

CHAPTER FIVE: LABORATORY TESTING AND RESULTS

5.1 Introduction

Assessing of bitumen is very important in handling and operation of asphalt products. There are qualitative measures of bitumen which gives an idea about its properties. Several tests can be done for this task. In assessing of bitumen or asphalt cement quality in Sri Lanka, current practice is to use two tests, namely penetration test and softening point test. Among the two, bitumen penetration test is the governing test. By penetration test it gives the consistency of asphalt cement at 25⁰C while softening point test gives an idea about the softening temperature of bitumen where solid-liquid phase change likely to occur. In this research, to assess the quality of bitumen these tests were used as major tests which are already evaluating under project level. Other than the penetration test and softening point test, viscosity of the samples were checked at 60⁰C and 135⁰C which is used rarely in project level. As per the current regulations, Sri Lanka use 60/70 penetration grade bitumen for road construction. 80/100 bitumen also used for road construction before year 2003 but now it was hardly used in asphalt pavements.



5.2 Laboratory testing

5.2.1 Penetration Test

Penetration test is the major test incorporated in the selection of asphalt cement in penetration grading system. Even though it is an empirical test it is still used widely around the world. ASTM D 05 carries the test method for testing of penetration of asphalt cements.

Twenty three collected bitumen samples from various locations around Sri Lanka were tested for penetration at the laboratory. The test procedure is described below.



Figure 5.1: Penetration apparatus-automatic (left) and manual (Right)

Sample Preparation

- Bitumen sample was heated to a temperature about 100°C where it can be freely poured
- While bitumen was heating it was stirred well to remove entrapped air and water if exist
- Then the heated bitumen was poured to a sample container which has a diameter of 55mm and internal depth of 35mm
- The sample container was further heated while stirring well
- Then the sample container was kept for cooling about 1 hour by covering the container with a lipped beaker

Procedure

- After cooling to room temperature the sample container was kept inside a water bath at 25°C for a period of 1-1.5 hours
- Then the sample container was placed on the penetration apparatus
- The penetration needle was lowered to the surface of the bitumen container to a point where needle is just on top of sample.

- Then the penetration starts and stopped at 5 seconds and the penetration reading was recorded
- After that the needle was pulled out of the container without disturbing it.
- The needle was then cleaned with kerosene and wiped again using a clean cloth
- A second penetration was recorded at least 1cm away from the first point and 1cm away from the edge of the container
- Likewise 5 readings were recorded for each bitumen sample at 25⁰C
- For each sample penetration readings were recorded at 30⁰C and 35⁰C also.

5.2.2 Softening point test

Other than the penetration test softening point test is the most important test related to penetration grading bitumen in Sri Lanka. This temperature gives the point where bitumen starts its plastic flow. ASTM D 36 carries out the test method to determine the softening point of a bitumen sample.

All twenty three bitumen samples were tested for softening point test and the softening point temperature of each bitumen sample was obtained. The test method is described as follows.



Figure 5.2: Softening point apparatus

Sample preparation

- A bitumen sample was heated to a temperature about 100⁰C where it becomes sufficiently fluid to pour.
- The two brass rings of the softening point apparatus was heated to the same temperature above
- Then the brass rings were placed on top of a brass plate where grease was applied on it
- Then bitumen was poured in to the brass rings while it filled completely with some excess

Procedure

- The sample was allowed to cool under normal conditions for 30 minutes
- After that the top of the brass ring is levelled by removing the excess bitumen
- The brass rings were then placed with ball centering guide on the rest of the apparatus and placed it inside water beaker for 15 minutes
- At the same time balls were also placed at the temperature which beaker had for 15minutes
- Finally the steel balls are placed on top of brass rings and start heating the whole set of apparatus
- The temperature increment kept at a constant of 5⁰C per minute
- The temperatures where the steel balls touches the bottom plate was recorded as the softening point temperature



5.2.3 Absolute viscosity test

Absolute viscosity test is the fundamental test in the viscosity grading system. This measures the viscosity of bitumen at 60⁰C. The properties of bitumen at a hot summer are predicted by this test. ASTM D 2171 is the test method used for this test.

Since the complexity of the apparatus for this test method not all the bitumen samples were tested for absolute viscosity. The pressure control system used in the apparatus was developed specially for the test (Figure 5.3) with some modifications to the same

unit illustrated in the ASTM D2171 (Figure 5.4). Asphalt Institute vacuum capillary viscometer was used for the absolute viscosity testing (Figure 5.5).

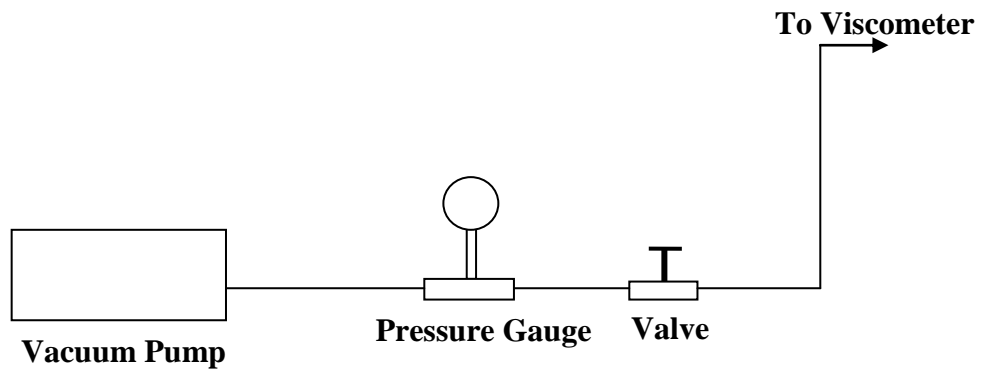


Figure 5.3: Pressure control system developed for absolute viscosity test

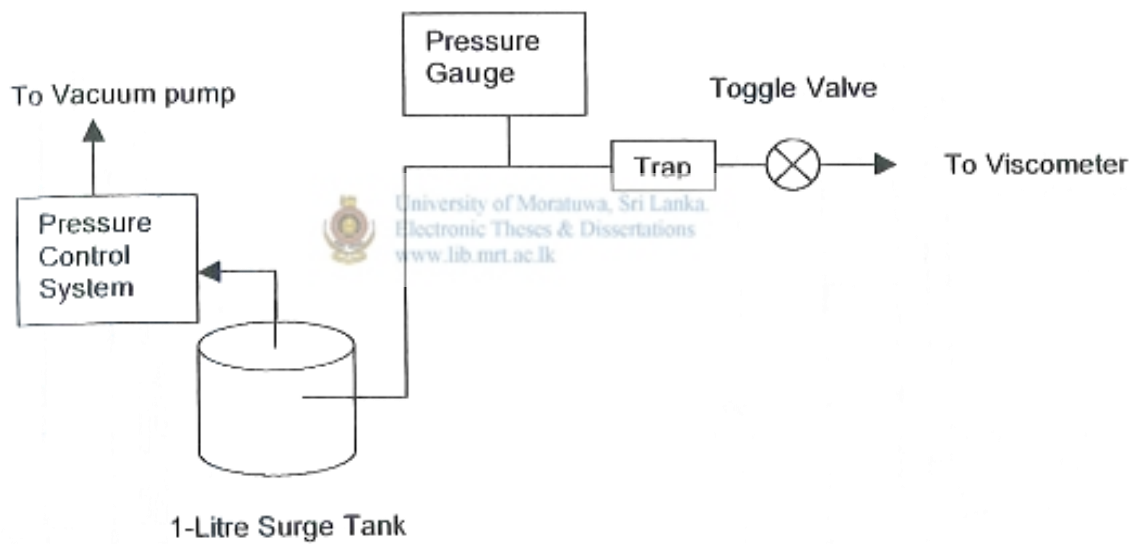


Figure 5.4: Suggested vacuum system by ASTM D 2171

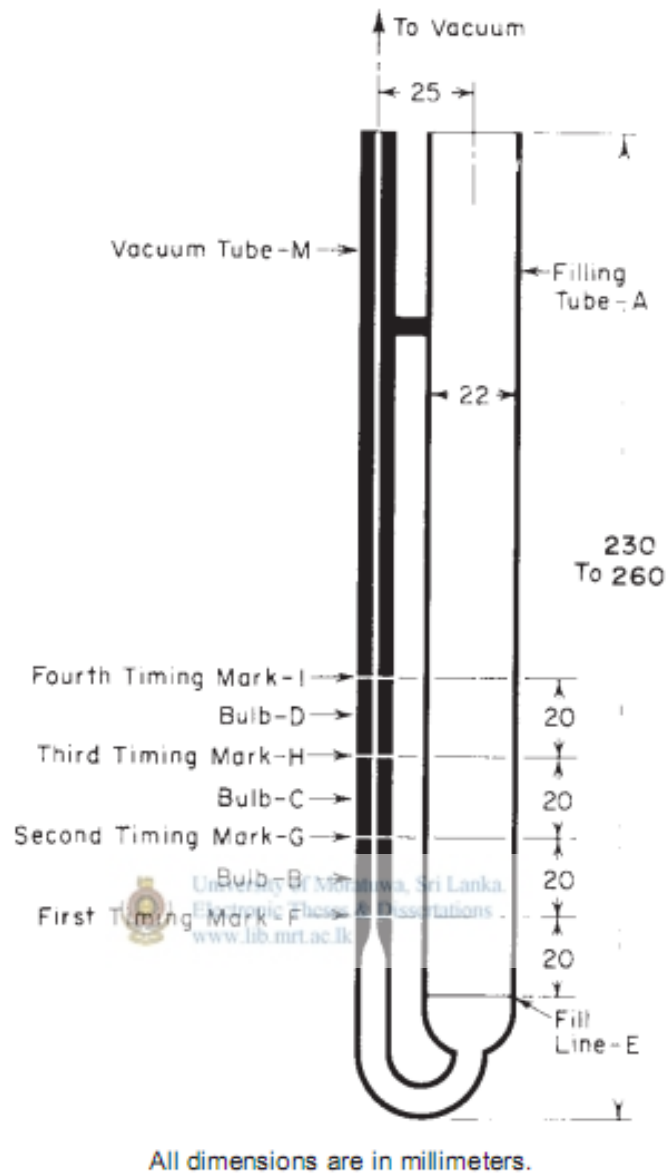


Figure 5.5: Asphalt Institute vacuum capillary viscometer

Sample preparation

- The bitumen sample was heated to a temperature about 100⁰C where it can easily poured.
- Then about 20ml of the sample was taken to a container and heated to a temperature of 135+/-5⁰C while stirring well

Procedure

- The viscometer was also heated to a temperature of $135\pm 5^{\circ}\text{C}$
- The heated bitumen sample was then poured in to the viscometer within $\pm 2\text{mm}$ from the fill line
- Then the viscometer was placed inside an oven at $135\pm 5^{\circ}\text{C}$ for 10 minutes
- After that the viscometer was placed inside the bath at 60°C for 30min.
- At the mean time 30mmHg pressure was established in the pressure control system and connected to the viscometer while the valve is closed
- After 30min the valve was opened and the bitumen starts flowing under the pressure of 30mmHg.
- The respective time taken by bitumen to pass the timing marks were recorded

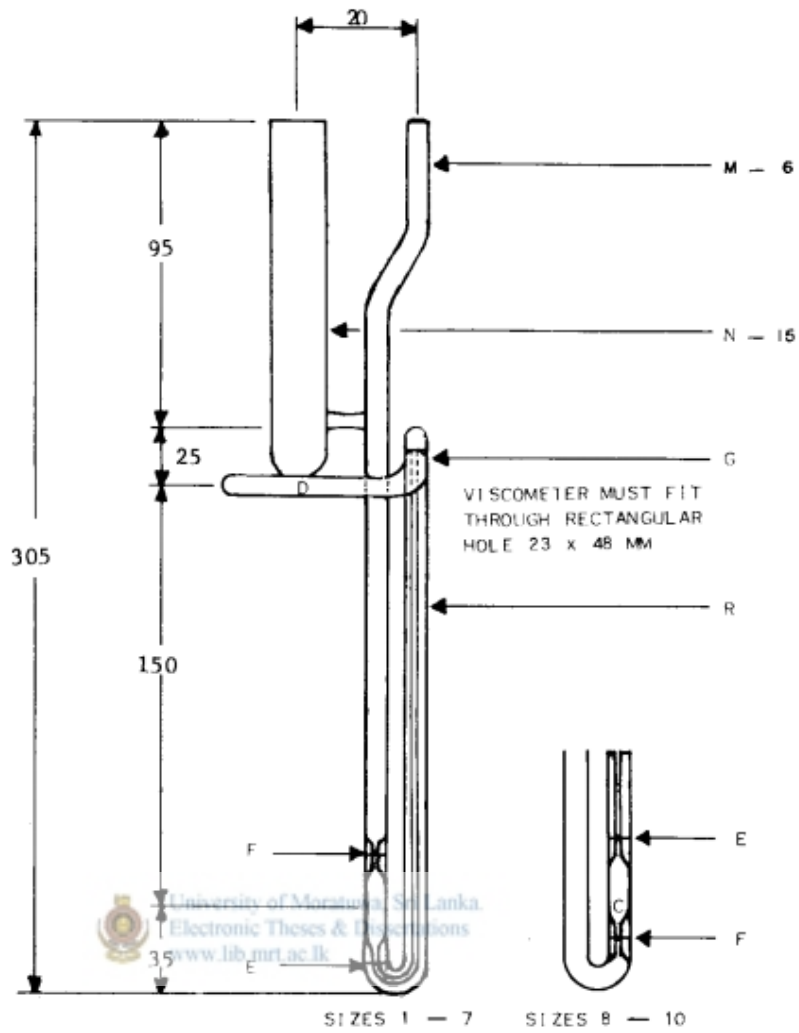
5.2.4 Kinematic Viscosity test

This test is one of the important tests which the viscosity value of bitumen at 135°C . This temperature is related to the mixing and compaction temperature of bitumen. ASTM D 2170 describes the test method for kinematic viscosity of bitumen. Zeitfuchs Cross-Arm Viscometer was used for viscosity testing.

All the bitumen samples were tested for kinematic viscosity test. The test procedure is explained below.



Figure 5.6: Kinematic viscometer and bath



NOTE 1—All dimensions are in millimetres.

Figure 5.7: Zeifuchs Cross-Arm Viscometer

Sample preparation

- The bitumen sample was heated to a temperature about 100°C where it can easily pour
- Then about 20ml of the sample was taken to a container and heated to a temperature of $135 \pm 5^{\circ}\text{C}$ while stirring well

Procedure

- The viscometer also heated to a temperature of $135\pm 5^{\circ}\text{C}$
- The heated bitumen sample was then poured in to the viscometer within $\pm 1\text{mm}$ from the fill line
- Then the viscometer was placed inside a viscosity bath at 135°C for 10 minutes
- After 10min a small pressure was applied to the bigger opening of the viscometer which allows flowing of bitumen under gravity
- The time elapsed for bitumen to pass successive timing marks were recorded
- The same test is done at two other temperatures (120°C and 150°C) for further analysis of bitumen samples

5.3 Test results

Twenty three bitumen samples of 60/70 penetration grade was test and the results are included in table 5.1. For further analysis of results, penetration at other temperatures (30°C and 35°C) are also obtained. The test results of the other two temperatures are included in annex B.

Twenty three samples used for the penetration test were used to determine the softening point. Results of the softening point test are shown in table 5.1.

The type of viscosity; Kinematic and absolute were determined. At 60°C absolute viscosity test was conducted to 10 bitumen samples according to ASTM D 2171. Due to the complexity of the test, only ten samples were test. Results are shown in table 5.3.

Kinematic viscosity test was conducted according to ASTM D 2170 to obtain the viscosity values at 135°C . For further analysis of samples viscosity at other temperatures (120°C and 150°C) are also measured. All 23 samples were measured for kinematic viscosity. The results of kinematic viscosity test at 135°C are included in table 5.2. The kinematic viscosity test values at other temperatures are included in the annex C.

Table 5.1: Penetration and softening point values for tested bitumen samples

Sample No.	Penetration at 25 ⁰ C	Softening point
1	56	51.8
2	69	51.5
3	70	51.5
4	66	53.0
5	47	52.5
6	61	48.5
7	61	51.5
8	56	51.0
9	53	50.1
10	64	48.0
11	60	49.5
12	60	50.2
13	59	49.8
14	63	50.3
15	57	50.0
16	58	50.1
17	48	53.1
18	58	50.4
19	63	49.2
20	67	48.1
21	53	51.6
22	61	51.2
23	49	53.7

Table 5.2: Kinetic viscosity for tested bitumen samples

Sample No:	Kinematic Viscosity at 135 ⁰ C in cSt
1	350
2	329
3	307
4	323
5	342
6	356
7	324
8	329
9	340
10	310
11	325
12	337
13	337
14	332
15	341
16	315
17	376
18	341
19	322
20	318
21	361
22	325
23	386

Table 5.3: Kinetic viscosity for tested bitumen samples

Sample No:	Viscosity at 60 ⁰ C in P
1	2403
3	1682
5	2139
6	1629
7	1861
10	1641
13	1774
15	2044
16	1880
17	2110
23	2659

5.4 Test report data

Apart from the collected samples, a collection of test reports data has been used for analysis. In normal practice, at the time of dispatch of the bitumen tanks from the bitumen supplier, they attach a report which has some bitumen test results. In Sri Lanka this test report includes the test results of penetration and softening point of bitumen. Mainly the amount of penetration and the softening point is included in the test report. A sample of a test report issued by a bitumen supplier is included in the annex A. Sometimes contractors test the bitumen samples again for verification by the use of laboratory facilities. At that time another test report of retest is issued at contractor's lab. A sample of that kind of a test report is included in annex A. A summary of test report data is shown in table 5.4.

Table 5.4: Test Report data from construction sites and bitumen suppliers

Sample No.	Penetration at 25⁰C	Soft. Point temperature in ⁰C	Sample No.	Penetration at 25⁰C	Soft. Point temperature in ⁰C
1	51	48	19	65	49
2	52	49.5	20	65	51
3	53	48	21	65	49
4	54	50	22	66	49
5	60	50	23	68	45
6	60	50	24	68	48.2
7	60	49	25	69	48.2
8	60	49	26	70	48
9	60	51	27	70	48
10	60	50	28	70	48
11	60	50	29	70	48
12	61	50	30	70	48
13	62	49.6	31	70	48
14	62	49.6	32	70	48
15	62	49.6	33	70	48
16	63	49.4	34	70	48
17	64	49.2	35	70	48
18	65	49			