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(54) **Eljárás csökkentett kötőanyagtartalmú, forró aszfaltkeverék előállítására**

The present invention relates to a process for preparing a hot mix that provides for mixes comprising a reduced content of binder according to the preamble of claim 1 while maintaining excellent mechanical performance. The invention also relates to the mixes obtained by this process as well as construction layers or coatings made therewith. The invention has thus applications in the civil engineering field and especially, the construction or renovation of taxiways or runways.

According to the invention, by "mix", it is meant aggregates mixed with a hydrocarbon binder such as bitumen or with synthetic binders manufactured from raw materials of petroleum origin or from biomass, used to make layers and/or coatings for road construction and/or civil engineering. The bitumen is the main hydrocarbon binder used in the road construction or civil engineering field. It can be used pure or modified by adding polymers; it is then called modified bitumen.

The currently used processes for producing aggregate and bituminous product mixes can be divided into two separate classes: the processes for producing cold or hot mixes ("enrobés" or "enrobage" in French). By "hot mix", it is meant an operation in a mix coating plant, comprising evaporating water from the material and putting the later at the coating temperature.

The invention focuses on hot mix coating processes carried out at temperatures higher than 100°C using bitumen in anhydrous form, in a flow state sufficient to ensure a good coating of the aggregates.

The traditional process for manufacturing a hot mix consists in injecting at once the hydrocarbon binder on a previously heated granular mixture and mixing them together. The manufacturing temperature is set out based on the viscosity of the bituminous binder used. In this process, the whole binder will coat the entire skeleton and the manufacture is done in one step.

A lot of research has been carried out to optimize the processes for preparing hot and cold mixes.

It was notably proposed in achieving a cold mix, more particularly, an emulsion mix, to perform a cold or hot pre-coating of the sand. This pre-coating step results in an agglomeration of the finest elements. There are hardly any free elements left having a size of less than 40 µm in the sand. So, these agglomerated sand fines no longer participate in the second coating. The FR Patent 2 686 630 discloses, for example, a process for manufacturing road asphalt mixes using simultaneously hot and cold coating techniques and especially the hot pre-coating of the sand. This process corresponds to the industrial process for producing the Compomac M2.

Processes for preparing hot mixes manufactured at reduced temperature, based on the use of two bituminous binders, were also proposed. The purpose of these processes is to control the binder viscosity in order to manufacture and implement the mix at lower temperature.

Mention may be particularly made of the soft binder and foamed bitumen-based Shell Kolo Veidekke process disclosed in the WO 01/62852 application. This process allows the mix to be implemented at lower temperature.

Mention may also be made of the DEUTAG DE 43 08 567 patent which discloses a process for producing asphalt mix at reduced temperature using a coating process in two phases involving successively a soft binder and then, a hard binder.

Finally, producing mixes with a lower content of binder, based on an incorporation order control of the components, was proposed. Thus, in the patent application EP 1 408 157, the whole bituminous binder is injected on the gravels, and then the finest elements of the stone skeleton are incorporated gradually prior to finally adding the sand. The US Patent 4,993,839 A also discloses a process for preparing a hot mix.

The present invention relates to a process for preparing hot mixes which enables to obtain mix formulations comprising a lower content of hydrocarbon binder. These compositions are optimized in term of performance and bitumen binder consumption. The process of the invention consists in incorporating the same bituminous binder in two successive steps at a single manufacturing temperature.

Therefore, the present invention relates to a process for preparing a hot mix with a reduced content of hydrocarbon binder, said mix comprising a specified amount of a hydrocarbon binder and a granular mixture comprising at least fine elements such as fines and coarse aggregates such as gravels, grits and/or sands, said process comprising at least the following successive steps:

- first, incorporating into the whole granular mixture only a first part of the hydrocarbon binder specified amount in a mixer,
- wet mixing to form a mastic,
- second, incorporating the remaining amount of hydrocarbon binder,
- mixing.

It is well understood that the first part of the binder specified amount, by total weight, is lower than 100% by weight and also higher than 0% by weight of the specified amount, and that the second part is the balance thereof to 100% by weight of the specified amount so that there would be two successive incorporations of binder.

According to the invention, the incorporation step of the first part of hydrocarbon binder is on the whole granular mixture. The term "whole" means that all the granular mixture forming components, i.e. the coarse aggregates and fine elements, are present during this first step. In the sense of the present application, the terms "granular mixture" and "stone skeleton" are used interchangeably.

According to the process of the invention, the first incorporation of binder results in an agglomeration of the finest elements and the gravels are only coated very partially. The thus obtained mastic is enriched in fine elements.

The mastic defines usually the mixture made up of the bituminous binder and the finest elements of the stone skeleton. However, without formally specifying the maximum size of the elements of its composition, the following reasoning can be applied. Under the assumption of a material consisting of spheres on which the binder would distribute evenly into a film of constant thickness, it can be demonstrated that the surface of elements having a diameter lower than 125 µm constitutes the majority of the contact surface developed by the stone skeleton, typically more than 80%. This limit can be thus selected for the maximum size of the mastic constituent parts. The first incorporation of binder agglomerates therefore all the fine elements of the granular mixture, including those present on the surface of the coarser elements of the sand and gravels.

Through this first step, fine enrichment of the first part of hydrocarbon binder limits its subsequent mixing with the remaining amount of binder. The remaining amount of binder can then finally coat all of the skeleton gravels, and as fines disappeared (they were taken by the binder during the first step), its viscosity changed little.

A mixture of bituminous binder and mineral fines has characteristics significantly different from those of the binder alone, including a modulus multiplied by a factor of around five to ten, and a substantially increased viscosity, which reduces its coating capacity. It was thus measured, for 2 10/20-grade hard bitumens, moduli on pure binders at 15°C, 10Hz of $2.99.10^7$ Pa and $3.75.10^7$ Pa, respectively, and on mastics prepared with these binders, moduli of $1.28.10^8$ Pa and $2.2.10^8$ Pa, an increase in the modulus between pure binder and mastic of a factor 4 to 6. In the case of the invention, the second binder incorporation provides the mixture with pure bitumen that is not loaded of fines, thus maintaining its own specific characteristics.

Surprisingly, the applicant discovered that by incorporating the bituminous binder in two steps, products are obtained having mechanical performance measured in laboratories that is virtually identical to that of a traditional method while reducing by 3% to 9% the amount by weight of bituminous binder required to prepare the mix, i.e. the amount required to form the hydrocarbon binder and stone skeleton mixture.

Moreover, according to the process of the invention, only one binder being used, the coating devices do not require major changes. In comparison with the process that would allow the reduction of the mix preparation temperature achieving an injection of two binders different in nature, the device of the invention is even simplified because a single binder tank can be implemented.

The process of the invention is therefore a process easy to implement and having clear economic benefits. This process does not require any modification of the coating existing structures, and more importantly, it allows significant savings in the quantities of hydrocarbon binder.

Taken in the general sense, mixes include all the types of asphalt mixes, for base and surface course. In all cases, it is a hydrocarbon binder and stone skeleton mixture comprising optionally dopes and/or additives. The different kinds of mixes can be distinguished according to their binder content and field of application.

Asphalt mixes that can be prepared according to the process of the invention include high modulus bituminous mixes (Enrobés bitumineux à Module Elevé or EME (French designation)), high modulus bituminous concretes (Bétons Bitumineux à Module Elevé or BBME), thick solution systems (Bétons Bitumineux Semi-Grenus or BBSG), thin asphalt concretes (Bétons Bitumineux Minces or BBM) and very thin asphalt concretes (Bétons Bitumineux Très Minces or BBTM). Preferably, the mixes obtained according to the invention comprise at least 4%, preferably 4.5% by weight of hydrocarbon binder (representing the specified amount of hydrocarbon binder).

The EME, BBME, BBSG, BBM are defined in the standard EN 13108-1: Mélanges bitumineux – Spécification des matériaux Partie 1 Enrobés bitumineux, of February 2007. The BBTM are defined in the standard EN 13108-2. These documents refer to the different performance classes which can be assigned to each of the mix formulations during the formulation test that should be done for any mixture according to the conditions described in the standard EN 13108-20 of June 2006. A minimum characteristic level, which is only recommendatory in nature, is thus defined in the national foreword to the standards EN 13108-1 and EN 13108-2 for each type of mixture.

The potential choice for the study of asphalt mix formulation, of the fundamental approach, wiped out the notion of minimum binder content. Nevertheless, prior to this normative evolution, the experience results in the fact that the bitumen content of the BBMEs is conventionally higher than that of the BBSGs. Thus, the conventional order of magnitude of the BBME 0/10 or 0/14 bitumen minimum dosage is generally 5.5% or 5.21%, respectively, by weight relative to the total weight of the granular mixture and hydrocarbon binder.

The main differences between BBSG and BBME are modulus mechanical performance and fatigue resistance. The table below referred to the characteristics recommended in the foreword of the standard EN 13108-1 in the case of the fundamental approach which requires modulus and fatigue resistance determination, determined according to the Annex A to the standard EN 12697-26 of December 2004 and Annex A to the standard EN 12697-24 of September 2007, respectively.

Mix types	PCG (% void) 60 gyrations (D = 10 mm) 80 gyrations (D = 14 mm)	Rutting % at 30 000 cycles	Stiffness modulus (15°C, 10 Hz) in MPa	Fatigue allowable deformation at 1 million cycles (10°C, 25Hz)
BBSG Class 1	5-10 4-9	≤ 10	≥ 5 500	$\geq 100.10^{-6}$

BBSG Class 2	5-10 4-9	≤ 7.5	≥ 7 000	≥ 100.10^{-6}
BBSG Class 3	5-10 4-9	≤ 5	≥ 7 000	≥ 100.10^{-6}
BBME Class 1	5-10 4-9	≤ 10	≥ 9 000	≥ 100.10^{-6}
BBME Class 2	5-10 4-9	≤ 7.5	≥ 11 000	≥ 100.10^{-6}
BBME Class 3	5-10 4-9	≤ 5	≥ 11 000	≥ 100.10^{-6}

Table 1: Comparison of the characteristics recommended for the BBSG and BBME in the national foreword of the standard NF EN 13108-1 Asphalt mixes.

The higher the performance of the mixes, the greater the class. The class of the BBSG or BBME results from the performance level in rutting resistance. It is higher as the test measured rut depth diminishes. By decreasing the binder content, the process of the invention helps to achieve better rutting resistance performance. Indeed, the rutting resistance decreases when the hydrocarbon binder content of the mixture increases. By contrast, it is noteworthy that this improvement is achieved without any loss of fatigue strength which is itself a characteristic also related to the binder content, but which varies inversely, namely, it grows with the binder content.

The EME formulation is based on the use of a hard binder, typically a special binder or a binder class 10/20, in large quantities, rather commonly with a dosage of more than 5.66%, to ensure high fatigue strength.

The following table refers to the EME mechanical characteristics.

	EME class 1	EME class 2
Rutting % plate mean voids Rut depth as % at 30 000 cycles 60°C	 7% ≤ V ≥ 10% ≤ 7.5%	 3% ≤ V ≥ 6% ≤ 7.5%
Complex modulus: - at % voids ranging between - Modulus at 15°C, 10 Hz	 7% ≤ V ≥ 10% ≥ 14 000 MPa	 3% ≤ V ≥ 6% ≥ 14 000 MPa
Fatigue strength - percentage of voids ranging between Relative deformation at 10^6 cycles	 7% ≤ V ≥ 10% ≥ 100 µdefs	 3% ≤ V ≥ 6% ≥ 130 µdefs

Table 2: Comparison of the characteristics recommended for the EMEs in the national foreword of the standard NF EN 13108-1 Asphalt mixes.

The process of the invention can also be used for preparing thin asphalt concretes (BBM) and very thin asphalt concretes (BBTM). The BBMs constitute a family of mixes applied into surface course, without real structuring characteristics unlike BBMEs and EMEs. Their application thickness is from 3 to 4 cm for the formulations 0/10 and 3.5 to 5 cm for the 0/14. 3 types can be distinguished (A, B or C) depending on whether the grading curve is discontinuous between 2 and 6.3 mm (type A), 4 and 6.3 mm (type B) or continuous (type C). The minimum binder content of these mixtures is 5%, except for BBMcs for which it is 4.8%. For each of the types (A, B, C), 3 classes can be distinguished depending on the rutting resistance result.

The invention being applicable to any type of mixture, the manufacturing temperature in the case of a traditional hot mix is according to the conditions laid down by the standard NF P 98-150-1 of January 2008. In the case of the use of a modified binder, the manufacturing temperature will be the one defined by the binder manufacturer.

In various embodiments of the invention, the following means can be used alone or in all technically possible combinations:

- the first part of the hydrocarbon binder amount incorporated by weight based on the total weight of the specified amount of hydrocarbon binder ranges between 30% and 70%, preferably between 40 and 60% or is from 30 to 50% and more preferably, 50%,
- the incorporation of the first amount of hydrocarbon binder is performed at the temperature specified for the bitumen class used,
- the incorporation of the remaining amount of hydrocarbon binder is performed at the temperature specified for the bitumen class used,
- the first and the second times are carried out in the same mixer,
- the granular mixture is heated before the incorporation of the first part of the binder specified amount,
- the same temperature is used during the two times,
- the mix is selected from high modulus bituminous mixes (EME), high modulus bituminous concretes (BBME), thick solution systems (BBSG), thin asphalt concretes (BBM) and very thin asphalt concretes (BBTM),
- the specified amount of hydrocarbon binder is less than from 3.5% to 10% by weight, preferably, from 5 to 10%, compared to the specified amounts of hydrocarbon binder used in the known hot mix preparation processes,
- fine elements comprise fines or fillers, i.e. elements having a dimension of less than 80 microns, fines or fillers represent from 1 to 10% by weight, preferably form 1 to 5% by weight based on the total weight of the mix, i.e. the hydrocarbon binder and stone skeleton mixture,

- aggregates represent from 80 to 95% by weight, preferably from 90 to 95% by weight based on the total weight of the mix, i.e. the hydrocarbon binder and stone skeleton mixture,

- the granular mixture comprises asphalt aggregates,

- when mixes are selected from high modulus bituminous mixes (EME) and high modulus bituminous concretes (BBME), the hydrocarbon binders have preferably a penetrability at 25°C, measured according to NF EN 1426 standard, of from 0 to 70 (1/10 mm), preferably from 0 to 50 (1/10 mm), and more preferably from 0 to 35 (1/10 mm), these hydrocarbon binders are preferably selected from the binders 10/20, 15/25 or 20/30, i.e. binders having a penetrability at 25°C in the range of 10-30 (1/10 mm) and a ring and ball temperature close to 68°C or higher to prepare EMEs, BBMEs,

- when the mix is a high modulus bituminous mix, it may comprise by weight based on the total weight of the mix, i.e. the hydrocarbon binder and stone skeleton mixture:

    - from 1 to 5%, preferably from 1.5 to 3%, and more preferably from 1.5 to 2.5% fines, preferably limestone filler,
    - from 90 to 95% aggregates, preferably aggregates 0/10, and
    - from 4.5% to 5.3%, preferably from 4.5% to 5%, and more preferably from 4.9 to 5.25% hydrocarbon binder (representing the specified amount of hydrocarbon binder according to the invention), preferably a pure bitumen of class 20/30,

- when the mix is a high modulus mix, it may comprise by weight based on the total weight of the mix, i.e. the hydrocarbon binder and stone skeleton mixture:

    - from 1 to 5%, preferably from 1.5 to 3%, and more preferably from 2 to 3% fines, preferably limestone filler,
    - from 90 to 95% aggregates, preferably aggregates 0/14, and
    - from 4.5% to 5.3%, preferably from 5% to 5.3% hydrocarbon binder, preferably a pure bitumen of class 10/20,

when the mix is thin asphalt concrete, it may comprise by weight based on the total weight of the mix, i.e. the hydrocarbon binder and stone skeleton mixture:

    - from 1 to 5%, preferably from 1.5 to 3%, and more preferably from 1.5 to 2.5% fines, preferably limestone filler,
    - from 90 to 95% aggregates, preferably aggregates 0/10, and
    - from 4.5% to 5.3%, preferably from 4.6% to 4.9% hydrocarbon binder, preferably a polymer-modified bitumen,

- the mixes of the previous families (BBSG, BBME, EME, BBM) can be made from modified binders of the ranges colflex® (Colflex N, J, S and HP), Bitulastic® (EA, EB, EC, EC+, ED, EF, EH), and sacerflex® (1, 2, 3, 4), but also any kind of modified binder.

- the use of asphalt aggregates in the mixture is also possible. This is a common practice to preserve aggregate resources. In this case, the binder reduction concerns exclusively the added binder of the mixture.

The present invention will be now exemplified by, but not limited to, the following description of an embodiment and with reference to Figure 1 which shows a schematic representation of a plant for producing a mix according to the invention.

Basically, the invention consists in incorporating the bituminous binder in two successive steps to produce a bituminous binder-efficient hot mix.

The first step (or time) in which the granular mixture and only a part of the bituminous binder are introduced in the mixer results in an agglomeration of the finest elements and the achievement of a mastic. The aggregates are then only very partially coated and the mastic thus formed is enriched in fine elements. The enrichment of the binder in fines forming the mastic limits the possibility of a subsequent mixing of the fines with the remaining binder during the second step. The remainder of the binder introduced during the second step may then coat easily all of the skeleton coarse aggregates. As the free fines disappeared (the fines were incorporated into the mastic obtained in the first step), the viscosity of the remaining binder which is introduced in the second step has not significantly changed.

The fixation of the finest elements by the first injection of binder (first step) generally results in a mix having a "greasier" appearance at the end of the mixing. This higher gloss of the binder film can be attributed to the absence of fines in the bituminous binder which coats the coarsest elements of the stone skeleton. It also shows the different distribution of the bituminous binder within the granular skeleton.

These two features make it possible to develop mix formulations optimized in term of performance and bituminous binder consumption.

The mixes can be produced in any mixing plant. A mixing plant is generally constituted of the following main elements:

- storage means for coarse aggregate 3, fine elements 2 and bitumen 4 as well as dosage means for each of these components 5, 6 and 7,
- a coarse aggregate drying unit,
- a mixing unit 1,
- means for introducing the different components in the mixer,
- means for recovering the hot mixes.

In the context of the invention, the coating is performed in the following sequence:

- incorporating on the whole stone skeleton (coarse aggregate and fine element mixture) a fraction of the hydrocarbon binder (first step),
- wet mixing (first step) to form a "mastic",

- incorporating the balance of hydrocarbon binder to achieve the total binder amount of the formula (second step),
- further mixing (second step).

The so-called "wet" mixing is a mixing of the hydrocarbon binder with aggregates in contrast to the so-called "dry" mixing which corresponds to the mixing of the different aggregates prior to the introduction of the binder.

There are two main types of processes for preparing asphalt mixes, namely continuous and batch processes. In order to ensure a good coating and good final mechanical performance, aggregates are conventionally dried and brought to a temperature close to that of the bitumen. Similarly, the bitumen is generally heat injected.

In practice, the introduction of the bituminous binder in two successive sequences can be made in industrial settings on a batch plant. In this case, the process of the invention extends slightly the production time of a batch, because this process requires two binder introduction sequences and two wet mixing periods. For example, a plant as schematically represented on the Figure 1 is used. This plant includes a mixer 1 which may receive batchwise in its tank the different size fractions of the aggregate including fines from a storage means 2, coarse aggregates from a storage means 3 and hydrocarbon binder from a storage means 4. An output 8 with a valve for recovering the produced mix is provided. Valves 5, 6 and 7 are respectively used to adjust the dosage of these elements with a control means 9 comprising sequenced means for actuating valves, mixer motor and other elements (for example for heating tank and/or storage means) of the plant not shown to simplify the Figure. The sequencing of controls allows mix to be produced in two stages with an intermediate production of mastic by using, in the first step, only a part of the hydrocarbon binder.

In a continuous process, aggregates enter continuously into a drum comprising a drying area including a means for heating and drying the aggregates. In another drum area, the aggregates coming from the drying area are coated by the liquid bitumen before leaving and being conveyed to a buffering storage hopper. The process of the invention can also be implemented in a continuous plant by setting up a second binder supply circuit and a second injection lance offset from the first injection lance.

The hydrocarbon binder is preferably bitumen, either a hydrocarbon material mixture of natural origin derived from the heavy fraction obtained during petroleum distillation, or from natural deposits in solid or liquid form, having a density of between 0.8 and 1.2. The bitumens of the invention can be prepared by any conventional technique. Also included as bitumens in the sense of the invention are binders of vegetable origin such as Végécol®, sold by the Colas company and described in the FR Patent 2 853 647, synthetic binders of petroleum origin such as the range of binders Bituclair® sold by the Colas company, bitumens modified by incorporating additives of all kinds, such as additives for improving adhesiveness characteristics, liquid additives that enable to produce mix at reduced temperature, by incorporating elastomers, as rubber crumb or other forms, or bitumens improved by adding polymers of various types, such as ethylene and vinyl acetate copolymers, or random or conjugated diene and styrene block copolymers, for example SBS block copolymers. It is understood that this list is not exhaustive. It is also possible to use bitumen mixture of various types.

The terms "aggregates" and "granular mixture" refer to the materials and aggregates described in the XP-P 18 545 and NF EN 13808-8 standards.

The following 3 non-limiting examples illustrate the present invention, in the case of a mixture with pure bitumen, an EME formulation incorporating asphalt aggregates and a modified binder-based formulation.

EXAMPLES

I. High modulus asphalt concrete 0/10 (BBME 0/10)

This first example describes the performance measured in the context of a laboratory formulation study in accordance with a fundamental approach within the meaning of the standard EN 13108-20, i.e. including the modulus and fatigue characteristic determination. The three compositions are in kilograms, which make it possible to check that the total binder dosage of the mixture is the only variable.

I.1. Formulation

a. Control BBME composition

Granular mixture:	6/10 Diorite	360 kg
	2/6 Diorite	300 kg
	0/2 Diorite	320 kg
	Limestone filler	20 kg
Pure 20/30 bitumen:		57 kg

This composition corresponds to a total binder dosage of 5.39% by weight, based on the total weight of the hydrocarbon binder and granular mixture.

b. BBME composition of the invention with about 3.5 wt.% reduction in hydrocarbon binder content

Granular mixture:	6/10 Diorite	360 kg
	2/6 Diorite	300 kg
	0/2 Diorite	320 kg
	Limestone filler	20 kg
Pure 20/30 bitumen:		55 kg

This second composition corresponds to a total binder dosage of 5.21% by weight, based on the total weight of the hydrocarbon binder and granular mixture.

c. BBME composition of the invention with about 8.5 wt. % reduction in hydrocarbon binder content

Granular mixture:	6/10 Diorite	360 kg
	2/6 Diorite	300 kg
	0/2 Diorite	320 kg
	Limestone filler	20 kg
Pure 20/30 bitumen:		52 kg

This third composition corresponds to a total binder dosage of 4.94%.

I.2. Preparation process

The traditional process consists in constituting the granular mixture and adding in only one step all of the hydrocarbon binder. The granular mixture is heated to 180°C. Then, the whole bitumen, which is itself at 180°C, is included. The mixing is carried out during 120 seconds at 180°C.

The process of the invention consists in constituting the granular mixture. This granular mixture is heated to 180°C. The bitumen is stored at 180°C. 50% by weight of the bitumen specified amount is incorporated in the mixer followed by mixing for 60 seconds at 180°C. The remaining bitumen (50%) is then incorporated and mixed again during 60 seconds at 180°C. In this example, each binder injection into the manufacturing process corresponds to the introduction of the half of the total binder needed for the manufacture of the mix.

I.3. Results

Mechanical performance comparative studies were performed between the control formula produced by the traditional process and the two mixes made according to the invention incorporating smaller amounts of bituminous binder. The following table summarizes this comparison:

Mechanical characteristics	Control formula BBME 0/10	Double coating (3.5% reduction)	Double coating (8.5% reduction)
Mixture binder content as %	5.39%	5.21%	4.9%
PCG test (EN 12697-31 January 2005) % voids at 60 gyrations	8.3	8.6	9.9
Duriez Test water resistance (NF P98-251-1 September 2002) Ratio r/R	0.86	0.87	0.85

Rutting test (EN 12697-22 June 2004) Rut as % at 30000 cycles 60°C	4.5	4.4	-
Modulus in MPa (EN 12697-26, Dec. 2004) Annex D : 15°C 0.02s Annex A : 15°C 10Hz % specimen voids	12900 6.5	14000 6.9	 12500 6.9
Fatigue strength (EN 12697-24 March 2005) ε_6 (µdefs) % specimen voids	115 6	114 7.4	111 7.4

In this example, it is noted that the incorporation of the binder in two successive steps results in a maintenance of the overall mechanical performance despite about 3.5% reduction in the total binder amount in the mixture. It is even possible that the fatigue strength is improved on this type of mixture obtained by double coating, because the measured value of 114 µdefs is obtained on less compact test specimens. If the reduction in binder content is amplified and brought to about 8.5% as in the example shown, a moderate reduction in the handling through the PCG test result, but maintenance of the water resistance measured on this mixture is observed.

It is understood that the invention can be implemented in accordance with procedures other than that is exemplified without departing from the general scope defined by the claims. For example, it is possible to use different proportions, other than 50%-50%, for each binder injection, while aiming at a reduction of the binder total amount compared to a similar formulation obtained by simply coating.

II. High modulus mix 0/14 cl2 (EME 0/14)

This second example shows the characteristics measured on a control formulation of EME 0/14, incorporating 20% asphalt aggregates, and on the same mixture prepared by double coating with an added binder content reduction. The two compositions are in kilograms, which make it possible to check that the total binder dosage of the mixture is the only variable. Only the results of water resistance, PCG handling, modulus and fatigue strength are shown.

II.1. Formulation

a. Control EME composition

Granular mixture:	10/14 Limestone	315 kg
	6/10 limestone	130 kg
	2/6 Limestone	130 kg

	0/2 Limestone	200 kg
	Asphalt aggregates	200 kg
	Limestone filler	25 kg
Added pure 10/20 bitumen:		50 kg
Total bitumen (Aggregates + Added)		60 kg

This composition corresponds to a total binder dosage of 5.71% by weight, based on the total weight of the hydrocarbon binder and granular mixture.

b. EME composition of the invention with 8%reduction in total binder content

Granular mixture:	10/14 Limestone	315 kg
	6/10 limestone	130 kg
	2/6 Limestone	130 kg
	0/2 Limestone	200 kg
	Asphalt aggregates	200 kg
	Limestone filler	25 kg
Added pure 10/20 bitumen:		45 kg
Total bitumen (Aggregates + Added)		55 kg

This composition corresponds to a total binder dosage of 5.27% by weight, based on the total weight of the hydrocarbon binder and granular mixture.

II.2. Preparation process

The preparation process is the same as in the previous example.

II.3. Results

Mechanical performance comparative studies were performed between the control formula produced by traditional process and the formulation made according to the invention incorporating smaller amounts of bituminous binder. The following table summarizes this comparison:

Mechanical characteristics	Control formula EME 0/14	Double coating (8% reduction)
Mixture binder content as %	5.71%	5.27%
PCG test (EN 12697-31 January 2005) % voids at 100 gyrations	0.9	3.4
Duriez Test water resistance (NF P98-251-1 September 2002) Ratio r/R	0.93	0.95

Modulus in MPa (EN 12697-26, Dec. 2004) Annex A : 15°C, 10Hz % specimen voids	15880 2.5	16220 3.3
Fatigue strength (EN 12697-24 March 2005) ε_6 (μdefs) % specimen voids	136 2.5	130 3.3

In this example, it is noted that the incorporation of the binder in two successive steps results in a maintenance of the overall mechanical performance of modulus and fatigue strength despite about 8% reduction in total binder amount in the mixture.

III. Thin asphalt concrete based on modified binder bitulastic EB 0/10 (BBMa 0/10 cl3)

This third example describes the performance measured in the context of a laboratory formulation study comprising PCG handling, water resistance with the Duriez test and rutting resistance determination, i.e. including the general characteristic determination required in the foreword of the standard EN 13108-1 for this kind of formulation. The three compositions are in kilograms, which make it possible to check that the total binder dosage of the mixture is the only variable.

III.1. Formulation

a. Control BBMa composition

Granular mixture:	6/10 Diorite	680 kg
	2/6 Diorite	300 kg
	Limestone filler	20 kg
Modified binder:		55 kg

This composition corresponds to a total binder dosage of 5.21% by weight, based on the total weight of the hydrocarbon binder and granular mixture.

b. BBMa composition of the invention with about 5.4 wt. % reduction in hydrocarbon binder content

Granular mixture:	6/10 Diorite	680 kg
	0/2 Diorite	300 kg
	Limestone filler	20 kg
Modified binder:		52 kg

This second composition corresponds to a total binder dosage of 4.94% by weight, based on the total weight of the hydrocarbon binder and granular mixture.

c. BBMa composition of the invention with about 9 wt. % reduction in hydrocarbon binder content

Granular mixture:	6/10 Diorite	680 kg
	0/2 Diorite	300 kg
	Limestone filler	20 kg
Modified binder:		50 kg

This last composition corresponds to a total binder dosage of 4.76%.

III.2. Preparation process

The laboratory manufacturing process is the same as in the previous example, the only variation is of the temperature, adapted to the nature of the modified binder used here, and set at 170°C.

III.3. Results

Mechanical performance comparative studies were performed between the control formula produced by the traditional process and the two mixes made in accordance with the invention incorporating smaller amounts of bituminous binder. The following table summarizes this comparison:

Mechanical characteristics	Control formula BBMa 0/10	Double coating (5% reduction)	Double coating (9% reduction)
Mixture binder content as %	5.21%	4.94%	4.76%
PCG test (EN 12697-31/01/2005) % voids at 40 gyrations	8.6	10.4	11
Duriez Test water resistance (NF P98-251-1 September 2002) Ratio r/R	0.95	0.94	0.92
Rutting test (EN 12697-22/06/2004) % plate mean void Rut as % at 30000 cycles 60°C	 8.3 6.5	 8.5 6.5	 7.9 4.8

In this example, it is noted that the incorporation of the binder in two successive steps results in a maintenance of the overall mechanical performance despite about 3.5% reduction in total binder amount in the mixture.

Szabadalmi igénypontok

1. Eljárás csökkentett szénhidrogén kötőanyag-tartalmú forró keverék előállítására, amely keverék meghatározott mennyiségű szénhidrogén kötőanyagot és egy szemcsés keveréket tartalmaz, amely keverék finom alkotóelemeket tartalmaz, mint amilyenek például finom és durva aggregátumok, mint például zúzalék, szemcsés homok és/vagy homok, és az eljárás legalább az alábbi, egymás után következő lépéseket tartalmazza:

- először a meghatározott mennyiségű szénhidrogén kötőanyag első részét belekeverjük a szemcsés keverékbe egy keverőgépben (1);
- nedvesen elkeverjük, így masztixot kapunk;
- majd belekeverjük a maradék szénhidrogén kötőanyagot;
- összekeverjük;

azzal jellemezve, hogy a szénhidrogén kötőanyag első része 30-70 tömeg% a szénhidrogén kötőanyag teljes tömegére számítva.

2. Az 1. igénypont szerinti eljárás, *azzal jellemezve*, hogy a szénhidrogén kötőanyag első része előnyösen 40-60 tömeg%, előnyösebben 50 tömeg% a szénhidrogén kötőanyag teljes tömegére számítva.

3. Az 1. vagy 2. igénypont szerinti eljárás, *azzal jellemezve*, hogy a két lépés során ugyanazt a hőmérsékletet alkalmazzuk.

4. Az előző igénypontok bármelyike szerinti eljárás, *azzal jellemezve*, hogy a keverék magas modulusú aszfaltkeverékek ((Enrobes a Module Elevé vagy EME), magas modulusú aszfaltbetonok (Bétons Bitumineux a Module Elevé vagy BBME), vastag rétegű aszfaltbetonok (Bétons Bitumineux Semi-Grenus vagy BBSG), vékony rétegű aszfaltbetonok (Bétons Bitumineux Minces vagy BBM) és nagyon vékony rétegű aszfaltbetonok (Bétons Bitumineux Trés Minces vagy BBTM) köréből választott.

5. Az előző igénypontok bármelyike szerinti eljárás, *azzal jellemezve*, hogy a szemcsés keverék vegyes aggregátumokat tartalmaz.

6. Az előző igénypontok bármelyike szerinti eljárás, *azzal jellemezve*, hogy a szénhidrogén kötőanyag penetrációja 25°C hőmérsékleten MSZ EN 1426 szabvány szerint mérve 0-70 (1/10 mm), előnyösen 0-35 (1/10 mm) a BBME és az EME esetén.

7. A 4. igénypont szerinti eljárás, *azzal jellemezve*, hogy a keverék egy magas modulusú aszfaltbeton, amely tartalmaz a keverék teljes tömegére vonatkoztatva:

- 1-5 tömeg% finomanyagot, előnyösen mészkő töltőanyagot;
- 90-95 tömeg% aggregátumot, előnyösen 0/10 aggregátumot, és

- 4,9-5,25 tömeg% szénhidrogén kötőanyagot, előnyösen tiszta 20/30 bitument.

8. A 4. igénypont szerinti eljárás, *azzal jellemezve*, hogy a keverék egy magas modulusú aszfaltkeverék, amely tartalmaz a keverék teljes tömegére vonatkoztatva:

- 1-5 tömeg% finomanyagot, előnyösen mészkő töltőanyagot;

- 90-95 tömeg% aggregátumot, előnyösen 0/14 aggregátumot, és

- 5-5,3 tömeg% szénhidrogén kötőanyagot, előnyösen tiszta 20/30 bitument.

9. A 4. igénypont szerinti eljárás, *azzal jellemezve*, hogy a keverék egy vékony rétegű aszfaltbeton, amely tartalmaz a keverék teljes tömegére vonatkoztatva:

- 1-5 tömeg% finomanyagot, előnyösen mészkő töltőanyagot;

- 90-95 tömeg% aggregátumot, előnyösen 0/14 aggregátumot, és

- 4,6-4,9 tömeg% szénhidrogén kötőanyagot, előnyösen tiszta 20/30 bitument.

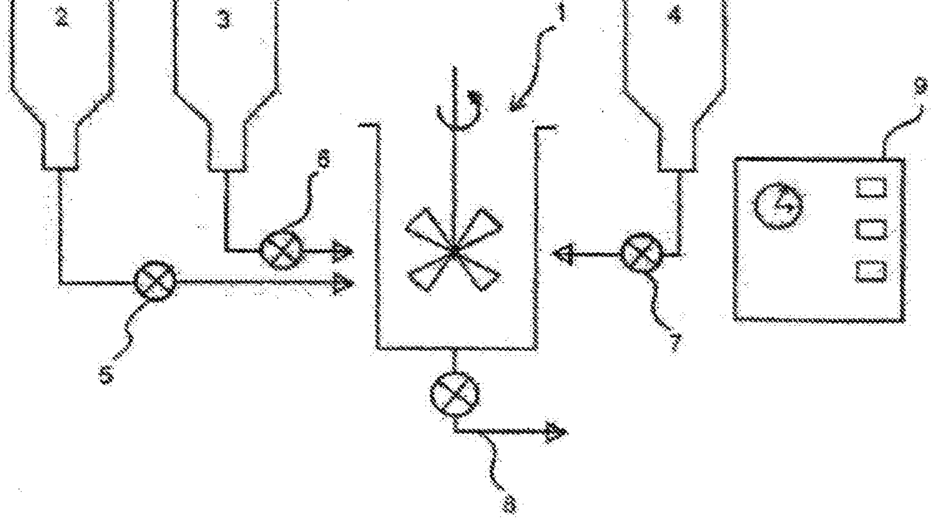

Fig. 1