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The effect of various micronized fillers on durability of asphalt concrete

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Abstract. Fillers are essential components for producing asphalt concrete mixture,although they are used in very little value in asphalt,but changes in type and value of fillers can affect significantly on its function improvement. Fillers are used in asphalt to reduce empty spaces,increase durability and increase permeability and so increase resistance against water. Thus,examining on durability and knowing the ways for increasing durability of these mixtures are very important.In this research,we used stone material with standard separation,pure bitumen 60-70 and contained powdered stone fillers,talc,kaolin and some mixture of these.Talc and kaolin fillers are among natural fillers which their sources are available and inexpensive. In this research,we determined the percentage of optimal bitumen for each asphalt mixture with different filers by using Marshal experimental method (AASHTO-D1559standard). We did marshal's resistance tests (AASHTO-T165) and indirect tension (AASHTO-T289)on some samples which were under the submerged regime (wet samples) and the saturation-solidification-fusion regime and on some samples which weren't under this regime (dry samples). Asphalt mixtures with micronized fillers compared with powdered stone fillers have more Marshal Resistance and tension and also the role of talc and kaolin fillers in increasing the durability of our samples are very obvious.

Keywords: Micronized fillers, talc,kaolin,asphalt durability

1. Introduction

Road Development of a country, one of the indicators of the progress of the country. Therefore the construction of roads and the maintenance of roads built, due to the high cost of making them is very important. In Iran, most of the roads are made of asphalt concrete procedures. The pavement design, pavement construction of safe, economical and durable, able to withstand smooth the traffic again. To achieve this goal, experts, researchers and engineers are looking for material selection for pavement damage can be minimized and for improvement Furnish performance [1]. flexible pavements are typically designed for a lifetime of 20 years. studies should be focused on choosing the right materials in addition be a low fee for ways to increase the efficiency of its life [2]. Research studies show that increasing the tensile strength of asphalt mixture depends on several factors such as the filler material, building materials and type of bitumen asphalt mix. If the asphalt mixture resistance is not well cause early demise [3]. Part of the fine-grain fillers through the sieve 200 as one of the most important components of asphalt mix, asphalt mix play an important role in determining the performance characteristics, particularly in adhesion, interlock between seeds and fill the empty space between aggregates have a great impact. In addition, can be mental, moisture sensitivity, hardness, durability, fatigue, rutting and asphalt mix is also effective [4]. Mixture of two main parts made of aggregate and bitumen. If any of these components do not meet the criteria of efficiency and reduced pavement lifetime is expected to be less than what is needed to improve pavement performance of bituminous mixtures of bitumen is basically depends on the combination. So make sure to choose the appropriate filler in the asphalt mixture improves the performance of mixed [5]. Test results

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indicate the potential impact of fillers on the properties of the asphalt concrete pavement is used. Fillers space between larger grains filled the pavements are causing increasing load power [6]. The role of filler in the asphalt mixture, increase pavement life and increase its resistance to the effects of water (durability) [7]. The filler used in hot asphalt mixtures in the Marshal stability has a considerable impact [9]. About filler and its effect on hot asphalt mixtures, research and many studies have been done, some of them even more than 90 years ago are concerned. Richard Klayf age at first researcher to research and studies in this branch of knowledge asphalt has published and released. He filler performance beyond a void filler material in asphalt mixes and believes that the filler and the binder is a physical process - based chemical[10].

Examination on theatrical discussions and the presented hypothesizes showed that it isn't yet completely clear that how and why the stripping failure occurs; but it is quite clear that the major reason for this failure is the presence of humidity in asphalt superstructure. One of the most important effective factors on this failure intensity is the kind of the used filler, such that the used filler has a significant role in controlling stripping phenomena[7,8].. Filler leads to solidify the bitumen and thereby decrease its shearing and thermal sensitivities in the asphalt mixture[12].. Numerous testing methods have been introduced for evaluating the stripping failure and examining the samples' durability, among which Indirect Tension Test (AASHTO-T283) and Marshal Resistance Ratio Test (AASHTO-T165) were applied here. [13]

2- Material and Methods

The used materials in this experiment include: silica grits, bitumen,powdered stone fillers, talc,kaolin. The used stone materials in asphalt are divided into three groups in terms of size and grading: a)macro grain stone material, b) fine grain stone material,c) filler.

The used grits in this experiment are siliceous (quartzite).These grits are acidulous and tend to being stripping. Thesiliceous materials were obtained from two resources: Ganjafrooz Mine and Khatirkooh Mine. The powdered stone was produced from the used fine grain grits and talc and kaolin fillerswere provided from the market.

Hydrate magnesium silicate talc filler is a material with greasy luster and low density and it is used as a filler and stabilizer in industry. Hydratealuminum silicate kaolin is a material with chemical formula of H4AL2Si209. Its color is yellowish white and sometimes it is alittle green or blue, it has the flavor of soil and in wet form,its smell likes soil's smell. Its specific weight is 6/2 $g/cm^3$and its melting point is 1785℃ .kaolin resources are often produced from weathering and mechanical decomposition of aluminum silicate stones.

Bitumen 60-70(relatively equivalent to Ac-10) is good for Iran's regional conditions, unless some specific conditions such as heavy traffic, junction's position,road's sharp slope and max absolute temperature of asphalt lyre in the time of operation, which may be sometimes over 60℃ , are selected and using some bitumen with higher density such as 40-50 (equivalent to Ac-20)becomes necessary.

After designing asphalt mixtures and determining bitumen's optimal percentage for each sample with different fillers, the effect of water on them and adhesion decreasing from saturation of these mixtures against water was controlled by standard tests. The suggested tests in publication 101 include Marshal Resistance Ratio Test(AASHT0-T165 standard) and Indirect Tension Test (AASH70-T283 standard).

2-1-Marshal Resistance Ratio Test

According to publication 101,for evaluating asphalt mixtures' durability, the average ratio of compressive resistance of three marshal experimental samples from asphalt bitumen mixture which are kept in submerged conditions in the water with 60 ± 1 ℃ for 24 hours compared with the average ratio of compressive resistance of three marshal experimental samples from dry asphalt bitumen mixture shouldn't be less than 0/75. Each group's trial resistance determination test is based on ASTM-D1559 method. So, asphalt samples were tested in two states:in first state, they were put in water with 60 ± 1 ℃ for 24 hours (wet group samples) and in the second state, only 20-30 minutes before they were located in marshal machine, the samples were put in water with 60 ± 1 ℃ (dry group samples) and then their Marshal Resistance Ratio, in wet state compared to dry state, was measured.

2-2- Indirect Tension Test

This test is one of the most practical tests for determining the tension specifities of asphalt superstructure. The following information can be obtained from this test:

-Tension,modulus of elasticity and Poisson's coefficient (with using static and dynamic loadings)

- Fatigue specifities

- Permanent deformation specifities of superstructure's material

This test can be used for evaluating the effect of humidity and asphalt mixtures' ability to stripping. Indirect tension test is done with loading a cylindrical sample and with posing a static or repetitive compressional force in longitudinal direct. In this kind of loading, there are some uniform tensile stresses perpendicular on loading direct and along with perpendicular diameter which ultimately lead to rupture as the form of refraction in direct of samples' perpendicular diameter.

Loading is done with the speed of50/8$^{mm}/_{minute}$ (2 $\frac{inch}{min}$) and the sample's rupture strength is recorded. The sample tension is calculated from the following relation:

(1) $$ITS = \frac{2P}{\pi.t.D}$$

ITS: indirect tension strength

P: terminal load

T: sample's thickness

D: sample's diameter

Tension strength rate is calculated from the following relation:

(2 $$TSR = \frac{ITS_{wel}}{ITS_{dry}}$$

3- Results & discussion

1-3-results of Marshal test ASTM-D1559

- The optimal bitumen percentage of those mixtures constructed with talc and kaolin fillers is less than the optimal bitumen percentage of those mixtures constructed with the powdered stone filler and also the optimal bitumen percentage of asphalt mixtures with a filler of mixing talc and powderedstone and with a filler of mixing kaolin and powdered stone is less than the optimal bitumen percentage of those asphalt mixtures with powdered stone filler.

- The fluidity of those mixtures constructed with talc and kaolin filler is more than the fluidity of those mixtures constructed with powdered stone.

- the compressive strength of those asphalt samples constructed with a filler mixing of powdered stone and talc and also with a filler mixing ofpowdered stone and kaolin is averagely 5 percent more than those samples with powdered stone.

- the compressive strength of those asphalt samples with talc filler and kaolin filler is less than the compressive strength of those asphalt samples with powdered stone filler.

-mixing powdered stone filler and talc and mixing powdered stone and kaolin in asphalt samples lead to increase compressive strength and also reduce the sample's optimal percentage; this causes to both effect on asphalt samples' strength and with less percentage of optimal bitumen, less bitumen is used in producing asphalt; so regarding to high price of bitumen and its destructive environmental effects and also the lower price of talc and kaolin fillers, some cheaper asphalt is produced and consequently it will lead to reduce the destructive effects on environment.

Figures 1, 2 and 3 show the optimal bitumen percentage ratio, fluidity and different samples' compressive strength with powdered stone, talc, kaolin and talc-powdered stone and kaolin- powdered stone fillers, respectively. Figures 4 and 5 show the fluidity diagram and marshal strength diagram in asphalt samples or in different fillers, respectively.

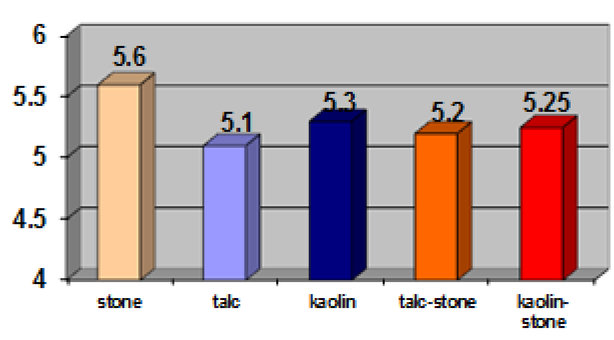

Figure 1. Comparing the optimal bitumen percentage in asphalt mixtures with different fillers.

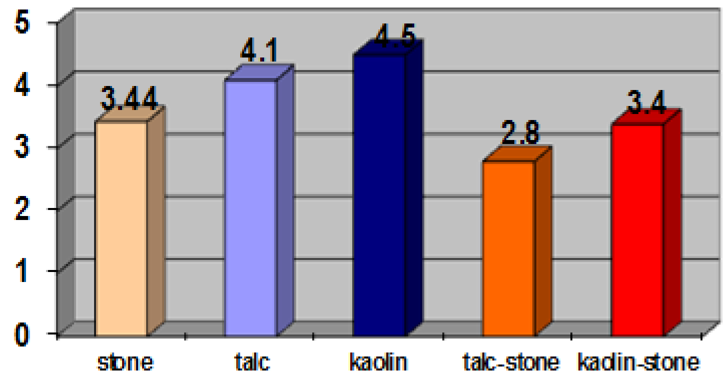

Figure 2. Comparing the fluidity of asphalt mixtures with different fillers.

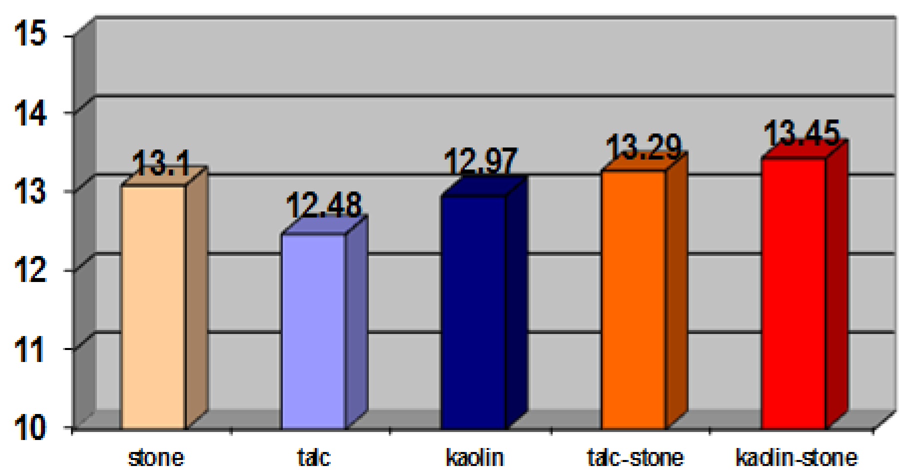

Figure 3. Comparing Marshal Resistance of asphalt samples with different fillers.

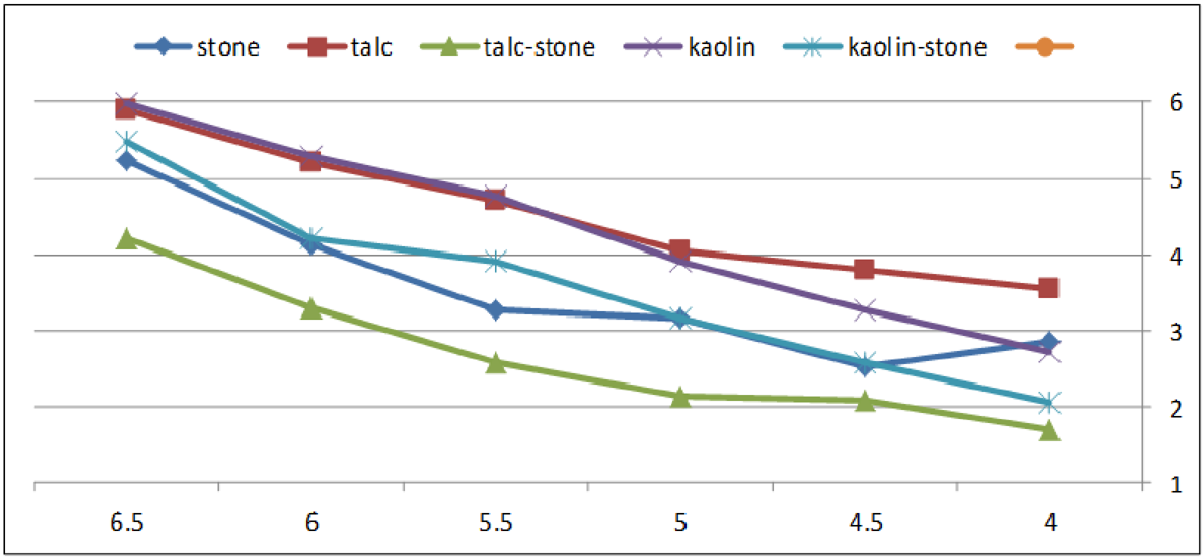

Figure 4. Fluidity diagram of asphalt mixtures with different fillers.

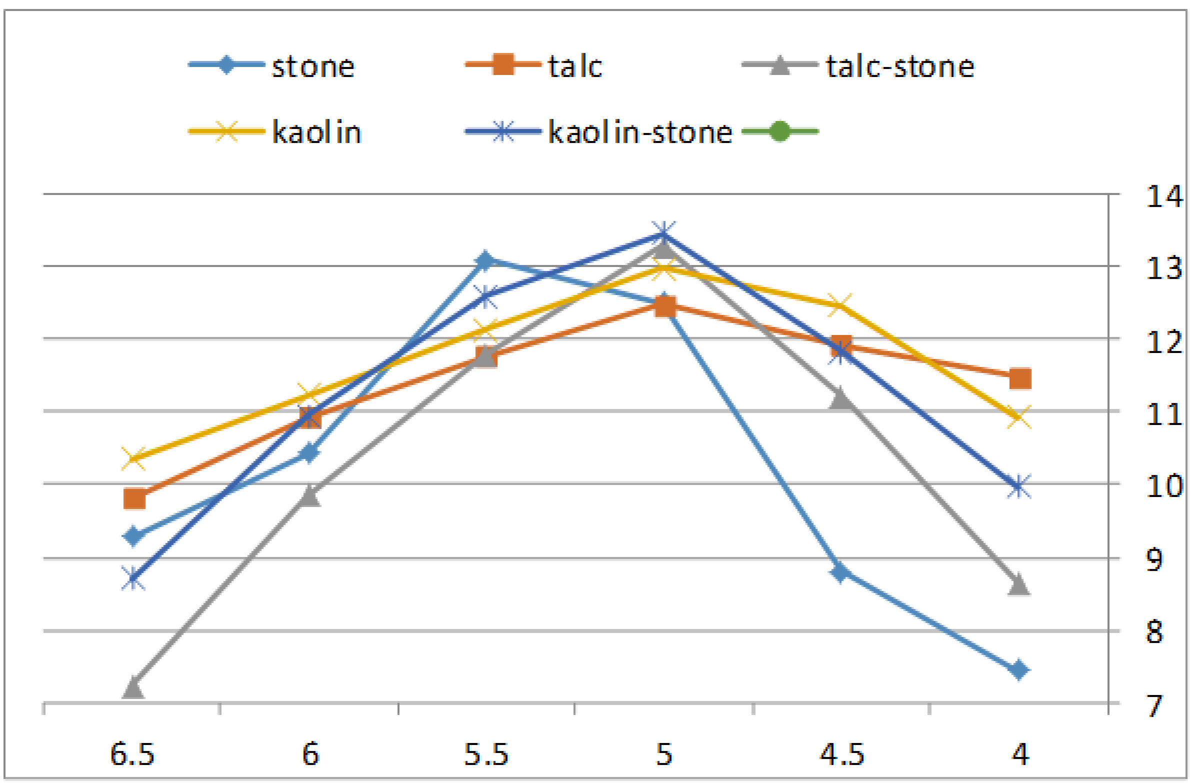

Figure 5. Marshal Resistance diagram of asphalt mixtures with different fillers.

3-2- The results of some tests related to asphalt mixtures' durability against water

The effect of water on asphalt mixtures and reducing the adhesion resulted from the saturation of these mixtures against water was controlled with standard test. The results of these tests were considered based on design regulations AASHT0-T166 standard and AASHTO-T283standard.

In marshal strength ratio test, according to publication 101, for the samples constructed with all fillers, the ratio of marshal strength in wet state to dry state is more than the suggested minimum value.

-In marshal ratio test,the ratio of marshal strength in those asphaltmixtures with talc and kaolin fillers is more than the ratio of those asphalt mixtures with a mixture of powdered stone and talc and a mixture of powdered stone and kaolin. Figure 6 shows the marshal ratios.

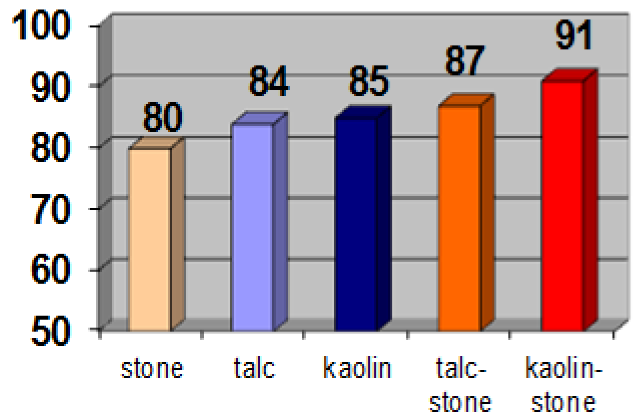

Figure 6. Comparing the asphalt samples' compressive resistance ratio.

In indirect tension test (according to standard AASHTO-T283), the tension ratio of the saturated samples to dry samples shouldn't be less than 80%. Examining on conducted experiments results in different states show that those samples comprised powdered stone filler with resistance ratio of 80% don't meet this need, according to the mentioned standard and also show that those samples with powdered stone filler are sensitive to humidity (TSR80) and those asphalt samples with a mixture of talc and kaolin fillers with powdered stone are more than standard's minimum value and those asphalt samples with a mixture of talc and powdered stone fillers, with the tension ratio of 0.91, have the most TSR. Figure 7 shows the tension ratio of some asphalt samples with different fillers in wet state compared with dry state (TSR).

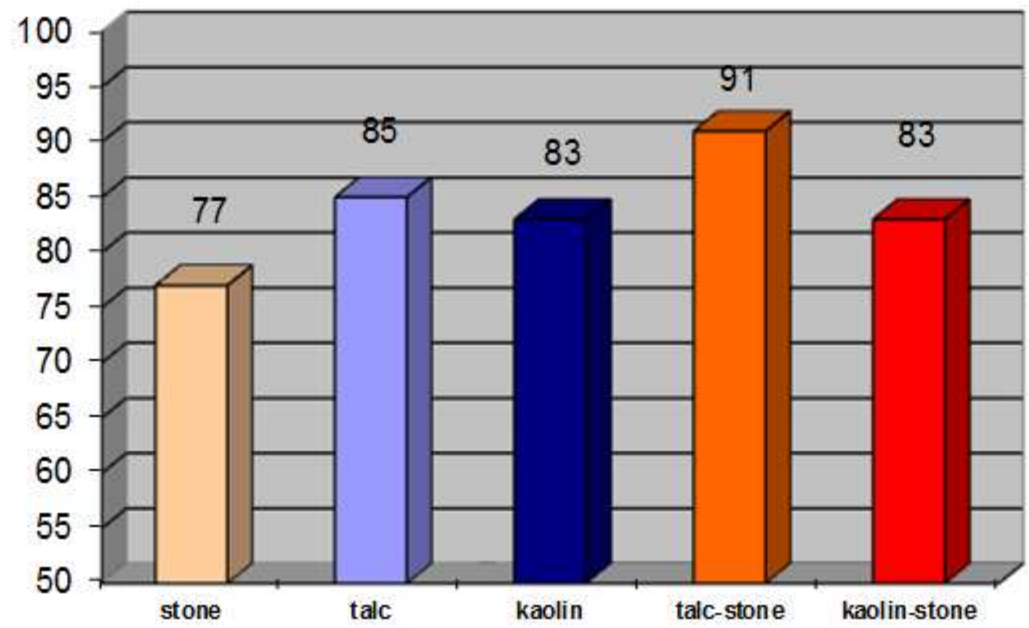

Figure 7. The tension ratio of some asphalt samples with different fillers.

Conclusion

-Mixing powdered stone filler and talc and mixing powdered stone and kaolin in asphalt samples lead to increase compressive strength and also reduce the sample's optimal percentage; this causes to both effect on asphalt samples' strength and with less percentage of optimal bitumen, less bitumen is used in producing asphalt; so regarding to high price of bitumen and its destructive environmental effects and also the lower price of talc and kaolin fillers, some cheaper asphalt is produced and consequently it will lead to reduce the destructive effects on environment.

-Adding micronized fillers to asphalt mixtures increases asphalt samples' tension. This leads to prevent from forming contraction cracks in cold weather.

-The effect of micronized saturated filler compared with dry filler on increasing tension is more.

-Asphalt mixtures contained micronized fillers have more TSR ratio as durability index and higher resistance against stripping than those asphalt mixtures with powdered stone.

Totally, results showed that those asphalt mixtures contained micronized fillers, such as talc and kaolin, have a good resistance against stripping (durability) and also a mixture of talc and kaolin fillers with equal powdered stone in asphalt samples have high comprehensive resistance and necessary durability according to publication 101 standard.

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