Office de la Propriété Intellectuelle du Canada
Un organisme d'Industrie Canada

Canadian Intellectual Property Office
An agency of Industry Canada

CA 2648966 C 2015/01/06

(11)(21) 2 648 966

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(86) Date de dépôt PCT/PCT Filing Date: 2007/04/12
(87) Date publication PCT/PCT Publication Date: 2007/10/18
(45) Date de délivrance/Issue Date: 2015/01/06
(85) Entrée phase nationale/National Entry: 2008/10/10
(86) N° demande PCT/PCT Application No.: AU 2007/000487
(87) N° publication PCT/PCT Publication No.: 2007/115379
(30) Priorité/Priority: 2006/04/12 (AU2006901936)

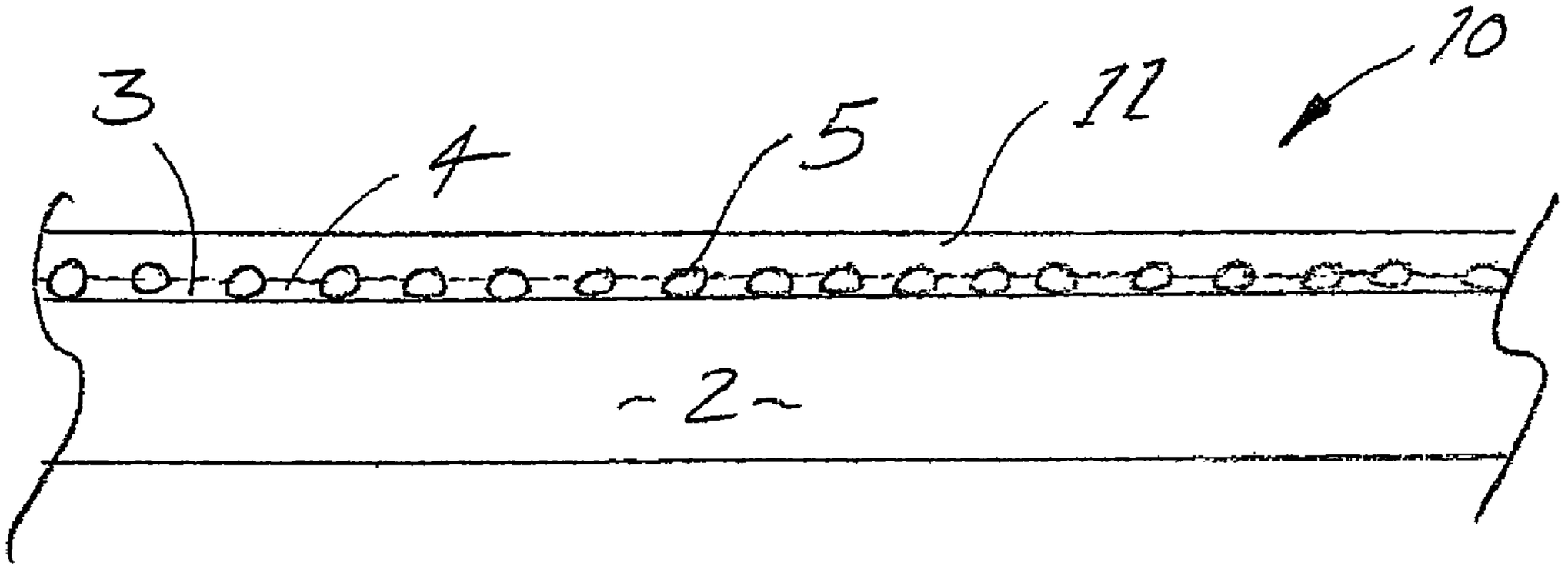
(51) Cl.Int./Int.Cl. *E04C 2/00* (2006.01), *B32B 13/02* (2006.01), *B32B 13/12* (2006.01), *B32B 13/14* (2006.01), *B32B 37/06* (2006.01), *B32B 37/16* (2006.01), *B32B 37/26* (2006.01), *E04C 2/26* (2006.01)

(72) Inventeurs/Inventors:
DUSELIS, STEVEN ALFRED, AU;
GLEESON, JAMES, AU;
KASCELAN, TIHOMIR, AU;
LYONS, DAVID, AU;
O'CHEE, MILTON TERRENCE, AU

(73) Propriétaire/Owner:
JAMES HARDIE TECHNOLOGY LIMITED, BM

(74) Agent: GOWLING LAFLEUR HENDERSON LLP

(54) Titre : ELEMENT DE CONSTRUCTION RENFORCE A SURFACE ETANCHE
(54) Title: A SURFACE SEALED REINFORCED BUILDING ELEMENT



(57) Abrégé/Abstract:
A building element (1) that is suitable for use as a structural element in wet areas or external decking. The building element (1) comprises a rigid substrate (2) having an upper face (3). Over the first face (3) lies a radiation curable resin (4) into which a layer of reinforcing material (5) is at least partially embedded. The reinforcing material (5) and resin (3) can be applied separately or together onto the first face (3) of the rigid substrate (2) or in some cases can be applied to both faces. An apparatus and method for producing the building sheet are also disclosed.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
18 October 2007 (18.10.2007)

PCT

(10) International Publication Number
WO 2007/115379 A1

(51) International Patent Classification:
E04C 2/00 (2006.01) *B32B 37/06* (2006.01)
B32B 13/14 (2006.01) *E04C 2/26* (2006.01)
B32B 37/26 (2006.01) *B32B 13/12* (2006.01)
B32B 13/02 (2006.01) *B32B 37/16* (2006.01)

(21) International Application Number:
PCT/AU2007/000487

(22) International Filing Date: 12 April 2007 (12.04.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2006901936 12 April 2006 (12.04.2006) AU

(71) Applicant *(for all designated States except US)*: **JAMES HARDIE INTERNATIONAL FINANCE B.V.** [NL/NL]; Atrium, 8th Floor, Strawinskylaan 3077, NL-1077 ZX Amsterdam (NL).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **DUSELIS, Steven, Alfred** [AU/AU]; 13 Therese Court, Baulkham Hills, NSW 2153 (AU). **GLEESON, James** [AU/AU]; 43 Austin Avenue, North Curl Curl, NSW 2099 (AU). **KASCELAN, Tihomir** [NZ/AU]; 12 Shipley Avenue, North Strathfield, NSW 2137 (AU). **LYONS, David** [AU/AU]; 3 Tegal Place, Pint Claire, New South Wales 2250 (AU). **O'CHEE, Milton, Terrence** [AU/AU]; 122 Chatham Road, Denistone, NSW 2144 (AU).

(74) Agent: **SHELSTON IP**; 60 Margaret Street, Sydney, NSW 2000 (AU).

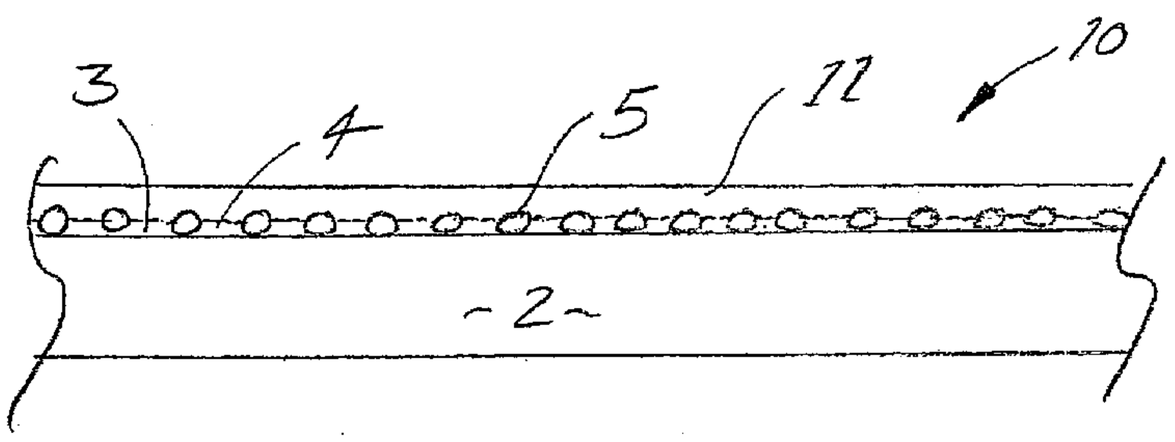
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: A SURFACE SEALED REINFORCED BUILDING ELEMENT



(57) **Abstract:** A building element (1) that is suitable for use as a structural element in wet areas or external decking. The building element (1) comprises a rigid substrate (2) having an upper face (3). Over the first face (3) lies a radiation curable resin (4) into which a layer of reinforcing material (5) is at least partially embedded. The reinforcing material (5) and resin (3) can be applied separately or together onto the first face (3) of the rigid substrate (2) or in some cases can be applied to both faces. An apparatus and method for producing the building sheet are also disclosed.

WO 2007/115379 A1

A SURFACE SEALED REINFORCED BUILDING ELEMENT

FIELD OF THE INVENTION

The present invention relates to a reinforced and preferably surface sealed building element and to a method and apparatus for the manufacture of these elements.

The invention was developed primarily for building sheet materials made predominantly from fibre cement and will be described hereinafter with reference to this application. However, it will be clear that the invention is not limited to this particular use and can readily be adapted to other building products and/or elements made from different materials.

BACKGROUND OF THE INVENTION

Any discussion of the prior art throughout the specification should in no way be considered as an admission that such prior art is widely known or forms part of common general knowledge in the field.

Selection of building materials for a given use depends largely upon the nature of the intended application and in many cases each of the products available represent a compromise between strength characteristics, durability and ease of installation, the latter being largely determined by workability characteristics such as ease of cutting, fixing and handling.

For example, natural timber has good inherent bending strength characteristics making it easy to transport and suitable for use in a variety of load bearing applications. However, it is generally fairly costly and lacks durability, particularly in damp or wet applications.

By contrast, manufactured wood products and fibre cement products, for example, are generally less expensive and more versatile in their application to form different

shapes and types of building elements. However, these products generally have relatively lower bending strength to weight ratio due to their inherent weakness under tensile loads. They are also generally porous and prone to some degree of moisture absorption. While in the case of fibre cement products, this does not lead to significant reductions in durability, with most materials there is usually a resultant decrease in the strength characteristics with prolonged and cyclic exposure to moisture. There is also usually a corresponding increase in mass, which may be relevant to the issue of transportation and installation.

The problem of low bending specific strength in building elements made of homogenous bonded materials such as fibre cement has been addressed to some degree by using various forms of added reinforcement. In some cases a reinforcing element is introduced into the main body of the building material during manufacture. However, this has generally required major modifications to the material manufacturing process which can be costly and may inhibit the flexibility of the manufacturing plant.

Other solutions have included the step of externally attaching some form of reinforcing element to the completed base product using fasteners or an adhesive. Examples of this concept as applied to fibre cement building substrates are described in WO 02/081842. However, in conventional production processes, this additional step is generally off line from the normal production line, requires a specific additional fastener/adhesive, is labour intensive and/or time consuming thereby adding substantially to the cost of the product.

It is an object of the invention to provide a reinforced building element, and a method and apparatus for the manufacture of such elements, which overcomes or

PCT/AU2007/000487
Received 7 February 2008

substantially ameliorates one or more of the disadvantages of the prior art or at least provides a useful alternative.

SUMMARY OF THE INVENTION

According to a first aspect of the invention, there is provided a reinforced building element including:

a cementitious rigid substrate having a first face; and

a layer of reinforcing material;

wherein said reinforcing material is adhered to said first face of said rigid substrate using a radiation curable resin.

The term "rigid" is used herein to refer to any kind of generally rigid and at least partially self supporting substrate and includes substrates that may have some degree of inherent flexibility due to their material and/or structure.

The term "radiation" is used herein to refer to radiation from UV (ultra violet) to higher wavelengths.

According to a second aspect of the invention there is provided a method of manufacturing a reinforced building element including the steps of:

(a) applying a radiation curable resin to a first face of a cementitious rigid substrate;

(b) applying a reinforcing material to the layer of a radiation curable resin; and

(c) curing the resin to thereby adhere said reinforcing material to the rigid substrate.

The radiation curable material may be undergo full curing in a single step in step c). Alternatively the radiation curable coating may be partially cured as an initial step prior to application of the reinforcing material. Preferably this initial partial curing

PCT/AU2007/000487
Received 7 February 2008

achieves a "tackiness" suitable for initial holding and positioning on the reinforcing material.

In one embodiment, the radiation curable material is fully cured prior to application of the reinforcing material. In this embodiment, the curable material is formulated to develop on adhesive/gripping texture on curing and thereby adhere the reinforcing material

The coating of radiation curable resin may be formed from one or more layers, preferably two layers, and the layer of reinforcing material is applied and embedded between these layers. In other words, in a particularly preferred embodiment, the radiation curable material is applied, optionally this layer undergoes a partial cure, the reinforcing material is applied over the first layer of radiation curable material, a second layer of such curable material applied, or indeed a different formulation, and the entire assembly subject to full curing.

The method may also include the further action of optionally applying several layers of radiation curable material with or without partial/full curing, prior to application of the reinforcing material.

In other variations, the partial/full curing of the radiation curable material may be applied in combination with mechanical keying by surface scuffing with equipment such as a fine sander or denibber. These intermediate steps can be repeated as desired to build up the layers of material prior to final curing step.

According to a third aspect, the present invention comprises a method of manufacturing a reinforced building element including the steps of:

(a) combining a reinforcing material with a radiation curable resin, the quantity of resin being sufficient to adhere the reinforcing material to a cementitious rigid substrate;

PCT/AU2007/000487
Received 7 February 2008

(b) applying the combined reinforcing material and resin to a first face of the rigid substrate; and

(c) curing the resin to thereby adhere said reinforcing material to the rigid substrate.

According to a fourth aspect of the invention, there is provided an apparatus for manufacturing a reinforced building elements, the apparatus including:

means for supporting a rigid substrate such that a first face thereof is exposed;

first coating means for applying a first layer of radiation curable resin to said first face;

application means for applying a reinforcing material to said first layer of radiation curable resin; and

first radiation application means for curing the applied resin.

In the preferred form, the apparatus comprises an automated system for producing a reinforced building element, the system including:

means to support a rigid substrate such that a first face thereof is exposed;

an applicator for applying a first layer of radiation curable resin to said first face of the substrate;

reinforcing feed means downstream of said applicator for feeding and applying a reinforcing material to said applied first layer of radiation curable resin; and

a radiation application device for applying radiation to the applied resin, reinforcing material and substrate assembly.

Desirably the system also includes means to automatically convey the substrate downstream through the applicators/devices etc. Optionally, the mechanism may also act to support the substrate in the required orientation.

In a particularly preferred form the system further includes;

a second radiation application device located immediately downstream of the first applicator device for applying a measured dose of radiation to achieve a predetermined "tackiness" in the resin prior to the reinforcing material being applied.

The system may also include a second resin applicator downstream of the reinforcing feed means to apply a second layer of radiation curable resin on top of the reinforcing material.

In other variations, additional resin applicator devices, with or without corresponding downstream radiation application devices, may be provided upstream of the reinforcing feed means, to build up the base resin coating prior to application of the reinforcing material.

Similarly, additional resin application devices, with or without corresponding downstream radiation application devices may be provided downstream of the reinforcing feed means for implying additional building up the top sealer coatings to the element prior to final curing of the applied resin, reinforcing and substrate assembly.

Preferably the rigid substrate is a manufactured matrix material. More preferably, the material is an hydraulically or cement bound material. Most preferably the material comprises fibre reinforced cement. In one preferred embodiment, the material is cellulose fibre reinforced cement.

In the preferred form, the building element is a building sheet or panel.

In one preferred form the building element is a sheet specifically configured for use as a structural element. The structural element can be structural flooring, such as a sub-floor panel. One advantage of the fibre cement structural flooring is that it does not require a tile backerboard to adhere tiles to the structural flooring. In typical

construction where it is desired to lay tile on a floor, a wood-based sub floor is first installed and then a tile backerboard is installed on top of the sub floor. The disclosed embodiments alleviate the necessity of hauling, sizing, and installing two layers of flooring prior to installing tile. In another preferred form, the building element is a sheet specifically configured for use in wet areas, such as bathrooms, laundry rooms, or kitchen areas where contact with water is possible. In a particularly preferred form, embodiments of the fibre cement sheet composition include those disclosed in US Patent No. 6,572,697 entitled "Fibre Cement Building Materials with Low Density Additives".

In addition, the preferred fibre cement sheets may be formulated according to embodiments disclosed in US Patent No. 6,346,146 entitled "Building Products" and also according to embodiments disclosed in Australian Patent No. 515151, entitled "Fibre Reinforced Cementitious Articles".

Most preferably, the reinforced building element is a structural flooring sheet for use in wet areas and is configured to include connecting means in the form of grooves formed in opposite longitudinal edges of each sheet configured either to interact with corresponding tongues formed on edges of adjacent sheets or with a complimentary elongate joining member adapted for simultaneous engagement with the respective adjacent grooves of adjoining sheets. This configuration is generally used where the joint is required to span between support framing such as floor joists.

In one particular embodiment, the planks are narrow "decking" type planks, joinable by the aforementioned tongue and groove arrangement. This clearly has a

significant advantage in being able to modify fibre reinforced cementitious planks for outdoor use in decking and the like.

The layer of reinforcing material can comprise any suitable continuous strand, ribbon, rod, mesh or sheet material having a higher tensile strength and similar or higher modulus of elasticity to that of the rigid substrate, where radiation curing can pass sufficiently through and/or around the material to cure the embedding sealer sufficiently to adhere the reinforcing material to the substrate. Preferably, the reinforcing material is selected such that once adhered to the substrate via the cured sealer it provides load transfer that results in an improved strength and toughness to the substrate material by greater than 5%.

Suitable reinforcing materials include fabrics made from continuous fibres such as glass fibre, alkali resistant glass fibre or carbon fibre.

The radiation curable resin can be any radiation curable material which provide efficient adherence between the fibre reinforce cement and the reinforcement materials.

The Applicant's have in fact found that radiation curable materials conventionally used as sealers for fibre reinforced cement are surprisingly useful for this purpose. Indeed they can be provided in quite low quantity, yet still act to secure the reinforcing material to the fibre reinforced cement. Further, if such a sealer is used the fibre reinforced rigid substrate is not only sealed but simultaneously, its mechanical properties are significantly improved by addition of the reinforced material.

In another embodiment, the radiation curable resin is a pressure sensitive adhesive. This embodiment is particularly useful since in some cases the reinforcing material will be applied to the rigid substrate by a roller. Applying a radiation curable pressure sensitive adhesive to the rigid substrate allows a roller to apply the fibre reinforced

material with potentially less prospect of the rollers being fouled with uncured or partially cured resin.

The radiation curable resin material is preferably applied in layers from 1 to 1000μm with 5 to 200μm being more preferable and 10 to 120μm being most preferred.

The curable or polymerisable components used in forming the radiation curable materials and blends of the present invention include, but are not limited to, urethane, acrylic, epoxy and polyesters or compounds having multiple functional types such as polyester epoxies and urethane acrylics.

The curable or polymerisable components may be monomers, oligomers or polymers. The oligomers are prepared from a range of monomers with functionality including, but not limited to, isocyanate, hydroxyl, polyether, epoxy, carboxylic acid and ethylenic unsaturation. The monomers used in such a composite, include but are not limited to acrylate functionalised alcohols, diols and polyols, acrylate functional ethoxylated and/or propxylated alcohol, diols and polyols, and acrylate functional ethylene and propylene glycols and ethylene and propyelene polyglycols. Other monomers effective in preparing such composites include but are limited to derivatives of unsaturated carboxylic acids and diacids such as acrylate, methacryalte, maleate and fumarate esters, and vinylic functional materials such as vinyl ethers, and vinyl pyrolidones. Blends or mixtures of the polymerisable components as herein described may also be used.

It is particularly preferred to use polymerisable compounds based on including ethylenically unsaturated monomers.

It is preferable that the curable resin compositions used in the present invention have high solids content. Particularly, it is preferred if the curable resin has a solids

curable polymerisable component content higher than 50%, more preferably higher than 70 and even more preferable if the resin forming compositions have a curable polymerisable content of around 80-100%. As will be clear to persons skilled in the art suitable curable resins may include pigmented systems where the pigment is a non-curable component or clear resin systems which have curable components in the greater 90% range.

It is preferable to use a combination of lower molecular weight monomers and higher molecular weight oligomers in order to achieve the most desirable viscosity for application, the best cure behaviour once exposed to radiation, and the most desirable physical and mechanical properties once cured. Lower molecular weight monomers may be present in amounts ranging from 10-50% by weight, with 10-30% being more preferable, and 15-25% being most preferred. Higher molecular weight oligomers may be present in amounts ranging from 10-50% by weight, with 15-40% being more preferable, and 20-35% being most preferred.

If filler is used, it may be present in amounts ranging from 5 to 80% by weight on the basis of the whole, whereas surface treatment additives are used in amounts ranging from 0.01 to 2% by weight, with respect to the filler, and from 0.01 to 0.5% by weight, with respect to the whole of the composition.

The above mentioned polymerisable compounds can be used as such or in mixture with additives such as catalysts, photo initiators, mineral or organic fillers, anti-wetting agents, dyes, plasticisers, pigments, stabilisers, shockproofing agents, insulating agents, flame retarding agents and the like, which are added in order to improve the physical-chemical properties of the finished product.

In some embodiments the building element has one or more additional functional surfaces to the first face, and these surfaces may also be sealed or processed in some other manner which may include lamination with other materials.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments in the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a side view of a first embodiment of a reinforced building element in accordance with the present invention;

Figure 2 is a side view of a second embodiment of a reinforced building element in accordance with the present invention; and

Figure 3 is a schematic layout showing a first embodiment of an apparatus as production method in accordance with the present invention.

PREFERRED EMBODIMENTS OF THE INVENTION

Referring to figure 1, there is shown a first embodiment face sealed and reinforced building element in the form of a building sheet 1. The sheet includes a rigid substrate 2 having an upper first face 3. Applied in a first layer is a coating of radiation cured sealer 4 into which a layer of reinforcing material 5 is at least partially embedded. In the preferred form this first layer of resin 4 extends over the full area of first face 3 so as to fully seal that surface.

The building sheet 1 is manufactured by: first applying a coating of radiation curable resin to the first face 3; then applying a layer of reinforcing material 5 to the applied layer of radiation curable resin 4 such that the material is at least partially embedded therein; and then fully curing the applied sealer to adhere the material to the substrate.

As shown in Figure 1, it is preferred that the upper surface of the reinforcing material 5 stands proud of the resin 4. Preferably the quantity of resin applied to the layer allows this to take place since it is important that rollers or other application techniques which apply the reinforcing layer to the rigid substrate are not fouled by the cured or partially cured resin 4.

In one preferred variation to this method, the applied layer of radiation curable resin 4 is first partially cured to achieve a predetermined "tackiness" in the resin so as to hold and retain the applied reinforcing material 5 prior to full curing of the resin.

A preferred second embodiment building sheet 10 is shown in figure 2. This embodiment is simply an enhancement of that shown in Figure 1 and accordingly corresponding numerals have been used to denote corresponding features. As in figure 1, the building sheet 10 has a rigid substrate 2 with a first layer of curable resin 4 applied to the first surface 3. This can be done with or without partial curing of the resin prior to the layer of reinforcing material 5 being applied thereto. The main variation is that prior to full curing of the resin, a further second layer of curable resin 11 is applied on top of the applied reinforcing material 5.

Please note that in variations to both embodiments, multiple first layers of curable resin 4 can be applied, with or without partial curing, prior to application of the reinforcing material, to build up the base coating. Similarly, in the embodiment of figure 2, multiple further layers of curable resin 11 can be applied on top of the reinforcing material, again with or without partial curing, prior to final curing on the final assembly.

Of course other application methods and thicknesses can be used, such as by wetting the reinforcement material with resin prior to placing it in contact with the

substrate. In this way, the reinforcing material sticks to the substrate without having a first base coat of resin applied to the substrate. Subsequently, a layer of resin can be applied to encapsulate the resin and increase the bonding between the substrate and reinforcing material.

It should be noted that where multiple layers of resin are applied, it is generally preferred to at least partially cure or mechanically key an underlying layer of resin prior to a further layer being applied, as this helps both the interlayer bonding and the application process.

This technique of several layers is useful for increasing film build and overcoming coverage problems or minimising defects in the underlying coats.

Referring next to figure 3, there is shown a schematic layout of an automated manufacturing apparatus 20 specifically configured for producing the preferred building sheet of figure 2.

The apparatus 20 includes a simple belt or roller conveyor 21 which serves to support the rigid substrate sheet 2 such that it's upper first face 3 is exposed and transfer the substrate in a downstream direction through the manufacturing apparatus. The conveyor 21 has a first end at a loading station 22 which is the location at which the prepared substrate sheets 2 are applied to the conveyor 21.

Immediately downstream of the loading station 22 is a first roller coating apparatus 23 for applying a first layer of radiation (preferably UV) curable resin e.g. sealer that has adjacent thereto a first radiation (preferably UV) application device 24 for optionally partially curing the sealer applied at 23.

After the radiation application device 24 a reinforcing material application device is provided as shown generally at 25. This device includes a feed attachment 26 for

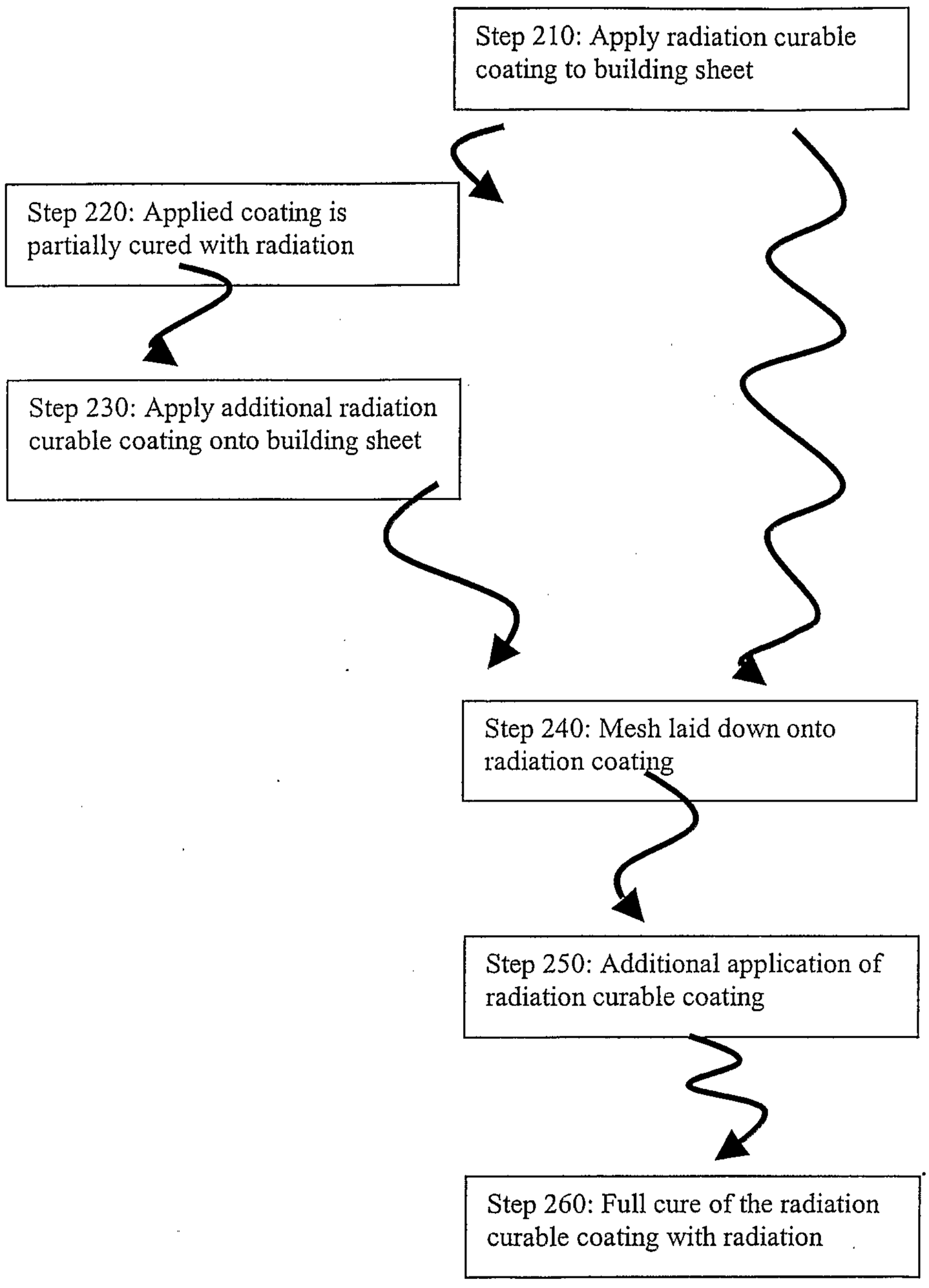
storing, tensioning and feeding a flexible layer of reinforcing material 5 and an application mechanism 27 which is adjustable to further control tension in the material and/or to apply pressure to push the reinforcing material onto the uncured or partially cured sealer coated substrate passing therebelow.

Downstream of the reinforcing material application device 25 is a second roller coating device or laminating device 28 for applying a second layer of radiation curable sealer on top of the applied reinforcing material 5. At the exit of this second roller coating device is one or more second radiation application devices for curing the applied radiation curable sealer.

In variations to this apparatus, the section marked X, comprising the first roller coating device 23 and first radiation application device 24, may be replicated at least once prior to the reinforcing material application device at 25. In this manner, it is possible to build up the layer of sealer before the reinforcing material is applied. Similarly, the section Y comprising the second roller coating device and second radiation application device or devices can also be replicated to build up the sealer applied on top of the reinforcing material. Such additional units would preferably be located at position Z.

In the preferred form a clear UV curable sealer is used.

This method and some limited representative variations is summarised schematically in the following flowchart and notes.



*Step **210**:*

In this step, a UV curable clear resin or sealer (such as that described in the example that follows) is applied onto the surface via a roller coater ensuring full coverage of the panel

*Step **220**: [Optional]*

In this step, the panel is then passed through mercury lamps at a reduced UV dosage & intensity to partially cure the UV clear resin

Step 230: [Optional]

In this step, the UV clear resin is reapplied onto the panel with no UV curing

Step 240:

In this step, the glass fibre mesh is layed down onto the wet or partially/gel cured resin which can be patted down or left sitting on the surface

Step 250:

In this step, the panels with the glass fibre mesh passes under the roller coater where the mesh is pushed down to follow the contours of the surface & another layer of resin is applied to bind down & encapsulate the glass fibre mesh.

Step 260:

In this step, the panel passes under the UV light (at higher UV dosage & intensity) to fully cure the coating.

Further optional steps can be inserted between steps 250 and 260 to apply further coatings of UV resin which can optionally be gel cured prior to application of further coats before the final cure at step 260.

EXAMPLE

Tests were conducted on a range of samples of fibre reinforced cement flooring panels modified in accordance with the preferred form of the invention. In each case the sample was tested against the unreinforced base product.

The materials specifications and processing details for the samples made according to the invention are set out below:

Materials	
Board Type	James Hardie™ 19mm **AquaTec™ wet area flooring**
UV Sealer	UV acrylate sealer ex Akzo Nobel (860301)
Mesh Type	**CAP80-20*20**

Further details of the mesh are provided under the section heading Reinforcing Materials hereafter.

The flooring board panel is a medium density (approx 0.95 g/cc) cellulose fibre reinforced cement board, which for the purposes of these tests were unsealed. The control board is identified as "no mesh" in the results table. This control board has neither the radiation curable resin or mesh applied.

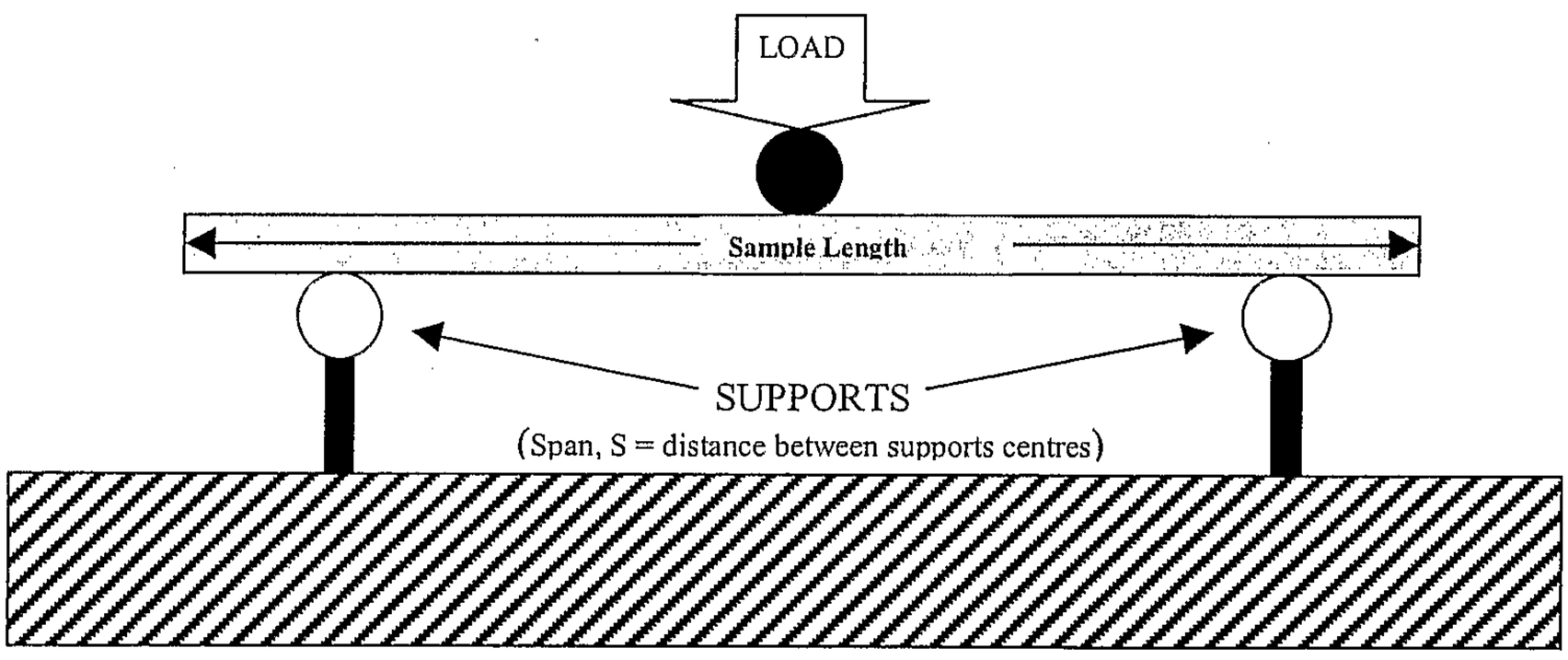
The board treated in accordance with the present invention is preferably sanded prior to application of the reinforcing material and radiation curable resin. Hence the apparent inconsistencies in the thickness between the control board and the treated board in the results table below.

	Processing	Parameters	Description			
1	1st application of UV resin on board	Roller Coater Type	Sorbini T/20-M Direct Roll Coater			
		Roller Hardness	25 Duro			
		Roller Coater Speed	30 m/min			
		1st Coat Film Build	50-60 g/m^2			
2	Gel Cure	Lamp Type	Nordson MPS-610V CW610 Lamphead			
		UV Line Speed	10 m/min			
			UVA	**UVB**	**UVC**	**UVV**
		Lamp Dose 1 (J/cm^2)	0.017	0.013	0.002	0.011
3	Mesh placement	CAP80-20*20 mesh	laid onto gel cured resin coated board then feed into the roll coater			
4	2nd application of UV resin on board	Roller Coater Type	Sorbini T/20-M Direct Roll Coater			
		Roller Hardness	25 Duro			
		Roller Coater Speed	30 m/min			
		2nd Coat Film Build	50-60 g/m^2			
5	Full Cure	Lamp Type	Nordson MPS-610V CW610 Lamphead			
		UV Line Speed	10 m/min (X 3 passes)			
			UVA	**UVB**	**UVC**	**UVV**
		Lamp Dose 2 (J/cm^2)	0.403	0.310	0.056	0.291

The samples of the invention were tested against the control samples under the following three conditions:

Testing Conditions	
Cut Direction	Long dimension of specimen parallel with sheet long dimension
Equilibrium (EQ)	Equilibrium room for 72 hours
Oven Dried (OD)	Oven dried at 60 C for 48 hours
Saturated (SAT)	Vacuum Saturated for 24 hours at -100 kPa

The 3 point flexural test was used to determine the bending strength of the materials manufactured according to the methods disclosed herein. The diagram below demonstrates the configuration of the test.



Samples are tested in different conditions to give the range of properties across fully saturated to fully dry. Samples taken from the examples given were tested in one or several of the conditions being saturated, equilibrium or oven dry.

Saturated Condition (SAT)

Specimens are fully immersed in water and vacuum saturated at -100KPa for a minimum of 24 hrs in standard laboratory conditions.

Equilibrium Condition (EQ)

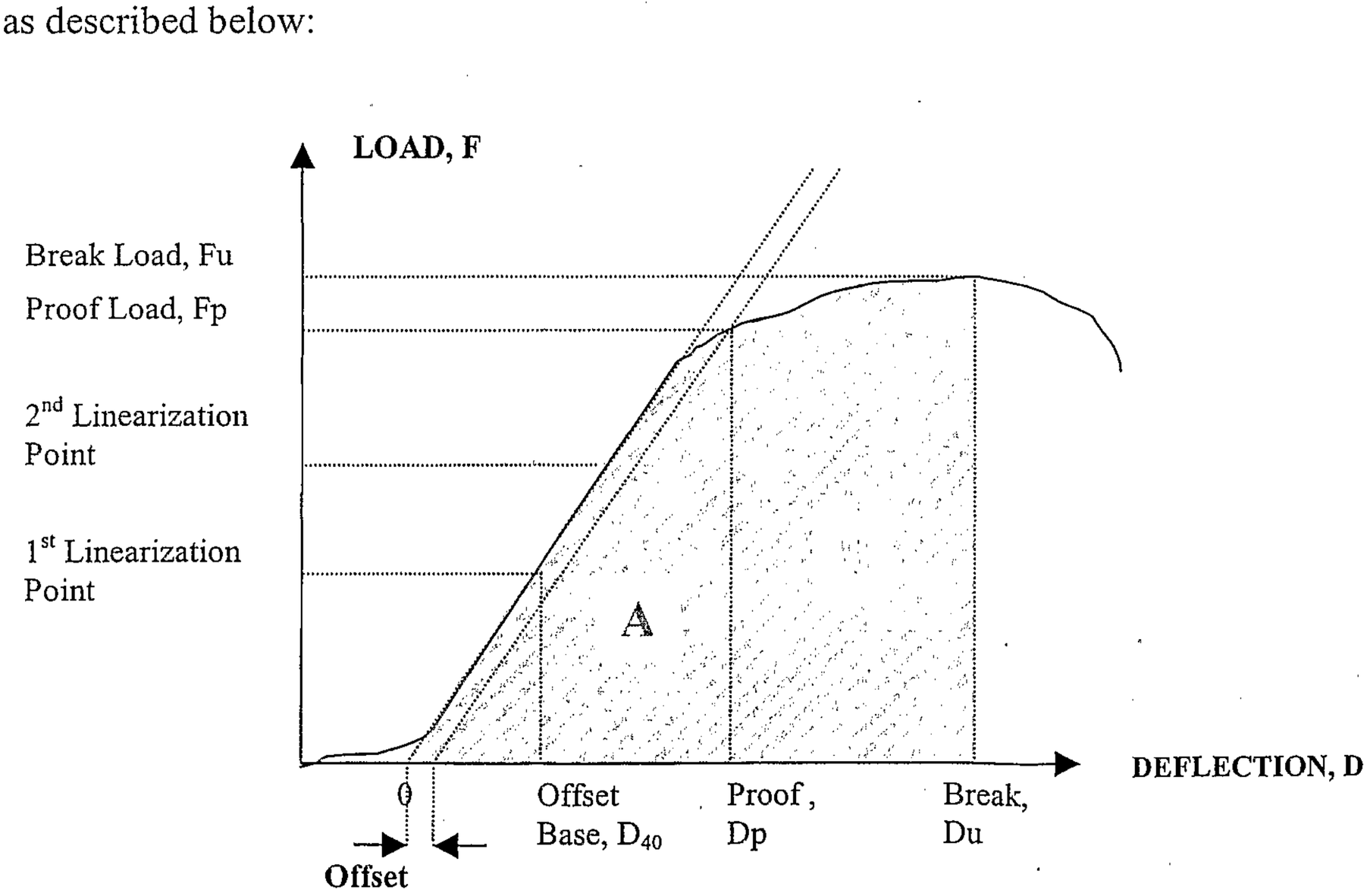
Specimens are conditioned in a controlled atmosphere to 23±2°C and 50±10% humidity for 3 days minimum.

Oven dry (OD)

Samples were conditioned in an oven set to 60±2°C for 48hrs minimum.

Samples are tested on a MTS Q-Test Universal Testing Machine. Specimen weight, thickness, length and width are measured before testing. The span used for testing the nominal 19mm thick material was 360mm. Load(N)and deflection(mm) were measured during the test until break occurred. The following calculations were used to determine the mechanical properties of the material.

The data from the test was then processed to derive various mechanical properties as described below:



Break Load, Fu, is the maximum load sustained b the specimen.

Break Deflection, Du, is the deflection, corrected to zero, at which the final maximum load, Fu, was recorded (i.e. The deflection at which the break load is recorded)

Linearization Points are the points on the load deflection curve used to calculate zero deflection. Loads for the 1st and 2nd linearization are 40% and 60%, respectively, of the Break Load.

Zero Deflection (0) is defined by the Linearization Points from which an extrapolation is extended to zero load to determine the corresponding zero deflection.

Offset Base, D_{40}, is the deflection corresponding to the base load of 40% the Break Load.

Offset is the displacement of a line drawn parallel to the line through the linearization points to calculate the proof load. The offset is given as a percentage of the offset base and is 10% of D_{40}.

Proof Load, Fp, is equal to or above the intersection of the load deflection curve and a line drawn parallel to the linearization points but displaced by the offset deflection. The proof load may be very close to the break load in very brittle materials.

Proof Deflection, Dp, is the deflection corresponding to the proof load, Fp.

Span, S, is the distance between the centre of the supports.

Thickness, t, is the average thickness measured at 4 points spaced out evenly around the specimen.

Width, w, is the average width measured at each end of the specimen.

Mechanical Property Calculations

Modulus of Rupture (MOR) is the maximum flexural stress supported by the specimen, and can be determined according to the following formula:

$$\text{MOR (MPa)} = \frac{3\ Fu\ S}{2\ t^2\ w}$$

Energy B is an estimate of the specific total energy absorbed by the specimen before breaking load. The specific total energy is proportional to the area of region B shown on the load/ deflection curve. This value is obtained by integration of the area B divided by specimen volume within the test span. **(kJ/m^3)**

Strain Ultimate is the strain at breaking load and can be calculated by the following formula:

$$\text{Strain Ultimate (um/m)} = \frac{6\ Du\ t}{S^2}$$

The results are set out in the table below:

Sample	Test Condition	Test Span	Strain Rate Ult	Thickness	Width	Length	Mass	Density	Break Load	Break Defn	M.O.R.	Strain Ult.	Energy B
		mm	Microns/	mm	mm	mm	g	g/cm^3	N	mm	MPa	Micro mm/mm	$Joule/m^3$
-No mesh	EQ	360	960	19.2	127.3	397	964	0.99	1258	6.9	14.5	6146	6.9
– Mesh CAP80	EQ	360	975	19.5	127.3	398	970	0.98	1786	12.7	19.9	11503	18.6
– No mesh	SAT	360	1003	19.2	129.0	400	1493	1.51	810	13.0	9.2	11556	10.2
– Mesh CAP80	SAT	360	976	19.1	129.0	400	1469	1.50	1118	13.9	12.9	12304	12.5
– No mesh	OD	360	1172	18.9	130.0	400	900	0.92	1203	3.2	14.0	2788	2.4
– Mesh CAP80	OD	360	943	18.9	130.0	400	922	0.94	1532	7.1	17.8	6207	7.9

As can be seen, the sealed reinforced product has significantly improved performance in all measured properties. It can be seen in virtually all areas namely Break Load, Break , Deflection, Modulous of Rupture, Strain Ultimate and Energy B the board treated in accordance with a preferred embodiment of the present invention has significantly improved properties as compared with the control board.

MATERIAL VARIATIONS

Substrate

The rigid substrate material is preferably a moisture stable sheet material such as cellulose fibre reinforced cement of a density range from 0.80g/cc to 1.5g/cc. Typical materials are James Hardie™ Fibre cement internal linings, external claddings and sheet flooring. When the invention is used as a reinforced sheet structural flooring material, it is preferable to use ≥15mm thick, nailable lower density fiber cement which is lighter weight, more workable and more nailable using conventional pneumatic and power nailing equipment than conventional compressed fibre cement products (approx. 1.6 g/cc dry density).

Preferably, the sheets must be strong enough to meet loading requirements for domestic construction flooring on supporting members spaced at 450mm and 600mm centres as specified, for example, in AS/NZS 1170.1:2002.

In line with the United States requirements, the supporting members need to be spaced out 16 inches, 19.2 inches and 24 inch centers in the US as specified in ASTM E330 and E661.

The preferred fibre cement sheets may be formulated according to embodiments disclosed in US Patent No. 6,346,146 entitled "Building Products" and also according to embodiments disclosed in Australian Patent No. 515151, entitled "Fibre Reinforced Cementitious Articles".

Most preferably, when used for structural flooring, the sheet is configured to include connecting means such as in the form of grooves formed in opposite longitudinal edges of each sheet configured either to interact with corresponding tongues formed on edges of adjacent sheets or with a complimentary

elongate joining member adapted for simultaneous engagement with the respective adjacent grooves of adjoining sheets.

In general terms it is preferable for the face of the substrate to which the sealer and reinforcing is to be applied to be relatively flat. However, where this is not possible, use of a sufficiently flexible reinforcing material, along with a deformable or contoured applicating device should assist in ensuring bonding to the contoured surface.

Reinforcing Material

The reinforcing material is any continuous strand, ribbon, rod or sheet material of significantly higher strength and similar or higher modulus of elasticity to that of the substrate material where radiation curing can pass sufficiently through and/ or around the material to cure the embedding resin sufficiently to adhere the reinforcing material to the sheet flooring and preferably also provide load transfer that results in an improved strength and toughness material by greater than 5 %. Examples of reinforcing material are continuous fibres such as glass fibre, alkali resistant glass fibre or carbon fibre.

The reinforcing material may be coated or uncoated. In some embodiments the reinforcing material may include a coating which is compatible with the radiation curable material to assist in adherence.

The supplier of the glass fibre used in the example described above is:-

A Jiangsu Jiuding New Material Co., Ltd., No.219 East Yuejin Road, Rugao City Jiangsu Province China. The glass fibres used were from this supplier were uncoated and coated fiberglass mesh CAP60-20*10 or polymer coated fiberglass mesh CAP80-20*20. The technica properties of this glass are listed below.

Supplier Item Number		CAP60-20*10	CAP80-20*20
Weave:		Plain	Plain
Material (Tex):	Warp	22*1*2	22*1*2
	Weft	44	44
Density (counts per inch):	Warp	20	20
	Weft	10	20
Unit Weight (g/m2)	Raw	54± 5	69± 5
	Finished Product	60± 5	80± 5
Content of Resin:		≥12%	≥14%
Tensile Strength (N/50mm):	Warp	≥650	≥1130
	Weft	≥650	≥1130
Tensile strength after 28 days conditio	Warp	≥60% of original	≥60% of original
in 5% NaOH:	Weft	≥60% of original	≥60% of original

The uncoated mesh was found to be more pliant and better able to follow irregularities in the base sheet.

Radiation Curable Material

The radiation curable material, resin or sealer is applied in layers which may be from 1 to 1000μm thick, with 5 to 200μm being more preferable and 10 to 120μm being most preferred. The curable or polymerisable components used in forming the radiation curable materials and blends of the present invention include, but are not limited to, urethane, acrylic, epoxy and polyesters or compounds having multiple functional types such as polyester epoxies and urethane acrylics.

The curable or polymerisable components may be monomers, oligomers or polymers. The oligomers are prepared from a range of monomers with functionality including, but not limited to, isocyanate, hydroxyl, polyether, epoxy, carboxylic acid and ethylenic unsaturation. The monomers used in such a composite, include but are not limited to acrylate functionalized alcohols, diols and polyols, acrylate functional

ethoxylated and/or propxylated alcohol, diols and polyols, and acrylate functional ethylene and propylene glycols and ethylene and propyelene polyglycols. Other monomers effective in preparing such composites include but are limited to derivatives of unsaturated carboxylic acids and diacids such as acrylate, methacryalte, maleate and fumarate esters, and vinylic functional materials such as vinyl ethers, and vinyl pyrolidones. Blends or mixtures of the polymerisable components as herein described may also be used.

It is particularly preferred to use polymerisable compounds based on including ethylenically unsaturated monomers.

It is preferable that the curable resin compositions used in the present invention have high solids content. Particularly, it is preferred that the curable resin has a solids content higher than 50%, more preferably higher than 70% and even more preferable if the resin forming compositions have a solids content of around 80-100%.

It is preferable to use a combination of lower molecular weight monomers and higher molecular weight oligomers in order to achieve the most desirable viscosity for application, the best cure behaviour once exposed to radiation, and the most desirable physical and mechanical properties once cured. Lower molecular weight monomers may be present in amounts ranging from 10 – 50% by weight, with 10 – 30% being more preferable, and 15 – 25% being most preferred. Higher molecular weight oligomers may be present in amounts ranging from 10 – 50% by weight, with 15 – 40% being more preferable, and 20 – 35% being most preferred.

If inorganic filler is used, it may be present in amounts ranging from 5 to 80% by weight on the basis of the whole, whereas surface treatment additives are preferably used

in amounts ranging from 0.01 to 2% by weight, with respect to the filler, and from 0.01 to 0.5% by weight, with respect to the whole of the composition.

The above mentioned polymerisable compounds can be used as such or in mixture with additives such as catalysts, photo initiators, mineral or organic fillers, anti-wetting agents, dyes, plasticizers, pigments, stabilizers, shockproofing agents, insulating agents, flame retarding agents and the like, which are added in order to improve the physical-chemical properties of the finished product.

Examples of radiation curable material/resin/sealer:

1. A commercially available radiation curable resin such as UV sealer: Akzo Nobel Clear Sealer R60301-001
2. A specifically formulated UV sealer such as that described in the table below:

UV Sealer Composition	**%w/w**	Description	Supplier	Supplier Location
Tripropylene Glycol Diacrylate (TPGDA)	20	SR306	Sartomer	Hong Kong, China
Bisphenol A Based Epoxy Acrylate	29	CN120	Sartomer	Hong Kong, China
Anti-Settling Additive	0.40%	Byk 410	Byk-Chemie	Wesel, Germany
2-Hydroxy-2-Methyl-1-Phenylpropan-1-one	1.80%	Darocur 1173	Ciba	NSW, Australia
2,4,6-Trimethylbenzoyl-Diphenyl-Phosphineoxide	1.50%	Lucirin TPO	BASF	Victoria, Australia
Calcium Carbonate	46.8%	Omyacarb 20	Omya Australia	NSW, Australia
Defoamer	0.50%	Byk077	Byk-Chemie	Wesel, Germany

Different techniques can be used for the preparation of the composite sheets. For example, a radiation curable compound may be flood coated, roller or brush coated or spray coated onto fibre cement.

To cure a UV curable form of the resin at a film build of 40 – 50 gsm a UV-A dose of at least 0.15J/cm^2 is required for full cure and a UV-A intensity >1 W/cm^2 . At

60 m/minute this equates to 3 medium pressure mercury lamps running at a power input of 450W/inch.

The preferred forms of resin/sealer are curable by UV, infra-red, or near infra-red.

In one example of the invention formation process, a fibre cement board is coated with a radiation curable material and a glass fibre mesh is immediately placed on top, this can then be cured with a suitable radiation source such as UV.

In another example the fibre cement board is coated with a radiation curable material which is partially radiation cured with just enough dose to create a tacky surface. A glass fibre mesh is applied to the tacky surface and a subsequent layer of radiation curable material is applied over the glass fibre mesh, and fully cured with a suitable radiation source.

In another embodiment the radiation curable material is a pressure sensitive adhesive. Such pressure sensitive adhesives which are radiation curable are known but have not been used for the purpose described. Suitable formulations include:

- a hydrogenated polybutadiene liquid oligomer (100 pts by wt) which has one or more ethylenically unsaturated terminal radicals, and a chain transfer agent (0-20 pts by wt).
- an oligomer having one or more acrylic double bonds in its molecule (100 pts by wt), a chain transfer agent (0-20 pts by wt)and an aliphatic polar monomer having a carboxyl group (0-30 pts by wt).
- poly (vinyl alkyl ether) oligomer, a liquid monoacrylate monomer and photoinitiator.
- polystyrenic block copolymers;

- epoxyfunctional liquid rubbers

METHOD OF MANUFACTURE

While the methods and apparatus detailed herein are ideally suited to achieving simultaneous sealing and reinforcing of the substrate, it will be appreciated that in the broadest form sealing of the substrate need not be achieved. Accordingly, the invention in at least one aspect is intended to include all methods by which a reinforcing material is adhered to a rigid substrate using a radiation curable resin. For example, rather than applying a full sealing coating of the resin to the substrate, a pattern of resin may be applied sufficient only to bond the reinforcing material to the substrate. Alternatively, the resin may be applied to the reinforcing material by methods such as dipping, rolling or spraying, prior to the reinforcing material being brought into bonding contact with the board. Such methods may include the steps of applying multiple layers of resin, with or without intermediate partial cure or gel cure steps along the lines outlined herein.

ADVANTAGES OF INVENTION

The invention in one of its broadest forms provides a simple but effective method of providing a building element with enhanced strength characteristics achieved by adhering a reinforcing material to a rigid substrate using a radiation curable resin. The use of a radiation curable resin as the adhesive makes the manufacturing process easy to automate as a continuous process and is readily adapted for most substrates and particularly suited for use with the preferred substrate fibre reinforced cement.

Similar advantages are obtained with that form of the invention that uses a meltable and resettable polymer solely to adhere the reinforcing material to the rigid substrate.

The invention in its preferred forms provides a very simple cost and time effective means of both sealing and simultaneously reinforcing building materials so as to improve their water resistance and strength characteristics.

This can result on the one hand, in products of only slightly increased thickness having substantially improved strength characteristics, which increases their potential range of applications, in that the products are potentially less brittle, easier to handle and more durable in terms of improved weather resistance and impact resistance.

Alternatively, the invention can be used to provide products having at least equivalent or potentially better strength characteristics to existing products, but in a form that is lighter in weight and easier to transport and handle.

The invention has particular advantages when applied to the specific field of structural flooring for use in wet area flooring and external decking. In this regard, fibre cement materials are potentially suited to such applications in terms of their durability and resistance to rot but the brittle nature of fibre cement and its reduced load bearing capabilities when wet, does in many ways limit its applications. However, as can be seen from the example above, modification of these basic flooring substrates in accordance with the invention, dramatically improves the strength characteristics of these boards. This also facilitates extended use of fibre cement products in decking applications where there may be some current resistance due to the brittleness of the base product. By having an integral reinforcing material, the product will be less prone to brittle type failure, but where this does occur the reinforcing may act to retain the fragments of the substrate in a similar manner to laminated glass products.

As mentioned above the building element of the present invention is particularly suitable for structural flooring as it does not require a tile backerboard to adhere tires to

the structural flooring. Similarly, the element is suitable for external decking due to the inventive synergistic combination of moisture resistance and increased structural integrity.

The invention also allows more conventional fibre cement products to be readily adapted for use in impact resistant walling applications such as is required in hospitals and schools.

Another advantage of the invention is that the applied reinforcing helps to resist edge break out when nailing the perimeter of a building sheet, or when the fastened sheet is exposed to shear or racking forcing when fastened to framing.

It should be mentioned, that while the invention was developed primarily for use with fibre cement substrate materials, it can clearly be seen that it will have useful application with a variety of other base materials including manufactured wood, plywood etc.

Similarly, while the invention has been described in relation to the preferred application to building sheets and building panels, the invention can be applied to non-planar building elements made from similar materials such as trim components and the like, the reinforcing elements serving to increase bending strength and thereby improve handle-ability etc.

Although the invention has been described with reference to specific examples it will be appreciated by those skilled in the art that the invention may be embodied in many other forms.

CLAIMS:

1. A reinforced building element including:

a rigid cementitious substrate having a first face; and

a layer of reinforcing material, wherein said layer of reinforcing material is adhered to said first face of said rigid cementitious substrate using a radiation curable resin.

2. A reinforced building element as claimed in claim 1 wherein the rigid cementitious substrate is constructed from fibre reinforced cement.

3. A reinforced building element as claimed in claim 1 or 2 wherein the rigid cementitious substrate is a cellulose fibre reinforced cementitious article.

4. A reinforced building element according to any one of claims 1 to 3 wherein the radiation curable resin is provided in a quantity sufficient to at least partially embed the reinforcing material therein.

5. A reinforced building element according to any one of claims 1 to 4 wherein the radiation curable resin covers the entire first face of the rigid cementitious substrate.

6. A reinforced building element as claimed in any one of claims 1 to 5 wherein the radiation curable resin is provided over a portion of the first face to give sufficient adherent contact with the reinforcing material.

7. A reinforced building element as claimed in any one of claims 1 to 6 wherein the resin is a UV radiation curable resin.

8. A reinforced building element as claimed in any one of claims 1 to 7 wherein the building element comprises a further coating to cover the reinforcing material.

9. A reinforced building element as claimed in any one of claims 1 to 8 wherein the reinforcing material is selected from continuous strand, ribbon, rod, mesh or sheet material or a combination thereof.

10. A reinforced building element as claimed in any one of claims 1 to 9 wherein the reinforcing material comprises continuous organic or inorganic fibres.

11. A reinforced building element as claimed in any one of claims 1 to 10 wherein said building element comprises an arrangement at least along its edges adapted to interlock with adjacent reinforced building elements and thereby form a reinforced panel or floor.

12. A reinforced building element as claimed in any one of claims 1 to 11 wherein a layer of reinforcing material is provided and adhered to both fist and second faces of the rigid cementitious substrate.

13. A reinforced building element as claimed in any one of claims 1 to 12 wherein the radiation curable resin is a pressure sensitive adhesive.

14. A reinforced building element as claimed in any one of claims 1 to 13 wherein the radiation curable resin is a sealer.

15. A reinforced building element as claimed in any one of claims 1 to 14 wherein element comprises one or more layers of radiation curable material above and below said reinforcing element.

16. A method of manufacturing a reinforced building element including the steps of:

(a) applying a radiation curable resin to a first face of a rigid cementitious substrate;

(b) applying a reinforcing material to the layer of a radiation curable resin; and

(c) curing the resin such that said reinforcing material adheres to the rigid cementitious substrate.

17. A method as claimed in claim 16 wherein the rigid cementitious substrate is constructed from fibre reinforced cement.

18. A method as claimed in claim 16 or 17 wherein the rigid cementitious substrate is a cellulose fibre reinforced cementitious article.

19. A method as claimed in any one of claims 16 to 18 wherein the radiation curable resin is provided in a quantity sufficient to at least partially embed the reinforcing material therein.

20. A method as claimed in any one of claims 16 to 19 wherein in step (a) the radiation curable resin covers the entire first face of the rigid cementitious substrate.

21. A method as claimed in any one of claims 16 to 19 wherein in step (a) the radiation curable resin is provided over a portion of the first face, said portion being sufficient to provide adherant contact with the reinforcing materials.

22. A method as claimed in any one of claims 16 to 21 wherein prior to step (b) the radiation curable resin is at least partially cured.

23. A method as claimed in any one of claims 16 to 22 wherein prior to step (b) the radiation curable resin is at least partially cured to achieve a predetermined "tackiness" in the resin.

24. A method as claimed in any one of claims 16 to 23, wherein the resin is fully cured prior to addition of the reinforced material.

25. A method as claimed in any one of claims 16 to 23 wherein after step (c), one or more further coatings of radiation curable resin is applied to cover the reinforcing material.

26. A method as claimed in any one of claims 16 to 23 wherein the resin is applied in step (a) as a series of coatings with or without partial curing there between each coating.

27. A method as claimed in claim 25, wherein the one or more of the further coatings of radiation curable resin are fully or partially cured in combination with mechanical keying with surface scuffing prior to application of another resin coat.

28. A method as claimed in any one of claims 16 to 26 wherein steps (a), (b) and (c) are applied to both faces of the rigid cementitious substrate such that a layer of reinforcing material is provided and adhered to both first and second faces of the rigid cementitious substrate.

29. A method as claimed in any one of claims 16 to 26 wherein the radiation curable resin is a pressure sensitive adhesive.

30. A method as claimed in claim 29, wherein the pressure sensitive adhesive is partially cured or allowed to dry prior to application of the layer reinforcing material.

31. A method as claimed in any one of claims 16 to 26 wherein the radiation curable resin is a sealer.

32. A method of manufacturing a reinforced building element including the steps of:

(a) combining a reinforcing material with a radiation curable resin, the quantity of resin being sufficient to adhere the reinforcing material to a rigid cementitious substrate;

(b) applying the combined reinforcing material and resin to a first face of the rigid cementitious substrate; and

(c) curing the resin to such that said reinforcing material adheres to the rigid cementitious substrate.

33. A method as claimed in claim 32 wherein the rigid cementitious substrate is constructed from fibre reinforced cement.

34. A method as claimed in claim 32 or 33 wherein the rigid cementitious substrate is a cellulose fibre reinforced cementitious article.

35. A method as claimed in any one of claims 32 to 34 wherein the radiation curable resin is provided in a quantity sufficient to at least partially embed the reinforcing material therein, when applied to the rigid cementitious substrate

36. A method as claimed in any one of claims 32 to 35 wherein prior to step (b) the radiation curable resin is at least partially cured.

37. A method as claimed in any one of claims 32 to 36 wherein prior to step (b) the radiation curable resin is at least partially cured to achieve a predetermined "tackiness" in the resin.

38. A method as claimed in any one of claims 32 to 37 wherein after step (c), one or more further coatings of radiation curable material is applied to cover the reinforcing material.

39. A method as claimed in claim 38, wherein the one or more of the coatings of resin are fully or partially cured in combination with mechanical keying with surface scuffing prior to application of another resin coat.

40. A method as claimed in any one of claims 32 to 39 wherein steps (a), (b) and (c) are applied to both faces of the rigid cementitious substrate such that a layer of reinforcing material is provided and adhered to both first and second faces of the rigid cementitious substrate.

41. A method as claimed in any one of claims 32 to 40 wherein the radiation curable resin is a pressure sensitive adhesive.

42. A method as claimed in any one of claims 32 to 40 wherein the radiation curable resin is a sealer.

43. An apparatus for continuous manufacture of a reinforced building element as defined by according to any one of claims 1 to 15 or according to the method defined by any one of claims 16 to 42, said apparatus including: (a) means for supporting a rigid substrate such that a first face thereof is exposed;

(b) coating means for applying radiation curable resin to said first face;

(c) application means for applying a reinforcing layer to said radiation curable resin; and

(d) radiation application means for curing said radiation curable resin.

44. A method of manufacturing a reinforced building element including the steps of:

(a) applying a radiation curable resin to a first face of a rigid cementitious substrate;

(b) applying a reinforcing material to the layer of a radiation curable resin; and

(c) curing the resin such that said reinforcing material adheres to the rigid cementitious substrate, wherein the resin is fully cured prior to addition of the reinforced material.

45. A method of manufacturing a reinforced building element including the steps of:

(a) applying a radiation curable resin to a first face of a rigid cementitious substrate;

(b) applying a reinforcing material to the layer of a radiation curable resin;

(c) curing the resin such that said reinforcing material adheres to the rigid cementitious substrate; and

(d) applying one or more further coatings of radiation curable resin to cover the reinforcing material.

46. A method as claimed in claim 45, wherein the one or more of the further coatings of radiation curable resin are fully or partially cured in combination with mechanical keying with surface scuffing prior to application of another resin coat.

47. A method of manufacturing a reinforced building element including the steps of:

(a) applying a radiation curable resin to a first face of a rigid cementitious substrate, wherein the radiation curable resin is applied as a series of coatings with or without partial curing there between each coating;

(b) applying a reinforcing material to the layer of a radiation curable resin; and

(c) curing the resin such that said reinforcing material adheres to the rigid cementitious substrate.

48. A method of manufacturing a reinforced building element including the steps of:

(a) applying a radiation curable resin to a first face of a rigid cementitious substrate;

(b) applying a reinforcing material to the layer of a radiation curable resin; and

(c) curing the resin such that said reinforcing material adheres to the rigid cementitious substrate,

wherein the radiation curable resin is a pressure sensitive adhesive that is partially cured or allowed to dry prior to application of the layer reinforcing material.

49. A method of manufacturing a reinforced building element including the steps of:

(a) combining a reinforcing material with a radiation curable resin, the quantity of resin being sufficient to adhere the reinforcing material to a rigid cementitious substrate;

(b) applying the combined reinforcing material and resin to a first face of the rigid cementitious substrate;

(c) curing the resin such that said reinforcing material adheres to the rigid cementitious substrate; and

(d) applying one or more further coatings of radiation curable material to cover the reinforcing material.

50. A method as claimed in claim 49, wherein the one or more of the coatings of resin are fully or partially cured in combination with mechanical keying with surface scuffing prior to application of another resin coat.

51. The reinforced building element of claim 1, wherein the reinforcing material provides improved strength and toughness to the substrate by greater than 5%.

52. A reinforced building element produced by the method of any one of claims 16-42 and 44 to 50.

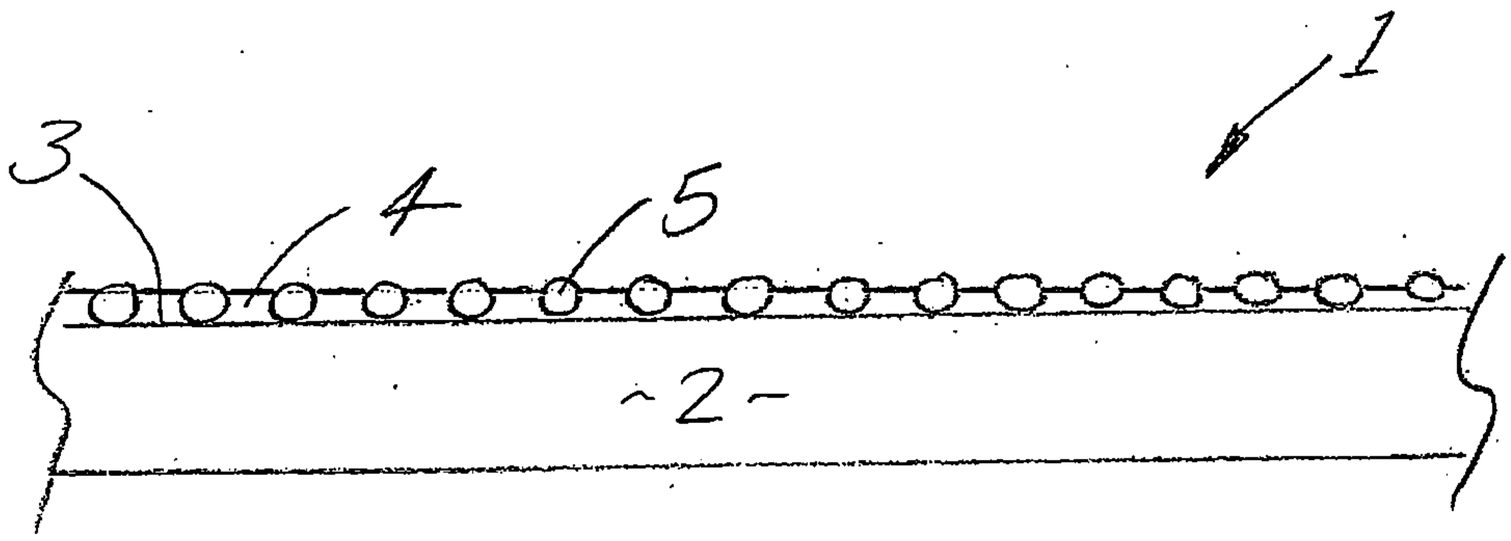


FIG. 1

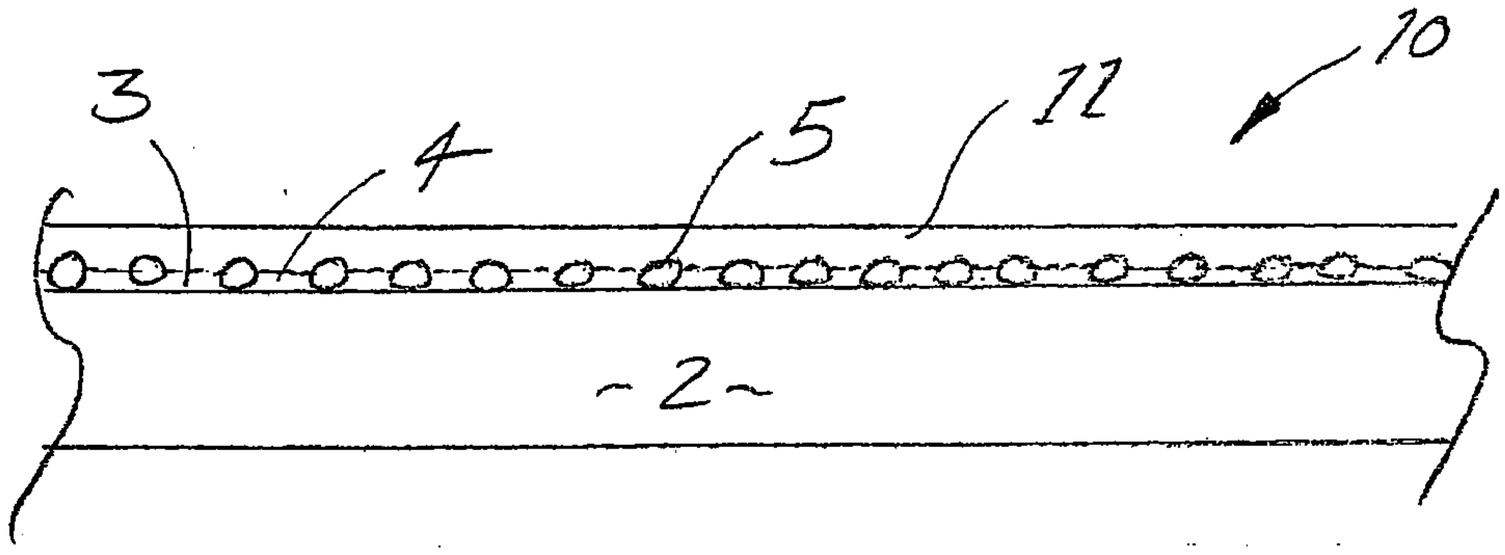


FIG. 2

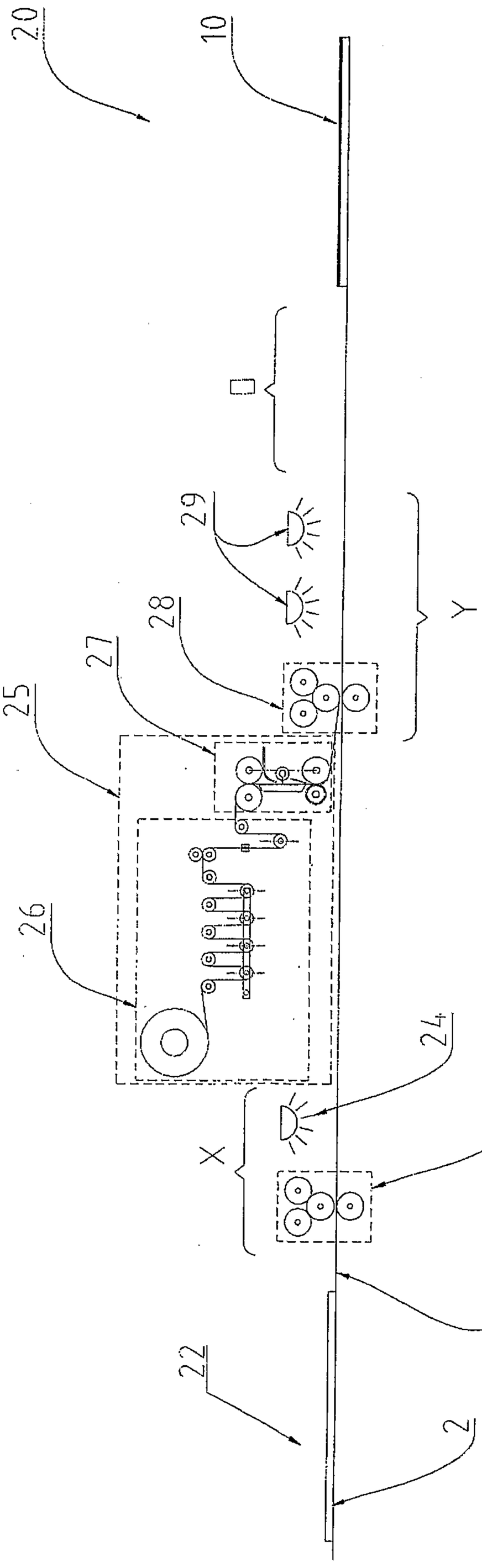
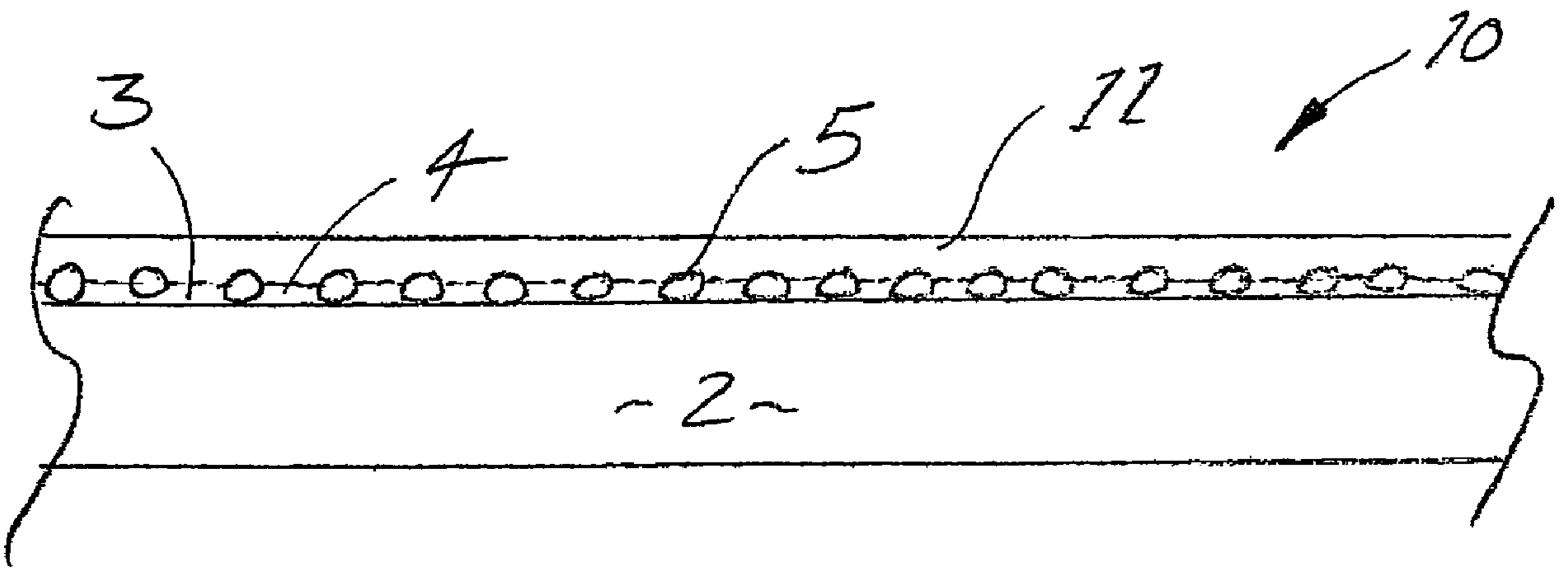


Fig. 3


3
4
5
11
10
- 2 -