Faculty of Engineering and Technology

Civil Engineering Department

Construction Materials Laboratory

ENCE215

Experiment # 12

" Ductility and viscosity of bitumen "

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Dateof performing the experiment: 10-12-2019

Date of submitting the experiment: 18-12-2019

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- **Introduction**

Background information

A bitumen blend should meet a number of standards in order to create a serviceable asphalt pavement. One of these is ductility, which is generally defined as the ability of any material to show a relatively huge plastic deformation before it fails. In the case of asphalt, it is required that the bitumen binder penetrates between the voids, and to form a thin coating around the aggregates so as to develop cohesion forces between the aggregates. However, if the bitumen has low ductility, the aggregates will poorly adhere to each other, and the mixture will probably crack. Cracks are disastrous in pavements since they increase the permeability and thus, they lower the strength capacity of the pavement.

The ductility test is performed by measuring the distance that a bitumen sample's end stretches by (at the point of failure) in briquette mold while the other clip end is held fixed. The stretching process is adjusted at a constant rate of 50 mm / min in a water bath that maintains a uniform temperature of 25 C^{o}. Usually, the ductility values range from 5 to 100 cm, but it is conventional to use a minimum value of 50 or 75 cm in most of pavement constructions.

The viscosity of bitumen is another important parameter that should be determined for the binder. It is defined as the property that hinders the flow of a liquid. It is also looked at as a measure of how much a fluid resists its flowing behavior. This property of bitumen is of a high concern, this is because it is directly related to the degree of compaction and thus it affects the stability of asphalt. If the binder had a low or high viscosity, it would disturb the compaction process, as a result the asphalt would have a lower stability. Also, if the viscosity is low, the binder acts as a

lubricant for the aggregates instead of forming a uniform coating, and that means a low adhesion which is not desired.

Experimentally, the viscosity of bitumen binder could be indirectly determined by measuring the time required for a 60 ml bitumen sample to flow through the orifice of a standard flask. The test is performed using a device called viscometer, which is more of a tank containing bitumen at a uniform temperature (70 C^o), the bitumen is poured in the flask through a nozzle in the device. It is noted that the longer the measured time is, the higher the viscosity of the bitumen is.

Purpose

1) To measure the ductility of bitumen samples using the ductility machine (measuring stretching distance).
2) To measure the viscosity of bitumen samples, using the viscometer device (measuring time of flow).

- **Hypotheses**

Bitumen is a very ductile material, so it is predicted that the samples would exhibit large deformation before breaking.

Unlike the ductility test, the viscosity test involves exposure of bitumen to air temperature. As a result, the errors are expected to be higher.

- **Procedure**

a) Ductility:

1) Three samples of bitumen were prepared and poured in three briquette molds.
2) The briquettes were placed in the ductility machine for about half an hour at a uniform temperature of 25 C^o.
3) One end of the mold was fixedly attached to the clip of the machine, and the other end was attached to the moving clip.
4) The machine was turned on and the three specimens were stretched at a constant rate of 5cm / min.
5) The distance of stretching is recorded for each specimen when it breaks. (note: standards suggest to stop the test if the distance exceeds 75cm and to record it as greater than 75, but we stopped at 100 cm).
6) After finishing the test, the molds were rinsed with benzene solution, and cleaned under pouring water.

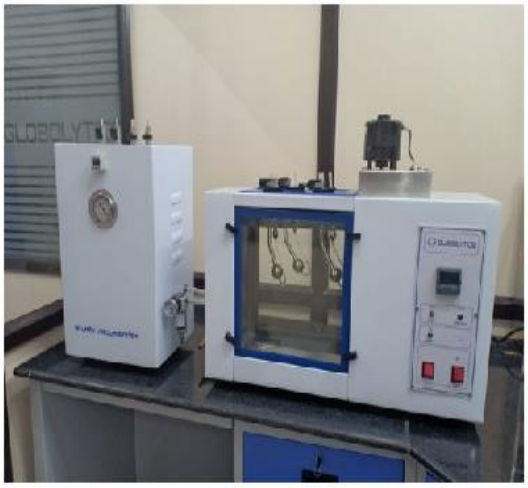
b) Viscosity test:

1) The bitumen sample was prepared and poured inside the viscometer.
2) The temperature of the viscometer was adjusted at 70 C^o.
3) The flask's orifice was placed under the nozzle of the viscometer in such a way as to ensure that bitumen is poured on one side of the flask to keep the 60 ml mark clear on the flask.
4) The nozzle was opened by removing the stopper and the stopwatch was turned on simultaneously.

5) While the flask was being filled, the stopper was cleaned using benzene solution.
6) The timer was stopped when the bitumen reached the 60 ml mark in the flask.
7) The viscometer was allowed to be emptied, by pouring all the bitumen it contains inside the flask.
8) The nozzle was closed again by using the cleaned stopper.
9) The bitumen in the flask was poured again inside the viscometer.
10) The flask was cleaned using water and benzene solution.
11) The same procedure was followed in the next two trials.

- **Instruments**

Apparatus and Tools:



fig(1): Viscometer

fig(2): Ductility machine

fig(3): Briqutte molds

fig(4): Flask (60 ml)

fig(5): Benzene squirt bottle

fig(6): stopwatch

- **Data & Calculations:**
- Ductility test:

The three samples stretched beyond 100 cm, so the test was stopped:

Sample (1): ductility greater than 100 cm.

Sample (2): ductility greater than 100 cm.

Sample (3): ductility greater than 100 cm.

- Viscosity test:

Sample (1): 98 sec.

Sample (2): 118 sec.

Sample (3): 244 sec. (rejected, large deviation).

Results & Conclusion

Table (1) summarizes the results:

Note: the samples are different for each test (6 samples in total not three).

Table(1): the viscosity and ductility tests results

Sample No.	Ductility (cm)	Viscosity (sec)	
1	>100	98	Avg
2	>100	118	108
3	>100	224 (rejected)	

For the ductility test, the three specimens were highly ductile, and all of them are accepted since they are higher than the minimum value specified by ASTM (50 or 75). This high

value indicates that the binder is more likely able to form a satisfactory cohesion between the aggregates in the pavement.

It is noticed that the values of the viscosity increased for trial (2) and were largely increased for trial (3), this could be explained by realizing that the viscosity is highly sensitive to temperature, as it is increased by temperature drop, hence, the duration extended.

(note: I couldn't find a standard requirements table for this type of viscosity test, there are tables for poise values and Pa-s viscosity tests).

Sources of error:

- Temperature effect.
- Bitumen residues left on the flask.
- Poor timing of the stopwatch.
- Sample preparation errors.
- Lumps in the specimen (viscosity).

- **References**

1. ABOUT CIVIL:

   https://www.aboutcivil.org/to-perform-ductility-test-on-bitumen.html

2. The Constructor:

   https://theconstructor.org/practical-guide/viscosity-test-for-cutback-bitumen/2573/