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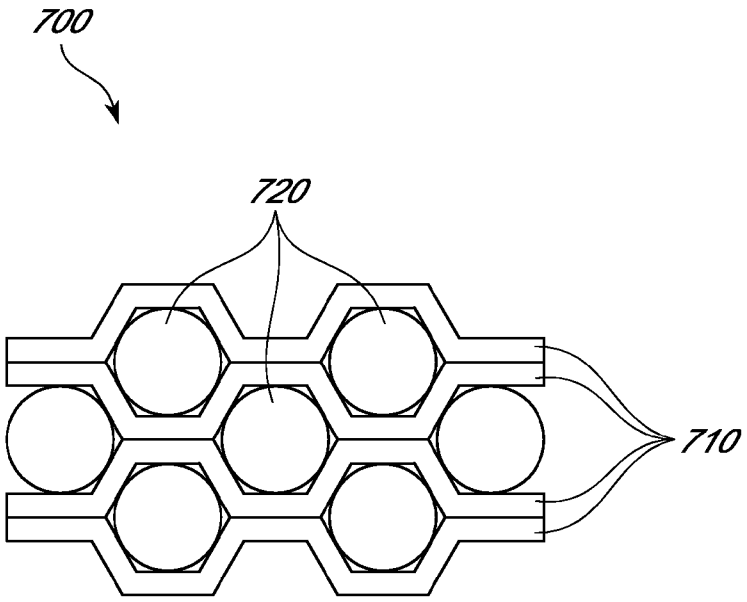


FIG. 7

(57) Abstract: Disclosed herein are composites as well as methods of making these composites. The composite may, for example, be used as light-weight, high-strength structural members and wall panels. In some embodiments, the composites can be prepared from a light-weight assembly using simple procedures. Also disclosed herein are assemblies for preparing the composites.

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COMPOSITE AND METHODS OF MAKING AND USING THE SAME

BACKGROUND

[0001] In areas of conflict or disaster, it is often necessary to provide temporary housing structures for affected individuals. Tents, mobile homes, etc. may be used to provide the necessary temporary housing. However, tents may not provide sufficient strength or safety for longer-term use. Meanwhile, mobile homes often require significant storage space, which may not be near the regions of conflict or disaster; therefore it may take an extended amount of time to transport the mobile homes to the affected regions.

SUMMARY

[0002] Some embodiments disclosed herein include a method of making a composite. The method can include providing a plurality of layers, applying water to the plurality of layers; and curing a resin in the layers to form the composite. In some embodiments, each layer includes a fabric sheet, the resin fixed to the fabric sheet, and a water-expandable polymer disposed along portions of each layer. In some embodiments, each layer is fixed to an adjacent layer at regions disposed between the portions of each layer having the water-expandable polymer.

[0003] In some embodiments, the method includes drying the plurality of layers.

[0004] In some embodiments, the method includes applying an ionic solution to the plurality of layers.

[0005] In some embodiments, curing the resin comprises applying heat, radiation, or water to the resin.

[0006] In some embodiments, a volume of the water-expandable polymer after applying the water is at least about 10 times greater than a volume of the water expandable polymer before applying the water.

[0007] In some embodiments, the regions of each layer fixed to an adjacent layer include an adhesive layer disposed between the adjacent layers. In some embodiments, the regions of each layer fixed to an adjacent layer comprise one or more fasteners.

[0008] In some embodiments, each layer comprises a plurality of tubular structures. In some embodiments, the water-expandable polymer is disposed within one or more lumens of the tubular structures.

[0009] In some embodiments, the regions of each layer fixed to an adjacent layer are located at repeating intervals. In some embodiments, the repeating interval is no more than about 800 mm. In some embodiments, the repeating interval is at least about 20 mm.

[0010] In some embodiments, each layer has a thickness of no more than about 20 mm. In some embodiments, each layer has a thickness of at least about 0.5 mm.

[0011] In some embodiments, the fabric sheet includes woven fabric. In some embodiments, the fabric sheet includes non-woven fabric. In some embodiments, the fabric sheet includes fibers including a material selected from cellulose, acryls, a protein, glass, aramids, polyesters, resins, and combinations thereof. In some embodiments, the resin fixed to the fabric sheet comprises a polymer having a hydroxyl group and a polymer having an isocyanate group.

[0012] In some embodiments, each layer includes at least about 20 of the portions of the water-expandable polymer.

[0013] Some embodiments disclosed herein include a composite prepared according to any of the methods disclosed in the present application.

[0014] Some embodiments disclosed herein include a composite. The composite can include a plurality of layers. In some embodiments, each layer includes a cured resin fixed to a fabric sheet. In some embodiments, adjacent layers of the plurality of layers are fixed together at regions disposed between the adjacent layers. The composite can include a plurality of lumens disposed between the adjacent layers.

[0015] In some embodiments, the regions of the adjacent layers fixed together comprise an adhesive layer disposed between the adjacent layers. In some embodiments, the regions of the adjacent layers fixed together comprise one or more fasteners.

[0016] In some embodiments, each layer comprises a plurality of tubular structures.

[0017] In some embodiments, the regions of the adjacent layers fixed together are located at repeating intervals. In some embodiments, the repeating interval is no more than about 800 mm. In some embodiments, the repeating interval is at least about 20 mm.

[0018] In some embodiments, each layer has a thickness of no more than about 20 mm. In some embodiments, each layer has a thickness of at least about 0.5 mm.

[0019] In some embodiments, the fabric sheet includes woven fabric. In some embodiments, the fabric sheet includes non-woven fabric.

[0020] In some embodiments, the fabric sheet includes fibers including a material selected from cellulose, acryls, a protein, glass, aramids, polyesters, resins, and combinations thereof.

[0021] In some embodiments, the cured resin is cured by applying heat, radiation, or water. In some embodiments, the cured resin includes a crosslink that includes a urethane.

[0022] In some embodiments, at least a portion of the plurality of lumens is at least partially filled with a resin or concrete.

[0023] In some embodiments, the plurality of lumens contain a water-expandable resin.

[0024] In some embodiments, a number of lumens in the composite relative to a number of layers in the composite is at least about 20 to 1.

[0025] Some embodiments disclosed herein include an assembly. In some embodiments, the assembly can include a plurality of layers. In some embodiments, the assembly can include a resin fixed to a fabric sheet. In some environments, the assembly can include a water-expandable resin disposed along portions of each layer. In some embodiments, each layer is fixed to an adjacent layer at regions disposed between the portions of each layer having the water-expandable resin.

[0026] In some embodiments, the assembly is disposed in a water-impermeable packaging.

[0027] In some embodiments, the water-expandable polymer is configured to expand at least 10 times by volume when water is applied.

[0028] In some embodiments, the resin fixed to the fabric sheet is configured to be cured by applying heat, radiation, or water to the resin.

[0029] In some embodiments, each layer comprises a plurality of tubular structures. In some embodiments, the water-expandable polymer is disposed within one or more lumens of the tubular structures.

[0030] In some embodiments, the regions of each layer fixed to an adjacent layer comprise an adhesive layer disposed between the adjacent layers. In some

embodiments, the regions of each layer fixed to an adjacent layer comprise one or more fasteners.

[0031] In some embodiments, the regions of each layer fixed to an adjacent layer are located at repeating intervals along each layer. In some embodiments, the repeating interval is no more than about 800 mm. In some embodiments, the repeating interval is at least about 20 mm.

[0032] In some embodiments, each layer has a thickness of no more than about 20 mm. In some embodiments, each layer has a thickness of at least about 0.5 mm.

[0033] In some embodiments, the fabric sheet includes woven fabric. In some embodiments, the fabric sheet includes non-woven fabric.

[0034] In some embodiments, the fabric sheet includes fibers including a material selected from cellulose, acryls, a protein, glass, aramids, polyesters, resins, and combinations thereof.

[0035] In some embodiments, the resin fixed to the fabric sheet comprises a polymer having a hydroxyl group and a polymer having an isocyanate group.

[0036] In some embodiments, each layer includes at least about 20 of the portions of water-expandable polymer extending along each layer.

[0037] The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0038] **FIG. 1** is a flow diagram of an illustrative embodiment of a method of making a composite.

[0039] **FIG. 2A** is a depiction of a side view of an illustrative embodiment of a sheet that can be included in an assembly.

[0040] **FIG. 2B** is a depiction of a top view of an illustrative embodiment of a sheet that can be included in an assembly.

[0041] **FIG. 3A** is a depiction of a side view of an illustrative embodiment of a sheet that can be included in an assembly.

[0042] **FIG. 3B** is a depiction of a top view of an illustrative embodiment of a sheet that can be included in an assembly.

[0043] **FIG. 4** is a depiction of a side view of an illustrative embodiment of a sheet that can be included in an assembly.

[0044] **FIG. 5** is a depiction of an illustrative embodiment of an assembly.

[0045] **FIG. 6** is a depiction of an illustrative embodiment of an assembly.

[0046] **FIG. 7** is a depiction of an illustrative embodiment of an assembly after being exposed to an aqueous solution.

[0047] **FIG. 8** is a depiction of an illustrative embodiment of an assembly after being exposed to an aqueous solution.

DETAILED DESCRIPTION

[0048] In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described in the detailed description, drawings, and claims are not meant to be limiting. Other embodiments may be utilized, and other changes may be made, without departing from the spirit or scope of the subject matter presented herein. It will be readily understood that the aspects of the present disclosure, as generally described herein, and illustrated in the Figures, can be arranged, substituted, combined, separated, and designed in a wide variety of different configurations, all of which are explicitly contemplated herein.

[0049] Disclosed herein are composites as well as methods of making these composites. A composite may, for example, be used as light-weight, high-strength structural members and wall panels. In some embodiments, the composites can be prepared from a light-weight assembly using simple procedures. Also disclosed herein are assemblies for preparing the composites.

[0050] **FIG. 1** is a flow diagram that depicts some embodiments of a method of making a composite. The method of making the composite may include: an operation "Provide an assembly," illustrated in block **100**, an operation "Apply water to the assembly," illustrated in block **110**, and an operation "Cure the assembly," illustrated in block **120**. Although operations **100**, **110** and **120** may be performed sequentially, it will be appreciated that one or more of these operations may be performed at about the same time. These operations may also be performed in a different order than is depicted in **FIG. 1**.

[0051] At operation **100** "Provide an assembly," an assembly is provided for forming the composite. In some embodiments, the assembly can include a multiple number of sheets. **FIG. 2A** depicts a side view of some embodiments of sheet **200** that may be included in the assembly. As depicted, sheet **200** includes a substrate **210**, adhesive regions **220**, and water-absorbent polymer regions **230**. **FIG. 2B** is a top view of sheet **200**.

[0052] The substrate of the sheet (e.g., substrate **210** in **FIGS. 2A** and **2B**) may, in some embodiments, include a resin fixed to a fiber cloth. The fiber cloth is not particularly limited and generally any type of fibers may be used in the fiber cloth. The fiber cloth may include fibers having a material such as cellulose, acryls, a protein, glass, aramids, polyesters, resins, and combinations thereof. The fibers in the fiber cloth are not limited to these materials, however. The fiber cloth may, for example, be a woven or a non-woven fiber cloth.

[0053] In some embodiments, the resin fixed to the fiber cloth is a curable resin. For example, the resin may be cured by applying water, heat or radiation to the resin. Various curable resins are known in the art and are within the scope of some embodiments. Examples of resins that may be configured to be curable include, but are not limited to, acrylics, epoxies, polyesters, polyamides, polyvinyls, polyurethanes, and the like. In some embodiments, the resin includes a polymer having an isocyanate group and a hydroxyl. Without being bound to any particular theory, isocyanate groups can react with hydroxyl groups in the presence of water to crosslink the polymer. The resin may, for example, be a water-curable resin commonly used in medical casts, etc. In some embodiments, the resin is a polyurethane. Japanese Unexamined Patent Application No. 2007-244856 and U.S. Patent No. 5,455,294 provide examples of water-curable resins that may be included in the resin. By including a curable resin, the substrate of the sheet may be flexible before curing to form a more rigid structure.

[0054] The manner in which the resin is fixed to the fiber cloth is not particularly limited. For example, the resin may be formed into a sheet that is laminated to the fiber cloth. As another example, the resin can be dip-coated or spray-coated onto the fiber cloth.

[0055] The adhesive regions of the sheet (e.g., adhesive regions **220** in **FIGS. 2A** and **2B**) are also not particularly limited and any known adhesive can be used. The adhesive regions may, for example, include an epoxy or an acrylic. As detailed further

below, the adhesive regions may fix together adjacent sheets in the assembly. Because other means for fixing the sheets together are within the scope of the present application, the adhesive regions are, however, optional.

[0056] In some embodiments, the adhesive regions are disposed along portions of the substrate. The adhesive regions may, for example, be located at repeating intervals along the substrate (e.g., as depicted in **FIGS. 2A-B**). The repeating interval may, for example, be at least about 20 mm; at least about 50 mm; at least about 100 mm; at least about 150 mm; or at least about 200 mm. The repeating interval may, for example, no more than about 800 mm; no more than about 600 mm; no more than about 400 mm; or no more than about 200 mm. In some embodiments, each of the adhesive regions has about the same width.

[0057] In some embodiments, the repeating interval for the adhesive regions is at least about two times the width of the adhesive regions. In some embodiments, the repeating interval for the adhesive regions is at least about three times the width of the adhesive regions. In some embodiments, the repeating interval for the adhesive regions is at least about four times the width of the adhesive regions. In some embodiments, the repeating interval for the adhesive regions is no more than about 10 times the width of the adhesive regions. In some embodiments, the repeating interval for the adhesive regions is no more than about eight times the width of the adhesive regions. In some embodiments, the repeating interval for the piece of regions is no more than about six times the width of the adhesive regions. In some embodiments, the repeating interval for the case of regions is about four times the width of the adhesive regions.

[0058] The number of adhesive regions in the sheet is not particularly limited and can vary based on various factors, such as the size and strength requirements for the final composite. The sheet may include, for example, at least about 5 adhesive regions; at least about 10 adhesive regions; at least about 20 adhesive regions; at least about 50 adhesive regions; or at least about 100 adhesive regions. The sheet may include, for example, no more than about 1000 adhesive regions; no more than about 800 adhesive regions; no more than about 500 adhesive regions; no more than about 200 adhesive regions; or no more than about 100 adhesive regions. In some embodiments the sheet can include from about five adhesive regions to about 1000 adhesive regions.

[0059] Water-absorbent polymer regions (e.g., water-absorbent polymer regions **230** in **FIGS. 2A** and **2B**) can include any polymer that exhibits substantial

volume expansion when exposed to water. In some embodiments, the water-absorbent resin is configured to expand at least about 10 times by volume when water is applied. In some embodiments, the water-absorbent resin is configured to expand at least about 15 times by volume when water is applied. In some embodiments, the water-absorbent resin is configured to expand at least about 20 times by volume when water is applied. In some embodiments, the water-absorbent polymer is configured to expand at least about 30 times by volume when water is applied. Numerous water-absorbent polymers are known in the art and are within the scope of the present application. For example, sodium polyacrylates are commonly used to absorb liquids as much as about 200 to about 300 times its mass. Other examples include, but are not limited to, water-absorbent polymers disclosed in U.S. Patent Nos. 5,225,506, 4,921,904, 5,563,218, and 6,335,398.

[0060] In some embodiments, the water-absorbent polymer regions are disposed along portions of the substrate. The water-absorbent polymer regions may, for example, be located at repeating intervals along the substrate (e.g., as depicted in **FIGS. 2A** and **2B**). The repeating interval may, for example, be at least about 20 mm; at least about 50 mm; at least about 100 mm; at least about 150 mm; or at least about 200 mm. The repeating interval may, for example, be no more than about 800 mm; no more than about 600 mm; no more than about 400 mm; or no more than about 200 mm. In some embodiments, the water-absorbent polymer regions are interposed between the adhesive regions. In some embodiments, each of the water-absorbent polymer regions is approximately equidistant between adjacent adhesive regions. In some embodiments, the repeating interval for the water-absorbent polymer regions is about the same as the repeating interval for the adhesive regions.

[0061] The number of water-absorbent polymer regions in the sheet is not particularly limited and can vary based on various factors, such as the size and strength requirements for the final composite. The sheet may include, for example, at least about 5 water-absorbent polymer regions; at least about 10 water-absorbent polymer regions; at least about 20 water-absorbent polymer regions; at least about 50 water-absorbent polymer regions; or at least about 100 water-absorbent polymer regions. The sheet may include, for example, no more than about 1000 water-absorbent polymer regions; no more than about 800 water-absorbent polymer regions; no more than about 500 water-absorbent polymer regions; no more than about 200 water-absorbent polymer regions; or no more than about 100 water-absorbent polymer regions. In some embodiments, the sheet can

include from about five water-absorbent polymer regions to about 1000 water-absorbent polymer regions. In some embodiments, the number of water-absorbent polymer regions in the sheet is about the same as the number of adhesive regions.

[0062] **FIGS. 3A** and **3B** depict another embodiment of a sheet **300** that can be used to form the composite. As depicted, sheet **300** includes a substrate **310** and water-absorbent polymer regions **320**. Substrate **310** can be generally the same as discussed above with respect to substrate **210** in **FIGS. 2A** and **2B**. Similarly, water expandable polymer regions **320** can be generally the same as those discussed above with respect to water-absorbent polymer regions **230** in **FIGS. 2A** and **2B**. However, as depicted in **FIGS. 3A** and **3B**, the sheet does not include an adhesive region. In some embodiments, the sheet does not include one or more adhesive regions. As will be discussed further below, each sheet can be fixed to an adjacent sheet using one or more fasteners. In some embodiments, each sheet can be fixed to an adjacent sheet using both adhesive regions and one or more fasteners. Other means for fixing adjacent sheets together are known in the art and within the scope of the certain embodiments.

[0063] **FIG. 4** depicts another embodiment of a sheet **400** that can be used to form the composite. As depicted, sheet **400** includes multiple tubular structures **410**, lumens **420**, adhesive regions **430**, and water-absorbent polymer regions **440**. The multiple tubular structures may, for example, be a fiber cloth wrapped around one or more times to form a generally tubular shape having lumens **420**. The fiber cloth may also be fixed to a resin. Both the fiber cloth and the resin can be, for example, any of those disclosed in the present application with respect to the layers in the assembly (e.g., the same those described above with respect to substrate **210** depicted in **FIG. 2** or substrate **310** depicted in **FIG. 3**). The multiple tubular structures **410** may be fixed together in sheet **400** by multiple adhesive regions **430**. However, other means for fixing together adjacent tubular structures are known in the art and within the scope of certain embodiments. For example, the tubular structures can be fixed together by one or more fasteners (not shown). Water-absorbent polymer regions **440** may be disposed within each of the lumens **420** in the tubular structures **410**. The water-absorbent polymer may, for example, be the same as those disclosed in the present application with respect to the layers in the assembly (e.g., the same as those described above with respect to adhesive regions **220** depicted in **FIG. 2**).

[0064] **FIG. 5** depicts one example of an assembly **500** having a multiple number of sheets that can be provided in operation **100** of **Figure 1**. As depicted, assembly **500** includes multiple sheets **510**, each of the sheets having a multiple number of adhesive regions **520** disposed along portions of sheets **510**. A multiple number of water-absorbent polymer regions **430** are also disposed along portions of sheets **510**. Adhesive regions **520** can be generally same as those discussed above with respect to the sheets in the assembly (e.g. adhesive regions **220** as depicted in **FIGS. 2A** and **2B**). Also, water-absorbent polymer regions **530** can be generally the same as those discussed above with respect to the sheets in the assembly (e.g. water-absorbent polymer regions **230** as depicted in **FIGS. 2A** and **2B**). Sheets **510** are each fixed together by adhesive regions **520** which contacts opposing sides of two adjacent sheets. In some embodiments, the assembly is modular.

[0065] The thickness of each of the sheets in the assembly (e.g. sheets **510** as depicted in **FIG. 5**) is not particularly limited. The thickness of each of the sheets in the assembly can be, for example, at least about 0.5 mm; at least about 1 mm; at least about 2 mm; at least about 5 mm; or at least about 10 mm. The thickness of each of the sheets in the assembly can be, for example, no more than about 20 mm; no more than about 15 mm; no more than about 10 mm; no more than about 5 mm; or no more than about 3 mm. In some embodiments, each of the sheets in the assembly has a thickness from about 0.5 mm to about 20 mm.

[0066] The number of sheets in the assembly is also not particularly limited. The number of sheets in the assembly can be, for example, at least about 4 sheets; at least about 10 sheets; at least about 25 sheets; at least about 100 sheets; or at least about 200 sheets. The number of sheets in the assembly can be, for example, no more than about 1000 sheets; no more than about 500 sheets; no more than about 200 sheets; no more than about 100 sheets; or no more than about 50 sheets. In some embodiments, the number of sheets in the assembly is from about 4 sheets to about 1000 sheets.

[0067] **FIG. 6** depicts another embodiment of an assembly **600** having a multiple number of sheets that can be provided in operation **100** of **FIG. 1**. As depicted, assembly **600** can include multiple sheets **610**, a multiple number of water-absorbent polymer regions **620**, and a multiple number of fasteners **630**. Both sheets **610** and water-absorbent polymer regions **620** can be generally the same as those discussed above with

respect to **FIG. 5**. However, assembly **600** includes a multiple number of fasteners **630** which fix adjacent sheets together in the assembly. Non-limiting examples of fasteners that may be used to fix together adjacent sheets include rivets, screws, nails, and the like. As will be appreciated by the skilled artisan, guided by the teachings in the present application, both fasteners and adhesive regions can be used in combination to fix together adjacent sheets in the assembly.

[0068] Returning to figure 1, operation **100** may be followed by operation **110**. At operation **110** ("Apply water to the assembly"), water can be applied to the assembly. The assembly can be, for example, any of those discussed above (e.g. assembly **500** or assembly **600** as depicted in **FIGS. 5** and **6**, respectively). Without being bound to any particular theory, it is believed that applying water to the assembly can cause the water-absorbent polymer to absorb water and expand in volume. The expanding polymer may increase the distance between regions in the adjacent sheets in the assembly, while portions of the sheets still remain fixed together (e.g. portions fixed together by the adhesive regions and/or fasteners). In some embodiments, the expanding polymer produces lumens extending along portions of the assembly. In some embodiments, the lumens are located at repeating intervals in the assembly that corresponds to a repeating interval of the water-absorbent polymer regions in the assembly.

[0069] **FIG. 7** is one example of an assembly **700** after water has been applied to the assembly. As depicted, assembly **700** includes a multiple number of sheets **710** and a multiple number of water-absorbent polymer regions **720**. Polymer **720** can be expanded due to the water that is absorbed. Sheets **710** in the assembly are fixed together at various portions of sheets **710** that face each other (adhesive regions or fasteners are not shown in **FIG. 7**). Thus, in some embodiments, applying water to the assembly may result in a honeycomb-like structure. In some embodiments, the structure of the assembly after applying water has a regular pattern (e.g. hexagonal pattern).

[0070] **FIG. 8** is another example of an assembly **800** after water has been applied to the assembly. As depicted, assembly **800** includes a multiple number of sheets **810**, a multiple number of tubular structures **820**, and multiple number of water-absorbent polymer regions **830**. The multiple number of sheets **810** may, for example, be prepared by fixing together a multiple number of sheets **400** depicted in **FIG. 4**. Sheets **810** in the assembly are fixed together at various portions of sheets **810** that face each other

(adhesive regions or fasteners are not shown in **FIG. 7**). The water-absorbent polymer regions **830** may be expanded due to the water that is absorbed. Thus, in some embodiments, applying water to the assembly may also result in a square lattice. Other lattice structures are also possible and within the scope of certain embodiments, such as a parallelogrammic lattice, rectangular lattice, hexagonal lattice, or a rhombic lattice.

[0071] The thickness of the assembly may, in some embodiments, increase after applying water to the assembly. The thickness of the assembly after applying water may, for example, increase at least about 50%; at least about 100%; at least about 150%; or at least about 200%.

[0072] Returning to figure 1, operation **110** may be followed by operation **120**. At operation **120** ("Cure the assembly"), the assembly can be cured to obtain a rigid composite. In some embodiments, the resin fixed to the fiber cloth in the sheet is cured. Various means for curing the assembly are well-known in the art, and are not particularly limited. For example, the assembly can be cured by applying heat, radiation, or water to the assembly. As will be appreciated by the skilled artisan, two or more of these curing methods may be applied either at about the same or different times to obtain a rigid composite.

[0073] The method of curing the assembly will vary depending upon the materials used in the assembly. For example, the resin in the fiber sheet may be a water-curable resin as discussed above. Thus, curing the assembly can include applying water to the assembly. When using a water-curable resin, operations **110** and **120** in **FIG. 1** may occur at about the same time. However, the disclosed methods may also include a separate curing operation that occurs after applying water to the assembly. In some embodiments, the assembly can be cured by applying heat to the assembly. As an example, the assembly may include an epoxy that will cure when applying sufficient heat. In some embodiments, the assembly can be cured by applying radiation to the assembly. As an example, electron beam radiation, gamma radiation, or ultraviolet radiation can be applied to the resin in the fiber cloth to cure the resin.

[0074] After operation **120**, the cured assembly may be in a rigid state to obtain the composite. For example, the composite may be configured as shown in **FIGS. 7A** or **7B** in a substantially rigid form. Thus, in some embodiments, the lumens produced by the water-absorbent polymer regions will remain even if the water-absorbent polymer regions are dried to remove the water therein.

[0075] Some of the methods disclosed herein may also include various other optional operations. As will be discussed further below, the assembly may be provided in a water-impermeable packaging. Thus, for example, the method may include removing the assembly from the water-impermeable packaging. In some embodiments, the water-impermeable packaging can be opened and water added to the packaging while the assembly remains in the packaging. The packaging may, in some embodiments, therefore serve as a container for immersing the assembly in water.

[0076] Various post-processing operations can also be included in the methods of the present application. In some embodiments, the composite can be dried. By drying the composite, for example, the water-absorbent polymer regions may decrease in volume such that the lumens produced by the water-absorbent polymer regions are generally empty. The composite can be dried by any known method. For example, the composite can be dried by applying heat or light. In some embodiments, an ionic solution (e.g. salt water) can be applied to remove water from the water-absorbent polymer regions. Without being bound to any particular theory, it is believed that adding an ionic solution inhibits the water-absorbent polymers' ability to absorb water.

[0077] In some embodiments, a reinforcing material can be added into the lumens of the composite after the water-absorbent polymer regions are dried. For example, concrete or resins can be added into these lumens to provide further structural support. All or a portion of the lumens in the composite can be filled with a reinforcing material.

[0078] The final composite can be used for building various structures that are not particularly limited. In some embodiments, two or more of the composites can be assembled into a shelter or fence. For example, one or more composite may be includes as wall panels in a structure (e.g., shelter).

[0079] Some embodiments disclosed herein include a composite. The composite may, for example, be produced by any of the methods described above (e.g. the method depicted in figure 1). In some embodiments, the composite can include a plurality of sheets. Each of the plurality of sheets may include a cured resin fixed to a fiber cloth. The fiber cloth can be any of those discussed above with respect to the substrate of the sheet in the assembly (e.g. substrate **210** depicted in **FIG. 1**).

[0080] Similarly, the cured resin can be any of the resins discussed above with respect to the substrate of the sheet in the assembly; however, the resin is in a cured state

(e.g. after applying heat, radiation, or water to cure the resin) and therefore substantially rigid. In some embodiments, the cured resin includes a cross-linked structure. As an example, the cured resin may include a cross-linking group having a urethane. A urethane cross-linking group may be obtained, for example, by reacting a hydroxyl group with an isocyanate group in the presence of water.

[0081] Each of the sheets in the composite may, in some embodiments, be fixed together at regions disposed between adjacent sheets. For example, adjacent sheets may be fixed together by adhesive regions or fasteners as discussed above.

[0082] In some embodiments, adjacent sheets are fixed together at repeating intervals. The repeating intervals may be the same as those discussed above with respect to the assembly (e.g. assembly **200** depicted in **FIGS. 2A** and **2B**). The repeating interval may, for example, be at least about 20 mm; at least about 50 mm; at least about 100 mm; at least about 150 mm; or at least about 200 mm. The repeating interval may, for example, no more than about 800 mm; no more than about 600 mm; no more than about 400 mm; or no more than about 200 mm. In some embodiments, the repeating interval is from about 20 mm to about 800 mm.

[0083] The thickness of the sheets in the composite is not limiting and may be generally the same as those discussed above with respect to the assembly used in some embodiments to form the composite. The thickness of each of the sheets in the composite can be, for example, at least about 0.5 mm; at least about 2 mm; at least about 5 mm; at least about 10 mm; or at least about 20 mm. The thickness of each of the sheets in the composite can be, for example, no more than about 60 mm; no more than about 20 mm; no more than about 15 mm; no more than about 10 mm; or no more than about 5 mm. In some embodiments, each of the sheets in the composite is about 0.5 mm to about 60 mm thick.

[0084] The number of sheets in the composite is also not limiting. The number of sheets in the composite can be, for example, at least about 4 sheets; at least about 10 sheets; at least about 25 sheets; at least about 100 sheets; or at least about 200 sheets. The number of sheets in the composite can be, for example, no more than about 1000 sheets; no more than about 500 sheets; no more than about 200 sheets; no more than about 100 sheets; or no more than about 50 sheets. In some embodiments, the number of sheets in the composite is from about 4 sheets to about 1000 sheets.

[0085] The composite may also include, in some embodiments, a plurality of lumens disposed between adjacent sheets in the composite. The lumens may, for example, be formed by water-absorbent polymer regions that were exposed to water (e.g. during operation **120** depicted in **FIG. 1**). Thus, in some embodiments, a water-absorbent polymer may be disposed within one or more of the lumens. The water-absorbent polymer may be expanded due to absorbed water, or may be dry.

[0086] The number of lumens in the composite may vary. The number of lumens in the composite relative to the number of sheets in the composite may, for example be at least about 20 to 1; at least about 40 to 1; at least about 50 to 1; or at least about 100 to 1. The number of lumens in the composite relative to the number of sheets in the composite may, for example, be no more than about 1000 to 1; no more than about 500 to 1; no more than about 200 to 1; no more than about 100 to 1; or no more than about 50 to 1. In some embodiments, a number of lumens in the composite relative to the number of sheets in the composite is from about 20:1 to about 1000:1.

[0087] Some embodiments disclosed herein include an assembly. The assembly may, for example, be used in a method for making a composite (e.g. the method depicted in **FIG. 1**). The assembly can be the same as any of those discussed above with respect to the method of making the composite. Thus, for example, **FIGS. 5** and **6** depict some embodiments of the assembly.

[0088] In some embodiments, the assembly can include a plurality of sheets. Each sheet can include a resin fixed to a fiber sheet and a water-absorbent resin disposed along portions of each sheet. In some embodiments, each sheet is fixed to adjacent sheets at regions disposed between the portions of each sheet having the water-absorbent polymer.

[0089] As discussed above, the assembly may, in some embodiments, include a water-impermeable packaging to limit exposure of the assembly to water. This may prevent premature curing or expansion of the assembly. The assembly may be removed from the water-impermeable packaging before curing, or as discussed above, the packaging may also serve as a container for immersing the assembly in water by simply adding water into the packaging.

[0090] With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or

from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations may be expressly set forth herein for sake of clarity.

[0091] It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims (*e.g.*, bodies of the appended claims) are generally intended as "open" terms (*e.g.*, the term "including" should be interpreted as "including but not limited to," the term "having" should be interpreted as "having at least," the term "includes" should be interpreted as "includes but is not limited to," etc.). It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to embodiments containing only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (*e.g.*, "a" and/or "an" should be interpreted to mean "at least one" or "one or more"); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should be interpreted to mean at least the recited number (*e.g.*, the bare recitation of "two recitations," without other modifiers, means at least two recitations, or two or more recitations). Furthermore, in those instances where a convention analogous to "at least one of A, B, and C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (*e.g.*, " a system having at least one of A, B, and C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). In those instances where a convention analogous to "at least one of A, B, or C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (*e.g.*, " a system having at least one of A, B, or C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). It will be further

understood by those within the art that virtually any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase "A or B" will be understood to include the possibilities of "A" or "B" or "A and B."

[0092] In addition, where features or aspects of the disclosure are described in terms of Markush groups, those skilled in the art will recognize that the disclosure is also thereby described in terms of any individual member or subgroup of members of the Markush group.

[0093] As will be understood by one skilled in the art, for any and all purposes, such as in terms of providing a written description, all ranges disclosed herein also encompass any and all possible subranges and combinations of subranges thereof. Any listed range can be easily recognized as sufficiently describing and enabling the same range being broken down into at least equal halves, thirds, quarters, fifths, tenths, etc. As a non-limiting example, each range discussed herein can be readily broken down into a lower third, middle third and upper third, etc. As will also be understood by one skilled in the art all language such as "up to," "at least," and the like include the number recited and refer to ranges which can be subsequently broken down into subranges as discussed above. Finally, as will be understood by one skilled in the art, a range includes each individual member. Thus, for example, a group having 1-3 cells refers to groups having 1, 2, or 3 cells. Similarly, a group having 1-5 cells refers to groups having 1, 2, 3, 4, or 5 cells, and so forth.

[0094] From the foregoing, it will be appreciated that various embodiments of the present disclosure have been described herein for purposes of illustration, and that various modifications may be made without departing from the scope and spirit of the present disclosure. Accordingly, the various embodiments disclosed herein are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

[0095] The present disclosure is not to be limited in terms of the particular embodiments described in this application, which are intended as illustrations of various aspects. Many modifications and variations can be made without departing from its spirit and scope, as will be apparent to those skilled in the art. Functionally equivalent methods and apparatuses within the scope of the disclosure, in addition to those enumerated herein,

will be apparent to those skilled in the art from the foregoing descriptions. Such modifications and variations are intended to fall within the scope of the appended claims. The present disclosure is to be limited only by the terms of the appended claims, along with the full scope of equivalents to which such claims are entitled. It is to be understood that this disclosure is not limited to particular methods, reagents, compounds, compositions or biological systems, which can, of course, vary. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting.

WHAT IS CLAIMED IS:

1. A method of making a composite, comprising:

providing a plurality of layers, each layer comprising:

a fabric sheet;

a resin fixed to the fabric sheet; and

a water-expandable polymer disposed along portions of each layer, wherein each layer is fixed to an adjacent layer at regions disposed between the portions of each layer having the water-expandable polymer;

applying water to the plurality of layers; and

curing the resin to form the composite.

2. The method of Claim 1, further comprising drying the plurality of layers.

3. The method of Claim 1, further comprising applying an ionic solution to the plurality of layers.

4. The method of any one of Claims 1-3, wherein curing the resin comprises applying heat, radiation, or water to the resin.

5. The method of any one of Claims 1-4, wherein a volume of the water-expandable polymer after applying the water is at least about 10 times greater than a volume of the water expandable polymer before applying the water.

6. The method of any one of Claims 1-5, wherein the regions of each layer fixed to an adjacent layer comprise an adhesive layer disposed between the adjacent layers.

7. The method of any one of Claims 1-6, wherein each layer comprises a plurality of tubular structures.

8. The method of Claim 7, wherein the water-expandable polymer is disposed within the lumens of the tubular structures.

9. The method of any one of Claims 1-8, wherein the regions of each layer fixed to an adjacent layer comprise one or more fasteners.

10. The method of any one of Claims 1-9, wherein the regions of each layer fixed to an adjacent layer are located at repeating intervals.

11. The method of Claim 10, wherein the repeating interval is no more than about 800 mm.

12. The method of any one of Claims 10-11, wherein the repeating interval is at least about 20 mm.

13. The method of any one of Claims 1-12, wherein each layer has a thickness of no more than about 20 mm.

14. The method of any one of Claims 1-13, wherein each layer has a thickness of at least about 0.5 mm.

15. The method of any one of Claims 1-14, wherein the fabric sheet comprises woven fabric.

16. The method of any one of Claims 1-15, wherein the fabric sheet comprises non-woven fabric.

17. The method of any one of Claims 1-16, wherein the fabric sheet comprises fibers including a material selected from the group consisting of cellulose, acryls, a protein, glass, aramids, polyesters, resins, and combinations thereof.

18. The method of any one of Claims 1-17, wherein the resin fixed to the fabric sheet comprises a polymer having a hydroxyl group and a polymer having an isocyanate group.

19. The method of any one of Claims 1-18, wherein each layer comprises at least about 20 of the portions of the water-expandable polymer.

20. A composite prepared according to any one of the methods in Claims 1-19.

21. A composite comprising:

a plurality of layers, each layer comprising a cured resin fixed to a fabric sheet, wherein adjacent layers of the plurality of layers are fixed together at regions disposed between the adjacent layers; and

a plurality of lumens disposed between the adjacent layers.

22. The composite of Claim 21, wherein the regions of the adjacent layers fixed together comprise an adhesive layer disposed between the adjacent layers.

23. The composite of Claim 21, wherein the regions of the adjacent layers fixed together comprise one or more fasteners.

24. The composite of any one of Claims 21-23, wherein each layer comprises a plurality of tubular structures.

25. The composite of any one of Claims 21-24, wherein the regions of the adjacent layers fixed together are located at repeating intervals.

26. The composite of Claim 25, wherein the repeating interval is no more than about 800 mm.

27. The composite of any one of Claims 25-26, wherein the repeating interval is at least about 20 mm.

28. The composite of any one of Claims 21-27, wherein each layer has a thickness of no more than about 20 mm.

29. The composite of any one of Claims 21-28, wherein each layer has a thickness of at least about 0.5 mm.

30. The composite of any one of Claims 21-29, wherein the fabric sheet comprises woven fabric.

31. The composite of any one of Claims 21-29, wherein the fabric sheet comprises non-woven fabric.

32. The composite of any one of Claims 21-31, wherein the fabric sheet comprises fibers including a material selected from the group consisting of cellulose, acryls, a protein, glass, aramids, polyesters, resins, and combinations thereof.

33. The composite of any one of Claims 21-32, wherein the cured resin is cured by applying heat, radiation, or water.

34. The composite of any one of Claims 21-33, wherein the cured resin comprises a crosslink that includes a urethane.

35. The composite of any one of Claims 21-34, wherein at least a portion of the plurality of lumens is at least partially filled with a resin or concrete.

36. The composite of any one of Claims 21-35, wherein the plurality of lumens contain a water-expandable resin.

37. The composite of any one of Claims 21-36, wherein a number of lumens in the composite relative to a number of layers in the composite is at least about 20 to 1.

38. An assembly for forming a composite, the assembly comprising:

a plurality of layers, each layer comprising:

a resin fixed to a fabric sheet; and

a water-expandable polymer disposed along portions of each layer, wherein each layer is fixed to an adjacent layer at regions disposed between the portions of each layer having the water-expandable resin.

39. The assembly of Claim 38, wherein the assembly is disposed in a water-impermeable packaging.

40. The assembly of any one of Claims 38-39, wherein each layer comprises a plurality of tubular structures.

41. The assembly of Claim 40, wherein the water-expandable polymer is disposed within one or more lumens of the tubular structures.

42. The assembly of any one of Claims 38-41, wherein the water-expandable polymer is configured to expand at least 10 times by volume when water is applied.

43. The assembly of any one of Claims 38-42, wherein the resin fixed to the fabric sheet is configures to be cured by applying heat, radiation, or water to the resin.

44. The assembly of any one of Claims 38-43, wherein the regions of each layer fixed to an adjacent layer comprise an adhesive layer disposed between the adjacent layers.

45. The assembly of any one of Claims 38-44, wherein the regions of each layer fixed to an adjacent layer comprise one or more fasteners.

46. The assembly of any one of Claims 38-45, wherein the regions of each layer fixed to an adjacent layer are located at repeating intervals along each layer.

47. The assembly of Claim 46, wherein the repeating interval is no more than about 800 mm.

48. The assembly of any one of Claims 38-47, wherein the repeating interval is at least about 20 mm.

49. The assembly of any one of Claims 38-48, wherein each layer has a thickness of no more than about 20 mm.

50. The assembly of any one of Claims 38-49, wherein each layer has a thickness of at least about 0.5 mm.

51. The assembly of any one of Claims 38-50, wherein the fabric sheet comprises woven fabric.

52. The assembly of any one of Claims 38-51, wherein the fabric sheet comprises non-woven fabric.

53. The assembly of any one of Claims 38-52, wherein the fabric sheet comprises fibers including a material selected from the group consisting of cellulose, acryls, a protein, glass, aramids, polyesters, resins, and combinations thereof.

54. The assembly of any one of Claims 38-53, wherein the resin fixed to the fabric sheet comprises a polymer having a hydroxyl group and a polymer having an isocyanate group.

55. The assembly of any one of Claims 38-54, wherein each layer comprises at least about 20 of the portions of water-expandable polymer extending along each layer.

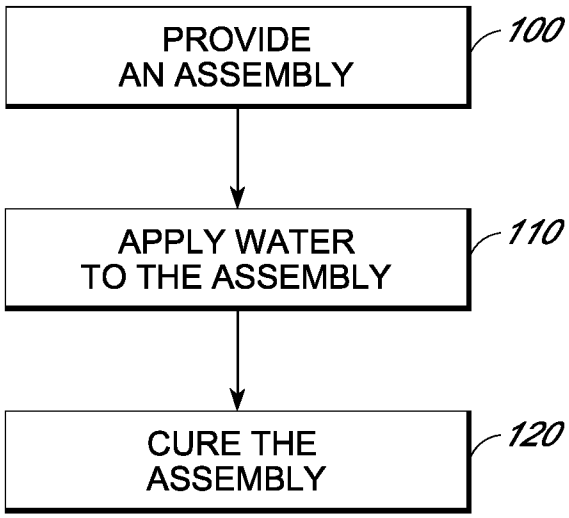

PROVIDE AN ASSEMBLY
100
APPLY WATER TO THE ASSEMBLY
110
CURE THE ASSEMBLY
120

FIG. 1

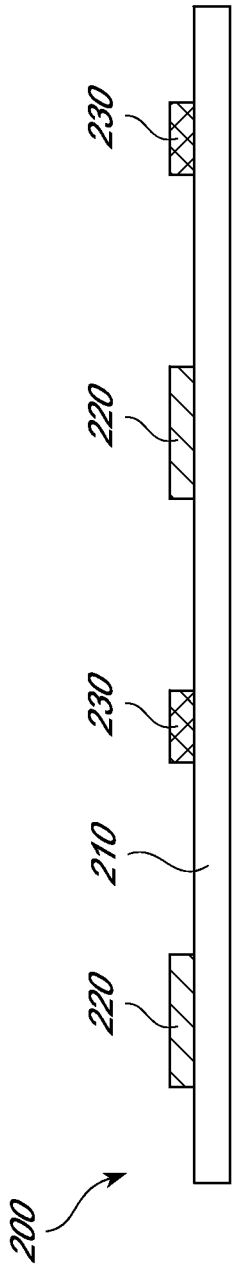


FIG. 2A

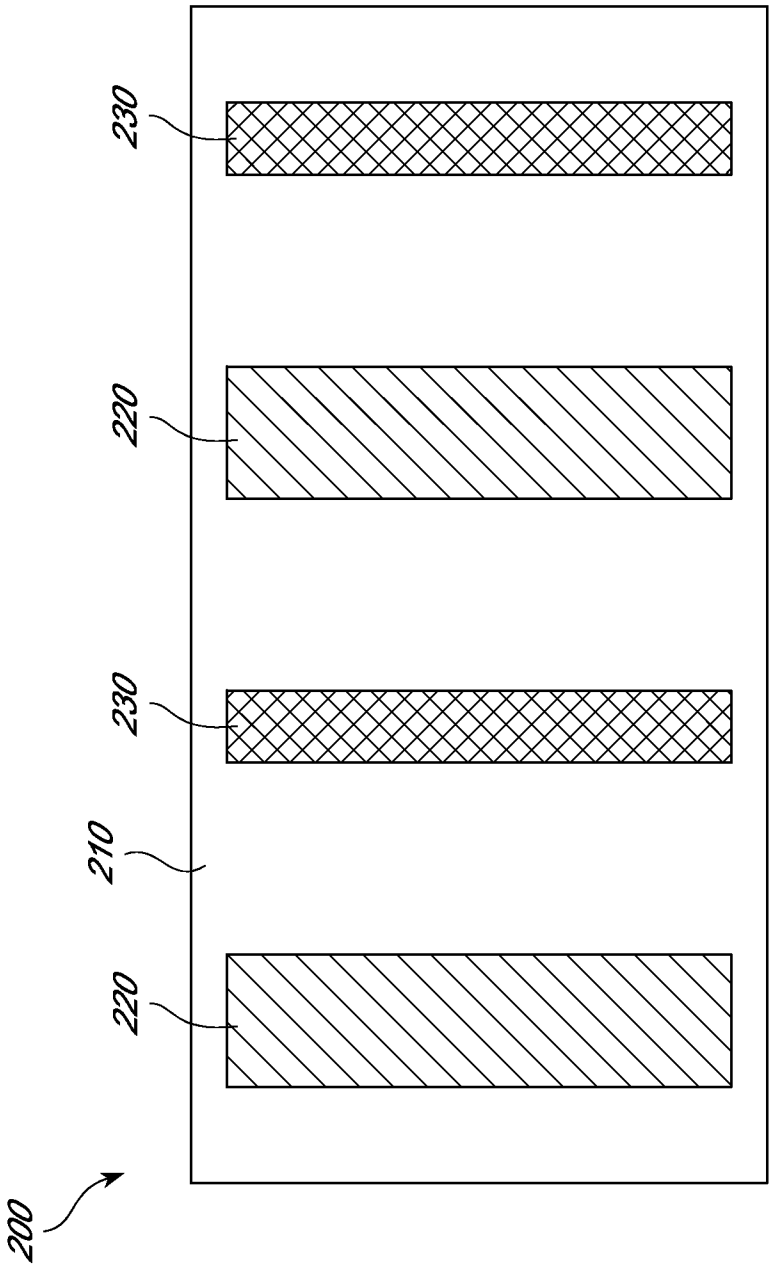


FIG. 2B

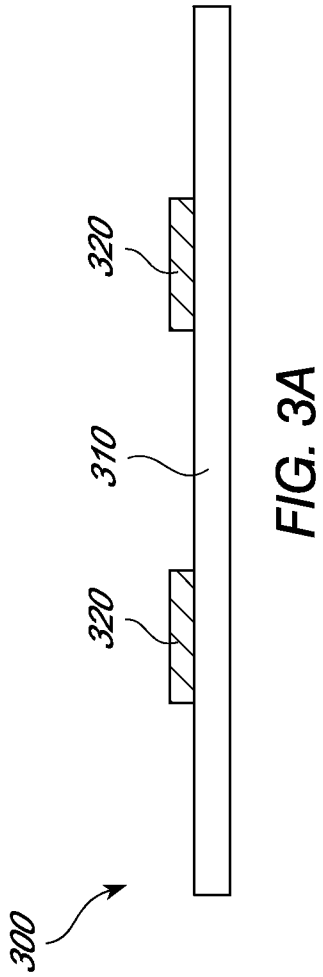


FIG. 3A

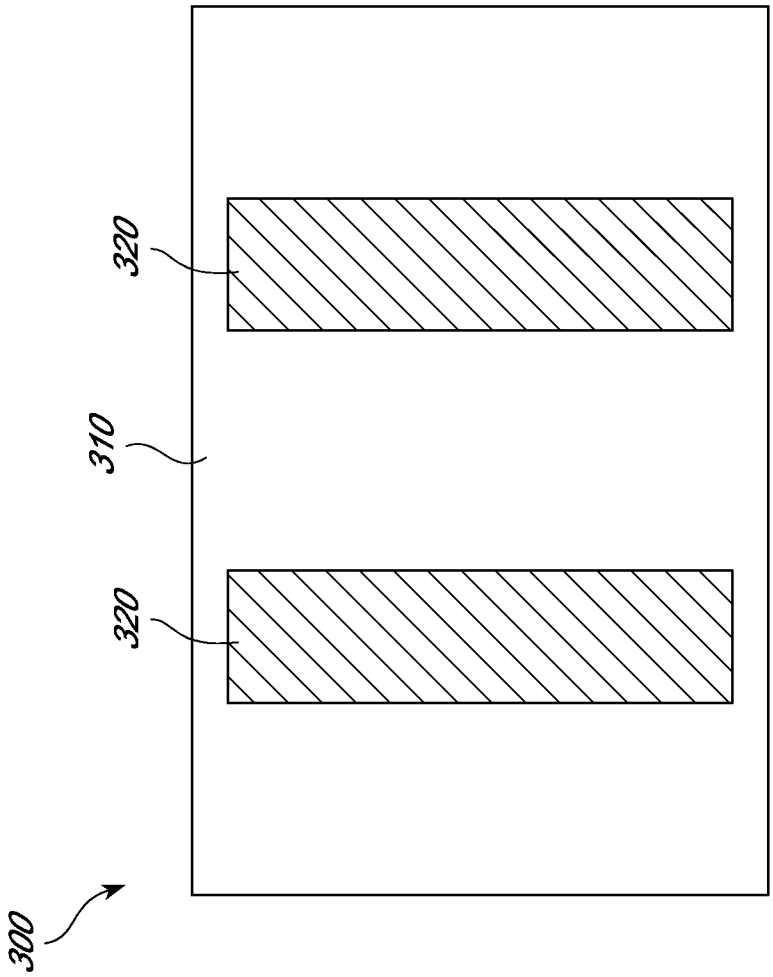


FIG. 3B

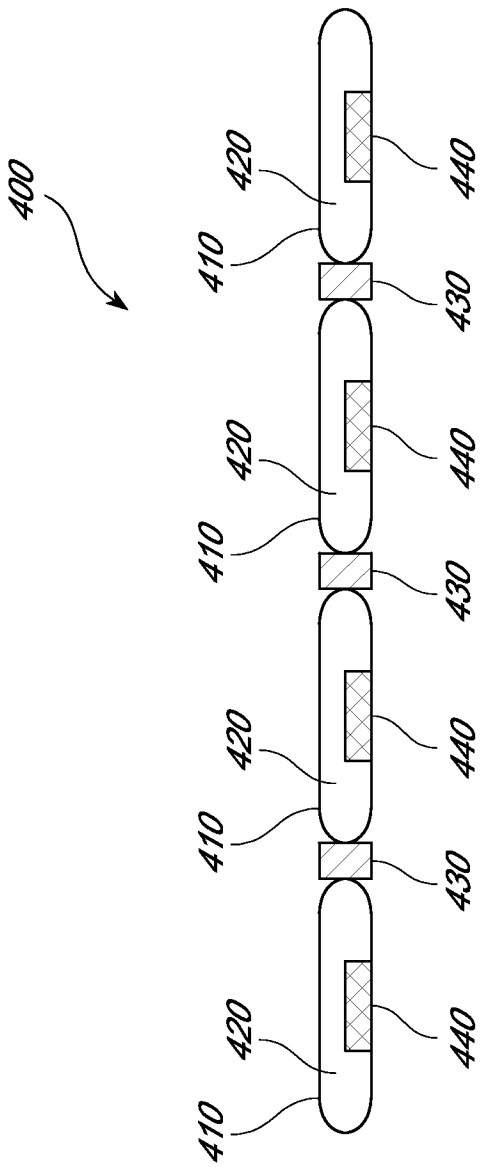


FIG. 4

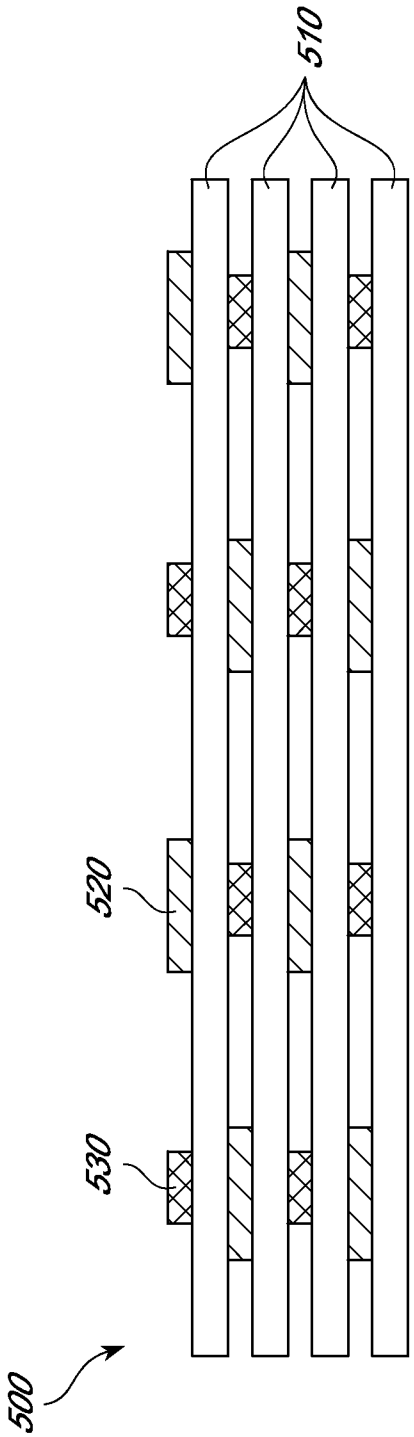


FIG. 5

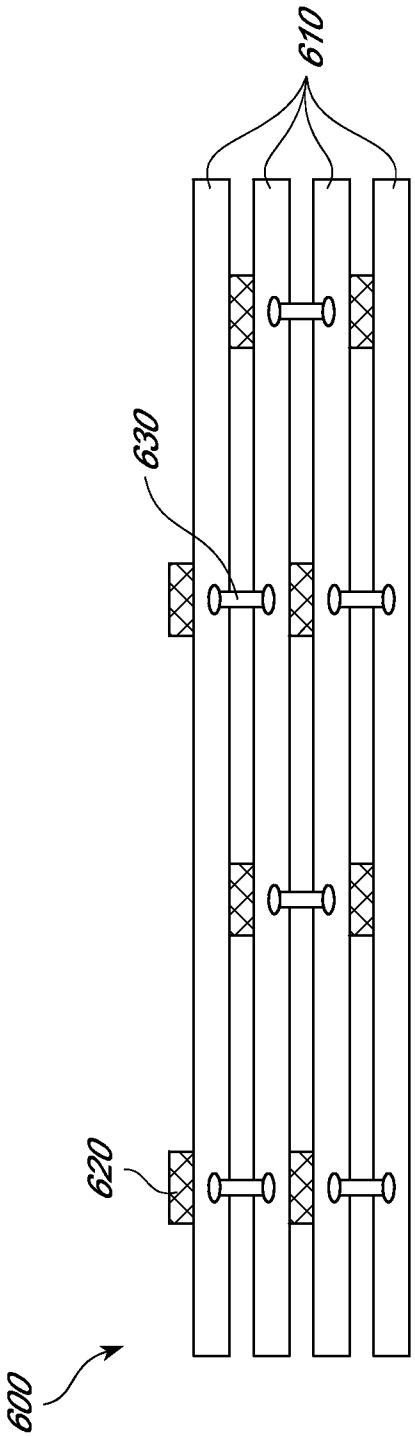


FIG. 6

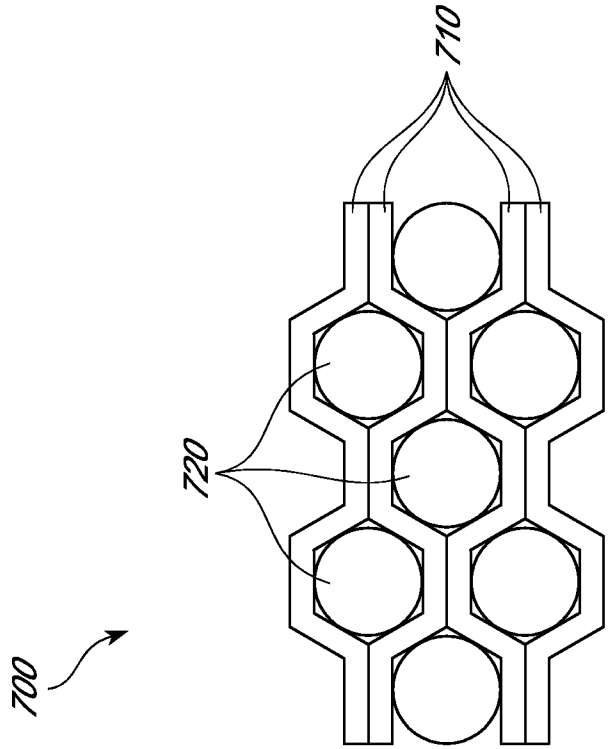


FIG. 7

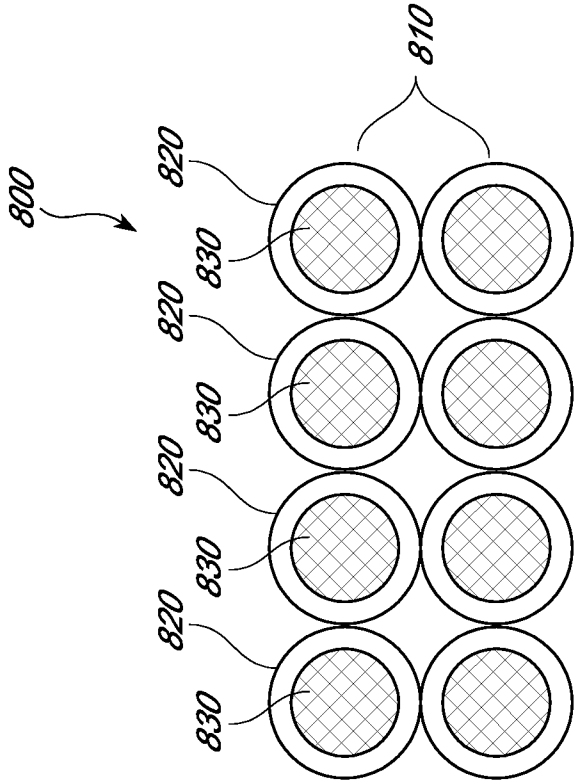


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2011/060632

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

E02D 17/20 (2006.01) ***B32B 5/28*** (2006.01) ***E04H 9/02*** (2006.01)
B29C 70/00 (2006.01) ***B32B 27/12*** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPODOC and WPI: /IC/EC B29 or B32B and keywords ((cloth+ or fabric+ or sheet+ or layer+ or substrate+) and (multi+ or matrix or laminate or composite or assembly+) and (bond+ or adhesive or glue or gluing or fixing or fasten+ or rivet+ or screws or nails or attach+) and (+between+ or repeat+ or space+ or intervals or stitch+ or intermit+ or honey+) and (swell+ or expand+ or absorb+) and water); EPODOC and WPI: and keywords ((swollen or swell+ or expan+) and (cells or pockets or zones or regions or areas or parts or sections or portions or space+) and (curing or cured or fixed) and (composite or laminate or multi+ or sandwich+)); EPODOC and WPI: /IC/EC E04H and keywords ((self+ or actuat+ or automat+ or inflate+ or instant+ or in_place+ or in_situ+) and (absorb+ or expan+ or swollen or swell+)); EPODOC and WPI: /IC/EC E04 or E02D and keywords ((+curing or +cure+ or cross_link+) and ((swoll+ 4d polymer) or (absorbent 4d polymer) or (expan+ 4d polymer) or (swell+ 4d polymer)); EPODOC and WPI: and keywords ((panel or composite or structure+ or geo_text+ or liner or water_proof+) and (+curing or +cured or cross_linking or polymerizing) and (swollen or swell+ or absorbent or SAP) and +urethane+); GooglePatents and keywords (honeycomb water absorbent polymer curing).

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5174231 A (White) 29 December 1992	
A	US 2003/0207981 A1 (Zhou et al.) 6 November 2003	
X	US 4784901 A (Hatakeyama et al.) 15 November 1988 See the abstract; figure 4, items (2, 3, 4, 12); and column 2 lines 35 to 59.	21-22, 25-33, 35, 37

☐ Further documents are listed in the continuation of Box C ☒ See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 January 2012	2 February 2012
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. +61 2 6283 7999	Authorized officer **JOHN DEUIS** AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No : +61 2 6283 2146

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2011/060632

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
See attached sheet:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Supplemental Box
(To be used when the space in any of Boxes I to IV is not sufficient)

Continuation of Box No: III

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

This Authority has found that there are different inventions based on the following features that separate the claims into distinct groups:

- Claims 1-20, 38-55 are directed to an assembly and method of making a composite thereof, comprising: providing a plurality of layers, each layer comprising: a fabric sheet; a resin fixed to the fabric sheet; and a water-expandable polymer disposed along portions of each layer, wherein each layer is fixed to an adjacent layer at regions disposed between the portions of each layer having the water-expandable polymer; applying water to the plurality of layers; and curing the resin to form the composite. The feature of each layer is fixed to an adjacent layer at regions disposed between the portions of each layer having the water-expandable polymer is specific to this group of claims.

- Claims 21-37 are directed to a composite comprising: a plurality of layers, each layer comprising a cured resin fixed to a fabric sheet, wherein adjacent layers of the plurality of layers are fixed together at regions disposed between the adjacent layers; and a plurality of lumens disposed between the adjacent layers. The feature of a plurality of lumens disposed between the adjacent layers is specific to this group of claims.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

When there is no special technical feature there is no unity of invention.

In the above groups of claims, the identified features may have the potential to make a contribution over the prior art but are not common to all the claims and therefore cannot provide the required technical relationship. Therefore there is no special technical feature present in the claims and the requirements for unity of invention are consequently not satisfied *a priori*.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2011/060632

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	5174231	AU	75991/91	AU	75992/91	AU	41350/93
		BR	9103267	BR	9103305	CA	2041081
		CA	2041167	CA	2100100	EP	0491453
		EP	0491454	EP	0606700	FI	912897
		FI	912898	HK	187496	HK	1012688
		HK	1013319	IE	912068	IE	912069
		JP	4293825	JP	6240571	JP	4247113
		MX	9100093	MX	9100097	NO	912317
		NO	912316	NZ	238550	NZ	238551
		PT	98253	PT	98254	US	5237945
		US	5346565	US	5346566	US	5389166
		ZA	9104645	ZA	9104647		
US	2003207981	AU	49038/00	BR	0010962	CA	2310483
		CN	1357071	EP	1192319	JP	2003500530
		MX	PA01011965	NO	20015741	PL	352040
		RU	2001135803	US	6610781	US	6737472
		WO	0073596				
US	4784901	NONE					

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX