volume of the material needs to be reserved in order to obtain a significant healing potential. While the matrix- incorporated bacteria function as catalyst and therefore need only a limited volume, it is typically the mineral precursor compound, the second component of the healing system, which will occupy a substantial volume when a significant healing capacity is needed. Particularly for larger cracks to become completely sealed, bulky internal reservoirs or alternatively an intrinsic transportation mechanism is needed. In concrete the latter could be provided by the water-filled continuous capillary pore system which is usually present. The mineral precursor compound could be present in dissolved state in the matrix pore water without affecting strength properties of the material what presumably occurs when specific internal healing agent containing reservoirs are needed. In any case however, incorporated bacteria and the mineral precursor compound should compromise concrete strength properties only to an acceptable extend.

EP2082999 describes a healing agent in cement-based materials and structures, wherein said healing agent comprises organic compounds and/or bacteria-loaded porous particles, which porous particles comprise expanded clay- or sintered fly ash. Furthermore, said porous particles are intact spheres, broken or crushed particles derived from said intact spheres, having a specific density between 0.4 and 2 g cm^{-3}.

SUMMARY

Prior art cementitious materials suffer from crack formation. Hence, the disclosure provides an alternative process of making a cementitious material and/or an alternative construction element (from such cementitious material) which preferably does not suffer from crack formation and/or which self heals cracks.

A possibility to maintain strength and/or other desired properties (such as liquid impermeability) is to add bacteria to the cementitious material, such as in the form of a healing agent, which bacteria may repair smaller cracks. Hence, the disclosure provides bacterial material to the starting material of the cementitious material. It further surprisingly appears that when adding biodegradable polymeric material, this biodegradable material may be used by the bacteria as substrate. By adding biodegradable fibrous reinforcement, for instance as individual fibers (herein also indicated as fiber particles) or as a textile (e.g. yarn, fabric), it surprisingly may seem that the fibers in the first stage of hardening assist in getting a strong cementitious material; after formation or setting of the cementitious material, such as within a few weeks from

making the cementitious material and starting to harden it, it appears that the fibers can be degraded without substantial loss of strength and/or other desired properties. As crack formation is a process that occurs over time, the biodegradable polymeric material may be consumed by the bacteria for crack reparation. Hence, advantageously, the biodegradable polymer in the form of fibers assists first in hardening and then also in maintenance of the cementitious material. Hence, in an embodiment, the fibres are provided as textile of fibres. In yet another embodiment, the fibres are provided as fibre particles (having the herein indicated dimensions). A textile of fibres may e.g. refer to a yarn or a fabric. The textile may be woven or non woven. Herein, the term "textile" especially refers to an aggregate or woven unit comprising a pluraty of individual fibers (which individual fibers have (average) diameters selected from the range of 5 – 750 μm, and having (average) lengths selected from the range of 50 μm – 150 mm). In an embodiment, the textile is provided as textile patch.

Hence, the disclosure provides a process for the production of a cementitious material, comprising mixing cement starting materials, a healing agent and a fibrous reinforcing material, wherein the healing agent comprises bacterial material, and wherein the fibrous reinforcing material comprises a biodegradable polymer, especially having an average molecular weight selected from the range of 10 – 1500 kg/mol, and wherein the fibrous material especially comprises fibers having (average) diameters selected from the range of 5 – 750 μm, and having (average) lengths selected from the range of 50 μm – 150 mm.

In one aspect, there is provided a process for the production of a cementitious material, comprising mixing cement starting materials, a healing agent and a fibrous reinforcing material, wherein the healing agent comprises bacterial material, wherein the fibrous reinforcing material comprises a biodegradable polymer, having an average molecular weight selected from the range of 10 – 1500 kg/mol, and wherein the fibrous material comprises fibers having diameters selected from the range of 5 – 750 μm, and having lengths selected from the range of 50 μm – 150 mm.

In another aspect, there is provided a cementitious material obtainable by the process as defined herein.

In another aspect, there is provided a cementitious material comprising (a) cement, (b) one of more of slag, ash, limestone and sand, (c) optionally super plastisizer, (d) healing agent, and (e) fibrous reinforcing material, wherein the healing agent comprises bacterial material, wherein the fibrous

reinforcing material comprises a biodegradable polymer, having an average molecular weight selected from the range of 10 – 1500 kg/mol, and wherein the fibrous material comprises fibers having diameters selected from the range of 5 – 750 μm, and having lengths selected from the range of 50 μm – 150 mm, having a weight ratio of healing agent to (a) cement, and (b) one of more of slag, ash, limestone and sand selected from the range of 0.2:100 – 10:100, and/or having a weight ratio of fibrous reinforcing material to (a) cement, and (b) one of more of slag, ash, limestone and sand selected from the range of 0.1:100 – 10:100. Further, the disclosure especially provides a cementitious material obtainable by the process as decribed herein.

In another aspect, there is provided a method for the production of a construction element, the method comprising providing the cementitious material as defined herein, and allowing the cementitious material to harden at a predetermined place or in a predetermined mold.

Further, in another aspect there is provided a construction element comprising hardened cementitious material, wherein the cementitious material further comprises bacterial material and one or more of (i) fibrous reinforcing material comprising a biodegradable polymer, and (ii) a conversion product of a bacterial conversion of the fibrous reinforcing material comprises a biodegradable polymer.

The disclosure uses degradable fibrous polymer which features a double functionality in cementitious materials, such as mortar and concrete. In a further embodiment, the disclosure uses fibrous reinforcing material comprising a biodegradable polymer featuring a double function. The first functionality provides a contribution to structural integrity, which is obtained via reinforcement, serving crack width control in early age restrained shrinkage situations. The second functionality is provided by polymer degradation over time, by which the degradation product can serve as a precursor compound for bacterial metabolic conversion into crack sealing material. In this way functionality can be regained, such as liquid tightness. Stresses cause delamination or cracking. Incorporation of fibrous reinforcement creates multiple cracks of limited widths, which are easier to close. Significant advantage is that the proposed degradable fibrous reinforcing material serves a dual function, enabling optimum use of properties. In the early age it is used structurally, as current fibers. After serving its structural purpose the material becomes available for a second functional purpose, namely as a compound for bacterial conversion. In the process minerals are deposited on the crack wall, preventing ingress of water or deleterious substances.

The disclosure solves two issues by one method, resulting in lower costs and a reduction in maintenance and repair during the service life of the cementitious element. An additional benefit is the biological base of the proposed degradable fibrous reinforcement, since currently common used materials are synthetic and therefore less sustainable. Since the disclosure combines two functions without modifying the system and offers a biological alternative, the material may directly replace a part of the fibrous reinforcement currently in use. The proposed degradable fibrous reinforcement can be applied to cementitious repair products. Furthermore it can (partially) replace crack width limiting reinforcement, currently made of steel.

CLAIMS:

1. A process for the production of a cementitious material, comprising mixing cement starting materials, a healing agent and a fibrous reinforcing material, wherein the healing agent comprises bacterial material, wherein the fibrous reinforcing material comprises a biodegradable polymer, having an average molecular weight selected from the range of 10 – 1500 kg/mol, and wherein the fibrous material comprises fibers having diameters selected from the range of 5 – 750 μm, and having lengths selected from the range of 50 μm – 150 mm.

2. The process according to claim 1, wherein the biodegradable polymer is selected from the group consisting of polybutylene succinate (PBS), polyhydroxybutyrate (PHB), and poly lactic acid (PLA).

3. The process according to any one of the preceding claims, wherein the fibrous material comprises fibers having diameters selected from the range of 10 – 100 μm, and having lengths selected from the range of 0.5 mm – 150 mm.

4. The process according to any one of the preceding claims, wherein the fibrous material comprises fibers having lengths selected from the range of 50 μm – 500 μm.

5. The process according to any one of the preceding claims, wherein the bacterial material is selected from the group consisting of a bacterium, a lyophilized bacterium and a bacterial spore of a bacterium.

6. The process according to claim 5, wherein the bacterium is selected from the group consisting of aerobic bacteria.

7. The process according to any one of claims 5-6, wherein the bacterium is selected from the group consisting of anaerobic bacteria.

8. The process according to any one of claims 5-7, wherein the bacterium is selected from the group consisting of bacteria that can form a phosphate or a carbonate precipitate in an alkaline medium.

9. The process according to any one of claims 5-8, wherein the bacterium is selected from the group of genera consisting of *Planococcus*, *Bacillus* and *Sporosarcina*.

10. The process according to any one of claims 5-9, wherein the bacterium is selected from the group of denitrifying bacteria.

11. The process according to any one of the preceding claims, wherein the healing agent comprises (1) one or more compounds selected from the group consisting of calcium formate, calcium acetate, calcium lactate, calcium gluconate, calcium nitrate, a carbohydrate, a fatty acid, a amino acid, a lactate, a maleate, a formate, a sugar, a pyruvate and a phytate and (2) a bacterial growth factor selected from the group consisting of a yeast extract, a peptone, an aspartate, a glutamate and trace elements.

12. The process according to any one of the preceding claims, wherein the fibres are provided as textile of fibres.

13. A cementitious material obtainable by the process according to any one of the preceding claims.

14. A cementitous material comprising (a) cement, (b) one of more of slag, ash, limestone and sand, (c) optionally super plastisizer, (d) healing agent, and (e) fibrous reinforcing material, wherein the healing agent comprises bacterial material, wherein the fibrous reinforcing material comprises a biodegradable polymer, having an average molecular weight selected from the range of 10 – 1500 kg/mol, and wherein the fibrous material comprises fibers having diameters selected from the range of 5 – 750 μm, and having lengths selected from the range of 50 μm – 150 mm, having a weight ratio of healing agent to (a) cement, and (b) one of more of slag, ash, limestone and sand selected from the range of 0.2:100 – 10:100, and having a weight ratio of fibrous reinforcing material to (a) cement, and (b) one of more of slag, ash, limestone and sand selected from the range of 0.1:100 – 10:100.

15. The cementitious material according to claim 14, further comprising water, and having a water-to-binder ratio selected from the range of 15:100 – 65:100.

16. A method for the production of a construction element, the method comprising providing the cementitious material as defined in any one of the preceding claims, and allowing the cementitious material to harden at a predetermined place or in a predetermined mold.

17. A construction element comprising hardened cementitious material, wherien the cementitious material further comprises bacterial material and one or more of (i) fibrous reinforcing material comprising a biodegradable polymer, and (ii) a conversion product of a bacterial conversion of the fibrous reinforcing material comprises a biodegradable polymer.