properties of any bituminous mix like stability, bulk density, air voids, are mainly dependent on the gradation of aggregates, binder content and its type, the type of compaction and compaction temperature. Marshall's Method of mix design as per MS -2 was adopted for this study. The Marshall Test specimens were prepared by adding 3.0, 3.5, 4.0, 4.5 and 5.0 per cent of bitumen by weight of aggregates. Compaction is done by imparting 112 blows (Modified Marshall) each side as per MS-2 of the specimen. Fulfilling the standard criteria's the specimens are prepared and tested as per the provisions of codal practice to determine Marshall stability, flow value, voids filled with bitumen, air voids and voids in mineral aggregate. The optimum binder content is worked out as 4.25% for which on test property curves values of bulk specific gravity, stability, voids in mineral aggregate, voids filled with bitumen, flow value and air voids are determined.

| **Laboratory Tests** | | | | |
|---|---|---|---|---|
| **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 | 11.5 |
| 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 |
| 6 | Atterberg's Limit ( As per 507.2.3) | Plasticity Index | 4 %Max | Non-Plastic |
| 7 | Water absorption value | Water absorption value | 2 % Max | 1.08 |

| **Properties of Aggregates** | | | | |
|---|---|---|---|---|
| **Size of Aggregate** | **Aggregate Proportions** | **Bulk Sp.Gravity** | **Apparent Sp.Gravity** | **Water Absorption** |
| 50 - 28 mm | 16% | 2.853 | 2.928 | 0.9 |
| 28 - 22 mm | 8% | 2.849 | 2.93 | 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% | 2.85 | 2.963 | 1.33 |
| Filler | 3% | 2.65 | - | - |

## Summary of test results of VG 30 grade bitumen with and without Zycosoil

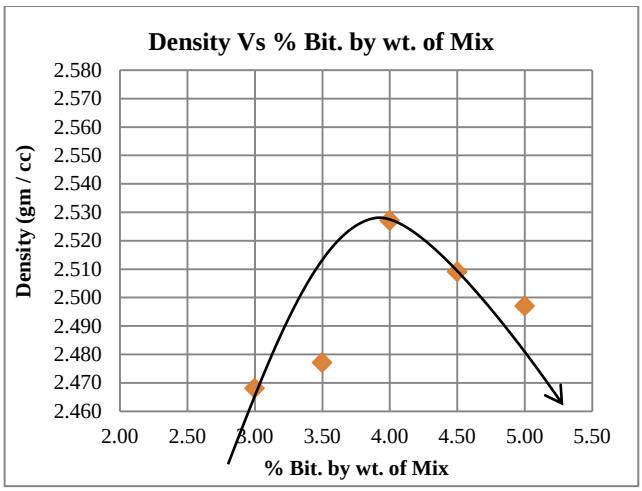
| **Characteristics of tests** | **VG-30** | **VG-30 + 0.03% Zycosoil** | **VG-30 + 0.04% Zycosoil** | **VG-30 + 0.06% Zycosoil** | **Min. Limit** | **Code** |
|---|---|---|---|---|---|---|
| Penetration (mm) | 68 | 62.67 | 59.67 | 57 | 50-70 | IS 1203 |
| Softening point (C°) | 48.7 | 49.75 | 49.75 | 55.25 | 47 | IS 1205 |
| Ductility (cm) | 87 | 81 | 83.3 | 86 | 40 | IS 1208 |
| Absolute Viscosity at 60 (C°) | 2483 | 2461 | 2458 | 2450 | Min 2400 Poise | IS 1206 (part 2) |
| Stripping Test | 90 | 95 | 100 | 100 | Min 95% | IS 6241 |

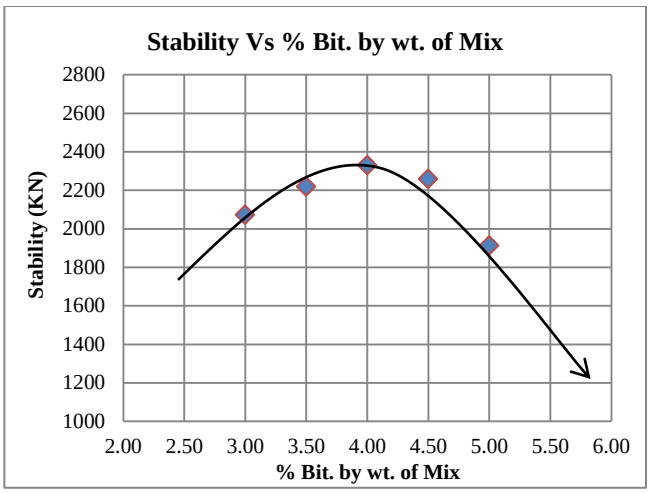


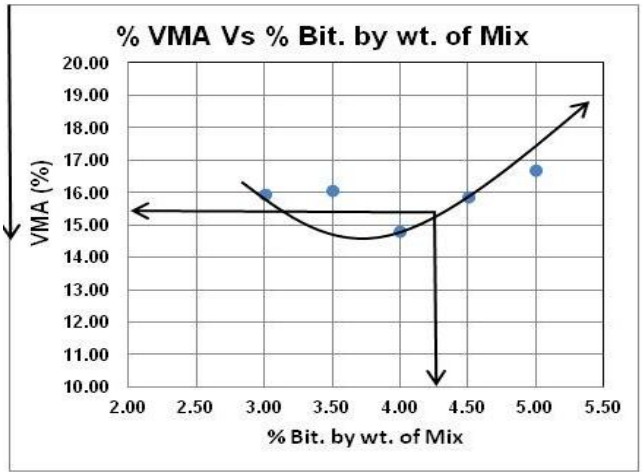
**Test property curves for DBM mix design data by Marshall Method**

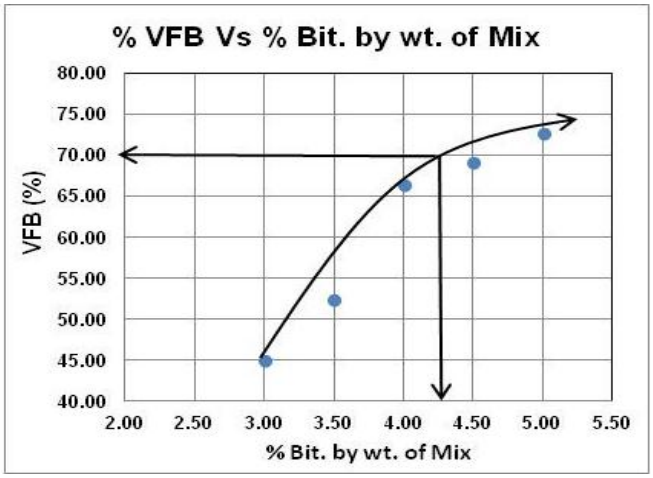
| % Bit. By Weight of Mix | Bulk Sp. Gr. (Gmb) | Stability (Kg) | Voids in Mineral Agg. VMA (%) | Voids Filled with Bitumen VFB (%) | Flow (mm) | Air Voids VA (%) |
|---|---|---|---|---|---|---|
| 3.00 | 2.468 | 2072 | 15.92 | 44.95 | 2.00 | 8.77 |
| 3.50 | 2.477 | 2218 | 16.06 | 52.25 | 3.10 | 7.67 |
| 4.00 | 2.527 | 2330 | 14.81 | 66.35 | 4.00 | 4.98 |
| 4.50 | 2.509 | 2258 | 15.85 | 69.05 | 5.60 | 4.90 |
| 5.00 | 2.497 | 1913 | 16.68 | 72.59 | 6.80 | 4.57 |
| | | | | | | |

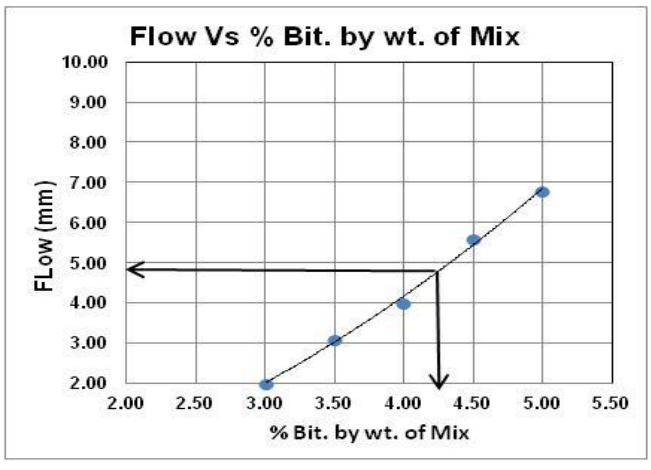
| Parameters | Binder Content 4.25(%) |
|---|---|
| Stability (Kg) | 2300.00 |
| Bulk Sp. Gr. | 2.520 |
| VA % | 4.50 |
| VFB % | 70.00 |
| VMA% | 15.25 |
| Flow | 4.8 |

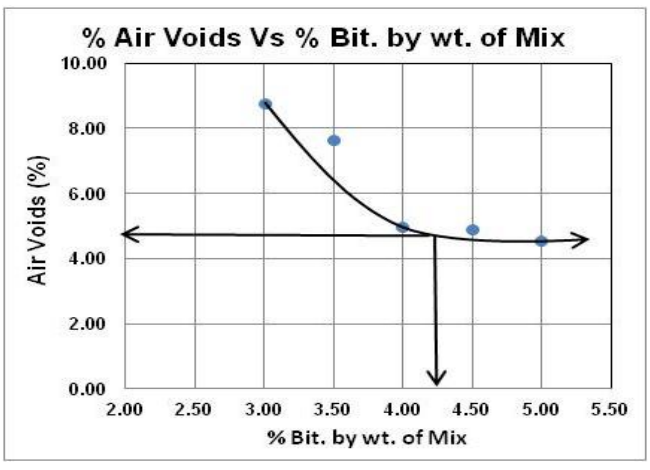


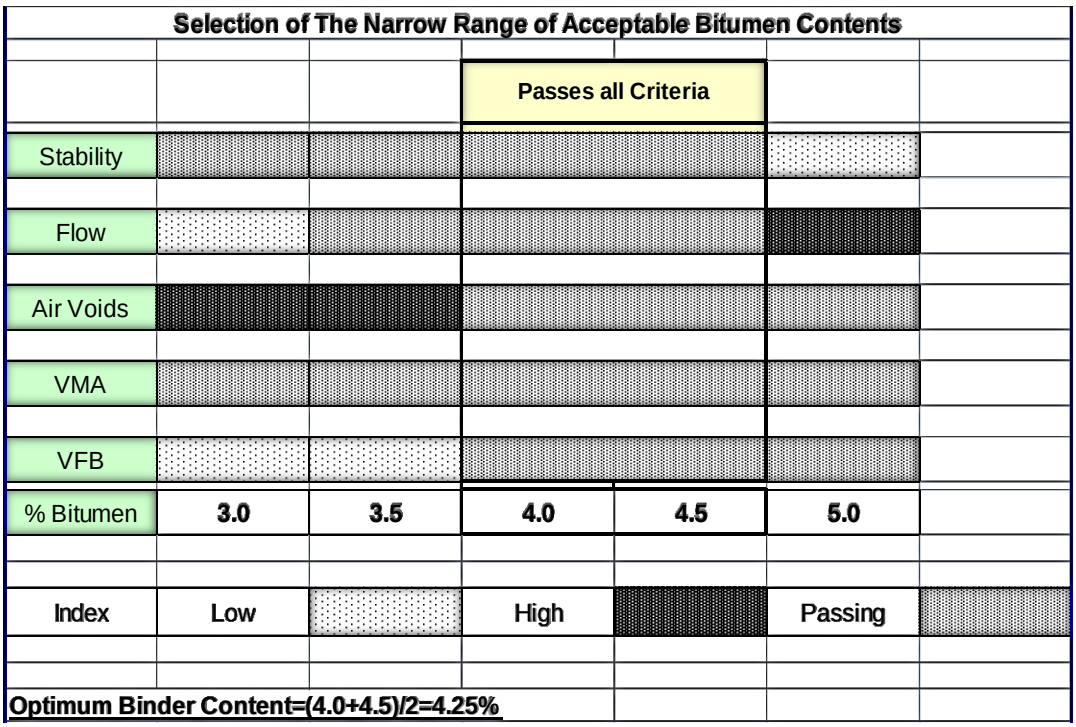



**Summary of test results for DBM mix design Grading I**




In order to arrive at homogenous mix with required standards, VG 30 bituminous mix with 4.25% optimum bitumen content is taken into consideration for Modified Marshall mix design by addition of 0.03%, 0.04% and 0.06% dosage of Zycosoil chemical at temperature 175°C.

| Abstract of Marshal Mix Design Test Values | | | | | | |
|---|---|---|---|---|---|---|
| **Bitumen content by wt. of total mix %** | **Stability (KN)** | **Unit Wight in gm/cc** | **Flow in mm** | **Air Voids in %** | **VMA in %** | **VFB in %** |
| 4.25% | 22.62 | 2.517 | 4.6 | 4.98 | 15.35 | 67.54 |
| 0.03% Zycosoil | **22.74** | 2.521 | **4.77** | 4.05 | 15.35 | 68.96 |
| 0.04% Zycosoil | **24.82** | 2.537 | **4.67** | 4.82 | 15.72 | 69.77 |
| 0.06% Zycosoil | **25.05** | 2.538 | **4.73** | 4.95 | 16.01 | 72.42 |
| **Specification Limits** | **20.25 KN** | **-----** | **03-Jun** | **03-Jun** | **Min.11.5** | **65 – 75%** |

**ASTM 3625 Boiling Test**

- Asphalt Grade: VG-30 (60-70)
- Procedure to prepare test samples with Zycosoil:
- VG-30 (60-70) grade asphalt binder is heated at 175°C.
- Then 0.03% Zycosoil of total asphalt is added in melted asphalt binder and is thoroughly mixed.
- Then test sample (control & Zycosoil) are prepared as per standard procedure. These samples are kept at room temperature condition.
- The prepared samples (regular & with Zycosoil) boiling test done at 100°C for 10 min, 30 min, 1 hr and 6 hr.

| Test Sample | 10 min | 30 min | 1 hour | 6 hour |
|---|---|---|---|---|
| 4.25% asphalt binder by weight of mix(without Zycosoil) | 78% | 85% | 90% | Total Failure |
| 4.25% asphalt binder containing Zycosoil (0.03%) by weight of mix | 94% | 93% | 93% | 89% |
| 4.25% asphalt binder containing Zycosoil (0.04%) by weight of mix | 100% | 99% | 98% | 97% |
| 4.25% asphalt binder containing Zycosoil (0.06%) by weight of mix | 100% | 99% | 98% | 97% |

Specification : <95% Fails

**Conclusions**

The results of the experimental study show that performance of chemically modified bituminous mix is better than that of conventional mix. Following conclusions can be drawn from this study:

- The summary of test results of VG 30 grade bitumen with and without Zycosoil shows that 100% coating is observed and found satisfactory for VG-30 + 0.06% Zycosoil for stripping test. Hence 0.06% is selected for DBM Grading – I. Also it is noted that penetration value decreases considerably as percentage of Zycosoil is increased indicating the improvement in temperature susceptibility resistant characteristics,

while softening point increases with the increase of Zycosoil, this phenomenon indicates that the resistance of the binder to the effect of heat is increased and it will reduce its tendency to soften in hot weather resulting in increased rutting resistance, durability, and load carrying capacity, improved resistance to weathering effects, increased stability and improved binding properties of HMA.

- The graphs showing volumetric and mechanical properties of Marshall specimens, obtained at varying binder content indicates optimum binder content of 4.25% (by weight of aggregates) satisfying the criteria's laid down in MoRTH section with respect to marshall stability, flow value, bulk specific gravity, percentage air voids in compacted mix and voids filled with bitumen.
- The Marshall stability value increased by more than 10 percent with 0.06 percent of Zycosoil chemical as compared to the DBM grading-1 mix without chemical. Field compaction is improved with the same compactive effort, resulting in construction cost savings and increased durability of asphalt pavement with reduced air voids.
- The flow value is maintained within the specified limits (3 to 6 mm) for this modified mix as per MoRTH specifications.
- Control samples were completely stripped in the boiling water test, while Zycosoil containing asphalt binder remained adhered to the aggregate surface even after six hours in boiling water which is evident.

It is concluded that chemically modified DBM grading-1 mix with 0.06 % Zycosoil chemical is showing better results as compared to conventional mix hence it is suggested to use for the construction of Flexible pavement.

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