

COMPOSITION OF POLYMERIC BONDING MATERIAL

TECHNICAL FIELD

The present invention generally relates to a composition in a bonding material
5 to bind layers of plaster, cement, concrete or the likes in construction or ornamental structures.

BACKGROUND OF THE INVENTION

Construction and renovation works often require the application of additional
10 layers of plaster, cement, or slab to provide for new finishing on surfaces of wall, ceiling, floor or the likes. In common construction or renovation practices, bonding materials are applied on surfaces of moldings, walls or lathing to provide adhesion to successive coats of plaster, cement, concrete or slab. In the application of a bonding material, a wall for example, is first prepared by brushing off dust and dirt on the surface of the
15 wall, followed by brushing the wall with water to help the bonding material to stick. A mix of the bonding material is then prepared and applied to the wall evenly. The bonding material is left to set and dry before the next layer of screed, such as cement, is applied to the wall.

Cracks and aggregate popouts can often be observed on intermediate or
20 finished surfaces over a period, possibly leaving cavities of various sizes and uneven surfaces after the dislocation of popout cones. Such defects are caused by physical conditions (freeze-thaw damage, salt crystallization damage, shrinkage, thermal movement, fire, abrasion, erosion), chemical conditions (alkali aggregate reaction, sulfate attack, seawater attack, acid or biological attack, ettringite formation), and/or
25 mechanical conditions (excessive load, vibration or seismic quake, settlement or movement, impact, explosion). Bad workmanship and the use of poor materials or design may further lead to early occurrence of such defects. According to European standards EN 1504 as an example, the general principles related to defects in concrete are: protection against ingress; moisture control; concrete restoration;
30 structural strengthening; physical resistance; and resistance to chemicals. Defects

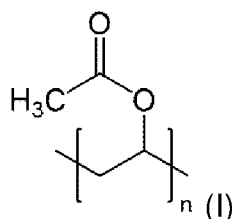
pose structural and safety problems, and as such will necessitate rectification works and cause delays in the delivery of complete constructions. Visible signs of structural deterioration include cracking, leaching, spalling, scaling, stains, disintegration, wear, efflorescence, corrosion of reinforcing steel, and growth of mildew and algae. In a scenario where cracks or popouts occur on a concrete substrate, a re-profiling mortar would be required to carry out cosmetic or structural repair. After surface preparation and prior to the application of the repair mortar, a bonding material is usually applied to enhance the bond between the substrate and the re-profiling mortar.

In construction or repair works, emphasis is commonly placed on the mixture of matrices that are strong and durable for concretes and cements, but the quality of bonding materials used for near-surface layering or coating of screeds is often neglected. Most of the current bonding materials have a certain degree of hydrophobicity to provide waterproofing even against low amounts of atmospheric moisture content. However, bonding materials used in constructions and renovations require more than just waterproofing. It is important that the material used for the bonding material can provide strong adhesion and high tensile strength, as well as being not susceptible to heat and reaction with atmospheric moisture content. Such characteristics are essential to ensure that the finishing is laid on a foundation that is not only waterproof, but also resistant to vibration, external mechanical forces and weather changes.

Bonding materials for screeds are generally potable water (In the case of dry, saturated surfaces), cement slurry, slurry of re-profiling mortar, or those made of polymeric substances, such as styrene-butadiene-rubber latex, solvent-free epoxy, vinyl acetate homopolymers, or acrylate latex typically consisting of vinyl acetate and acrylic acid copolymer. Many of these bonding materials are unable to withstand moisture and cannot re-emulsify to form intertwining bonds upon contact with a subsequent plaster coating. Besides that, many types of acrylate polymer-based bonding material form a highly rigid layer after solidification and hence are not flexible and are unable to withstand vibration or external mechanical forces. Therefore, another alternative that can overcome the current weaknesses of the existing bonding materials is required.

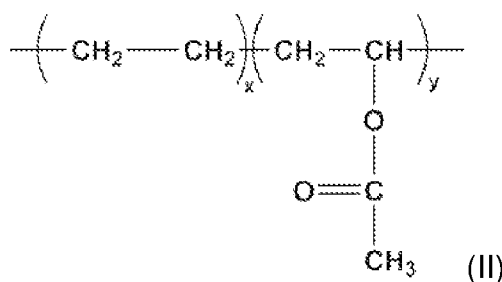
More specifically, this invention discloses a composition of bonding material, comprising a polymer of vinyl compound and a polymer of alkene compound added to the polymer of vinyl compound, characterised in that the composition is a mixture of 45–50% by weight of the polymer of vinyl compound and 0.1–0.3% by weight of the polymer of alkene compound, for re-emulsification of the composition upon contact with a substrate and a screed to achieve intertwining and homogeneous bond between the substrate, the composition and the screed.

Preferably, the polymer of vinyl compound is a vinyl acetate polymer having the formula (I):



where n is a number of repeating units.

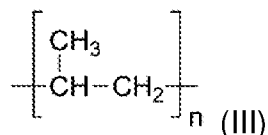
Preferably, the polymer of vinyl compound is a vinyl acetate-ethylene copolymer having the formula (II):



where x and y are numbers of repeating units that may vary from one another.

Preferably, the polymer of vinyl compound is in the form of resin.

Preferably, the polymer of alkene compound is a polypropylene polymer having the formula (III):



where n is a number of repeating units.

- 5 Preferably, the polypropylene polymer is in the form of synthetic fibres.

Preferably, the polymer of alkene compound is in the form of synthetic resinous polymer.

Preferably, the composition of bonding material is in the form of resin.

Preferably, the composition re-emulsifies upon contact with water at 35–50°C.

- 10 The composition is also characterised as having high tensile adhesion strength and high resistance to heat, which makes it advantageous to be used in structural engineering, such as construction, renovation and ornamental structures.

Besides that, this invention also discloses a method of preparing a composition of bonding material, comprising step of mixing a polymer of vinyl
 15 compound and a polymer of alkene compound, characterised in that 45–50% by weight of the polymer of vinyl compound is mixed with 0.1–0.3% by weight of the polymer of alkene compound, for re-emulsification upon contact with a substrate and a screed to achieve intertwining and homogeneous bond between the substrate, the composition and the screed.

- 20 The present invention may be embodied in other specific forms without departing from its essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore indicated by the appended claims rather than by the foregoing description. All changes, which come within the meaning and range of equivalency of
 25 the claims, are to be embraced within their scope.

BRIEF DESCRIPTION OF THE DRAWINGS

To further clarify various aspects of some embodiments of the present invention, a more particular description of the invention will be rendered by references to specific
5 embodiments thereof, which are illustrated in the appended drawings. It is appreciated that these drawings depict only typical embodiments of the invention and are therefore not to be considered limiting of its scope. The invention will be described and explained with additional specificity and detail through the accompanying drawings in which:

10 Figure 1 shows the composition of bonding material comprising a mixture of vinyl acetate-ethylene and polypropylene.

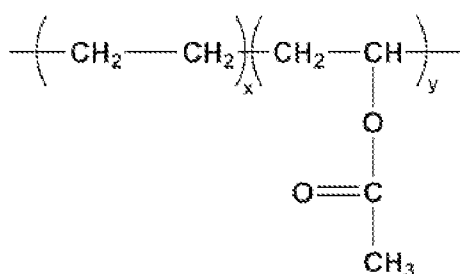
Figure 2 illustrates a pull-out test performed on plasters bonded to concrete blocks of 50 × 50 mm.

Figure 3 illustrates a flexible bending test performed on a flexible acrylic panel bonded with a layer of cement and sand.

15 Figure 4 is an illustration showing the application of the bonding material on a substrate, which is followed by a layer of cement.

DETAILED DESCRIPTION OF DISCLOSURE

In the composition of bonding material in the present invention, a major polymer of vinyl compound in the composition, preferably vinyl acetate-ethylene (VAE) copolymer or vinyl acetate (VA) polymer, is mixed with a polymer of alkene compound, such as polypropylene (PP). VAE is an elastomeric copolymer of ethylene and vinyl acetate that produces materials which are "rubber-like" in softness and flexibility. The material has good clarity and gloss, low-temperature toughness, stress-crack resistance, hot-melt adhesive waterproof properties, and resistance to UV radiation. The VAE copolymer has the following chemical structure:

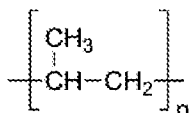


where x and y are numbers of repeating units that may vary from one another.

VAE exists in three different types, which differ in their vinyl acetate (VA) contents and the way the materials are used. Low VA contents (<4%) renders the resulting VAE to be thermoplastic, characterised in that the material becomes plastic on heating and harden on cooling and that these processes are repeatable. Medium VA contents (4-30%) renders the resulting VAE to be thermoplastic elastomeric, characterised in that the material has viscoelasticity (having both viscosity and elasticity) and very weak inter-molecular forces, making it an elastic polymer, i.e. rubbery in addition to its thermoplastic characteristic. High VA contents (>40%) renders the material elastomeric with low or without thermoplasticity.

PP is a thermoplastic polymer that is normally tough and flexible, especially when copolymerized with ethylene, and is resistance to weakening caused by repeated loads. PP as the second most important plastic after polyethylene is resistant to fatigue and has low density. Such characteristics make PP a durable and light-weight material. Chemically, PP is resistant to almost all organic solvents and oxidants at room temperature. The addition of randomly polymerized ethylene monomer to PP homopolymer decreases the crystallinity of the polymer, lowers the melting point and

makes the polymer more transparent. Solidified PP is resistant to heat, so it is suitable for many applications. Addition of PP into the VAE polymer enhances re-emulsification of the composition upon contact with water. This feature enables substantial molecular intertwining between the composition and the surfaces of which screeds are joined by the composition, which therefore helps to reduce cracking and spalling. The PP polymer has the following chemical structure:



where n is a number of repeating units.

In the present invention, the composition is a mixture of VAE copolymer and PP polymer, as illustrated in Figure 1. The composition contains 45–50% of VAE copolymer by weight. The PP polymer, preferably in the form of fibres, are added to the VAE copolymer in a proportion of 0.1–0.3% by weight of the entire composition. Alternatively, the VAE copolymer and the PP polymer is mixed at a VAE to PP ratio of 237:1 by weight.

Vinyl acetate-ethylene (VAE) copolymer

Preferably, the VAE copolymer is in an aqueous form of emulsion or resin during the preparation of the composition. A high content of VA is present in the VAE copolymer, which contains 54.5–56.5% by weight of solids content. The VAE copolymer has viscosity of 1500–3000 cP at 25°C, pH 4.8–6.0, and glass transition temperature onset (T_g) at 2–8°C. Preferably, polyvinyl alcohol is used as a stabilizing agent for the copolymer. The copolymer appears non-plasticized milky white in the aqueous form, which eventually forms a flexible, clear and glossy film after evaporation of its water content.

Polyvinyl alcohol (PVA)

Preferably, the PVA stabilizing agent is partially hydrolysed (hydrolysed content 86–89% by mole) with viscosity of 50–58 cP at 4.0% by weight and 20°C, and pH 5.0–7.0.

The PVA also has volatile content of 5% by weight and below and ash (sodium oxide, Na_2O) content of 0.5% by weight and below.

Polypropylene (PP) fibres

5 Preferably, the PP fibres are polymers of propylene that are added into the composition as macrofibres (1 mm in diameter or more), microfibres (between 1 μm to 1 mm in diameter) or nanofibers (between 1 nm to 1 μm in diameter). The PP fibres are in the form of hair-like or straw-like resinous strands.

10 The composition of bonding material further comprises water, defoamer, humectant, plasticizer and preservative. Water content provides moisture for the emulsification of the composition. Defoamer, such as insoluble oils, polydimethylsiloxane, silicones, alcohols, stearates or glycols, is added to prevent and reduce the formation of foams and bubbles during the preparation and use of the
15 composition. Humectant, such as propylene glycol, hexylene glycol, and butylene glycol, alpha hydroxy acids, glyceryl triacetate, lithium chloride, polymeric polyols or sugar polyols, is added to prevent rapid loss of moisture from the composition. Plasticizer, such as phthalate esters, is added to improve flexibility and durability and to reduce brittleness of the composition during its application. Preservative, such as
20 sorbates, benzoates and hydroxybenzoates, sulfur dioxide and sulfites, nitrite, nitrate, lactic acid, propionic acid, and sodium propionate, is added to prevent microbial contamination in the composition. Another stabilizer of 20–40% by weight is added to promote emulsification and prevent degradation of the composition.

In application of the present invention, a surface to be bonded is coated with a
25 thin layer of the composition (approximately 3 to 10 mm thickness), which can then be left to set at a long open time of up to 10 days before the application of a new layer of screed to be bonded to the surface.

The present invention consists of features and a combination of parts hereinafter fully described and illustrated in the following examples, it being
30 understood that various changes in the details may be made without departing from the scope of the invention or sacrificing any of the advantages of the present invention.

EXAMPLE 1

A pull-out test was conducted to determine the adhesion strength of the bonding material. The bonding material was coated on a concrete surface, followed by the application of a plaster (sample) of length $\times$ width measurements of 50 $\times$ 50 mm, hence covering an area of 2500 mm², as demonstrated in Figure 2. The test was conducted 14 days and 28 days after the application of the bonding material and the sample onto the concrete. The sample was then subjected to increasing loads until the sample was detached (pull-out) from the concrete. Maximum load is the highest amount of force incurred by a load onto the sample before a cohesion or adhesion failure occurred. Pull-out strength is computed as the maximum load over the test area.

The results of the pull-out test are shown in Table 1. Adhesion between the sample and the concrete by the bonding material was strong that pull-outs occurred only due to failure within the concrete. The pull-out strength was higher as the number of days after sample application increased.

TABLE 1

Sample age at test (days)	14	28
Sample size (mm)	50 $\times$ 50	50 $\times$ 50
Test area (mm ²)	2500	2500
Maximum load (kN)	0.92	1.50
Pull-out strength (N/mm ²)	0.368	0.600
Mode of failure	☐ Cohesion failure within sample [No] ☐ Adhesion failure between sample & concrete [No] ☒ Cohesion failure within concrete [Yes] ☐ Adhesion failure between sample & bonding material [No]	☐ Cohesion failure within sample [No] ☐ Adhesion failure between sample & concrete [No] ☒ Cohesion failure within concrete [Yes] ☐ Adhesion failure between sample & bonding material [No]

Subsequent pull-out test in five replicates demonstrates consistency in the results achieved, as shown in Table 2.

TABLE 2

Sample replicate	1	2	3	4	5	Average
Sample size (mm)	50 × 50	50 × 50	50 × 50	50 × 50	50 × 50	50 × 50
Test area (mm ²)	2500	2500	2500	2500	2500	2500
Maximum load (kN)	2.98	4.26	2.19	2.93	4.54	3.38±0.99
Pull-out strength (N/mm ²)	1.2	1.7	0.9	1.2	1.8	1.36±0.38
Mode of failure	☐ Cohesion failure within sample [No] ☐ Adhesion failure between sample & concrete [No] ☐ Cohesion failure within concrete [No] ☒ Adhesion failure between sample & bonding material [Yes]	☐ Cohesion failure within sample [No] ☒ Adhesion failure between sample & concrete [Yes] ☐ Cohesion failure within concrete [No] ☐ Adhesion failure between sample & bonding material [No]	☐ Cohesion failure within sample [No] ☐ Adhesion failure between sample & concrete [No] ☐ Cohesion failure within concrete [No] ☒ Adhesion failure between sample & bonding material [Yes]	☐ Cohesion failure within sample [No] ☒ Adhesion failure between sample & concrete [Yes] ☐ Cohesion failure within concrete [No] ☐ Adhesion failure between sample & bonding material [No]	☐ Cohesion failure within sample [No] ☒ Adhesion failure between sample & concrete [Yes] ☐ Cohesion failure within concrete [No] ☐ Adhesion failure between sample & bonding material [No]	N/A

A further pull-out test was performed to determine the tensile adhesion strength between concrete (substrate) and mortar 12 days after casting. The results (Table 3) demonstrated that adhesion or cohesion failures did not occur in the bonding material.

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TABLE 3

Sample reference	1	2	3	4	5	6
Water cement ratio (%)	24					
Test condition	24±2°C at 50±5% Humidity					
Area (mm ²)	2500					
Age at test (days)	12			12		
Substrate	Concrete column			Column		
Mortar	Conventional plaster mortar			Non-shrink grout		
Maximum load (kN)	0.65	0.32	0.30	1.46	4.17	0.27
Pull-out strength (N/mm ²)	0.26	0.12	0.12	0.58	1.68	0.11
Average pull-out strength (N/mm ²)	0.166			0.78		
Mode of break point	Adhesion failure between mortar and pull-head plate	Mortar cohesion failure		Adhesion failure between grout and pull-head plate	Mortar cohesion failure	

EXAMPLE 2

A flexible bending test was conducted to determine the susceptibility of bonded screed to spalling upon bending. A layer of the bonding material was coated on a flexible acrylic panel, which was subsequently plastered with a screed layer of cement and sand. The panel was bent for five times, with a time interval after each repeat, from an angle of 45° to 180° each time (Figure 3a). A portion of spalling occurred only after the fifth bending, while other parts of the screed remained bonded to the panel albeit the occurrence of cracks (Figure 3b).

EXAMPLE 3

An example of application of the bonding material is illustrated in Figure 4. A single layer of the bonding material is applied to a substrate, which may be an existing concrete, mortar or the like, and part of the bonding material is absorbed into the substrate (Figure 4a). VAE copolymer chains in the bonding material start to react chemically and release the PP fibres into the substrate (Figure 4b). Additionally, cement stringers form after hydrating with water and penetrate through the bonding material into the substrate. Then, VAE copolymer chains that are cross linked with cement stringers intertwine with the PP fibres to create a strong adhesion to the substrate (Figure 4c).

The present invention may be embodied in other specific forms without departing from its essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore indicated by the appended claims rather than by the foregoing description. All changes, which come within the meaning and range of equivalency of the claims, are to be embraced within their scope.

CLAIMS

1. A composition of bonding material for construction, renovation or ornamental structure, comprising:

5 a polymer of vinyl compound; and

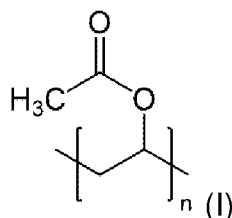
a polypropylene polymer added to the polymer of vinyl compound,

characterised in that the composition is a mixture of 45–50% by weight of the polymer of vinyl compound and 0.1–0.3% by weight of the polypropylene polymer, wherein the polypropylene polymer is in the form of fibres, such that the composition
10 is not susceptible to cohesion failure within the composition or adhesion failure between the composition and a surface in contact after setting.

2. The composition of bonding material according to claim 1, wherein the composition re-emulsifies upon contact with a substrate and a screed to achieve
15 intertwining between the substrate, the composition and the screed.

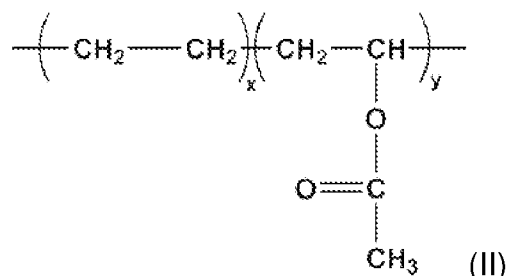
3. The composition of bonding material according to claim 1, wherein the composition re-emulsifies upon contact with a substrate and a screed to achieve homogeneous bond between the substrate, the composition and the screed.

4. The composition of bonding material according to claim 1, wherein the polymer of vinyl compound is a vinyl acetate polymer having the formula (I):



where n is a number of repeating units.

5. The composition of bonding material according to claim 1, wherein the polymer of vinyl compound is a vinyl acetate-ethylene copolymer having the formula (II):



5 where x and y are numbers of repeating units that may vary from one another.

6. The composition of bonding material according to claim 1, wherein the polymer of vinyl compound is in the form of resin.

10 7. The composition of bonding material according to claim 1, wherein the polypropylene polymer is added into the composition as macrofibres, microfibres, nanofibres or any combination thereof.

15 8. The composition of bonding material according to claim 1, wherein the bonding material has an open time of up to 10 days for joining the substrate and the screed.

9. The composition of bonding material according to claim 1, wherein the composition is in the form of resin.

20

10. The composition of bonding material according to claim 1, wherein the composition re-emulsifies upon contact with water at 35–50°C.

25 11. The composition of bonding material according to claim 1, wherein the composition has high tensile adhesion strength.

12. The composition of bonding material according to claim 1, wherein the composition has high resistance to heat.

13. The method of preparing a composition of bonding material for construction, renovation or ornamental structure, comprising step of:

5 mixing a polymer of vinyl compound and a polypropylene polymer, characterised in that 45–50% by weight of the polymer of vinyl compound is mixed with 0.1–0.3% by weight of the polypropylene polymer, wherein the polypropylene polymer is in the form of fibres, such that the composition is not susceptible to cohesion failure within the composition or adhesion failure between the composition and a surface in contact after setting.

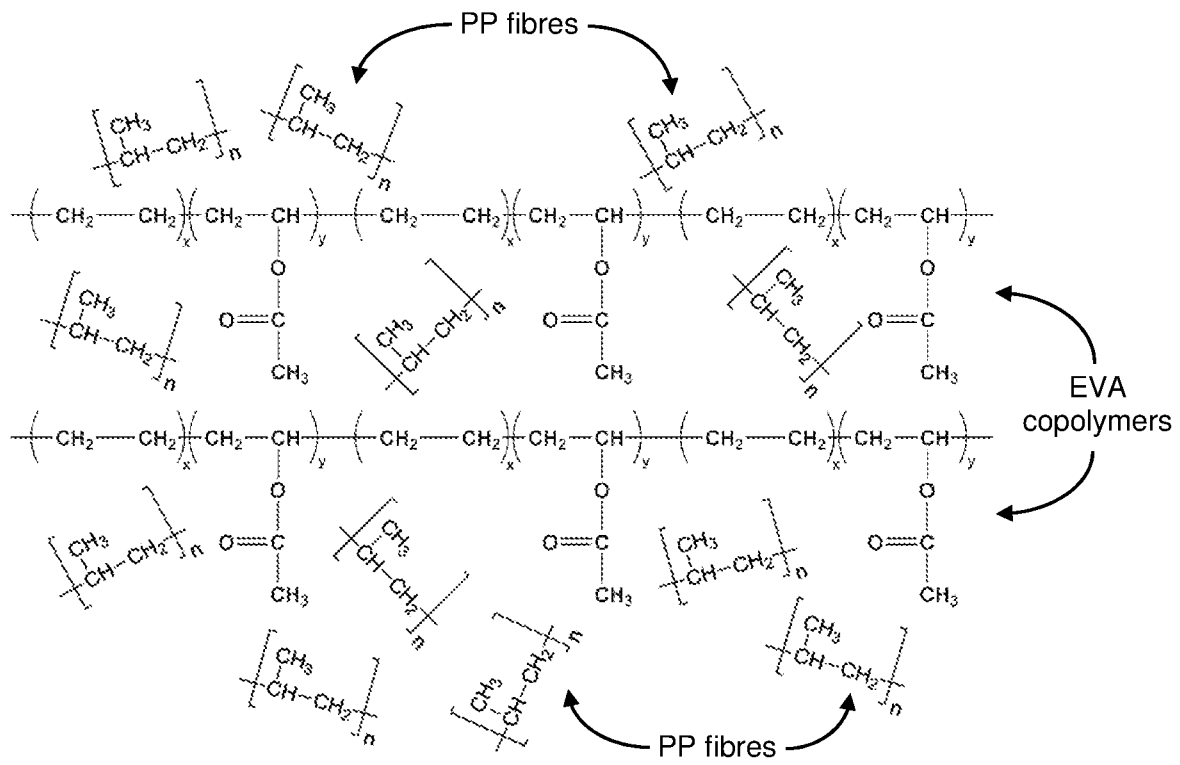


Figure 1

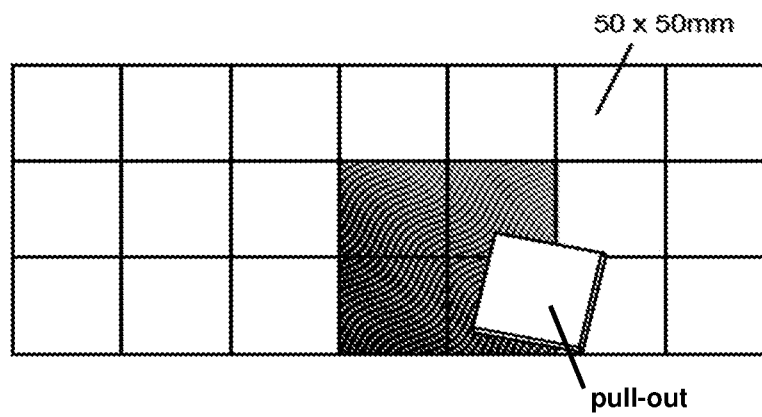


Figure 2

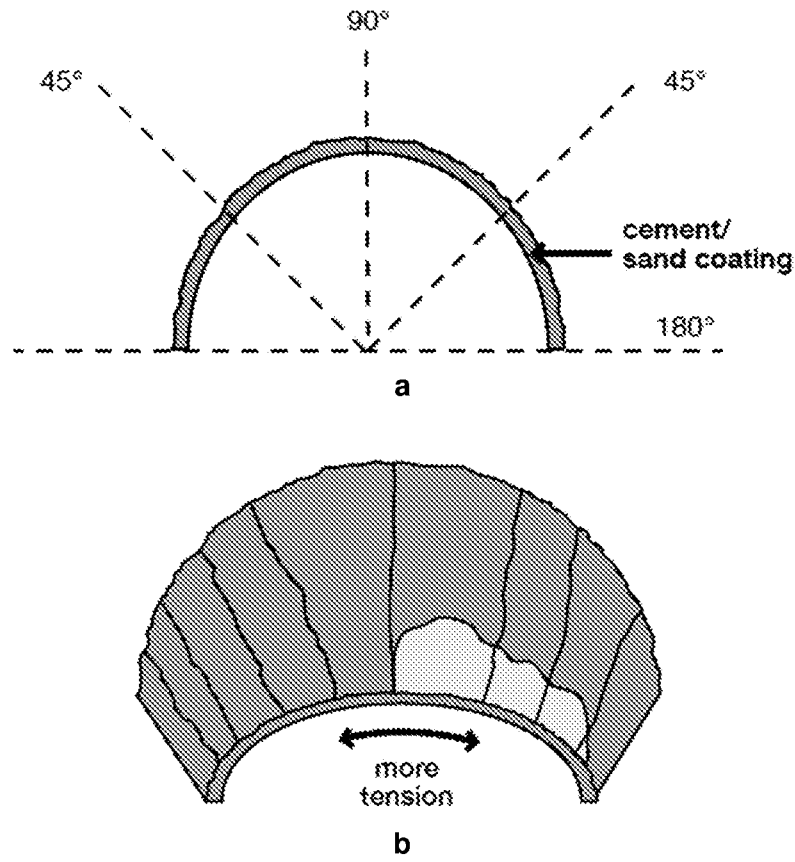


Figure 3

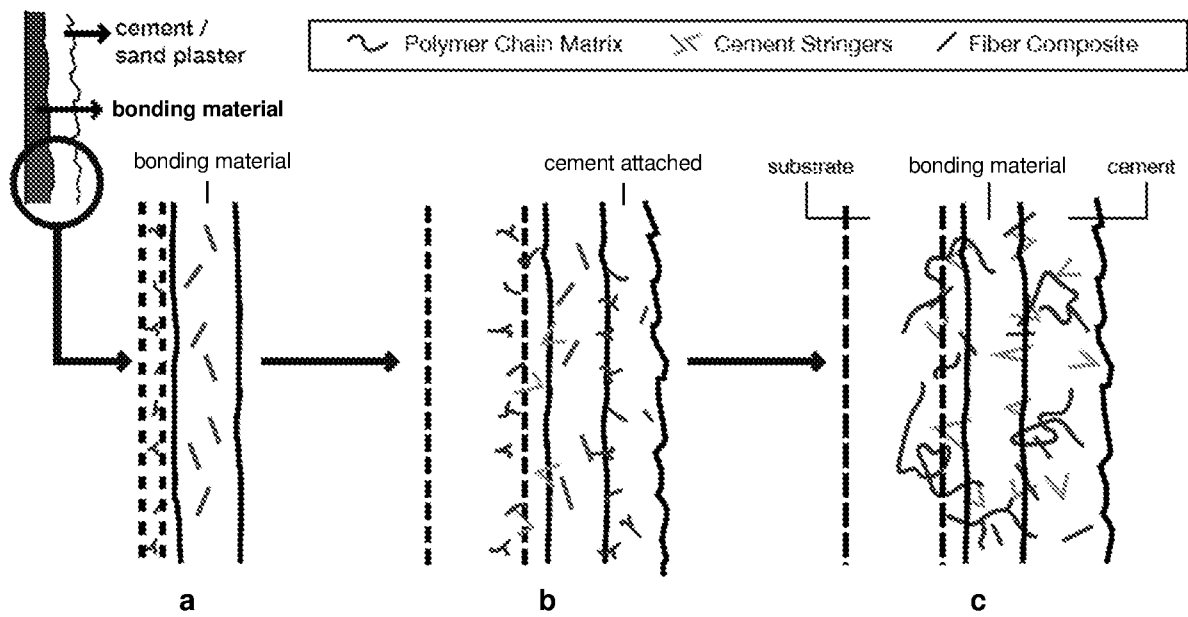


Figure 4