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Measured bond strength of asphaltic material using developed blister method

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HIGHLIGHT

- This paper presented new idea to measured adhesion between asphalt binder and aggregate.

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ABSTRACT

The blister test was aimed to develop and establish a simple, partial and reliable laboratory adhesion test method for direct measurement of the adhesive bond strength of bitumen and aggregate. Blister test was conducted by a device manufactured locally to measured bond strength of asphaltic material. Materials that used in this work were asphalt and aggregate. The local asphalt cement was obtained from Durah refinery, south–west of Baghdad .The aggregate used for comparison was limestone. This paper presents the development of pressure–loaded blister test and apparatus to measure the adhesion of asphaltic materials. The blister test provides the interfacial fracture energy, which is related to the adhesion strength. In this test air is injected at the interface between the substrate (aggregate disc) and adhesive layer (asphalt) to create blister. The air pressure and blister height were measured as function of time. By using two parameters, the interfacial fracture energy is calculated. In this paper was found that the energy required to displacement the asphalt binder increased with time until failure (adhesion failure) due to loss of adhesion between aggregate substrate and asphalt binder and also the required energy to failure decreased with increased binder thickness.

1. Introduction

Flexible pavement may be defined as a combination of aggregate, asphalt and filler mixed predetermined ratio .Although different types of flexible pavements have different properties and serve different purposes based on the traffic level, soil characteristics, climate and other factors all are designed and constructed to meet the demands for the following qualities; able to resist deformation, cracking and water or moisture damage, and be durable over time [10]. Water or moisture considers one of the most factors that has adverse effect on the performance and serviceability of the pavement. The existence of water in the structure of the pavement and ferocious effects on the pavement properties, commonly known as moisture damage.

The interaction of water or moisture with asphalt mixture (asphalt, filler and aggregate) due to loss of stiffness and strength of the mixture. The results initially in the form of raveling, surface wearing, stripping, rutting and fatigue cracking that would to serious of damage, and therefore the pavement will loss the serviceability early. [16].

In spite of that the occurrence of the pavement distress is not necessarily initiated by the presence of the water or moistures, various kinds of the distress mechanisms could increase their expand and severity due to the presence of water or moisture [2]. There are different forms of failures that the moisture damage can show itself by there as cohesive failure within bitumen (bitumen – filler mastic), cohesive failure within aggregate, adhesive failure between bitumen-filler mastic and aggregate, and freezing & thawing in the pavement structure [7,3,9]. Adhesion may be defined as the molecular force of attraction in the area of contact between unlike bodies (i.e. adhesive and substrates)that acts to hold the bodies together [4]. In case of asphalt mixture, adhesion refer to total energy that required to displacement the asphalt from aggregate by break the bond between them.

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Based on the study by [5], moisture damage is mainly characterized by the adhesive failure between asphalt and aggregate. Adhesive failure happened when the asphalt coatings aggregate displacement by water.

In the blister test the deformation under pressure is used to calculate the adhesion strength or interfacial fracture energy [12–15]. Adhesion strength is a function of the pressure and blister height . Pressure and blister were varied over time and the maximum pressure and blister height were used to calculate adhesion strength.

2. Objective of the study

The main objective of this study was to develop and establish simple practical and reliable monotonically- loaded laboratory adhesion test method for direct measurement of the adhesive bond strength of asphaltic material and aggregate.

3. Materials and experimental procedures

3.1. Materials

3.1.1. Asphalt cement

In this study local asphalt cement binder from Durah refinery, south–west of Baghdad of Iraq was tested. To prepare an asphalt sample for the blister test, an oven was preheated to (softening point +90 or 160–170 °C (340 °F)), at which point the samples were placed in the oven and allowed to melt. The average melting time of the sample was approximately 30 min. A small amount of the melt was poured into three small circular molds. All samples were cooled for an additional hour prior to the test (BS EN 14770:2012), as shown in Table 1

3.1.2. Aggregate substrate

For the purpose of this work the cores of rocks that shown in Plate 1-a bring by Iraqi Geological Survey from Najaf Province. The chemical properties of aggregate are shown in Table 2 below.

Table 1
Physical properties of the asphalt cement.

Test	Result
Penetration (25 °C, 100 g, 5 s) ASTM D-5	50
Penetration of residue after RTFOT- ASTM D-1754	41
Softening point (°C) – ASTM D36	51
Viscosity cP, 135 °C) ASTM D-2170	543

From the chemical composition of core stones shown in Table 2 it can be seen that the average ratio of calcium oxide for all samples is (36.24), and as a result of discussion with Geological Technicon in Central Laboratories Department in Iraq Geological Survey the mineral analysis of rock is limestone; http://www.mineralszone.com.

3.2. Aggregate samples Preparation (Aggregate Disc)

The samples of aggregate (aggregate disc substrate) must be prepared to suit the requirements of the blister test. To prepare the disc of aggregate sample; the core stone shown in Plate 1-a was cut in slices with a uniform thickness (15 mm) to achieve the torus disc then the aggregate disc was perforation at the center of this disc Plate 1-b and c [11]. The dimensions of inner and outer diameters were respectively 10 mm, 85 mm.

The aggregate discs were polishing to reduce the effect of surface roughness of aggregate disc. The purpose of polishing process is to remove the damage and smoothing the surface roughness of aggregate disc to make sure that asphalt distributed regularly on the surface of the aggregate substrate to get the required desired uniform thickness for completion the test.

The polishing process it has been done in three phases by using abrasive paper with different scale that includes (P30), (P800), (P1000) to reduce surface texture gradually. The final scale (P1000) represents the surface roughness of aggregate disc as shown in Plate 1-d.

3.3. Manufacture blister test device

The bond strength (work required to failure, fracture or take off thin film asphalt binder from aggregate disc) calculated by developing local blister test device. Locally manufactured blister device consist of several parts as shown in Plate 2;

The mold used in the local blister device manufactured is cylindrical shape of compact plastic. The mold hollow from the middle with inner and outer diameters equal to 88 mm and 118 mm respectively to be allowed to enter the sample of aggregate disc and installed .The mold provided from the sides by screws to install the sample of aggregate disc and prevented it from vertical movement during the rush of air during the experiment. The height of the plastic cylindrical mold is 48 mm and its inner depth 27 mm. The manufactured mold is shown in Plate 3.

The mold pierced from the bottom with hole about 10 mm diameter allows entry of vertical tube rises inside the mold about 12 mm to pass the air through it. A tube diameter of 9 mm made

Plate 1. Aggregate Sample Preparation Steps; a) The Core Sample of Limestone Rock; b) Rock Sawing Machine; c) Aggregate Disc Sample after Sawing; d) Polishing Machine; e) Specimen of Aggregate Disc Coated with Thin Film Asphalt Binder before Testing.