ASSESMENT OF THE USE OF DIATOMITE AND PUMICE IN STONE MASTIC ASPHALT AS STABILIZER

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Abstract: Stone Matrix Asphalt (SMA) has been preferred to start because of its better resistance to rutting due to slow, heavy and high volume of traffic. Structure of SMA consists of high coarse aggregate, high asphalt contents and fiber additives as stabilizers. The stabilizing additives generally composed of cellulose fibers, mineral fibers or polymers are added to SMA mixtures to prevent draindown from the mixture. In this study, usability of diatomite and pumice are investigated in SMA as stabilizer. Initially, Marshall samples of SMA mixtures with cellulose fibers with varying binder content are prepared. The optimum binder content is determined keeping the suggested air void content in the mix. Thereafter, the draindown characteristics are studied with diatomite and pumice added SMA mixtures. It is observed that there is a high possibility use of 0.25 % diatomite and 0.20 % pumice in SMA at determined optimum binder as stabilizer.
Keywords: Stone Mastic, Asphalt, Stabilizer

Introduction

SMA has been accepted to be more advantageous than dense graded mixes for high volume roads. It was firstly developed in Germany in the 1960s, to resist the damage caused by studded tires. As SMA showed good rutting by heavy traffic and high volume roads at high temperatures, its use has been continued even after that. SMA also improved resistance to fatigue effects and cracking at low temperatures, increased durability, reduced permeability and sensitivity to moisture of Hot Mix Asphalts.

SMA has gap graded mixture. This makes it possible for the SMA mixtures to have higher amount of voids. Therefore, stabilizing additives are used in the SMA mixture to prevent bitumen draindown and to provide better binding. Initially, asbestos fiber has been used in SMA successfully. Later, its use was restricted for health and environmental reasons. Nowadays, commonly polypropylene, polyester, mineral and cellulose fibers are used in SMA.

Investigation of alternative stabilizers in SMA mixtures has an important topic for researchers. Waste and natural materials have remarkable potentials for this aim. Brown et al. (1996) studied cellulose, rock wool and slag wool as fiber in SMA. They reported that fibers have a very important role especially at higher temperatures to prevent the draindown of asphalt cement during production and lay out of SMA mixtures. Putman et al. (2004) investigated use of waste tire and carpet fibers in SMA mixtures and compared cellulose fibers. Authors reported that there is no significant difference in permanent deformation or moisture susceptibility between waste fibers and cellulose fibers. They also concluded that tire, carpet and polyester fibers significantly improved the toughness of the mixture than cellulose fibers. Kumar et al. (2007) used jute fibers coated with low viscosity binder as alternative fibers and compared conventional fibers in SMA. Authors concluded that results of strength tests with jute fiber samples comparable to the patented fibers according to Marshall stability tests, rutting test and fatigue life test. They also reported that jute fiber adding samples have better aging index than prepared with patented fibers. In this study two natural materials, dytomite and pumice were used in SMA mixture as stabilizer and investigated draindrown capacity of these materials according to specifications.

Materials and Methods

Cellulose fiber

Cellulose fiber most commonly preferred in SMA mixtures. The most commonly adopted fibers in SMA mixtures are cellulose fibers. The main component of this fiber is cellulose, a polysaccharide. Cellulose fibers are commonly obtained from plants. It is harmless for human and environment because produced of purely natural cellulose resources. To stabilize the SMA mixture very small amount of cellulose fiber (about 0.3%) is required.

Diatomite

Diatomite (kizelgur), formed with the cumulation of the diatom shells and having a composition of SiO2.nH2O, is a light material and it can be easily crumbled. In other words, diatomite is comprised from watermosses and it is an organic solution. Diatomite can be found in the nature easily and its color is generally white. Also, when it is crushed, it changes to a very thin and white-beige dust. This dust has an effect of corrosive and it is light because of its foam-like structure. Diatomite is formed from the fossil of silika and diatom. Diatom is an algae type with hard shells. (Crangle, 2009). The most important features of diatomit are high porosity, low bulk specific gravity and whiteness. When it is dry, the specific gravity is in between 0.15-0.40 g/cm3. Opal hardness in 4.5-6.0 and the hardness of it is not more than 1.5. Generally it is loose and it may be broken by hand easily. The color is light beige, white and sometimes gray. However, the diatomite having rich materials can be brown, dark green or black. (Brady ve Clauser, 1991). Except for the potential areas, it is seen that the reservoir of the World is 2 billion tons. The well-known and biggest diatomite reservoirs are closely located in the Lompoc area, California, USA. The production of diatomite is especially made in USA, France, Spain, Denmark, South Korea, Mexico, Romania and Italy (Breese, 1994).

Diatomite, commonly used in all over Turkey, is found especially in Hırka village in terms of size of rezerves. Although the existence of the diatomite material is known since 1900's, the use of diatomite as a construction material has never been taken into consideration.

Pumice

There are two types of pumice in the nature. One of them is callded acidic pumice. The other one is called basic pumice. The most common pumice type is acidic pumice. Acidic pumice is also widely used in many areas. The amount of SiO2 determines whether the pumice is acidic or basic. If the amount of SiO_2 is increased, this means the pumice is getting more acidic. In this case, as the amount of SiO_2 increases, the stability of pumice increases. Moreover, when the amount of Al_2O_3 is more, it can be said that pumice has more resistancy to fire and heat. In the construction sector, generally it is expected pumice should be acidic and have low amount of Fe_2O_3 and high amount of Al_2O_3. Chemical composition of diatomite and pumice that used in this study are seen in Table 1.

Table 1. Chemical Composition of Diatomite and Pumice

	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	Na_2O	K_2O	SO_3	KK
Diatomite	85,2	1,85	3,83	1,49	0,45	0,47	0,44	0	0
Pumice	72,03	1,02	12,34	1,09	0,34	5,15	4,62	0,08	3,93

Experimental Work

Marshall Test

The SMA samples were fabricated according to the Marshall Test procedure specified in ASTM D 6927-06. The coarse, fine aggregates and mineral filler with 0.3 cellulose fiber were mixed according to the Type II gradation as given in Figure 1. SMA samples were prepared in different proportions in the mixes starting from 5.5% to 8.0% with an increasing of 0.5% of the total mix to obtain the optimum binder requirement. After mixing the materials the mixture was poured in to preheated Marshall moulds and the samples were fabricated using a compactive effort of 50 blows on each side. The specimens were kept over night for cooling to room temperature. Then the samples were extracted and tested at 60°C according to the standard testing procedure.

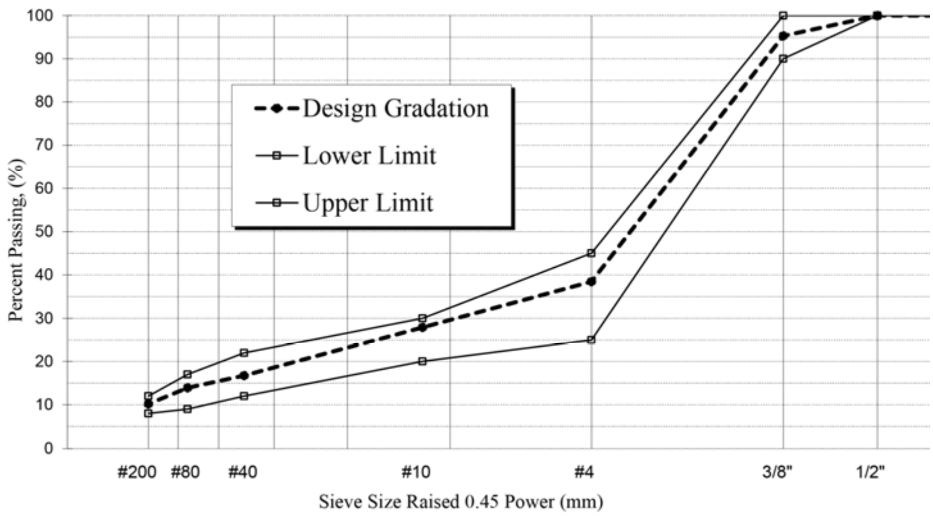

Figure 1. Gradation curve of SMA design

Marshall mix design has been used to determine optimum bitumen content and characterization of bituminous mixes. This design method has also been used to test SMA mixes. Considering Marshall parameters such as Marshall stability, flow value, unit weight, air voids, VMA, VFA optimum binder content of the SMA mixture with 0.3 cellulosic fiber is determined 7.05%.

Draindown Test

SMA is gap grading hence draindown of binder is a major problem for these mixtures. To learn draindown behavior of SMA is very important to study for SMA mixture. There are many version methods to evaluate the draindown characteristics of SMA mixtures. In this study the Schellenberg draindown test was used. This method commonly used in Europe. It is conducted on approximately 1 kg mixture. The prepared mixture is poured into a 1000 ml glass beaker and weighed. The glass beaker with the mixture is then kept in an oven for 60 minutes at 170°C. Then the mixture is removed from the beaker and placed by quickly turning the beaker upside down without shaking. The final weight of the mixture is taken and the percentage draindown is calculated. Losses greater than 0.3% indicate that segregation problem may be occurred in SMA mix (ASTM D6390, 2011).

After determined the optimum binder content of SMA mixture, various amount of diatomite and pumice added mixtures were prepared with optimum bitumen content for draindown test. Diatomite and pumice are added to SMA mixtures as percentages of 0.5%, 1.0%, 1.5% and 2.0% of dry aggregates. Obtained pictures and charts after draindown test are seen in Figure 2.

Figure 2. Remaining materials in the glass beakers after the Schellenberg draindown test

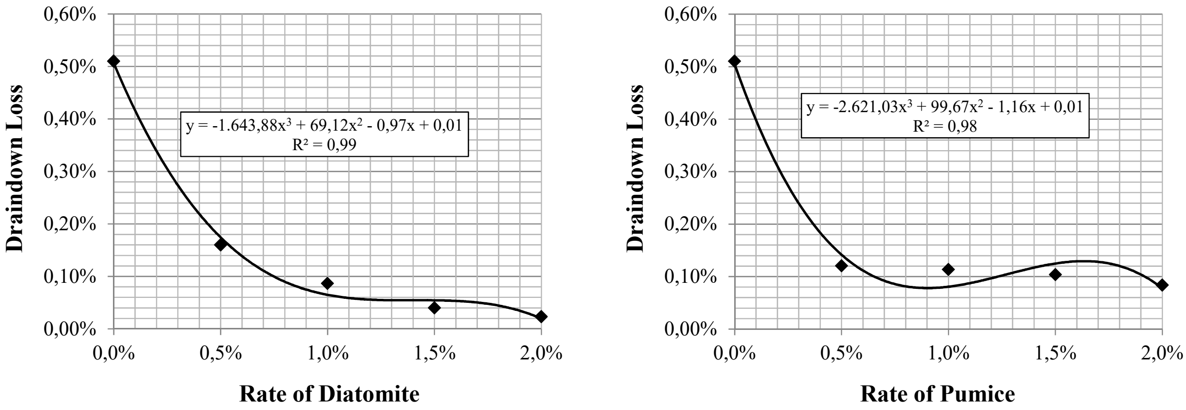

Figure 3. Schellenberg draindown test results of diatomite and pumice added SMA specimens.

It is clearly seen in Figures 3, draindown losses without any fiber additives 0.50% which is out of specifications. According to Turkish Highway Specifications, draindown loss using by Schellenberg method is allowed maximum 0.3%. When examined both charts those are diatomite and pumice added samples, it is obtained that a decreasing trend is clearly seen with the increase of stabilizer material. To find possible suitable diatomite and pumice amount regarding 0.3% maximum allowed limit, it can be seen that 0.25% and 0.20% diatomite and pumice can ben use in the SMA mixture respectively. However, it must be noted that other Marshall parameters must be investigated when adding these materials.

Conclusions

Stone Mastic Asphalt has good rutting performance by heavy traffic and high volume roads at high temperatures. It also has better fatigue resistance and cracking at low temperatures, durability, permeability and sensitivity to moisture than Hot Mix Asphalts. Because of SMA has gap graded mixture, it has higher amount of voids in the mix. Therefore, stabilizing additives are used in the SMA mixture to prevent bitumen draindown and to provide better binding. In this paper, usability of dytomite and pumice are investigated in SMA as stabilizer using by Schellenberg draindown method. According the results there is a high possibility use of 0.25 % diatomite and 0.20 % pumice in SMA at determined optimum binder as stabilizer. However, it must be noted that other Marshall parameters and performance characteristics of SMA must be investigated when adding these alternative stabilize materials.

References

ASTM D 6927 (2006). Standard test method for Marshall Stability and flow of bituminous mixtures., West Conshohocken, PA

ASTM D6390 (2011). Standard Test Method for Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures, ASTM International, West Conshohocken, PA.

BRADY G. S.,1991, Clauser, H. R., “Materials Handbook”, Mc Graw, New York

BREESE R.O.Y., 1994, Diyatomite, Industrial Minerals and Rocks, Carr (Ed), 397-412, Colarado, USA..

Brown E.R., Haddock J.E. and Crawford C. (1996), “Investigation of Stone Matrix Asphalt Mortars”, TRR 1530, National Research Council, TRB, USA, pp 95 ±102

Crangle, R.D., Jr., 2010, Diatomite: U.S. Geological Survey Mineral Commodity Summaries 2010.

Kumar Pawan, Chandra Satish and Bose Sunil (2007), 'Laboratory Investigations on SMA mixes with Different Additives', International Journal of Pavement Engineering, Volume 8, Issue1, pp 11-18

Putman B.J. and Amirkhanian S.N. (2004), “Utilization of Waste Fibers in Stone Matrix Asphalt Mixtures”, Resources, Conservation and Recycling, Volume 42, Issue 3, pp 265-274

