Faculty of Engineering and Technology

Civil Engineering Department

Construction Materials Laboratory

ENCE215

Experiment # 10

“ Marshal testing ”

Instructors :-

Dr. Nizar Assi.

Eng. Yasser Saad

Done By Group #C :-

Mojahed Sabbah 1171996

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Background information

- **Introduction**

Asphalt concrete is a blend of aggregates bonded together by a binding material (such as bitumen) mixed at a high temperature. The major use of asphalt is road constructing and paving roads by hot rolling and compaction.

A good asphalt blend must own numerous characteristics and qualities to achieve a sufficient degree of serviceability. Some of which are the stability and flow of asphalt. The stability of asphalt could be looked at as the synonym of strength in concrete. The stability of asphalt is a feature that enables it to resist the loads subjected on it by the traffic movement, without exhibiting a significant plastic deformation. This is more like talking about the elasticity of asphalt, which is the deformation resistance caused by external loads. Experiments have shown that stability is a function of the binder content and the cohesion between aggregates, so that a high binder content causes a lower stability, and a strong cohesion increases it.

In the other hand the flow of asphalt, is a property related to the flexibility of the blend. Paving and road constructions require that a serviceable asphalt should posses some instinct of flexibility. The asphalt pavement is imposed on by a high traffic load at regular basis, so if the asphalt was designed to have high stiffness it would be more prone to fatigue and consequently cracks (alligator cracks). To avoid cracking of asphalt pavements and increase its fatigue life it is important to provide a certain amount of elasticity to the mixture, this could be achieved by increasing the amount of binder and designing a mixture with low stiffness.

It turns out from the above information that the stability and flow are two opposite properties of an asphaltic mixture. Both of them are required, but it is absolutely vital to be aware that they are related in a way such that by manipulating one of them the other is affected inversely. Hence, designing an asphalt pavement should aim to obtain the optimum stability with an optimum range of flow.

Practically, one can measure the stability and flow of asphalt by performing the Marshal test. The Marshal test attempts to find the optimum binder content for the aggregate mix type and the traffic load intensity. This test defines stability as the maximum load carried by a compacted specimen at a standard test temperature of 60 C^o. Also defines flow as the vertical deformation (diameter change) at that point of failure. The Marshal test also provides analysis of voids and densities which are key values required for the 'Asphaltic Job Mix Design'.

- **Purpose:**

To perform the Marshal testing in order to measure the stability and flow of asphalt samples, in addition to find out the necessary calculations required for densities and voids analysis.

- **Hypothesis:**

The logical assumption suggests that the stability and flow are inversely proportional, thus, if one value is obtained large the other should be small and vice versa.

- **Formulas:**

1) $B = W - W_W$

Where:

B: Volume of sample. W: sample mass in air. W_W : sample mass in water.

2) $SM = \frac{W}{B}$

Where:

SM: actual density. B: Volume of sample. W: sample mass in air.

3) $STH = \frac{100}{\frac{W1}{S1} + \frac{W2}{S2} + \frac{W3}{S3} + \frac{WB}{SB}}$

Where:

STH: theoretical density. WB: binder percentage. SB: binder density.

4) $Vm = \frac{STH - SM}{STH} * 100$

Where:

Vm: voids percent in total mix STH: theoretical density. SM: actual density.

5) $Va = \frac{WB - SM}{SB} * 100$

Where:

Va: voids in aggregates. SM, SB (as above).

6) $Vf = \frac{WB * SM}{Va * SB} * 100$

Where:

Vf: voids filled with binder. SM, SB, WB, Va (as above).

7) $SA = SM * \frac{100 - WB}{100}$

Where:

SA: CAD SM (as above).

Instruments

Apparatus and Tools:

fig.1: Coarse aggregates

fig.2: Fine aggregates

fig.3 Oven

fig.4: Balance

fig.5: Balance suspending apparatus

fig.6: Pycnometer jar

fig.7: water squirt bottle

fig.8: Heater

- **Data & Calculations:**

- **Results & Conclusion**

Coarse (1):

$G.S_b$ = =2.40

$G.S_b$ (SSD) = 2.50

$G.S_b$ = 2.66

%Abs = 4.08 %

Coarse (2):

$G.S_b$ = 2.44

$G.S_b$ (SSD) = 2.53

$G.S_b$ = 2.69

%Abs = 3.70 %

Fine (1):

$G.S_b$ = 4.81

$G.S_b$ (SSD) = 3.05

$G.S_b$ = 1.74

%Abs = -36.5 %

Fine (2): $G.S_b$ = 4.69

$G.S_b$ (SSD) = 3.11

$G.S_b$ = 1.82

%Abs = -33.5 %

For the coarse aggregates the specific gravities are within the range (2.40 to 2.90). However, the absorption capacities are higher than the permissible limit suggested by (BS 8007) which is 3%, hence these aggregates are rejected or the test should be remade. For fines, It turns out that we have a blunder (very large mistake), since the recorded oven dry weight is larger than the saturated surface dry weight, and hence most of the computations done are not correct, also the absorption could never be a negative value.

Source of error:

1- Systematic errors in the balance.
2- Maybe a misreporting blunder.
3- Improper drying of the water film surrounding the aggregates.
4- Overheating of the fine samples.
5- Errors in filling the pycnometer because of the meniscus reading difficulty.
6- Probable that tarring the balance was forgotten.
7- Loss of a portion of the fine sample while pouring the water out of the pycnometer.

- **References**

1. Department of Transportation (2006) Aggregate Production and Testing: Construction Inspector’s Training Manual. Washington State, Department of Transportation. Environmental and Engineering Program, Construction office.

2. https://theconstructor.org/building/aggregates-specific-gravity-water-absorption-test/1358/?fbclid=IwAR0Bm89wilGozpszFxhqQuPu-WJ0GCbILwYJPGHOcE_mmZ8ZqxZEWibOIP8