Asphalt Paving Materials

by Thomas J. McLean, P.E.

Editor's note: The information below has been requested by many road agents around New Hampshire. It is one of the best short introductions to pavement materials we have come across and we are happy to bring it to you in this special report issue of* Road Business. *It has been edited and reprinted with permission from the Center for Local Government Technology, Oklahoma State University.

Asphalt is man's oldest engineering material. It was in use as an adhesive and waterproofing agent more than 5,000 years ago. Natural deposits of asphalt were used in ship building, water tanks, and for masonry and highway construction. While natural deposits still are present in many areas of the world, almost all asphalt produced and used in the United States is refined from petroleum. The asphalt produced is of many types and grades, from solids to thin liquids (see diagram below). Petroleum asphalt for use in pavements is usually called paving asphalt or asphalt cement to distinguish it from asphalt made for nonpaving uses, such as roofing. At normal temperatures, paving asphalt is a sticky, semi-solid, highly viscous material. It is composed chiefly of complex hydrocarbon molecules. Because of its adhesive quality, it sticks to aggregate particles and can be used to bind them into asphalt concrete. Paving asphalt is waterproof and is unaffected by most acids, alkalies and salts. It is a thermoplastic material, softening as it is heated and hardening as it cools. The unique combination of characteristics and properties of asphalt make it a very versatile construction material.

Rapid-curing (RC), medium-curing (MC), and slow-curing (SC) are designations of cutback asphalt types. Rapid-curing (RC) cutback asphalt is manufactured by blending asphalt cement with a specific amount of solvent (cutter stock) which will rapidly evaporate after using, leaving only the asphalt cement. The solvent (cutter) used in producing RC cutback is a material with a low boiling point such as gasoline or naptha. Medium-curing (MC) cutback asphalts are produced by blending asphalt cement with an intermediate boiling point solvent such as kerosene. The kerosene solvent evaporates more slowly than the gasoline solvent used in (RC) cutback, thus, the designation medium-curing. Slow-curing (SC) cutback asphalt may be produced by blending asphalt cement with a high boiling point gas oil or may be extracted as a residual material during the petroleum refining process.

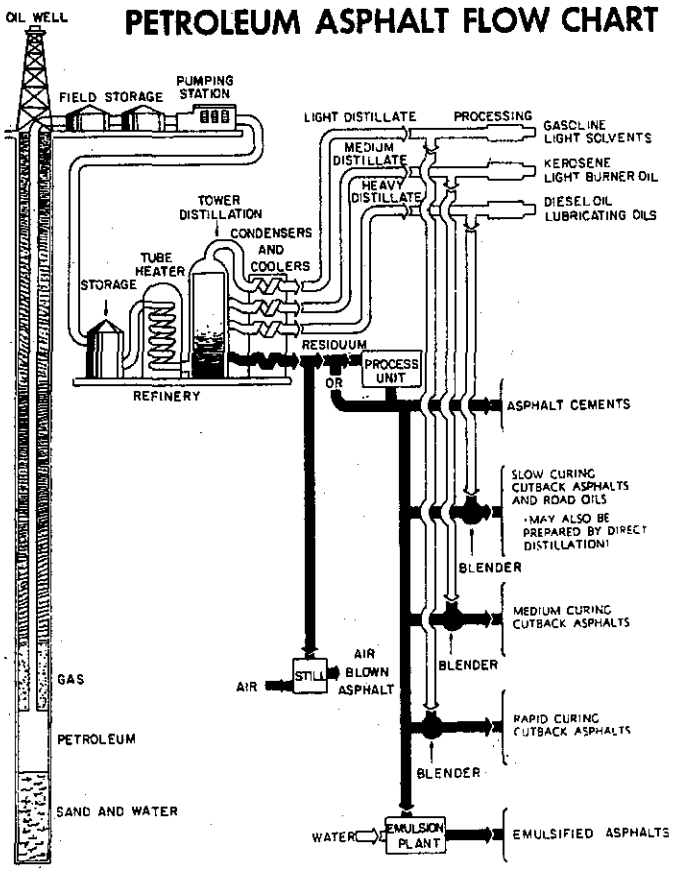
Emulsified asphalt is a combination of water, asphalt cement, and an emulsifying agent. Since asphalt cement will not dissolve in water, it exists in small ($1/25000$ in. to $1/2500$ in. diameter) globules suspended in the water-emulsifying agent mixture. The emulsifying agent (commonly soap) prevents the asphalt spheres from coalescing. When an emulsion is mixed with an aggregate or spread thinly on a surface, the interfacial balance is disturbed and the water and asphalt phases separate. On aggregate, the asphalt globules coalesce into a continuous film that cements the aggregate particle while the water drains off and/or evaporates. There are two types of emulsified asphalt. Anionic emulsified asphalt is an alkaline, water-phase product in which the surface of the asphalt droplets carry a negative change. Best results are obtained when this type of emulsion is used with electro-positive aggregates such as limestone and dolomite. Cationic emulsified asphalt is acidic and the asphalt droplets carry a positive charge; therefore, best results are obtained when it is used with electro-negative aggregates, such as sand, and other siliceous aggregates. Some emulsions require that the aggregates be pre-wet. Anionic and cationic emulsions are incompatible and cannot be mixed or stored together.

In an asphalt-aggregate mixture used in paving, aggregates normally constitute 90% to 95% by weight of the total mixture. It is fairly obvious that the nature and quality of the aggregate will have a considerable effect on the resulting pavement. Hard, durable aggregate is required for strong, high-quality wearing courses where strength requirements are not as high as for the surface course. Locally available and lower-cost aggregates can be used in base courses and thus reduce the pavement cost. Particles of aggregate larger than about ¼ inch (particles retained on a ¼-inch sieve), called coarse aggregate, are normally obtained from crushing rock and screening gravel. Particles smaller than about ¼ inch, called fine aggregate, are obtained from natural sand or fine screenings from rock crushing operations. Sometimes a mineral filler such as rock dust is added to the fine aggregate.

Types of Asphalt Pavement Construction

Plant Mix: asphalt paving mixtures prepared in a central mixing plant are known as plant mixes. Asphalt concrete is considered the highest quality type of plant mix.

continued on p. 3



Petroleum Asphalt Flow Chart—Reprinted with permission from The Asphalt Institute

There are many types and grades of asphalts, from solids to thin liquids.

Protection of Concrete...
continued from p. 1

surface, etc., are often offered when air-entrained concrete fails in service. The fact remains that failures continue to occur and while more vigilant and costly inspection at the time of placing the concrete may obviate some of these difficulties, it could not entirely eliminate the possibility of human error.

Protective coatings are harmless, easily applied, low-cost materials, which can be applied in thin coats to seal the pores of the concrete and thus prevent the entrance of water and corrosive solutions. These are a practical means of correcting the trouble at its source. Although we will primarily review linseed oil as a protective coating, various other substances, such as synthetic resins, silicates, and silicones have also been suggested as protective coatings for concrete. One major manufacturer of synthetic resins has recently undertaken an advertising campaign in national magazines to call public attention to the problem and to highlight the need for winter roadway protection.

The water-repellency characteristics of linseed oil films suggested, many years ago, its application for this purpose. The Portland Cement Association and the Salt Institute have pointed out the value of linseed oil as a protective coating for non-air-entrained concrete. Others have even suggested the use of boiled linseed oil for additional protection with non-air-entrained concrete. A number of state, county, and municipal highway departments have used and are still using linseed oil for both types of concrete.

To apply a protective coating of linseed oil costs around $.10 per square yard for materials. While application costs can vary, estimates indicate that this will not exceed an additional $.10 per square yard when readily-available, efficient spreading equipment is used.

Double-boiled linseed oil is preferred to raw oil because of its more rapid dryng and film-forming characteristics. To decrease the viscosity and facilitate spreading, it is common practice to mix the oil with an equal volume of mineral spirits.

When the mixture is used, it is customary to apply two coats, the first at .025 gallons per square yard. When this has thoroughly dried, it is followed by a second coat applied at the rate of .015 gallons per square yard.

For more information on using boiled linseed oil as a protective coating on concrete surfaces, see the directions printed on page 3 of this newsletter.

The above article was written for *Road Business* by Harvey S. Goodwin, Assistant Bridge Maintenance Engineer, NH DOT ■

Directions For Using Boiled Linseed Anti-Spalling Compound

Protect your concrete surfaces

Linseed anti-spalling compound protects concrete surfaces in two ways: by penetrating the porous surface of the concrete to a depth of approximately ⅛"; and by combining with atmospheric oxygen to form a protective coating through which destructive moisture and salt solutions cannot penetrate.

Uses: Linseed anti-spalling compound is used to protect roads, bridge decks, sidewalks, curbs, abutments, endposts, concrete handrails, and all exposed concrete surfaces from de-icing agents. Usually, it is not applied to the undersides and backsides of structures which are less exposed to chlorides.

For more information, see the article on the front page of this newsletter.

Material: 50% double boiled linseed oil and 50% petroleum spirits (AASHTO M-233-79 Type II).

Time of Application: Surfaces should be cleaned and washed annually in the spring of the year and oiled every two years. Linseed anti-spalling compound can be used on new and old concrete.

The oil is most effective if applied to new concrete upon completion of the initial curing period, usually considered to be about 28 days after placement. However, it has been successfully applied to new concrete after 2 weeks curing.

Linseed anti-spalling compound can be applied to concrete of any age. However, it is most effective in preserving sound concrete surfaces.

Pre-application conditions:

(1) The concrete should be dry and the solution should not be applied within 24 hours of a rainstorm.

(2) Remove sand and debris from joints, drains and bridge shoes (use high pressure water wash and let dry 24 hours).

(3) New concrete should be at least two weeks old. Ideally, it should be 28 days old.

(4) The ideal atmospheric temperature at the time of application is 70 degrees Fahrenheit or above. Successful applications have been made, however, at temperatures as low as 35 degrees Fahrenheit.

Application: Two coats are recommended, applied as follows:

1st Coat: 0.25 gal. per sq. yd. (40 sq. yds. per gal.)
2nd Coat: 0.15 gal. per sq. yd. (67 sq. yds. per gal.)

Application may be by spray or hand but should be uniform. The coverage of *each* coat shall *not* be more than 50 square yards per gallon of the mixture. When applying the mixture to concrete surfaces, the contractor should take all necessary precautions to ensure that the mixture does not contaminate adjoining asphalt pavements. The mixture will cause a potential safety hazard by making the asphalt pavement slippery. Also, the petroleum based linseed oil mixture may have a tendency to weaken the asphalt.

Complete drying should be permitted between coats. At temperatures of 70 degrees Fahrenheit or above, drying is complete within a few hours. At lower temperatures, proportionately longer drying times are required.

CAUTION: Linseed anti-spalling compound has a flash point around 120 degrees Fahrenheit. While not dangerously flammable, it nevertheless should not be heated.

Care should be exercised to cover the concrete surface completely, including all edges, which are sometimes missed in spraying. Maximum protection is afforded only when coverage is complete.

The preceding information has been provided by Harvey S. Goodwin, Assistant Bridge Maintenance Engineer, NH DOT. ■

Paving Materials...
continued from p. 2

It consists of well-graded, high-quality aggregate and asphalt cement. The asphalt and aggregate are heated separately from 250 to 325 degrees Fahrenheit, carefully measured and proportioned, then mixed until the aggregate particles are coated with asphalt. Mixing is done in the pugmill unit of the mixing plant. The hot mixture, kept hot during transit, is hauled to the construction site, where it is spread on the roadway by an asphalt paving machine. The smooth layer from the paver is compacted by rollers to proper density before the asphalt cools.

Asphalt concrete is but one of a variety of hot-asphalt plant mixes. Other mixes, such as sand asphalt, sheet asphalt, and coarse-grade mixes are prepared and placed in a similar manner. However, they have one common ingredient—asphalt cement.

Asphalt mixes containing liquid asphalt also may be prepared in central mixing plants. The aggregate may be partially dried and heated or mixed as it is withdrawn from the stockpile. These mixes are usually referred to as cold mixes, even though heated aggregate may have been used in the mixing process.

Asphalt mixtures made with emulsified asphalt and some cutback asphalts can be

continued on p. 4

Principal Uses of Various Types of Asphaltic Products

Reprinted with permission from The Asphalt Institute and the University of Oklahoma

Type Construction	Asphalt Cements: 40/50	60/70	85/100	120/150	200-300	Rapid-Curing (RC): 0	1	2	3	4	5	Medium-Curing (MC): 0	1	2	3	4	5	Slow-Curing (SC): 0	1	2	3	4	5	Emulsified: RS-1	RS-2	MS-2	SS-1	SS-1h	Inverted Emulsions	Cationic Emulsions
Plant-Mix Hot Laid		X	X	X	X																									
Modified Hot Laid										X	X					X	X					X	X				X			
Cold Laid-Macadam Aggr. Type									X	X	X					X	X						X				X			X
Cold Laid-Graded Aggr. Type				X[2]	X[2]									X	X	X		X[1]	X[1]		X	X					X			
Penetration Macadam Large Voids			X	X	X																									
Small Voids								X	X															X						
Mixed-in-Place Macadam Aggregate									X	X	X					X	X										X			X
Open Graded Aggregate								X	X	X	X				X	X	X					X	X				X			X
Dense Graded Aggregate														X	X	X				X	X	X					X	X	X	
Surface Treatments With Cover Aggregates				X	X		X	X	X	X	X		X	X	X									X	X		X		X	X
Seal Coats					X			X	X	X	X	X	X	X										X	X		X[5]			
Black Seal, Fog or Color Coat																												X[4]		
Tack Coat						X	X																				X[4]			
Prime Dust Laying																		X	X								X[4]			
Soil Treatment Mixtures														X	X	X	X			X	X	X	X				X	X	X	
Membrane Envelope	X[6]																													
Hydraulic Structures Membrane Linings-Canals & Reservoirs	X[5]																													
Hot Laid, Graded Aggr. Mix for Groins, Dam Facings, Canal and Reservoir Linings		X																												
Curbs Graded Aggregate Mix		X	X																											
Blocks Graded Aggregate Mix	X																													
Crack Filling																								X			X[3]			
Expansion Joints	Blown Asphalts, Mineral-Filled Asphalt Cement and Performed Joint Compositions																													
Roofing	Blown Asphalts																													
Miscellaneous-See Note 8																														

[1] In combination with powdered asphalt
[2] With water or liquifier ordinarily not exceeding 3%
[3] Slurry mix
[4] Water diluted
[5] Also 50-60 pen. blown asphalt and prefabricated panels
[6] Specially prepared asphalts used for pipe coverings, battery boxes, automative undercoating, electrical wire coating, insulation, tires paints, asphalt tile, wallboard, paper sizing, water-proofing, floor mats, ice cream sacks, adhesives, phonograph records, tree grafting compounds, grouting mixtures, etc.

Paving Materials... continued from p. 3

spread and compacted on the roadway while quite cool. Such mixtures are called cold-laid asphalt plant mixes. They are hauled and placed in normal warm-weather temperatures. To hasten the evaporation of emulsification water from cutback solvents, these mixtures, after being placed on the roadway, are sometimes processed or worked back and forth laterally with a motor grader before being spread and compacted.

Mixed-in Place (Road Mix): emulsified asphalt and many cutback asphalts are fluid enough to be sprayed on and mixed with aggregate at moderate to warm-weather temperatures. When this is done on the area to be paved, it is called mixed-in-place construction. Although mixed-in-place is the more general term, and is applicable whether the construction is on a roadway, parking area, or airfield, the term "road mix" is often used when construction is on a roadway.

Mixed-in-place construction can be used for surface, base, or sub-base courses. As a surface or wearing course, it usually is satisfactory for light and medium traffic. However, mixed-in-place layers covered by a high-quality asphalt plant mix surface course make a pavement suitable for heavy traffic service. Advantages of mixing-in-place include:

1. Utilization of aggregate already on the roadbed or available from nearby sources and usable without extensive processing; and

2. Elimination of the need for a central mixing plant. Construction can be accomplished with a variety of machinery often more readily available, such as motor graders, rotary mixers with revolving tines, and traveling mixing plants.

Asphalt Spray Applications: many necessary and useful purposes are served when paving asphalt—temporarily in a fluid condition—can be sprayed in uniform and controlled amounts onto a surface.

The table above shows the principal uses of various types of asphalt. This table and much of the information contained in this article is from The Asphalt Institute.

For further information on seal coats and other surface treatments the reader is referred to the December 1986 issue of *Road Business,* available at no cost from the Technology Transfer Center, 1-800-423-0060.

More information on asphalt paving materials is available in *The Asphalt Handbook.* A copy of the handbook can be purchased from: R. J. Joubert, The Asphalt Institute, 101 Amesbury Street, Lawrence, MA 01841—(617) 681-0455. ■