University of salahaddin-Hawler
College of Engineering
Civil Engineering Department
Third Year

Manual of Highway Engineering Laboratory

Prepared by:

Dr. Abdulhakim O.Salih Kozapanky

BSc. in Civil Engineering (University of Sulimny-1980)
BSc. in Law (University of Slahaddin-1995)
MSc. in Transportation Eng. (Traffic Safety) (University of Slahaddin-1990)
Phd. in Transportation Eng.(Traffic Safety) (University of Baghdad-2000)

2022-2023

Test No: 1

Penetration Test

Introduction:

Penetration is a measure of hardness or consistency and is the vertical distance (*expressed in hundred of a centimeter*) that a standard steel needle will vertically penetrate into the sample of asphalt under standard load, temperature and time conditions. Generally these conditions are 100 gm, 25°C and 5 seconds respectively through test and be conducted under the following conditions too:

S1.No.	Temp. (°C)	Load (gm)	Time (sec.)
1		200	60
2	**25**	**100**	**5**
3	41.6	50	5

After determining the penetration value, the sample is denoted with standard grades designated by ASTM which is given below:

0 – 20, 20 – 30, 30 – 40, 40 – 60, 60 – 80, 80 –100, 100 – 120, 120 – 160, 160 – 200, 200 – 300

Thus asphalt with a penetration grade of 30 – 40 is harder than the one with a penetration grade of 80 – 100 designate accordingly.

For different types of works and in different temperature zones, materials will be chosen according to their penetration grades. The test is useful to determine the penetrations index which is given as:

$$P_I = \frac{3P}{20} + 1$$

Where P_I: is the penetration index
P: is the penetration value.

Apparatus:

(1) Penetrometer.
(2) Standard needle of 50mm length and 0.1mm diameter at the tip.
(3) Containers: 55mm in diameter and 35mm or 57mm in depth.
The deeper ones will be used for material having penetration of 225mm or more.
4) Transfer dish.
5) Controlled water bath containing not less than 10 litters of water and transfer dish.
6) Stop watch, laboratory heater gloves, tongues, Cleveland and open cup, etc.

Precision:

(1) Allowable error: The difference between the lowest and highest (among minimum 3 observations) values should not exceed by the following limits:

For	0 – 49	50 – 149	150 – 249	Above 249
Permitted limit	2	4	6	8

(2) Repeatability: should not exceed more than 4%.
(3) Reproducibility: should not exceed more than 10%.

Test Procedure:

It consists of two parts:

(a) Preparation of sample:

i) Heat the material to fluid consistency for pouring.The temperature may be slightly more than its softening point, i.e 75°C to 100°C.

ii) Stir the material thoroughly until it becomes homogeneous and is free from air bubbles and water. Pour it in a container to a depth at least 15mm more than its expected penetration depth.

iii) Cool sample in atmosphere *not lower than 18oC* for one hour.

(b) Testing the sample:

i) Place the air cooled sample in the controlled water bath whose temperature is maintained at **25** ± 0.1°C (or the relevant testing temperature) and allowed to remain for at least one hour.

ii) Check the penetrometer for the followings:

a) Load the needle such that the total load (weight + needle + ferrule) is **100** ± 0.25gm (or the other relevant test load).

b) Clean the needle with benzene to remove all dust and bitumen.

c) Test the clamp and release and see that the penetrometer is working properly.

iii) Place the sample can in a transfer dish containing water at test temperature and keep the assembly on the base of the penetration apparatus under the needle.

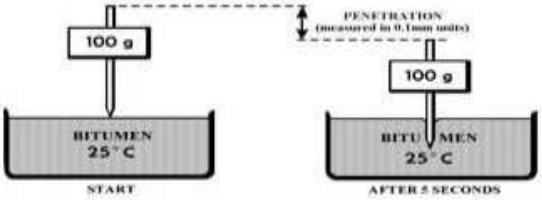
iv) Adjust the needle to make contact with the surface. This can be verified by seeing the image of the needle over the top surface of the sample by the help of a suitable light source.

v) Note the initial reading of the dial indicator.

vi) Release the needle for exactly 5 seconds (for the other relevant test time). Then adjust the penetrometer to measure the penetration distance. Record the reading (each division indicates mm). The difference between final and initial reading is the penetration value for this trial.

vii) Raise the needle from the sample and clean it with benzene. Repeat the penetration test for at least three times at different points on the surface of the sample at least 10mm apart. After each test, the sample shall be kept in water bath maintained at test temperature.

viii)Continue to repeat the trials until at least three penetration values are within tolerable limits.



DATA SHEET

Test No:- **1**

Title:- **Penetration Test**

Name:- Group:- Sec:- Date:- / / 2023

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- Pouring temperature = C°
- Depth of sample in container = mm
- Air cooling period = min.
- Period of cooling in water bath = min.
- Testing temperature = C°
- Weight of load on needle = gm

Trial	1	2	3	*Mean value
Final reading				
Initial reading				
Penetration value				

* Must meet the tolerance required.

Result:

- Penetration value of material:
- Grade of material:

B 40/50 **B 50/60** **B 60/70** **B 85/100**

Signature

Bituminous Material

Test	Origin	Grade of bitumen			
		B40/50	B50/60	B60/70	B85/100
1. Penetration at 25° C (100gm, 5 sec) 1/10mm	AASHTO T49 – 74	**40 – 50**	**50 – 60**	**60 – 70**	**85 – 100**
2. Flash point **°C**(min.)	AASHTO T73 – 74	**240**	**230**	**230**	**230**
3. Loss on heating (5 hrs at 163° C) **%max**	AASHTO T47 – 74	**0.75**	**0.80**	**0.80**	**1.0**
4. penetration after heating Min. % of original	AASHTO T49 – 74	**52**	**50**	**50**	**50**
5. Ductility (at 25° C, 5cm per min.) **Cm** (min).	AASHTO T51 – 74	**100**	**100**	**100**	**100**
6. Ductility after heating (at 25° C, 5cm per min.) **Cm** (min.)	AASTO T51 – 74	**50**	**50**	**50**	**75**
7. Softening point R.B. **°C**	AASHTO T53 – 74	**54 – 60**	**52 – 57**	**49 – 64**	**45 – 50**
8. Increase of softening point R.B. after heating (5hrs of 163°C) **°C** (max.)	AASHTO T53 – 78	**10**	**10**	**10**	**10**
9. Solubility in Organic Solvents. **%** (min.)	AAHTO T44 – 70	**99**	**99**	**99**	**99**
10. Paraffin content **%**(max.)	DIN 52015	**2**	**2**	**2**	**2**
11.Specific Gravity (15.6 °C)		**1.04**	**1.04**	**1.04**	**1.04**

Reference: **SORB**

Test No.: 2

Flash and Fire point

Introduction:

The **flash point** of a bituminous material is the temperature at which the substance momentarily takes fire in the form of a flash for **1** second under specified test conditions.

The **fire point** of bituminous material is the lowest temperature at which the material gets ignited and burns on the surface continuously for **5** seconds under specified test conditions.

Significance:

1) This test is intended to determine the temperature to which the material may be heated safely for constructional purpose.
2) The flash point test is sometimes used to determine the existence of impurities like gasoline or kerosene in the material.

Apparatus:

1) Cleveland opened tester complete set.
2) Thermometer :
   - Low range = 7^{o}C to 110 ^{o}C
   - High range = 90^{o}C to 370 ^{o}C
3) Source of flame.
4) Gloves, tongues, … etc.

Precision:

The result shall not differ from the mean value by more than the following:

- 3 ^{o}C in case of flash point.
- 6 ^{o}C in case of fire point.

Precautions:

1) The apparatus should be shielded from air draughts.
2) Continuous stirring is essential to break surface films of slice.
3) The bluish flame that surrounds the test flame should not be confused with true flash.
4) The test flame should not be applied frequently as the surface layer is likely to be superheated.

Test Procedure:

1) All the part of the cup should be thoroughly cleaned and dried before the test is started particular care should be taken to remove all traces of solvent used for cleaning.

2) Fill the cup with the material under tests to the level indicated by the filling mark.
3) Insert the desired thermometer into the sample. The bottom of the thermometer should not touch the bottom of the cup.
4) Switch on the heater. Apply heat at such a rate that the temperature rise is 5ºC to 6ºC per minute.
5) Light and adjust the test flame so that it is of the size of a bead of 4mm in diameter.
6) Turn the stutter at a rate of approximately 60 revolutions per minute.
7) Apply the test flame at each temperature reading which a multiple of 1oC to 104 oC. For the temperature range above 104 ºC, apply the test flame at each reading which is a multiple of 3 ºC, the first application of the test flame being made at a temperature of 17 ºC below the actual flash point. The flame must be kept in lowered position for one second and then quickly raised to its high position. The material should not be stured while test flame is applied.
8) Report flash point as the thermometer at the time when the flame application causes a distinct bluish flash in the interior of the cup for one second.
9) Continue heating and subsequent application of the flame at interval of 3ºC. This will be continued until the material ignites and continuous to burn for 5 seconds, the temperature of the material at this instance as read in the thermometer is recorded as the fire point.

Data sheet

Test No: 2

Title: Flash and Fire Point

Student Name: *Sec:* *Group:* *Date:* / / 2023

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*

- Type of the Material:
- Grade of the Material:

Time (min)	Temp (°C)	Temp. Rise °C/min	Remarks

Results:

Flash Point ____ **°C**

Fire Point ____ **°C**

Signature

Test No: 3

Specific Gravity of Bituminous Materials

Introduction:

Specific gravity is the ratio of the mass of a given volume of the substance to the mass of an equal volume of water, the temperature of both being specified.

The specific gravity can be determined either by Pycnometer method or by Balance method.

Significance:

The test is done for the following purposes:

1) For billing purpose while being transshipped from one place to another.
2) For incorporation in the mix design method (calculations).
3) To identify the various kinds of bituminous material with reference to the specific gravity values.
4) To detect the presence of impurities in the material.

Apparatus:

a. Pycnometer method: Specific gravity bottles of 50 ml capacity.
b. Balance method : Analytical balance, 12mm diameter brass mold, beaker.

Cleveland open cup, laboratory heater, tongues, gloves, …etc, will be required in both methods.

Precision:

Test results will not differ from the mean by more than **±0.005**.

I: Pycnometer method:

Precautions:

1) Only refresh boiled distilled water shall be used.
2) During weighing, the temperature of apparatus should exceed the specified value.
3) While filling the apparatus and inserting the stopper, no air bubbles should be present in the pycnometer.
4) Weight should be determined just after filling the apparatus and shall be accurate to 0.10 gm.
5) In order to avoid breakage of the bottle while cleaning in case of very viscous materials, it is advisable to warm it at a temperature less than 100^{o}C, until most of the material is poured out and then to swab it with cotton waste. When cooled, it may finally be rinsed with benzene and wiped clean.

Test Procedure:

1) Clean, dry and weigh the specific bottle together with the stopper.
2) Fill it with freshly boiled distilled water and insert the stopper firmly.

3) Keep the bottle for about half an hour in a beaker containing distilled water maintained at 25 ± 0.1°C? Wipe the surface with clean cotton and weigh again.
4) In case of solids and semisolid material, gently heat a small amount of the material to a fluid condition, care being taken to prevent loss by evaporation.
5) Pour the material into the specific gravity bottle to fill to approximately half of it. Slightly warm the bottle before filling.
   Note: In case of liquids, fill the bottle up to the brim and insert the stopper quickly.
6) To prevent escape of entrained air bubbles, allow the bottle to remain for half an hour at the room temperature.
7) Cool the bottle to the specified temperature (25°C) and weigh it with the stopper.
8) Fill the bottle with distilled water and insert the stopper firmly.
9) Keep the bottle in a beaker containing distilled water at 25 ±0.1°C for half an hour.
10) Remove the bottle from the bath and wipe the surface with clean dry cloth and weigh again.

Observations:

1)	Grade of the material	=	
2)	Room temperature	=	
3)	Weight of bottle (empty)	=	(a)
4)	Weight of bottle filled with water	=	(b)
5)	Weight of bottle + half filled with material	=	(c)
6)	Wight of bottle + half filled with material + Remaining filled with water	=	(d)

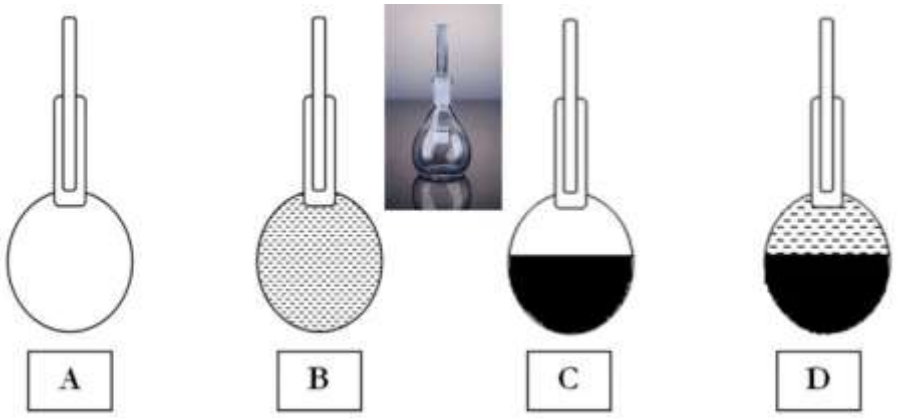
In case of liquid materials only:

Weight of bottle + completely filled with liquid material = (e)

Calculations:

a) Specific gravity of solid & semisolid materials = (c-a)/((b-a)-(d-c))

b) Specific gravity of liquid materials = (e-a)/(b-a)



II: Balance method:

Precautions:

1) No parts of the support for beaker should touch the balance.
2) No parts of the specimen should touch the beaker.
3) Care should be taken to avoid inclusion of air bubbles while pouring the material into the mold.

Test procedure:

1) Melt a small quantity of material by gentle application of heat, care being taken to avoid loss by evaporation.
2) Pour the hot material into the brass mold placed on a brass plate. The plate and the bottom edge of the mold should be amalgamated before this.
3) After cooling the sample in room temperature, cut the excess material by means of a hot spatula.
4) Remove the specimen from the mold.
5) Tare the balance with a piece of fine waxed silk thread.
6) Attach the test specimen to the thread so as to be suspended about 25mm above the straddle from the hook on the pan support and weigh it to the nearest 0.10 gm.
7) Weigh the specimen, still suspended by the thread and completely immersed in freshly boiled distilled water at 25±0.1^{o}C to the nearest 0.1 mg. there should not be any air bubbles in the water.

Observations:

Weight of dry specimen in air = a
Weight of the specimen when immersed in distilled water 25^{o}C = b

Calculations:

$$Specific\ gravity\ of\ the\ material = \frac{a}{a-b}$$

DATA SHEET

Test No:- **3**

Title:- **Specific Gravity of Bituminous Materials**

Name:- Group:- Sec:- Date:- / / 2023

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- Grade of Bitumen:
- Weight of bottle empty (a) =
- Weight of bottle filled with water (b) =
- Weight of bottle half filled with bitumen (c) =
- Weight of bottle + half filled with bitumen + remaining filled with water (d) =

- **In case of liquid materials only**:
- Weight of bottle + completely filled with liquid material (e) =

$$Specific\ gravity\ of\ solid\ and\ semisolid\ materials = \frac{c-a}{(b-a)-(d-c)}$$

$$Specific\ gravity\ of\ liquid\ materials = \frac{e-a}{b-a}$$

Result:

Specific gravity =

Signature

Test No: 4

Softening Point

Introduction

Softening point of a bitumen material is the temperature at which the substance attains a particular degree of softening under specified test conditions. In other words, it is the temperature at which the material just changes from semisolid to liquid state under controlled heating.

Significance

1) It gives an idea of temperature susceptibility. Higher the softening point, lower the temperature susceptibility.
2) It is used in specifications for asphalts for crack filling, joint sealing, roofing, …etc where the materials are used in thick films. Usually any value between **45ºC to 65ºC** is desired.

Apparatus

1) Ring and ball apparatus which consist of steel ball (3/8" dia. and 3.5 gms in weight), ball guide supports, brass ring, glass container, …etc.
2) Thermometer of relevant range.
3) Stirrer.
4) Laboratory heater, Cleveland open cup, laboratory tongues, stop watch, …etc.

Precision

Test result shall not differ from the mean by more than the followings:

Softening point	Repeatability	Reproducibility
Below 30ºC	2 ºC	4 ºC
30ºC to 80ºC	1 ºC	2 ºC
Above 80ºC	2 ºC	4 ºC

Precautions

1) Only freshly boiled distilled water shall be used in the test to avoid bubble formation on the specimen.
2) The specified rate of heating should be strictly observed to ensure accurate results.
3) The rate of temperature rise shall not be distributed over the period of test and any test in which the rate of temperature rise does not fall within specified limits after the first three minutes shall be rejected.

Test Procedure

It consists of:

(a) Preparation of sample.

(b) Testing of sample.

(a)Preparation of sample

1) Heat the material to 75ºC – 100ºC above its approximate softening point, stir until it is completely fluid and free from air bubbles and water.
2) Heat the rings to the temperature of the molten material and place on brass plate previously amalgamated.
3) Pour the hot material into the rings sufficiently in order to give excess above the top level of the ring when cooled.

4) Cool the ring containing the material in air for a period of 30 minutes and level the material by removing the excess material by a hot spatula.

(b)Testing of sample

1) Assemble the apparatus with rings, thermometer and ball guides in position. Fill the glass container with water to a height of 100 mm.
2) The bath temperature is to be maintained at 5°C for 15 minutes.
3) Place the ball (already cooled to 5°C) over the surface of the material in the ring using forceps.
4) Heat the water at the rate of 5° ± 0.5°C per minute until the material softens and allows the ball to fall down (through a distance of 25mm) and touch the bottom of the beaker. Read the temperature in the thermometer at this instance which is recorded as the softening point.
5) Repeat the test for the second time and find the mean value.

Deviation

For material whose softening point is above 80°C, the following deviations will be made in the test specifications:

1) Glycerin should be used as heat media in place of water.
2) Initial temperature should be kept as 32°C in lieu of 5°C

DATA SHEET

Test No:- **4**

Title:- **Softening Point**

Name:- Group:- Sec:- Date:- / / 2023

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Grade of the material =

Room temperature =

Cooling time in room temperature =

Time for which the specimen was kept in 5^{o}C water bath =

Time readings (minute)	Temperature (^{o}C)	Temperature rise (^{o}C /min)	Remarks

Result:

Softening Point = ____ ^{o}C

Signature

Test No: 5

Ductility

Introduction

Ductility is the property which permits asphalts to undergo deformation without breaking. The ductility of a bituminous material is measured by the distance in centimeters to which it will elongate before rupture when two ends of a standard briquette specimen of the material are pulled at a speed of 50 ± 2.5 mm per minute at a temperature of 25^{o} ± 0.5^{o}C or other relevant test conditions (speed of 10 ± 0.5mm per minute at a temperature of 4^{o} ± 0.5^{o}C).

Significance

High ductility is associated with high temperature susceptibility. Also, materials with high ductility have generally good binding power and ability to resist shocks and vibrations. However, the ductility value of a good material should be within the desired/permitted range which has been specified to be **50 t0 110 cm by AASHTO(>100cm by SORB)**.

Apparatus

(1) **Ductility Testing Machine:** It consists of a rectangular water bath fitted with a moving device at a constant speed of **5** cm/minute (also could be alternated to 1 cm/minute). The test piece is so fitted that one of its ends is clamped while the other is pulled.

(2) **Mould:** It is made of brass and is used to prepare briquettes. It gives a test briquette such that its cross section at the center is 1 cm^{2}.

(3) Laboratory heater.

(4) Cleveland open cup, thermometer, laboratory tongues, …etc.

Precision

The test result shall not differ from the mean by more than the followings:

Repeatability	**5%**
Reproducibility	**10%**

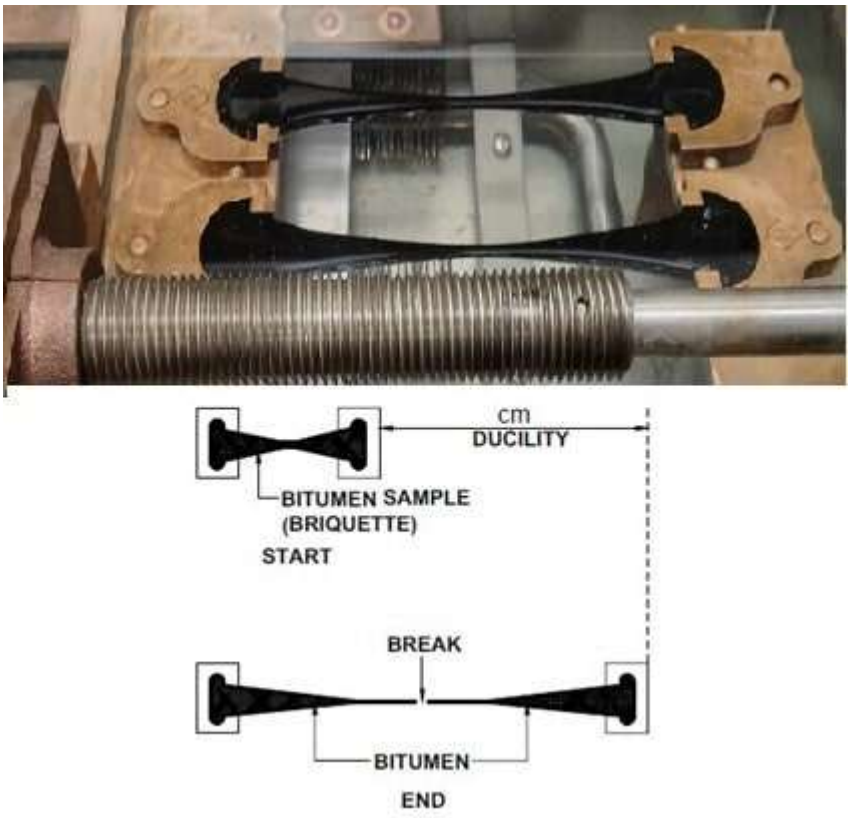
Precautions

1) The bitumen should be poured in thin layers and evenly throughout so that no air pockets are left in the molded sample.
2) In filling the mould, care should be taken not to disarrange the parts and thus distort the briquette.
3) The plates on which the moulds are placed shall be perfectly flat and level so that the bottom surface of the mould touches it throughout.

Test Procedure

1) Soften the material to fluid consistency under a temperature of 75^{o}C to 100^{o}C approximately above the softening point of the material.
2) Assemble the mould on a brass plate previously amalgamated with HCI and mercury or soap solution. The interior surfaces of the sides of the mould should also be thoroughly amalgamated.
3) Pour the material in a stream back and forth from end to end of the mould until it is more than level full.
4) Allow it to cool at room temperature for 30 to 40 minutes and then place it in a water bath maintained at a temperature 25^{o}C ± 0.5^{o}C for 30 minutes.
5) Take out the moulds from the water bath and cut off the excess bitumen by means of a hot spatula so that the mould is just level full.

6) Place the mould with specimen and plate in water bath **25ºC** ± 0.5ºC for a period of 85 to 95 minutes.
7) Remove the briquette from the plate, detach the side pieces and attach the rings at each end of the clips to the ends for hooks in the testing machines.
8) Start the machine to the specimen horizontally at a rate of **50 mm per minute** until the sample is ruptured.
9) Measure the distance in centimeters through which the clips have been pulled to produce ruptured. During the test, be sure that the water in the tank of the testing machine covers the specimen both above and below by at least 10mm and is maintained within ±0.5ºC of the specified temperature.
10) Three test should be conducted on a sample and mean value should be reported.
11) If the sample thread sags down in the water from its horizontal line, the specific gravity of water can be increased by addition of salt (Nacl), and in case the sample floats up above the water level, the specific gravity of water can be decreased by addition of methyl alcohol.



DATA SHEET

Test No:- **5**

Title:- **Ductility**

Name:- Group:- Sec:- Date:- / / 2023

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Grade of material:
Pouring temperature (°C):
Test temperature (°C):
Period of cooling (min.) in air:
Period of cooling (min.) in water bath before trimming:
Period of cooling (min.) in water bath after trimming:

Result:

Ductility value (cm)= °C

Signature

Test No: 6

THE THIN FILM OVEN TEST

(Loss on Heating Test on Bitumen)

The loss on heating test measures the mass of volatile content in bitumen, which gives an idea about the durability of asphalt. This amount is important in the industry, especially in the paving construction. When the bitumen is heated, volatile content present is evaporated and bitumen becomes brittle which can be damaged easily. So, to know the amount of loss ness we will perform this test.

The significance of the test:

A bitumen with a high amount of loss on heating will be hardened. As a result, it becomes less flexible and brittle. Thus, if such a bitumen binder is used in pavement, the asphalt cannot endure load and temperature changes. As a result, asphalt quality is reduced.

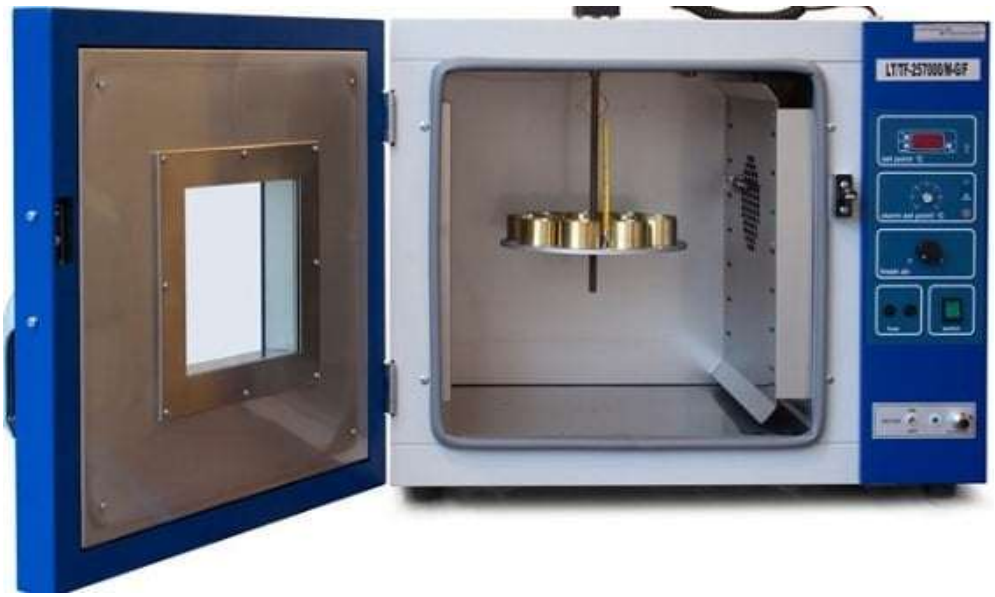
Bitumen binder for pavement constructions must have a loss on heating up to 1 percent. The case of bitumen with a penetration of 150 to 200 can have up to 2 % loss on heating.

Test Procedure:

To perform this test, 50cc of bitumen sample, note down its weight to 0.01gm accuracy at room temperature and placed in a cylindrical flat bottom pan 5.5in. dia. (3\5) deep, asphalt layers only 1\3" deep. Then the sample is placed and heated in a rotating shelf in a ventilated oven at 325 F (163^{o} c) for 5 hours. After that take out the sample and cooled it to room temperature and take the weight to 0.01gm accuracy and note down the value. Then for the two values of weight before and after heating, the amount of bitumen mass loss is determined.

Penetration tests before and after, measure the hardening characteristics.

The loss should be less than the maximum values (percent of total weight) given in table by SORB for different grades of asphalt, otherwise it is not preferred for construction.



DATA SHEET

Test No:- **6**

Title:- **Thin Film Oven Test**

Name:- Group:- Sec:- Date:- / / 2023

- Grade of asphalt used =
- Depth of sample in container = mm.
- Testing temperature = 163 C^o
- Time remaining in oven = 5hrs.

Results			
Description	value	Specification (%)	Remark
Initial Weight(gm)		**Max.** AASHTO T47 – 74	
Final Weight (After 5 hrs) (gm)			
%Weight loss on heating(163C^o,5hrs)			
Penetration value before testing		**Min.** AASHTO T49 – 74	
Penetration value after testing			
% Decrease of original penetration(163C^o,5hrs)			

Signature

Test No: 7

Say-bolt Furol Viscosity of Cutback

Introduction

Viscosity is the property of a fluid by which it resists flow due to internal friction. One of the methods by which it is measured, is by determining the time taken by 50 cc of the material to flow from a cup (container) through a specified orifice under standard test conditions and at specified temperature.

Significance

The test is quite useful to designate the material according to its viscosity and to choose the most ideal material for different works.

Apparatus

a) Viscometer: the various parts of a viscometer are:
- Cup- having standard dimensions.
- Valve- it serves to close the orifice.
- Sleeves- to receive the cup and to hold it in position.
- Stirrer- to maintain the uniform temperature of the material.
- Curved shield- it carries an insulated handle for rotating the stirrer, a support for thermometer and a support for the valve.

b) Receiver- 100 ml graduated cylinder (beaker) for receiving the material flowing out from the orifice.
c) Thermometer- 2 standard thermometers are required one for the bath and the other for the cup.
d) Laboratory heater, Cleveland open cup, stop watch,… etc.

Precision

In case of	**Redwood No.1** Viscosity (seconds)		**Redwood No.2** Viscosity (seconds)
	100 or less	more than 100	100 or more
Repeatability	1 sec.	1% of mean	1% of mean
Reproducibility	2 sec.	2% of mean	4% of mean

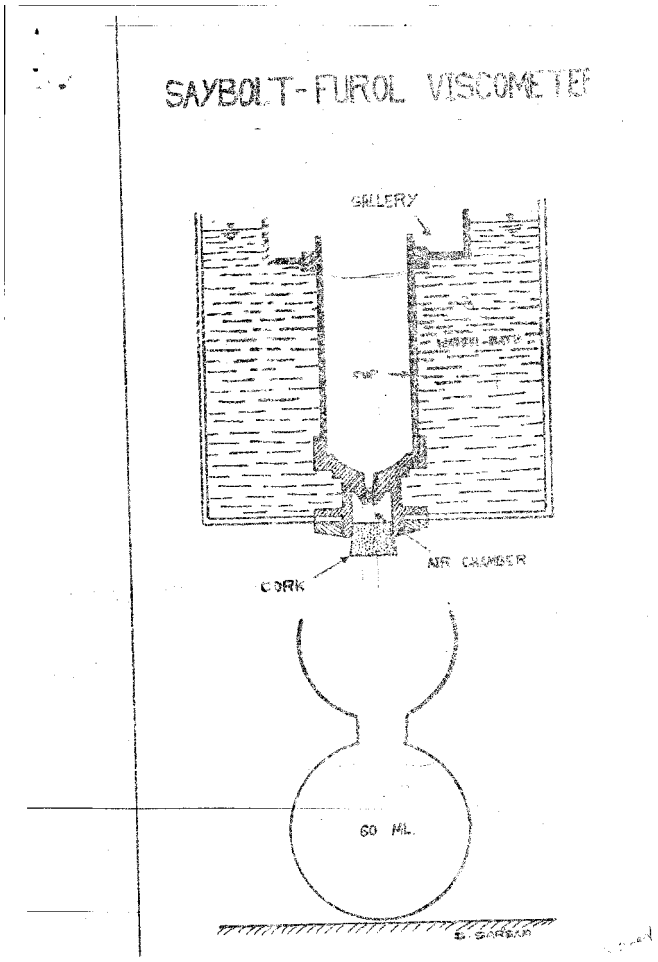
Precautions

1) The temperature of test shall be a multiple of 50 and shall not be lewer than 200.
2) The cup is a critical part of the viscometer and care should be taken in its handling.
3) The orifice of the cup shall be tested at frequent intervals with a suitable gauge.
4) The working range of the instrument (with 4 mm orifice for cut-back) is such that the time of efflux shall be between 20 and 200 seconds.
   Note: - In case of tar materials, the orifice shall be 10 mm diameter and the time of efflux shall be between 10 and 140 seconds.
5) No stirring should be done just after the valve is suspended.

Procedure

1) Adjust the viscometer so that its top is level.

2) Heat the water in the bath to the temperature specified for the test. (Say **50ºC**) and maintain it within ±0.1C throughout the test. At this time, the stirrer should be continuously rotated.
3) Clean the cup orifice of the viscometer with a suitable solvent (say Benzene) and dry it thoroughly.
4) Warm and stir the material to 20 ºC above the specified temperature of the test and cool it.
5) When the temperature has fallen to slightly above the specified value, pour the material under test into the cup until the leveling pins on the valve rod is just immersed when the later is vertical.
6) Pour into the graduated receiver 20 ml of mineral oil or soap solution and place it under the orifice of the cup.
7) Place the other thermometer in the material and stir it until the temperature is within ±0.1 ºC of the specified value.
8) Allow the assembled apparatus to stand for 5 minutes during which period, the thermometer reading shall remain within 0.05°C of the specified temperature.
9) Remove the thermometer and quickly remove any excess material so that the final level is on the centre line of the leveling pins when the value is in its vertical position.
10) Immediately suspend the value by means of the hemisphere at the upper end in the value support which shall be brought immediately previously to its inner position.
11) Start the stop watch when the reading in the receiver is 25 ml and stop it when it is 75 ml. Note the time lapse in second which will be reported as the viscosity of the material at the test temperature.



DATA SHEET

Test No:- **7**

Title:- **Saybolt-Furol Viscosity**

Name:- Group:- Sec:- Date:- / / 2023

****

Saybolt-Furol Viscosity Grades

Saybolt-Furol, Seconds	Grade⊗	Using
15 – 30	0	•Used as a tack, a thin adhesive bonding coat for hard dense surface, and as a prime or penetrating coat for very open surface.
40 – 80	1	
100 – 200	2	•Higher viscosity. •Used in surface treatments and penetration macadam applications. •More heat must be used with the higher grades, but less diluents is used.
250 – 500	3	
600 – 1200	4	
1500 – 3000	5	

⊗*For 60 ml of liquid asphalts at 60 Cº.*

RC (Rapid Curing Cutback) = Asphalt of Penetration (70 – 110) + Naphtha or Gasoline
MC (Medium Curing Cutback) = Asphalt of Penetration (70 – 250) + Kerosene
SC (Slow Curing Cutback) = Manufactured by straight run distillation or road oils

R.C: 1) Hard-base asphalt.
2) Solvent evaporates at low temperature.
3) Used in a northern region.

M.C: 1) Softer-base asphalt.
2) Less volatile solvent and cure at slower rate.
3) Used in the deep south.

Also these are differences depending on curing rate.

S.C:

Principal uses are in road – mixing and dust laying applications, also used in stockpile patching mixes, plant mixes with graded aggregates, and occasionally for priming. They are useful in the type of work where construction involves seasonal tearing and relaying of the existing of SC oil material. The SC materials do not have the fire or toxicity hazards that are inherent in the cutback liquid asphalts.

Result:

Time: ☐ seconds, **Grade:** ☐

Signature

Test No: 8

Marshal Stability Test

Introduction

The **stability** of the mix is defined as a maximum load carried by a compacted specimen at a standard test temperature i.e 140º F (60º C).

Equipment

1) mould Assembly: Cylindrical moulds of 4 inch (10.16 cm) diameter and 3 inch(7.5 cm) height with base plate and collar extension.
2) Compaction hammers, weight 10 lbs (4.55 Kg.) for a drop of 18 inch (45.7 cm).
3) Specimen extractor.
4) Compaction pedestal and specimen mould holder.
5) Breaking head assembly with 4" dia; gauge for flow measurements.
6) Loading unit.
7) Oven or hot plate.
8) Balance, sieve shaker, mixing pan, spatula.
9) Water bath.
10) Thermometers of range up to 400°F (203°C).

Significance

The test aim at an economical blend of aggregates and binder so as to fulfill the designed properties of the mix.

Precautions

1) Heating of bitumen for more than one hour should be avoided.
2) The time elapsed for the test after the removal of specimen from water bath to the maximum load determination should not exceed 30 seconds.

Test Procedure

It consists of the following steps:

1) Preparation of batch mixes.
2) Compaction.
3) Weighing the samples.
4) Stability and flow values.

1) Preparation of batch mixes

i. Select the grading of aggregate as given in Table (2).
ii. Weigh the different sizes of aggregates in different pans to from 1150 gms of the mix, and then place in a mixing container.
iii. All the constituents are mixed, and then placed either in hot oven or on hot plate to heat them to the required mixing temperature (154 °0).
iv. Heat the bitumen binder of the specified grade to the required mixing temperature (154°0).
v. Place the container having all sizes of aggregate on the balance and to this add the required quantity of hot bitumen.
vi. Mix the aggregates and bitumen manually or with a mechanical mixer as quickly and thoroughly as possible. At the start of the compaction, the mix should attain the desired compacting temperature (138ºC).

- For mixing and compacting operations, the following temperatures are recommended:

Bitumen Grade	Temperature	
	Mixing	compacting
180/200	290º F (138º C)	270º F (132º C)
80/100	310 º F (154º C)	290 º F (138º C)
60/70	320 º F (160º C)	300 º F (149º C)

2) Compaction

i. In advance to preparing batch mix, the face of compaction hammer and compaction moulds (3 Nos.) are thoroughly cleaned, heated to 200 to 300° F (100 to 150°C).
ii. Pour the hot batch mix into the hot mould.
iii. Place the compaction mould along with batch mix on the compaction pedestal.
iv. Place the hammer face over the batch top and the mix is compacted by giving 50 blows of hammer.
v. Reverse the mold and apply 50 blows to the mix again.

Note: *If the mix is designed for an expected tyre pressure of 7 Kg/cm² (100 P.s.i) or medium traffic, specimen is compacted by giving 50 blows of the hammer on each side of the specimen. For a tyre pressure of 14 Kg/cm² (200 P.s.i) or for heavy traffic, 75 blows on each side are given. However for a light traffic 35 blows on each side are sufficient.*

vi. Remove the collar and base plate and allow the specimen along with mould to cool in water for at least 2 minutes.
vii. Remove the specimen from the mould with the help of extrusion device.
viii. Number each specimen.
ix. Allow the specimen to cool at room temperature for 24 hours.

3) Weighing the samples

The samples should be weighted in air, in water and saturated surface dry , so that to determine the total voids in the mix, aggregate voids filled with bitumen and the unit weight of the sample.

4) Stability and flow values

i. Immerse the test specimen in hot water bath at 140 ± 1.8°F (60 ± 1°C) for 30 to 40 minutes before the test.
ii. Place the flow dial gauge over the guide rod and adjust the dial gauges of proving ring and flow value to read zero.
iii. Clean and lubricate the testing head and quickly place the specimen on the base plate of the compression testing machine.
iv. Apply the testing load to the specimen at a constant rate of deformation of 5 cm/minute, until the maximum value is reached.
v. Record the values of maximum load and the flow dial gauges.
vi. Reverse the machine.

Report

Record all the above data in the prepared data sheet and draw the following graphs:

i. Corrected stability Vs %bitumen content {make use of Correction Table(3)}.
ii. Flow values Vs %bitumen content.
iii. % voids Vs %bitumen content.
iv. % voids filled with bitumen Vs %bitumen content.
v. Unit weight Vs %bitumen content.

And by making use of the limiting criteria in Table(1), determine the Optimum Asphalt Content.

Criteria For Design

This determination is made by the application of the following limiting criteria to test data for the mix at its binder content.

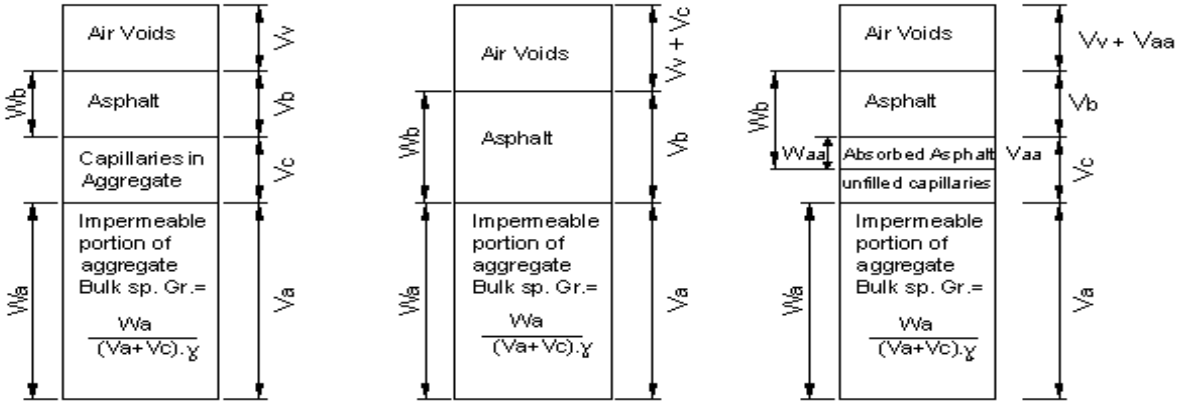
Table (1): Properties of Bituminous Materials	Property	
	Binder course	Surface course
Stability Marshal (75 blows on each face)	Min. 7 kN	Min. 8 kN
Flow Marshal	(2 – 4) mm	(2 – 4) mm
Percentage voids in Mix	(3 – 7)%	(3 – 5)%
Swelling after 28 days (%Vol.)	Min. (1.0)%	Min. (1.0)%
Voids filled with bitumen (%)	(60 – 80)%	(70 – 85)%
Index of Retained strength (AASHTO T165)	Min. 80%	Min. 80%

From "Standard Specifications for roads & Bridges", Iraqi specification

Table(2) BITUMINOUS MIXTURE GRADINGS

U.S Sieve size		Percentage Passing by Weight of Total Aggregate	
mm	Imperial	Binder Course	Surface Course
25.0	1"	100	
19.0	$\frac{3}{4}$"	90-100	100
12.5	$\frac{1}{2}$"	70-90	80-100
9.5	$\frac{3}{8}$"	60-80	70-85
4.75	No.4	42-60	60-80
2.0	No.10	27-47	40-60
1.0	No.18	20-37	28-48
0.6	No.30	15-30	22-40
0.25	No.60	8-20	10-30
0.125	No.120	6-15	8-20
0.075	No.200	5-10	6-12
Asphaltic Cement (%weight of total mix)		4-6	4.5-6.5

Effect of Absorption



Three Methods of Correction:

1) Design of bulk Sp. Gr. then adding asphalt absorbed into the stone to the design quantity to obtain corrected optimum asphalt content.
2) To employ the average of the Bulk Sp. Gr. and the Apparent Sp. Gr. in making the calculations.
3) Using effective Sp. Gr.

****

In actual practice

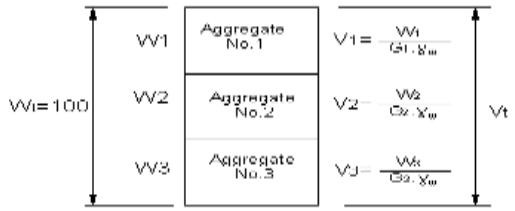
$$effective\ Sp.Gr. = \left\{\frac{Apparent\ Sp.Gr. + Bulk\ Sp.Gr.}{2}\right\}$$

****

Specific Gravity of Combined Aggregates

$$Average\ density = G.\gamma_w = \frac{W_t}{V_t} = \frac{100}{\left[\frac{W_1}{G_1.\gamma_w}\right] + \left[\frac{W_2}{G_2.\gamma_w}\right] + \left[\frac{W_3}{G_3.\gamma_w}\right]}$$

$$G = \frac{100}{\left[\frac{W_1}{G_1}\right] + \left[\frac{W_2}{G_2}\right] + \left[\frac{W_3}{G_3}\right]}$$



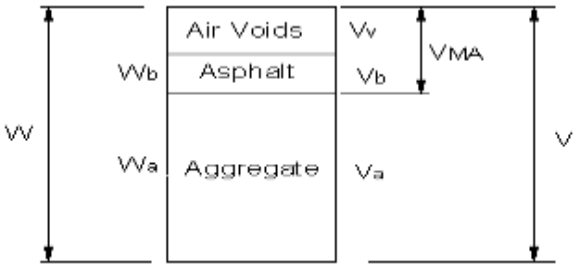
Where:

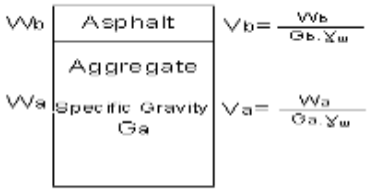
W_1, W_2 & W_3: Weight of each Aggregate (Wts%)

G_1, G_2 & G_3: Sp. Gr. of Aggregates.

Ref.: "Asphalt pavement Engineering" by Wallace & Martin

Marshal Stability Test
(Volume Relation of Asphaltic Concrete)





(G) – Actual

(G_o) – Theoretical

(Total volume of specimen)

$$Bulk\ volume = \left\{\begin{matrix} Wt.of\ spec. \\ saturated\ surface \\ dry\ in\ air \end{matrix}\right\} - \left\{\begin{matrix} weight\ of \\ spec.in \\ water \end{matrix}\right\}$$

$$Bulk\ density\ of\ spec.G = \left[\frac{Wt.in\ air}{Bulk\ Volume}\right]$$

(Volume of solids in specimen)

$$G_o = \left[\frac{W}{V_b + V_a}\right] = \frac{W}{\left[\frac{W_b}{G_b \cdot \gamma_w}\right] + \left[\frac{W_a}{G_a \cdot \gamma_w}\right]}$$

$$G_o = \left[\frac{W}{\frac{W_b}{G_b} + \frac{W_a}{G_a}}\right] = \frac{100}{\left[\frac{W_b}{G_b}\right] + \left[\frac{100 - W_b}{G_a}\right]}$$

$$G_o = \frac{100}{\left[\frac{W_b}{G_b}\right] + \left[\frac{W_a}{G_a}\right]}$$

When W=100, W_b & W_a in Wt.%

****

$$Total\ volume\ of\ solid\ (\%) = \left[\frac{V_b + V_a}{V}\right] * 100$$

$$V_b + V_a = \frac{W}{G_o \cdot \gamma_w} \quad , \quad V = \frac{W}{G \cdot \gamma_w}$$

$$R = \left[\frac{W/(G_o \cdot \gamma_w)}{W/(G \cdot \gamma_w)}\right] * 100 = \left[\frac{G}{G_o}\right] * 100 = \%theoretical\ density.\ (\%solids\ by\ volume).$$

$$100 - R = percentage\ volume\ of\ air\ voids.$$

$$VMA\% = \left[\frac{V - V_a}{V}\right] * 100 = \left(1 - \frac{V_a}{V}\right) + \left\{1 - \frac{W_a/(G_a \cdot \gamma_w)}{W/(G \cdot \gamma_w)}\right\} * 100 = 100 - W_a\left[\frac{G}{G_a}\right]$$

Put W=100

VMA%= %Volume of voids in mineral aggregate.
W_a=Aggregate content percent by weight.

{ – for on sized or poorly graded Agg. ≥ 35%
+ for well graded Agg. <20% }

$$\%voids\ filled\ by\ Asphalt = \left[\frac{VMA - (100 - R)}{VMA}\right]$$

Ref.: "Asphalt pavement Engineering" by Wallace & Martin

Table (3): Stability Correction Ratios

Volume of specimen (cc)	Correction ratio	Volume of specimen (cc)	Correction ratio	Volume of specimen (cc)	Correction ratio	Volume of specimen (cc)	Correction ratio
200-213	5.56	302-316	2.78	406-420	1.47	509-522	1.00
214-225	5.00	317-328	2.50	421-431	1.39	523-535	0.96
226-237	4.55	329-340	2.27	432-443	1.32	536-546	0.93
238-250	4.17	341-353	2.08	444-456	1.25	547-559	0.89
251-264	3.85	354-367	1.92	457-470	1.19	560-573	0.86
265-276	3.57	368-379	1.79	471-482	1.14	574-585	0.83
277-289	3.33	380-392	1.67	483-495	1.09	586-598	0.81
290-301	3.03	393-405	1.56	496-508	1.04	599-610	0.78
						611-625	0.76

Test No :

Marshall Stability Test

Hot-mix design data by the Marshall Method

Name :

class : sec : class No :

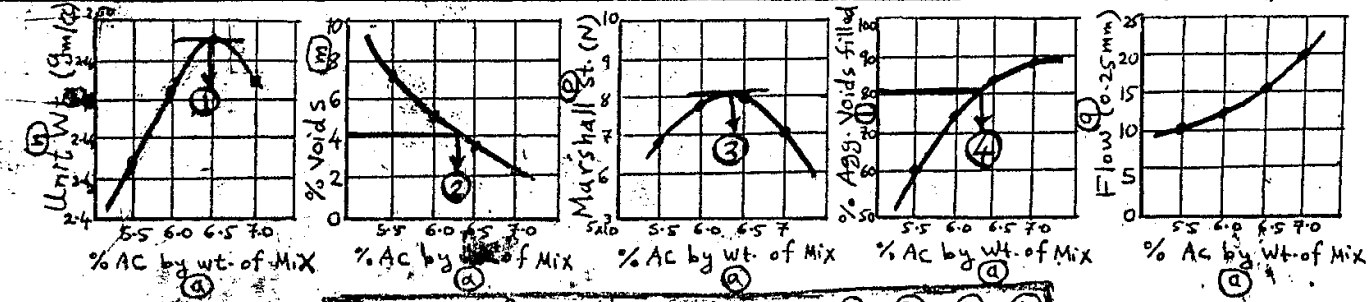
Date :

Sp. gr. of AC = 1.0 (0.95 - 1.05) ; Av. sp. gr. Agg. Blend = 2.8 (2.6 - 3.0) ; Pen. Grade AC : 80 - 100

% AC Spec.	Weight (gm)			Bulk Volume	Spec. Gravity		Volume (% Total)			Voids (%)			Unit Weight	Stability (N)		Flow
No.	in air	in water	S.S.D. in air	cc.	Bulk «G»	Max. Theo. «Go»	Ac.	Agg.	Voids	Agg. (VMA)	Filled (Agg.)	Total Mix	(gm/cc)	Meas.	Adjust	1/100" (0.25mm)
a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q
% AC. by wt. of Mix				(d-c)	$\frac{b}{e}$	*	$\frac{a \cdot f}{GAc.}$	$\frac{(100-a)f}{GAgg.}$	100-h-i	100-i	$\frac{h}{K} \times 100$	$100-\frac{100f}{g}$	1.0 x f		* *	

* $Go = \frac{100}{\frac{\% AC}{GAc} + \frac{\% Agg.}{GAgg.}}$

** See Conversion Table.



• Result :

Optimum Asphalt Content = $\frac{① + ② + ③ + ④}{4}$

Typical Report

University of Salahaddin-Hawler
College of Engineering
Civil Eng.Department
Highway Engineering Lab.
3rd Year

Test No.	
Test Name	
Date of Test	
Date of Report	
Student Name	
Section	
Group	

Test No.
Test Name:
Object:

Introduction:

All important data i.e: definitions, formulas...etc related to the test are recorded here

Apparatus:

Hand Sketch of most important instrument used in proper scale

Procedure:

Mention all the deviations with standard procedure

Observations & Calculations:

All observations & calculations recorded in table as data sheet& details in appendix

Results:

The final result of table-or graph- should be recorded here briefly

Discussion:

This will be in 3 paragraphs:
1.Compare the final result with standard limits and decide,
2.Mension the sources of deviations (errors), and
3.Explain the practical application of the Test, make use to the references here.

●Put the data sheet at the end of the report after completing it by pen and signed by the supervisor, and any report without the data sheet will be neglected

●Try to prepare the report by yourself, and any two or more similar reports will neglected

●Finally the report submitted after 1 week of the test excecution

●Appendix

All details of calculations are put here