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Evaluation of marble waste dust in the mixture of asphaltic concrete

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Abstract

In the study the use of marble dust collected during the shaping process of marble blocks has been investigated in the asphalt mixtures as filler material. The samples having marble dust and limestone dust filler were prepared and optimum binder content was then determined by Marshall test procedure. Dynamic plastic deformation tests were carried out by using the indirect tensile test apparatus. Optimum filler content was then determined considering the filler/bitumen ratio and filler ratio. Test results showed that plastic deformation of marble waste is between the upper and the lower limits of grounded marbles. The study showed that marble wastes, which are in the dust form could be used as filler material in asphalt mixtures where they are available and the cost of transportation is lower than ordinary filler materials.
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Keywords: Mineral filler; Mechanical properties; Waste; Dust

1. Introduction

Leaving the waste material to the environment directly can cause environmental problems. Therefore many countries have still been working on how to reuse the waste material so that they give fewer hazards to the environment. Developed countries have strict rules to protect the environment whereas many developing countries have almost no rules to protect the environment against wastes. Wastes can be used to produce new products or can be used as admixtures so that natural sources are used more efficiently and the environment is protected from waste deposits.

Marble blocks are cut into smaller blocks in order to give the required smooth shape. During the cutting process about 25% marble is resulted in dust. In Turkey marble dust is settled by sedimentation and leaved directly in situ which result in ugly appearance of environment and also causes dust in the summer and threat both agriculture and health. Therefore, using the marble dust in different sectors will help to protect the environment. These sectors are mainly construction, agriculture, glass and paper industry.

In Turkey limestone dust which was obtained from the breakage of limestone was generally used in asphalt mixtures as filler material. However, in recent years many quarries were closed off because of the environmental protection rules put into practice. Therefore, highway authorities and municipalities have difficulties for finding suitable filler material in the asphalt mixtures. As a result use of the waste material as filler material needs to be investigated for road construction. In the paper, use of marble dust is investigated in asphalt mixtures as filler material.

Different filler materials may have different mechanical properties in the asphalt mixture. Dukatz and Anderson [1] have investigated eight different filler materials to investigate the mechanical properties of asphalt and they found that different filler materials have different effects

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on stiffness and had almost no effect Marshall stability and void ratio. Puzinauskas [2] has investigated that mixture of filler-asphalt. However, Mogawer and Stuart [3] investigated eight different filler materials which were known in Europe and they found that good quality fillers and poor quality fillers did not affect the performance of mixtures. Many tests were carried out on asphalt mixtures to investigate the filler behavior. These are mainly wheel tracking apparatus [3,4], Marshall tests [5–9] and indirect tensile test equipment [4,9]. Many different waste materials such as fly ash [7], coal dust [10], pumice dust [11], sewage sludge ash [8] were used in asphalt mixtures as filler material.

2. Materials

Crushed limestone was obtained from quarries around Isparta which are mainly used for highway construction. The aggregate properties are given in Table 1 [12].

In the study, aggregate grading curves for asphalt mixtures were obtained from Turkish Highway Construction Specifications (Table 2) [13]. Sieve analyses were carried out and available grading curve for the aggregate used in the study was close to binder layer course as shown in Fig. 1.

Table 1
Properties of aggregate used in the tests

Test name	Specification	Measured values
Specific gravity and adsorption of coarse aggregate	Density	2691 kg/m^3
	Saturated density	2696 kg/m^3
	Water absorption ratio	0.2%
Specific gravity and adsorption of fine aggregate	Density	2580 kg/m^3
	Saturated density	2624 kg/m^3
	Water absorption ratio	2.3%
Los Angeles wearing test	Wearing	17%
Freezing and thawing test	Loss of material	6.8%
Stripping test by Nicholson method	Stripping	24%

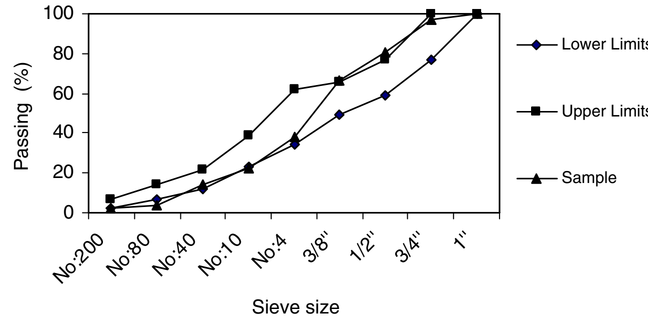

Fig. 1. Grading curves of binder Type C and the aggregate.

Table 3
Gradation of marble dust after washing

Sieve size	Passing % (by washing)
2.000 mm (No. 10)	100.00
0.600 mm (No. 30)	99.40
0.300 mm (No. 50)	95.10
0.075 mm (No. 200)	91.20

Limestone dust was obtained from sieving test of the aggregate from No. 200 sieve, whereas marble dust was obtained in wet form directly taken from deposits of marble factories. Therefore the marble dust must be dried before the sample preparation. Waste marble dust contains several marble types, saw parts and marble particles. Therefore, waste marble dust was washed at first and sieved from No. 200 sieve, gradation of the dust is shown in Table 3. 75–100 penetration asphalt cement was used to prepare Marshall samples.

3. Experimental study

Marshall stability tests were carried out in order to find optimum bitumen content (OBC) of the mixes (Fig. 2). As shown in Fig. 2, stability of the samples containing limestone dust is higher than the samples containing marble dust. Similar flow values for both materials were obtained from Marshall flow test results (Fig. 3). After obtaining OBC, the samples were prepared for different filler/bitumen

Table 2
Gradation limits of aggregates [13]

Sieve	Binder course passing (%)			Wearing course passing (%)					
	Type A	Type B	Type C	Type A	Type B	Type C	Type D	Type E	Type F
1″	100	100	100	–	–	–	–	–	–
3/4″	82–100	80–100	77–100	100	100	100	–	–	–
1/2″	68–87	63–81	59–77	89–100	84–100	81–100	100	100	100
3/8″	60–79	54–72	49–66	80–95	75–91	71–87	87–100	87–100	80–100
No. 4	46–65	50–58	34–52	64–81	57–75	52–70	66–82	60–77	55–72
No. 10	34–51	28–45	23–39	48–65	42–59	36–53	47–64	41–58	36–53
No. 40	17–29	14–25	12–22	26–40	22–35	17–30	24–36	20–32	16–28
No. 80	9–18	8–16	7–14	15–26	12–22	9–19	13–22	11–19	8–16
No. 200	2–7	2–7	2–7	4–10	4–10	4–10	4–10	4–10	4–10

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