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Use of MARBLE's WASTE IN ASPHALT MIXTUREs

By

S. Khedr[*] N. Nagy[**] A. El-Desouky[**]

A. Abbas[***]

ABSTRACT

In this study the use of marble dust, marble limestone and crushed marble collected during the shaping process of marble blocks has been investigated in the asphalt mixtures as filler material, limestone and sand. Six different asphalt mixes having marble dust, limestone dust filler, crushed marble, sand, limestone aggregate and marble aggregate were prepared. The optimum binder content was then determined by Marshall test procedures. The study showed that marble's wastes, which are in the dust form and crushed form could be used as filler material and sand in asphalt mixtures where they are available. This may reduce the cost of transportation compared to that when using ordinary paving materials.

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.

* Professor, Construction Engineering Department, AUC, Cairo, Egypt
** Egyptian Armed Forces
*** Syrian Armed Forces

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 and more30% is resulted in crushed and limestone marble [1], [2]. In many countries marble dust is settled by ugly sedimentation and leaved directly in situ which result in 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, and glass and paper industry.

In many countries 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 and sand material needs to be investigated for road construction. In the paper, use of marble dust and crushed marble are investigated in asphalt mixtures as filler and sand material. Karaşahin and Terzi (2006) [3] conducted experiments on asphalt mixtures. They used different percentages of limestone dust and marble dust and subjected the samples to test Marshall and got the results.

Test results showed that as the filler/bitumen ratio of the sample containing limestone dust increases the plastic deformations decrease up to 7% filler/bitumen ratio; after that the plastic deformation increases. Test results of the samples containing the marble dust and limestone dust have almost similar plastic deformations. Therefore, asphalt mixtures containing marble dust can be used directly in the mix without any process. Since the asphalt mixtures containing the marble dust have slightly higher plastic deformations, it is recommended to the asphalt mixtures containing marble dust for low volume roads such as secondary roads and local roads.

Akbulut and Gürer (2006) [2] Conducted experiments on asphalt mixtures. Four kinds of aggregates were used in this study; a waste marble (A), an andesite (B) as well as two different limestones (C and D). Subjected the samples to test Marshall and got the results.
In this study, the properties of waste marble and andesite aggregates were compared with the properties of control aggregates specimens. For this purpose, standard pavement aggregates tests and Marshall Stability tests were carried out. The conclusions drawn from this study are as follows:

1. According to the Los Angeles abrasion test results, the abrasion loss of specimen A was within the specification limits (27.44%).
2. According to the freezing and thawing test results the loss value of all the

aggregate specimens was less than 12%.

3. According to the Marshall Mix design results, the stability value of mixes produced from specimen B was higher than the other specimens. The flow measurements of the four specimens were in the order of: C>A>D>B.
4. The optimum AC contents of specimen mixes; A (4.68%), C (4.3%) and D (4.53%) were within specified limits [4]. The high porosity of specimen B is indicated by its high optimum AC content (8.10%).
5. From the results of aggregate and hot mix tests described above we can infer that waste marble aggregates can be used in light to medium trafficked asphalt pavement binder courses.

MATERIALS AND METHOD

Aggregate and asphalt cement

Four kinds of limestone aggregates and four kinds of marble's wastes were used in this study; the use of waste marble aggregates has the potential to reduce road construction budgets as well as encourage environmental protection. The bitumen used is 60/70 penetration grade (ASTM D 946).

Experimental design

The plan of this study is outlined below:

Determination of physical properties of aggregates: this section includes sieve analysis [5]; specific gravity of coarse, fine and filler aggregates [6], [7] ASTM (1996) Standards as shown in Fig.(1,2) . Test method for specific gravity and adsorption of fine aggregate Annual Book of ASTM Standards USA; 1992.[7] and [8] Los Angeles abrasion value (LAV) test [9].

Marshall test and optimum AC content determination: in determining the optimum AC content a series of test specimens were prepared with a range of different AC contents so that the test data curves show a well-defined optimum value [10]. The Marshall stability and flow tests were performed on the specimens prepared. Conclusions were drawn based on the results and have been presented below.

TEST RESULTS

The experimental study was performed in two sections; aggregate tests and hot mix tests.

Aggregate blending

Specific gravities of the aggregate specimens and sieve analysis are presented in Table 1 and Table 2. Design gradation limits of aggregate specimens for hot mix asphalt from the aggregate specimens as shown in Table 3. Standard aggregate test methods were applied to the aggregates.

Table 1: Specific gravities of aggregates

Type / Properties	SEN-1	SEN-2	Marble-1/2'''	Marble-1/2''	Marble-1
Dry weight.	1993.25	1994.86	1996.40	1996.10	1992.90
Weight after 24 h	2019.56	2023.84	2022.50	2044.33	2014.77
Weight in water	1249.80	1251.22	1250.35	1254.60	1255.09
Total specific weight	2.59	2.58	2.59	2.53	2.62
Dry saturated Weight	2.62	2.62	2.62	2.59	2.65
Apparent specific weight	2.68	2.68	2.68	2.69	2.70
(Total + App)/2	2.64	2.63	2.63	2.61	2.66
Absorption	1.50	1.50	1.30	2.40	1.10
LOS Anglos	25.90	25.90	31.90	40.50	39.10

Table 2: Aggregate Gradation

Sieve Size		Passing (%)							
(#)	mm	MF	sand	Sen-	Sen-1	Marble1/2	Marble30	8"	Marble
3	76.2	100	100	100.0	100.0	100	100	100	100
2.5	63.	100	100	100.0	100.0	100	100	100	100
2	50.8	100	100	100.0	100.0	100	100	100	100
1.5	38.1	100	100	100.0	100.0	100	100	100	100
1	25.4	100	100	100.0	100.0	100	100	100	100
3/4	19	100	100	56.7	100	100	100	100	100
1/2	12.5	100	100	56.7	100	100	100	100	100
3/8	9.5	100	100	25.2	74.7	98.8	100	100	43.2
#4	4.75	100	100	1.7	50.8	53	100	100	3.1
#8	2.36	100	97.8	0	18.3	14.8	100	99.8	2.3
#30	0.6	100	66	0	7.4	2.7	100	9.38	1.5
#50	0.3	98.8	35.4	0	5.3	2.6	84.92	5.68	1.3
#100	0.15	94.	17.7	0	4.3	2.5	66.2	4.52	1
#200	0.12	86.4	4.5	0	0.3	2.5	59.35	4.12	0.8

Table 3: Design gradation limits of aggregate specimens

Sieve (mm)	Passing (%)							
	C. Mix	Mix1	Mix2	Mix3	Mix4	Mix5	Lower–upper limits	
25.4	100.0	100.0	100.0	100.0	100.0	100.0	100	100
19	89.2	89.2	89.2	89.2	100.0	89.2	80	100
9.50	70.7	70.7	70.7	70.7	76.4	70.7	60	80
4.75	54.8	54.8	54.8	54.8	48.1	54.8	48	65
2.36	40.1	40.1	40.2	40.4	37.2	40.3	35	50
0.60	26.6	26.6	22.6	19.0	24.8	20.4	19	36
0.30	17.1	16.4	15.0	13.1	16.1	13.1	13	23
0.15	11.5	10.1	10.5	9.7	10.7	8.6	7	15
0.07	5.7	4.4	5.7	5.7	6.6	4.3	3.00	8

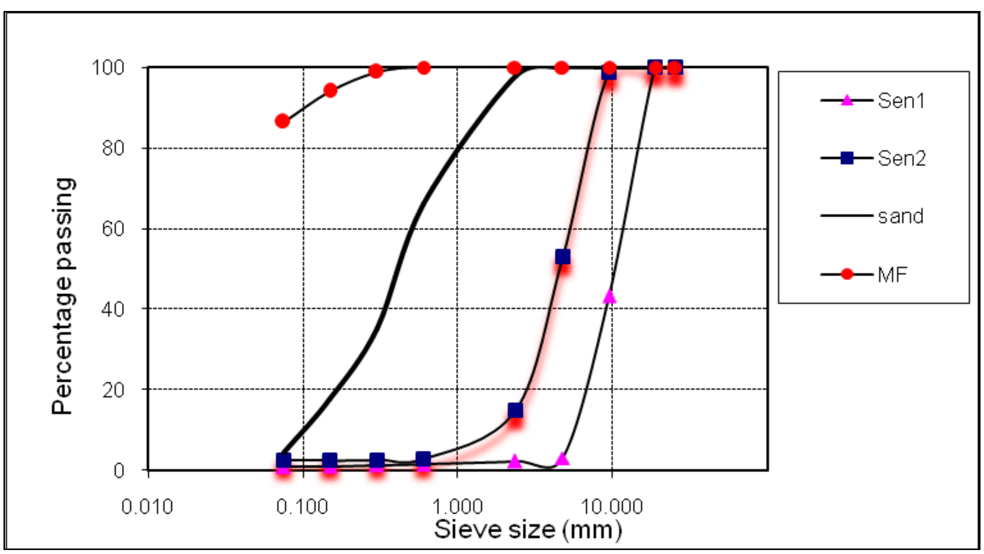

Fig.1: Limestone Aggregate Gradation

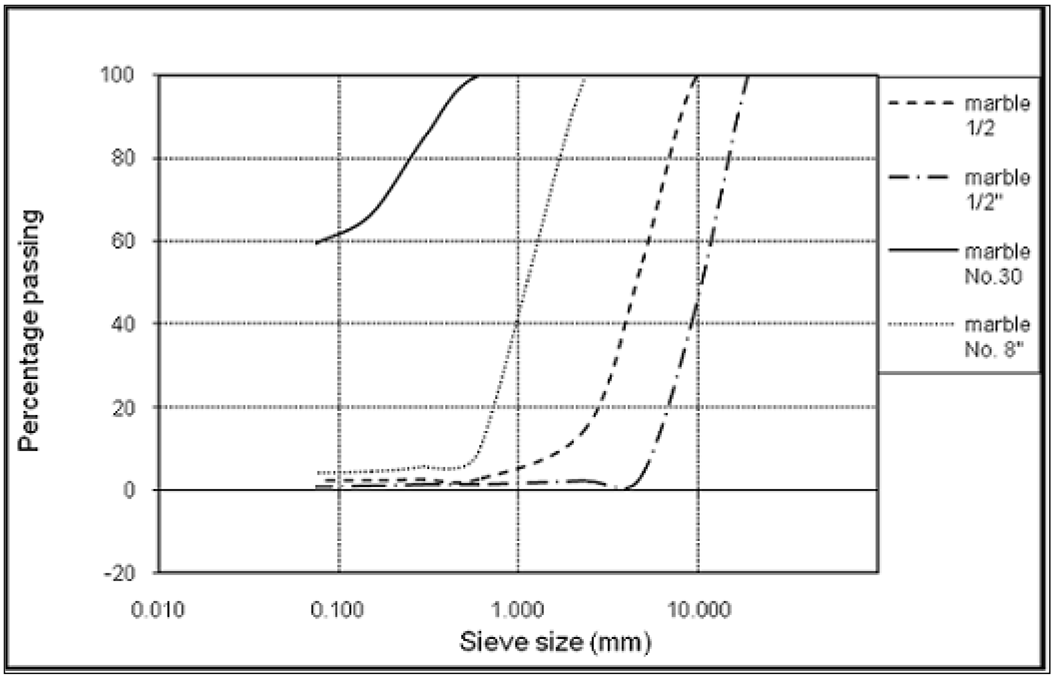

Fig. 2: Marble Aggregate Gradation

Table 4: Different trials of aggregate proportions by weight (%)

Trial Number	Proportion by weight (%)							
	Sen-1	Sen-2	Sand	Powder	Marble-1/2''	Marble-8''	Marble-30''	Marble-1/2''''
C. Mix	42	25	28	5	-	-	-	-
Mix1	42	25	28	-	-	-	5	-
Mix2	42	25	21	5	-	7	-	-
Mix3	42	25	14.5	5	-	13.44	-	-
Mix4	-	-	28	5	26	-	-	41
Mix5	42	25	17	-	-	11	5	-

In this study, aggregate grading curves for asphalt mixtures were obtained from AASHTO Specifications. 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.4.

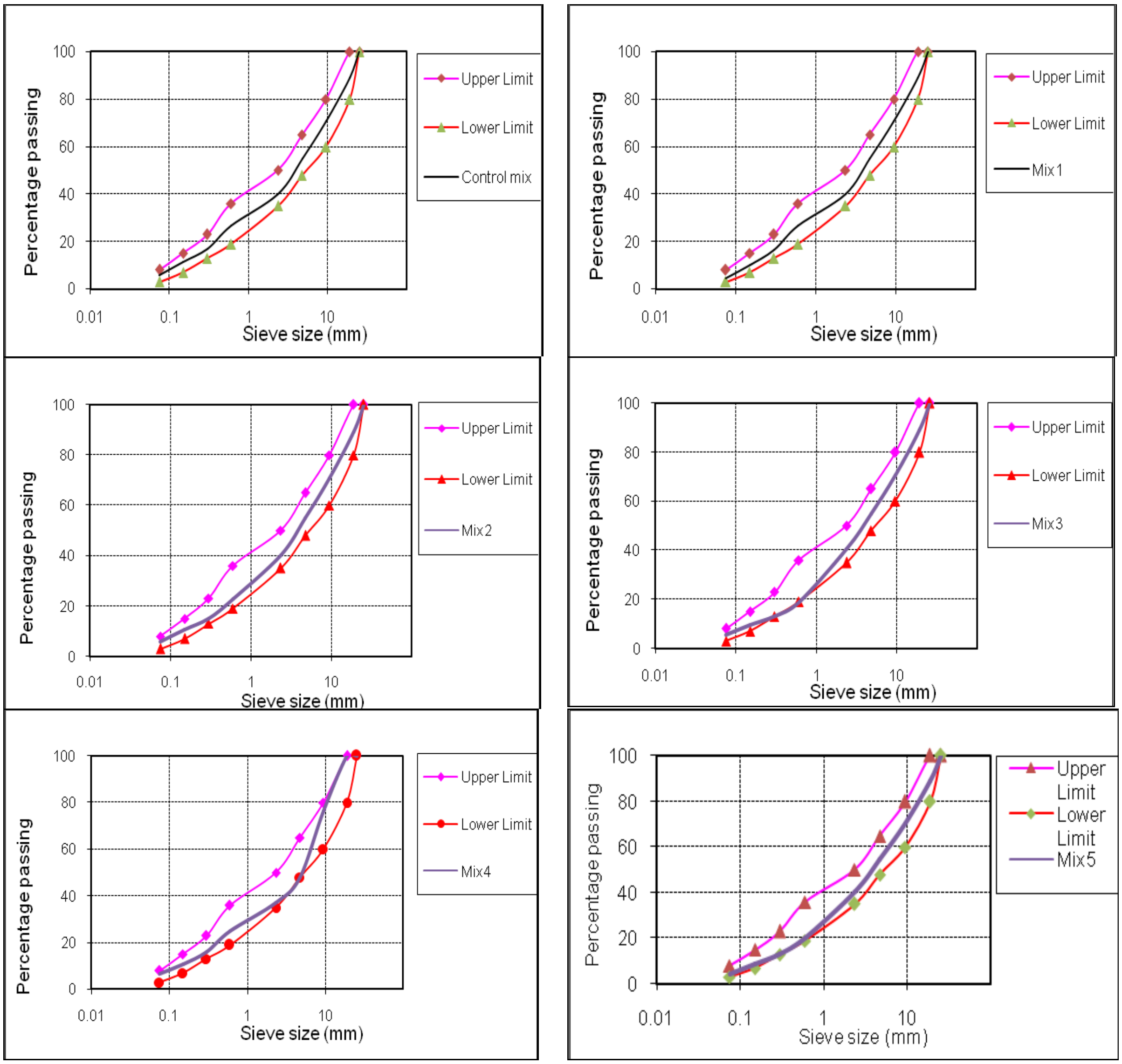

Fig. 4: Candidate Mixes Gradation and Specifications

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. 30 sieve.

Hot mix tests

Marshall mix design

Optimum AC content was determined by the Marshall mix design method after the mechanical properties of the aggregates were determined. Tests were scheduled on the basis of 0.5% increment of asphalt content. Three asphalt cement concrete (ACC) specimens were prepared for each AC content. Thus, 15 test specimens were used for a hot-mix design study using five different AC. The specimens are preheated to a prescribed temperature placed in the special test head and the load is applied at a constant stain (2 in/min). While the stability test is in progress, the dial gauge is used to measure the vertical deformation of the specimens; the deformation read at the load failure point is expressed in units of 0.25 mm and is called the Marshall flow value of the specimen [11], [12] and [13]. The test was repeated for the specimens of each AC content (asphalt cement) and the optimum AC value for each mix was determined. Since the specific gravity of the aggregates and asphalt, bulk density, stability and flow value of the specimens were known, the following curves were plotted:

(a) Unit weight or bulk specific gravity (Dp) versus AC content.
(b) Corrected Marshall stability versus AC content.
(c) Marshall flow versus AC content.
(d) Percentage of void (Vh) in the total mix versus AC content.
(e) Percentage of void filled with asphalt (VFA) versus AC content.
(f) Percentage of void in mineral aggregate (VMA) versus AC content.

To determine the optimum AC content for the mix design, the average values of the following three AC obtained from the graphs described above were considered:
(i) AC content corresponding to maximum stability.
(ii) AC content corresponding to maximum bulk specific gravity (Dp).
(iii) AC content corresponding to the median of designed limits of percent air voids (Vh) in the total mix (i.e., 3–5%).

The stability value, flow value and at the optimum asphalt content were determined from the curves and it was ensured that each of these values correspond with the Marshall mix design specification values. Following this, the optimum asphalt contents versus specifications Marshall flow and % VMA were checked. Results of the Marshall Mix design are shown in Figureas (5 -10).

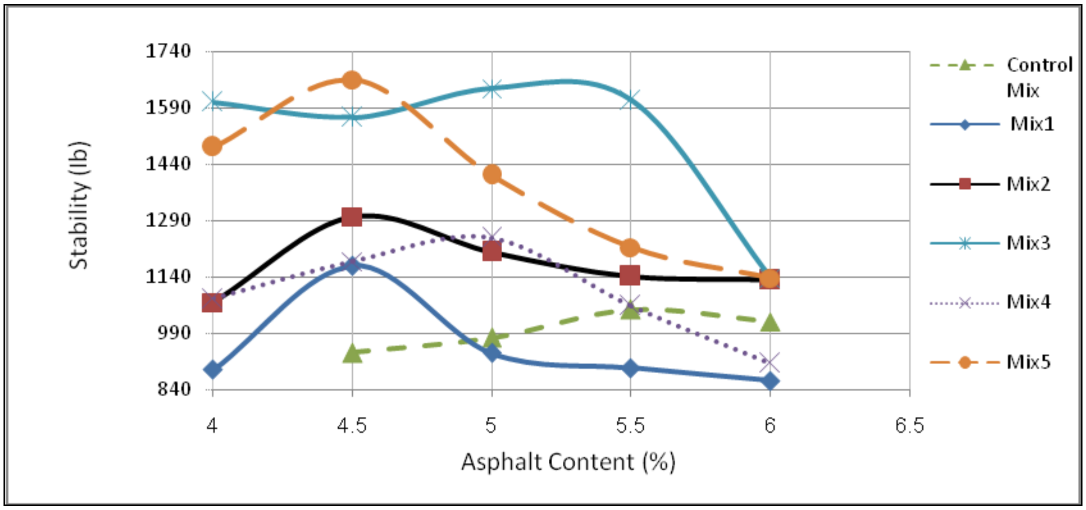

Fig. 5: Stability versus asphalt content, all mixes

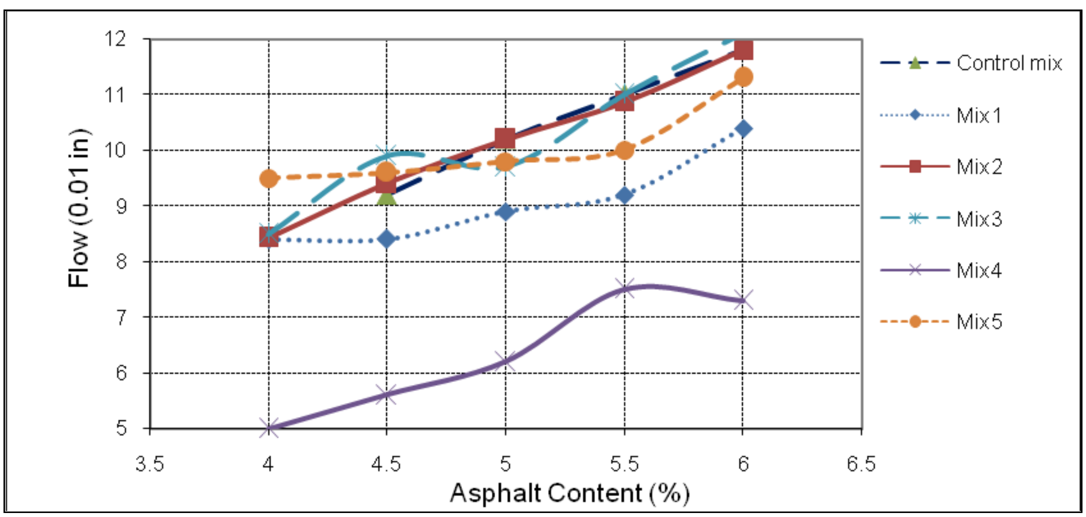

Fig. 6: Flow versus asphalt content, all mixes

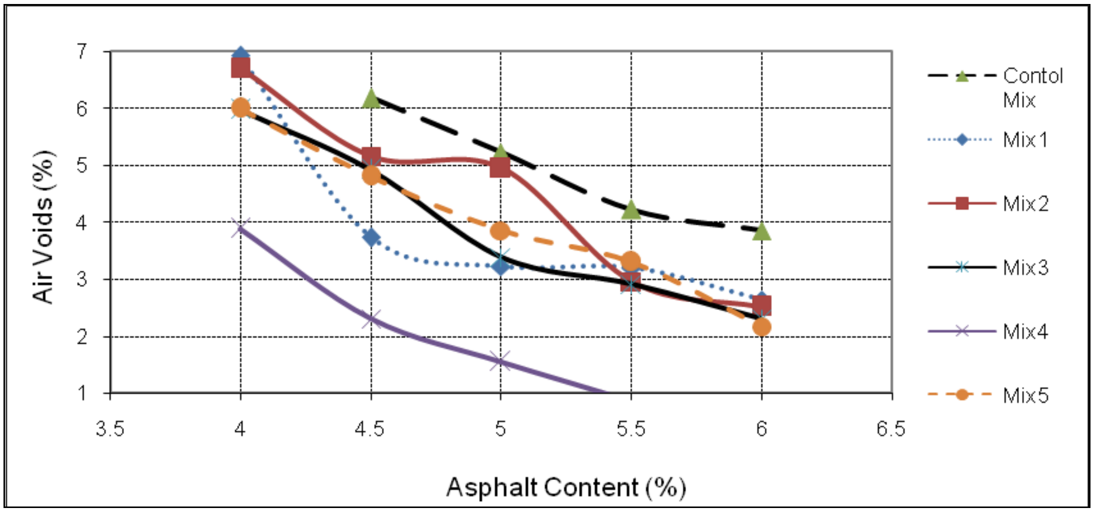

Fig.7: Air voids versus asphalt content, all mixes

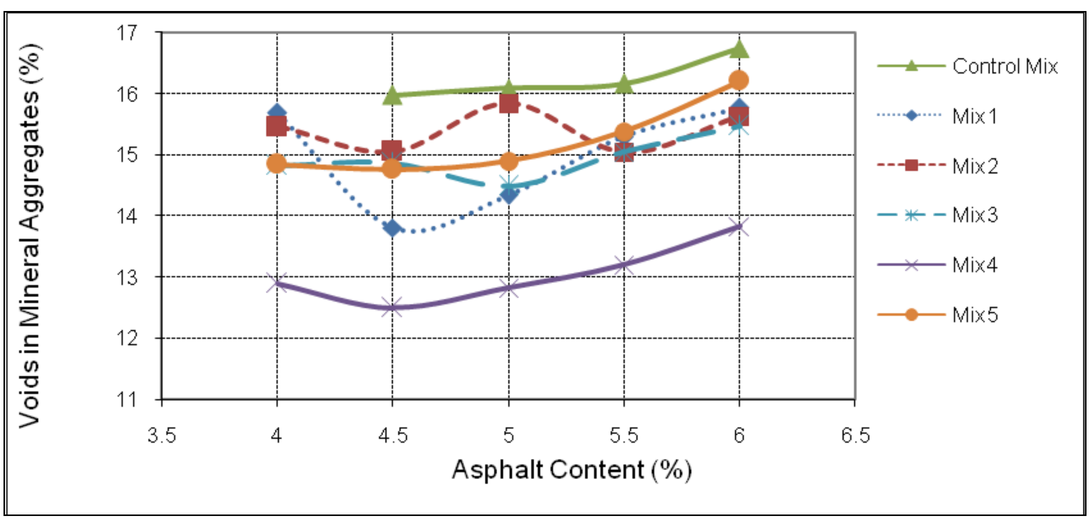

Fig. 8: Voids in mineral aggregate versus asphalt content, all mixes

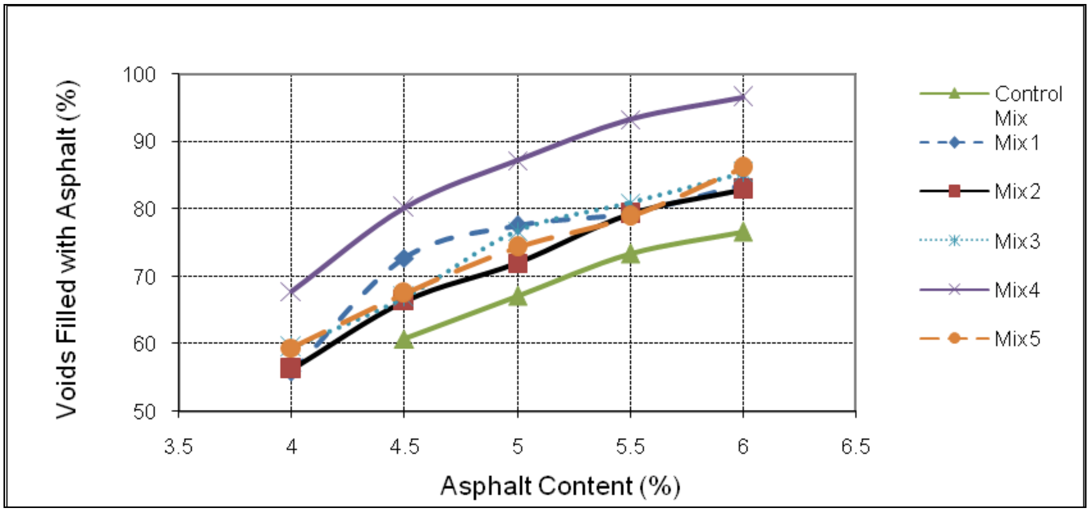

Fig. 9: Voids filled with asphalt versus asphalt content, all mixes

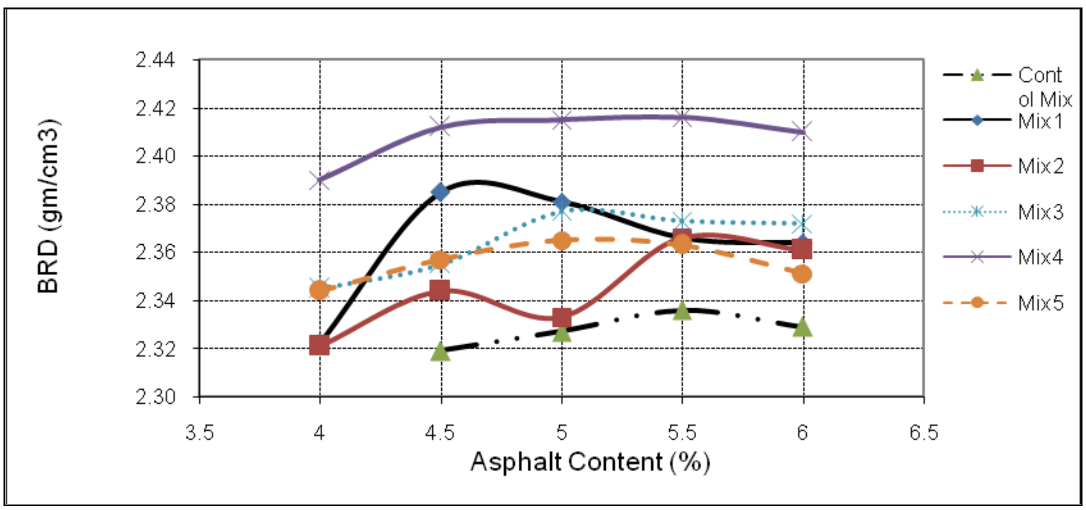

Fig. 10: Density versus asphalt content, all mixes

CONCLUSION

Use of marble dust collected during the shaping process of marble blocks in the asphalt mixtures was investigated. The samples containing either marble dust or limestone dust were prepared and optimum bitumen content of the mixes was obtained. Marshall Stability, Flow, density, air void, VMA and VFA were carried out on the prepared samples. Test results showed that use waste of marble increased stability and decreased OAC. Therefore, asphalt mixtures containing marble dust and marble sand can be used directly in the mix without any process.

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