Introduction

Bituminous materials are widely used all over the world in highway construction. These hydrocarbons are found in natural deposits or are obtained as a product of the distillation of crude petroleum. The bituminous materials used in highway construction are either asphalts or tars.

Bitumen

Mixture of hydrocarbons compound may contain some nonmetal derivatives, it is liquid, semisolid or solid and it is completely soluble in carbons disulfide.

The terms asphalt and bitumen are often used interchangeably to mean both natural and manufactured forms of the substance. In North America, bitumen is commonly known as “asphalt cement” or “asphalt”. While elsewhere, “asphalt” is the term used for a mixture of small stones, sand, filler and bitumen, which is used as a road paving material. Approximately 85% of all the bitumen produced is used as the binder in asphalt for roads. It is also used in other paved areas such as airport runways, car parks and footways.

All bituminous materials consist primarily of bitumen (called also asphalt) and have strong adhesive properties (therefore acts as cementations material) with colours ranging from dark brown to black. They vary in consistency from liquid to solid; thus, they are divided into liquids, semisolids, and solids. The solid form is usually hard and brittle at normal temperatures but will flow when subjected to long, continuous loading.

SOURCES OF ASPHALT

Asphalt is found in natural deposits in different parts of the world or as a product of the distillation of crude petroleum.
1. Natural Deposits

Natural deposits of asphalt occur as either native asphalt (e.g. lake asphalt) or rock asphalt. The largest deposit of native asphalt is known to have existed in Iraq several thousand years ago.

Natural deposits can be classified into:

A- Native asphalt was at one time used extensively as binders in highway construction. The properties of native asphalt vary from one deposit to another; particularly with respect to the amount of insoluble material the asphalt contains, its vary from 6-40 % insoluble material.

B- Rock asphalt is a natural deposit of sandstone or limestone rocks filled with asphalt. The amount of asphalt varies from one deposit to another and can be as low as 4.5 percent and as high as 18 percent.

2. Artificial Asphalts (Petroleum Asphalt)

The asphalt materials obtained from the distillation of petroleum are in the form of different types of asphalts, which include asphalt cements, slow-curing liquid asphalts, medium-curing liquid asphalts, rapid-curing liquid asphalts, and asphalt emulsions.

Production of Asphalt (petroleum Asphalt)

Petroleum Asphalt is produced from the refinery process of Petroleum.

The refining processes used to obtain petroleum asphalts can be divided into two main groups:

1. Fractional distillation: The fractional distillation processes involve the separation of the different materials in the crude petroleum without significant changes in the chemical composition of each material. The resulted asphalt may be called crude petroleum asphalt.

2. Destructive distillation (cracking). The destructive distillation processes involve the application of high temperature and pressure, resulting in chemical changes. The resulted asphalt may be called cracked asphalt.
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<th>Fractional Distillation.</th>
<th>Destructive distillation (cracking)</th>
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<td>1- Produce crude petroleum asphalt.</td>
<td>1- Produce cracked asphalt.</td>
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<tr>
<td>2- No significant changes in the chemical composition of each material.</td>
<td>2- High temperature and pressure, resulting in chemical changes.</td>
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<td>3- Steam or a vacuum is used to gradually increase the temperature.</td>
<td>3- Intense heat and high pressures are applied.</td>
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<td>4- The products obtained during this first phase of separation are gasoline, kerosene</td>
<td>4- The products are larger amounts of the light fractions of materials (such as motor fuels).</td>
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<td>distillate, diesel fuel, lubricating oils, and the heavy residual material that</td>
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<td>contains the asphalt.</td>
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<td>5- Further processing of the heavy residue obtained after the first separation will</td>
<td>5- The asphalt obtained from cracking is not used widely in paving, because it is more susceptible</td>
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<td>give asphalt cement of different penetration grades depending on the additional</td>
<td>to weather changes than that produced from fractional distillation.</td>
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<td>processing carried out. Emulsified asphalts also can be obtained.</td>
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Figure 1. A Schematic Example of a Petroleum Distilling Plant
Figure 2. A Schematic for the output of the furnace in refining process

Figure 3. The production of refinery process
BITUMINOUS MATERIALS TYPES

Bituminous binders can be classified into three general groups: asphalt cement, asphalt cutbacks, and emulsified asphalt. Blown asphalt and road tars are also other types of bituminous material that now are not used commonly in highway construction.

1. Asphalt Cements

Asphalt cements are obtained after separation of the lubricating oils. They are semisolid hydrocarbons with certain physiochemical characteristics that make them good cementing agents. They are also very viscous, and when used as a binder for aggregates in pavement construction, it is necessary to heat both the aggregates and the asphalt cement prior to mixing the two materials. The particular grade of asphalt cement has been designated by its penetration and viscosity. Asphalt cements are used mainly in the manufacture of hot-mix and in a variety of ways, including the construction of highways and airport pavement surfaces and bases, parking areas, and industrial floors. The specific use of a given sample depends on its grade.

2. Asphalt Cutbacks

The asphalt cutbacks are slow-curing asphalts, medium-curing cutback asphalts, and rapid-curing cutback asphalts. They are used mainly in cold-laid plant mixes, road mixes (mixed-in-place), and as surface treatments.

Rapid-Curing Asphalt (tack coat); Rc, Produced by blending asphalt cement with an oil distillate that will easily evaporate, thereby facilitating a quick change from the liquid form at time of application to the consistency of original asphalt. – Gasoline or naphtha is used as the solvent. Specifications for the use of these asphalts are given in AASHTO.

Medium-Curing Asphalt (prime coat); Mc, Produced by fluxing or cutting the residual asphalt (120-150 penetration) with light fuel oil or kerosene (harden faster than Sc and similar in consistencies). The fluidity of Mc depends on the amount of solvent in material.

Mc-3000 (20% solvent) and Mc-70 (45% solvent).

Slow-Curing Asphalts; Sc, Can be obtained directly as slow-curing straight run asphalts through the distillation of crude oil by cutting back asphalt cement with a
heavy distillate such as oil (lower viscosity than asphalt and very slow to harden). Slow-curing asphalts usually are designated as SC-70, SC-250, SC-800, or SC-3000. Where, the numbers relate to the approximate kinematic viscosity in centistokes at 60 C°. Specifications for the use of these asphalts are no longer included in AASHTO.

A prime coat is an application of low viscosity asphalt to a granular base in preparation for an asphalt surface course. It is usually a light grade of medium curing cutback.

• To coat and bond loose material particles on the surface of the base.
• To harden or toughen the base surface to provide a work platform for construction equipment
• To plug capillary voids in the base course surface to prevent migration of moisture.
• To provide adhesion between the base course and the succeeding course

A tack coat is a thin bituminous liquid asphalt, emulsion or cutback layer applied between HMA pavement lifts to promote bonding. Adequate bonding between constructions lifts and especially between the existing road surface and an overlay is critical in order for the completed pavement structure to behave as a single unit and provide adequate strength.

3. Emulsified Asphalts

Emulsified asphalts are produced by breaking asphalt cement, usually of 100 to 250 penetration range, into minute particles and dispersing them in water with an emulsifier. They remain in suspension in the liquid phase as long as the water does not evaporate or the emulsifier does not break. Asphalt emulsions therefore consist of asphalt, which makes up about 55 to 70 percent by weight, water, and an emulsifying agent. Emulsified asphalts are used in cold-laid plant mixes and road mixes (mixed in place) for several purposes, including the construction of highway pavement.

4. Blown Asphalts

Blown asphalt is obtained by blowing air through the semisolid residue obtained during the latter stages of the distillation process. Blown asphalt generally is not used as a paving material. However, it is very useful as a roofing material, for automobile undercoating, and as a joint filler for concrete pavement.
5. Road Tars

Tars are obtained from the destructive distillation of such organic materials as coal. Their properties are significantly different from petroleum asphalts. In general, they are more susceptible to weather conditions than similar grades of asphalts, and they are rarely used for highway pavements. They are classified into three general categories based on the method of production.

- Gashouse coal tars
- Coke-oven tars.
- Water-gas tars.

**PROPERTIES OF ASPHALT MATERIALS**

The properties of asphalt materials used for pavement construction can be classified into four main categories:

1. Consistency
2. Aging and temperature sustainability
3. Rate of curing
4. Resistance to water action

1. Consistency

The consistency properties of an asphalt material usually are considered under two conditions: (1) variation of consistency with temperature and (2) consistency at a specified temperature.

*Variation of Consistency with Temperature*

The consistency of any asphalt material changes as the temperature varies.

*Consistency at a Specified Temperature*

For different types of asphalt and under specific temperature, the consistency may be differed according to type of asphalt.

2. Aging and Temperature Sustainability

When asphaltic materials are exposed to environmental elements, natural deterioration (change in state) gradually takes place, and the materials eventually lose their plasticity.
and become brittle. This change is caused primarily by chemical and physical reactions that take place in the material. This natural deterioration of the asphalt material is known as weathering. The ability of an asphalt material to resist weathering is described as the durability of the material.

Factors affect weathering

Oxidation:

Oxidation is the chemical reaction that takes place when the asphalt material is attacked by oxygen in the air. This chemical reaction causes gradual hardening (eventually permanent hardening) and considerable loss of the plastic characteristics of the material.

Volatilization:

Volatilization is the evaporation of the lighter hydrocarbons from the asphalt material. The loss of these lighter hydrocarbons also causes the loss of the plastic characteristics of the asphalt material.

Temperature:

It has been shown that temperature has a significant effect on the rate of oxidation and volatilization. The higher the temperature, the higher the rates of oxidation and volatilization.

Surface area:

The exposed surface of the material influences the rate of oxidation and volatilization. There is a direct relationship between surface area and rate of oxygen absorption and loss due to evaporation in grams/cm3/minute. This fact is taken into consideration when asphalt concrete mixes are designed for pavement construction, in that the air voids are kept to the practicable minimum required for stability to reduce the area exposed to oxidation.
3. Rate of curing

Curing is defined as the process through which an asphalt material increases its consistency as it loses solvent by evaporation.

Factors affect curing

- Volatility of the solvent
- Quantity of solvent in the cutback
- Consistency of the base material
- Temperature
- Ratio of surface area to volume
- Wind velocity across exposed surface

4. Resistance to water action

When asphalt materials are used in pavement construction, it is important that the asphalt continues to adhere to the aggregates even with the presence of water. If this bond between the asphalt and the aggregates is lost, the asphalt will strip from the aggregates, resulting in the deterioration of the pavement. The asphalt therefore must sustain its ability to adhere to the aggregates even in the presence of water.