Oversættelse af europæisk patentskrift
The present invention is directed, in one aspect, to bituminous asphalt binder materials which are modified by the addition of crumb rubber or ground tire rubber and a cross-linking agent. In a second aspect, the present invention is directed to a method of producing a modified asphalt binder containing crumb rubber or ground tire rubber and a cross-linking agent. The modified asphalt binders of the present invention comprise neat asphalt, crumb rubber, one or more acids and a cross-linking agent. Optionally, the modified asphalt binder may include one or more polymer additives. The crumb rubber may be obtained from recycled truck and/or automobile tires.

The addition of crumb rubber in asphalt binders can improve the consistency and properties of the asphalt binders at high and low temperatures. In particular, the modified asphalt binders of the present invention exhibit improved elastic behavior, resulting in improved performance of roads or other surfaces paved using the modified asphalt binder. Road resistance to permanent deformation, fatigue cracking and thermal cracking is improved by use of the modified asphalt binder. The addition of the cross-linking agent may also improve the stability of the modified asphalt binder for storage.

As used herein and in the claims, the phrase "asphalt binder" refers to a bituminous material, sometimes referred to as bitumen, used as a binder in asphalts used to pave roads or other surfaces, or used in construction materials such as roofing materials, coatings, and water sealants. Examples of bitumen that may be used in the compositions and methods of the present invention include natural bitumens, pyrobitumens and artificial bitumens. Bitumens that are particularly preferred are those used for roadways, such as asphalt or maltha. Asphalt paving material is made by mixing the asphalt binder with aggregate.

As used herein and in the claims, the phrase "crumb rubber" refers to rubber particles which have a particle size of less than 5 mm, and preferably have a particle size of less than 2 mm. Crumb rubber may be obtained from grinding of used truck tires or automobile tires, or from any other appropriate source of ground rubber.

The use of crumb rubber and polyphosphoric acid in asphalt binders was described previously in publication number WO 04/081098, titled "Bituminous Binder and Method for the Production Thereof." As described in that published patent application, by combining between 0.5% by weight to 5% by weight polyphosphoric acid, and between 0.5% by weight to 25% by weight crumb rubber (or ground tire rubber) with the bituminous asphalt binder, the properties of the asphalt binder may be advantageously modified without increasing the rotational viscosity such that the mixing process requires high temperature conditions.
Asphalt binders are frequently used in applications where there can be a wide variation in environmental conditions, particularly when used in pavements. Accordingly, the properties of the asphalt binder in high and low temperature conditions is a concern. At low temperatures, some binder materials can become brittle, leading to long transverse fissures due to thermal stress. At higher temperatures, the asphalt binder becomes more fluid (i.e. the viscosity is lower), which can lead to rutting of a pavement due to the passage of vehicles over the surface. Resistance to fatigue and impact, and the adherence of the asphalt binder to aggregate in paving applications, are properties of a particular binder that also must be considered in particular applications.

Some asphalt binders may require a relatively high elastic behavior, for example where the corresponding asphalt paving mixture is used in areas of high traffic rates and high loads. Crumb rubber (or ground tire rubber), used alone or used in combination with polyphosphoric acid, does not sufficiently improve the elastic behavior of the asphalt paving mixture for high traffic and high load uses. When a high elasticity is required, large amounts of crumb rubber must be added to the asphalt binder. This can cause an undesirable increase in rotational viscosity, as well as problems related to storage of the binder material.

Accordingly, among the objects of the present invention is to provide an asphalt binder material with a relatively high elasticity, an acceptable rotational viscosity, and that can be stored for adequate periods of time. Another object of the present invention is to provide methods of making an asphalt binder having these properties.

In one aspect, the present invention is directed to a modified asphalt binder material comprising asphalt, crumb rubber, one or more acids, a cross-linking agent, and, optionally, one or more polymers. In one embodiment of the invention, neat asphalt is modified by adding 0.5% to 30% by weight of crumb rubber, 0.05% to 5% by weight of one or more acids, and 0.01% to 5% by weight of a cross-linking agent. The modified asphalt binder may also include between 0.5% by weight and 30% by weight of one or more polymer additives. The asphalt binders of the present invention typically have between 10% to 90% elastic recovery under a standard elastic recovery test, such as the test protocols set forth in AASHTO T51, ASTM D6084-04, NLT329 or other standard tests.

In another aspect, the present invention is directed to a method of producing a modified asphalt binder material comprising asphalt, crumb rubber, one or more acids, one or more cross-linking agents, and, optionally, one or more polymers.
In yet another aspect, the modified asphalt binders of the present invention may be mixed with water and an emulsifier to form a emulsion. The emulsified asphalt binder may be mixed with an aggregate material, spread to form a layer of the desired thickness, and the emulsion will be broken to form an asphalt pavement. Alternatively, the emulsified asphalt binder may be spread upon a surface, an aggregate material may be spread over the emulsified binder, and the emulsion may be broken.

The present invention is directed to modified asphalt binders and a method of making modified asphalt binders. The modified asphalt binders comprise neat asphalt, crumb rubber, one or more acids, and one or more cross-linking agents. Optionally, the compositions may further include one or more polymers. It will be understood that "crumb rubber" as used herein includes crumb rubber, such as ground tire rubber or any other rubber provided in particle form suitable for mixture with an asphalt binder. Typically, a substantial portion of the crumb rubber will have a particle size less than 5 mm, preferably less than 2 mm, and more preferably less than 1 mm. The invention is not limited in this regard, and the crumb rubber may have any particle size distribution that results in an asphalt binder with the desired properties.

The modified asphalt binders of the present invention comprise between 60% by weight to 98.9% by weight neat asphalt, between 0.1% by weight to 30% by weight crumb rubber, between 0.05% by weight to 5% by weight of one or more acids, and between 0.01% by weight to 5% by weight of a cross-linking agent. Optionally, the modified asphalt binder may further comprise between 0.5% by weight to 30% by weight of one or more synthetic polymers.

Preferred acids for use in the modified asphalt binder of the present invention include phosphoric acid, polyphosphoric acid (more than 100% expressed as orthophosphoric content)("PPA"), sulfuric acid at more than 90% wt, boric acid, and carboxylic acids such as, for example, adipic acid, citric acid, oxalic acid, tartaric acid, maleic acid, valeric acid, succinic acid, fumaric acid, glutamic acid, phthalic acid, acetic acid, and combinations of the above acids. The invention is not limited in this regard, and any appropriate acid known to those skilled in the art may be used in the modified asphalt binder.

The acid may be added to the asphalt binder in either a solid form or in a liquid solution. Where a solid form of the acid is used, the acid can be either a pure acid, such as boric acid or polyphosphoric acid, or the acidic component may be combined with an inert component for ease of handling, such as for example a SiO₂-PPA additive.
Preferred cross-linking agents include sulfur based compounds such as, for example, benzothiazoles, diphenylguanidine, dithiocarbamate, and elementary sulfur and/or a mixtures thereof. The butaphalt crosslinker is also suitable, as are the crosslinkers cited in the following United States patents and published applications: U.S. Pat. No. 6,451,886; application Ser. No. 2003144387 and U.S. Pat. No. 5,256,710. The invention is not limited in this regard and any appropriate rubber cross-linking agent known to those skilled in the art may be utilized in the present invention.

In those embodiments of the present invention in which a synthetic polymer is used, preferred synthetic polymers include styrene butadiene, styrene butadiene styrene ("SBS") three block, ethylene vinyl acetate, ethylene propylene copolymers, polyvinylchloride (PVC), nylon, polystyrene, polybutadiene, acrylate resins, fluororocarbone resins, phenolic resins, alkyd resins, polyesters, polyethylene (linear or crosslinked), epoxy terpolymer, polypropylene (atactic or isotactic), and combinations of the above polymers. The invention is not limited in this regard, and any appropriate synthetic polymer known to those skilled in the art may be used in the modified asphalt binder.

In a second aspect, the present invention is directed to a method of producing the modified asphalt binder. For those embodiments of the present invention which do not include a synthetic polymer additive, the preferred method for manufacturing the modified asphalt binder comprise the steps of (1) heating the asphalt to a temperature of between 120°C and 200°C, (2) adding a first modifying ingredient, (3) mixing the asphalt and the first modifying ingredient with a high shear mixer, such as, for example, a rotor-stator type mixer (i.e. a SILVERSON type mixer) for a period of between 5 minutes and 10 hours, (4) adding a second modifying ingredient to the modified asphalt binder, (5) mixing the second modifying ingredient and the modified asphalt binder in a high shear mixer for a period of between 5 minutes and 10 hours, (6) adding a third modifying ingredient to the modified binder material, and (7) agitating the third modifying ingredient and the modified asphalt binder in a low shear mixer (such as, for example, a propeller type mixer driven by a motor at 250 rpm, similar to an IKA type lab mixer) for a period of between 5 minutes and 48 hours.

The first modifying ingredient is either crumb rubber or one or more acids. Where the first modifying ingredient is crumb rubber, the second modifying ingredient is the cross-linking agent, and the third modifying ingredient is one or more acids. Alternatively, where the first modifying ingredient is one or more acids, the second modifying ingredient is crumb rubber and the third modifying ingredient is a cross-linking agent. Preferably, crumb rubber is added to the asphalt to achieve a crumb rubber level of between 0.1% by weight
and 30% by weight in the final modified asphalt material, one or more acids are added to achieve a total acid concentration of between 0.05% by weight and 5% by weight in the modified asphalt material, and the cross-linking agent is added to achieve a level of between 0.01% by weight to 5% by weight of the cross-linking agent.

In other embodiments of the method of the present invention, one or more synthetic polymers are added to the modified asphalt composition. In these embodiments of the present invention, the preferred method of modifying the asphalt binder generally include the steps of (1) heating the asphalt to a temperature of between 120°C and 200°C, (2) adding a first modifying ingredient, (3) mixing the asphalt and the first modifying ingredient with a high shear mixer, such as, for example, a rotor-stator type mixer (i.e. a SILVERSON type mixer) for a period of between 5 minutes and 10 hours, (4) adding a second modifying ingredient to the modified asphalt binder, (5) mixing the second modifying ingredient and the modified asphalt binder in a high shear mixer for a period of between 5 minutes and 10 hours, (6) adding a third modifying ingredient to the modified binder material, (7) optionally, mixing the third modifying ingredient and the modified asphalt binder for a period of between 5 minutes and 10 hours, (8) adding one or more synthetic polymers as fourth modifying agent to the modified binder material, and (9) agitating the fourth modifying ingredient and the modified asphalt binder in a low shear mixer (such as, for example, a propeller type mixer driven by a motor at 250 rpm, similar to an IKA type lab mixer) for a period of between 5 minutes and 48 hours.

The modifying ingredients used in these embodiments of the method are crumb rubber, one or more acids, one or more synthetic polymers, and a cross-linking agent as described above. The cross-linking agent is added to the asphalt after the crumb rubber has been added, but the cross-linking agent may be added before or after either the acids.

In these embodiments of the method of the present invention, crumb rubber is added to the asphalt to achieve a crumb rubber level of between 0.1% by weight and 30% by weight in the final modified asphalt material, one or more acids are added to achieve a total acid concentration of between 0.05% by weight and 5% by weight in the modified asphalt material, one or more synthetic polymers are added to achieve a total polymer concentration of between 0.5% by weight and 30% by weight, and the cross-linking agent is added to achieve a level of between 0.01% by weight to 5% by weight of the cross-linking agent.

It will be understood by those skilled in the art that low shear mixers may be used in place of high shear mixers in the method described above depending upon the temperatures and
the mixing times used, and one skilled in the art can readily determine the appropriate mixing times based upon the temperature and the additive materials used.

The preferred synthetic polymers and the preferred acids used in the method of the present invention are described above.

Several exemplary embodiments of the method of the present invention are described below:

**Crumb Rubber-Acid-Cross-Linking Agent System**

**Example 1**

- Neat asphalt is heated to a temperature of between 120°C to 200°C
- Add from between 0.1 % by weight to 10% by weight of crumb rubber
- Mix with high shear mixer for between 5 minutes to 10 hours
- Add from between 0.01% by weight to 5% by weight of a cross-linking agent
- Mix with a high shear mixer for between 5 minutes to 10 hours
- Add from between 0.5% by weight to 3% by weight of one or more acids
- Agitate the modified asphalt obtained with low shear mixer from 5 minutes to 48 hours

**Example 2**

- Neat asphalt is heated to a temperature of between 120°C to 200°C
- Add from between 0.5% by weight to 3% by weight of one or more acids
- Mix with high shear mixer for between 5 minutes to 10 hours
- Add from between 0.1% by weight to 10% by weight of crumb rubber
- Mix with a high shear mixer for between 5 minutes to 10 hours
- Add from between 0.01% by weight to 5% by weight of a cross-linking agent
- Agitate the modified asphalt obtained with low shear mixer from 5 minutes to 48 hours

**Crumb Rubber-Polymer-Acid-Cross-Linking Agent System**

**Example 3 (Method not according to the invention)**

- Neat asphalt is heated to a temperature of between 120°C to 200°C
- Add from between 0.5% by weight to 5% by weight of one or more synthetic polymer
• Mix with high shear mixer for between 5 minutes to 10 hours
• Add from between 0.1% by weight to 10% by weight of crumb rubber
• Mix with a high shear mixer for between 5 minutes to 10 hours
• Add from between 0.5% by weight to 3% by weight of one or more acids
• Add from between 0.01% by weight to 5% by weight of a cross-linking agent
• Agitate the modified asphalt obtained with low shear mixer from 5 minutes to 48 hours

Example 4 (Method not according to the invention)

• Neat asphalt is heated to a temperature of between 120°C to 200°C
• Add from between 0.5% by weight to 5% by weight of one or more synthetic polymer
• Mix with high shear mixer for between 5 minutes to 10 hours
• Add from between 0.5% by weight to 3% by weight of one or more acids
• Mix with a high shear mixer for between 5 minutes to 10 hours
• Add from between 0.1% by weight to 10% by weight of crumb rubber
• Mix with a high shear mixer for between 5 minutes to 10 hours
• Add from between 0.01% by weight to 5% by weight of a cross-linking agent
• Agitate the modified asphalt obtained with low shear mixer from 5 minutes to 48 hours

Example 5 (Method not according to the invention)

• Neat asphalt is heated to a temperature of between 120°C to 200°C
• Add from between 0.1% by weight to 10% by weight of crumb rubber
• Mix with high shear mixer for between 5 minutes to 10 hours
• Add from between 0.5% by weight to 5% by weight of one or more synthetic polymers
• Mix with a high shear mixer for between 5 minutes to 10 hours
• Add from between 0.5% by weight to 3% by weight of one or more acids
• Add from between 0.01% by weight to 5% by weight of a cross-linking agent
• Agitate the modified asphalt obtained with low shear mixer from 5 minutes to 48 hours

Example 6 (Method not according to the invention)

• Neat asphalt is heated to a temperature of between 120°C to 200°C
• Add from between 0.1% by weight to 10% by weight of crumb rubber
• Mix with high shear mixer for between 5 minutes to 10 hours
- Add from between 0.5% by weight to 3% by weight of one or more acids
- Mix with a high shear mixer for between 5 minutes to 10 hours
- Add from between 0.5% by weight to 5% by weight of one or more synthetic polymers
- Mix with a high shear mixer for between 5 minutes to 10 hours
- Add from between 0.01% by weight to 5% by weight of a cross-linking agent
- Agitate the modified asphalt obtained with low shear mixer from 5 minutes to 48 hours

**Example 7 (Method not according to the invention)**

- Neat asphalt is heated to a temperature of between 120°C to 200°C
- Add from between 0.5% by weight to 3% by weight of one or more acids
- Mix with high shear mixer for between 5 minutes to 10 hours
- Add from between 0.5% by weight to 5% by weight of one or more synthetic polymers
- Mix with a high shear mixer for between 5 minutes to 10 hours
- Add from between 0.01% by weight to 5% by weight of a cross-linking agent
- Agitate the modified asphalt obtained with low shear mixer from 5 minutes to 48 hours

**Example 8 (Method not according to the invention)**

- Neat asphalt is heated to a temperature of between 120°C to 200°C
- Add from between 0.5% by weight to 3% by weight of one or more acids
- Mix with high shear mixer for between 5 minutes to 10 hours
- Add from between 0.1% by weight to 10% by weight of crumb rubber
- Mix with a high shear mixer for between 5 minutes to 10 hours
- Add from between 0.5% by weight to 5% by weight of one or more synthetic polymers
- Mix with a high shear mixer for between 5 minutes and 10 hours
- Add from between 0.01% by weight to 5% by weight of a cross-linking agent
- Agitate the modified asphalt obtained with low shear mixer from 5 minutes to 48 hours

Tests were conducted to measure the properties of modified asphalt binders using cross-linking agents according to the present invention. In one set of tests, a modified asphalt
binder was prepared using only crumb rubber and PPA, while a second modified asphalt binder was prepared using crumb rubber, 0.1% sulfur as a cross-linking agent, and PPA. In both cases, crumb rubber was first added to the asphalt binder and stirred with a high shear mixer for two hours. For the first modified binder, PPA was added and mixed using a high shear mixer for 30 minutes. For the second modified binder, sulfur was added and mixed using a high shear mixer for 15 minutes, followed by addition of PPA and further mixing with a high shear mixer for 30 minutes. The measured properties of the resulting modified asphalt binders are summarized below in Table 1.

<table>
<thead>
<tr>
<th></th>
<th>5</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>% CR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% PPA</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Cross-linker</td>
<td>None</td>
<td>0.1% S</td>
</tr>
<tr>
<td>Asphalt</td>
<td>PG 64-22</td>
<td>PG 64-22</td>
</tr>
<tr>
<td>Temperature</td>
<td>320°C</td>
<td>160°C</td>
</tr>
<tr>
<td>Visc, cP, 135°C</td>
<td>890</td>
<td>1020</td>
</tr>
<tr>
<td>ER, %, 25°C</td>
<td>35</td>
<td>45</td>
</tr>
<tr>
<td>Top end tru-grade</td>
<td>72</td>
<td>72.9</td>
</tr>
<tr>
<td>BBR, Stiffness, MPa</td>
<td>180</td>
<td>205</td>
</tr>
<tr>
<td>BBR, m-value</td>
<td>0.323</td>
<td>0.321</td>
</tr>
</tbody>
</table>

A series of tests were conducted in which a modified asphalt binder was produced by addition of SBS, polyphosphoric acid and crumb rubber to an asphalt binder. In one of the modified asphalt binders, a cross-linking agent was added to the asphalt binder following the addition of the crumb rubber. The mixing times using a high shear mixer were as follows (mixing times following the addition of each component was the same regardless of the order of addition): following addition of crumb rubber, 2 hours; following addition of SBS, 6 hours; following addition of sulfur, 30 minutes; following addition of PPA, 30 minutes. The properties of the modified asphalt binders obtained in the tests are summarized in Table 2.
Table 2

<table>
<thead>
<tr>
<th>Order of addition</th>
<th>SBS-PPA-CR</th>
<th>SBS-CR-PPA</th>
<th>CR-Crosslinker-SBS-PPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>% CR</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>% PPA</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>% SBS</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Crosslinker, %</td>
<td>None</td>
<td>None</td>
<td>1% SULFUR</td>
</tr>
<tr>
<td>Temperature</td>
<td>160°C</td>
<td>160°C</td>
<td>160°C</td>
</tr>
<tr>
<td>Visc, cP, 135°C</td>
<td>1400</td>
<td>1320</td>
<td>1320</td>
</tr>
<tr>
<td>ER, %, 25°C</td>
<td>50</td>
<td>50</td>
<td>57.5</td>
</tr>
<tr>
<td>Top end trugrade, °C</td>
<td>74.4</td>
<td>75.6</td>
<td>74.8</td>
</tr>
<tr>
<td>BBR, Stiffness, MPa</td>
<td>143</td>
<td>156</td>
<td>163</td>
</tr>
<tr>
<td>BBR, m-value</td>
<td>0.329</td>
<td>0.326</td>
<td>0.321</td>
</tr>
</tbody>
</table>

As can be seen in the above tables, in each case, the modified asphalt binder containing crumb rubber and a cross-linking agent demonstrated improved elasticity compared to formulations that did not include a cross-linking agent.

The modified asphalt composition may be used in an emulsion type process to apply the asphalt binder material. In one embodiment, the emulsion process comprises the following steps:

1. - the modified asphalt composition is prepared as described above;

2. - an emulsion of the modified asphalt composition obtained in step 1 is prepared by mixing water, the modified asphalt composition and an emulsifier at ambient temperature;

3. - the emulsion obtained in step 2 is spread in order to obtain a uniform layer of the emulsified asphalt binder; and

4. - the emulsion is broken.

Prior to breaking the emulsion, an aggregate material may be spread on the emulsified asphalt binder. Alternatively, the process described above may include an additional step in which aggregate is added, with stirring and at ambient temperature, to the emulsion obtained in step 2 of the process to form an asphalt pavement material. The asphalt
pavement material is spread to the desired thickness and the emulsion is broken. The emulsifier may be any appropriate emulsifier known to those skilled in the art. Also, the emulsion may be broken using conventional methods for breaking asphalt emulsions.

It will be recognized by those skilled in the art that the compositions or methods described above may be altered in numerous ways without departing from the scope of the present invention. For example, one or more of the mixing steps described above may be omitted, two or more of the modifying ingredients may be added to the asphalt together or at the same time, or additional modifying agents may be added to the composition to further modify the properties of the composition. Accordingly, the preferred embodiments described herein are intended to be illustrative rather than limiting in nature.
Patentkrav

1. Modifieret asfaltbindemiddel-sammensætning, omfattende:
   
a. 60 til 98,9 vægtprocent asfaltbindemiddel-materiale;
   
b. 0,1 til 30 vægtprocent gummungranulat;
   
c. 0,05 til 5 vægtprocent af mindst én syre; og
   
d. 0,01 til 5 vægtprocent af et tværbindingssmidel.

2. Sammensætning ifølge krav 1, hvor en væsentlig del af gummungranulatet har en partikelstørrelse på mindre end 2 mm.

3. Sammensætning ifølge krav 1, hvor den mindst ene syre er valgt fra gruppen bestående af phosphorsyre, polyphosphorsyre (mere end 100% udtrykt som orthophosphorsyreindhold), svovlsyre ved mere end 90 vægtprocent, borsyre, og carboxylsyrer såsom, for eksempel, adipinsyre, citronsyre, oxalsyre, vismin, maleinsyre, valeriansyre, ravsyre, fumarsyre, glutaminsyre, phtalsyre, eddikesyre, og kombinationer deraf.

4. Sammensætning ifølge krav 3, hvor tværbindingssmidlet er elementært svøl.

5. Sammensætning ifølge krav 1, yderligere omfattende én eller flere syntetiske polymerer.


7. Sammensætning ifølge krav 6, hvor den mindst ene syre er valgt fra gruppen bestående af phosphorsyre, polyphosphorsyre (mere end 100% udtrykt som orthophosphorsyreindhold), svovlsyre ved mere end 90 vægtprocent, borsyre og carboxylsyrer såsom, for eksempel, adipinsyre, citronsyre, oxalsyre, vismin, maleinsyre, valeriansyre, ravsyre,
fumarsyre, glutaminsyre, phthalsyre, eddikesyre, og kombinationer deraf.

8. Sammensætning ifølge krav 7, hvor tværbindingsmidlet er elementært svøl.

5 9. Fremgangsmåde til fremstilling af modificeret asfaltbindemiddel-sammensætning, omfattende trinnene at:

a. tilvejebringe ublandet asfalt i en passende beholder;

b. opvarme den ublandede asfalt til en temperatur på mellem 120 og 200°C.;

c. tilsætte en første modificerende bestanddel valgt fra gruppen bestående af gummigranulat og én eller flere syrer til den ublandede asfalt;

d. blande asfalten og den første modificerende bestanddel med en af en high shear-blander eller en low shear-blander i en periode på mellem 5 minutter og 10 timer

e. tilsætte en anden modificerende bestanddel valgt fra gruppen bestående af gummigranulat og tværbindingsmidler til det modificerede asfaltbindemiddel;

f. blande den anden modificerende bestanddel og det modificerede asfaltbindemiddel med en af en high shear-blander eller en low shear-blander i en periode på mellem 5 minutter og 10 timer

g. tilsætte en tredje modificerende bestanddel valgt fra gruppen bestående af tværbindingsmidler og én eller flere syrer til det modificerede bindemiddel-materiale; og

h. omrøre den tredje modificerende bestanddel og det modificerede bindemiddel-materiale med en af en high shear-blander eller en low shear-blander i en periode på mellem 5 minutter og 48 timer;

med det forbehold at når den første modificerende bestanddel er én eller flere syrer, er den anden modificerende bestanddel gummigranulat, og den tredje modificerende bestanddel er et tværbindingsmiddel eller at når den første modificerende bestanddel er gummigranulat, er den anden modificerende bestanddel et tværbindingsmiddel, og den tredje modificerende bestanddel er én eller flere syrer.

11. Fremgangsmåden ifølge krav 9, hvor den første modificerende bestanddel er mellem 0,5 vægtprocent og 30 vægtprocent gummigranulat, den anden modificerende bestanddel er mellem 0,01 vægtprocent og 5 vægtprocent af et tværbindingsmiddel, og den tredje modificerende bestanddel er mellem 0,05 vægtprocent og 5 vægtprocent af mindst én syre.

12. Fremgangsmåden ifølge krav 9, hvor den første modificerende bestanddel er mellem 0,05 vægtprocent og 5 vægtprocent af mindst én syre, den anden modificerende bestanddel er mellem 0,1 vægtprocent og 30 vægtprocent af gummigranulat, og den tredje modificerende bestanddel er mellem 0,01 vægtprocent og 5 vægtprocent af et tværbindingsmiddel.

13. Fremgangsmåden ifølge krav 9, yderligere omfattende trinnet at tilsætte en fjerde modificerende bestanddel til det modificerede asfaltbindemiddel-materiale hvor den fjerde modificerende bestanddel er én eller flere syntetiske polymerer.

14. Fremgangsmåden ifølge krav 13, hvor den første modificerende bestanddel er mellem 0,5 vægtprocent og 30 vægtprocent af mindst en syntetisk polymer, den anden modificerende bestanddel er mellem 0,1 vægtprocent og 30 vægtprocent af gummigranulat, den tredje modificerende bestanddel er mellem 0,5 vægtprocent og 5 vægtprocent af mindst én syre, og den fjerde modificerende bestanddel er mellem 0,01 og 5% af et tværbindingsmiddel.

15. Fremgangsmåden ifølge krav 13, hvor den første modificerende bestanddel er mellem 0,5 vægtprocent og 30 vægtprocent af mindst en syntetisk polymer, den anden modificerende bestanddel er mellem 0,05 vægtprocent og 5 vægtprocent af mindst én syre, den tredje modificerende bestanddel er mellem 0,1 vægtprocent og 30 vægtprocent af gummigranulat, og den fjerde modificerende bestanddel er mellem 0,01 og 5% af et tværbindingsmiddel.

16. Fremgangsmåden ifølge krav 13, hvor den første modificerende bestanddel er mellem 0,1 vægtprocent og 30 vægtprocent af gummigranulat, den anden modificerende bestanddel er mellem 0,5 vægtprocent og 30 vægtprocent af mindst en syntetisk polymer,
den tredje modificadorende bestanddel er mellem 0,05 vægtprocent og 5 vægtprocent af
mindst én syre, og den fjerde modificadorende bestanddel er mellem 0,01 og 5% af et
tværbindingsmiddel.

5 17. Fremgangsmåden ifølge krav 13, hvor den første modificadorende bestanddel er mellem
0,1 vægtprocent og 30 vægtprocent af gummigranulat, den anden modificadorende
bestanddel er mellem 0,05 vægtprocent og 5 vægtprocent af mindst én syre, den tredje
modificadorende bestanddel er mellem 0,5 vægtprocent og 30 vægtprocent af mindst en
syntetisk polymer, og den fjerde modificadorende bestanddel er mellem 0,01 og 5% af et
tværbindingsmiddel.

18. Fremgangsmåden ifølge krav 13, hvor den første modificadorende bestanddel er mellem
0,5 vægtprocent og 5 vægtprocent af én eller flere syrer, den anden modificadorende
bestanddel er mellem 0,5 vægtprocent og 30 vægtprocent af mindst en syntetisk polymer,
den tredje modificadorende bestanddel er mellem 0,1 vægtprocent og 30 vægtprocent af
gummigranulat, og den fjerde modificadorende bestanddel er mellem 0,01 og 5% af et
tværbindingsmiddel.

19. Anvendelse af det modificerede asfaltbindemiddel-materiale ifølge krav 1 i en
fremgangsmåde til fremstilling af et belægningsmateriale omfattende trinnene at:

(a) blande det modificerede asfaltbindemiddel med vand og et emulgeringsmiddel
ved omgivelsestemperatur for at danne en asfaltemulsion;

(b) sprede asfaltemulsionen ved en ønsket tykkelse; og

(c) bryde emulsionen.

20. Anvendelsen ifølge krav 19, hvor før trinnet at sprede asfaltemulsionen, blandes
aggregat med asfaltemulsionen.