

EVALUATION OF MARSHALL PROPERTY OF SHORT TERM AGING OF BITUMINOUS CONCRETE MIX

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Abstract

Aging of bituminous pavements typically occurs through oxidation of the bitumen and evaporation of the lighter compounds from the binder. The main objective of this study is to evaluate influence of aging on performance of bituminous concrete mix. Bituminous concrete mix were prepared as per Marshall Method of mix design, and subjected to short term aging (STA) procedure which involved in heating the loose mix in oven for aging period of 1 to 5 hours with an interval of 1 hour at a temperature of 135°C.

Keywords: Marshall Properties, Short-term ageing, Control mixture, Material characterization.

1. INTRODUCTION

1.1 Short Term Aging

India has a road network of about 4.6 million Km with majority of roads are flexible pavement. The top surfaces of flexible pavement are constructed mainly with the use of naturally available aggregates and bitumen binder, where aggregates are dried and mixed with hot bitumen to produce the hot mix asphalt. The properties of bituminous mix begin to change from the time of mixing, transporting from plant and laying due to aging, which are recognized as one of the major problems faced by bituminous mix during its service life, Aging causes the bituminous mix to stiffen and become brittle which leads to a higher potential for fatigue and thermal cracking. It was found that four hours of oven aging at 135°C appears representative of the short-term aging in the field during mixing and placement.

1.2 Material Characterization

The materials used in this work are bitumen binder, aggregate and filler. The properties of materials were tested as per the relevant test procedures and the results were compared with MORT&H specified limits. The bitumen binder used in this work is VG-30. It was obtained from Mangalore Refineries and Petrochemicals Ltd. (MRPL). The bitumen properties are shown in Table 1. The aggregate used in this work was obtained from a local quarry near Mydala, Tumkur District. This aggregate is widely used in Tumkur city for bituminous mixes. The coarse and fine aggregates used in this work were sieved, and recombined in proper proportions to meet the wearing course gradation as per MORT&H specifications. The physical properties and selected gradation curve for the aggregates are presented in Table 2 and Fig 1 respectively.

Table 1: Properties of VG-30 bitumen

Sl no	Properties	Code	Results	Requirements as per MORT&H
1	Penetration at 25°C (mm)	IS 73:2006	65	50-70
2	Ductility at 25°C (cm)	IS 73:2006	74	Min 45
3	Softening point (°C)	IS 73:2006	52	Min 45°C
4	Specific gravity at 25°C	IS 73:2006	1.01	0.97 – 1.02
5	Flash & Fire point (°C)	IS 73:2006	285 °c 310 °c	Min 220°c Min 270°c

Table 2: Properties of aggregates

Sl. No	Properties	Code	Results	MORT&H specification
1	Aggregate Impact value	IS:2386 Part 4	21.8 %	30 % max
2	Los Angeles Abrasion value	IS:2386 part 4	24.23 %	30 % max
3	Aggregate Crushing value	IS:2386 part 4	22.87 %	30 % max
	Specific gravity			

4	20 mm down	IS:2386 part 3	2.6	2.5-3.2
	12.5 mm down		2.54	2.5-3.2
	Dust		2.52	-
5	Water absorption (%)	IS:2386 part 3		
	20 mm down		0.36	Max 2 %
	12.5 mm down		0.54	Max 2 %
	Dust		2.89	-

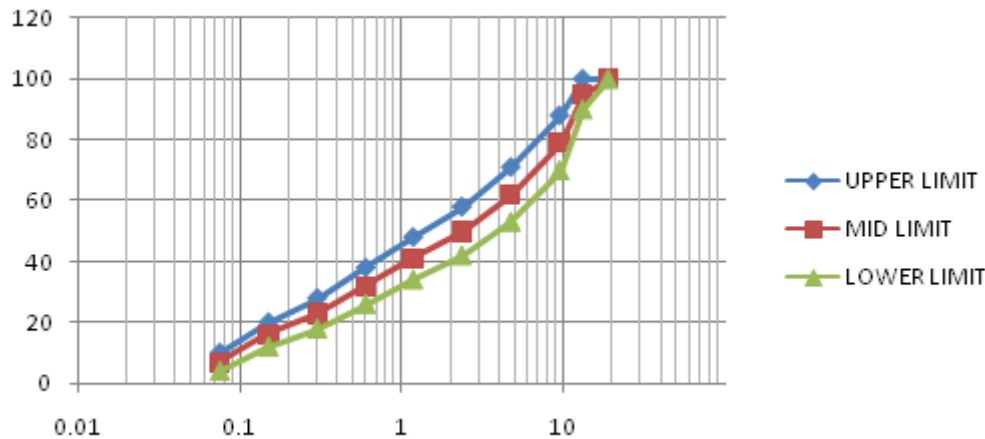


Fig 1: Gradation curve

1.3 Preparation of Mixtures

Two types of mixtures were prepared for the study using Marshall Method of mix design, control mixture, short - term aged mixtures.

1.4 Preparation of Control Mixture

The efficiency of mixing procedure depends on providing homogenous mix and uniform coating of aggregate with bitumen binder. The aggregates were washed, dried to a constant weight at 110°C, and then sieved. The graded aggregates were heated to a temperature of 160°C before mixing with bitumen. The bitumen binder was heated to a temperature of 160°C and added to the heated aggregates to obtain desired weight, and mixed thoroughly by spatula for 2 minutes until all aggregate particles were coated with bitumen binder. The mix is filled in the Marshall Mould assembly. The temperature of the mixture immediately prior to compaction was kept between 140-150°C. Then, 75 blows were on the top applied and bottom of the specimen with a compaction hammer of 4.5 kg sliding weight, with a free fall of 457 mm. The specimen in mould was left to cool

at room temperature for 24 hours and then removed from mould by using sample extractor.

1.5 Short-Term Aging

The Marshall method of mix design was adopted to prepare the bituminous mix to simulate short term aging in the lab. The loose mix was spread to an uniform thickness in the pan and placed in an oven for 1 to 5 hours at a temperature of 135°C to obtain bituminous concrete mixes of different aging. The loose mix was compacted in the same way as that of control mix.

2. EXPERIMENTAL METHODS AND RESULTS

DISCUSSION

The experimental work was started by determining the optimum binder content for all the bituminous mix using the Marshall method of mix design .Table 3 shows the experimental programming of Marshall stability, Flow and ITS values of controlled, Short term Long term aged bituminous concrete mixes.

Table 4: Summary of the properties of bituminous mix at optimum binder content

Sl. No	Mix type	Properties					
		Density (g/cc)	Marshall Stability (kN)	Flow (mm)	ITS conditioned (kPa)	ITS unconditioned (kPa)	TSR
1	Controlled mix	2.30	17.77	2.55	46.05	52.50	0.88
2	Short term aging	Density (g/cc)	Marshall Stability (kN)	Flow (mm)	ITS conditioned (kPa)	ITS unconditioned (kPa)	TSR

	1 hours	2.33	13.38	2.83	52.72	58.46	0.90
	2 hours	2.31	10.32	3.46	65.40	65.00	1.00
	3 hours	2.34	12.37	5.9	81.26	73.00	1.11
	4 hours	2.32	13.60	6.2	75.90	63.00	1.20
	5 hours	2.32	15.29	6.16	74.52	59.26	1.26

Effects of Aging on Marshall Stability

Figure 3 shows Marshall stability for controlled, Short term oven aged and Long term oven aged bituminous concrete samples. Controlled sample has a strength of 18 kN. Short term oven aged for 2 hours show 10 kN and is lowest. The field sample show nearly the same stability value and both have same strength. Beyond 2 hour of Short term aging, the stability increases till 5 hours.

However all samples show stability value greater than 9 kN and meet MORT&H specification. It can be concluded that

the 2 hours Short term aging is equivalent to short term field aging due to mixing, transportation and compaction of bituminous concrete mix in the pavement.

From figure 2, the stability of bituminous concrete mix is found to be decreasing up to 2 hours of aging after which the value increases with the aging hour. This can be attributed to the loss of volatile components from the mix due to which the pavement becomes stiff and show increase in stability value.

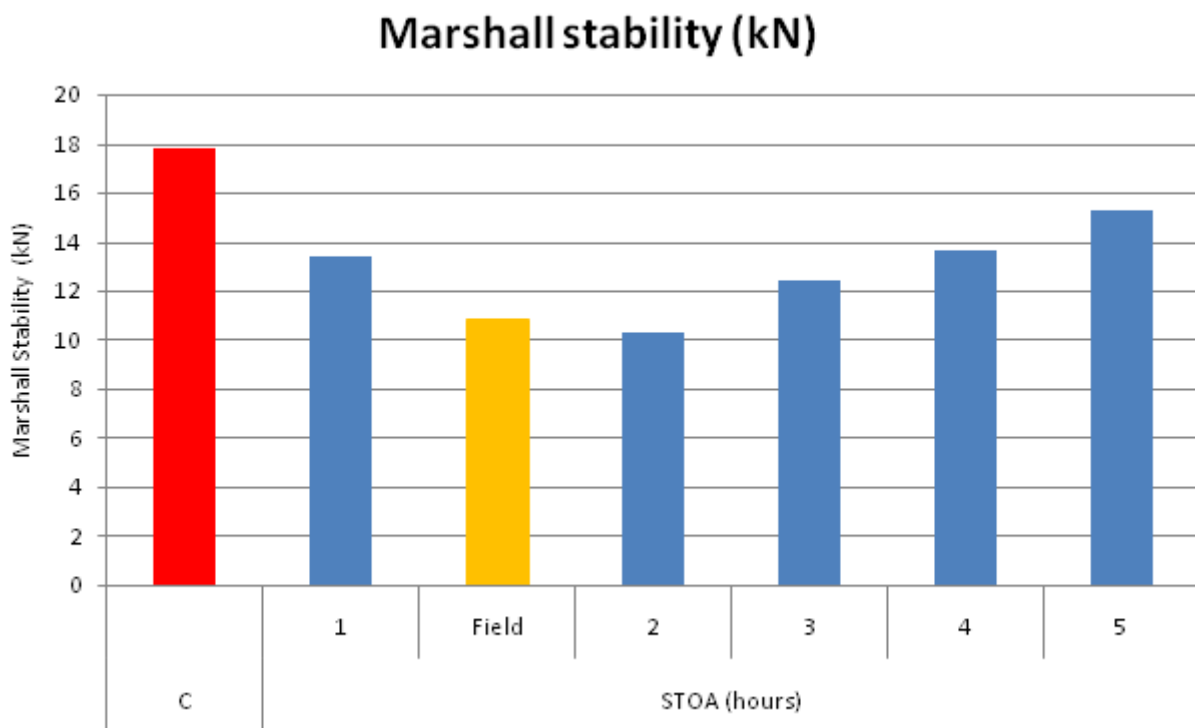


Fig 2: Marshall Stability v/s Aging

3. CONCLUSION

The Marshall Stability and 2 hour oven aged samples are same. Therefore, the 2 hour oven aged sample is equivalent to short term aging related to mixing, transporting, laying and compaction. The Marshall stability is high for controlled sample, decreases with aging attains minimum value at 2 hour Short term oven age and then increases.

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