Asphalt Cement

Introduction

- In HMA, asphalt functions as a waterproof, thermoplastic, viscoelastic adhesive
- By weight, asphalt generally accounts for between 4 and 8 percent of HMA and makes up about 25 – 30 percent of the cost of an HMA pavement

Asphalt Physical Properties

1. Durability.
    - Durability is a measure of how asphalt binder physical properties change with age. Sometimes it is called age hardening.
    - In general, as an asphalt binder ages, its viscosity increases and it becomes more stiff and brittle.
2. Rheology.
    - Rheology is the study of deformation and flow of matter.
    - Deformation and flow of the asphalt binder in HMA is important in HMA pavement performance.
    - HMA pavements that deform and flow too much may be susceptible to rutting and bleeding.
    - HMA pavements that are too stiff may be susceptible to fatigue cracking.
    - HMA pavement deformation is closely related to asphalt binder rheology.
    - Rheological properties of asphalt binder vary with temperature, so rheological characterization involves two key considerations.
        - First, to fully characterize an asphalt binder, its rheological properties must be examined over the range of temperatures that it may encounter during its life.
        - Second, to compare different asphalt binders, their rheological properties must be measured at some common reference temperature.
3. Safety.
    - Asphalt cement like most other materials, volatilizes (gives off vapor) when heated.
    - At extremely high temperatures (well above those experienced in the manufacture and construction of HMA), asphalt cement can release enough vapor to increase the volatile concentration immediately above the asphalt cement to a point where it will ignite (flash) when exposed to a spark or open flame. This is called the flash point.
    - For safety reasons, the flash point of asphalt cement is tested and controlled.
4. Purity.
    - Asphalt cement, as used in HMA paving, should consist of almost pure bitumen.
    - Impurities are not active cementing constituents and may be detrimental to asphalt performance

Specific Gravity of Asphalt Cement

- Because the specific gravity of asphalt binders change with temperature, specific gravity tests are useful in making volume corrections based on temperature.
- The specific gravity at 15.6° C (60° F) is commonly used when buying/selling asphalt cements.
- A typical specific gravity for asphalt for Riyadh refinery asphalt is around 1.026.
- Almost as same as specific gravity for fine aggregate.
- Purpose of specific gravity test of asphalt is to determine:
  - Air void in HMA.
  - Target density for compaction operations.
  - Amount of bitumen absorbed due to porosity of the individual aggregate particles.
- If the percent air voids are too low, rutting and shoving of the pavement can occur.
- If the percentage of air voids is too high, the pavement can be subject to moisture damage, exhibit decreased strength and have a shorter fatigue life when compared to correct air void percentages.

- Calculate the specific gravity to the nearest 0.001 as follows:

$$\gamma_a = \frac{C - A}{(B - A) - (D - C)}$$

Where:

γ_a = Specific Gravity of asphalt.

A = Weight of pycnometer plus stopper.

B = Weight of pycnometer filled with water.

C = Weight of pycnometer partially filled with asphalt, and

D = Weight of pycnometer plus asphalt plus water.

- Calculate density to the nearest 0.001 as follows:

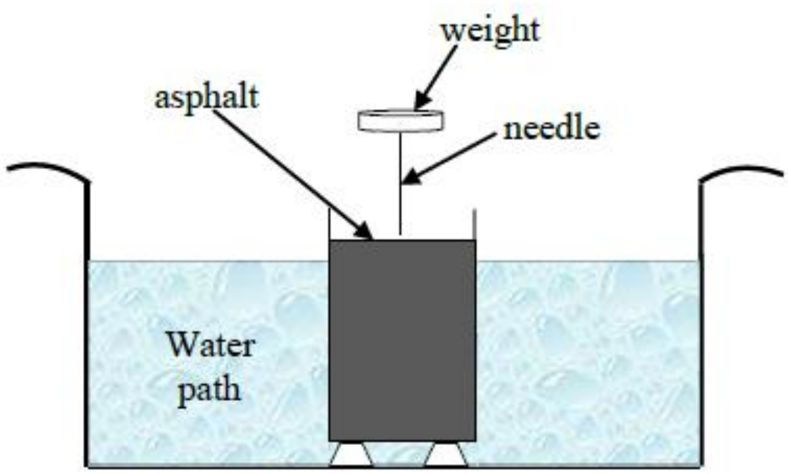
$$\rho = \gamma_a \times \rho w$$

Where: ρw = Density of water at test temperature 25°C = 0.9971 g/cm3

Penetration Test

- Consistency tests:
  - @ Normal and cold temperature, use penetration test.
  - @ Hot temperature, use viscosity test.
  - @ Warm temperature, use softening point.

- Penetration test involves a needle is typically loaded a weight and allowed to penetrate an asphalt cement sample for a period of time. Prior to conducting the test, the asphalt cement sample is brought to the testing temperature.



- The test is normally carried out at a temperature of 25°C with the total weight of the needle, spindle and added weights being 100 grams, the needle is released for a period of 5 seconds. If it is not possible to obtain these conditions or if there are special circumstances, one of the following alternative conditions may be used:

Temperature, °C	0 °C or 4 °C	25 °C	46.1 °C
Total sliding weights, gm	200 gm	100 gm	50 gm
Time, seconds	60 s	5 s	5 s

- Penetration is measured in 0.1 mm unit

  If the reading is 60, ➔ penetration is 6 mm.

- A harder asphalt cement will have a lower penetration while a softer asphalt cement with have a higher penetration.
- he maximum difference between highest and lowest readings shall be:

Penetration (d-mm)	0 – 49	50 – 149	150 – 249	250 – 500
Maximum Difference	2	4	12	20

- If the differences exceed the above values, the results are ignored, and the test must be repeated on the second sample. If the differences are again exceeded by the second sample, the results must be ignored, and the test completely repeated.
- Typical penetration grades are expressed as a classification in the form of PG grade, PG (minimum boundary – maximum boundary).

Sample results:

<table>
<tr><th>Sample</th><th>Trial</th><th>Penetration</th><th>Difference between Max. and Min.</th><th>Acceptable?</th><th>Average</th></tr>
<tr><td rowspan="3">1</td><td>1</td><td>79</td><td rowspan="3">79 – 74 = 5</td><td rowspan="3">5 > 4 ➔ No</td><td rowspan="3"></td></tr>
<tr><td>2</td><td>76</td></tr>
<tr><td>3</td><td>74</td></tr>
<tr><td rowspan="3">2</td><td>1</td><td>84</td><td rowspan="3">84 – 82 = 2</td><td rowspan="3">2 < 4 ➔ Yes</td><td rowspan="3">83</td></tr>
<tr><td>2</td><td>82</td></tr>
<tr><td>3</td><td>83</td></tr>
</table>

➔ the penetration grade is PG (80 – 90)

- If penetration is measured over a range of temperatures, the temperature susceptibility of the bitumen can be established.
- A Penetration Index (PI) has been defined for which the temperature susceptibility would assume a value of zero for road bitumen, as given by:

$$PI = \frac{20(1 - 25A)}{1 + 50A}$$

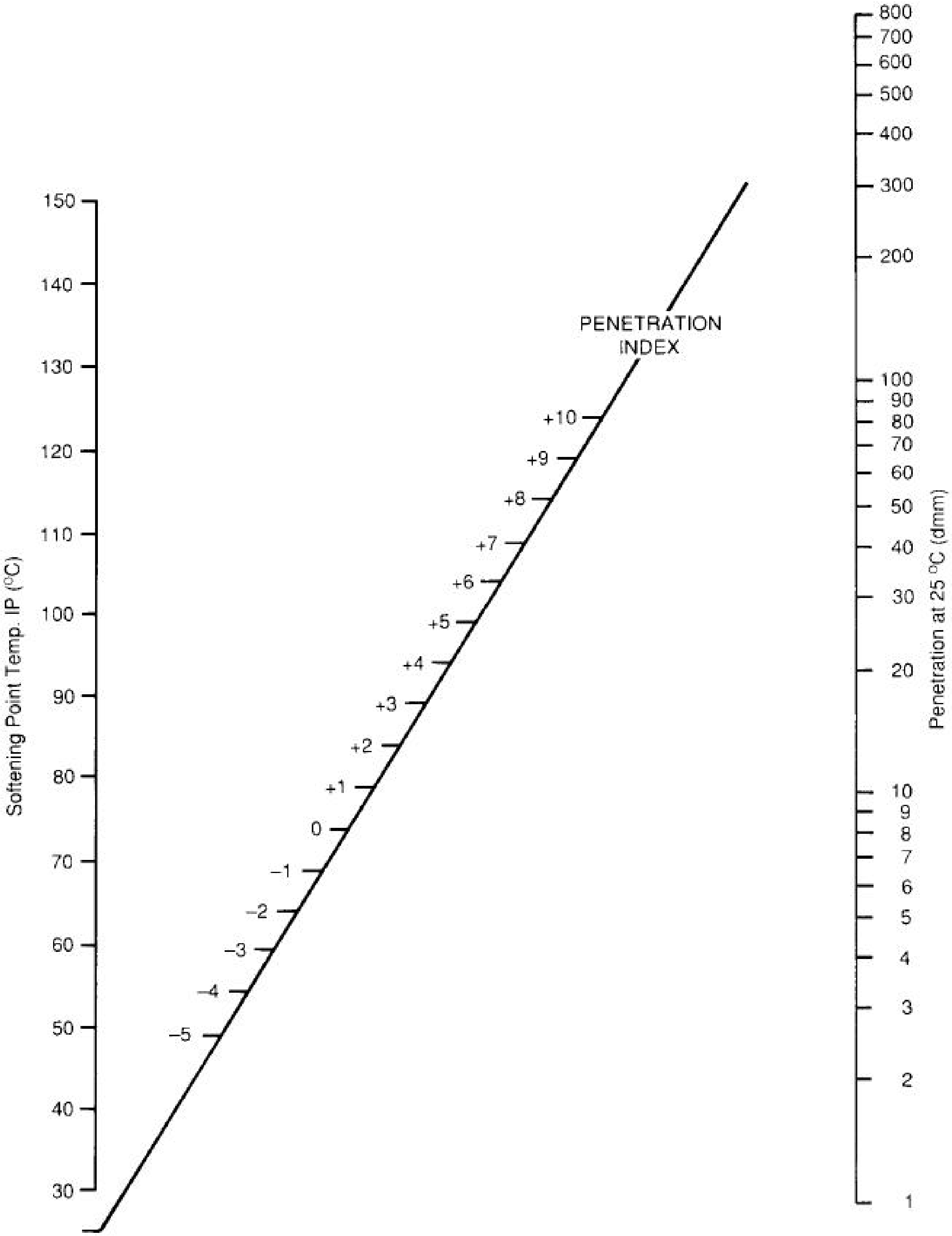
- The value of A (and PI) can be derived from penetration measurements at two temperatures, T_1 and T_2, using the equation:

$$A = \frac{\log(pen\ @T_1) - \log(pen\ @T_2)}{T_1 - T_2}$$

- the Ring-and-Ball Softening Point temperature is the same as that which would give a penetration of 800 d-mm. This, together with the penetration at 25 oC, can be used to compute A where:

$$A = \frac{\log(pen\ @25°C) - \log 800}{25 - Softening\ Point}$$

- The nomograph as given in Figure below enables the PI to be deduced approximately from the penetration at 25 ^{o}C and the softening point temperature.



Softening Point Temp. IP (°C)
150
140
130
120
110
100
90
80
70
60
50
40
30
PENETRATION
INDEX
+10
+9
+8
+7
+6
+5
+4
+3
+2
+1
0
−1
−2
−3
−4
−5
Penetration at 25 °C (dmm)
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1