When To Use What Grade of Asphalt and Why

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Asphalt is one of the oldest adhesives and waterproofing materials known to man. Its early uses, dating back as far as 3800 B. C., were as mortar for building stones, reservoir and canal linings, and paving blocks.

These early asphalts occurred as seeps and natural pools at the earth's surface. Many such sources are still known throughout the world. Two of the better known sources are the deposits on the Island of Trinidad and the La Brea "Tar" Pits of California. Other natural asphalts such as Gilsonite—a hard asphalt, and rock asphalt—impregnated sandstone and limestone, have been employed for many purposes.

The first use of asphalt as a paving material in this country was in Newark, New Jersey, about 90 years ago. Some six years later (1876) additional work was done in Washington, D. C. After this beginning, its use as a paving material has increased steadily until today approximately 90 per cent of all paving is done with asphalt.

During the early years naturally occurring asphalts were employed predominately; however, in about 1900 asphalts refined from petroleum appeared on the scene. In 1902 some 20,000 tons of asphalt was refined from petroleum in this country. This production has grown steadily and rapidly, to 3,000,000 tons in 1924, 9,000,000 tons in 1946, 19,000,000 tons in 1956, and now to more than 22,000,000 tons per year.

With the rapid increase in asphalt production its uses have also grown. Roofing, pipe coatings, enamels, and other specialty uses consume large quantities of asphalt. However, the majority, approximately 80 per cent of total production, is carefully manufactured to meet the specific needs of the paving industry. It is this latter material that we wish to discuss. More specifically, what asphalt should we use for certain applications and why is it best adapted for such use.

As implied in the last paragraph, paving asphalt is not a single material but rather a large family of types and grades, manufactured

and processed to meet the many and varied requirements of roadbuilding. Paving asphalt is divided into two major categories, asphalt cements and liquid asphalts. These latter materials are further subdivided into two types, cutbacks and emulsions. Further division of the several types into grades identifies the specific properties of these materials.

Basically the product used as a binder in pavements is always an asphalt cement. Liquid asphalts, either cutbacks or emulsions, are simply modifications of asphalt cements to permit use under conditions not suitable for the basic cement. For many applications, however, more than one type or grade may be used, and in some cases choice of the proper material or materials makes the problem confusing. Before proceeding further, then, it will be well to consider the function of asphalt in a mixture. What does it have to do to perform properly?

1. First, it must be fluid enough at the application temperature to permit it to properly spray, mix, coat, or penetrate as the application requires.
2. It must have the ability to coat and adhere to aggregate surfaces and to the roadway under the conditions required for any given construction.
3. It must provide a suitable quantity of asphalt cement in the mixture to act as a binder after curing or setting is complete.
4. It must have curing or setting properties which are compatible with the type of construction being used.
5. It must have the ability to retain its contact with aggregate in the presence of water—stripping resistance.
6. It must be durable under service conditions.

It is to meet the above requirements that a specific asphalt is selected for any job. To understand this selection, it is necessary to understand the general properties of each type and grade of asphalt and what these properties mean with respect to use on the road. In a generalized way each of these will be described.

ASPHALT CEMENT

Asphalt cement, the basic asphalt binder, is defined by ASTM Standard D8 as an asphalt specially prepared as to quality and consistency for direct use in the manufacture of bituminous pavements. Asphalt, in turn, is defined as a black or dark brown solid or semi-solid cementitious material which generally liquifies when heated in which the predominating constituents are bitumens, all of which occur in the soild or semi-solid form in nature or are obtained by refining

petroleum, or which are combinations of the bitumens mentioned with each other or with petroleum or derivatives thereof.

To boil this down, paving grades of cements are semi-solid asphalts which require heating to produce a fluid state in which the material can be sprayed or mixed. For the most part, they are employed in hot plant mixed paving mixtures where temperature and mixing time can be carefully controlled and in hot asphalt penetration of coarse stone (macadam) layers. The softer grades are also used in some seal coat or surface treatment work, but in such cases the application of aggregate must be made immediately and before the asphalt chills.

Asphalt cements are specified by penetration grade. This is simply a means of specifying the viscosity, consistency, or fluidity of the asphalt. Penetration is measured by permitting a standard needle, loaded to a weight of 100 grams, to penetrate into an asphalt sample which has been brought to a temperature of 77°F. Penetration continues for five seconds and the depth penetrated is measured in units of one-tenth millimeters. This value is called the penetration number and may range for paving grades from 60 to 300. The larger the penetration number the softer the asphalt. The Asphalt Institute specifies four penetration grades: 60-70, 85-100, 120-150, and 200-300. The 60-70 grade is usually used only in pavements where traffic is very heavy such as principle city streets and very heavily trafficked rural highways. The second grade, 85-100, is by far the most widely used material for plant mixes and is suitable for most pavements. It is also used in penetration macadam construction. The 120-150 grade is primarily used in relatively light trafficked pavements. It is often employed where the pavement structure is expected to deflect appreciably under heavier loads—that is, where the design is for light traffic. This grade is also used for penetration macadam. Less often used in plant mix is the 200-300 grade. It is generally softer than desired for this purpose. It is, however, used in traveling plant applications and in seal coats. This material is sometimes used for penetration work but less often than the above grades.

CUTBACK ASPHALTS

Cutback asphalts are asphalt cements which have been combined with solvents to increase their fluidity, permitting use with less heating and in some cases no heating. Three types are manufactured; rapid curing, medium curing, and slow curing. Each of these types is further subdivided into grades, zero through five, to produce a range of materials of each type which varies in fluidity or viscosity from almost

water thin to about the consistency of cool molasses. The range in consistency provides for the broad range of uses to which these materials are put.

In general the zero grade (RC-0, MC-0, or SC-0) contains the most solvent and the least asphalt cement. The percentage of asphalt uniformly increases and, conversely, the percentage of solvent decreases as the grade number increases. There may be as little as 50 per cent asphalt in the zero grade (40 per cent in SC-0) while in grade five there is more than 80 per cent. The fluidity or viscosity of each grade is essentially the same regardless of the solvent used (cutback type). In selecting a grade for a given use, it is desirable to select the grade containing the most asphalt, provided, of course, this grade meets other requirements. To understand cutbacks the types must be discussed separately.

Rapid Curing Cutbacks—To produce this material an asphalt cement in the penetration range of 80 to 120 is combined with a naphtha or gasoline solvent in varying amounts to produce the several consistencies required by specifications (grades zero through five). Gasoline is a very volatile solvent which evaporates rapidly under normal construction conditions—hence the designation, Rapid Curing.

Since the solvent is gasoline, RC cutbacks are highly flammable and care must be exercised in heating these materials. A range of maximum application temperatures from 120°F to 275°F for the several grades is specified as a safety measure.

RC-0 and RC-1, very fluid at low application temperatures, are used primarily as tacking asphalts. Their fluidity or low viscosity permits easy spraying at low rates of application. RC tack coats cure rapidly, develop a residue with good cementing power and permit subsequent operations to proceed rapidly. RC-1 may sometimes be used for machine mixing with very fine sands in stabilization work.

RC-2 is also used as a tacking asphalt prior to resurfacing. More often this material is used for road mixing of finely-graded aggregates such as sands and densely-graded sand-gravel or crushed-stone mixtures. This grade is especially well adapted to machine mixing of fine sands. Proper curing before compaction is required.

RC-3 and RC-4 require more heat than lighter grades to spray properly, up to 200°F and 250°F, respectively. They are used for road mixing where the operation can be completed rapidly. Blade mixing can be used but it is more satisfactory to use machine mixing. Blade

mixing is usually employed only when very coarsely-graded aggregates are employed. Both of these grades may be used for surface treatment work, as may RC-5. When used for this purpose, cover aggregate should follow the asphalt spread as closely as possible.

RC-4 and RC-5 are both well adapted to stationary- or travel-plant mixing where complete coating and spreading are accomplished with little manipulation on the road. Usually the lighter grade is applied to finer-graded materials.

All of the three heavier grades may be used for penetration treatments of macadam type aggregate. In general, the smaller the maximum aggregate particle size the lower the grade number employed. For the most part, RC-4 and RC-5 should be employed for this treatment.

Even though these cutbacks loose their solvent rapidly, care must be exercised that curing has progressed sufficiently prior to compacting the course. This is particularly important when the mix contains considerable fine aggregate. When the mix begins to get fluffy and the asphalt tacky, it is usually ready to compact.

Medium Curing Asphalt—These liquid asphalts are manufactured by combining a relatively soft asphalt cement, 120 to 300 penetration, with a kerosene type solvent. They are widely used where appreciable time is desired prior to reduction of the asphalt to a high consistency material. Care must be exercised in curing these materials, hence they are often used with open-graded aggregates which, when compacted, result in pavement courses having relatively large pores. This is certainly not always the case, but when the fine-graded materials are used manipulation must continue until a considerable portion of the solvent has evaporated.

MC-0 and MC-1 are probably the most widely employed priming materials. They are very fluid and remain so for relatively long periods. Both the fluidity and the retarded curing assist in producing deep penetration into granular bases. Very dense materials containing a high percentage of soil or rock fines should be primed with MC-0, while those surfaces which are more open may be primed with MC-1. The latter is by far the most widely used prime material. Penetration of prime is always better if the base is slightly damp but not wet. Curing is essential for these primes to insure that most of the solvent have evaporated before subsequent paving courses are placed. The curing period will range from a minimum of 48 hours in hot, dry weather to more than a week during humid or rainy weather. Curing should continue until the surface is no more than slightly tacky.

MC-2 is sometimes used in road mixing but usually heavier grades are superior for this purpose. The main application of this grade is its use in production of stockpile mixtures. Its high percentage of solvent permits it to remain workable over long periods and at relatively low temperatures.

MC-0, 1, and 2 are used in stabilization of densely-graded sand or sand and gravel mixtures which contain considerable silty material. The more finely graded the material, the lower the grade number used. In this work blade mixing is usually employed and manipulation must continue until most of the solvent has been removed.

To facilitate coating and mixing, water is first added to moisten the aggregate. Just enough water to produce a fluffy, mealy mass is desired. Mixtures of this nature are often employed in areas where standard aggregates are scarce and thus expensive.

MC-3 and MC-4 are the principle asphalt materials used for road mix when blade mixing is employed. Grade four is used during the hotter part of the season and grade three is used in the cooler portions—usually early and late season work. These materials must be manipulated until about one-half the solvent has evaporated prior to compacting. This point is usually indicated when, during the hotter part of the day, the mix begins to get tacky and fluffy. After initial compaction, it is often necessary to apply additional compaction for several days until sufficient curing permits the surface to reach a firm state. If sealing of surfaces containing MC-asphalt is required, this operation should be delayed until curing has rendered the surface firm.

MC-5 is not widely employed; it may, however, be used for road mixing with coarse-graded, one-size aggregate mixtures. Also, it is sometimes used for plant mixes and in such cases curing prior to compaction is important.

MC-4, 5, and sometimes MC-3 may be used for sealing. It must be remembered that considerable time is required to cure these asphalts to high consistency and thus they do not retain cover aggregate well when first laid. In areas where traffic is light or speed may be closely controlled, quite satisfactory sealing can be done with MC-4 and 5. The slow curing rate makes seals with this material particularly vulnerable to rainfall occurring within the first few days after application. In general, MC-cutbacks are not as well adapted to seal work as are RC-cutbacks or RS-emulsions.

Slow Curing Asphalt—This type is rarely used in this area except in the lighter grades for dust control on aggregate surfaces. It may

however be successfully employed for many of the uses outlined for medium-curing asphalt. Light grades, particularly cracked asphalts, are useful in stabilizing fine-grain materials. In general, practice common to this area indicates the use of other types of liquid asphalts.

ASPHALT EMULSIONS

These materials are produced in two forms; the so-called standard emulsion, which consists of tiny droplets of asphalt suspended in water, and inverted emulsions, in which tiny droplets of water are suspended in asphalts. Both forms may be manufactured with either negative or positive electrical charges at the asphalt surface and are designated as anionic or cationic, respectively. Theoretically, selection of type depends upon the surface charge present on the aggregate to be used. Often either type may be used successfully with a given aggreate. In general, but with many exceptions, anionic emulsions function best on limestone aggreates and cationic emulsions on silicious agregates. Only anionic emulsions are specified in Indiana at present and discussion will pertain largely to this type.

Emulsions are further subdivided into three groups, not dissimilar in some respects to the cutback asphalts, although the approach is much different.

The Rapid Setting (RS) Emulsions—This group has two members, RS-1 and RS-2, whose counterparts with respect to curing in cutbacks are the RC-group. These emulsions are used primarily as penetrating and sealing asphalts, respectively. Both are characterized by rapid separation of water and asphalt upon contact with aggregates, hence the name Rapid Setting. It should be noted that there are two distinct steps in the setting of these and all emulsified asphalts. The first is referred to as the "break" which occurs when the asphalt separates from suspension in water and coats the aggregate surface. The second step occurs when water is essentially removed, leaving only asphalt in contact with aggregate.

RS-1 has a low viscosity, that is, it is very fluid. Its fluidity permits it to penetrate into relatively open macadam type aggregate and at the same time break as it contacts aggregate surface. This breaking prevents excessive drainage toward the bottom of the macadam course and promotes uniform coating.

RS-2 is a much higher viscosity (less fluid) emulsion than RS-1; however, Indiana specifies a lower viscosity than do most agencies. Its advantage in seal work is that rather large quantities may be sprayed

on the surface with little or no runoff. Thus a rather deep layer of asphalt is in place to receive cover stone.

Medium Setting (MS) Emulsions—These materials are designated as mixing grades. They do not break as readily as RS emulsions, permitting time for manipulating the mixture to insure thorough coating of the aggregate. In general, AE-60, AE-90, and AE-150 in this group are used with relatively coarse open-graded materials which preferably have little or no material passing a No. 200 sieve, that is, little or no dust. AE-200 and AE-M are medium-setting grades intended to be used for mixing with dense-graded aggregates. All of this group have viscosity requirements very similar to RS-1; however, AE-60 and 90 have no upper limit to viscosity and can be similar to RS-2 in this respect. HERPIC Report 3-61 tabulates the uses of these materials and the grade for each application.

Slow Setting (SS) Emulsions—These materials are not specified in Indiana and thus will receive little attention here. It should be noted, however, that this type is intended for mixing with aggregate containing considerable dust. They are useful in treating and stabilizing these materials.

The preceding discussion has very briefly presented those paving asphalts commonly used in Indiana and their usual applications. This information is further summarized in the following tabulation "Selection of Asphalt Type and Grade." It is realized that the material presented cannot fully clarify selection of the proper asphalt for use in all situations. It is, however, hoped that a broad understanding of these materials and a basis for selection of type for a given use will be established. Where questions exist pertaining to the proper asphalt to use and/or construction methods for a specific application, inquiry should be made to The Asphalt Institute or to HERPIC for further information.

SELECTION OF ASPHALT TYPE AND GRADE

Application	Asphalt Type and Grade	When to Use and Why
Prime	MC-0, 1, 2	MC-0 employed on very dense surface. Its low viscosity and high solvent content result in excellent penetration. MC-1 is suitable for most bases. It penetrates well but has higher viscosity than MC-0 preventing excessive penetration. MC-2 is used only on very open bases. Its higher viscosity prevents deep penetration.
Tack	RC-0, 1, 2	Use lower number (less viscosity and more solvent) grades for thinner tack coats.
	RS-1, AE-60, 90, 150	Usually use same grade as used in course. May be diluted at the plant to obtain a thinner tack coat.
Hot Asphaltic Concrete Base, Binder, or Surface	AP-1, 3, 5	AP-1 often used on low to medium traffic roads where a soft asphalt is desired. AP-3 is the most generally used grade and is suitable for most roads from light to heavy traffic. AP-5 is used on very heavily trafficked roads only. Does not perform as well as above grades on low traffic roads.
Bituminous Coated Aggregate Base and Surface	RC-4, 5	RC-4 usually used for early season work and for smaller sizes (Nos. 4, 8, 9, 11) of aggregate. RC-5 because of its higher viscosity used with larger sizes (No. 2 and 4) of aggregate.
	AE-60, 90, 200	AE-60 and AE-90 are used with No. 2, 4, 8, 9, 11, 12 gravel and stone. Often the softer AE-90 is preferred, especially with stone. AE-200 used with No. 53B aggregate. Coat well with damp stone.
Bituminous Surface Treatment	RC-3, 4	Use lower grade in cool weather and higher grade in hot weather. With travel plant use RC-4. Work rapidly in short sections. Interference with traffic minimized.

SELECTION OF ASPHALT TYPE AND GRADE (Continued)

Bituminous Surface Treatment (cont.)	MC-3, 4, 5	Use grades 3 or 4 for road mix and 4 or 5 for travel plant depending on the season. Permits more manipulation and requires more curing.
	AE-90, 150	Use AE-90 for travel plant and AE-150 for blade mix because of viscosity difference.
Seal Coats	RC-3, 4, 5	RC-3 generally used with fine-aggregate seals. Viscosity too low to prevent runoff. RC-4 or 5 best in hot weather when seal work should be done. The higher the grade number the more can be put down per sq. yd. without runoff and the larger the aggregate that can be retained, but viscosity must be low enough for proper wetting of the aggregate.
	MC-3, 4, 5	Use only on very low traffic roads and in hot weather. Apply same procedures described for RC's. These materials (MC) are not as well adapted because of slow curing.
	RS-2	A good seal material for most conditions. Do not use over cutbacks until they have cured. RS-2 has high viscosity, giving it good retention without runoff.
	AE-60, 90	These medium-setting emulsions, when used at high viscosity, retain aggregate well provided sufficient curing period can be allowed.
Bituminous Coated Aggregate Base (dense graded)	AE-60, 90, 200	AE-60 or 90 provide harder asphalt for these bases than AE-200 and are often preferred when rounded aggregates are employed. When angular aggregate is used AE-90 or 200 is used with the latter possibly preferable when the gradation is on the fine side.
Bituminous Coated Blended Aggregate Base and Surface	AE-60, 90, 200	The grade varies with both traffic and gradation. For higher trafficked pavement, the harder grade is used and for lower traffic the softer grades (90, 200). Surfaces should preferably be AE-60 or AE-90 for all but lowest traffic.
Road Mix Base or Surface	RC-2, 3, 4	These materials are most often used for travel plant work. RC-2 is rarely used except for very fine No. 53B aggregate. RC-3 or 4 are used according to season. When blade mixed, rapid manipulation is required.

SELECTION OF ASPHALT TYPE AND GRADE (Continued)

	MC-2, 3, 4	These are the blade mix grades for base work, with MC-3 being used in the cooler portion of the season and MC-4 being used during hot weather. Not too well adapted to plant mix because of slowly evaporating solvent.
	AE-90, 150, 200	AE-90 used for all plant mix and AE-150 for all blade mix except with No. 53B aggregate. In this case AE-200 is employed since it coats fine aggregate better.
Penetration Macadam Base	AP-3	Best for use when reasonably dry stone is assured.
	RC-4, 5	Used under same conditions set forth for AP-3. With No. 1A stone solvent aids penetration. May also be slightly better on damp stone. Must be cured. Grade 4 in cooler weather and grade 5 in hot. Grade 5 on No. 1 stone because of higher viscosity.
Penetration Macadam Base (cont.)	RS-1, 2	RS-1 is usually preferable but RS-2 may be required because of its higher viscosity when No. 1 stone is used in shallow courses. RS-1 is generally suitable. These materials coat well on damp stone.
	AE-60, 90, 150	AE-60 or 90 may be preferable on No. 1 stone because of the higher viscosity which can be achieved. AE-150 has lower viscosity and this material or low viscosity AE-60 or 90 should be used with No. 1A stone.
Bituminous Retread Surface	RC-3, 4, 5	These one-sized aggregate mixes, prepared with blade or travel plant, are well adapted to use with RC-cutbacks, since rapid coating can be accomplished and the open texture provides for good curing. Grades 3 and 4 are used with No. 4 stone and grade 4 or 5 with No. 2 stone. Grade selected depends on whether weather is hot or cool—higher grade in hot weather.
	MC-3, 4, 5	Use grade 3 or 4 for road mix and 4 or 5 for plant mix depending on aggregate size and season. MC permits more manipulation time but requires more curing.
	AE-90, 150	Use AE-90 for travel plant and AE-150 for blade mix because of viscosity difference.