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RELATING ASPHALT ABSORPTION TO PROPERTIES OF ASPHALT CEMENT AND AGGREGATES

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ABSTRACT

Mineral aggregates used in hot mix asphalt (HMA) mixtures have some porosity and as such tend to absorb some amount of asphalt cement. Several indirect and direct methods for estimating or determining asphalt absorption have been researched in the past. However, there is a need to study the asphalt absorption phenomenon as related to the physical properties of the mineral aggregate and asphalt cement binder.

Eight mineral aggregates of different absorptive characteristics, geologic origin and mineral compositions were selected from the SHRP Materials Reference Library (MRL). Four asphalt cements ranging from AC-5 to AC-30 grades were also obtained from SHRP MRL. A total of 96 HMA mixtures were prepared and tested for asphalt absorption. Physical properties of aggregates (including pore characteristics) and asphalt cements were determined.

Generally, the asphalt absorption decreased with increase in viscosity (at the mixing temperature) of the asphalt cement. A high percentage of maltene (oil) fraction in asphalt cement is likely to increase the total asphalt absorption possibly due to selective absorption. There appears to be a threshold pore diameter of 0.05 micron in the aggregate below which no appreciable asphalt absorption takes place. The most important pore size range affecting the asphalt absorption appears to be 0.05-0.1 microns.

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INTRODUCTION

Mineral aggregates used in hot mix asphalt (HMA) mixtures have some porosity and as such tend to absorb some amount of asphalt cement. Although some absorption may lead to improved strength in a compacted mixture through particle interlocking, the portion of the asphalt that is absorbed is no longer available as binder (1). The situation is further aggravated because of the time-dependent nature of the absorption phenomenon. Moreover, the asphalt available in thin films serving as a binder may have different physical, chemical and theological properties if selective absorption takes place (2). The absorption of asphalt in mineral aggregates may cause the following which may lead to premature failure of the asphalt paving mixtures (1):

1. Incorrect computation of percent air voids, voids in mineral aggregate or voids filled with asphalt. Since one or more of these are generally used as criteria for asphalt mixture design, incorrect calculations may lead to mixtures lacking durability or stability.

2. Not having enough effective binder may lead to ravening, cracking, or stripping.

3. Possible premature age hardening and low temperature cracking as a result of changes in asphalt properties due to selective absorption.

4. Construction problems such as segregation and tender mixes.

In view of the above consequences, the absorption of asphalt by mineral aggregates needs to be studied. Often times aggregates having relatively high asphalt absorption may have to be utilized either because of high quality aggregates getting depleted at an ever increasing rate or because geographic proximity often predicates the use of such aggregates.

Most highway agencies utilize the Rice method (maximum theoretical specific gravity of voidless paving mixtures) in calculating the amount of asphalt absorbed. Other methods such as bulk impregnated specific gravity are also used. Also, some aggregates have been observed to continue to absorb asphalt with time during construction and the early life of an asphalt pavement. Hot mix asphalt (HMA) mixtures which appear very rich during production can get leaner and leaner with time inducing premature ravening and/or cracking(3). There is a need to study the asphalt absorption phenomenon as related to the properties of the mineral aggregate and asphalt cement binder.

REVIEW OF LITERATURE

Many investigators in the past have attempted to evaluate asphalt absorption of aggregates through correlations with absorption using other liquids of which kerosene has been the most commonly used. Hveem (4) devised the centrifuge kerosene equivalent test (CKE) in 1942. The CKE is defined as the quantity of kerosene absorbed by 100-g of aggregate under specified

conditions of soaking and centrifuging. It has been shown to be a function of the surface area and absorptive capacity of the aggregate and has been used as a part of the design of bituminous mixtures by Hveem method. Lohn (5) also used a similar approach and correlated asphalt absorption of an aggregate with kerosene absorption. He studied the effects of factors such as saturation time, centrifuge force and centrifuge time as well and finally adopted 10-minutes of saturation and 8-minutes of centrifuging at a force of 400 times gravity. DonaldSon et al (6) further proposed some modifications to the Hveem CKE method by increasing the soaking time to 30-minutes and by testing a non-absorptive aggregate of the same gradation for the purpose of comparison. Since kerosene has wetting properties similar to that of asphalt, it has been believed to give a better representation as an absorption agent as compared to water (6, 7). A modified CKE procedure was developed by Cechetini (8), which can determine the surface areas and evaluate absorptive behavior of crushed aggregate mixes. Together with this information and the data characterizing the asphalt to be used, the amount of asphalt needed by an aggregate can be determined from a nomograph. Some other investigators (9, 10) have tried to use oils to evaluate the absorptive capacity of coarse aggregates. However, because of the differences in wetting properties and viscosities of these liquids and asphalts, only approximate estimations could be made of the asphalt absorption of the aggregates.

In 1936, a procedure was described by Reagel (11) for determination of relative absorption of water and liquid bituminous material by the coarse aggregate using a water displacement method. It was recommended that absorption of liquid bituminous material be estimated at 75 percent of the water absorption.

In 1942, Goshorn and Williams (12) developed the immersion method. The aggregate is in contact with an unlimited supply of asphalt at relatively low viscosity for an extended period of time in this method. Therefore, the absorption is much higher than would be expected in actual HMA mixtures (13).

Rice (14, 15) proposed a vacuum procedure to determine the maximum specific gravity of the voidless HMA mixture. In this method, the absorption of asphalt by aggregates is calculated from the maximum specific gravity of the mixture, the asphalt content, and the bulk specific gravity of the aggregate used in the HMA mixture. This method is now standardized as ASTM D2041.

A different approach was used by Larsen (16) who conducted a high pressure test instead of vacuum saturation to determine the effective specific gravity of the aggregate. Asphalt absorption was calculated as percent of the volume of aggregate and ranged from 26 to 88 percent of the water absorption.

The U.S. Army Corps of Engineers (17. 18) developed and has used the bulk impregnated specific gravity in the design and control of bituminous mixtures. It is a function of the ratio of asphalt to water absorption, which varies widely but follows a definite pattern with different types of aggregates. The asphalt absorption can be found knowing the bulk impregnated specific gravity of the mixture, the bulk specific gravity of the aggregate and the specific gravity of the asphalt used in the HMA mixture.

Absorption of asphalt by aggregates has also been determined by calorimetric analysis with photometer (13). The basic principle is that the amount of light absorbed by a given solution is proportional to the intensity of the incident light and to the concentration of the absorbing species