

(19)



(11)

EP 3 336 250 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
20.06.2018 Bulletin 2018/25

(51) Int Cl.:
E01C 3/00 (2006.01)
E01C 7/18 (2006.01)
E01C 7/14 (2006.01)

(21) Application number: **17208703.3**

(22) Date of filing: **19.12.2017**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD TN

(30) Priority: **19.12.2016 GB 201621657**
18.07.2017 GB 201711563

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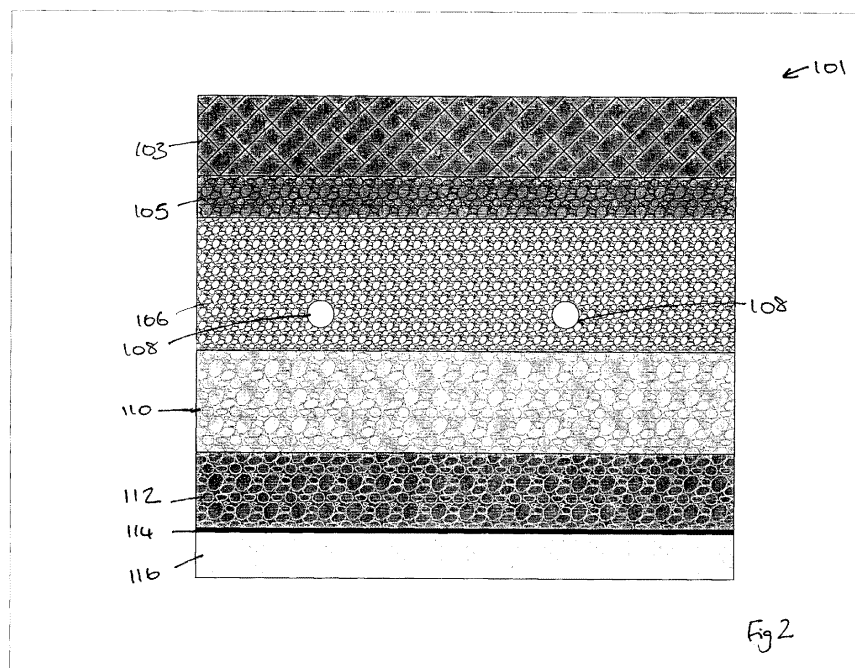
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(54) A PAVED STRUCTURE

(57) A paved structure (101) comprising a surface layer (103) formed from a non-permeable asphalt composition, a permeable asphalt composition, a non-permeable concrete composition or permeable concrete composition; and a layer (112) comprising carbon negative aggregate particles located beneath the surface layer, wherein the carbon negative aggregate particles com-

prise a solid precursor material selected from paper sludge combustion material, pulverised fuel ash, cement kiln dust, limestone particles, chalk particles, marble particles, Portland cement, sand, silt and mixtures thereof which has been reacted with carbon dioxide to form a solid aggregate material.



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Description

[0001] The present invention relates to a paved structure and in particular to a paved structure that includes a carbon negative aggregate material.

[0002] It is desired to provide an environmentally friendly impact for paved surfaces by including within the paved structure a component which is carbon negative. In other words, a component which utilises or traps more carbon than is used in its production.

[0003] According to a first aspect of the invention, there is provided a paved structure comprising a surface layer formed from a non-permeable asphalt composition, a permeable asphalt composition, a non-permeable concrete composition or permeable concrete composition; and a layer comprising carbon negative aggregate particles located beneath the surface layer, wherein the carbon negative aggregate particles comprise a solid precursor material selected from paper sludge combustion material, pulverised fuel ash, cement kiln dust, limestone particles, chalk particles, marble particles, Portland cement, sand, silt and mixtures thereof which has been reacted with carbon dioxide to form a solid aggregate material.

[0004] As noted above, the paved structure may be used in the preparation of roads, paths (e.g. pavements, sidewalks, etc.), parking lots, airports, schools, universities and such like. In the context of the present invention the term "paved" includes a structure which has a surface layer formed from a substantially continuous layer (such as asphalt or concrete) and a structure which has a surface layer formed from a number of close-set discrete elements which together substantially cover the surface of the structure (i.e. a discontinuous layer).

[0005] Based on the above, the skilled person will appreciate that a surface layer formed from a concrete material may comprise a substantially continuous layer of a concrete composition or it may comprise a surface layer comprised of concrete block which define gaps between adjacent blocks and/or within each block.

[0006] The carbon negative aggregate particles are known. For example, WO2007/096671 describes a process for incorporating carbon dioxide into an aggregate material by reacting a precursor solid material with a little water in a carbon dioxide-rich environment. The result is a hard aggregate material in which carbon dioxide is effectively locked. The precursor materials are typically waste fines from certain processes (e.g. quarrying and combustion processes), which are then combined and carbonated to form the carbon negative aggregate material. As the formed aggregate materials consume more carbon dioxide that is generated in the manufacturing process, they are said to be carbon negative aggregate materials.

[0007] It is estimated that the carbon negative aggregate material can be incorporated into the paved structure in an amount whereby one square metre of the paved structure will have an equivalent effect of planting one

new tree.

[0008] In order to further increase the environmentally friendly nature of the paved structure, the surface layer may be a water-permeable surface layer.

[0009] Permeable paved surfaces are known and these were developed to allow the movement of water, for example rainwater, through the surface to prevent or minimise flash flooding and erosion. Such surfaces have been used for roads, paths, parking lots, airports, schools, universities and such like.

[0010] Accordingly, permeable paved surfaces are considered to be more environmentally friendly than non-permeable paved surfaces.

[0011] Accordingly, in an embodiment of the invention, the surface layer may comprise a permeable asphalt composition or it may comprise a pervious concrete layer. The pervious concrete layer may be formed from a permeable concrete composition or it may be formed from discrete concrete blocks wherein gaps are defined between adjacent blocks and/or each block defines at least one channel therethrough. For example, each block may define therethrough one or more gaps, voids or conduits.

[0012] In an embodiment of the invention, the carbon negative aggregate particles further comprise a binder selected from cement kiln dust and Portland cement. In embodiments in which the solid precursor material is capable of reacting with carbon dioxide (for example, limestone fines, marble fines, chalk fines, paper sludge combustion fines, pulverised fuel ash, cement kiln dust or Portland cement), the use of a binder may not be necessary. However, in embodiments in which the precursor material is substantially inert (for example, sand, silt or quarry fines), then a binder which is able to react with carbon dioxide, such as cement kiln dust or Portland cement, is typically required to form the aggregate material.

[0013] In embodiments in which the surface layer is water-permeable, water, such as rain water, is permitted to permeate or infiltrate through the surface layer. In order to capture the water that has permeated through the surface layer, a reservoir layer may be provided between the permeable surface layer and the carbon negative aggregate layer. The reservoir layer permits the storage of a volume of the water therein.

[0014] Suitably, the reservoir layer comprises an aggregate material and/or a soil material. Advantageously, the reservoir layer may act to filter out contaminants and/or pollutants from the water as it passes through the reservoir layer under the action of gravity. Accordingly, the water towards the bottom of the reservoir layer may have been purified to some extent.

[0015] The reservoir layer may include one or more outlet pipes which act to direct the water in the reservoir layer away from the paved structure, for example to a collection point, a storage container or area, or an existing waterway. Suitably, the or each outlet pipes are located towards the bottom of the reservoir layer. In other words, the or each outlet pipe may be located in a lower portion of the reservoir layer.

[0016] As the purpose of the carbon negative aggregate layer is to capture and store carbon dioxide and it does not play a significant role in the transport of water away from the surface of the paved structure, a water-impermeable membrane may be located above the carbon negative aggregate layer, for example, between the carbon negative aggregate layer and the bottom of the reservoir layer.

[0017] The skilled person will appreciate that the features described and defined in connection with the aspect of the invention and the embodiments thereof may be combined in any combination, regardless of whether the specific combination is expressly mentioned herein. Thus, all such combinations are considered to be made available to the skilled person.

[0018] An embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 shows a cross-sectional view through a paved structure according to a first embodiment of the invention;

Figure 2 shows a cross-sectional view through a paved structure according to a second embodiment of the invention; and

Figure 3 shows a cross-sectional view through a paved structure according to a third embodiment of the invention.

[0019] For the avoidance of doubt, the skilled person will appreciate that in this specification, the terms "up", "down", "front", "rear", "upper", "lower", "width", etc. refer to the orientation of the layers as found in the example when provided for their intended use as shown in the Figures.

[0020] Figure 1 shows a paved structure 1 comprising a permeable asphalt surface layer. The structure 1 comprises a permeable asphalt surface layer formed from an outer layer 2 of permeable asphalt having 20mm particle size and an inner layer 4 of permeable asphalt having 10 mm particle size. The outer layer 2 has a depth of about 100mm and the inner layer 4 has a depth of about 50mm.

[0021] Beneath the inner layer 4 of permeable asphalt is a layer 6 of Type 3 SUDS (sustainable drainage systems) soil which acts as a reservoir layer. The reservoir layer 6 has a depth of about 300mm. Located towards the bottom of the reservoir layer 6 are outlet pipes 8 which are perforated and carry away the water that has infiltrated to the lower portion of the reservoir layer 6.

[0022] Located beneath the reservoir layer 6 is a layer 10 of compacted layer of Type 1 soil, although any impermeable soil or aggregate can be used for the layer 10. The compacted soil layer 10 has a depth of about 150mm.

[0023] Beneath the compacted soil layer 10 is a layer 12 of carbon negative aggregate which is the result of reacting a waste precursor fines material with water in an atmosphere which is rich in carbon dioxide. Such a

carbon negative aggregate material is available from Carbon8 Aggregates Limited (Medway, Kent, United Kingdom). The carbon negative aggregate layer 12 has a depth of about 100mm.

[0024] In order to prevent water infiltrating beyond the carbon negative layer 12, a water-impermeable membrane 14 is located between the carbon negative layer 12 and a layer of native earth 16.

[0025] The use of the carbon negative aggregate material in layer 12 results in a paved structure 1 which consumes or locks-in more carbon dioxide than is used to prepare the structure, thus resulting in a net loss in carbon dioxide from the atmosphere. In addition, the paved structure 1 helps to minimise flash-flooding and erosion, and filters water falling on the surface through its permeable nature above the membrane 14.

[0026] Figure 2 shows a paved structure 101 which is similar to the structure shown in Figure 1. Located on top of a native soil layer 116 is water-impermeable membrane 114 and above the membrane 114 is provided a carbon negative aggregate layer 112 which is the same as described above with reference to Figure 1. Furthermore, a layer 110 of compacted Type 1 soil is located in turn above the carbon negative aggregate layer 112. Accordingly, the membrane 114 and the layers 110, 112, 116 are the same as described above in connection with Figure 1.

[0027] The structure 101 shown in Figure 2 differs from that shown in Figure 1 in the layers above the layer 110 of compacted Type 1 soil. Located immediately above the soil layer 110 is a reservoir layer 106 formed from a coarse grade aggregate. The reservoir layer 106 has a depth of about 300mm. As with the reservoir layer 6 described above, outlet pipes 108 are provided towards the bottom of the reservoir layer 106. These pipes transport away the water that has infiltrated through the reservoir layer 106.

[0028] Located immediately above the reservoir layer 106 is a sand layer 105 having a depth of about 50mm. The sand layer 105 forms a foundation for a surface layer 103 formed from permeable concrete blocks. The permeable blocks define small gaps (1-10mm) between them and tessellate to define a surface over which traffic, such a vehicular or pedestrian traffic, can move.

[0029] The arrangement shown in Figure 2 and described above is suitable for areas having a light to medium traffic use.

[0030] The structure 201 shown in Figure 3 differs from the structure 101 shown in Figure 2 only by the reservoir layer.

[0031] Accordingly, the structure 201 shown in Figure 3 includes a native soil layer 216, a membrane 214, a carbon negative aggregate layer 212, and a compacted soil layer 210. Similarly, the structure 201 includes a surface layer 203 of permeable concrete blocks located on a foundation layer 205 of sand.

[0032] However, instead of a reservoir layer which comprises simply a coarse grade aggregate material, the

reservoir layer of the structure 201 comprises an upper layer 206a formed from a coarse graded aggregate material and having a depth of about 300mm; and a lower layer 206b formed from a Type 3 SUDS soil and having a depth of about 250mm. As can be seen in Figure 3, the structure 201 includes outlet pipes 208 located within the lower layer 206b formed from the Type 3 SUDS soil.

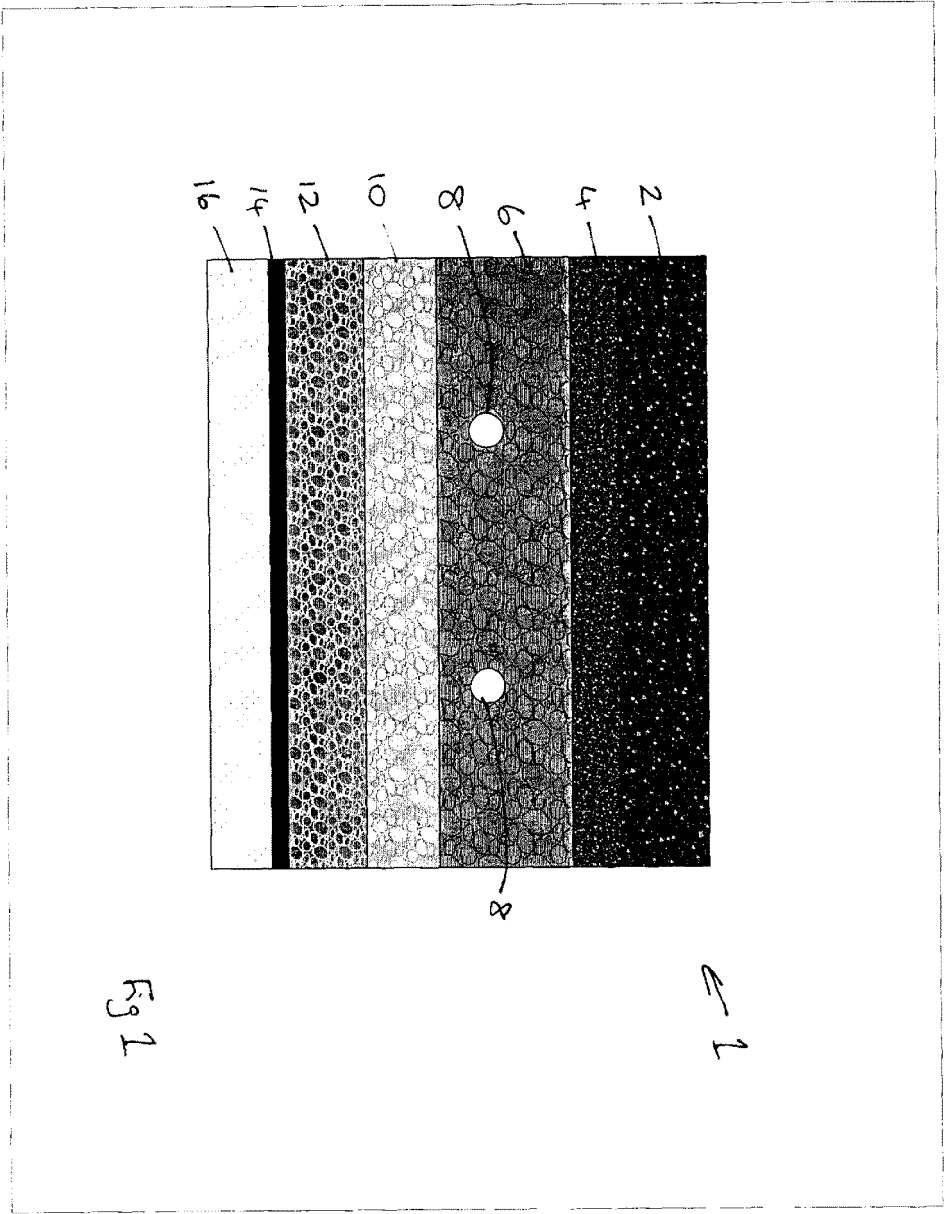
[0033] The arrangement shown in Figure 3 and described above is suitable for areas having a medium to heavy traffic use.

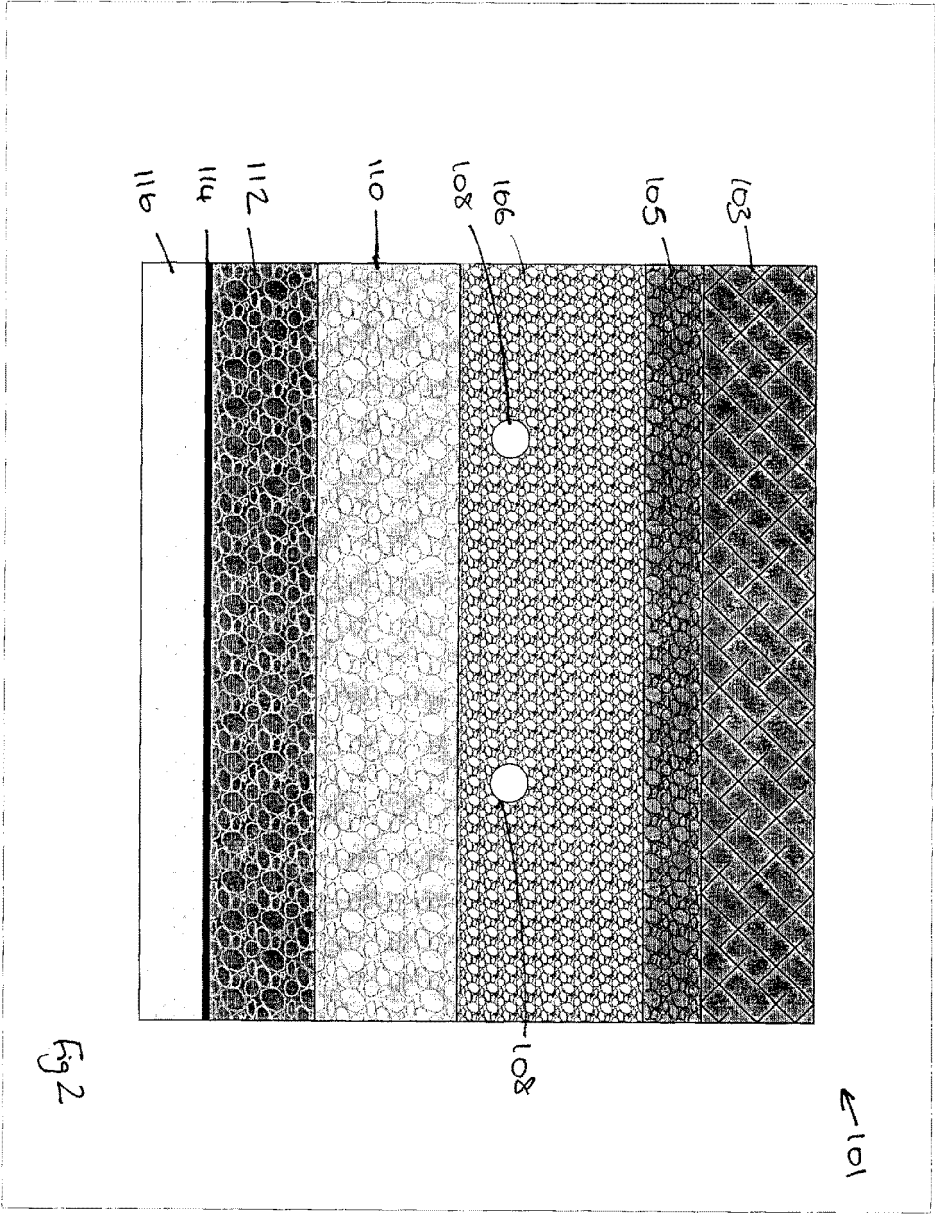
figured to carry away water located within the reservoir layer.

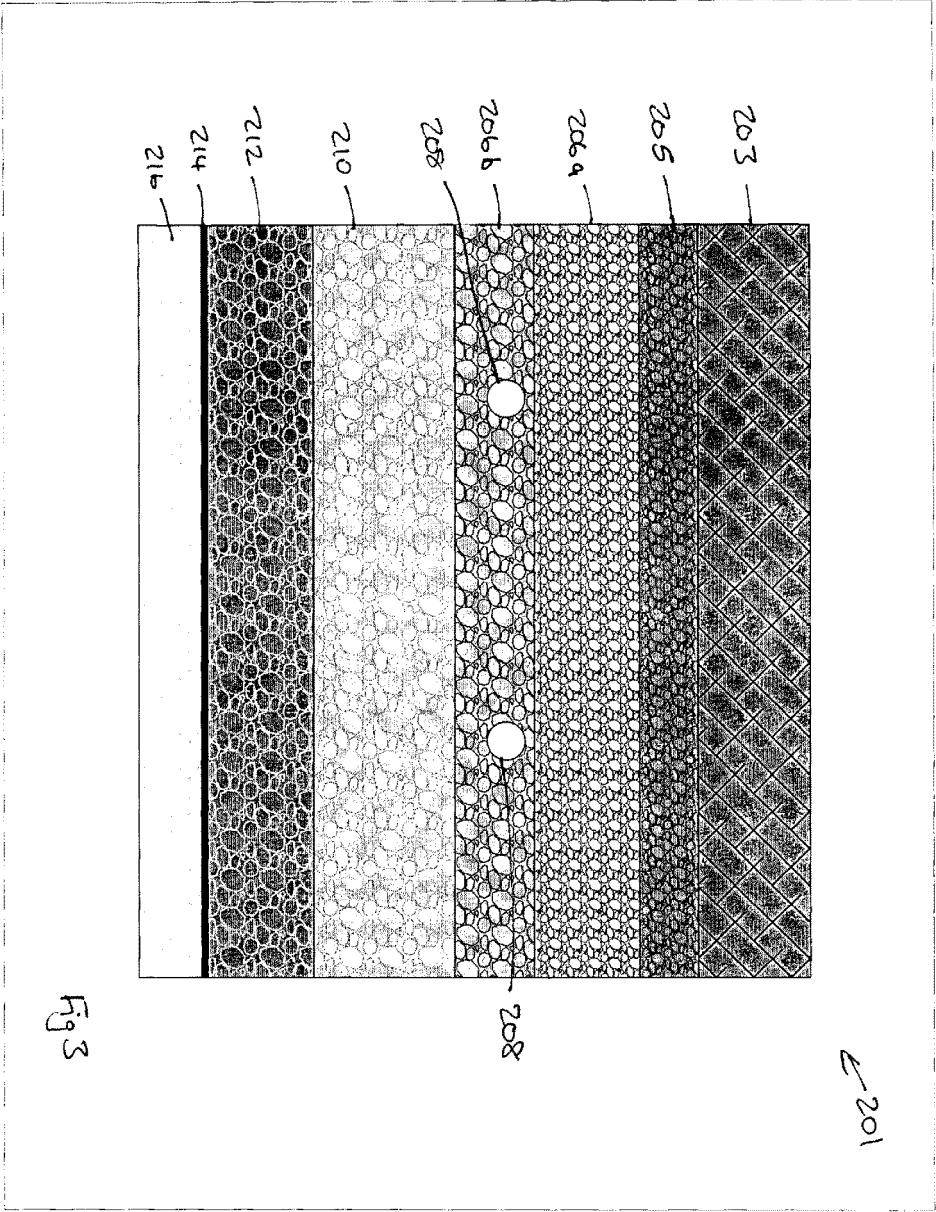
9. A paved structure according to Claim 7 or Claim 8, wherein the structure further includes a water impermeable membrane located between the reservoir layer and the carbon negative aggregate layer.

Claims

1. A paved structure comprising a surface layer formed from a non-permeable asphalt composition, a permeable asphalt composition, a non-permeable concrete composition or permeable concrete composition; and a layer comprising carbon negative aggregate particles located beneath the surface layer, wherein the carbon negative aggregate particles comprise a solid precursor material selected from paper sludge combustion material, pulverised fuel ash, cement kiln dust, limestone particles, chalk particles, marble particles, Portland cement, sand, silt and mixtures thereof which has been reacted with carbon dioxide to form a solid aggregate material.
2. A paved structure according to Claim 1, wherein the surface layer is water-permeable.
3. A paved structure according to Claim 2, wherein the surface layer comprises a permeable asphalt composition or a pervious concrete layer.
4. A paved structure according to Claim 3, wherein the surface layer comprises an array of discrete concrete blocks, wherein a gap is defined between adjacent surfaces of the blocks.
5. A paved structure according to Claim 4, wherein each block defines therethrough at least one channel.
6. A paved structure according to any of Claims 1 to 5, wherein the carbon negative particles further comprise a binder selected from cement kiln dust and Portland cement.
7. A paved structure according to any of Claims 1 to 6, wherein the structure further includes a reservoir layer located between the permeable surface layer and the carbon negative aggregate layer, wherein the reservoir layer includes a water permeable aggregate material or a soil material.
8. A paved structure according to Claim 7, wherein reservoir layer includes one or more outlet pipes con-









EUROPEAN SEARCH REPORT

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 3 May 2018	Examiner Beucher, Stefan
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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