REPORT OF COMMITTEE ON MATERIALS AND CONSTRUCTION

H S MATTIMORE, *Chairman*

Engineer of Tests and Materials Investigations, Pennsylvania Highway Department

LIQUID BITUMINOUS MATERIALS FOR PLANT MIXED SURFACES

BY PREVOST HUBBARD

Chemical Engineer, The Asphalt Institute

AND C S REEVE

The Barrett Company

SYNOPSIS

The characteristics of petroleum distillates, rapid curing asphalt cut-backs, medium curing asphalt cut-backs, and slow curing petroleum residuals or blends, in relation to their use as primers and binders for aggregates are discussed These, with asphalt emulsions, are the general classes of liquid petroleums and asphaltic products commonly used in the construction of cold-laid plant mixed surfaces Recently developed specifications for such products are given in Table I

The liquid tar products adapted to various types of plant mixes are described and their ranges in characteristics are illustrated by a tabulation (Table II) of their consistencies, with references to suitable specifications Table III shows the types and ranges in percentage of tar binders for use with representative gradings of aggregates

PETROLEUM AND ASPHALTIC PRODUCTS

There are five general classes of liquid petroleum and asphaltic products commonly used in the construction of cold laid plant mixed surfaces

1 Petroleum distillates (naphthas)
2 Rapid curing cut-backs (asphalt cement and rapidly volatile distillate)
3 Medium curing cut-backs (asphalt cement and medium volatile distillate)
4 Slow curing petroleum residuals or blends
5 Asphalt emulsions

As asphalt emulsions have been made the subject of a separate report only the first four will be discussed in this paper

Two main divisions of the liquid products may be made according

to the purpose they are intended to serve and these may be conveniently subdivided as shown in the following classification

I Primers for Aggregates
  a Petroleum distillates (commonly termed liquefiers) the use of which is followed by application of a coating of asphalt cement
  b Medium curing cut-backs of low viscosity that produce a very thin coating of asphalt upon which a thicker film of asphalt binder may be readily deposited

II Binders for Aggregate
  a For open-graded aggregates, containing little or no 200 mesh particles
    1 Rapid curing cut-back asphalts for commercial crushed aggregate products
    2 Medium curing cut-back asphalts for gravel and sand aggregates in which there exists a regular gradation in size down to and including particles passing 10 mesh
  b For dense graded aggregates containing over 5 per cent of 200 mesh particles
    1 Medium curing cut-back asphalts
    2 Slow curing products

PRIMERS

Distillate primers are employed not only for the purpose of facilitating the uniform coating of a cold aggregate with hot asphalt cement but of temporarily softening the film of asphalt surrounding each aggregate particle enough to permit ready workability and compressibility of the mixture during construction Petroleum naphtha or gasoline is ordinarily used Specifications for liquefier have not been standardized but typical requirements call for a product showing an end point on distillation of not over 450 or 500°F with 45 to 50 per cent distilling at not over 293 to 325°F While some engineers lay considerable stress upon the particular grade of naphtha and require a heavier less volatile grade for delayed use of the mixture, as compared with immediate use, fine distinctions along this line are of doubtful importance as the proportion of distillate added to the mix with relation to the proportion of asphalt cement and absorptive character of the particular aggregate can be made to produce greater differences in the so-called setting qualities of the mixture than will be produced by slight differences in distillation ranges of the liquefier.

Medium curing cut-backs have not as yet been extensively used as aggregate primers but they possess certain advantages over the distillates which are of considerable practical value In the first place they immediately produce a thin tenacious moisture resistant coating of

asphalt over each particle which serves as an adequate base for uniformly applying a thicker film of either an asphalt cement or a highly viscous cut-back asphalt Moreover, once the aggregate has been coated with the thin film of asphalt it may be stock piled indefinitely with practically no adhesion between the individual particles and may be later cold mixed with the asphaltic binder immediately prior to construction It is of course important that the medium curing primer be of very low viscosity so that a small percentage may be rapidly mixed with the aggregate to produce thin films of asphalt cement Typical requirements for such a product are shown in the accompanying table of specifications

BINDERS FOR OPEN GRADED AGGREGATES

When the inherent stability of an aggregate is entirely dependent upon the intimate interlocking of its individual particles, as typified by a single commercial size of crushed stone, it is essential that the asphaltic product with which it is to be mixed should possess or quickly develop a strong mechanical bond to resist successfully displacement of the mixture under traffic Moreover the coating or film of binder on each individual particle should be as heavy as consistent with good workability in order to produce a bond which is durable and which, if disturbed, will readily reform A rapid curing cut-back asphalt of as high an initial viscosity as is practicable to incorporate with the cold aggregate is best adapted for this purpose, and in general, the coarser the aggregate the higher should be the viscosity of the cut-back in order to secure the most satisfactory immediate results A Furol viscosity as high as 700 to 1400 at 140°F is desirable when all of the aggregate is retained on the $\frac{1}{4}$ inch screen and the maximum size runs as high as $1\frac{1}{2}$ inches This is particularly true when the mixture is to be laid immediately after preparation during warm weather When it is to be stored or transported for long distances before use or when it is to be used for cold patching or to be laid in cool weather, the viscosity of the binder may, however, be lowered advantageously

When the inherent stability of the aggregate is largely dependent upon the presence of relatively small diameter particles which pack the voids between the larger particles, as typified by a gravel containing a substantial proportion of sand but free from material passing the 200 mesh sieve, the choice of the most suitable liquid asphaltic binder becomes a matter of experience and judgment which is difficult to reduce to hard and fast rules Choice may lie between a rapid curing cut-back of relatively low viscosity or a medium curing cut-back of higher viscosity

When the percentage passing the 10 mesh sieve is insufficient to pack closely the voids between the coarser particles a rapid curing product may often be used to advantage In other cases, except for sand ag-

gregates, the medium curing type is to be preferred Even with the sand aggregate it may often be advisable to add 200 mesh material and use a medium curing cut-back In general the medium curing product is preferable except for base course construction rather than the use of unaltered sand with a rapid curing product

BINDERS FOR DENSE GRADED AGGREGATES

Dense graded aggregates are those with a more or less continuous gradation in size from the maximum diameter particle down to and including a substantial percentage of mineral matter passing the 200 mesh sieve Specifications for such aggregates commonly call for 7 to 14 per cent passing the 200 mesh sieve Many aggregates of this type, as represented by pit run gravel and crusher run stone, produce excellent wearing courses without any bituminous binder when a certain optimum water content is present Strength of bond of the bituminous binder with which they may be mixed is therefore not as important as in the case of open graded aggregates However the viscosity of the binder should be high enough to permit a sufficient quantity being used to prevent absorption of large amounts of moisture and displacement of the bituminous films by water

Rapid curing cut-backs are usually unsatisfactory for use with the dense graded aggregates because they do not distribute uniformly but tend to ball in the presence of appreciable quantities of 200 mesh particles The choice therefore lies between a medium curing cut-back and a slow curing product There is little to be said in favor of the latter except its usually lower cost Where traffic and moisture conditions are not severe the slow curing product has in many instances produced excellent low cost road mixtures but generally speaking, use of a medium curing cut-back is a much safer proposition In either case the viscosity of the product should be as high as possible without interfering with the workability and compressibility of the mixture During and after construction the medium curing cut-back increases in viscosity to a much greater extent than the slow curing product, which is a distinct advantage

CHARACTERISTICS OF LIQUID ASPHALTIC PRODUCTS

During the past three years as the result of extensive cooperative work between the United States Bureau of Public Roads, the various state highway departments and the producers of asphalt, a fairly complete set of specification requirements has been developed for liquid asphaltic road materials Such of these specifications as are applicable to cold laid plant mix construction are shown in Table I to illustrate the preceding brief discussion The development of the medium curing cut-backs shown in this table has been of rather recent origin and many highway engineers have not as yet become acquainted with their pecul-

TABLE I

LIQUID ASPHALTIC MATERIALS FOR PLANT MIXED SURFACES

Use	Primer	Binder						
Aggregate	Crushed Aggregate	Open Graded, containing little or no 200-mesh					Dense Graded, containing 7–14% of 200 mesh	
		Commercial Crushed Aggregate			Gravel and Sand			
Type Asphaltic Product	Medium Curing	Rapid Curing			Medium Curing		Medium Curing	Slow Curing
Water and Sediment	—	Free-from	Free-from	Free-from	Free-from	Free-from	Free-from	2–
Flash Point (Cleveland Open Cup) °F	—	—	—	—	—	—	—	250+
Flash Point (Open Tag) °F	—	80+	80+	80+	150+	150+	150+	—
Furol Viscosity at 77°F	40–150	—	—	—	—	—	—	—
Furol Viscosity at 122°F	—	200–400	—	—	—	—	—	—
Furol Viscosity at 140°F	—	—	275–400	700–1400	500–800	—	300–500	350–550
Furol Viscosity at 180°F	—	—	—	—	—	170–280	—	—
Distillation, per cent by volume								
Total distillate to 437°F	10–	10+	3+	0 5+	1–	1–	2–	2–
Total distillate to 600°F	25+	20+	14+	7+	16–	14–	8-20	8–
Total distillate to 680°F	50–	35–	30–	25–	25–	20–	25–	18–
Tests on Residue from distillation								
Float at 122°F	—	—	—	—	—	—	—	25+
Penetration at 77°F , 100 g , 5 sec	70–300	60–120	60–120	60–120	100–300	100–300	100–300	—
Ductility at 77°F	60+	60+	60+	60+	60+	60+	60+	—
Per cent soluble in Carbon Disulphide	99 5+	99 5+	99 5+	99 5+	99 5+	99 5+	99 5+	99 0+

TABLE II

CONSISTENCIES OF TYPICAL TAR PRODUCTS

	A	B	C	D	E
Specific Viscosity at 40°C	8–13	—	—	—	35–80
Specific Viscosity at 50°C	—	26–36	—	—	—
Float Test at 50°C	—	—	40–80	60–120	—
A S T M Specifications	D–104–30	D–104–30	D–110–30	D–110–30	D–106–28 T
	D–105–30	D–105–30	D–111–30	D–111–30	D–107–28 T

A is a thin fluid product, commonly used for surface treatment but also suitable for a primer to be used on aggregate in place of the more frequently used volatile solvent

B is a fairly viscous refined tar product adapted for use in road mixtures as distinguished from plant set-ups, particularly with graded broken stone and gravels which will furnish a well-graded stable mixture, not too dense to permit adequate setting-up within a short period Such a mixture, for example, may correspond to the "retread" type of surfacing, but may include aggregates of smaller maximum size than are commonly used for "retread" work

C is a viscous refined tar especially adapted for use with graded fine aggregate Due to its greater initial adhesiveness, it may be used with aggregates of closer grading than material "B," and ordinarily in such mixtures a certain proportion of fine aggregate is desirable Mixtures with this grade of tar product may be made ordinarily with aggregate at summer atmospheric temperature, and may be laid without heating The tar must be heated before mixing with the aggregate While it is especially adapted for use with graded fine aggregate, it may also be used in road mixed work where a heavier binder than "B" is required

D is a grade of refined tar heavier than "C" and almost semi-solid, requiring its heating before use with aggregate It is adapted for use with graded coarse aggregates, or at summer temperatures with fine aggregate such as described for material "C " Such mixtures with material "D" may also be made ordinarily with aggregates at summer atmospheric temperatures and may be laid without heating

"E" is a cut-back tar product commonly used in patching mixtures but also well adapted for use with graded aggregates of maximum sizes ranging from ¼ inch to 1½ inches Material of this viscosity may be used at ordinary temperatures, and only in cool weather is slight heating necessary or desirable

TABLE III

Percentage Passing	Fine	Intermediate	Coarse	Medium Patching	Fine Patching
2¼ Inch Screen	—	—	100	—	—
1½ Inch Screen	—	100	—	—	—
1¼ Inch Screen	—	—	30–60	—	—
1 Inch Screen	—	—	—	100	—
¾ Inch Screen	—	30–60	—	—	—
⅝ Inch Screen	100	—	—	—	100
½ Inch Screen	—	—	—	35–70	—
¼ Inch Screen	40–70	0–5	0–5	10–25	40–70
No 10 Screen	10–35	—	—	—	10–35
Percentage of Tar Binder	7–9	3–5	2 5–4 0	5–7	7–9
Type of Tar Binder	C or D*	D	D	E	E

* Selection dependent on season, method of handling, etc

iar advantages for use with certain types of aggregate. They are particularly well adapted for utilizing pit run gravel and crusher run stone when the aggregate has any merit as a road building material.

TAR PRODUCTS

The range of liquid tar products adapted to various types of plant mixes is best shown by consistencies of typical tar products in Table II The other characteristics will substantially conform to requirements of the A S T M specifications indicated under each type, except as distillation limitations are necessarily modified by consistency Considering the wide variation in aggregates available for plant mixtures and in service conditions, products of other consistencies than shown are adapted for use, it is advisable, however, from a manufacturing standpoint to limit the number of grades of material, provided that a sufficient number are provided for satisfactory utilization under all important conditions

While there is a wide variation in preferences for grading of aggregates in plant mixes, the gradings shown in Table III are fairly representative of average practice The type and proper range of percentage of tar binder is also shown