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METHOD OF MAKING BITUMINOUS PAVING COMPOSITIONS AND PAVEMENTS

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This invention relates to paving compositions employing bituminous material as a binder for aggregate particles. More particularly it relates to the manufacture of pavements and paving compositions which remain friable after mixing even though the temperature of the composition is below that at which the bituminous binder in the ultimate pavement is quite stiff and which after mixing can therefore be transported to the point of use and laid without requiring the application of heat to keep the composition in a workable condition.

A bituminous binder in a completed pavement should be sufficiently hard at atmospheric temperature to impart stability to the road sufficient to withstand the demands of traffic. It is regarded as good practice to use in the completed pavement a bituminous binder having a softening point (ball and ring) of about 95° F. to about 160° F. and having a penetration of about 35 to about 150 at 77° F. For a great many years bituminous binders of this character have been applied to aggregate such as stone by first reducing it to a molten condition, e. g. at a temperature of about 225 to about 350° F. and applying it to aggregate that has previously been heated. The resulting mixture tends to cool and become set up quite rapidly, however, which places great limitation on the transportation and laying of the material. This "hot mix" method has the advantage, however, of great pavement stability immediately upon laying.

Because of the disadvantages of the "hot mix" method of road making, many "cold mix" proposals have been made for mixing the paving composition or laying the paving composition or both at a temperature substantially below that which is required using the hot mix method. One form of cold mix that has been used extensively in the manufacture of pavements involves the admixture with aggregate of a bituminous binder divided into two component parts, one too soft at atmospheric temperature to form a stable pavement and the other too hard to be properly adhesive. Upon mixing the aggregate with the two component parts of the binder they do not blend or amalgamate with each other immediately and the bituminized aggregate remains friable so as to permit shipment or storage and laying of the composition without application of heat. After laying and under the pressure of a roller or traffic the two bitumens blend or amalgamate to form a binder of desired stability. For example, in carrying out this type of cold mix method one of the binder components may

be a substantially non-volatile flux oil that is liquid at ordinary temperatures and the other component may be a powdered asphalt adapted to gradually blend or amalgamate with the flux oil to produce a permanent binder having a melting point and penetration required in the ultimate pavement. Usually the flux oil is first applied to the aggregate until the aggregate is coated and then the powdered asphalt is mixed for a brief interval of time to distribute it through the mass. Sometimes with a heavy flux oil it is heated somewhat to make it flow more readily, especially in cold weather and the aggregate may be supplied quite warm if it has just come from a drier; but it is also possible to carry out the entire process at atmospheric temperature or substantially so. While this cold mix method has many advantages, the pavement immediately after laying does not have as great stability as desired and has considerably less stability immediately after laying than a pavement of the hot mix type. In addition even after the components of the bituminous binder after a time become sufficiently amalgamated to afford a pavement of desired stability, the binder usually has less durability and wearing capacity than an asphalt cement of the same penetration applied by the hot mix method.

Another cold mix method of road construction has been based upon the use of sufficient volatile solvents to render a paving asphalt cement of the type ordinarily used in the hot mix method sufficiently fluid at relatively low temperatures to allow the aggregate to be coated and laid without resort to the high temperatures required for the hot mix method. After a paving composition including a volatile solvent is laid it is expected that the solvent will evaporate leaving only the stable asphalt cement. But the disadvantages of such compositions are well known. In order to permit evaporation of the volatile solvent the pavement must be left "open," that is with a multiplicity of open passages therein through which the solvent may evaporate; but a pavement containing such a high percentage of voids is not desirable. Also in such pavements, especially where it is attempted to make them more dense, a substantial proportion of the volatile solvent becomes entrapped and cannot evaporate with the result that the asphalt cement remains soft and tends to bleed or flush to the surface excessively. Such a pavement is deficient in resistance to excessive internal movement and tends to rut and shove under traffic. This type of cold mix pavement also has the disadvantages of

not having requisite stability immediately after laying.

It is a purpose of this invention to afford a cold mix type of pavement which avoids the defects of cold mix pavements heretofore proposed. It is a further purpose of this invention to afford a cold mix paving method which has the advantages of good stability immediately after laying and of durability and denseness of the order of hot mix pavements and which at the same time has the advantages of easy handling and storing of cold mix types of pavements.

It is a feature of this invention that in a process wherein a binder is applied to the aggregate in the form of two component parts, one component being a flux oil and the other component a powdered hard bitumen adapted to amalgamate gradually with the flux oil, a paving bituminous cement is also used, the paving bituminous cement being commingled with the flux oil, to form a friable composition comprising aggregate particles carrying unamalgamated powdered hard bitumen and flux oil together with paving bituminous cement commingled with the flux oil. I have found that a bituminous cement can be used for example when heated above its softening point in the manner mentioned and notwithstanding that the cement tends to become hardened at ordinary atmospheric temperature the mixture retains the advantages of good workability at relatively low temperatures that are incident to cold mix methods of pavement construction. At the same time the pavement is greatly improved as to stability immediately after laying and compaction. Moreover this method makes available in cold mix pavements high ductility paving asphalt cements and enables cold mix pavements to be manufactured that are of improved ductility and wearing qualities.

By referring to paving bituminous cement reference is made to those adhesive bituminous binders which are quite hard at ordinary temperatures and which are generally used in the manufacture of pavements by the hot mix methods wherein the bituminous cement is applied to aggregate in a heat liquefied condition. Such paving bituminous cements are commonly supplied in various ranges of penetration, the more usual ranges being between about 50 to about 120 penetration. (The A. S. T. M. penetration test using 100 grams, 5 secs. at 77° F. is referred to throughout this specification.) The penetration of paving bituminous cement does not run lower than about 20 or above about 300. The term paving bituminous cement includes the ordinary asphalt paving cement and other bituminous materials having corresponding softening point or penetration.

By non-volatile flux oil reference is made to those oils, generally derived from petroleum, that are characterized by being of fluid character (as distinguished from a bituminous cement solid at atmospheric temperatures) and that have the capacity to flux or blend with harder bituminous materials used in the present process such as, for example, powdered hard asphalt. Flux oils vary from oils that are quite fluid at ordinary temperatures to those which flow quite slowly at ordinary temperatures and which, if desired, can be heated somewhat to make them flow more readily. The flux oils that are preferably used in the practice of this invention will be described more in detail hereinbelow.

The powdered hard bitumen referred to above is bituminous material that is so hard and non-

adhesive at ordinary temperatures that it can be reduced to a powdered form. This material has a low penetration ranging from 0 to about 5.

In carrying out this invention it is not necessary that the paving bituminous cement be adapted to blend or amalgamate with either the powdered hard bitumen or the flux oil and in the practice of some of the modification of this invention it is preferable that the paving bituminous cement amalgamates only slightly with the flux oil at least before the flux oil amalgamates with the powdered hard bitumen. For this reason one can select a paving bituminous cement to obtain optimum properties of ductility and toughness. The flux oil and powdered bitumen that are used should be selected so that they will amalgamate with each other to form a stable bituminous binder upon laying and consolidation in place. As to the selection of complementary pairs of flux oil and powdered bitumen appropriate for proper amalgamation with each other reference is made to the patents of Alfred R. Ebberts No. 1,937,749 and 2,067,264.

In order that this invention and the practice thereof may be better understood it will be described in connection with a specific example that has proved to be satisfactory in practice. According to this example mineral aggregate of desired size was mixed in a mechanical mixer so as to receive a total of about 8% of bituminous material and after mixing the mixture was taken to the point of use and laid and was rolled or thrown open to traffic to consolidate it in place. The paving asphalt cement consisted of 92 penetration asphalt derived from petroleum and constituted 4% of the final mixture or 50% of the total bituminous binder. The asphalt cement was reduced to a molten condition by heating to about 325° F. To the molten asphalt cement the flux oil was added at a temperature of about 125° F., the mixing being only sufficient to distribute the flux oil in the molten paving asphalt. In the resultant mixture the paving asphalt and flux oil formed a rather stringy mixture without complete mutual solution or amalgamation between these two components of the binder. The flux oil constituted about 2.2% of the entire mix or about 27% of the total bituminous binder and consisted of flux oil having a viscosity Furol of about 600 to 800 seconds at 122° F. and exhibiting a loss of less than 5% on heating 50 grams for 5 hours at 325° F.

As soon as the paving asphalt cement and flux oil were admixed in the manner aforesaid, the admixture was applied to the previously dried aggregate at a temperature of about 100° F. while the aggregate was in the mixer and mixing was continued until the aggregate was coated. Thereafter the powdered asphalt at atmospheric temperature e. g., about 70° F. was mixed in, the powdered asphalt being about 1.8% of the composition or about 23% of the total bituminous binder. The powdered asphalt had a penetration of approximately 1 and the mixing was continued only for a short time, e. g. 10 to 20 seconds. The flux oil and powdered asphalt in the quantities used were adapted upon amalgamation to form a bituminous cement having a penetration in the neighborhood of 100. It may be noted that the bituminous cement resulting from the amalgamation of the flux oil and powdered hard bitumen constituted approximately 50% of the total bituminous binder in the finished pavement and that the paving bituminous cement added to the flux oil also con-

stituted approximately 50% of the total bituminous binder in the finished pavement.

The composition prepared as above described was easily workable and could be satisfactorily transported and laid. Upon application of pressure by a roller or by traffic the pavement exhibited pronounced stability, both initially because of the initially stable bituminous binder present in the form of paving asphalt, and permanently because of the binder formed by the amalgamation of the flux and powdered hard asphalt. The stability was of the order of that obtained upon cooling a hot mix type of road composition and was a great improvement upon cold mix compositions using flux oil and powdered asphalt alone or using paving asphalt cement cut back with volatiles.

While the foregoing constitutes a preferred illustration of the practice of this invention it is apparent that the process of the specific example above given can be varied without departing from the scope of the invention. Thus the amount and penetration of the paving bituminous cement may be varied considerably to control during mixing and laying the stiffness of the mix and the rapidity of the setup of the mix after laying. One of the advantages of this invention is the control that is possible over conditions of mixing and laying and over the characteristics of the finished pavement. One of these controls can be exercised merely by varying the relative proportion of paving bituminous cement used in the binder. In general the greater the amount of the paving bituminous cement the greater will be the stiffness of the composition in the mixer and the quicker will be the setup and pavement stability after the composition has been laid. The advantage of the quick setup after laying has been commented upon above. The control of the stiffness during mixing is likewise advantageous. When a flux oil and powdered asphalt are used alone the flux oil sometimes tends to scrub off the aggregate, particularly off the coarser part of the aggregate, so that non-uniformity of coating results. By use of the paving bituminous cement the consistency of the material applied to the aggregate can be controlled while still retaining friability and more uniform coating of the aggregate secured. Especially when the total amount of bituminous binder is relatively high in proportion to the aggregate the improved consistency obtained by incorporating the paving asphalt mixed but not completely amalgamated with the flux oil is advantageous in obtaining uniform coating of the aggregate particles.

Referring to the foregoing example, the bituminous binder in the completed pavement, which was a combination of the paving cement resulting from substantially complete amalgamation of the flux oil and powdered hard bitumen together with the added paving bituminous cement mixed with the flux oil, had a penetration of the same order as the penetration of these two bituminous cements, namely, slightly under 100. If it is desired to vary the penetration of the composite binder in the completed pavement this can be readily accomplished by varying the relative proportions of the flux oil and powdered asphalt. Thus to decrease the penetration of the composite binder more of the powdered asphalt and less of the flux oil are used and conversely to increase the penetration of the composite binder more of the flux oil and less of the powdered asphalt are used. This control of the characteristics of

the ultimate binder is another distinct advantage of this invention. It is to be noted that the penetration of the ultimate composite binder in the finished pavement can be varied independently of the variations in the stiffness of the composition during mixing and the rapidity of setup. So far as I am aware such relative control has not been possible in connection with paving methods heretofore known.

In good practice the amount of paving bituminous cement that is used varies from about 20% to about 60% of the total bituminous binder and in preferred practice from about 30% to about 50% when relatively coarse aggregate is used, such as when, for instance, about 30% of the aggregate is $\frac{1}{4}$ " stone or larger. When "sheet" aggregates, or those consisting largely of particles passing a 10 mesh screen are used, the amount of paving bituminous cement used varies from about 10% to 50% of the total bituminous binder, preferably not being over about 40%.

The penetration of the paving bituminous cement that is used may vary considerably, i. e. from about 20 to as high as 300 depending upon the type of pavement being manufactured and the amounts and characteristics of the flux oil and powdered bitumen that are also used. For the usual types of road pavements I prefer to use paving bituminous cements having a penetration of about 40 to about 120. When the penetration of the paving bituminous cement is in the lower part of the range indicated above it is usually preferable to employ somewhat less of the paving bituminous cement in proportion to the amount of the binder that is added in the divided form of flux oil and powdered hard bitumen. I prefer to employ paving bituminous cement produced in the refining of petroleum. However, other bituminous materials or asphalts may be used such as tar, pitch, natural asphaltic materials and the like.

Any good grade of flux oil may be used in the practice of this invention. Preferably non-volatile flux oils produced by petroleum refining from any good asphaltic base crudes are used, although other bituminous flux oils such as those derived from mixed base crudes or tars may be employed. The viscosity range of oils that may be selected vary quite widely between about 100 and 2500 seconds Furol at 122° F. In preferred practice the viscosity of the oil used usually varies from about 200 to 1600 seconds Furol at 122° F.

Usually it is desirable that the flux oil constitutes at least about 20% of binder in order to get good workability of the mixture during mixing and good coating of the aggregate. The amount of powdered bitumen that is used is sufficient to amalgamate with the flux oil to form a bituminous cement of the paving grade. The amount of powdered bitumen has been varied from about half to twice the amount of flux oil used. In general it is desirable to use a mixture of flux oil and powdered bitumen that will amalgamate with each other and that will when substantially completely amalgamated form a binder cement with a penetration test of about 50 to about 120, although a wider range is permitted under certain circumstances, e. g. about 20 to 200. A test for determining the capacity of the flux oil and powdered bitumen to amalgamate with each other is described on page 4 of the Ebberts Patent No. 1,937,749 above referred to. In order that the amalgamation may take place at proper rate the powdered hard bitumen is preferably

such that 50% will pass an 80 mesh screen and 95% shall pass a 20 mesh screen although coarser material, e. g. passing a 10 mesh screen may be used.

As aforesaid the binder derived from the flux oil and powdered bitumen constitutes for good practice at least 40% of the total bituminous binder and preferably constitutes about 50% to 60% of the total bituminous binder.

It is not essential that the penetration of the binder resulting from the amalgamation of the flux oil and powdered hard bitumen correspond with the penetration of the paving bituminous cement component of the binder. It is usually preferable however to use a paving bituminous cement that has a penetration approximating that desired in the ultimate pavement and to use a flux oil and powdered bitumen mixture which yields a bituminous material that has approximately the same penetration or differs by about 10 to 20 points therefrom. However, if one is limited as to the type of paving bituminous cement that is available and one must use a paving bituminous cement that has either a higher or lower penetration than the required penetration of the total binder in the finished pavement, it is advantageous that the presence of a bituminous cement of too low penetration can be compensated for by using a flux oil and powdered asphalt binder the penetration of which when amalgamated is higher than desired for the total binder in the pavement and compensates for the too low penetration of the bituminous paving cement so as to obtain the desired penetration in the finished pavement; and the converse is also true.

While it is to be preferred, it is not essential that the flux oil and paving bituminous cement be premixed previous to application of the paving bituminous cement to the aggregate. Thus substantially the same effect but to a lesser degree can be produced by mixing the flux oil and paving bituminous cement on the aggregate particles. To illustrate, the flux oil and paving bituminous cement may be added separately to the aggregate in the mixer, the powdered hard bitumen preferably being added after the incorporation of one or the other or both of the other bituminous ingredients. While in such case it is preferable that the paving bituminous cement be applied to the aggregate either substantially simultaneously with flux oil or after flux oil has been applied to the aggregate, the paving bituminous cement in a heat liquefied condition may be satisfactorily added at any stage of the mixing operation under certain conditions. In the first place, sufficient mixing time should be allowed, if the flux oil and paving bituminous cement are added separately, to permit good commingling of these materials on the aggregate, preferably while the paving bituminous cement is still in a heat liquefied condition. In the second place, sufficient of the flux oil unamalgamated with powdered hard bitumen should be present during the mixing so that the mass remains in a friable condition because of the occurrence of the paving bituminous cement in a commingled state with flux oil and because of the presence of a substantial amount of the powdered hard bitumen in an unamalgamated and non-adhesive condition. However, while it is possible to add the paving bituminous cement and the flux oil separately and commingle them on the aggregate as aforesaid, the procedure is less desirable than premixing these materials before application to the ag-

gregate because the bituminous coating for the aggregate is usually less uniform than when the flux oil and paving bituminous cement are premixed and because the paving bituminous cement frequently tends to ball up and form small lumps throughout the aggregate. It is also possible to apply paving bituminous cement in an emulsified condition and remove excess water and commingle it as thus added with flux oil and powdered hard bitumen but this method is much less desirable than the other methods described herein.

The temperature during mixing should as aforesaid preferably be below that which tends to prematurely cause a melting of the bituminous components together prior to laying. For this reason customary hot mix temperatures, e. g. 225° F. to 375° F. are avoided. When the flux oil and powdered asphalt blend quite gradually mixing temperatures as high as about 200° F. may be used in the practice of this invention; and especially in cold weather or when an abnormally viscous flux oil is used fairly high temperatures below about 200° F. may be employed. In preferred practice, however, temperatures which are usually below the softening point of the paving bituminous cement, e. g. ranging from normal summer temperatures to about 140° F. are employed during mixing thereby taking full advantage in mixing the materials of avoiding the expense and inconvenience of working at higher temperatures while still retaining workability and friability of the composition. To produce uniform coating of the aggregate the aggregate is preferably at approximately the same temperature throughout.

The aggregate that is used is generally a graded mineral aggregate consisting of sand, crushed stone, stone screenings, slag, or gravel, or a combination of these. Aggregates of usual particle size ranging from sand and the like to relatively coarse stone, e. g. about 1½ inch may be included. When the aggregate contains a high percentage of fines, e. g. sand or screenings, it is preferable to select a paving asphalt cement of relatively high penetration, e. g. from over 85 to about 200. When filler is used such as powdered limestone, fine sand or the like, the filler may be present during mixing although it is usually preferable to add the filler after the flux oil and paving bituminous cement have been applied to the aggregate. If desired, any filler that is used can be added with the powdered hard bitumen. In carrying out the processes above described the aggregate becomes coated substantially uniformly throughout so that in preferred practice each of the aggregate particles carries a similar coating of powdered hard bitumen unamalgamated with flux oil and paving bituminous cement commingled with flux oil.

Other examples of the practice of this invention are as follows:

An amount of coarse aggregate, consisting of quarter inch stone and comprising 50% of a total aggregate, was placed in a mixer at a temperature of 125° F. To the stone a quantity of flux oil at a temperature of 125° F. was added, and mixing was continued for a short time, whereupon paving asphalt of 90 penetration liquefied by heating to a temperature of 325° F. was added and was commingled with the flux oil on the coarse aggregate by mixing, the paving asphalt cement by this operation being commingled with the flux oil during the application of the paving asphalt cement to the aggregate. The remainder of the aggregate, consisting of sand and filler,

was then added and mixing was continued until all was thoroughly coated, when powdered asphalt was mixed in. The flux oil, which was about 800 sec. viscosity Furol at 122° F. comprised 3.0% of the total mixture or 37% of the binder material, the asphalt cement comprised 2.7% of the total mixture or 33% of the binder material and the powdered asphalt comprised 2.4% of the mixture or 30% of the binder. It was found that by virtue of the paving asphalt cement being mixed with relatively liquid flux oil on the coarse aggregate, it was possible to coat the total aggregate, including the fines, easily and at a low temperature. In this example and in the following two, the flux and powdered asphalt were used in such proportions as to give upon substantially complete amalgamation a bituminous cement having a penetration of about 80. The paving composition was friable until compacted, and then formed a firm mass bound by both the paving asphalt cement and the cement formed by the amalgamation of the flux and powdered asphalt.

As another example, an amount of flux oil at a temperature of 125° F. was added to paving asphalt cement at a temperature of about 300° F., and the resulting mixture was immediately added, after very little stirring, to aggregate in a mixer. When the aggregate particles were thoroughly coated with the mixture, powdered asphalt was added and mixed with the coated aggregate. The paving asphalt cement comprised 3.3% of the total mixture or 30% of the binder, the flux oil comprised 4.2% of the mixture or 38% of the binder, and the powdered asphalt comprised 3.5% of the mixture or 32% of the binder. When it was desired to prepare a mixture in which only fine aggregate, consisting of sand and filler should be used, but which should have more stability than most cold mixes and yet should handle easily and store well, a mixture was made in the example above, but in which the asphalt cement comprised 1% of the total mixture or 13% of the binder, the flux comprised 3.7% of the mixture or 48% of the total binder, and the powdered asphalt comprised 3% of the mixture or 39% of the binder. The aggregate in this mixture was not as firmly or heavily coated with bituminous materials as that in the preceding examples, but the mixture was much more stable immediately after compaction than a similar mixture in which no paving asphalt cement was employed.

In the practice of this invention and as exemplified by the foregoing examples the paving bituminous cement is commingled with the flux oil as applied to the aggregate particles and notwithstanding the fact that the paving bituminous cement would be quite stiff at the temperature occurring during mixing, the commingled materials together with the powdered hard bitumen satisfactorily and readily coat the aggregate at such temperatures. In fact the coating that is obtainable is more complete and more uniform than when flux oil and powdered asphalt are used by themselves and forms thicker films than when paving asphalt cement is applied by itself under hot mix conditions.

Maximum workability at any given temperature is obtained when the flux oil and paving asphalt are commingled on the aggregate or are applied to the aggregate promptly after having become commingled. This is because the flux oil and paving asphalt cement do not immediately blend or amalgamate with each other but are merely commingled with retention in large degree of the

free flowing and coating characteristics of the flux oil and these conditions are preferred in the practice of this invention. Moreover, when the flux oil is not completely blended with the paving bituminous cement the flux oil more actively tends to blend or amalgamate with the powdered hard bitumen.

As mentioned above the capacity of the paving bituminous cement to flux or blend either with the flux oil or with the powdered hard bitumen is not essential. In fact, it is preferable that the paving bituminous cement have little solubility either with the flux oil or with the powdered hard bitumen as under these conditions optimum workability during mixing and laying is obtained. Since many of the paving bituminous cements which have very high ductility e. g. 100 plus at 77° F. A. S. T. M. test and which have superior wearing properties in the finished road have little if any solvent power for powdered hard bitumen at low temperatures, it is preferable in the practice of this invention to select such materials both from the point of view of workability during mixing and laying and from the point of view of obtaining desired characteristics in the ultimate pavement. Since, however, the paving bituminous cements have very little solvent power for powdered hard bitumen, the flux oil that is used should be of such character and quantity as to blend with the powdered hard bitumen to produce a bituminous cement of desired penetration.

In the practice of this invention the presence of volatile solvent for the powdered bitumen or paving bituminous cement is undesirable. It has been mentioned above that any volatile solvent that is present during laying is undesirable because it is injurious in the pavement and cannot be driven off from a pavement of desirable density. It is one of the advantages of the present invention that pavements of high density can be manufactured which are resistant to internal movement after the laying and consolidation. The presence of volatile solvent during the mixing of the materials is also undesirable because the presence of the solvent promotes mutual solubility of the flux oil and powdered hard bitumen and while the volatile solvent has a somewhat thinning action on the bituminous material this is counteracted by the premature setting up effect that results from premature amalgamation of the intermingled components of the bituminous binder. While substantially complete absence of constituents volatile at ordinary temperatures is much to be preferred some of the advantages of this invention can be achieved even though a small amount of volatile material such as kerosene, naphtha or the like is present, e. g. about 5% of the total binder material and preferably less than 3%. In such case premature solvent action is not excessive and the presence of the small amount of solvent in the finished pavement, even if the pavement is dense, will not result in excessive bleeding of the pavement, or excessive rutting. If any volatile matter is present during mixing it is least harmful when present in the paving bituminous cement upon application of the paving bituminous cement to the aggregate. If any volatile matter is present it is preferable to keep mixing temperatures low to avoid premature amalgamation of the bitumen components during the mixing thereof with the aggregate and it is preferable to use slightly more powdered hard bitumen than would be used in the absence of any volatile material to counteract the presence of any volatile material that may remain en-

trapped in the finished pavement for a considerable period of time.

While it is ordinarily preferable to mix the materials in a mechanical mixer such as the ordinary pug mill mixer, the pavement can be mixed in place on the road foundation. In such case it is usually desirable to preliminarily dry the aggregate and the drying may be assisted by the use of a drag or blader. When the paving composition is mixed it is usually desirable that conditions be such that ease of mixing is promoted as by using a paving bituminous cement that has a somewhat higher penetration than that employed for plant mix work or as by using slightly more flux or a flux of lower viscosity. The mixing in of the flux oil, paving bituminous cement, and powdered hard bitumen with the aggregate can be accomplished in any suitable way as by the use of bladers, drags, or the like.

It is an advantage of this invention that no expensive or special apparatus is required, that the method of mixing is economical, and that the materials used are readily available.

While mention has been made of the manufacture of a composition suitable for the manufacture of road pavements, it is apparent that the method described herein can be used in the manufacture of other pavements (the term being used broadly) including but without limitation such pavements as sidewalks, levee linings, roofs, asphalt blocks, and the like.

While this invention has been described in connection with certain exemplifications of the practice thereof this has been done for the purpose of affording a better understanding thereof, it being understood that variations in the practice thereof may be made without departing from the scope of the invention. In fact it is one of the advantages of this invention that the paving method can be varied so as to achieve control of the mixing consistency and the coating of the aggregate as well as the penetration and initial stability of the completed pavement while retaining the mass in a physical state such that the composition, notwithstanding the presence therein of substantial quantities of paving bituminous cement, can be readily mixed, stored, transported and laid at relatively low temperatures. The scope of my invention is therefore to be governed by the language of the following claims construed in the light of the foregoing description of my invention.

I claim:

1. In a method of making a paving composition, the steps comprising utilizing a normally solid paving bituminous cement, powdered hard bitumen and a substantially non-volatile flux oil having a viscosity Furol at 122° F. between 100 and 2500 seconds and constituting at least about 20% of the bituminous binder material in the composition, commingling said paving bituminous cement in a heat-liquefied condition with said flux oil, coating the aggregate particles with the flux oil and paving asphalt cement while the flux oil acts as a carrier for paving bituminous cement unamalgamated therewith, and then incorporating the powdered hard bitumen and distributing it throughout the mass, thereby forming a paving composition wherein the aggregate particles substantially uniformly throughout the mass are coated with the flux oil containing paving bituminous cement unamalgamated with the flux oil and containing powdered hard bitumen that is unamalgamated with the flux oil and paving bitu-

minous cement, said composition being adapted upon consolidation in place and upon amalgamation of the flux oil and powdered hard bitumen to produce a pavement resistant to internal movement in which aggregate particles are bonded both by the paving bituminous cement and by the cement resulting from the amalgamation of the flux oil and the powdered bitumen.

2. In a method of making pavements or the like, the steps comprising utilizing a normally solid paving bituminous cement having approximately the penetration desired for the binder in the completed pavement together with a substantially non-volatile bituminous flux oil and powdered hard bitumen, the said bituminous flux oil and powdered hard bitumen being adapted to gradually amalgamate to form a bituminous cement having approximately the penetration desired for the binder in the completed pavement and said flux oil having a viscosity Furol at 122° F. between 200 and 1200 seconds, and mixing said paving bituminous cement while above its softening point with said non-volatile flux oil to commingle said flux oil and paving bituminous cement without complete amalgamation of the mixture, coating the aggregate particles with the mixture of commingled flux oil and paving asphalt cement, and adding said powdered hard bitumen, thereby forming a friable composition containing the aggregate particles coated substantially uniformly with the commingled and incompletely amalgamated flux oil and paving bituminous cement together with particles of powdered hard bitumen unamalgamated with either the flux oil or paving bituminous cement, said flux oil plus said powdered hard bitumen constituting at least about 40% of the total bituminous material in the composition and said paving asphalt cement constituting at least 20% of the total bituminous material.

3. A method comprising the steps according to claim 2 wherein the amount of said powdered hard bitumen is about half to about twice the amount of said flux oil.

4. In a method of making pavements or the like, the steps comprising utilizing paving bituminous cement having a penetration of about 20 to 300, together with a substantially non-volatile flux oil and powdered hard bitumen, the said bituminous flux oil and powdered bitumen being adapted to gradually amalgamate to form a bituminous cement having a penetration of about 40 to 200 and said flux oil having a viscosity Furol at 122° F. between 100 and 2500 seconds; and mixing the paving bituminous cement in heat-liquefied condition with the flux oil to commingle said paving bituminous cement with said flux oil, coating the aggregate particles with the admixture of commingled flux oil and paving bituminous cement and adding said powdered hard bitumen, thereby forming a paving composition that is friable at temperatures below the softening point of the paving bituminous cement and that contains said commingled flux oil and paving bituminous cement together with powdered hard bitumen unamalgamated with either the flux oil or paving bituminous cement; said unamalgamated flux oil and powdered hard bitumen upon laying and consolidating the friable composition in place being adapted to amalgamate with each other in situ to solidify the composition in the form of a pavement wherein the aggregate particles are bound in conjoined relationship by a bituminous binder comprising the said paving bituminous cement together with the bituminous

cement resulting from the amalgamation of the flux oil with the powdered hard bitumen.

5. A method according to claim 4 wherein said paving bituminous cement has a penetration between about 40 and about 120 and wherein said substantially non-volatile bituminous flux oil and powdered hard asphalt are adapted to amalgamate to form a bituminous cement having a penetration between about 50 to about 120, the powdered hard bitumen being about one-half to twice the amount of said flux oil, and said flux oil having a viscosity Furol at 122° F. between 200 and 1200 seconds.

6. A method according to claim 4 wherein the powdered hard bitumen is about one-half to twice the amount of the substantially non-volatile bituminous flux oil, said flux oil has a viscosity Furol at 122° F. between 200 and 1200 seconds, the bituminous cement formed by amalgamation of the flux oil and powdered hard bitumen constitutes at least about 40% of the total bituminous cement in the completed pavement, and said paving asphalt cement constitutes at least 20% of the bituminous cement in the completed pavement.

7. In a method of making pavements or the like, the steps comprising utilizing paving bituminous cement having a penetration of about 20 to 300 together with a substantially non-volatile bituminous flux oil having a viscosity Furol at 122° F. of about 100 to 2500 seconds and powdered hard bitumen having a penetration of about 0 to 5, the powdered hard bitumen being about half

to about twice the amount of flux oil and being adapted to gradually amalgamate with the flux oil to produce a bituminous binder cement which has a penetration of about 40 to 200 and which constitutes at least about 40% of the total bituminous material in the pavement; and mixing the paving bituminous cement in heat-liquefied condition with the flux oil to commingle said paving bituminous cement with said flux oil, coating aggregate particles while the aggregate is at a temperature below 200° F. with the admixture of commingled flux oil and paving bituminous cement, and adding said powdered hard bitumen, thereby forming a paving composition that is friable and that contains said commingled flux oil and paving bituminous cement together with powdered hard bitumen unamalgamated with either the flux oil or paving bituminous cement; said unamalgamated flux oil and powdered hard bitumen, upon laying and consolidating the friable composition in place, being adapted to amalgamate with each other in situ to solidify the composition in the form of a pavement wherein the aggregate particles are bound in conjoined relationship by a bituminous binder comprising the said paving bituminous cement together with the bituminous cement resulting from the amalgamation of the flux oil with the powdered hard bitumen, and any component of the bituminous binder materials that is volatile at ordinary temperatures being not more than 5% of the total of said bituminous binder materials.

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