Bituminous Materials are used for highway construction because:

1. Excellent binding & cementing power.
2. Water-proofing properties.
3. Relatively low cost.

Bitumen: Black or dark colored solid or viscous cementious substances composed of high molecular weight hydrocarbons.

Bitumen is soluble in carbon disulfide.
### Bituminous Materials Categories

<table>
<thead>
<tr>
<th>ASPHALT</th>
<th>TARS</th>
</tr>
</thead>
</table>
| ● Residue of petroleum (Separated by fractional distillation) or as native asphalt  
● Used extensively as binders for highways  
● Dissolve in petroleum oils  
● Black color  
● More resistance to weathering  
● Less susceptible to temp.  
● Has no odor  
● Used in highways & airports | ● Residues from the destructive distillation (chemical change) of organic substances such as coal, wood, or petroleum  
● Crude tars must undergo further refinement to become road tars  
● Do not dissolve in petroleum oils, therefore it is used to seat asphalt concrete surfaces to improve oil resistance of asphalt surfaces  
● Brown or Black color  
● Used in airport, auto parking, fueling areas.  
● More expensive |
Asphalts are the residue, byproducts of the refinery of petroleum oils.

Depending on the sources & characteristics of the crude oils & on properties of asphalt required more than one processing method may be employed.

Consistency can be controlled by the amount of heavy gas oil removed.

Consistency can be further modified by air blowing.

Air blowing is used to increase viscosity of asphalt residue.

Air blowing = Oxidation (i.e. air and high temp.)
OIL WELL
FIELD STORAGE
PUMPING STATION
TOWER DISTILLATION
STORAGE
TUBE HEATER
CONDENSERS AND COOLERS
RESIDUUM
PROCESS
PROPERTY
LIGHT DISTILLATE
MEDIUM DISTILLATE
HEAVY DISTILLATE
PROCESSING
GASOLINE
LIGHT SOLVENTS
KEROSENE
LIGHT BURNER OIL
DIESEL OIL
LUBRICATING OILS
SLOW CURING CUTBACK ASPHALTS AND ROAD OILS (MAY ALSO BE PREPARED BY DIRECT DISTILLATION)
MEDIUM CURING CUTBACK ASPHALTS
RAPID CURING CUTBACK ASPHALTS
EMULSIFIED ASPHALTS
EMULSIFIED PLANT
BLENDER
BLENDER
BLENDER
WATER
PETROLEUM
SAND AND WATER
GAS
Refinery Operation

- Field Storage
- Pumping Station
- Light Distillate
- Heavy Distillate
- Process Unit
- Asphalt Cements
- Residuum
- Medium Distillate
- Gas
- Storage
- Tube Heater
- Condensers and Coolers
- Sand and Water
- Petroleum
- Air Blown Asphalt
- Air
- Still
- For Processing Into Emulsified and Cutback Asphalts
Asphalt cement is semisolid at room or normal temperature (stiff).

To make asphalt workable (soften) it should be heated.

Softening by heating is not feasible in all cases.

In order to attain workable asphalt cement at ambient temp. they must be liquefied.

Asphalt is liquefied by two methods:
1. Dissolve (Cut) the asphalt in solvent.
2. Emulsify asphalt in water.
Asphalt Cement Components

- **Asphaltenes**
  - Large, discrete solid inclusions (black)
  - High viscosity component

- **Resins**
  - Semi-solid or solid at room temperature
  - Fluid when heated
  - Brittle when cold

- **Oils**
  - Colorless liquid
  - Soluble in most solvents
  - Allows asphalt to flow
Cutback Asphalt

- Asphalts are mixed with volatile solvents.
- **Cutback asphalt = AC + Petroleum solvent**
- After cutback asphalt is exposed to air, the volatile solvent evaporates, and asphalt regains its original characteristics.
- Rate of curing can vary depending on the volatility of the solvent used (few minutes to several days):
  1. Rapid-curing (RC): gasoline or naphtha.
  2. Medium-curing (MC): Kerosene
  3. Slow-curing (SC): Road oil
Cutback Asphalts

RAPID CURING (RC)
85-100pen+gasoline
ASPHALT + NAPHTHA
SURFACE TREATMENT
ROAD MIX (FB-1, FB-2)

MEDIUM CURING (MC)
120-150pen
ASPHALT + KEROSENE
STOCKPILE PATCH
Road Mixing

SLOW CURING (SC) (Road Oil)
200-300pen+diesel
ASPHALT + OIL
Prime Coat
Dust Control

30% solvent
 RC - 30
 RC - 70
 RC - 250

10% solvent
 RC - 800

AASHTO M81
AASHTO M82
ASTM D2026

Grades based on min. Kinematic Viscosity @ 60C (cSt)

\[ \nu = k \times t \text{ (sec)} \]

\[ \text{stoke} = St = \text{cm}^2/\text{sec} \]
Composition of Cutback Asphalts

<table>
<thead>
<tr>
<th>GRADE</th>
<th>30% solvent</th>
<th>10% solvent</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAPTHA FOR RC</td>
<td>15-30</td>
<td>35-70</td>
</tr>
<tr>
<td>KEROSENE FOR MC</td>
<td>30-60</td>
<td>70-140</td>
</tr>
<tr>
<td>LIGHT OIL FOR SC</td>
<td>250-500</td>
<td>800-1600</td>
</tr>
<tr>
<td>ASPHALT CEMENT</td>
<td>1000-3000</td>
<td>3000-6000</td>
</tr>
</tbody>
</table>

APPRX. FUROL VIS., 140°F, SEC.
APPROX. KINEMATIC VIS. 140°F, CS
Cutback Asphalts used less frequently now

use of emulsions becoming more common.

1. Env. Concerns (especially with RC's)
   Hydrocarbons evaporate into air.

2. Economic - costly to buy 2 petroleum products.


4. Higher application temp, dry conditions required
Emulsified Asphalts

- It’s a mixture of asphalt cement, water, and emulsifying agent (1-2% by volume).
- Emulsifying agents place electrical charge around each droplet of asphalt.
- Negative (Anionic).
- Positive (Cationic).
- Since like electrical charges repel, asphalt droplets stay suspended in water.
- The emulsion stay in this stable situation until disturbed by:
  1. Mixing with aggregates.
  2. Evaporation of water.
Emulsions

- When used (i.e. exposed to air), it sets or breaks.
- Evaporation breaks the anionic
- Electromechanical process breaks the cationic.
- Emulsions are graded based on the rate of setting:
  1. Rapid Setting (RS)
  2. Medium Setting (MS)
  3. Slow setting (SS)
- Anionic emulsions use RS, MS, SS
- Cationic emulsions use CRS, CMS, CSS
EMULSIONS

ASPHALT
+ WATER
+ EMULSIFIER

ANIONIC
(-)
ALKALINE

CATIONIC
(+)
ACID

LIMESTONE

SILICA
(Sil. Gravel)
Emulsions

- **RAPID SETTING (RS)**
  - Tack Coat
  - Surface Treatment (spray applications)

- **MEDIUM SETTING (MS)**
  - Road Mix (open-graded)

- **SLOW SETTING (SS)**
  - Road Mix (dense)
  - Slurry Seals
  - Tack Coat
  - Fog Seal

Weaker surface charge
# Emulsion Grades

<table>
<thead>
<tr>
<th>ANIONIC</th>
<th>AASHTO M140</th>
<th>ASTM D977</th>
<th>CATIONIC</th>
<th>AASHTO M208</th>
<th>ASTM D2397</th>
</tr>
</thead>
<tbody>
<tr>
<td>RS</td>
<td>RS-1</td>
<td>RS-2 (more viscous, more asph.)</td>
<td>CRS - 1</td>
<td>more asph than CRS - 2</td>
<td>anionic</td>
</tr>
<tr>
<td>MS</td>
<td>MS-1</td>
<td>MS-2</td>
<td>MS-2h</td>
<td>CMS-2</td>
<td>CMS-2h</td>
</tr>
<tr>
<td>SS</td>
<td>SS-1</td>
<td>SS-1h</td>
<td></td>
<td>CSS-1</td>
<td>CSS-1h</td>
</tr>
</tbody>
</table>

"h" = harder AC (40-90 pen)  
[usually 100-200 pen]

*high float emulsions - test to measure property of emulsion residue
Advantages of Emulsions

- Pollution free (i.e. no solvents required).
- Used with no additional heat.
- Less cost than cutback.
- More energy efficient than cutback.
Bitumen Laboratory tests

I- Purity Tests:
1. Solubility test.
2. Presence of water.

II- Consistency Tests:
1. Kinematic and Absolute viscosity.
2. Penetration.
3. Softening Point.
4. Ductility.

III- Volatility & Aging Tests:
1. Distillation.
2. Loss on heating
3. Thin film oven test
4. Flash point
Purity Tests/ Solubility

- Measures the purity of asphalt
- 2 g of AC dissolved in 100 ml of trichloroethylene and filtered through a fiberglass filter pad.
- Amount of material retained on the filter is weighed and expressed as % of original sample.
- Spec. + 99% pure.
Solubility Test
Water present in asphalt cause asphalt to foam when heated above 100 C.

AASHTO specifies that AC should be homogeneous, free from water, and shall not foam when heated to 175 C.
**Consistency Tests/ Viscosity**

- **Viscosity**: the ratio between the applied shear stress and the rate of shear.
- **Viscosity**: Resistance of a fluid to flow.

<table>
<thead>
<tr>
<th>Absolute</th>
<th>Kinematic</th>
</tr>
</thead>
<tbody>
<tr>
<td>- U-shaped tube with timing marks &amp; filled with asphalt</td>
<td>- Cross arm tube with timing marks &amp; filled with asphalt</td>
</tr>
<tr>
<td>- Placed in 60°C bath</td>
<td>- Placed in 135°C bath</td>
</tr>
<tr>
<td>- Vacuum used to pull asphalt through tube</td>
<td>- Once started gravity moves asphalt through tube</td>
</tr>
<tr>
<td>- Time to pass marks</td>
<td>- Time to pass marks</td>
</tr>
<tr>
<td>- Visc. in Pa s (Poise)</td>
<td>- Visc. in mm² / s (centistoke)</td>
</tr>
<tr>
<td></td>
<td>- = Absolute/ density</td>
</tr>
</tbody>
</table>
Viscosity Tubes

Asphalt Institute Tube

Zietfuchs Cross-Arm Tube
<table>
<thead>
<tr>
<th>Viscosity Grades for AC</th>
<th>Viscosity of normal AC based on 60c in poises</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC 2.5</td>
<td>250+/- 50</td>
</tr>
<tr>
<td>AC 5</td>
<td>500 +/- 50</td>
</tr>
<tr>
<td>AC 10</td>
<td>1000 +/- 200</td>
</tr>
<tr>
<td>AC 20</td>
<td>2000 +/- 400</td>
</tr>
<tr>
<td>AC 30</td>
<td>3000 +/- 600</td>
</tr>
<tr>
<td>AC 40</td>
<td>4000 +/- 800</td>
</tr>
</tbody>
</table>
The distance in hundredths of centimeters (or tenths of mm) to which a standard needle penetrates the material under known conditions of time, loading, and temp. (25)

Penetration grades: (40-50) (60-70) (85-100) (120-150) and (200-300)
Consistency/ Softening Point

- Ring and Ball method
- Sample melted into a brass ring.
- Ring suspended in water bath.
- Steel balls placed on surface of bitumen in the ring.
- Elevate temp. at constant rate.
- The temp. at which balls touches the bottom of the ring after falling down a distance of 1 inch is reported.
Consistency Tests/ Ductility

- Property of material that permits it to elongate (undergo great deformation) without breaking.
- Ductility: Distance in centimeters to which a standard sample may elongate without breaking.
- 25 c, 5 cm/min,
- Spec. +100 cm
Ductelometer
Distillation: Used to separate volatile from nonvolatile substances.

Distillation used in Cutback asphalt

Loss on heating: determine % of volatile material.

50 g in container put in oven @ 163 c for 5 hrs, then find loss in wt.
Volatile Tests/ Thin Film Oven Test

- Excessive high temp. during plant mixing will harden the mixture (i.e. age it) and reduce pavement life.
- In measuring hardening, penetration is conducted before & after aging.
- 50 cm³ poured in pan (bottle) for thin film thickness.
- Place in ventilated oven @163 c and rotated at specified rate for 5hrs.
- Penetration is found for aged samples.
- Calculate % penetration.
Thin Film Oven

Outside of Oven

Pan

Rotating Shelf

Thermometer
Known as safety test.
Cleveland Open cup.
AC heated at specified rate.
Flames pass across the surface.
Min temp. at which sparks appear on the AC surface is reported as flash point.
Flash Point (Safety)

Thermometer

Cup filled with asphalt

Wand attached to gas line
Classification of Bituminous Materials

- Penetration Specification
  - Five Grades
    - 40 - 50
    - 60 - 70
    - 85 - 100
    - 120 - 150
    - 200 - 300
## Classification of Bituminous Materials

### Viscosity of Original AC Specification

<table>
<thead>
<tr>
<th>AC grade</th>
<th>Viscosity (poise)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC 2.5</td>
<td>250 ± 50</td>
</tr>
<tr>
<td>AC 5</td>
<td>500 ± 100</td>
</tr>
<tr>
<td>AC 10</td>
<td>1000 ± 200</td>
</tr>
<tr>
<td>AC 20</td>
<td>2000 ± 400</td>
</tr>
<tr>
<td>AC 30</td>
<td>3000 ± 600</td>
</tr>
<tr>
<td>AC 40</td>
<td>4000 ± 800</td>
</tr>
</tbody>
</table>
## Classification of Bituminous Materials

### Viscosity of Reclaimed AC Specification

<table>
<thead>
<tr>
<th>AR grade</th>
<th>Viscosity (poise)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR 10</td>
<td>1000 ± 250</td>
</tr>
<tr>
<td>AR 20</td>
<td>2000 ± 500</td>
</tr>
<tr>
<td>AR 40</td>
<td>4000 ± 1000</td>
</tr>
<tr>
<td>AR 80</td>
<td>8000 ± 2000</td>
</tr>
<tr>
<td>AR 160</td>
<td>16000 ± 4000</td>
</tr>
</tbody>
</table>
Rotational Viscometer

AASHTO TP 48 and ASTM D 4402: Viscosity Determination of Asphalt Binder Using Rotational Viscometer
Mixing/Compaction Temps.

Mixing viscosity range (170 ± 20 CSt)
Compaction viscosity range (280 ± 30 CSt).