Chapter 2
Asphalt and Asphalt Paving Materials

ASPHALT DEFINED

The black cementing agent known as asphalt has been used for road construction for centuries. Although there are natural deposits of asphalt, or rock asphalt, most used today is produced by the oil refining industry. Asphalt is a constituent of most petroleums and is isolated through the refining process of distillation. (See Figure 2-1.)

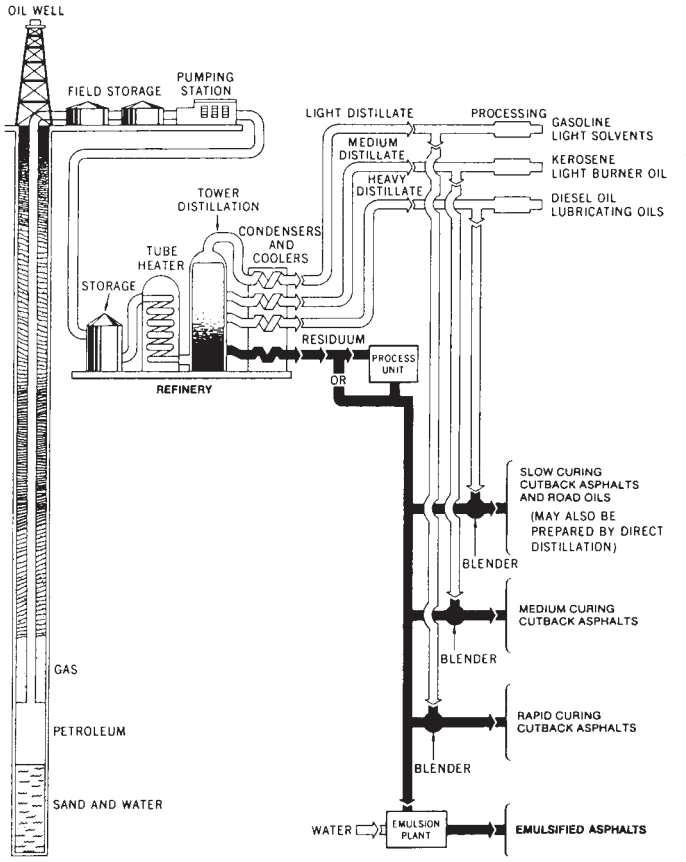

Figure 2-1. *Petroleum Asphalt Flow Chart for Emulsified and Cutback Asphalts.*

Asphalt is called a bituminous material because it contains bitumen, a hydrocarbon material soluble in carbon disulfate. The tar obtained from the destructive distillation of soft coal also contains bitumen. Both petroleum asphalt and coal tar are referred to as bituminous materials. However, because their properties differ greatly, petroleum asphalt should not be confused with coal tar. Whereas petroleum asphalt is composed almost entirely of bitumen, the bitumen content in coal tar is relatively low. The two materials should be treated as separate entities.

One of the characteristics and advantages of asphalt as an engineering construction and maintenance material is its great versatility. Although a semi-solid at ordinary temperatures, asphalt may be liquified by applying heat, dissolving it in solvents, or emulsifying it. Asphalt is a strong cement that is readily adhesive and highly waterproof and durable, making it particularly useful in road building. It is also highly resistive to the actions of most acids, alkalis, and salts.

Covering more than 90 percent of the nation's paved highways, Asphalt Concrete is the most widely used paving material in the United States. For versatility, durability, and ease of construction, it has no equal.

AGGREGATES

Aggregates (or mineral aggregates) are hard, inert materials such as sand, gravel, crushed stone, slag, or rock dust. Properly selected and graded aggregates are mixed with the cementing medium asphalt to form pavements. Aggregates are the principal load-supporting components of an Asphalt Concrete pavement. They total 90 to 95 percent of the mixture by weight and 75 to 85 percent by volume.

Classifications

Asphalt Concrete paving aggregates are classified according to source or means of preparation. A brief description of the classifications follows.

Pit or Bank-Run Aggregates

Both gravel and sand are typically pit or bank-run natural aggregates. They usually are screened to proper size and washed to remove dirt before being used for Asphalt Concrete paving purposes.

Processed Aggregates

When natural pit or bank-run aggregate has been crushed and screened to make it suitable for Asphalt Concrete pavements, it is considered a processed aggregate. Crushing typically improves the particle shape by making the rounded particles more angular. Crushing also improves the size distribution and range.

Crushed stone is also a processed aggregate. It is created when the fragments of bedrock and large stones are crushed so that all particle faces are fractured. Variation in size of particles is achieved by screening. Aggregates that have received little or no screening are known as crusher run. These aggregates are generally more economical than screened aggregates and can be used in Asphalt Concrete pavements in many instances.

In the processing of crushed limestone, the rock dust produced is separated from the other crushed aggregate and may be used as crushed sand or as a mineral filler in Asphalt Concrete pavements.

Synthetic Aggregates

Aggregates produced by altering both physical and chemical properties of a parent material are called synthetic or artificial aggregates. Some are produced and processed specifically for use as aggregates; others are the byproduct of manufacturing and a final burning process. Blast furnace slag is an example of a synthetic aggregate.

Desirable Properties of Aggregates

Selection of an aggregate material for use in an Asphalt Concrete pavement depends on the availability, cost, and quality of the material, as well as the type of construction for which it is intended. To determine if an aggregate material is suitable for use in asphalt construction, evaluate it in terms of the following properties:

1. Size and grading. The maximum size of an aggregate is the smallest sieve through which 100 percent of the material will pass. How the Asphalt Concrete is to be used determines not only the maximum aggregate size, but also the desired gradation (distribution of sizes smaller than the maximum).

2. Cleanliness. Foreign or deleterious substances make some materials unsuitable for paving mixtures.

3. Toughness. Toughness or hardness is the ability of the aggregate to resist crushing or disintegration during mixing, placing, and compacting; or under traffic loading.

4. Soundness. Although similar to toughness, soundness is the aggregate's ability to resist deterioration caused by natural elements such as the weather.

5. Particle shape. The shapes of aggregate particles influence the asphalt mixture's overall strength and workability as well as the density achieved during compaction. When compacted, irregular particles such as crushed stone tend to "lock" together and resist displacement.

6. Surface texture. Workability and pavement strength are influenced by surface texture. A rough, sandpapery texture results in a higher strength than a smooth texture. Although smooth-faced aggregates are easy to coat with an asphalt film, they are generally not as good as rough surfaces. It is harder for the asphalt to "grip" the smooth surface.

7. Absorption. The porosity of an aggregate permits the aggregate to absorb asphalt and form a bond between the particle and the asphalt. A degree of porosity is desired, but aggregates that are highly absorbant are generally not used.

8. Stripping. When the asphalt film separates from the aggregate because of the action of water, it is called stripping. Aggregates coated with too much dust also can cause poor bonding which results in stripping. Aggregates readily susceptible to stripping action usually are not suitable for asphalt

paving mixes unless an anti-stripping agent is used.

ASPHALT CEMENT

Asphalt is produced in a variety of types and grades ranging from hard-brittle solids to near water-thin liquids. The semi-solid form known as asphalt cement is the basic material used in Asphalt Concrete pavements. Liquid asphalt is produced when asphalt cement is blended or "cut back" with petroleum distillates or emulsified with water and an emulsifying agent. Liquid asphalt products may be produced for various uses and applications.

Some of the types and characteristics of asphalt are noted in the following table.

Table 2-1. Asphalt Types, Characteristics and General Uses

ASPHALT BINDER	TYPE OF CORRIDOR	LOCATION	TYPE OF MIX
PG 70-22	Heavy Duty Class V-VI	Full Depth Asphalt	Surface Mixture (sp125 or SMA) and first underlying lifts
PG 64-22			Remaining lifts
PG 70-22		Asphalt Overlays	All Mixtures
PG 64-22	Medium Duty Class III-IV	Full Depth and Overlays	All Mixtures
PG 64-22	Light Duty Class I-II	Full Depth and Overlays	All Mixtures

Type/Grade*	Percent Asphalt (Min)	Types-Percent Cutback	Penetration (Min-Max)	Flash Point (Min)	Applic. Temp.	General Uses
SS- 1	57	Water 43	100-200	↑	70- 160	Tack
SS-1 H	57	Water 43	40-90	↑	70- 160	Tack, Slurry Surface Treatment
CSS- 1	57	Water 43	100-250	↑	70- 160	Tack
CSS-1 H	57	Water 43	40-90	Boils Over at 180°F	70-160	Tack, Slurry Surface Treatment
RS-1	55	Water 45	100-200		70-140	Bituminous Seal Coat
RS-2	63	Water 37	100-200		125-185	Bituminous Seal Coat
CRS-1	60	Water 40	100-250		125-170	Bituminous Seal Coat
CRS-2	65	Water 35	100-250 viscosity	↓	125-170	Bituminous Seal Coat
RC-70	55	Naphtha 45	70-140	80°F		Tack
MC-30	55	Kerosene 45	120-250	100°F	70-150	Prime
MC-70	55	Kerosene 45	70-140	100°F	145-165	Bit. Seal Coat, Tack, Cold Mix, Patch Mix
MC-250	67	Kerosene 33	250-500	150°F	165-200	Bit. Seal Coat, Tack, Cold Mix, Patch Mix
MC-800	75	Kerosene 25	800-1600	150°F	175-255	Bit. Seal Coat, Tack, Cold Mix, Patch Mix
MC-3000	80	Kerosene 20	3000-6000	150°F	215-290	Bituminous Seal Coat

Note: Flashpoint does not necessarily indicate burning or explosive point. However, care should be exercised when heating all RC and MC asphalts because the cutback used reacts the same as gasoline. All material used as cold patch should be mixed at the lowest temperature possible to prevent loss of cutback causing the mixture to harden before use.

ASPHALT CONCRETE

Asphalt Concrete is known by many different names: hot mix asphalt, plant mix, bituminous mix, bituminous concrete, and many others. It is a combination of two primary ingredients - aggregates and asphalt cement. The aggregates total 90 to 95 percent of the total mixture by weight. They are mixed with 5 to 10 percent asphalt cement to form Asphalt Concrete.

The aggregates and asphalt are combined in an efficient manufacturing plant capable of

producing specified materials. Plant equipment includes: cold bins for storage of graded aggregate; a dryer for drying and heating aggregates to the required mixing temperature; a pug mill for combining the graded, heated aggregate and liquid asphalt cement according to specified mix formulas; and tanks for storing the liquid asphalt.

Asphalt Concrete is transported by truck to the paving site where it is spread to a uniform thickness with a mechanical paving or finishing machine. Then the material is compacted to the required degree by heavy, self-propelled rollers, producing a smooth, well-compacted pavement course.

The paving or finishing machine places the Asphalt Concrete at temperatures above 225° F. The material should be compacted before the mix temperature falls below 175° F to achieve adequate density.

COLD MIX ASPHALT CONCRETE

Cold mix Asphalt Concrete, or cold placed mixture, is generally a mix made with emulsified or cutback asphalt. Emulsified asphalts may be anionic or cationic MS or SS grades. Aggregate material may be anything from a dense-graded crushed aggregate to a granular soil having a relatively high percentage of dust. At the time of mixing, the aggregate may either be damp, air-dried, or artificially heated and dried.

Mixing methods may be performed either in the roadway, on the side of the roadway, or in a stationary mixing facility. The resultant mixtures usually are spread and compacted at atmospheric temperatures.

Cold mix asphalt may be used for surface, base, or subbase courses if the pavement is properly designed. Cold mix surface courses are suitable for light and medium traffic; however, they normally require a seal coat or hot Asphalt Concrete overlay as surface protection. When used in the base or subbase, they may be suitable for all types of traffic.

Bituminous Treated Aggregate Base

Bituminous treated aggregate base is one type of cold mix Asphalt Concrete. It can consist of processing gravels; crushed stones; or blends of gravel, sand, and crushed stone materials – each stabilized with a specified percentage of asphalt. Job mix formulas (mentioned in Chapter 3) are not required. These mixtures are placed as a base course and stabilized-shoulder surfacing, although other uses may be assigned by special design. All designs should provide for a seal coat or surface course to provide protection from traffic abrasion and weathering.

Table 2-2 acts as a guide to uses of asphalt in cold mixes.

For additional information on asphalt and asphalt paving materials, refer to The Asphalt Handbook. Other references are listed in Appendix D.

Table 2.2. General Uses of Emulsified Asphalt

	ASTM D2397 AASHTO M140								ASTM D2397 AASHTO M140					
Type of Construction	**RS-1**	**RS-2**	**MS-1, HFMS-1**	**MS-2, HFMS-2**	**MS-2h, HFMS-2h**	**HFMS-2s**	**SS-1**	**SS-1h**	**CRS-1**	**CRS-2**	**CMS-2**	**CMS-2h**	**CSS-1**	**CSS-1h**
Asphalt-aggregate mixtures:														
For pavement bases and surfaces:	....	....	....	....	X[A]	....	....	....	....	....	....	....	....	....
Plant mix (hot)														
Plant mix (cold)	....	....	....	X	X	....	....	....	....	....	X	X	....	....
Open-graded aggregate	....	....	....	....	....	X	X	X	....	....	....	....	X	X
Dense-graded aggregate	....	....	....	....	....	X	X	X	....	....	....	....	X	X
Sand														
Mixed-in-place:														
Open-graded aggregate	....	....	....	X	X	....	....	....	....	....	X	X	....	....
Dense-graded aggregate	....	....	....	....	....	X	X	X	....	....	....	....	X	X
Sand	....	....	....	....	....	X	X	X	....	....	....	....	X	X
Sandy soil	....	....	....	....	....	X	X	X	....	....	....	....	X	X
Slurry seal	....	....	....	....	....	X	X	X	....	....	....	....	X	X
Asphalt-aggregate applications:														
Treatment and seals:														
Single surface treatment (Chip Seal)	X	X	....	....	....	....	....	....	X	X	....	....	....	....
Multiple surface treatment	X	X	....	....	....	....	....	....	X	X	....	....	....	....
Sand seal	X	X	X	....	....	....	....	....	X	X	....	....	....	....
Asphalt applications:														
Fog seal	....	....	X[A]	....	....	....	X[B]	X[B]	....	....	....	....	X[B]	X[B]
Prime coat-penetrable surface	....	....	....	X[C]	....	....	X[C]	X[C]	....	....	....	....	X[C]	X[C]
Tack coat	....	....	X[A]	....	....	....	X[B]	X[B]	....	....	....	....	X[B]	X[B]
Dust binder	....	....	....	....	....	....	X[B]	X[B]	....	....	....	....	X[B]	X[B]
Mulch treatment	....	....	....	....	....	....	X[B]	X[B]	....	....	....	....	X[B]	X[B]
Crack filler	....	....	....	....	....	....	X	X	....	....	....	....	X	X
Maintenance mix:														
Immediate use	....	....	....	....	....	X	X	X	....	....	....	....	X	X

A Grade of emulsion other than FHMS-2h may be used where experience has shown that they give satisfactory performance

B Diluted with water by the manufacturer.

C Diluted with water

D Mixed in prime only.