論 説 報 告

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ON THE EFFECTS OF CALCAREOUS MATTERS TO THE ASPHALT MIXTURE*

Yasuhei Emori, C.E., Assoc. Member.

Synopsis

The present paper covers the author's study on the effects of calcareous matters to the asphalt mixture, when they are used as mineral fillers or aggregates. The surface energy of those materials when combined with bitumen seems to have a large void reducing effect in the mixture, and accordingly gives various other favorable results.

Introduction.

As is generally known, the chief function of the mineral filler in the asphalt mixture is to reduce voids in mineral aggregates, and consequently to make a dence and watertight asphalt mixture, as well as less liable to interior displacements.

Down to the present, the effect of mineral filler in the asphalt mixture has been considerd to be entirely mechanical and its fineness or grading was regarded as a single factor of it.

However, it must be remembered that there is another important factor. That is, the physical surface structure of mineral filler particles. As they are discussed later, generally the filler of calcareous matter seems to have a higher void reducing effect than that of silicious matter.

In this experiment, the difference of characters of the substances will be studied, taking the limestone and the silica as the two representatives of those distinct substances.

Surface Energy of Calcareous Matter.

At first, to make a preliminary investigation, two series of void test were made on a sheet asphalt sand in which the limestone dust or the silica dust was added as the filler respectively, increasing in a certain increment.

The sand used was an usual silica sand of gracial origin and which was

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widely used as an asphalt sand. The limestone dust was an usual ball mill product, and the silica dust was a biproduct of a glass manufacturing. Both of these materials are those used widely in the asphalt industry.

Voids in those mixtures of sand and filler which afterwards will be called simply "Aggregates" were determined by the two distinctive methods. The former is a cone method and void are determined in a dry state, using an usual galvanised iron cone. The latter is a socalled asphalt mixture method. In this method, to those mixtures a certain amount of asphalt is added, and after a complete mixing, these asphalt mixtures are moulded to briquet of 2 inches dia. and 2 inches height. In this case, the asphalt can be considered to work as a lubricant to reduce voids in aggregates, instead of nothing in the former case. Voids in this case can be calculated out by the following well known formulae.

$$V=\frac{100(D-d)}{D}$$

$$D=\frac{100}{\frac{W_1}{g_1}+\frac{W_2}{g_2}}$$

$$d=\frac{d'(100-W_3)}{100}$$

where

V=percentage of void in aggregate of compressed mixture,

D=theoretical maximum density of aggregate alone in specimen, taking bitumen out of consideration,

d=actual density of aggregates alone in specimen,

W_1=percent of sand by wt. in aggregate alone,

W_2=percent of filler ,, ,, ,, ,

W_3=percent of bitumen by wt. in total mixture,

d'=actual density of specimen (determined by a displacement method),

g_1, g_2, g_3=densities of sand, filler and bitumen respectively.

As shown by two curves in **Fig. 1, PL. II,** when the limestone dust or the silica dust is added to the sand in a dry state, and tested by a cone method, their void reducing effects in the sand are not so much different. Or, it will be understood that there is not so much difference of mechanical function as filler between the limestone dust and silica dust in a dry state.

But, as shown in **Fig. 2, PL. II,** when the asphalt is added in them, there occurs a large difference between these two materials in void reducing effects.

To arrive at those results, there should be some distinct difference in property between those two substances. After a careful consideration, it can be said that the main cause exists in the difference of the physical surface structures or the surface energy of the two materials.

In order to study physical structures of the two materials, they were examined under a microscope. As expected, the limestone dust has a very irregular shape and its surface is very rough and pitted. On the contrary, the shape of the silica dust is very sharp edged and its surface is very glassy. (**PL. I.**)

According to those facts, when the asphalt is combined with calcareous matter, such as limestone dust or limestone sand, it adheres very closely, absorbed or sometimes absorbed to the surface of mineral materials, and those closely absorbed asphalt film seems to serve as a good lubricant between particles, leading to their close contact.

However, when the asphalt is combined with some silicious matter, sand or silica dust, in the mixture, the asphalt can not adhere so closely to the surface of silicious particles because of their poor adhesive power.

Void Reducing Effect of Calcareous Matter.

From the preceding investigation, it can be considered that we can reduce more void by increasing more calcareous materials in the asphalt mixture or by even making the whole part of aggregates with calcareous materials.

To attain this object, the following experiment was sugested. It is the preparation of a series of asphalt mixtures in which the content of calcareous matter or limestone aggregates is gradually increased. Here, to this purpose, besides those materials used before, the artificial limestone sand was used of various separated sizes. In order to let other factors remained unchanged except the calcareous matter content, the grading of the completed aggregates or the bitumen content was made carefully constant throughout all series.

Voids in mixture and voids in aggregates were determined in briquets of these mixtures which were made as before, and from those results, the relations between the amount of calcareous matter and the void reducing effects were obtained as shown by curves A-E in **Fig. 3** and **Fig. 4, PL. II.**

Here, the meaning has been stated before about the void in aggregates, and the void in mixture means the true existing void in the compressed specimen which can be calculated by the following formulae,

$$V=\frac{100(D-d)}{D}$$

$$D=\frac{100}{\frac{W_1}{g_1}+\frac{W_2}{g_2}+\frac{W_3}{g_3}}$$

where

V=percentage of void in mixture,

D=theoretical maximum density of specimen,

d=actual density of specimen (determined by a displacement method),

W_1, W_2, W_3=percent by wt. of sand, filler and bitumen,

g_1, g_2, g_3=densities of sand, filler and bitumen respectively.

In these figures, Point A expresses an all silicious matter mixture, ordinary silica sand and silica dust being used as mineral aggregates, and containing no calcareous matter at all.

Point B is the mixture of 15.4 percent calcareous matter, limestone dust being used as a fiiller and other aggregates being silica sand.

Point C is a mixture in which limestone is used as a filler and also in 80—200 mesh part, its percentage of calcareous matter being 35.5 percent.

Point D is a mixture in which limestone is used as a filler, 80—200 mesh part and also one half of 40—80 mesh part, its calcareous percentage being made 55.5 percent.

Point E is a mixture in which the whole aggregates are of limestone, and its calcareous matter percentage is 89.5, the balance being the bitumen.

Examining these smooth curves A-E in both figures, one cannot ignore the fact that the amount of calcareous matter in the mineral aggregates has a large effect in reducing void in mixture and in aggregates.

Especially, in **Fig. 3,** the void in mixture of 8.5 percent in the whole silicious aggregate mixture was reduced to 1.0 percent by increasing limestone to 35 percent. By increasing still more limestone, void is reduced further and at last it reaches a point of −2.4 percent when the whole aggregates was made of limestone. There should not be minus void, and it means absorption of asphalt by the mineral aggregate and the real existing void in the mixture will be nearly nothing. The volume of absorbed asphalt of 2.3 percent corresponds to the amount of about 1.0 percent by weight.

Various Other Effects.

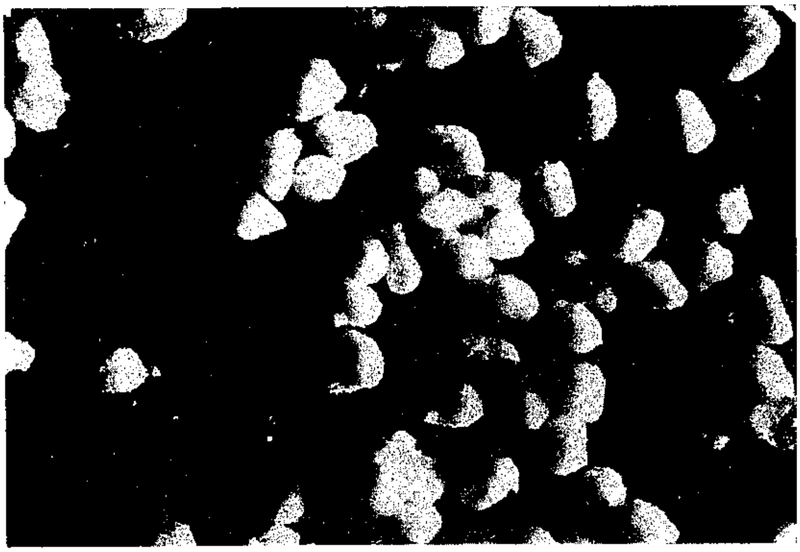
The specimens of all these series were tested of all their stability or the resisting force to the displacement by the improved penetration stability machine. Results of these tests will not be stated here, but it can be said that the stability of the asphalt mixture has some relation with the void in aggregates, eventhough their relation is not direct. And generally, the stability of the asphalt mixture can be raised by increasing the calcareous matter in its aggregates.

Also, the watertightness was studied on these various mixtures and the following conclusion was reduced. That is, the watertightness of the asphalt mixture largely depends upon the denseness or the voids in mixture, therefore the calcareous matter in the aggregates which reduces more void in mixture is more effective in making the mixture watertight.

Thinking of all these results of experiments, we are led to believe that an intimate relation exists between the asphalt and the calcareous aggregates. The well known success of the European rock asphalt and the Uvalde rock asphalt might be according to their aggregates of calcareous matter.

The End.

PL. I.



Limestone Dust

Silica Dust

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PL. II.

Fig. 1. Void Test of Mineral Aggregates by "Cone Method"

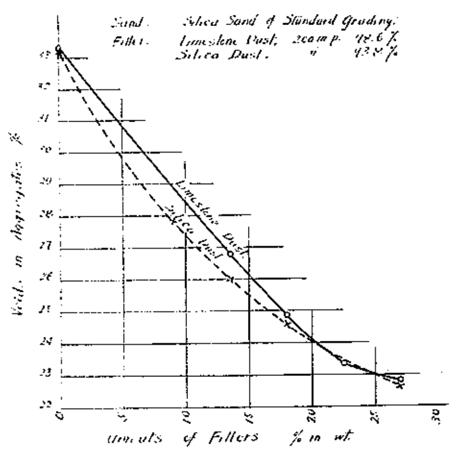

Fig. 2. Void Test of Mineral Aggregates by "Asphalt Mixture Method"

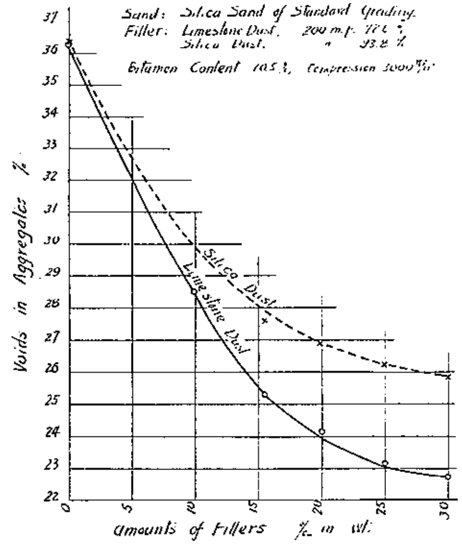

Fig. 3. Effects of Calcareous Matter in reducing Void of Asphalt Mixture. "Void in Mixture"

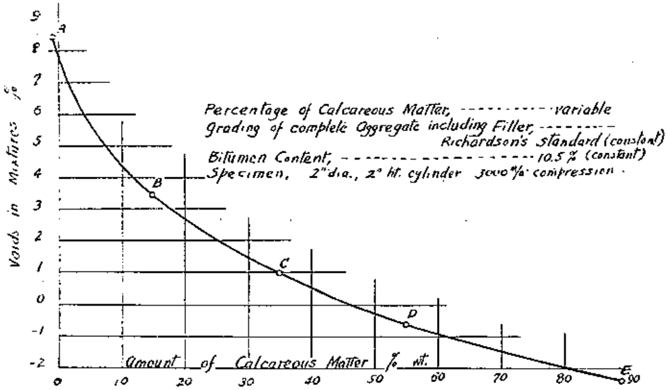

Fig. 4. Eeffects of Calcareous Matter in reducing Voids of Asphalt Mixture "Void in Aggregates"