SPECIFICATION

ASPHALT MODIFIER AND ASPHALT MIXTURE

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

The present invention relates to asphalt modifiers and asphalt mixtures comprising the same and, more particularly, to an asphalt modifier to be advantageously used in a high-function pavement, such as an open-graded pavement.

2. BACKGROUND ART

Recently, a high-function pavement, imparted with a function such as water permeability or a noise reducing ability, has come to attract the attention of those skilled in the art. For example, for the purpose of securing favorable water drainage during rainfall, an open-graded pavement that has water permeability due to the voids present in the asphalt mixture has attracted the attention thereof. Further, for the purpose of reducing the noise caused by the passage of cars, an open-graded pavement that aims at noise reduction due to the voids present in the asphalt mixture has also attracted the attention of those skilled in the art. In such open-graded pavements, a modifier comprising a resin, for example, is added in many cases, since the amount of asphalt to be used as a binder per unit volume can be smaller by such an addition of a modifier. Also by the addition thereof, the physical properties of the

asphalt mixture, such as wear resistance, impact resistance, and flow resistance, can be enhanced.

As an ordinary method of producing the asphalt mixture, a plant-mix method (hereinafter referred to also as "plant-mixing") is known, in which the asphalt modifier is added at the time of production of the asphalt mixture at an asphalt plant. According to the plant-mix method, an appropriate amount of the asphalt modifier may be added to the asphalt. Further, it is not necessary to install a specific apparatus or the like for pre-mixing the asphalt and the asphalt modifier. Under these circumstances, the plant-mix method has many advantages over a pre-mix method (hereinafter referred to also as "pre-mixing") in which the asphalt modifier is previously added to the asphalt.

In the plant-mix method, it is important to mix the asphalt and the asphalt modifier in a short period of time when producing the asphalt mixture. In this connection, in order to enhance the solubility (or compatibility) of the asphalt modifier in the asphalt, the asphalt modifier is proposed in which a block copolymer of a vinyl aromatic hydrocarbon and a conjugated diene, a tackifying resin, and a process oil, are mixed together (refer to Patent Document 1). Further, among such asphalt modifiers as described above, an asphalt modifier is proposed in which workability at the time of production or storage stability are enhanced (refer to Patent Document 2).

Patent Document 1: JP-A No. 5-295273; and

Patent Document 2: JP-A No. 9-25416.

With an increase in demand for a high-function asphalt, an asphalt modifier is required that is excellent in workability and storage stability, and that can enhance physical properties such as wear resistance, impact resistance, and flow resistance.

SUMMARY OF THE INVENTION

The present invention has been achieved under these conditions. An object of the present invention is to provide an asphalt modifier that not only has an excellent solubility in asphalt, but that also has excellent workability and storage stability. Another object of the present invention is to provide an asphalt modifier that can enhance physical properties such as wear resistance, impact resistance, and flow resistance. Still another object of the present invention is to provide an asphalt modifier that allows reclaimed aggregate, obtained from the waste material of an existing pavement, to be utilized again in a high-function pavement. Previously, reclaimed aggregate has been difficult to apply to high-function asphalt through the use of conventional techniques.

In order to achieve the aforementioned objects, according to a first aspect of the present invention, there is provided an asphalt modifier comprising a block copolymer

of a vinyl aromatic hydrocarbon and a conjugated diene having a melt flow value of less than 15 g/10 minutes. The asphalt modifier further comprises, from 0 parts by weight to 100 parts by weight of a tackifying resin and from 5 parts by weight to 100 parts by weight of a process oil, based upon 100 parts by weight of the block copolymer. The asphalt modifier may still further comprise 40 parts by weight or less of a rubber based on 100 parts by weight of the entire amount of the block copolymer, the tackifying resin and the process oil. The term "melt flow value" as used in the first aspect of the present invention is intended to mean a value measured in accordance with the method specified in JIS K 7210, "Testing Methods for Fluidity of Thermoplastic Plastics." The melt flow value is obtained under conditions in which the testing temperature is 200°C and the testing load is 49.03 N. Further, the term "40 parts by weight or less of a rubber" as used herein is intended to include 0 parts by weight of rubber, namely, a case in which no rubber is contained.

The asphalt modifier according to the first aspect of the present invention is excellent in workability and handling properties. By adding the asphalt modifier, physical properties such as wear resistance, impact resistance, and flow resistance of the asphalt mixture can be further enhanced.

According to a second aspect of the present invention, an asphalt modifier is provided according to the first aspect

of the present invention in which the content of the aromatic component in the process oil is in a range from 20% to 60%, and further, the dynamic viscosity of the process oil at 40°C is in a range from 70 mm^2/s to 900 mm^2/s. When the content of the aromatic component and the dynamic viscosity of the process oil are in the aforementioned ranges, the shape-holding ability of the asphalt modifier is improved and the handling properties or workability of the asphalt modifier can further be enhanced.

According to a third aspect of the present invention, there is provided an asphalt composition that is produced by mixing the asphalt modifier, according to the first or second aspect of the present invention, with asphalt. The term "asphalt" as used herein is intended to mean asphalt as a binder for the purpose of binding aggregates such as pebbles or fillers (hereinafter also referred to as "aggregates" as a whole) to one another.

Herein, modified asphalt in which the asphalt modifier and the asphalt are blended with each other is called an "asphalt composition". Further, a composition in which the asphalt modifier, the asphalt, and any one of the aggregates are mixed together is called as an "asphalt mixture". Ordinarily, pavement is achieved by paving a road with the asphalt mixture.

In the case of a plant-mix method, the asphalt mixture is produced at the asphalt plant. The asphalt modifier is added

at the asphalt plant. Whereas, in the case of a pre-mix method, the asphalt and the asphalt modifier are mixed to prepare the asphalt composition and then the asphalt mixture is produced by mixing any one of the aggregates to the thus-prepared asphalt composition.

According to a fourth aspect of the present invention, there is provided an asphalt mixture that is produced by mixing the asphalt modifier, according to the first or second aspect of the present invention, the asphalt, and any one of the aggregates. The asphalt mixture is excellent in physical properties such as wear resistance, impact resistance, and flow resistance. Even when the amount of the asphalt per unit volume is small, the asphalt mixture can result in a pavement having the same or a higher physical strength than a conventional asphalt mixture. Therefore, the asphalt mixture according to the present invention is particularly suitable for a high-function pavement, such as an open-graded pavement.

According to a fifth aspect of the present invention, there is provided the asphalt mixture according to the fourth aspect of the present invention in which reclaimed aggregate obtained from the waste material of an existing pavement is used as one of the aggregates. By this condition, the reclaimed aggregate obtained from the waste material of existing asphalt pavement can more effectively be utilized. Conventionally, the reclaimed aggregate has been difficult to utilize in a

high-function pavement. Furthermore, since the asphalt mixture according to the present invention is excellent in toughness and tenacity, even when reclaimed aggregate is used, the asphalt mixture has the characteristic that the reclaimed aggregate is rarely stripped off or removed from the asphalt mixture.

According to a sixth aspect of the present invention, there is provided a method for producing an asphalt mixture by mixing the asphalt modifier, according to the first aspect or the second aspect of the invention, the asphalt, and any one of the aggregates, by a plant-mix method. Since the asphalt modifier according to the present invention has excellent solubility in the asphalt, the asphalt modifier can be rapidly mixed in the asphalt. Therefore, the asphalt modifier is particularly suitable for production of an asphalt mixture produced by the plant-mix method.

According to the present invention, an asphalt modifier can be provided that has excellent solubility in the asphalt, and further, excellent workability, storage stability, and the like. Additionally, an asphalt modifier can be provided that can further enhance physical properties such as wear resistance, impact resistance, and flow resistance. Further, an asphalt modifier can be provided that allows a reclaimed aggregate obtained from the waste material of existing pavement to be utilized again in a high-function pavement. Conventionally,

the reclaimed aggregate has been difficult to apply to high-function asphalt.

DETAILED DESCRIPTION OF THE INVENTION

An asphalt modifier according to the present invention enhances physical properties such as wear resistance, impact resistance, and flow resistance of an asphalt mixture by being added to asphalt. The asphalt modifier comprises a block copolymer of a vinyl aromatic hydrocarbon and a conjugated diene having a melt flow value of less than 15 g/10 minutes. The asphalt modifier further comprises from 0 parts by weight to 100 parts by weight of a tackifying resin, and from 5 parts by weight to 100 parts by weight of a process oil, based upon 100 parts by weight of the block copolymer. The asphalt modifier may still further comprise 40 parts by weight or less of a rubber, based upon 100 parts by weight of the entire amount of the block copolymer, the tackifying resin and the process oil. Hereinafter, each of such components as described above is described in more detail.

[Block copolymer of vinyl aromatic hydrocarbon and conjugated diene]

According to the present invention, there is no particular restriction as for a block copolymer of a vinyl aromatic hydrocarbon and a conjugated diene (hereinafter referred to also as "block copolymer"), so long as it can

ordinarily be used as a material to be added to asphalt. For example, block copolymers are permissible which are partially or completely hydrogenated or modified by a modifier such as maleic anhydride. Specifically, an SBS (styrene-butadiene block copolymer), an SIS (styrene-isoprene block copolymer), an SEBS (styrene-ethylene-butylene block copolymer) and the like, can be used.

Ordinarily, for example, a block copolymer that has at least one, preferably two, polymeric blocks (A), each comprising a vinyl aromatic hydrocarbon as a main component, and at least one polymeric block (B), comprising a conjugated diene as a main component, can be used.

The polymeric block (A), comprising a vinyl aromatic hydrocarbon as a main component, is a polymeric block having a vinyl aromatic hydrocarbon in an amount of over 50% by weight, preferably from 60% by weight to 100% by weight, more preferably from 70% by weight to 100% by weight, and still more preferably from 80% by weight to 100% by weight, and is also a polymeric block which is a homopolymer of a vinyl aromatic hydrocarbon or comprises a vinyl aromatic hydrocarbon and a conjugated diene. A distribution of the conjugated diene in the polymeric block (A) may be in any one of the following forms, random form, tapered form, partial block form, and combinations thereof. The polymeric block (B), comprising a conjugated diene compound as a main component, is a polymeric block having a conjugated

diene in an amount of over 50% by weight, preferably from 60% by weight to 100% by weight, more preferably from 70% by weight to 100% by weight, and still more preferably from 80% by weight to 100% by weight, and is also a polymeric block which is a homopolymer of a conjugated diene or comprises a conjugated diene and a vinyl aromatic hydrocarbon. A distribution of the vinyl aromatic hydrocarbon in the polymeric block (B) may be in any one of the following forms, random form, tapered form, partial block form, and combinations thereof.

The block copolymer may have either a linear structure or a branched structure. Preferably, the block copolymer will have a structure as represented by any one of the following general formulas (1) to (7):

(1). (A-B)m;

(2). (A-B)n-A;

(3). (B-A)m-B;

(4). ((A-B)n)p-X;

(5). ((B-A)m)p-X;

(6). ((A-B)n-A)p-X; and

(7). ((B-A)n-B)p-X.

In these general formulas, A represents a polymeric block (A), comprising a vinyl aromatic hydrocarbon as a main component; B represents a polymeric block (B), comprising a conjugated diene as a main component; X represents a residue of a poly-functional coupling agent or a residue of a

poly-functional initiator; m represents an integer of 1 or more, preferably 2 or more and more preferably from 2 to 6; n represents an integer of 1 or more, preferably from 1 to 6 and more preferably 1; and p represents an integer of from 2 to 6.

The composition ratio of the vinyl aromatic hydrocarbon to the conjugated diene in the block copolymer is not particularly limited, but in order to allow binder features such as toughness and tenacity, or low temperature characteristics, to be highly balanced, the composition ratio is in the range of from 5:95 to 95:5, preferably from 10:90 to 50:50, and more preferably from 15:85 to 45:55, in terms of a percentage by weight.

The amount of a vinyl group bonded to the conjugated diene portion of the block copolymer is not particularly limited but ordinarily is 90% or less, preferably in the range of from 1% to 60%, and more preferably from 5% to 30%. When an unduly large amount of the vinyl group is to be bonded, penetration of the asphalt composition is sometimes reduced.

The molecular weight of the block copolymer according to the present invention is not particularly limited, but in order to allow binder features such as solubility in the asphalt, penetration, toughness, tenacity, and low temperature characteristics, to be highly balanced with one another, the weight average molecular weight is in the range of from 10,000

to 1,000,000, preferably from 20,000 to 800,000, and more preferably from 50,000 to 500,000, in terms of polystyrene measured by GPC.

The block copolymer according to the present invention can be produced in accordance with a known method, for example, as described in JP-B No. 36-19286, 43-17979, 45-31951, or 46-32415, by allowing a vinyl aromatic hydrocarbon and a conjugated diene to react with each other in a hydrocarbon solvent while using an organic lithium compound as an initiator. At the time of polymerization, a polar compound can be used for the purpose of, for example, adjusting the reaction ratio between the vinyl aromatic hydrocarbon and the conjugated diene, varying the microstructure of a polymerized conjugated diene portion, and adjusting the polymerization speed.

Examples of such vinyl aromatic hydrocarbons include styrene, α-methyl styrene, o-methyl styrene, p-methyl styrene, p-t-butyl styrene, 2,4-dimethyl styrene, vinyl naphthalene, and vinyl anthracene. Among these vinyl aromatic hydrocarbons, styrene is particularly favorable. These vinyl aromatic hydrocarbons may be used either individually or in any combinations thereof.

Examples of such conjugated dienes include 1,3-butadiene, isoprene, 1,3-pentadiene, 2,3-dimethyl-1,3-butadiene, and 1,3-hexadiene. Among these conjugated dienes, 1,3-butadiene and isoprene are favorable, and 1,3-butadiene is particularly

favorable, among other things. These conjugated dienes may be used either individually or in any combinations thereof.

Examples of such hydrocarbon solvents which are each used as a polymerization solvent at the time of producing the block copolymer include aliphatic hydrocarbons such as butane, pentane, hexane, isopentane, heptane, octane, and isooctane; alicyclic hydrocarbons such as cyclopentane, methyl cyclopentane, cyclohexane, methyl cyclohexane, and ethyl cyclohexane; and aromatic hydrocarbons such as benzene, ethyl benzene, and xylene. These hydrocarbon solvents may be used either individually or in any combinations thereof. Any one of the hydrocarbon solvents is ordinarily used such that the monomeric concentration comes to be in the range of from 1% by weight to 50% by weight.

Examples of such polar compounds include ethers such as tetrahydrofuran, diethyl ether, anisole, dimethoxybenzene, and ethylene glycol dimethy ether; amines such as triethyl amine, tetramethylene diamine, N-dimethyl aniline, and pyridine; thioethers; phosphines; phosphoamides; alkylbenzene sulfonic acids; and alkoxydes such as those of potassium and sodium. These polar compounds are appropriately selected depending on required performances. Although the amount of any one of the polar compounds to be used is appropriately determined depending on the type of the compound or the required characteristics, it is ordinarily in the range

of from 0.001 mol to 1 mol, and favorably from 0.01 mol to 0.5 mol, based on 1 mol of an organic lithium compound.

A poly-functional initiator such as an organic monolithium compound or an organic dilithium compound is mentioned as the organic lithium compound to be used as the initiator. Specific examples of such organic lithium compounds include n-butyl lithium, sec-butyl lithium, tert-butyl lithium, n-hexyl lithium, iso-hexyl lithium, phenyl lithium, naphthyl lithium, hexamethylene dilithium, butadienyl dilithium, and isoprenyl dilithium. Ordinarily, organic monolithium compounds are used. For this occasion, they are used either individually or in any combinations thereof. An amount thereof to be used is appropriately selected depending upon the molecular weight of the polymer to be targeted at and the type of the organic lithium compound. For example, take the case in which n-butyl lithium is used. The n-butyl lithium is in the range of from 0.001 parts by weight to 1 part by weight, and preferably from 0.01 parts by weight to 1 part by weight, based upon 100 parts by weight of an entire monomer.

A polymerization reaction may be either an isothermal reaction or an adiabatic reaction and is ordinarily conducted at a temperature in the range of from 0°C to 150°C, and preferably from 20°C to 120°C.

As for the block copolymer, an article that is prepared

by the aforementioned polymerization reaction, and then, being added with a poly-functional coupling agent, can also be used. Examples of such poly-functional coupling agents include metallic compounds such as tin tetrachloride, tin dichloride, tin tetrabromide, silicon tetrachloride, silicon tetrabromide, silicon tetraiodide, germanium tetrachloride, lead dichloride, methyl trichlorosilane, dimethyl dichlorosilane, butyl trichlorosilane, dibutyl tin dichloride, bistrichlorosilyl ethane, bistrichlorostannyl ethane, tetramethoxysilicon, tetramethoxytin, tetraethoxysilicon, tetraethoxytin, tetrabutoxysilicon, and tetrabutoxytin; unsaturated nitriles such as ethyl acrylonitrile; dihalogenatd hydrocarbons such as dibromobenzene, dichlorobenzene, and dibromoethylene; carboxylic acid esters such as dimethyl adipate, diethyl adipate, ethyl benzoate, dimethyl terephthalate, diethyl terephthalate, dimethyl phthalate, and dimethyl isophthalate; carboxylic acid halides such as terephthalic acid dichloride, phthalic acid dichloride, isophthalic acid dichloride, and adipic acid dichloride; and carbon tetrachloride.

These poly-functional coupling agents may be used either individually or in any combinations thereof. An amount thereof to be used is ordinarily in the range of from 0.01 equivalent weight to 2 equivalent weight, preferably from 0.05 equivalent weight to 1.0 equivalent weight, and more preferably from 0.1 equivalent weight to 0.5 equivalent weight, based upon

the equivalent weight of the organic lithium compound. A coupling reaction is ordinarily conducted at a temperature in the range of from 0°C to 150°C for a time period in the range of from 1 hour to 20 hours.

As for the block copolymer, an article can be used that is partially or completely hydrogenated. Such hydrogenation is conducted by using:

(1) a heterogeneous catalyst in which a metal such as Ni, Rt, Pd, or Ru, is supported on a carrier such as carbon, silica, alumina, or diatomaceous earth;

(2) a Ziegler catalyst which uses an organic salt of Ni, Co, Fe, or Cr, or an acetyl acetone salt and a reducing agent such as an organic aluminum; or

(3) a homogeneous catalyst such as an organic complex catalyst comprising an organic metallic compound of Ru, Rh, or the like.

Ordinarily, a method is adopted in which the hydrogenation is performed in an inactive solvent in the presence of a hydrogenation catalyst, as described in JP-B No. 42-8704 or 43-6636, JP-A No. 52-41690, 59-133203, or 60-220147.

Further, an article can be used as the block copolymer that is produced by being added with a denaturing agent after the aforementioned polymerization reaction is conducted. Examples of such denaturing agents include an unsaturated carboxylic acid such as maleic anhydride as described in JP-B No. 62-61615, an imino compound, a cyanamide compound, an

aziridinyl compound, and an amide compound as described in JP-B No. 4-387770.

With reference to the block copolymer of the vinyl aromatic hydrocarbon and the conjugated diene according to the present invention, those each having a melt flow value of less than 15 g/10 minutes, under conditions in which a testing temperature is 200°C and a testing load is 49.03 N (5 kgf), are used either individually or in any combinations thereof. The term "melt flow value" as used herein is intended to mean a value of an extruding speed at which a melted thermoplastic synthetic resin is extruded through a die having given length and diameter. The melt flow value is an indicator of flowability, viscosity, dynamic viscosity, or the like, of the thermoplastic synthetic resin in a melted state.

When the melt flow value is larger than the aforementioned range, the shape-holding ability of the asphalt modifier is deteriorated; for example, grains of the asphalt modifier in pellet form adhere to one another, thereby causing a problem in long-term storage.

[Process oil]

As for the process oils according to the present invention, vegetable oils such as a rice bran oil and a soya bean oil; animal oils such as fish oils and whale oil; and petroleum heavy hydrocarbon oils such as a cylinder oil and a lubricating oil can be used. However, taking economical

efficiency, ease of distribution in the market, and the like, into consideration, it is preferable to use the petroleum heavy hydrocarbon oils, particularly, aromatic hydrocarbon oils. Process oils, each comprising a paraffin-type or naphthene-type hydrocarbon, can also be used.

The process oil in which the content of the aromatic component is preferably in the range of from 20% by weight to 60% by weight, and more preferably in the range of from 30% by weight to 55% by weight, while the dynamic viscosity value at 40°C is preferably in the range of from 70 mm^2/s to 900 mm^2/s, and more preferably in the range of from 100 mm^2/s to 900 mm^2/s, is favorable.

The term "content of aromatic component" as used herein is intended to indicate the entire content of aromatic hydrocarbons such as benzene, naphthalene, and anthracene, and derivatives thereof in which any one of various types of functional groups, such as a vinyl group, is added to any one of those aromatic hydrocarbons. The content of the aromatic component in the process oil can be measured in accordance with an ordinary method.

In the case in which the content of the aromatic component in the process oil and the dynamic viscosity value of the process oil are respectively over the aforementioned ranges, a problem is generated in that when the modifier is processed to be in pellet form, the modifier tends adhere to the

pelletizer blade, or grains of the modifier in pellet form tend to adhere to one another during a storage period; therefore, the case is not favorable. Whereas, in the case in which the content of the aromatic component in the process oil and the dynamic viscosity value of the process oil are respectively lower than the aforementioned ranges, another problem is generated in that when the asphalt modifier is processed to be in pellet form, for example, the shape-holding property of the asphalt modifier is deteriorated. A ratio of the remaining components, namely, components such as a naphthenic component and a paraffinic component other than the aromatic component is not particularly limited.

A usage of the process oil is preferably in the range of from 5 parts by weight to 100 parts by weight, and more preferably from 10 parts by weight to 75 parts by weight, based on 100 parts by weight of the block copolymer. In the case in which the usage of the process oil is very small, characteristics such as solubility in asphalt or extensibility are deteriorated. In contrast, in another case in which it the usage of the process oil is very large, characteristics such as the melting point or toughness are deteriorated; therefore, both cases are not favorable.

[Tackifying resin]

The tackifying resin according to the present invention is not particularly limited so long as the tackifying resin

is commercially used. Examples of such tackifying resins include a coumarone-indene resin, a phenol resin, a p-t-butyl phenol-acetylene resin, a phenol-formaldehyde resin, a terpene-phenol resin, a polyterpene resin, a xylene-formaldehyde resin, a C_5-type petroleum resin, a C_9-type petroleum resin, a dicyclopentadiene-type resin, polybutene, rosin and derivatives of these components, such as those hydrogenated or denatured by maleic anhydride.

These tackifying resins can be used either individually or in any combinations thereof. The usage of the tackifying resin is preferably in the range of from 0 parts by weight to 100 parts by weight, based on 100 parts by weight of the block copolymer. The minimum value 0 means that when tackiness is not particularly required in the asphalt mixture, the tackifying resin is not needed to be mixed. The usage of the tackifying resin is more preferably in the range of from 5 parts by weight to 75 parts by weight, based on 100 parts by weight of the block copolymer.

When the usage of the tackifying resin is very small, characteristics such as melting point, viscosity at 60°C, and the dynamic stability of the asphalt mixture are deteriorated. Solubility in asphalt is also diminished when the usage of the tackifying resin is very small. In contrast, when the usage of the tackifying resin is very large, characteristics of the asphalt mixture such as toughness and tenacity are

deteriorated.

[Rubber]

In the asphalt modifier according to the present invention, 40 parts by weight or less of a rubber is added, based upon 100 parts by weight of the entire amount of the aforementioned components, namely, the block copolymer of the vinyl aromatic hydrocarbon and the conjugated diene, the process oil, and the tackifying resin. For example, the rubber may be used that is ordinarily used in a commercial product. Examples of such rubbers include SBR (styrene-butadine rubber), chloroprene rubber, a natural rubber, polyisoprene rubber, polybutadiene rubber, a nirile-type rubber, ethylene-propylene rubber, an acrylic rubber, and isoprene-isobutyl rubber. The rubber may be used either in an emulsion state or in a solid state. When the rubber is used in the emulsion state, 40 parts by weight or less, in terms of the solid content, of the rubber is added.

When the amount of the rubber to be added is more than 40 parts by weight, workability of the asphalt modifier is deteriorated. Further, physical properties, such as flow resistance, of the asphalt mixture are also deteriorated.

Such methods as described below can be adopted as methods of adding the rubber.

(Mixture method)

At the time the block copolymer, the process oil, and

the tackifying resin are mixed together, the rubber is added thereto and subjected to a given treatment, thereby producing the asphalt modifier. The given treatment means that, for example, they are mixed together under heating to prepare a homogeneous composition and the composition is molded into a predetermined form and size according to need. For example, the block copolymer of the vinyl aromatic hydrocarbon and the conjugated diene, the tackifying resin, the process oil, and the rubber are mixed together under heating to prepare a homogeneous composition and the thus-prepared composition is processed to be in pellet form, to thereby obtain the asphalt modifier. In the case where rubber is not added, after the block copolymer of the vinyl aromatic hydrocarbon and the conjugated diene, the tackifying resin, and the process oil are mixed together under heating to prepare a homogeneous composition, the thus-prepared composition is processed to be in pellet form, thereby obtaining the asphalt modifier.

According to this method, since it is not necessary to separately transfer and store the asphalt modifier and the rubber, less work is required. Further, since the components can be loaded altogether at one time when they are mixed into asphalt, production efficiency is enhanced.

(Separation method)

A block copolymer, a process oil, and a tackifying resin are mixed together and subjected to a given treatment, thereby

obtaining a homogeneous composition. Then, rubber is added at the time of mixing the thus-obtained composition with asphalt. Namely, when an asphalt modifier is mixed with asphalt, as in this separation method, rubber components and other components may be added separately. According to this separation method, an appropriate amount of the rubber can be added in accordance with the desired features or the like of the asphalt.

[Asphalt]

As for what asphalt is to be used in the present invention, no particular restriction is put thereon and a conventional asphalt can be used, such as a straight asphalt, a semi-blown asphalt, a blown asphalt, a cutback asphalt, a reclaimed asphalt, or the like. These asphalts can be used either individually or in any combinations thereof and can also be applied to a discolored binder or a high-viscosity binder of a pre-mix.

The asphalt modifier according to the present invention is used in the range of preferably from 1 part by weight to 100 parts by weight, more preferably from 3 parts by weight to 50 parts by weight, and most preferably from 5 parts by weight to 30 parts by weight, based upon 100 parts by weight of asphalt. When the usage of the asphalt modifier is below the aforementioned range, no modifying effect of asphalt is substantially recognized. In contrast, in the case in which

the usage of the asphalt modifier is over the aforementioned range, the viscosity of the asphalt mixture is so high as to deteriorate the workability thereof; to a great extent, this situation is economically disadvantageous.

[Aggregates]

When the asphalt modifier according to the present invention is used in a road-paving application, ordinarily, the asphalt modifier is mixed with an aggregate and a filler (hereinafter, referred to also as "aggregates" as a whole), to prepare an asphalt mixture. The asphalt mixture is then used in the road-paving application. As for the aggregates, the aggregate or the filler for a dense-graded, fine-graded, or coarse-graded mixture to be used in an ordinary road-paving application, or for an open-graded mixture to be used in a permeable pavement, a draining pavement, a sound-absorbing pavement, or the like, can be used. Examples of usable aggregates include crushed stone, pebble, gravel, sand, and any combinations thereof. Examples of usable fillers include stone powder, talc, calcium carbonate, and any combinations thereof.

As for the aggregates for use in the asphalt mixture, not only any new aggregate may be used, but also asphalt reclaimed aggregate produced by crushing a waste material consisting of existing pavement. Further, a mixture of the new aggregate and asphalt reclaimed aggregate may be used. In

this case, the amount of the reclaimed aggregate to be used is in the range of preferably from 0% by weight to 70% by weight, and more preferably from 0% by weight to 50% by weight, based upon the weight of the entire amount of aggregate to be used. By using asphalt reclaimed aggregate, the reclaimed aggregate, which is obtained from waste material of existing asphalt pavement and has conventionally been difficult to be reused in a high-function pavement, has come to be effectively utilized. Further, even when the reclaimed aggregate is used therein, the asphalt mixture has characteristics in that the reclaimed aggregate is hard to be stripped off or removed from the asphalt mixture. The reason for these characteristics are due to the asphalt mixture containing the asphalt modifier according to the present invention, and the asphalt modifier being excellent in toughness and tenacity. Further, the asphalt mixture in which the asphalt modifier according to the present invention is added, even with the reclaimed aggregate being used therein, has characteristics in that it is excellent in physical properties such as flow resistance and impact resistance, to the same or a greater extent than a conventional asphalt modifier.

Methods for mixing the aggregates are not particularly limited. For example, a pre-mix method can be utilized in which an asphalt composition, comprising asphalt and the asphalt modifier, which has previously been prepared, and the

aggregates are mixed together. A plant-mix method can also be utilized in which the asphalt modifier, asphalt, and the aggregates are mixed together at the plant. However, the plant-mix method is a method that can make more effective use of the characteristics of the present invention. Examples of such plant-mix methods include:

(a) a method in which a filler, a heated aggregate, and a heated asphalt are previously mixed together, and then an asphalt modifier is added to the resultant mixture while mixing;

(b) another method in which a filler, a heated aggregate, heated asphalt, and an asphalt modifier, are simultaneously mixed together; and

(c) a further method in which a filler, a heated aggregate, and an asphalt modifier are previously mixed together, and then heated asphalt is added to the resultant mixture while mixing.

[Other components]

An additive that is ordinarily used in a conventional asphalt composition can be mixed with the asphalt composition of the present invention. The additive is not particularly limited. Specific examples of such additives include stripping inhibitors such as slaked lime, amines and amides; fibrous reinforcing materials such as methyl cellulose and polyvinyl alcohol; elasticity improving agents; viscosity depressing agents; viscosity enhancing agents; fillers;

pigments; softening agents; antioxidants; ultraviolet-ray absorbing agents; light stabilizing agents; and thermoplastic resins.

Further, the asphalt modifier according to the present invention may optionally be added with an anti-blocking agent. The anti-blocking agent is not particularly limited so long as it is ordinarily used in a commercial basis. Examples of such usable anti-blocking agents include organic or inorganic compounds described in JP-A Nos. 56-136347, 61-101503, 5-98051, and 6-228521.

Examples of such organic anti-blocking agents include higher fatty acid monoamides such as stearic acid amide, oleic acid amide, lauric acid amide, palmitic acid amide, erucic acid amide, and behenic acid amide; higher fatty acid bisamides such as methylene-bis-stearic acid amide, ethylene-bis-stearic acid amide, ethylene-bis-oleic acid amide, and ethylene-bis-lauric acid amide; complex-type higher fatty acid amide such as N-stearyl oleic acid amide, N-stearyl erucic acid amide, N-stearyl stearic acid amide, N-oleyl stearic acid amide and distearyl adipic acid amide; higher fatty acid salts such as a lithium salt, a sodium salt, a potassium salt, a magnesium salt, a calcium salt, a barium salt, a zinc salt, an aluminum salt or an iron salt of lauric acid, myristic acid, palmitic acid, margaric acid, stearic acid, behenic acid, oleic acid, linolenic acid, α-eleostearic acid, β-eleostearic acid or α-

linolenic acid; polyolefins such as polyacrylamide, polyvinylchloride, polystyrene and high-density polyethylene; and resinous compounds such as polymethylmethacrylate, polycarbonate, and a styrene-acrylonitrile copolymer.

Examples of such inorganic anti-blocking agents include silica, calcium carbonate, magnesium carbonate, calcium sulfate, aluminum hydroxide, zinc oxide, talc, and clay.

These anti-blocking agents can be used either individually or in any combinations thereof. Among other things, the inorganic anti-blocking agents are favorable. An amount of the anti-blocking agent to be used is ordinarily in the range of from 0 parts by weight to 50 parts by weight, preferably from 0.1 parts by weight to 10 parts by weight, and more preferably from 0.5 parts by weight to 5 parts by weight, based upon 100 parts by weight of the modifier.

The asphalt modifier according to the present invention can optionally be added with any one of the antioxidants of, for example, a hindered-phenol type, a sulfur type, and a phosphorous type; the ultra-violet ray absorbing agents of, for example, a benzophenone type; the light stabilizing agents of, for example, a hindered-amine type; the thermoplastic elastomers such as a block copolymer, except the block copolymer of the vinyl aromatic hydrocarbon and the conjugated diene according to the present invention; the polyolefinic

resins such as an ethylene-ethylacrylate copolymer and an ethylene-vinylacetate copolymer; the thermoplastic resins such as a polystyrene resin and a polyvinylchloride resin; and inorganic fillers such as glass beads, silica, and carbon black.

For example, a method for producing the asphalt modifier may follow an ordinary method in which initially the aforementioned components are mixed together by using a mixer such as a heat-melt vessel, a roll mill, a monoaxial extruder, a biaxial extruder, or a Henschel mixer, and then the resultant mixture is subjected to molding processing by, for example, a press, a pelletizer, an extrusion molding machine, or a processing-molding machine.

The shape of the asphalt modifier according to the present invention is not particularly limited and is allowed to be in any one of the following forms: pellet form, strand form, plate form, block form, and the like. The pellet form is particularly favorable form with regards to solubility in asphalt. Pelletization of the asphalt modifier can be achieved by initially mixing the aforementioned components with one another, secondly extruding the resultant mixture into strand form, thirdly cooling the thus-extruded mixture in strand form with, for example, cold water, and finally, finely cutting the thus-cooled mixture in strand form by use of a pelletizer, for example. In the case in which an anti-blocking

agent is sprinkled over the cooled strand formed mixture, the workability of the finely cutting process is improved and accordingly, this case is favorable. Further, in a case in which the size of the resultant pellet is in the range of from 0.5 mm to 50 mm, preferably from 1 mm to 20 mm, and more preferably from 2 mm to 10 mm, the solubility thereof in asphalt is remarkably improved. As a result, this case is also favorable.

EXAMPLES

Hereinafter, the present invention will be described in more detail with reference to specific examples; however, the examples should not be interpreted as limiting the present invention in any way.

In the Examples, block copolymers as shown in Table 1 were used. In Table 1, marks A through D respectively denote the following substances:

SIS: styrene-isoprene block copolymer;

SBS: styrene-butadiene block copolymer;

SEBS: styrene-ethylene-butylene block copolymer; and

MFR: melt flow value (200°C, 49.03 N).

Table 1

Block copolymer of vinyl aromatic hydrocarbon and conjugated diene		
Mark	Type	MFR (g/10 min.)
A	SIS	2
B	SBS	<1
C	SEBS	6
D	SIS	15

Further, in the Examples, the tackifying resins, process oils, and rubbers shown in Tables 2 to 4 were used. In Table 4, marks K and L respectively denote the following substances:

SBR: styrene-butadiene rubber; and

CR: chloroprene rubber.

Table 2

Tackifying resin	
Mark	Type
E	Terpene-phenol resin
F	Terpene resin

Table 3

Process oil		
Mark	Content of aromatic component (wt%)	Dynamic viscosity (40 °C) (mm^2/s)
G	40.2	325
H	47.6	589
I	27.4	51
J	56.4	996

Table 4

Rubber	
Mark	Type
K	SBR
L	CR

[Production of asphalt modifier]

Asphalt modifiers were produced by using the materials of marks A to L in Tables 1 to 4. A processing test and storage stability test were conducted using the thus-produced asphalt modifiers. Tables 5 and 6 show compositions of the asphalt modifiers produced as Examples according to the present invention and test results (Examples 1 to 15). Table 7 shows compositions of the asphalt modifiers produced as Comparative Examples according to the present invention and test results (Examples 1 to 8). In Tables 5 to 7, content ratios of the asphalt modifiers are shown in terms of percentage by weight. However, as far as rubbers (K, L) are concerned, content ratios thereof are each shown in terms of parts by weight (percentage by weight) based upon 100 parts by weight of the total amount of the block copolymer, the tackifying resin, and the process oil.

Specifically, in order to produce the asphalt modifier the tackifying resin was loaded in a Henschel mixer having a 200-liter capacity and stirred for 5 minutes at a low speed (25 Hz). The block copolymer was then added thereto and stirred for 1 minute. Thereafter, the process oil and if necessary, rubbers, were gradually added thereto and stirred for 9 minutes at a high speed (35 Hz). The resultant mixture was extruded into strand form using a 65-mmϕ monoaxial extruder and

subsequently cooled in a cooling bath having a water temperature of 15°C. Next, the resultant mixture was sprinkled with 1% by weight of calcium carbonate and cut into pellets, each having sizes of 3 mmϕ x 4 mm, by using a water-cooled pelletizer provided with a rotary cutter.

(Workability test)

The adhesion state between the modifier and the rotary cutter, at the time of having operated the aforementioned pelletizer for 10 minutes, was observed and evaluated based upon the following 3-stage evaluation criterion:

O (large circle): No adhesion of the modifier to the rotary cutter was observed;

Δ (triangle): Although it was observed that a few pieces of pellets had adhered to the rotary cutter, the cutting operation was able to be performed for 10 minutes; and

X (large cross): The strands of the modifier were wound around the rotary cutter and the pelletizer was stopped without being able to completely perform the 10 minute cutting operation. The test results are shown in Table 5.

(Storage stability evaluation)

120 g of the pellets of each modifier were put into bags having a size of 7x10 cm^2. A load of 50 g/cm^2 was applied to the bags and the loaded bags were allowed to stand in an oven for 3 hours at 90°C. Subsequently, the state of the pellets were evaluated based upon the following 3-stage criterion:

O (large circle): No adhesion of the pellets to one another was observed;

Δ (triangle): Although it was observed that the pellets were adhered to one another, the adhesion failed when the force of a finger was applied to the pellets; and

X (large cross): The pellets were adhered to one another, the adhesion did not fail even when the force of a finger was applied. The test results are shown in Table 5.

Table 5

Asphalt modifier										
Examples		1	2	3	4	5	6	7	8	9
Block copolymer	A	60	0	35	35	60	75	50	60	70
	B	0	35	0	25	0	0	0	0	0
	C	0	25	25	0	0	0	0	0	0
	D	0	0	0	0	0	0	0	0	0
Tackifying resin	E	25	25	25	25	25	0	40	0	25
	F	0	0	0	0	0	0	0	20	0
Process oil	G	15	15	15	15	15	25	10	20	5
	H	0	0	0	0	0	0	0	0	0
	I	0	0	0	0	0	0	0	0	0
	J	0	0	0	0	0	0	0	0	0
Rubber	K	0	0	0	0	15	0	0	0	0
	L	0	0	0	0	0	0	0	0	0
Test result	Workability	O	O	O	O	O	O	O	O	O
	Storage stability	O	O	O	O	O	O	O	O	O

Table 6

Asphalt modifier							
Example		10	11	12	13	14	15
Block copolymer	A	50	60	60	60	60	60
	B	0	0	0	0	0	0
	C	0	0	0	0	0	0
	D	0	0	0	0	0	0
Tackifying resin	E	10	20	25	25	25	25
	F	0	0	0	0	0	0
Process oil	G	40	0	15	15	15	15
	H	0	20	0	0	0	0
	I	0	0	0	0	0	0
	J	0	0	0	0	0	0
Rubber	K	0	0	0	10	20	40
	L	0	0	15	0	0	0
Test result	Workability	O	O	O	O	O	Δ
	Storage stability	O	O	O	O	O	Δ

Table 7

Asphalt modifier									
Comparative Example		1	2	3	4	5	6	7	8
Block copolymer	A	0	30	40	40	60	60	60	60
	B	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0
	D	60	30	0	0	0	0	0	0
Tackifying resin	E	25	25	50	10	25	20	25	25
	F	0	0	0	0	0	0	0	0
Process oil	G	15	15	10	50	0	0	15	15
	H	0	0	0	0	0	0	0	0
	I	0	0	0	0	15	0	0	0
	J	0	0	0	0	0	20	0	0
Rubber	K	0	0	0	0	0	0	60	60
	L	0	0	0	0	0	0	0	0
Test result	Workability	X	Δ	Δ	Δ	X	X	X	X
	Storage stability	X	Δ	Δ	Δ	X	X	X	X

As is seen from Examples 1 to 5, in the asphalt modifier in which one type, or two or more types of the block copolymers were used, each having a melt flow value of less than 15 g/10

minutes, excellent workability and the storage stability resulted. In contrast, as seen from Comparative Examples 1 and 2, in the asphalt modifier in which a block copolymer was used having a melt flow value of 15 g/10 minutes or more, even when the block copolymer having a melt flow value of less than 15 g/10 minutes was simultaneously used, the resulting workability and the storage stability were deteriorated.

Further, as seen from Comparative Examples 5 and 6, when any one of the process oils I and J is used, each having a dynamic viscosity outside the range of from 70 mm^2/s to 900 mm^2/s at 40°C, or when, as shown in Comparative Example 7, the amount of the rubber thus used was over 40 parts by weight based upon 100 parts by weight of the total amount of the block copolymer, the tackifying resin, and the process oil, the resulting workability and the storage stability of the asphalt modifier were deteriorated.

[Production of asphalt composition]

Adding any one of asphalt modifiers shown in Tables 5 to 7 to asphalt produced an asphalt composition. Specifically, each asphalt modifier was added to straight asphalt heated at 180°C in a glass container having a 1-liter capacity. The resultant mixture was continuously stirred so as to allow the asphalt modifier to be completely dissolved in the straight asphalt, thereby producing the asphalt composition. Physical properties of the thus-produced asphalt composition were

measured. The test results are shown in Tables 8 to 10.

In Tables 8 to 10, the numbers indicating the Examples and Comparative Examples of the asphalt compositions correspond to respective numbers of the Examples and Comparative Examples of the asphalt modifiers. For example, the asphalt composition in Example 1 in Table 8 has the added asphalt modifier in Example 1 in Table 5. Similarly, in the asphalt composition in Comparative Example 1 in Table 10 has the added asphalt modifier in Comparative Example 1 in Table 7.

Further, the term "quality specification," as used in Tables 8 to 10, is intended to mean the quality specifications of high-viscosity modified asphalt as defined by the Japan Modified Asphalt Association Specifications (JMAAS01-01). Still further, only the dissolving time in asphalt is a targeted value set by the present inventors taking an application of the plant-mix method into consideration.

Methods for measuring the physical properties of the asphalt compositions are described below.

(1). Solubility

Solubility of the asphalt modifier in the asphalt was tested in accordance with a method of "Sample Preparation of Modified Asphalt" as described in "Pavement Testing Handbook" compiled by the Japan Road Association. In this case, the asphalt modifier was added to asphalt that had been previously

heated at 180°C. The resultant mixture was then stirred and the time period (min) until the disappearance of undissolved material was determined.

(2). Penetration

Penetration (1/10 mm) of the asphalt composition was measured in accordance with JIS K2207.

(3). Softening point

A softening point (°C) of the asphalt composition was measured in accordance with JIS K2207.

(4). Toughness/Tenacity

Toughness (N·m) and tenacity (N·m) of the asphalt composition were measured in accordance with a method described in "Pavement Testing Handbook" compiled by the Japan Road Association.

(5). Viscosity at 60°C

Viscosity at 60°C (Pa·s) of the asphalt composition was measured in accordance with a method described in "Pavement Testing Handbook" compiled by the Japan Road Association.

Table 8

Asphalt composition								
Example	1	2	3	4	5	6	7	Quality specification
Mixing ratio (asphalt modifier/ asphalt)	12/ 88	12/ 88	12/ 88	12/ 88	14/ 88	12/ 88	12/ 88	-
Dissolving time in asphalt (min)	15	15	10	20	15	20	10	20 or less
Penetration (1/10 mm)	44	43	43	42	42	40	48	40 or more
Softening point (°C)	86.8	90.1	87.2	89.9	87.6	90.4	82.5	80 or more
Toughness (N·m)	28.5	26.7	29.2	34.0	35.2	21.2	22.4	20 or more
Tenacity (N·m)	21.7	20.6	22.5	27.0	28.3	15.3	16.1	15 or more
Viscosity at 60°C ($x10^4$Pa·s)	24.8	34.5	23.2	26.8	35.8	15.9	3.9	2 or more

Table 9

Asphalt composition					
Example	8	9	10	11	Quality specification
Mixing ratio (asphalt modifier/ asphalt)	12/ 88	12/ 88	12/ 88	12/ 88	-
Dissolving time in asphalt (min)	10	20	10	10	20 or less
Penetration (1/10 mm)	46	41	49	46	40 or more
Softening point (°C)	84.1	89.6	71.7	85	80 or more
Toughness (N·m)	25.3	23.1	20.2	25.7	20 or more
Tenacity (N·m)	18.2	16.4	15.6	18.6	15 or more
Viscosity at 60°C ($x10^4$Pa·s)	17.8	41.4	2.5	18.9	2 or more

Table 10

Asphalt composition					
Comparative Example	1	2	3	4	Quality specification
Mixing ratio (asphalt modifier/ asphalt)	12/ 88	12/ 88	12/ 88	12/ 88	-
Dissolving time in asphalt (min)	10	10	10	10	20 or less
Penetration (1/10 mm)	47	45	52	55	40 or more
Softening point (°C)	66.2	73.6	66.3	62.9	80 or more
Toughness (N·m)	10.4	14.8	9.4	6.2	20 or more
Tenacity (N·m)	5.6	8.5	4.0	2.8	15 or more
Viscosity at 60°C ($x10^4$Pa·s)	0.8	1.4	0.6	0.3	2 or more

As shown in Examples 1 to 5, when an asphalt modifier was added in which the asphalt modifier used one type, or two or more types, of block copolymers each having a melt flow value of less than 15 g/10 minutes, values of toughness, tenacity, and viscosity at 60°C, of the asphalt composition were over those values specified in respective quality specifications. For contrast, as shown in Comparative Examples 1 and 2, when an asphalt modifier was added in which the asphalt modifier used a block copolymer having a melt flow value of 15 g/10 minutes or more, the resulting values of some of the physical properties of the asphalt compositions were below those specified in respective quality specifications.

Further, as shown in Example 5 in Table 8, it was confirmed that by adding rubber, some features of the asphalt composition were improved. Namely, it was found that it is possible by

adding rubber to obtain an asphalt modifier in which not only was the solubility in asphalt excellent, but also the physical strength was improved. The specific values of, for example, toughness, tenacity, and viscosity at 60°C, were all above the quality specification values.

Still further, as shown in Examples 1 and Examples 6 to 8, regardless of the type of the tackifying resin, asphalt compositions were obtained in which values of softening point, toughness, tenacity, and the like, were over the values specified in respective quality specifications, as long as the weight of the tackifying resin was in the range of from 0 parts by weight to 100 parts by weight based, upon 100 parts by weight of the block copolymer. In contrast, as shown in Comparative Example 3, when an amount of the tackifying resin thus used was over 100 parts by weight based upon 100 parts by weight of the block copolymer, an asphalt composition was obtained in which values of softening point, toughness, tenacity, and the like were below the values specified in respective quality specifications.

Further, as shown in Example 1 and Examples 9 to 11, an asphalt composition was obtained in which values of softening point, toughness, tenacity, and the like, were over the values specified in respective quality specifications. The asphalt composition used an asphalt modifier having added any one of the process oils G and H, each having a dynamic viscosity at

40°C in the range of from 70 mm^2/s to 900 mm^2/s, in an amount from 5 parts by weight to 100 parts by weight based upon 100 parts by weight of the block copolymer asphalt modifier. The asphalt modifier had a content of an aromatic component in the range of from 20% by weight to 60% by weight. In contrast, as shown in Comparative Example 4, when the amount of the process oil thus used was over 100 parts by weight based upon 100 parts by weight of the block copolymer, an asphalt composition is obtained in which values of softening point, toughness, tenacity, and the like, were below the values specified in respective quality specifications.

[Production of asphalt mixture]

The asphalt modifier, asphalt, and any one of the aggregates, as shown in each of Tables 5 to 7, were mixed together to thereby produce the asphalt mixture. Then, various parameters indicating physical properties of the thus-produced asphalt mixture were measured. The results are shown in Tables 11 and 12. Further, numbers identifying Examples and Comparative Examples of the asphalt mixtures in Tables 11 and 12 respectively correspond to those indicating the Examples and Comparative Examples of the asphalt modifiers. For example, the asphalt modifier in Example 1 in Table 5 was added to the asphalt mixture of Example 1 in Table 11. Similarly, the asphalt modifier of Comparative Example 1 in Table 7 was added to the asphalt composition of Comparative

Example 1 in Table 12. The term "reclaimed material" as used in Tables 11 and 12 for the aggregate type is intended to mean that reclaimed material of existing asphalt pavement was used.

Methods for measuring physical properties of the asphalt mixtures are described below.

(Void Content)

A void content (%) of the asphalt mixture was measured in accordance with a method using slide calipers as described in the appendix of the testing method "JHS217-1992," defined by the Japan Highway Public Corporation (hereinafter, referred to also as "JH" for short)

(Dynamic stability)

In regard to dynamic stability of the asphalt mixture, a wheel-tracking test was conducted in accordance with a method as described in "Pavement Testing Handbook" compiled by the Japan Road Association. The dynamic stability (times/mm) was then computed.

(Cantabro Loss)

Cantabro loss (%) of the asphalt mixture was measured in accordance with the testing method "JHS231-1992" defined by the JH.

Table 11

Asphalt mixture							
Example	1	5	12	1	13	14	15
Mixing ratio (asphalt modifier/ asphalt)	12/ 88	14/ 88	14/ 88	12/ 88	14/ 88	12/ 88	12/ 88
Aggregate type	New material	New material	New material	Reclaimed material	Reclaimed material	Reclaimed material	Reclaimed material
Void content (%)	21.4	20.7	21.0	19.9	20.2	20.5	20.5
Cantabro loss (20°C)	12.9	8.1	9.6	17.4	13.1	10.9	14.5
Cantabro loss (-20°C)	22.4	19.3	20.2	25.5	23.4	21.3	24.6
Dynamic stability (times/mm)	4250	5300	5188	3219	4302	5300	3846

Table 12

Asphalt mixture		
Comparative Example	7	8
Mixing ratio (asphalt modifier/asphalt)	14/ 88	14/ 88
Aggregate type	New material	Reclaimed material
Void content (%)	21.2	21.0
Cantabro loss (20°C)	22.5	28.4
Cantabro loss (-20°C)	28.8	Broken
Dynamic stability (times/mm)	3680	1870

As shown in Examples 1, 5, and 12 to 15, when the amount of the rubber thus added was in the range of from 0 parts by weight to 40 parts by weight, based upon 100 parts by weight of the entire amount of the block copolymer, the tackifying resin, and the process oil, regardless of the aggregate type, the resulting cantabro loss of the asphalt mixture was low while

the dynamic stability was high. Particularly, in the asphalt mixture in which the amount of the rubber thus added was in the range of from 10% to 20%, when reclaimed aggregate was used the physical properties were remarkably improved as a result. In contrast, as shown in Comparative Example 7, when the amount of the rubber thus added was over 40 parts by weight, based upon 100 parts by weight of the entire amount of the block copolymer, the tackifying resin, and the process oil, the resulting physical strength (such as the cantabro loss and the dynamic stability) of the asphalt mixture was deteriorated.

WHAT IS CLAIMED IS:

1. An asphalt modifier, comprising:

a block copolymer of a vinyl aromatic hydrocarbon and a conjugated diene having a melt flow value of less than 15 g/10 minutes; and

from 0 parts by weight to 100 parts by weight of a tackifying resin and from 5 parts by weight to 100 parts by weight of a process oil, based on 100 parts by weight of the block copolymer.

2. The asphalt modifier as set forth in Claim 1, wherein a content of an aromatic component of a process oil is in the range of from 20% to 60%, and further, a dynamic viscosity of the process oil at 40°C is in the range of from 70 mm^2/s to 900 mm^2/s.

3. An asphalt modifier, comprising:

a block copolymer of a vinyl aromatic hydrocarbon and a conjugated diene having a melt flow value of less than 15 g/10 minutes;

from 0 parts by weight to 100 parts by weight of a tackifying resin and from 5 parts by weight to 100 parts by weight of a process oil, based upon 100 parts by weight of the block copolymer; and

40 parts by weight or less of a rubber based on 100 parts by weight of an entire amount of the block copolymer, tackifying resin and the process oil.

4. The asphalt modifier as set forth in Claim 3, wherein a content of an aromatic component of a process oil is in the range of from 20% to 60% and, further, a dynamic viscosity of the process oil at 40°C is in the range of from 70 mm^2/s to 900 mm^2/s.

5. The asphalt modifier as set forth in Claim 1 or 2, being obtained by a method comprising the steps of:

mixing a block copolymer of a vinyl aromatic hydrocarbon and a conjugated diene, a tackifying resin and a process oil under heating to prepare a homogeneous composition; and

processing the thus-prepared composition to be in pellet form.

6. The asphalt modifier as set forth in Claim 3 or 4, being obtained by a method comprising the steps of:

mixing a block copolymer of a vinyl aromatic hydrocarbon and a conjugated diene, a tackifying resin, a process oil, and a rubber, under heating to prepare a homogeneous composition; and

processing the thus-prepared composition to be in pellet

form.

7. An asphalt composition, being obtained by a method comprising the step of:

mixing the asphalt modifier as set forth in any one of Claims 1 to 4 and an asphalt.

8. An asphalt mixture, being obtained by a method comprising the step of:

mixing the asphalt modifier as set forth in any one of Claims 1 to 4, an asphalt and any one of aggregates.

9. An asphalt mixture, being obtained by a method comprising the step of:

mixing the asphalt modifier as set forth in Claim 5, an asphalt and any one of aggregates.

10. An asphalt mixture, being obtained by a method comprising the step of:

mixing the asphalt modifier as set forth in Claim 6, an asphalt and any one of aggregates.

11. The asphalt mixture as set forth in Claim 8, wherein an asphalt reclaimed aggregate obtained from a waste material of an existing pavement is used as one of the aggregates.

12. The asphalt mixture as set forth in Claim 9, wherein an asphalt reclaimed aggregate obtained from a waste material of an existing pavement is used as one of the aggregates.

13. The asphalt mixture as set forth in Claim 10, wherein an asphalt reclaimed aggregate obtained from a waste material of an existing pavement is used as one of the aggregates.

14. A method for producing an asphalt mixture, comprising the step of:

mixing the asphalt modifier as set forth in any one of Claims 1 to 4, an asphalt and any one of aggregates by a plant-mix method.

15. A method for producing an asphalt mixture, comprising the step of:

mixing the asphalt modifier as set forth in Claim 5, an asphalt and any one of aggregates by a plant-mix method.

16. A method for producing an asphalt mixture, comprising the step of:

mixing the asphalt modifier as set forth in Claim 6, an asphalt and any one of aggregates by a plant-mix method.