Study on the Influence of Anti-Stripping Agents in Bituminous Construction

Rejani V U[1], Asif Hussain A[2], Gayathri Krishnadas[3], Goutham Rajesh[4]

[1]*Associate Professor, Dept. of Civil Engineering, NSS College of Engineering, Palakkad, Kerala, India*
[2,3,4] *B.Tech student, Dept. of Civil Engineering, NSS College of Engineering, Palakkad, Kerala, India*

---***---

Abstract - *Kerala, having almost 130 rainy days per year, has a wet and maritime tropical climate. Storm water runoff over the pavements causes its degradation, threatens the longevity of pavement due to stripping and leads to formation of potholes. Presence of water in bituminous pavement may cause failure at binder-aggregate interface which lead to stripping. The affinity between bitumen and aggregate may be enhanced by adding small amount of chemicals, known as anti-stripping agents, which change the behaviour of aggregates or the bitumen to have increased affinity towards each other. The objective of this study is to evaluate the effect of anti-stripping agents on the performance of bituminous concrete with locally available aggregates. Various laboratory tests are conducted on aggregates, bitumen, and the modified bituminous concrete samples.*

Key Words: Bituminous pavements, anti-stripping agent, Rediset LQ 1102, tensile strength ratio, TSR.

1.INTRODUCTION

Bituminous concrete (BC) is a mixture of coarse aggregates and sand with bitumen as the binding material and is provided as surfacing layer in bituminous roads, parking lots, airports as well as the core of embankment dams. Many developments in the recent past have improved the performances of bituminous mixtures and allowed the use of recycled of materials demolished pavements. But the significance of bitumen-aggregate adhesion is often disregard. The distresses in flexible Pavements due to action of water is the most common problem leading to its premature failure. The main contributing factor to this issue is the poor adhesion between bitumen and aggregates which causes water to filter in between the materials, leading to the premature aging of the bituminous mixture, and formation of instabilities that impair the pavement performance. Use of anti-stripping agents in the mix can ensure improved adhesion between aggregates and bitumen. Even though Kerala has two rainy seasons by which roads are constantly in contact with moisture and water, the usage of anti-stripping agents is not so popular and hence studies in this area can help increase its usage and understand the correct dosage of each under local conditions.

2. LITERATURE REVIEW

Throughout the years many researchers have studied the modifications applicable for bituminous concrete under moisture susceptibility. Some have been applied widely in pavement constructions. Similarly, one such way of improving moisture susceptibility is the use of anti-stripping agents in the bituminous concrete. Goel et al. [1] conducted studies on the variation in Tensile Strength Ratio (TSR) of bituminous mixes on addition of antistripping agents (ASA) to two different bituminous binders, VG30 and CRMB55. According to his studies, a dosage of 0.05% of ASA with VG30 fulfilled the requirement of 80% TSR value whereas CRMB55 satisfied the requirements even without ASA. Mansourkhaki et al [2] studied effect of a liquid Nanomaterial anti-stripping agent, namely Zycotherm, on asphalt mixture (AM). Wet/dry Indirect Tensile Strength (ITS) tests were conducted to check the moisture susceptibility and it was inferred from the results that a dosage of 0.1% improved the fatigue performance of warm mix asphalt. Zhu et al. [3] investigated the influence of anti-stripping agents likeM5000, M1 and LOF-6500 on the rheological properties of asphalt binder and it was found from the results that all the ASA modified asphalt binders showed the lower high temperature stability compared with blank sample. All ASA modified asphalt binders after RTFO had the higher, complex modulus, phase angle values and effectively improved ability to resist RTFO. The mechanical properties and moisture sensitivity of the Sulphur Extended Asphalts (SEA) mixtures modified with ASA were studied by Faramarzi et al. [4]. It was found that the mechanical characteristics were improved and the adhesion between aggregates and sulphur-extended asphalt was enhanced by the addition of ASA. A mathematical model between the stripping failure and the factors which affect long term resistance of asphalt mixtures against stripping was developed by Haghshenas et al [5]. The model predicts the rehabilitation time, and also explains the influence of each individual factor on the stripping process. The influence of porous asphalt incorporating Sasobit prepared with hydrated lime and a newly developed anti-stripping known as Pavement Modifier (PMD) was investigated by Aman et al. [6]. The resistance to moisture damage was determined from the indirect tensile strength test (ITS) for dry and conditioned specimens. It was found that, specimens prepared with PMD exhibits better tensile strength and greater resistance to moisture damage at 125°C compared to specimens prepared with hydrated lime. Hesami et al. [7] conducted tensile strength ratio (TSR) and semi-circular Bending (SCB) tests to study the effects of two types of liquid amine-based anti-stripping agents on the performance of HMA and the results showed that the efficiency of the additives was significantly reduced after long-term heating for HMA production. Also, it was recommended that the dosage of anti-stripping additives, suggested by the manufacturer should be carefully examined. From the above studies, it can be understood that anti-stripping agents can improve the moisture susceptibility of bituminous concrete. Kerala being a place with a wet climate for about half of the year, it would be useful to conduct studies on the influence of anti-stripping agents in improving the performance of our roads.

3. OBJECTIVES

- To study the utilization of anti-stripping agents in bituminous construction.
- To compare the properties of the modified bituminous mix with the conventional mix.

4. METHODOLOGY

The methodology consists of collection of aggregates, bitumen and anti-stripping agents, and conducting the respective tests on their properties and finally preparation of normal and modified marshal specimen and their testing.

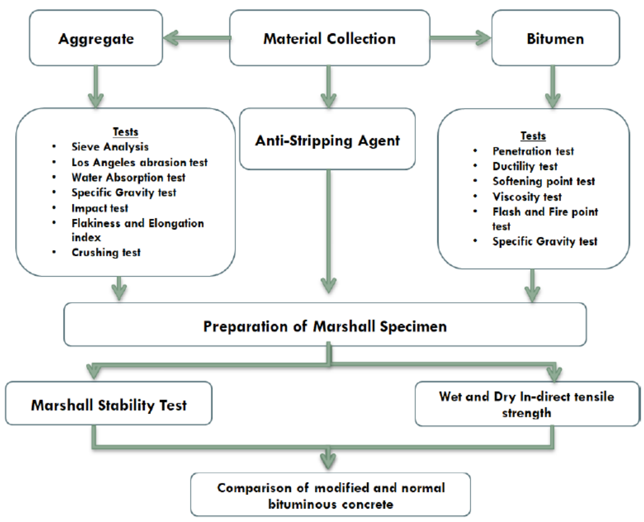

Fig -1: Methodology

4.1 Anti-stripping Agent

The bonding between asphalt and aggregate is very important as it is the key factor that influences the reliability of the pavement. The adhesion between aggregates and bitumen can be improved through the usage of anti-stripping agents. The anti-stripping agent used in the present study is Rediset LQ 1102CE. It is a compaction aid for hot and warm mixes and a heat-stable adhesion promoter. It permits a decrease in mixing and paving temperatures along with an anti-stripping effect. The dosage suggested by the manufacturer is 0.3 to 1% by weight of bitumen.

4.2 Mix design

Among the various methods available for mix design, Marshall method of mix design is the most popular one and is used here.

5. EXPERIMENTAL ANALYSIS

The aggregates used for the study is taken from a nearby quarry. Bitumen used is VG30. The physical properties of the aggregates and bitumen used for bituminous concrete mix design were determined to check its suitability. Marshall specimens were prepared and both wet and dry stability tests were conducted. The results of the different experiments and stability tests are included in this section.

5.1 Physical Properties of Coarse Aggregates

The physical properties of aggregates and bitumen were tested in the laboratory and the results along with the required specifications as per MoRTH [8] are given in tables 1and 2.

Table -1: Properties of Coarse Aggregates

Properties	Obtained Value	Specification
Specific Gravity	2.64	2.5-3
Water Absorption (%)	0.55	Max 2
Impact Value (%)	20.4	Max 24
Combined Flakiness and Elongation Indices (%)	34.2	Max 35
Crushing Value (%)	33.7	Max 35

Table -2: Properties of Bitumen

Properties	Obtained Value
Penetration (100g,5sec@25°C), mm	67
Ductility@27°C, cm	77
Softening Point (Ring and Ball apparatus),°C	57.5
Flash Point, °C	205
Fire Point, °C	214
Specific Gravity	0.99

5.2 Mix Proportion of Aggregates

The aggregate gradation was selected in order to get the combined grading specified in Table 500-17 of Specifications for Road & Bridge Works (Fifth Revision), published by the Indian Roads Congress [8]. The midpoint of Grade-2 for Bituminous Concrete was selected for uniformity in testing, and the results are given in Table 4.

Table -4: Gradation of Aggregates (BC-Grade 2)

IS Sieve (mm)	Cumulative % by weight of total aggregate passing	Cumulative % by weight taken for experiment
19	100	100
13.2	90-100	95
9.5	70-88	79
4.75	53-71	62
2.36	42-58	50
1.18	34-48	41
0.6	26-38	32
0.3	18-28	23
0.15	12-20	16
0.075	04-10	7

5.3 Test on Specimens without Anti-Stripping Agent

Marshall tests were conducted on specimens having different bitumen contents (% by weight of total aggregates) as per the specifications to fix the optimum bitumen content required. These results are given in Table 3.6 and 3.7.

Table -5: Stability and flow values of specimens without ASA

Bitumen content (%)	Stability value (kN)	Flow value (mm)	Tensile Strength of Water Conditioned Specimen (kN)	Tensile Strength Ratio (%)
4.25	9.61	2.05	7.17	71.66
4.75	11.43	2.42	9.06	76.30
5.25	10.72	3.67	9.22	80.04
5.75	9.11	4.71	8.12	77.13

Table -6: Density and void analysis of specimens without ASA

Bitumen content %	Wt. in air, (Wm) kg	Wt. in water, (Ww) kg	Theoretical Spec. Gravity, Gt	Spec. Gravity of mix, Gm	Vv (%)	Vb (%)	VMA (%)	VFB (%)
4.25	1.25	0.71	2.50	2.31	7.42	9.63	17.05	56.47
4.75	1.27	0.73	2.48	2.35	5.24	10.88	16.13	67.48
5.25	1.28	0.74	2.46	2.37	3.80	12.06	15.87	76.04
5.75	1.26	0.73	2.45	2.38	2.83	13.19	16.02	82.34

5.4 Determination of Optimum Bitumen Content

Marshall graphs are plotted as shown in fig 2 to find the optimum bitumen content (OBC).

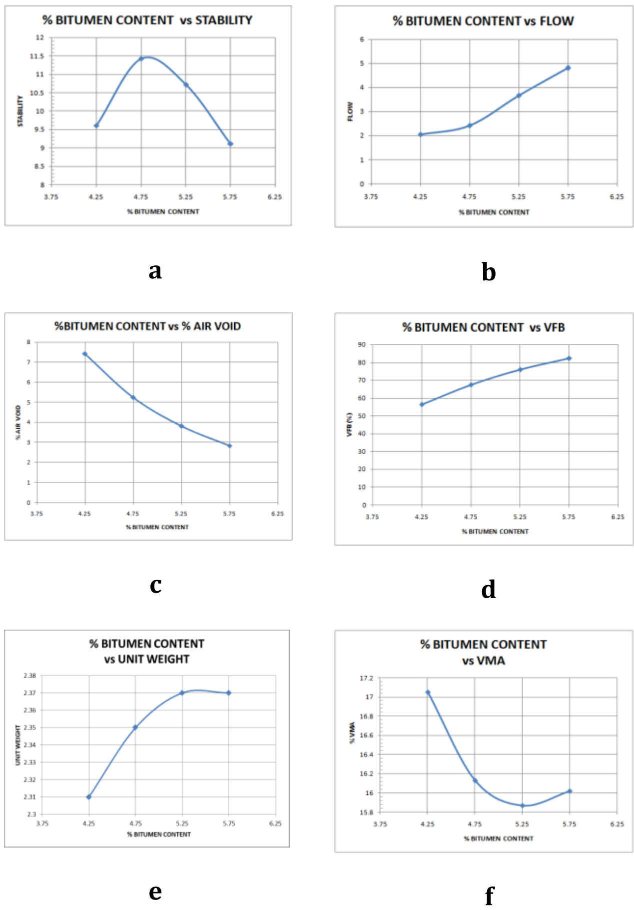

Chart -1a-f: Graphical plots of specimens without ASA

Considering binder content corresponding to maximum stability, binder content corresponding to maximum bulk specific gravity (G_m) and binder content corresponding to the median of designed limits of percentage air voids (V_v) in the total mix (i.e. 4%), the optimum bitumen content is obtained as 5.2%. The obtained value of optimum bitumen content as per calculation is 5.2%, but the minimum optimum bitumen content specified for bituminous construction as per MoRTH specifications is 5.4%. The stability value, flow value, and VFB at 5.4% are checked with the Marshall mix design specification. The optimum bitumen content of 5.4% is adopted.

5.5 Test on Specimens with Anti-Stripping Agents (ASA)

Marshall Tests were conducted on specimens at OBC with different percentages of the anti-stripping agent Rediset LQ 1102. These results are given in table 6. The Tensile strength ratios (TSR) of mixes with and without ASA are found to check the variation in moisture susceptibility of mixes on addition of ASA. The results are given in table 7.

Table -6: Comparison of specimens with and without ASA

Mix Parameter	Obtained value		
	Mix Without ASA	Mix With 0.55% ASA	Mix With 0.75% ASA
Bitumen Content, %	5.4	5.4	5.4
Marshall Stability, KN	10.24	11.08	11.86
Flow, mm	3.4	3.4	3.6
Marshall Quotient, KN/mm	3.01	3.26	3.29
Bulk Density, kg/m^3	2390	2401	2412
percentage air voids, Vv %	3.81	3.76	3.72
Voids Filled with Bitumen (VFB), %	73.04	73.38	73.45
Voids in Mineral Aggregate (VMA), %	13.5	13.67	13.72

Table -7: TSR values of mixes

Mix Type	TSR VALUE (%)
VG30 without ASA	79.16
VG30 with 0.65% ASA	86.32
VG30 with 0.75% ASA	88.56

6. CONCLUSIONS

- On conducting Marshall Tests on specimens without Anti-Stripping Agents the optimum bitumen content is found to be 5.4%.
- The addition of anti-stripping agent Rediset LQ 1102CE at OBC reduces the percentage air voids in the mixes at OBC. The bulk density is slightly increased.
- Specimens prepared with Anti-Stripping Agent shows an increase in the stability of the mix.
- After conducting tests on dry and water conditioned specimens with and without Anti-stripping Agents, it is observed that there is an increase in the Tensile Strength Ratio of mixes on addition of ASA.
- Hence, in areas like Kerala with a wet and maritime tropical climate, it will be a better option to use Anti-stripping Agents in bituminous mixes for pavement construction to improve the longevity of roads.

5.1 SCOPE FOR FUTURE STUDY

- The study can be further extended on aggregates from different places and different types of Anti-stripping Agents and finding the optimum dosages of ASAs in each case.
- Further studies can also be done in this topic by conducting tests on the other properties of adhesion between the aggregates and bitumen.

7. ACKNOWLEDGEMENT

The authors would like to acknowledge the Kerala State Council for Science, Technology and Environment (KSCSTE) for the financial assistance received.

REFERENCES

[1] G. Goel, S. N. Sachdeva, “Performance of bituminous concrete mixes with modified binder and anti-stripping agent”, Indian Highways, vol 47, Sep 2019.

[2] Z. A. Mansourkhaki, A. Aghasi, “Performance of rubberized asphalt containing liquid nanomaterial anti-strip agent”, Construction and Building Materials, vol. 214, July 2019, pp 468-474.

[3] C. Zhu, G.g Xu, H. Zhang, F. Xiao, S. Amirkhanian, C. Wu, “Influence of different anti-stripping agents on the rheological properties of asphalt binder at high temperature”, Construction and Building Materials, vol. 164, March 2018, pp 317-325.

[4] M. Faramarzi , B. Golestani , K. W. Lee, "Improving moisture sensitivity and mechanical properties of sulphur extended asphalt mixture by nano-antistripping agent", Construction and Building Materials, vol.133, 15 Feb 2017, pp 534-542.

[5] H. F. Haghshenas, A. Khodaii, M. Saleh, "Long term effectiveness of anti-stripping agents". Construction and Building Materials. Vol. 76, Fob 2015, pp 307-312.

[6] Y. B. A. Mohamad, O. H. Meor, "Effects of Anti-Stripping Additives on Moisture Sensitivity of Warm Porous Asphalt Mixtures", International Journal of Construction Technology and Management, Vol. 1, Feb 2014.

[7] E. Hesami, G. Mehdizadeh, "Study of the amine-based liquid anti-stripping agents by simulating hot mix asphalt plant production process", Construction and Building Materials, Vol. 157, 30 Dec 2017, pp 1011-1017.

[8] Ministry of Road Transport & Highways: Specifications for Road and Bridge works (Fifth Revision). Indian Roads Congress, New Delhi, 2013.