

MECHANICAL PROPERTIES OF WARM MIX ASPHALT CONCRETE APPLICATION USING ADVERA

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The article presents the study of physical characteristics of warm mix asphalt cement concrete (WMA), components designed by the Marshall Method. Stability, flow rate, strength index, air void, and percent voids in mineral aggregate (VMA) of a total of 77 specimens were examined as a general standard specification test of the Department of Highways, Thailand. Limestone was used as aggregate. Adhesive mixtures of asphalt grade 60/70 were mixed with admixture “ADVERA” to the ratios of 0.20%, 0.25%, and 0.30% by weight of aggregate. WMA-mixing and compaction temperatures were controlled at 115°C, 120°C, and 125°C. The results were that the asphalt cement mixed with 0.25% of ADVERA (by total mixed) at 125°C shows the best mechanical properties standard, with higher value of stability (2,200lbs, i.e., more than the standard 1,800lbs), flow rate, air void, VMA and hardness index. Finally, this study indicates that asphalt concrete added with admixture ADVERA (WMA) could reduce the mixing and compaction temperature during production processes from $>160^{\circ}\text{C}$ to $\leq 125^{\circ}\text{C}$.

Keywords: Asphalt cement concrete, Department of highways, Thailand, Para-WMA, Natural rubber.

1 INTRODUCTION

Mechanical properties of hot mixed asphalt (HMA) have been studied by many researchers (Monismith et al. 1997, Ruth and Olson 1977, Bonnaure et al. 1982 and Sousa et al. 1988) but few researchers (Jansen et al. 2010, You et al. 2011, and NAPA 2010) have studied the mechanical properties of warm mixed asphalt (WMA). It is interesting to study the mechanical properties of both.

2 OBJECTIVES

To determine the appropriated proportion of admixture (ADVERA) that uses in Warm mix processes by considering from physical properties of WMA's samples.

3 MATERIALS

WMA's materials were asphalt cement grade 60/70, admixture or a mineral additive called “ADVERA”, and limestone in Suphan Buri, Thailand. The gradation and mix proportion of Limestone is shown in Table 1, and the gradation curve of mixed bin of limestone is shown in Figure 1.

Table 1. Gradation and mix proportion of limestone.

SEIVE (size)		%PASSING					TOLERANCE	
Inch	mm	BIN1	BIN 2	BIN 3	BIN 4	Total	Lower limit	Upper Limit
1"	25.00	100.0	100.0	100.0	100.0	100.0	100	100
3/4"	19.00	100.0	100.0	100.0	100.0	100.0	100	100
1/2"	12.50	100.0	100.0	90.4	16.8	90.6	80	100
3/8"	9.50	100.0	100.0	36.7	3.3	83.4	65	95
# 4	4.75	100.0	26.2	1.2	0.1	55.5	44	74
# 8	2.36	81.7	0.8	0.0	0.0	38.7	28	58
# 16	1.18	58.5	0.4	0.0	-	27.6	18	47
# 30	0.60	37.8	0.3	-	-	17.9	8	35
# 50	0.30	26.2	-	-	-	12.3	5	21
# 100	0.15	17.7	-	-	-	8.3	4	15
# 200	0.08	12.8	-	-	-	6.0	2	10
Mix proportion		47	32	11	10	46:31:11:10 (by mass)		

4 METHODS

The specifications of limestone properties/gradations and the nominal maximum size of aggregate at 12.5 mm refer to the Department of Highway (DOH) standard. Job Mix Formula of all specimens was applied in this study. Adhesive mixtures were asphalt grade 60/70 mixed with "ADVERA" to the ratios of 0.20%, 0.25%, and 0.30% by weight of aggregate. Mixing and compaction temperatures were controlled at 115°C, 120°C, and 125°C. This study determined under laboratory conditions the fundamental properties of samples, and evaluated their possible use for WMA, particularly the potential use of ADVERA. These fundamental properties included:

- Testing on stability and flow by Marshall Method
- Testing on strength index by Marshall Method
- Indirect tensile strength test
- Void in Asphalt Mixture (Air void, VTM, VMA, VFA)

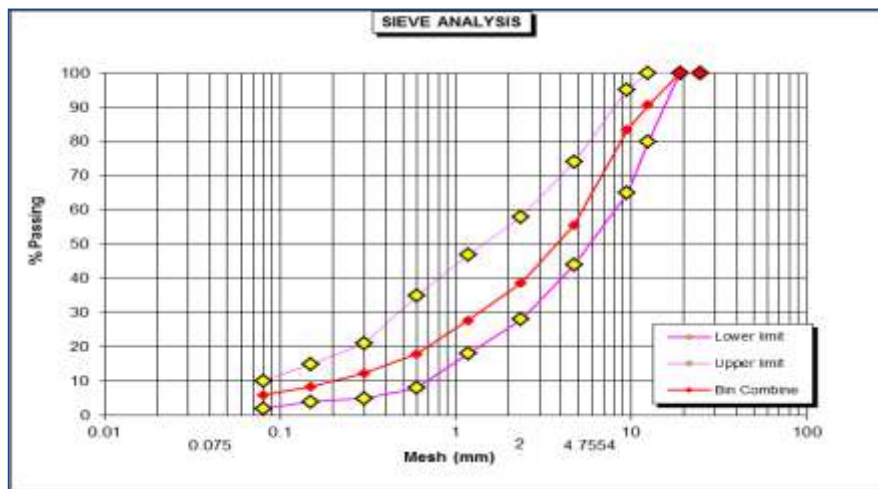


Figure 1. Gradation curve of mixed-limestone.

Table 2. DOH Thailand's standard specification of HMA.

Items	Type of Surface Courses				
	Wearing Course 9.5 mm.	Wearing Course 12.5 mm.	Binder Course	Base Course	Shoulder
Blows	75	75	75	75	75
Stability N (lb)	8006 (1800)	8006 (1800)	8006 (1800)	7117 (1600)	7117 (1600)
Flow 0.25 mm (0.01 in.)	8-16	8-16	8-16	8-16	8-16
Percent air voids	3-5	3-5	3-5	3-5	3-5
Percent voids in material aggregate (VMA, min)	15	14	13	12	14
Stability/Flow, min					
N/0.25 mm (lb/0.01 in.)	712 (160)	712 (160)	712 (160)	645 (145)	645 (145)
Percent strength index	75	75	75	75	75

5 RESULTS AND DISCUSSION

Seventy seven WMA specimens were examined as a general standard specification test under standards set by DOH Thailand. The physical engineering characteristics of asphalt concrete, such as voids in mineral aggregate (VMA), density, percentage of air voids, voids filled in bitumen (VFB), and stability and flow are shown in Figure 2.

5.1 Stability and Flow of WMA

The maximum stability's value of all specimens could be determined by controlling the settlement rate of specimens (2 inches per minute) with temperature (60°C). The flow's values were determined during the same period. Table 3 shows the average of stability, flows, and stability per flow when varying the mixing ratio of ADVERA. The results show that all stability and flow values give a higher value than DOH Thailand's standard. Also, the results of using ADVERA as 0.2% - 0.3% of aggregate indicated that the average stability and flow are at the same range. Using ADVERA as 0.2% of aggregate at 125°C shows the highest value.

5.2 Strength Index of WMA

The strength index of WMA's specimens were tested by following the Ontario Vacuum Immersion Marshall Test. The results are shown in Table 4. Only using ADVERA as 0.2% of aggregate at 120°C shows a value lower than DOH Thailand's standard.

Table 3. Stability, flow, and stability per flow of WMA specimens.

Test	ADVERA 0.20%			ADVERA 0.25%			ADVERA 0.30%			DOH,TH Standard
	T115	T120	T125	T115	T120	T125	T115	T120	T125	
Average Stability (lb)	2424	2776	2676	2526	3089	3157	2863	2547	2661	>1800
Average Flows (1/100 in)	13	13	14	13	15	12	14	14	13	8-16
Stability/Flow (1/100 lb/in)	182	208	191	199	201	263	209	186	205	>160

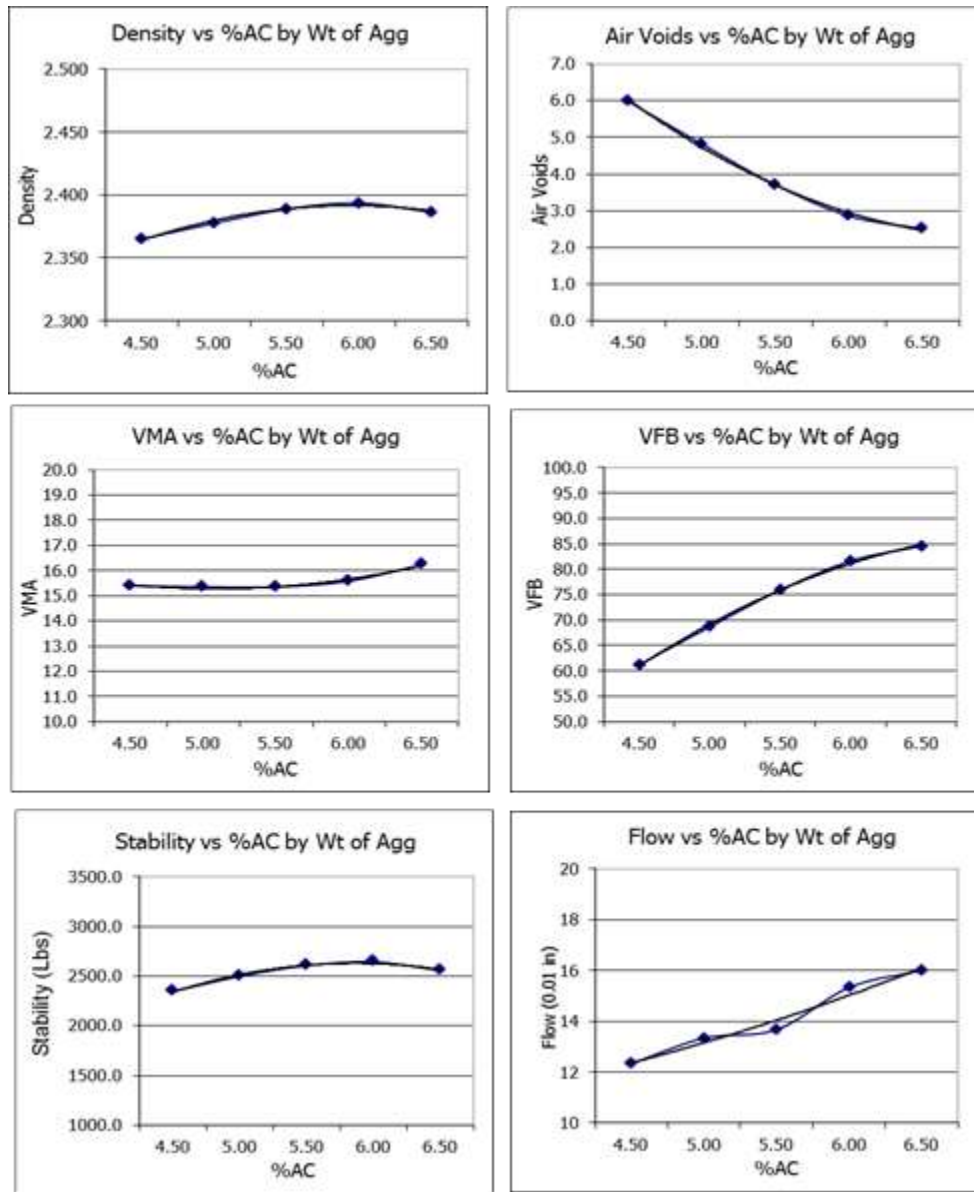


Figure 2. Voids in Mineral aggregate (VMA), density, percentage of air void, void filled in bitumen (VFB), stability and flow.

Table 4. Strength index of WMA specimens.

Test	ADVERA 0.20%			ADVERA 0.25%			ADVERA 0.30%			DOH,TH Standard
	T115	T120	T125	T115	T120	T125	T115	T120	T125	
Conditioned (lb)	2271	1794	1885	1881	2748	2649	2335	2612	2423	
Normal Conditioned (lb)	2839	2544	2499	2317	2792	3053	2712	2748	2649	8-16
Strength Index (%)	80	71	75	81	92	87	86	59	91	>75

5 CONCLUSION

The results show that the stability indexes (2,200 to 3,200 lbs) for WMA are higher than the DOH Thailand standard (1,800 lbs). Asphalt cement mixed with 0.25% of ADVERA at 125°C shows the best physical properties standard, with highest value of stability (3,157.32 lbs.), flow rate (12/100 inches), air void (4%), VMA (15%) and the highest hardness index (95.04%). This study also indicates that asphalt cement WMA with admixture ADVERA reduces the mixing and compaction temperature (from >160°C to ≤125°C) during the production and paving process, lowering environmental impact.

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