The use of Borax, Sepiolite, Zeoliıe, Waste Meerschaum and Contaminated River Sediment in Asphalt Concrete Mixtures

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ABSTRACT: The purpose of this study is to investigate the possibility of using mineral and river materials to make asphalt concrete. It was investigated that influences of borax, sepiolite, zeolite, meerschaum, and sediment incineration bottom ash (SIBA) on indirect tensile" strength, density, flow and Marshall stability. Asphalt concrete mixes were prepared by mixing the 0, 4, 7, and 10% borax, sepiolite, zeolite, meerschaum and SIBA by the weight of optimum bitumen content. When the percentage and the amount of borax, sepiolite, zeolite, meerschaum and SIBA were increased, indirect tensile strength and density values are decreased. However, flow values are increased. Marshall Stability properties of specimens prepared with different mineral were different. When the amount sepiolite was increased, Marshall Stability values are increased. Marshall Stability values of specimens prepared with borax, zeolite, meerschaum and SIBA are decreased.

1. INTRODUCTION

Disposal of industrial wastes is a worldwide problem. Environmental awareness of the drawbacks of landfill sites is forcing nations to look for better ways to recycle industrial wastes (Tuncan et al., 2003). Also, there are plenty of industrial wastes in Turkey. These wastes cause environmental pollution. Using these wastes in the asphalt concrete pavement not only decreases environmental pollution but also improves some properties of asphalt mixtures (Ali et al., 1996). Different additives and waste materials have been used in asphalt mixtures in the world in recent years. Additives and waste materials can be used as percentage of total weight of asphalt or natural filler. The use of industrial wastes as additives in asphalt mixtures is not a new technique. Additives have been used in road construction for more then 80 years (Al-Abdul-Wahhab, H.& Al-Amri, G.. 1991). Additives incorporated in asphalt mixtures to enhance the properties and performance of asphalt concrete pavements. Result of these studies indicated that fly ash could be used as a mineral filler to improve the resilient modulus characteristics and stripping resistance. The production of municipal wastes in the European community is estimated at about 150 million ton per year. Only 20% is incinerated which represents about 9 million ton of municipal solid waste incinerator (MSWI) ash. These quantities will increase considerably with the growth of municipal waste production, the progressive closing of landfill, the definition of new environmental standards, reuse and elimination policies (Pecqueur, G., Crignon, C, Quenee, B., 2001). According to this study bottom ash is often treated with binder to improve its mechanical features. Nevertheless, bottom ash is subject to chemical problems. These problems induce an expansion which brings about cracking and finally road destruction. Therefore, it is necessary to estimate the swelling potential of MSWI bottom ash prior utilization. If there is a undesired results, chemical stabilization can be gotten by using some chemical elements. The heavy metals in the fly ash generated in MSW (municipal solid wastes) incinerators can be stabilized effectively by adding sodium sulfide and thiourea. The volume expansion due to the addition of the foregoing chemicals is negligible. Another effective treatment method for the fly ash is to leach the heavy metals from the ash by using complex agents such as EDTA (Youcai et al., 2002).

In this studies, it was investigated that the effects of borax, sepiolite, zeolite, meerschaum and SEBA on indirect tensile strength, density, flow and Marshall Stability in the laboratory.

2. MATERIALS

2.1. Aggregate

In this study, crushed stone was used as type of aggregate. The properties of aggregate are given in Table 1. Ratios of aggregate used are given in Table 2.

Table 1. Properties of aggregate.

Properties	Values
Coarse aggregate specific gravity (gr/cm)	2.718
Fine aggregate specific gravity (gr/cm^3)	2.743
Filler specific gravity (gr/cm^3)	2.769
Coarse aggregate water absorption (%)	0.85
Coarse aggregate water absorption (%)	1.18

Table 2. Ratio of aggregate.

Aggregate	Size	Ratio (%)
Coarse aggregate	>#4	36
Fine aggregate	#4-200	54
Filler	<#200	10

2.2. Asphalt cement

Asphalt cement used has 75-100 penetration grades. This asphalt is widely used in pavement constructions in Turkey. Also it can be obtained from the Asphalt Work Sites easily. This Asphalt cement was subjected to typical standard laboratory tests. Results of these tests are given in Table 3.

Table 3. The result of tests on asphalt cement

Properties	Values
Specific gravity (gr/cm^3)	1.021
Penetration, 25 °C,100gr, 5 s (l/100mm)	80
Ductility, 25 °C, 5 cm/min	100+
Softening point, (°C)	47
Flash point, (°C)	231

2.3. Borax

Borax used was gotten from Kirka, Eskişehir. Borax pentahidrat ($Na2B_407.5H_20$) is obtained by refining Borax Tinkal ($Na2B_4O7.10H_2O$). Boron minerals are among the most important minerals in modern technology, and they are gradually gaining importance. They have wide areas of utilization such like drug industry, agriculture, metallurgy, space industry, nuclear applications, and construction of fire-proof materials. 63% of all the reserves in the world are in Turkey, and 16% is in USA (Koyuncu, and Güney, 2003).

2.4. Sepiolite

The material used in this study is a natural sepiolite from Mayas Mining Company in Sivrihisar, Turkey. Sepiolite exist different types in nature. It can be found easily in Eskişehir.

2.5. Zeolit

In this study, natural zeolit which was obtained from Balikesir (Gördes) was used. This zeolit is rich zeolitical tufa. It can be formulated as (Na4K4)(Aİ8Sİ4o096)24H20. Zeolites are a group of basic, hydrous alumino-silicate minerals. They have an open aluminosilicate framework structure containing channels filled with water molecules and cations which are usually exchangable at temperatures below 100°C. Natural zeolites are common in saline-alkaline lake deposits, hydrothermally altered volcanic or sedimentary rocks and deep-sea sediments (Bish and Guthrie, 1994). Clinoptinolite is one of the most predominant species of sedimentary zeolite and generally occurs in association with montmorillonite (Minato, 1980).

2.6. Meerschaum

Meerschaum used in this study was obtained from Kayi village in Eskişehir. Commercial meerschaum pipe waste was collected and ground. Then it was used instead of filler. Meerschaum is formation which is containing sepiolit.

2.7. Sediment Incineration Bottom Ash (SIBA)

Sediments were taken from Porsuk River in Çalca region. Total sediment load of the river Porsuk was estimated to be around 5 million ton/year (Koyuncu et al., 2003). Çalca is located around Kütahya outlet of Porsuk River. Porsuk River is contaminated by Nitrogen Products Plant, ceramic factory, sugar factory and magnesite wastes. There are high concentrations of zinc, lead and nickel in Çalca river sediments. Water content and organic materials of these sediments were high. The sediment was dried at 105 °C for 72 hours in oven. Then, sediment samples were incinerated on 750 °C at 2 hours.

Table 4. Chemical compositions of filler materials (%)

	Borax	Sepioli	Zeolite	Meerschaum	SIBA
Boron Oxide (B_20_3)	47.26	-			
Silica ($Si0_2$)	12.46	54.13	71.39	52.90	55.33
Alumina (AI2O3)	3.93	1.29	13.30	1.40	21.23
Iron Oxide (Fe20s)	0.13	0.37	0.94	0.33	1.54
Lime (CaO)	1.12	0.56	2.74	0.97	2.23
Magnesia (MgO)	2.23	21.34	0.71	25.89	0.02
Titania ($Ti0_2$)	0.01	0.08	0.23	0.16	0.40
Soda (Na_20)	21.85	0.12	0.47	0.02	1.48
Potash (K_20)	0.31	0.58	3.69	0.11	0.20
Sulphates (SO3)	0.01	0.31	0.01	0.45	0.71

According to triangular classification method, the class of this sediment is silt. Sediments are found to be highly contaminated by metals. Sediment was carried out at a temperature of 750°C and SIBA added to filler materials in ratio of 0%, 4%, 7% and 10%.

Chemical compositions of borax, sepiolite, zeolit, meerschaum and SIBA which were used as filler materials ar& given Table 4. Also physical and chemical properties of these filler materials are given in Table 5.

Table 5. Physical and chemical properties of filler materials

	Borax	Sepiolite	Zeolite	Meerschaum	SIBA
Specific gravity	1.88	1.56	2.63	1.40	2.46
Loss on Ignition (%)	6.13	17.24	6.25	19.21	0.02
CEC (meq/lOOg)	27.45	64.25	165.17	70.65	12.21
EC (mS/cm)	3.46	0.52	2.09	0.41	3.21
pH	9.46	9.27	8.20	9.30	9.57
Fine Sand (0.475-0,075)	5	18	2	13	0
Silt (0,075-0,002)	71	63	74	70	92
Clay (less than 0,002)	26	19	24	17	8

CEC. Canon Exchange Capacity, EC. Electrical Conducavity

3. LABORATORY STUDY

In this study, the effects of borax, sepiolite, zeolit, meerschaum and SIBA which were used as filler materials on asphalt concrete pavements were investigated. Mixture ratio of borax, sepiolite, zeolit, meerschaum and SIBA are given in Table 6.

Table 6. Mixtures properties of filler materials (%).

	Coarse aggregate	Fine aggregate	Natural Filler (stone powder)	Filler Materials (Additives)
Mixture 1	36	54	10	0
Mixture 2	36	54	6	4
Mixture 3	36	54	3	7
Mixture 4	36	54	0	10

Borax, sepiolite, zeolit, meerschaum and SBBA were added to mixture as percentage of filler. Their ratios are 0%, 4%, 7% and 10% of filler, respectively. Mixture 1 is control mixture. Asphalt cement content was 6% in all mixtures. Coarse and fine aggregate ratios were 36% and 54%, respectively. These ratios are constant. There are four mixtures. Ratios of borax, sepiolite, zeolit, meerschaum and SIBA were changed as 0%, 4%, 7% and 10% in the mixtures.

In laboratory studies were carried out as given below,

1. Asphalt cement was heated in the oven at 160 °C
2. Test container for mixing was kept in the oven at 160 °C

3. Aggregates required amount were kept in the oven at 160 °C
4. Borax, sepiolite, zeolit, meerschaum and SIBA were added to mixture at 0%, 4%, 7% and 10% ratio of filler material.
5. All materials were mixed until to get homogeneous mixtures.
6. Test specimen were prepared and kept in water at 60 °C for 40-50 minutes for cure.
7. Indirect tensile strength, density, flow and Marshall Stability tests are applied to test specimen. Test results were given for indirect tensile strength, density, flow and Marshall Stability tests separately.

4. RESULTS AND DISCUSSION

4.1. Indirect tensile test

The indirect tensile strength results are given in Figure 1. Indirect tensile strengths of mixtures decrease with increasing the amount of borax, sepiolite, zeolit, meerschaum and SIBA. The largest decrement was observed in mixtures which contain borax. Decrement of indirect tensile strength in sepiolite and SIBA is low. The least decrement was observed in mixtures which contain sepiolite.

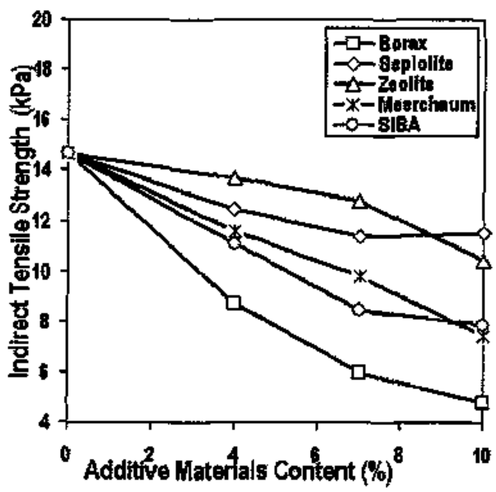

Figure 1. Indirect tensile strengths value of specimens.

4.2. Density test

The results of density tests are given in Figure 2. Density of mixtures decrease with increasing the amount of borax, sepiolite, zeolit, meerschaum and SIBA. The largest decrement was observed in mixtures which contain meerschaum. Meerschaum is a light mineral. This case can cause to decrement of density. The least decrement was observed in mixtures which contain SIBA.

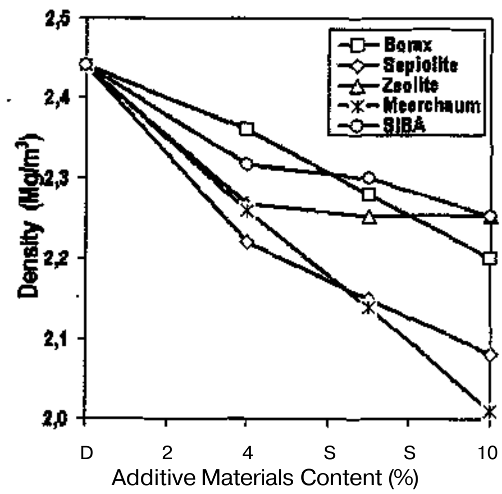

Figure 2. Density value of specimens

4.3. Flow test

The results of flow tests are given in Figure 3. Row values of mixtures increase with increasing the amount of borax, sepiolite, zeolit, meerschaum and SIBA. While the addition of borax and meerschaum 'as filler increases the flow of asphalt pavement significantly. The least increment was observed in mixtures which contain sepiolite, zeolit and SIBA.

4.4. Marshall stability test

The results of Marshall stability tests are given in Figure 4.

Different results are obtained while borax, sepiolite, zeolit, meerschaum and SIBA were added as an additive material. While addition of 7% and 10%

sepiolite increased the Marshall stability value by 18 kN and 22 kN, respectively. The addition of borax to mixtures causes to decrement of Marshall stability values significantly. The least decrement was observed in mixtures which contain zeolite and SIBA.

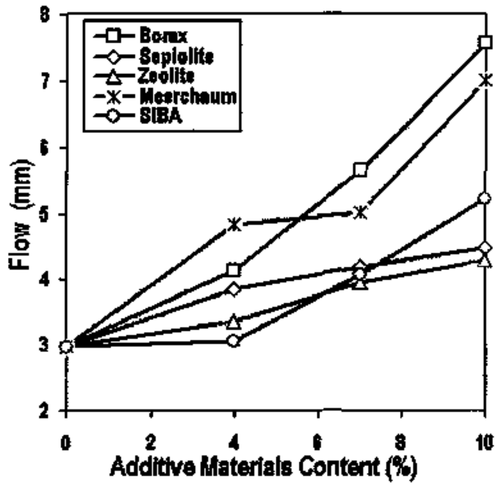

Figure 3. Flow value of specimens.

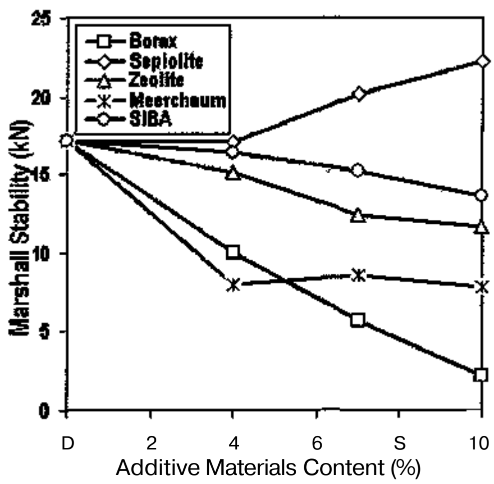

Figure 4. Marshall stability value of specimens

5. CONCLUSIONS

In this study, experimental results showed that indirect tensile strengths of mixtures decrease with mcreasing the amount of borax, sepiolite, zeolit, meerschaum and SIBA. The least decrement was observed in mixtures which contain sepiolite and zeolit. Indirect tensile strengths test is very important for predicting pavement performance. 4% and 7% mixed sepiolite and zeolit can be used as filler in asphalt mixtures.

If borax, sepiolite, zeolit, meerschaum and SIBA are added to mixtures, densities of asphalt mixtures are decreased. However, density of 4% and %7 mixed SIBA is nearest value to control specimens.

While the addition of borax, sepiolite, zeolit, meerschaum and SIBA as filler increases the flow of asphalt pavement. The largest increment was observed in mixtures which contain sepiolite.

In this study, different results were obtained for different mineral point of view Marshall stability. The addition of borax to mixtures causes to decrement of Marshall stability values significantly. The least decrement was observed in mixtures which contain zeolite and SIBA. If sepiolite add to asphalt mixtures as filler by 7% and 10% ratio, Marshall stability value increase by 18 kN and 22 kN, respectively.

According to experimental result of this study, sepiolite and SIBA can be used as filler in asphalt pavements. Especially, sepiolite and SIBA are found in Eskişehir easily. Using sepiolit and SIBA will get economical utility. If borax uses m asphalt mixtures, it will increase flow. On the other hand, zeolit and meerschaum can not use for asphalt mixtures.

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