THE EFFECT OF ASPHALT PLANT WASTE ON ASPHALT CONCRETE PERFORMANCE

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Abstract— Pavements used on the road superstructure can be produced as cement concrete or asphalt concrete. Asphalt concrete has a wider use area. However, the cost of asphalt concrete is high. Recent studies are aimed at reducing this cost. Usage of environmental waste is very important in reducing the cost. In this study, "plant waste" which ensues from the asphalt plants where the production of asphalt concrete is made, was used. The effect of plant waste on the asphalt concrete performance properties was investigated. Plant waste; Is the material deposited in the filters during the mixing of the aggregates with the bitumen. These wastes are used in place of fine and filler aggregates in the study. 25%, 30%, 40% and 50% by weight of the aggregate were added to the asphalt concrete mixture. The samples were prepared according to Marshall Design. The test results were also evaluated according to this design. Optimum bitumen ratio has been reduced with the addition of plant waste to asphalt concrete. Samples containing plant waste provide the boundary conditions required for the road surface structure. As a result, plant waste can be used in the production of asphalt concrete. In this way a waste material that creates environmental pollution can be utilized and this provides a sustainable environment and life.

Index Terms— Asphalt concrete, plant waste, sustainable environment.

I. INTRODUCTION

The discovery of refining bitumen in crude oil at the beginning of the 1900's and the increase in the production of motor vehicles have increased the interest in asphalt concrete in road construction. Nowadays different types of asphalt concrete pavements are produced according to usage purpose, traffic load and environmental conditions [1]. Asphalt concrete pavements should provide the expected performance characteristics during their service life.

Asphalt concrete is a composite material composed of aggregate and bitumen. The aggregate materials used in road construction are generally supplied from quarries which are close to the road course under construction. However, the quantity of good quality aggregate has been decreasing day by day. Bitumen is obtained by distillation of crude oil. Bitumen sourced from oil is a highly expensive material. Also, the total quantity of energy consumed in HMA sector is about 136*106 MWh/year. On the other hand, the average world crude oil production was 84.523 millions of barrels per day in average [2]. This means that the whole industry of HMA consumes 0.28% of the world's
crude oil production. Therefore, the minimization of energy requirements for manufacturing HMA and the associated lowering of asphalt plant emissions have become important issues [3], [4].
The effective use of aggregate and bitumen in asphalt concrete will be beneficial for the efficient use of limited resources of developing countries and sustainable living. Asphalt plant residue (APR) which was used in this study is shown in Fig. 1.



Fig. 1. Asphalt plant residue.

On the other hand, there is an environmental deposition problem of the wastes resulting from industrial production. Deposition sites for those wastes are getting limited increasingly. In the course of events, it has become compulsory for researches to use those wastes in asphalt concrete. There are still many studies for increasing the performance of asphalt concrete. It has become an aim for researchers to provide better performance values using waste materials with less substance in the mixture. There have been deep changes in the way we live and work. Among these changes, conservation and recycling of such waste materials have become some of the major issues to manage the resource. Many authorities and researchers are going to seek to privilege the re-use of wastes in an environmentally and economically sustainable way. Hence, it is accomplished both to economise on the materials and to prevent environmental contamination [5], [6].

The waste materials can broadly be categorized as follows:
a. industrial wastes such as cellulose wastes, wood lignins, bottom ash and fly ash,
b. municipal/domestic wastes such as incinerator

residue, scrap rubber, waste glass and roofing shingles,
c. mining wastes such as coal mine refuse [7].

When the waste materials are evaluated in the asphalt plant, they can be used as aggregate, bitumen or mixture. Recently, several studies are conducted for using of wastes in Portland cement concrete and HMA mixtures [8-11].
In this study, the effects of asphalt plant waste on performance characteristics of asphalt concrete were investigated. 25%, 30%, 40% and 50% by weight of the aggregate is added to the asphalt concrete mixture. The Marshall Experimental Design was applied to the preparation of the samples. The test results were also evaluated according to this design.

II. MATERIALS AND METHODS

A. Materials

In this study limestone was used as aggregate. 50/70 penetration bitumen obtained from Izmit Tüpraş refinery was used. Aggregate and bitumen test results are given in Table I and II. The chemical properties of the asphalt plant waste used in the mixture are as shown in Table III.

Table I. Rheological properties of bitumen.

Experiment	Value	Standard
Source of Bitumen	Tüpraş, İzmit, Türkiye	
Penetration (at 25°C, 100 g, 5 sec)	64(50/70)	ASTM D5
Softening Point (°C)	48	ASTM D36/D36M-09
Specific Gravity (g/cm^3)	1.026	ASTM D70-09e1
Ductility (25 °C, 5 cm/min)	>100 cm	ASTM D113-07
Loss on Heating (%)	0.43	ASTM D6-95
Flash Point (°C)	336	ASTM D92-05a
Viscosity (at 135°C , cP)	437.5	ASTM D4402-06
Viscosity (at 165°C , cP)	137.5	ASTM D4402-06

Table II. The physical properties of aggregates.

Properties		Values	Standard
Specific gravity (g/cm^3)			
Coarse Aggregate	Apparent Specific Gravity (g/cm^3)	2.718	ASTM C127
	Specific gravity (g/cm^3)	2.665	
	Saturated surface dry gravity (g/cm^3)	2.685	
Fine Aggregate	Apparent Specific Gravity (g/cm^3)	2.797	ASTM C128
	Specific gravity (g/cm^3)	2.697	
	Saturated surface dry gravity (g/cm^3)	2.733	
Filler	Specific gravity (g/cm^3)	2.754	ASTM C128
Compacted bulk density (g/cm^3)		1.369	ASTM C 29
Loose bulk density (g/cm^3)		1.026	ASTM C 29
Los Angeles wearing test (%)		12.8	ASTM C 131
Flatness index (%)		16	ASTM D 4791
Freeze-thaw resistance (%)		4	ASTM C 88

Table III. The chemical properties of APR.

Compound	Unit (%)	Element	Unit (%)
L.O.I.	0.000	Mn	0.01297
P_2O_5	0.106	Ti	0.01530
SO_3	0.477	Ca	10.06990
K_2O	0.314	Fe	0.16067
MgO	13.637	Sr	0.00567
Al_2O_3	2.368	Br	0.86309
SiO_2	6.263	Ni	0.00607
Fe_2O_3	1.098	Al	0.20902
NiO	0.037	Mg	1.35081
SrO	0.027	O	86.7146
CaO	75.471	Si	0.50335
TiO_2	0.122	K	0.04685
MnO	0.080	S	0.03357
		P	0.00813
TOTAL	**100.000**		**100.00000**

In the study. a blend of both the asphalt surface course-type II used by KGM (General Directorate of Highways) and the grain distribution used in the Superpave Design Method was tried to be used together. The results of aggregate grain distribution are given in Table IV.

Table IV. Aggregate grain distribution.

		KTŞ 2006 Range		Control Range		Forbidden Range		
Sieve (mm)	0.45	LB	UB	LB	UB	LB	UB	Specimen
19.00	3.76	100	100	100	100			**100**
12.50	3.12	83	100	90	100			**94**
9.500	2.75	70	90		90			**80**
4.750	2.02	40	55					**49**
2.360	1.47	29	42	28	58	39.1	39.1	**34**
2.000	1.37	25	38			33	35	**31**
1.180	1.08	18	32			25.6	31.6	**24**
0.600	0.79	12	25			19.1	23.1	**18**
0.420	0.68	10	20			17	20	**16**
0.300	0.58	8	18			15.5	15.5	**14**
0.180	0.46	6	15					**11**
0.150	0.43	5	13					**10**
0.075	0.31	4	10	2	10			**5.5**
LB: Lower Bound UB: Upper Bound								

B. Methods

Marshall Design is a design to determine the optimum amount of bitumen to be used in asphalt concrete. This experiment will also provide the necessary information to find the flow resistance of HMAs containing aggregates with a maximum grain size of up to 25 mm. to make the mixture calculation. to manufacture and also for post-manufacturing. 1150 g. samples of asphalt concrete were prepared in the

design. Bitumen and aggregates were heated at 160°C and samples were produced. Aggregate and bitumen were mixed for 1.5 minutes in a mixer to ensure homogeneous mixing. The sample diameter is 10 cm and the height is about 6.5 cm. Results were obtained for 75 blows in the study. Bitumen ratios used in the mixture range from 3.5-6.5%. Three samples were prepared at each bitumen ratios as a percentage of the weight of the aggregate. The Marshall samples prepared in Fig. 2 are shown.



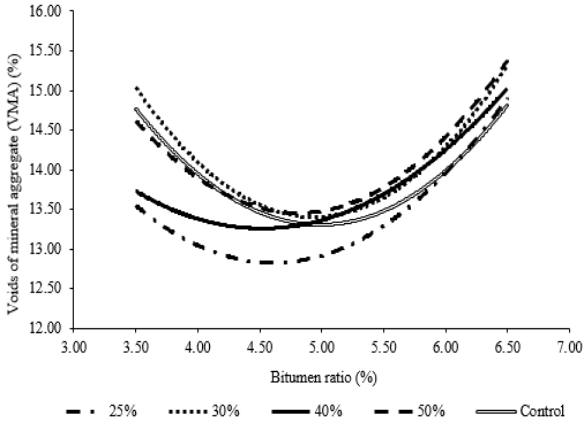
Fig. 2. Marshall Design specimens.

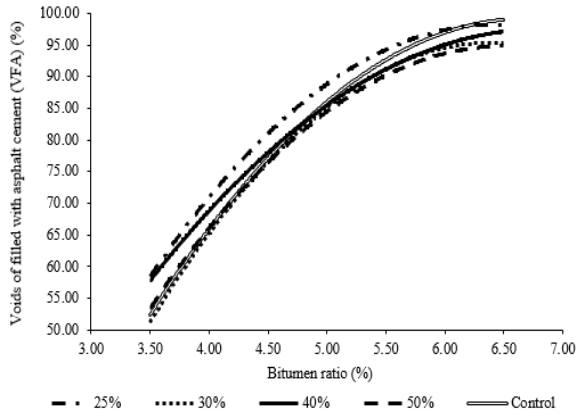
Four criteria are taken into account when determining the optimum bitumen ratio in Marshall Design. These are the practical specific gravity (PSG). Marshall Stability (MS). void ratio (V). voids of filled with asphalt cement (VFA). It is desired that Marshall stability and practical specific gravity values are highest. void ratio is 4%. VFA is 65-75%. These criteria are checked according to the specification limit values. Specification limits for the samples and the obtained test results are given in Table V.

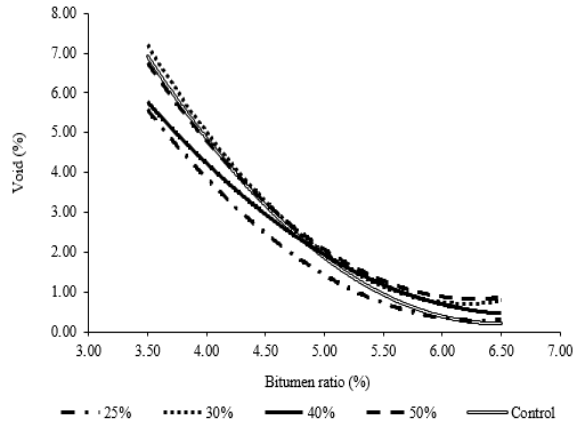
Table V. Specification limits and test results.

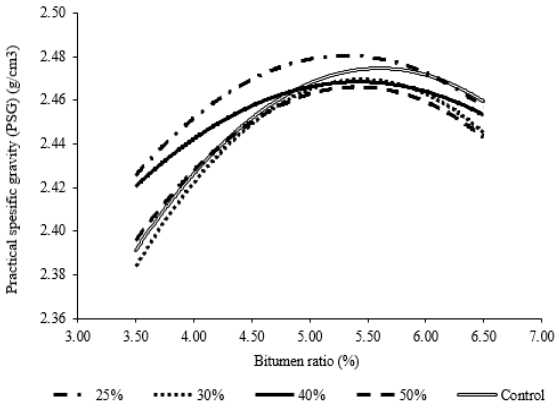
Experiment	50 blow	75 blow	Specifications values
Practical specific gravity (PSG) (kg/cm^3)	6.79	5.74	Max
Marshall stability (MS) (kg)	4.54	3.65	Max
Void (V) (%)	4.81	4.33	3-5
Voids of filled with asphalt cement (VFA) (%)	4.63	4.25	65-75
ORTALAMA	**5.20**	**4.49**	
Flow (mm)	2.88	2.18	2-4
Voids of mineral aggregate (VMA) (%)	14.63	13.73	Min 14
Marshall coefficient (MQ)	450.89	722.73	--

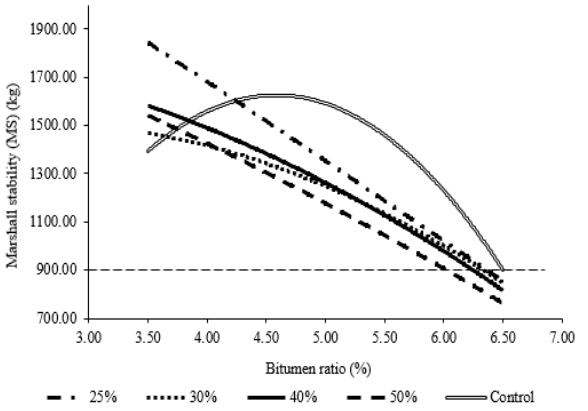
In addition, the Marshall Design results for 50 and 75 blows according to various bitumen ratios are graphically presented in Fig. 3.

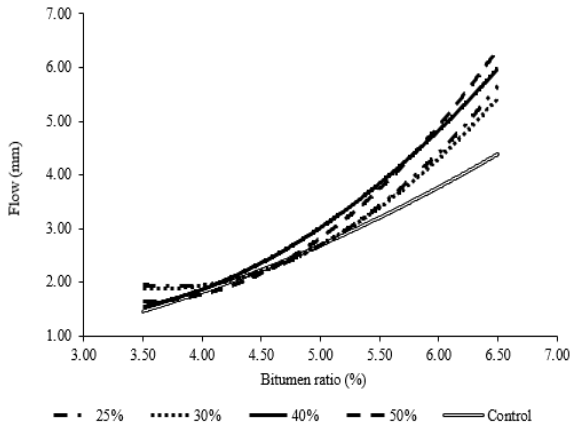


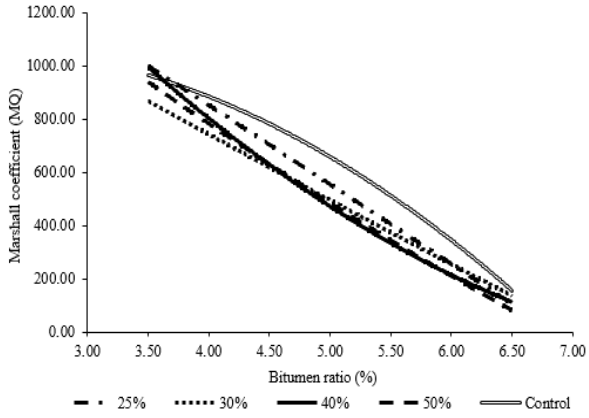












CONCLUSION

In this study. the effects of asphalt plant waste on the performance characteristics of asphalt concrete were investigated. The experiments were carried out according to Marshall Design. The results obtained can be listed as follows:

The optimum bitumen ratio of specimens containing plant waste was lower than normal specimens. This is due to the presence of bitumen particles of the plant waste produced during casting. More economical asphalt concrete can be obtained because the optimum bitumen ratio is reduced in specimens which contain plant waste.

Marshall stability of the plant waste added specimens and normal specimens are close to each other. All specimens meet the specification limit 900 kg.

Flow values are lower in specimens containing plant waste than in normal specimens. This indicates that vertical deformation is less in specimens containing plant waste.

The Marshall coefficient is a parameter that indicates the rigidity of the specimens. It is desirable that this value is high. However, at very high values. the specimens move away from flexibility. According to the test results. the Marshall coefficients of the specimens are close to each other.

As a result; asphalt plant waste provides the required specification values for road superstructure. Specimens containing plant waste provide great advantages as the optimum bitumen is reduced. Low cost asphalt concrete can be produced using plenteous waste. This ensures efficient use of resources. In addition, environmental pollution is prevented and a sustainable environment and living conditions are achieved.

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